Eight countries, connected by one ecosystem, working together to secure its future.

# Transboundary Diagnostic Analysis

## Volume 2: Background and environmental assessment

### Bay of Bengal Large Marine Ecosystem Project

**DRAFT – NOVEMBER 2010**

*This TDA document is for use in national consultations. A penultimate version will be drafted after consideration of the comments from the national consultations by a Regional Workshop in early 2011.*

# CONTENTS

**Abbreviations and Acronyms**

| | |
|---|---|
| ADB | Asian Development Bank |
| APFIC | Asia-Pacific Fishery Commission |
| BOB | Bay of Bengal |
| BOBLME | Bay of Bengal Large Marine Ecosystem |
| CBM | Community-based Management |
| CPI | Corruption Perceptions Index |
| EEZ | Exclusive Economic Zone |
| ESI | Environmental Sustainability Index |
| EVI | Environmental Vulnerability Index |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GFC | Global Financial Crisis |
| GPA | Global Programme of Action for the Protection of the Marine Environment from Land-based Activities |
| HDI | Human Development Index |
| IW | International Waters |
| LME | Large Marine Ecosystem |
| NGO | Non-governmental Organization |
| NPK | Nitrogen, Phosphorus, Potassium |
| PDF | Project Development and Preparation Facility |
| POP(s) | Persistent Organic Pollutant(s) |
| SAP | Strategic Action Programme |
| SEDAC | Socioeconomics Data and Applications Centre |
| TDA | Transboundary Diagnostic Analysis |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UN ESCAP | United Nations Economic and Social Commission for Asia and the Pacific |
| UNSD | United Nations Statistics Division |
| USD | United States of America Dollar |
| WWF | Worldwide Fund for Nature |

# 1. INTRODUCTION

1. This document is Volume 2 of the Transboundary Diagnostic Analysis (TDA) for the Bay of Bengal Large Marine Ecosystem (BOBLME). It describes:

- Scope and characteristics of the BOBME;
- Legal, administrative, political context and constraints;
- Assessment of marine living resources and the environment (including critical habitats and pollution); and
- Background of the BOBLME transboundary issues.

2. It provides the background to Volume 1, which focuses on the transboundary issues and presents a causal chain analysis that identifies the proximate and root causes of the issues that provide the basis for the development of a Strategic Action Plan (SAP) to identify the inventions required to address the transboundary issues.

3. Both volumes are based on a preliminary framework TDA (Verlaan, 2004) that 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. Inputs included theme reports (Angell, 2004), (Edeson, 2004), (Kaly, 2004), (Preston, 2004), and (Townsley, 2004) and national reports (Ali, 2003), (Hossain, 2003), (Joseph, 2003), (Juntarashote, 2003), (Myint, 2003), (Omar, 2003), (Purnomohadi, 2003), and (Sampath, 2003)1 and outputs from Regional Workshops (BOBLME/REP/1, 2003), (BOBLME/REP/2, 2003) and (BOBLME/REP/2RW, 2004).

4. The three main areas of concern covered in this TDA are:

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

5. Volume 1 presents the transboundary issues and their proximate and root causes of these three areas of concern. Many of the statements in Volume1 are made without references, data or information, which are covered in considerable detail in this Volume 2.

# 2. SCOPE AND CHARACTERISTICS OF THE BOBLME

## 2.1 Boundary and General Characteristics of the Region

6. 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. The BOBLME covers an area of about 6.25 million km2.

7. Bangladesh, Maldives, Myanmar and Sri Lanka have 100% of their coastlines within the BOBLME as defined, but only part of the coastline of India, Indonesia, Malaysia and Thailand are in the BOBLME.

8. Just over 68 % 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 (both east coast

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

and Andaman and Nicobar Islands), Maldives, Myanmar, Indonesia, Sri Lanka, Thailand, Bangladesh and Malaysia (Table 2.1).

9. The BOBLME region also includes the watersheds that feed into the Bay of Bengal, Andaman Sea, Straits of Malacca and the northern Indian Ocean.

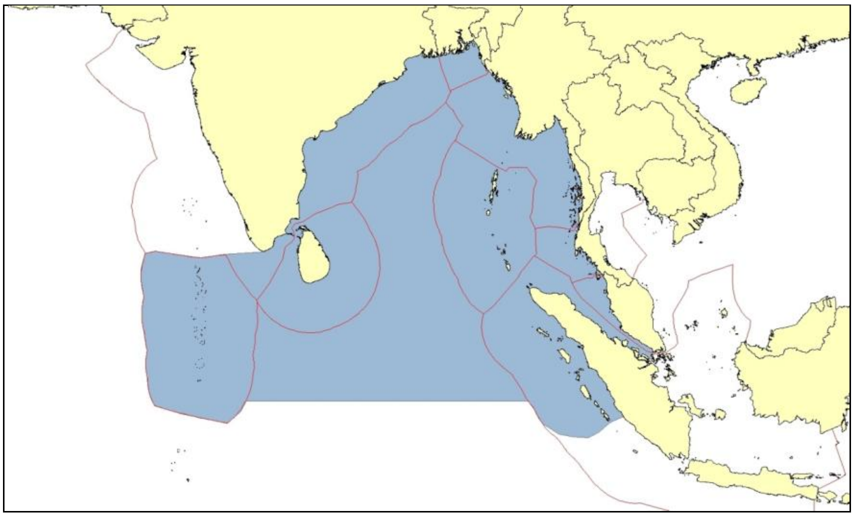


**Figure 2.1. BOBLME boundaries and EEZ boundaries[2].** ***Source: BOBLME Project***

**Table 2.1. Length of coastline and EEZ areas of countries in the BOBLME (Note: area only in the BOBLME).**

| Country | Length of coastline (km) | Estimated area of the EEZ (km$^2$) | Percentage area |
|---|---|---|---|
| **Indonesia** | ~2,000 | 719,300 | 11.5% |
| **Malaysia** | 1,110 | 68,750 | 1.1% |
| **Thailand** | 740 | 118,600 | 1.9% |
| **Myanmar** | 3,000 | 520,260 | 8.3% |
| **Bangladesh** | 710 | 78,540 | 1.3% |
| **India** | 4,645 | 1,326,510 | 21.2% |
| **Sri Lanka** | 1,770 | 530,680 | 8.5% |
| **Maldives** | n/a | 916,190 | 14.7% |
| **High seas** | - | 1,972,170 | 31.5% |
| **Total** | **~14,000** | **6,251,000** | |

*Source: (SAUP, 2010)*

[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.

## 2.2 Biophysical Characteristics

### 2.2.1 Climate and currents

10. The BOBLME lies in a high rainfall/monsoonal climate zone and it includes substantial expanses of low-lying coastal land. Monsoons blow from the southwest from May to October and from the northeast from November to April. The southwest or summer monsoon occurs when warm, moist air from the Indian Ocean flows onto the land, and is usually accompanied by heavy rain. The northeast monsoon occurs when cold, dry winter air flows out of the interior of Asia from the northeast and brings the cool, dry winter season.

11. The monsoon influences the wind-driven surface circulation in the BOBLME that changes seasonally, forming a stronger clockwise gyre during the southwest monsoon and a weaker anti-clockwise gyre during the northeast monsoon. Although the monsoon is a recurring event, it is characterized by great inter-annual variability in the time of its onset and its intensity, neither of which can as yet be adequately predicted, although the monsoon dynamics are linked with the Indian Ocean Dipole (IOD). The IOD is an irregular oscillation of sea-surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean. It interacts with similar phenomena like the El Niño-Southern Oscillation (ENSO) in the Pacific Ocean. A significant positive IOD occurred in 1997-8, with another in 2006.

12. The BOBLME has no true seasonal upwelling. 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, this phenomenon occurs on the northeast coast of India, the western coast of Thailand and off the south coast of Sri Lanka. During the southwest monsoon, the eastward-flowing equatorial current supplies nutrients to the BOBLME from the Somali upwelling in the Arabian Sea. During the season of current reversal, saline water invades the estuaries and lower reaches of coastal rivers. Tides are mostly semi-diurnal and the range is quite large (e.g., from 0.7 m in Sri Lanka to 7 m in Myanmar (springs); effects are felt up to 130 km inland in the northern and up to 340 km in the north-eastern estuaries of Bangladesh).

13. Many large rivers flow into the BOBLME, e.g. the Ganges, Brahmaputra and Meghna in the north from Bangladesh and India; the Ayeryawady and Thanlwin in the east from Myanmar; and the Mahanadi, Godavari, Krishna and Cauvery in the west from India. The Ganges-Brahmaputra-Meghna Basin, which covers nearly 1.75 million km2 spread over five countries (Bangladesh, Bhutan, China, India and Nepal), is the second largest hydrologic region in the world. Numerous rivers also flow into the BOBLME from Indonesia, Malaysia, Sri Lanka and Thailand. These rivers introduce huge fluxes of fresh water and large quantities of silt into the coastal and marine environment of the BOBLME. As much as 80% of the annual discharge enters in the summer during the southwest monsoon.

### 2.2.2 Sea surface temperature and primary productivity

14. The LME shows considerable spatial and temporal variability, particularly in the surface water along the coast, notwithstanding the existence of the seasonal gyres circulation. The influx of fresh water from the major rivers affects the salinity and productivity of the coastal and estuarine waters as well as coastal circulation patterns, especially in the north. Monsoon rain and flood waters produce a warm, low-salinity, nutrient and oxygen-rich layer to a depth of 100 - 150 m; this layer floats above a deeper, more saline, cooler layer that does not change significantly with the monsoons (Dwivedi & Choubey, 1998). Perennially low salinity exists in the northern Bay owing to the Ganges-Brahmaputra river discharge and as a result, the upper mixed layer in the northern Bay is much shallower than in the south.

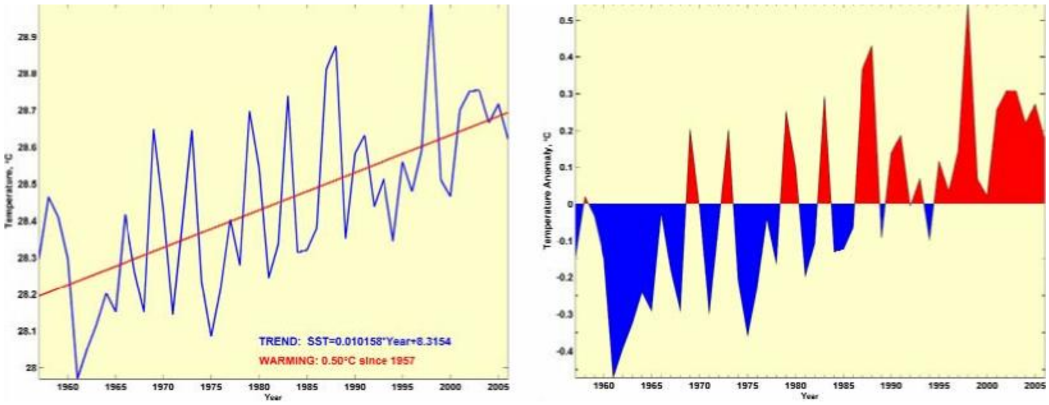



**Figure 2.2. Bay of Bengal LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology.** ***Source: (Belkin, 2009).***

15. This inter-annual variability of the monsoon also eventually affects SST variability, in the Bay of Bengal that varies with an average magnitude of <0.5°C on a scale of 3 to 5 years (decadal variability is not distinct) (Fig 2.2). A positive phase of the IOD results in greater-than-average sea-surface temperatures and greater precipitation in the western Indian Ocean region, with a corresponding cooling of waters in the eastern Indian Ocean. The negative phase of the IOD brings about the opposite conditions, with warmer water and greater precipitation in the eastern Indian Ocean, and cooler and drier conditions in the west. The steady, slow average warming of the Bay of Bengal is also obvious in Fig 2.2 - 0.5o C since 1957.

16. The BOBLME is considered to be a Class I, highly productive ecosystem (>300 gC/m2/y. While large nutrient input from river run-off supports high primary production in coastal waters, the central parts of the bay are less productive because of the absence of large-scale mixing or upwelling (Fig. 2.3). The presence of different water masses in coastal areas has produced sub-systems along the coast that differ in their environmental characteristics and community composition. These sub-systems are described by Dwivedi (1993). Productivity in the EEZ waters of the BOBLME averages 730gC/m2/year, ranging from a low of 385 in the Maldives to a high of 1700 in Bangladesh (SAUP, 2010). There is no exact estimate of the average primary productivity for the area defined as the BOBLME for the BOBLME Project, but it would be in the order of 500gC/m2/year.

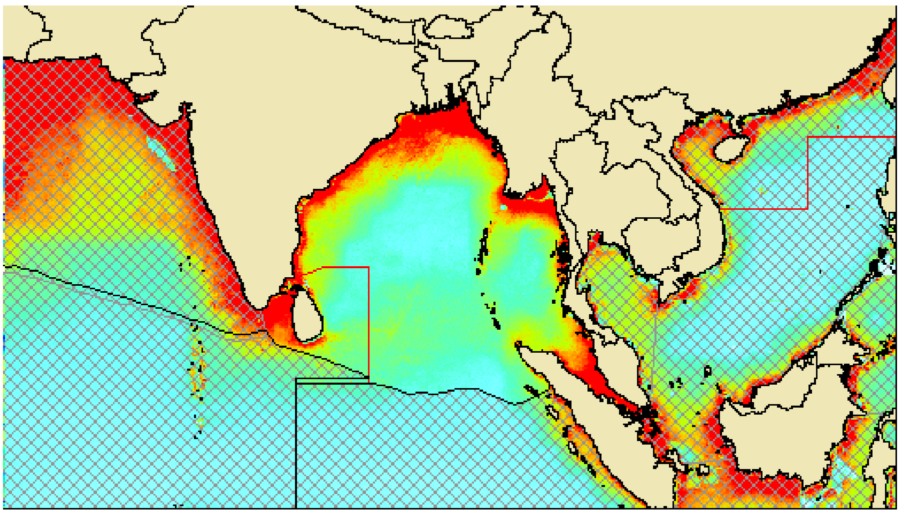


**Figure 2.3. Average annual primary productivity in the BOBLME. Red denotes high productivity.** ***Source: (SAUP, 2010)***

17. The BOBLME is subject to destructive cyclones that form over the open sea and head shoreward in a generally westward direction, as well as to storm surges. Their effects are most

severe along the western continental and island coasts. They occur most often just before and after the monsoon rains. Bangladesh, for example, experiences storm surges up to 160 km inland to the north.

### 2.2.3 Bathymetry

18. In the Bay of Bengal itself, the continental shelf tends to be quite narrow except in the northern part of the BOBLME (Fig. 2.4). Because of the large sediment load, the BOBLME is relatively shallow for a large part of its area although along the western, oceanic side of the Andaman-Nicobar Islands the Java Trench stretches south past the western side of Sumatra (and Java) Islands in Indonesia. The Java Trench is seismically active and the only area in the BOBLME where ocean floor is subducted. The slippage of the tectonic plates caused the December 2004 tsunami that affected most of the BOBLME. In the Andaman Sea, east of the Andaman-Nicobar Islands, is an active spreading centre, where new ocean floor is produced, and two large seamounts have been noted - more can be expected to exist.

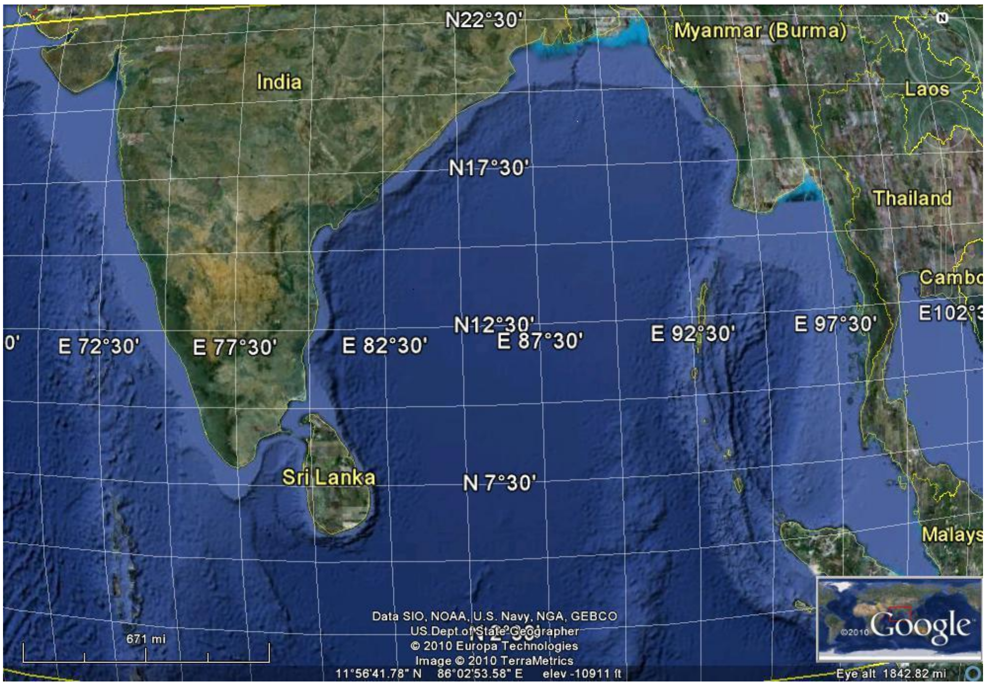



**Figure 2.4. Bathymetry of the BOBLME.** ***Source: Google Earth (NOAA add-on)***

### 2.2.4 Natural resources and marine biodiversity

19. The BOBLME is rich in natural resources. These include extensive mineral and energy resources, marine living resources that support major fisheries, and forest and land resources. The LME is the home of three important critical habitats – mangroves, (11.9% of the world), coral reefs (8.0% of the world) and seagrass. 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, with activities such as fishing, shrimp farming, tourism and shipping contributing to food security, employment and national economies. These are discussed in more detail in the following sections.

## 2.3 Socio-economic characteristics

20. The eight countries bordering the Bay of Bengal Large Marine Ecosystem (BOBLME) are characterized by a diverse range of political systems that have evolved out of equally diverse histories. However, in more recent times, their political and social systems have converged as a result of the influence of western European culture which has left a legacy of strong public sector institutions and bureaucracies. While the BOBLME nations are following different paths for their own development they share many challenges in securing a prosperous and sustainable future for the BOBLME. This section illustrates the socio-economic factors that underlie many of the

management and development challenges. It starts with the people themselves and the ever expanding coastal populations. It then provides an overview of the predominant economic activities directly related to the BOBLME. This overview is followed by a summary of the issues concerning coastal livelihoods and poverty in the BOBLME, and notably the important role that marine resources have in supporting the livelihoods of millions of coastal dwellers. Some of the key elements relating to governance are then briefly reviewed. The section concludes with a discussion that illustrates some key areas of vulnerability to change.

### 2.3.1 Population

21. The countries surrounding the BOBLME include some of the most populous on earth, with India, Indonesia and Bangladesh being among the world's top ten. Collectively the BOBLME countries are home to some 1.75 billion people, or approximately a quarter of the world's population. The population of the BOBLME countries has grown rapidly over the last 50 years, tripling from its level 660 million in 1960 to its current level.

**Table 2.2: BOBLME national population statistics in 2010 and 2020 based on 2008 trends.**

| Country | Population (millions) (2010 | Population (millions) (2020) | Population density #/km$^2$ (2010) | Population density #/km$^2$ (2020) | % Urban Population (2010) | Urban growth 2010-2015 |
|---|---|---|---|---|---|---|
| **Indonesia** | 223 | 259 | 122 | 136 | 44 | 1.72 |
| **Malaysia** | 28 | 33 | 85 | 99 | 72 | 2.44 |
| **Thailand** | 50 | 71 | 133 | 139 | 34 | 1.77 |
| **Myanmar** | 50 | 56 | 74.6 | 83 | 34 | 2.95 |
| **Bangladesh** | 164 | 189 | 1142 | 1310 | 28 | 3.13 |
| **India** | 1,214 | 1,403 | 369 | 427 | 30 | 2.38 |
| **Sri Lanka** | 20 | 22 | 311 | 335 | 14 | 1.06 |
| **Maldives** | 0.31 | 0.35 | 1053 | 1229 | 40 | 4.24 |

*Source:* (UNDP, 2009)

22. Despite having similar total land areas (3,497,300 km2 in the west, 3,425,000 km2 in the east) the total population of the western BOBLME countries is 1.399 billion, as opposed to 351 million in the east, i.e. about 85% live in the western countries (Table 2.2). These populations are estimated to increase to 1.615 billion and 0.42 billion respectively by 2020 (i.e. total over 2 billion).

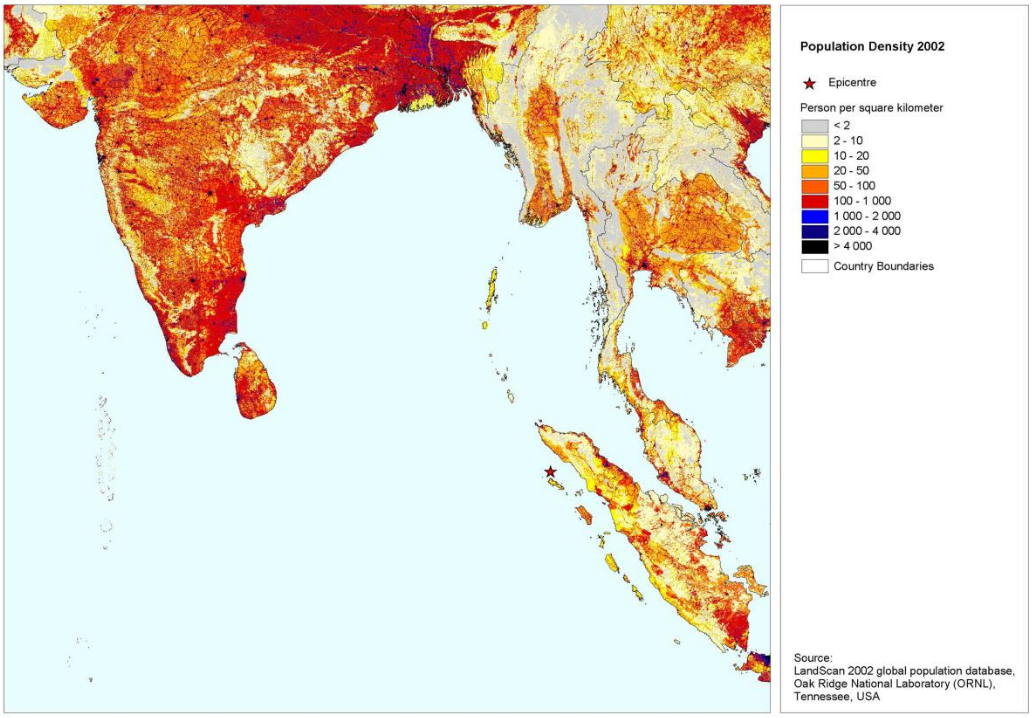
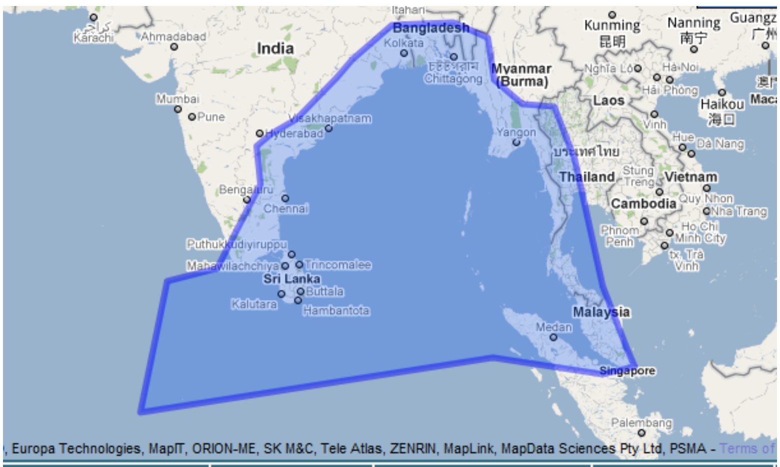



**Figure 2.5. Population densities of countries surrounding the BOBLME. Source: (Landscan, 2002)**

23. The high populations are coupled with very high levels of population density (Fig. 2.5), particularly in the four western BOBLME countries. The levels of population density are some of the highest in the world with an average of 719 persons/km2 in the western countries compared to a density of 104 persons/km2 in the eastern BOBLME countries and a world average of 51 persons/km2.

24. The BOBLME countries are still primarily rural, but are undergoing rapid urban growth with average urban population growth rates between 1.06% in Sri Lanka and 3.13% in Bangladesh and 4.14% in the Maldives (Table 2.2)

25. Estimates of the proportion of the total population living on the coast of the BOBLME vary. However, using the Population Estimation Service tool – based on SEDAC Gridded Population of the World Data 2005 – it is possible to make a crude estimate; it is estimated that 447 million people live within approximately 200km of the coastline in 2005 (Fig. 2.6).




| Standard Deviation | Land Area km² | Mean Unit Area km² | Population 2005 |
|---|---|---|---|
| 8,982 | 1,428,733 | 1,377 | 447,351,600 |

**Figure 2.6. Estimates of coastal populations in 2005. Source: (SEDAC, 2010)**

26. This figure is likely to have grown since 2005 as recent trends of increasing urbanization will mean that the towns and cities already concentrated within the coastal zone have continued to expand.

27. While this estimation is based on the physical proximity to the coast this paints only part of the picture in terms of the importance that marine resources play in the livelihoods of the people in the nations adjacent to the BOBLME. The services provided in terms of food, trade and transportation will involve a far larger number of people than just those who live nearby.

### 2.3.2 BOBLME economies

28. Despite their generally large populations, the BOBLME countries have relatively small economies. In terms of GDP, none of them ranks among the world's top ten (India is number 12, Indonesia number 18) (*Table* 2.3).

29. All BOBLME nations have experienced rapid growth over the past two decades – particularly in the industry and service sectors - this has lead to increasing levels of industrial development in the coastal zones surrounding the BOBLME. Much of the industry has centred on transforming raw materials into steel, paper, chemicals, paints, plastics and textiles; also important are leather tanning, oil refining, and electricity generation (Kaly 2004). All of the economies are decreasing their reliance on the agriculture sector (including fisheries) as growth in the industry and service sectors has been the predominant force behind the long-term growth of GDP.

**Table 2.3: Estimates of GDP (per capita) for BOBLME countries 2007 (in 1990 US dollars)**

| | **Indonesia** | **Malaysia** | **Thailand** | **Myanmar** | **Bangladesh** | **India** | **Sri Lanka** | **Maldives** |
|---|---|---|---|---|---|---|---|---|
| **GDP**[1] | 1,160 | 4,847 | 2,916 | 457 | 455 | 792 | 993 | 2,453 |
| *(Growth 2000-2005)*[2] | *(4.7%)* | *(4.7%)* | *(5.1%)* | *(12.9%)* | *(5.4%)* | *(7.0%)* | *(4.0%)* | *(4.8%)* |
| **Agriculture**[1] | 13% | 10% | 11% | 50% | 19% | 18% | 13% | 6% |
| *(Growth 2000-2005)*[2] | *(3.2%)* | *(3.2%)* | *(2.3%)* | *(11.4%)* | *(2.5%)* | *(2.8%)* | *(0.7%)* | *(7.5%)* |
| **Industry**[1] | 46% | 47% | 44% | 15% | 29% | 28% | 32% | 17% |
| *(Growth 2000-05)*[2] | *(3.9%)* | *(4.0%)* | *(6.3%)* | *(17.4%)* | *(7.4%)* | *(7.1%)* | *(3.5%)* | *(8.4%)* |
| **Services**[1] | 40% | 43% | 45% | 34% | 53% | 54% | 55% | 77% |
| *(Growth 2000-2005)*[2] | *(6.5%)* | *(5.6%)* | *(4.5%)* | *(13.6%)* | *(5.7%)* | *(8.5%)* | *(4.73%)* | *(3.4%)* |

**Percent expressed as a percentage of total value added**

*Source[1]: UNSD (2010), Source[2]: ESCAP (2009)*

**30.** Throughout 2005 – 2010 growth has continued across the countries, although all have been adversely affected by the current global financial crisis (GFC) that started in 2007 and as of 2010 is still ongoing. This crisis has once again emphasized the interconnectedness of the global economy.

31. For some of the BOBLME economies a strong reliance on export led growth e.g. Thailand (76.6% of GDP), Maldives (86.6%) and Malaysia (110.2%), has left them vulnerable to external economies (Fig. 2. 7).

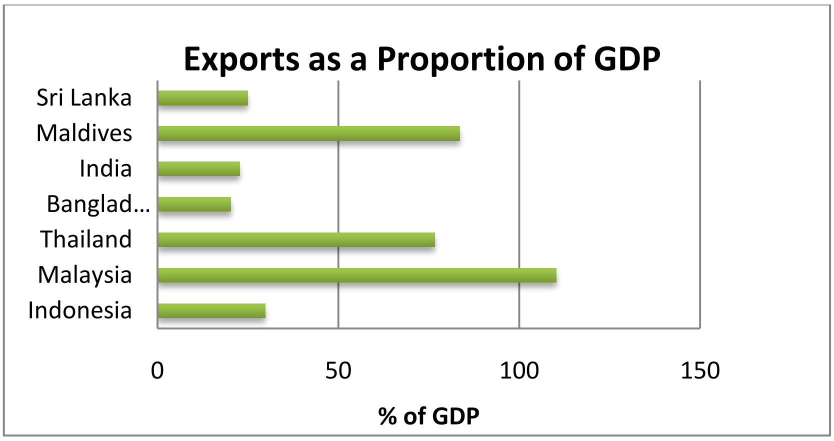



**Figure 2.7: Exports as a percentage of GDP prior to the Global Financial Crisis of 2007**

32. Following the GFC, import demand from the advanced economies shrank and many Asian countries faced a sudden drop in exports. These losses have been estimated by comparing 2008 exports with what they might have been had they followed recent trends. The results were most startling for India (losses of US$32billion), Thailand (losses of US$11billion) and Indonesia (losses of US$724 million) (ADB, 2010).

## Fisheries

33. With the exception of Maldives and Myanmar where it contributes 6.25% and 9.9%, respectively, fisheries make a modest contribution to GDP of the countries bordering the BOBLME (Table 2.4), noting that these figures are probably underestimates as they do not fully include small-scale fisheries contributions.

Table 2.4: Percentage contribution of fisheries and tourism to GDP. *Source: (APFIC, 2008), (ESCAP, 2010), (Maldives Ministry of Planning and National Development, 2010).*

| | **% Contribution of capture fisheries to GDP (2006)** | **% contribution of tourism (2007)** |
|---|---|---|
| **Indonesia** | 1.9 | 1.3 |
| **Malaysia** | 1.1 | 9 |
| **Thailand** | 1.6 | 8.4 |
| **Myanmar** | 9.9 | |
| **Bangladesh** | 2 | 0.1 |
| **India** | 0.5 | 0.9 |
| **Sri Lanka** | 1.3 | 2.3 |
| **Maldives** | 6.25 | 55.5 |

34. Fisheries are nevertheless of major socio-economic importance to BOBLME countries in terms of employment, food security and local revenue generation. Marine capture fisheries provide direct employment to at least 2 million fishermen who operate primarily in coastal and inshore waters and over 4 million people directly employed in marine capture fisheries (Table 2.5).

**Table 2.5: Number employed and number of active fishermen in BOBLME countries**

| | Employment in Fisheries [3] | | |
|---|---|---|---|
| | Number Employed (000s) | Prop. of Workforce | Active fishermen |
| **Indonesia 2008** | 1,775 | 2% | 536.3 |
| **Malaysia 2008** | 122.1 | 1% | 53.4 |
| **Thailand (2008)** | 425.6 | 1% | 92.8 |
| **Myanmar** | n/a | n/a | 506.0 |
| **Bangladesh 2005** | 1,095 | 2% | 259.5 |
| **India 2005** | 905.9 | n/a | 517.6 |
| **Sri Lanka (2006)** | 144 | n/a | 212.5 |
| **Maldives 2006** | 8.388 | 8% | n/a |
| | **4,476** | | **2,178** |

*Source:* FAO Country profiles, (2010), CMFRI, (2006), SEAFDEC (2009), *Unpublished reports to APFIC*

35. In addition to those involved in direct primary production of fish, there are people involved in other ancillary activities, such as processing, net and gear making, ice production and supply, boat construction and maintenance, manufacturing of fish processing equipment, packaging, marketing and distribution. Others are involved in research, development and administration connected with the fishery sector. No official data exist on the estimated numbers of people involved in these other activities, but some estimations indicate that, for each person employed in capture fisheries and aquaculture production, there are about four jobs produced in the secondary activities, including post-harvest (FAO 2008).

36. Fish are also very important for food security and make up a significant proportion of the daily intake of protein in many coastal communities in the BOBLME, and in marginalized hill tribes when dried fish is distributed to these areas. The nations around the BOBLME all achieved recent gains in reducing the number of people who are undernourished. To this end, there has been significantly more progress in the eastern countries with Thailand and Myanmar reducing levels by 40% and 60%, respectively (FAO, 2009). However, 2009 has been a devastating year for the world's hungry, marking a significant worsening of an already disappointing trend in global food security since 1996.

---

[3] As defined in ILO survey based on category Employment - 2B Total employment, by economic activity (Thousands) International Standard Industrial Classification of all Economic Activities (ISIC-Rev.2, 1968) [1]See http://laborsta.ilo.org/

The global economic slowdown, following on the heels of the food crisis in 2006–08, has deprived an additional 100 million people access to adequate food.

**Table 2.6: Percapita seafood consumption (kcal/person/day), total dietary protein (g/person/day) in 2003-2005, seafood dietary protein consumption (g/person/day) in 2003-2005, and Meat Offal, Milk & Eggs 2003-2005 dietary protein consumption (g/person/day) in 2003-2005.**

| | Indonesia | Malaysia | Thailand | Bangladesh | Myanmar | India | Sri Lanka | Maldives |
|---|---|---|---|---|---|---|---|---|
| **Per capita seafood consumption** | 48.92 | 89.64 | 59.1 | 26.28 | 43.5 | 9.16 | 50.27 | 368.14 |
| **Dietary Protein** | 53 | 77 | 57 | 48 | 66 | 56 | 54 | 106 |
| **Dietary Protein Fish / seafood** | 6.89 | 15.4 | 9.12 | 3.84 | 5.94 | 0 | 6.48 | 55.12 |
| **Dietary Protein Consumption Meat/dairy/eggs** | 4.24 | 26.18 | 13.68 | 2.88 | 9.34 | 7.84 | 5.94 | 16.96 |

*Source: FAO Fishstat (2010*)

37. Fish also provides a valuable supplement for a diversified and nutritious diet in many BOBLME countries. Not only does it provide high-value protein, but also represents an important source of a wide range of essential micronutrients, minerals and fatty acids. Globally, fish provides on average 30 kilocalories per person per day (FAO, 2008). In many of the BOBLME countries this figure is significantly higher (Table 2.6). In the Maldives it provides up to 368 kilocalories per person per day, while Indonesia, Malaysia, Myanmar, Thailand and Sri Lanka all have well above average levels. 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%)). In all cases the figures are based at a national level and probably underestimate the importance of fish in the diets of the coastal populations. For example, Deya, et al. (2005) observed both differences in the types of fish consumed by the rich and poor but also that per capita fish consumption was substantially higher in rural areas compared to urban areas in countries such as Bangladesh, India, Indonesia and Thailand.

38. Although most fishery production is consumed domestically, there are substantial exports of high-value commodities, especially from Thailand, India and the Maldives. Primary export commodities are shrimp and tuna, which may contribute significantly to national foreign exchange earnings in BOBLME countries. Trading of fish has been a major activity in BOBLME countries for years. Trends in fish trade, however, are now being driven by major fish import economies. To export fish and seafood products to the EU or USA, for example, the BOBLME economies must comply with various quality and documentation requirements. In addition, major retailers of fish and seafood products are increasingly demanding sustainability and traceability documentation and labels. The USA supermarket chain Wal-Mart and United Kingdom retailers, such as Sainsbury and Waitrose, prefer to buy fish and seafood products with Marine Stewardship Council and Aquaculture Certification Council sustainability certification. These labels are earned through extensive processes that examine scientific information and fisheries and aquaculture management plans and activities.

39. Overexploitation of shrimp resources in coastal waters has reduced the amount of exports from capture fisheries, and there is now a growing tendency for exports to come from the aquaculture sector. During the last decade, some countries have developed offshore fishing for tuna, notably longlining by Indonesia, purse seining by Thailand, gill-netting by Sri Lanka and pole and line by the Maldives. While the majority of tuna catches continue to come from coastal fisheries, offshore fisheries provide the majority of export-grade tuna. Squid is becoming more commercially important; although its production is relatively small, values are high.

## Tourism

40. Tourism in the BOBLME region is evolving in its nature; growing in importance, spreading geographically, and becoming an increasingly important source of wealth (see Table 2.4).

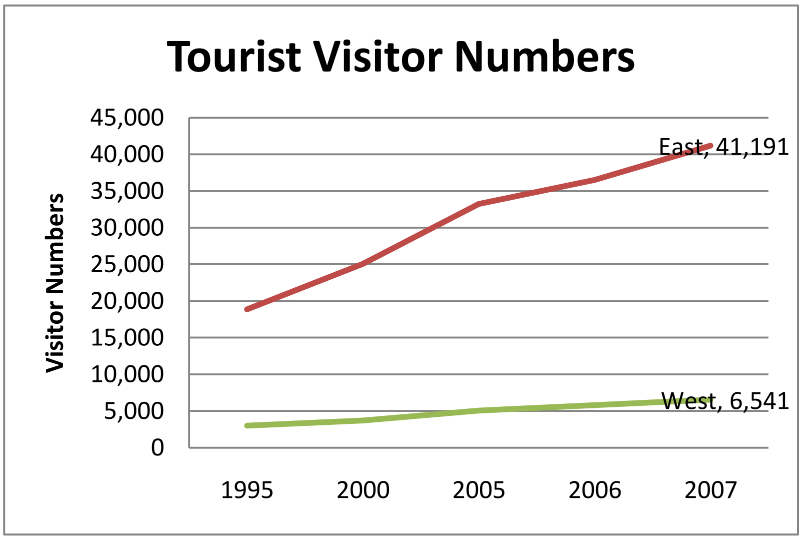



**Figure 2.8. Growth in tourism, 1995 to 2008 in eastern and western BOBLME.**

41. The eastern countries of the BOBLME have dominated the tourism markets in terms of absolute numbers (with Malaysia recording over 20million tourists in 2007 and Thailand over 14 million) (Fig. 2.7). All countries have experienced growth in tourism, which included an almost threefold increase on 1995 levels for Malaysia, and approximately doubling of numbers of tourists in Bangladesh, Myanmar, Maldives, Thailand, and India.

## Oil and gas

42. The Bay of Bengal is reputed to be one of the major hydrocarbon-rich areas in the world, comparable to basins such as 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 or due to international boundary disputes. However, major discoveries have been made recently, for example, the findings in the two main basins in the BOBLME -Krishna-Godavari and Mahanadi – which 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 any of the other uses.

43. All of the countries surrounding the Bay either have done or are in the process of auctioning off blocks for exploration. Between the countries there are also varying levels of boundary disputes – notably between India, Bangladesh and Myanmar.

## Shipping

44. The main shipping route passing through the BOBLME runs along the south of Sri Lanka and across the BOB before entering the Straits of Malacca. The strait is the main shipping channel between the Indian Ocean and the Pacific Ocean, linking major Asian economies such as India, China, Japan and South Korea. Over 50,000 vessels pass through the strait per year, carrying about

one-quarter of the world's traded goods including oil, Chinese manufactures, and Indonesian coffee (US Energy Information Administration, 2010).

45. Along the Indian coastline, there is also intense shipping traffic and associated oil pollution through operational discharge of waste, mostly by medium and small ships where installation of oil-water separators is not mandatory (Sampath, 2003).

### 2.3.3 Socio-economic characteristics of coastal communities

46. Although some coastal areas are relatively wealthy, poverty in coastal communities remains a major issue. Flat, well-watered coastal plains are often focal points for the growth of urban centres, transport by road, rail and sea, and communications networks. Some of the biggest cities in the world surround the BOBLME including Kolkata (over 20 million people), Chennai (7.5 million), Chittagong (5 million), Yangon (4.4 million), Medan (2 million) and Kuala Lumpur (1.5 million) (DESA, 2010) and as they grow and expand, many slum areas are created. Agriculture development is also frequently greater in coastal plains.

#### Poverty in coastal communities

47. However, even when coastal areas are relatively well-developed, pockets of "hidden" poverty may remain. Because they are located amidst relative prosperity, they often remain unseen (IMM/ICC, 2003). Certain features of some coastal areas – the presence of diverse open-access resources and a wide range of livelihood "niches" - often attract the poor who find opportunities along the coast that are not available elsewhere. Many of the people living in the BOBLME's catchment area (particularly in the western countries) are among the world's poorest, subsisting at or below the national poverty level (as deemed appropriate by the national authorities). This is especially true in Bangladesh, India, and Sri Lanka where some 81%, 76% and 40% respectively, of the population has an income less than the equivalent of USD 2 per day (UNDP, 2009). Brown et al (2008) estimated that four BOBLME countries were in the top 10 countries in terms of coastal poor (Table 2.7) and the BOBLME countries contained over 50% of all of the worlds coastal poor people.

#### Health and education

48. People's human resources, including health and education, play an important role in their ability to take up and maintain a particular livelihood strategy. They are of course critical in respect to people's capacity to change, either in response to a threat (e.g. declining resource, natural disasters) or an opportunity (e.g. new employment or improving existing strategy).

49. The key areas of concern for the BOBLME lie in the west where the low rates of educational survival[4] (India 65.8 and Bangladesh 54.8) correlate with low levels of literacy (India 66% and Bangladesh 53.5%) (Table 2.8). Thus, in these countries people's abilities to take advantage of the new opportunities brought about by the significant national economic growth may be restricted.

50. Coastal and marine livelihoods are affected by a range of health risks that are often specific to coastal areas. Sanitation and water supply are often problematic in coastal areas, especially where water tables are affected by saline intrusion. HIV is often very prevalent due to the relative mobility of fishermen. Exposure to natural disasters, such as cyclones and floods that characterise some coastal areas of the region can have important long-term impacts on overall health conditions, causing loss of life, epidemics and injury. Access to health services is often affected by the same constraints as those experienced for education. Infrastructure is frequently lacking and staff may be unwilling to go to remote coastal areas (Townsley, 2004).

[4] Educational survival – defined by UN ESCAP as the attendance to school to the last grade of primary level.

## Coastal migration

51. Migration and mobility have always been an integral part of life in coastal areas of the BOBLME. People living in the coast, and particularly the poor, often have to move in order to adapt to seasonal variations in the availability of resources. Examples of these seasonal migrations include the movement of fishermen from the west coast of Sri Lanka to the north and east during the different monsoon seasons, and the migration of fishermen from Andhra Pradesh to southern Orissa and Gujarat on the west coast. In other cases, the dynamic nature of the coastal environment, particularly in estuarine areas where land is constantly being formed and washed away by the action of the sea and silt deposition from upstream (e.g. the char lands in Bangladesh), means that coastal dwellers are constantly migrating in response to changes in their environment (IMM, 2003).

52. The increasing levels of industrialization in some of the coastal zones of the BOBLME have attracted new waves of migrants and have increased the pressures for developing new residential and industrial zones outside of the towns and cities. An example of this trend can be seen in Orissa in India. Salagrama (2006) observed that the competition for space and resources, often involving powerful interest groups, is likely to increase as a result of further liberalization of the economy and new opportunities (such as tourism) emerging in coastal areas. Such developments can create pressure on existing coastal communities, especially where they are made up of groups such as fishers who often have little political influence.

**Table 2.7: Numbers of poor people in coastal areas of the world**

| Country | Number of coastal poor* | % of world's coastal poor |
|---|---|---|
| **India** | 68,226,700 | 27% |
| **Indonesia** | 33,768,000 | 13% |
| **Bangladesh** | 23,247,500 | 9% |
| **Vietnam** | 12,440,000 | 5% |
| **China** | 11,730,700 | 5% |
| **Philippines** | 11,247,000 | 4% |
| **Nigeria** | 8,897,690 | 4% |
| **Myanmar** | 6,209,340 | 2% |
| **Brazil** | 6,145,760 | 2% |
| **North Korea** | 3,899,890 | 2% |

*Data is based on estimates of poverty combined with population density in the 100km coastal strip to estimate the density and absolute number of coastal poor around the world's poor countries. For more detailed breakdown of calculation see Brown et.al. (2008).

**Table 2.8: Education indicators in BOBLME countries**

| | Survival Rate to last grade of primary level (%) | Adult literacy Rate (% aged 15 and over) |
|---|---|---|
| | **2005** | **2007** |
| **Indonesia** | 79.5 | 92.0 |
| **Malaysia** | 89.3 | 91.9 |
| **Thailand** | - | 94.1 |
| **Myanmar** | 71.5 | 89.9(2004) |
| **Bangladesh** | 54.8 | 53.5 |
| **India** | 65.8 | 66.0 |
| **Sri Lanka** | 93.4 | 90.8 |
| **Maldives** | - | 97.0 |

*Source*: ESCAP (2010)

53. Some of the migratory movements are not specific to coastal areas and are driven by much wider trends that affect many areas of South and South East Asia. The nations of the BOBLME have experienced growing labour migration over the past two decades. Annual labour migration from Bangladesh, mainly to the Middle East and Malaysia, more than doubled from 103,000 in 1990 to 252,000 in 2005, while in 2007 it climbed to over 800,000. Labour migration from India to the Middle East averaged about 355,000 per year in the decade between 1993 and 2002. Indonesia sent over 712,000 workers abroad in 2006. Between 2000 and 2006, an annual average of 204,000 labour migrants left Sri Lanka, the majority to destinations in the Middle East. It should be noted that the actual number of migrant workers from the region is likely to be greater because there are unknown flows of workers who move without registering with national authorities.

54. Feminization is an important feature of labour migration in the region, as an increasing number of women are crossing borders for employment. Female migration has become prominent in terms of both absolute numbers and proportions of the migrant population. For instance, women constitute a large majority of migrant workers leaving Indonesia (79 %) and Sri Lanka (64 %) (ESCAP, 2009).

55. All migrant groups can be vulnerable to a range of issues including HIV, exploitation, lack of representation and lack of access to services. However, where people move across borders illegally they are especially vulnerable (see Box 1).

### 2.3.4 Government in coastal communities

56. Agricultural, forestry, fisheries, urban and industrial activities both in upstream catchments and in the coastal area all have impacts on the lives of the people in the coastal zones of the

BOBLME. The policies developed for these different sectors, by the various institutions and agencies responsible for them, often overlap and conflict with each other and with the strategies developed by people to sustain their livelihoods.

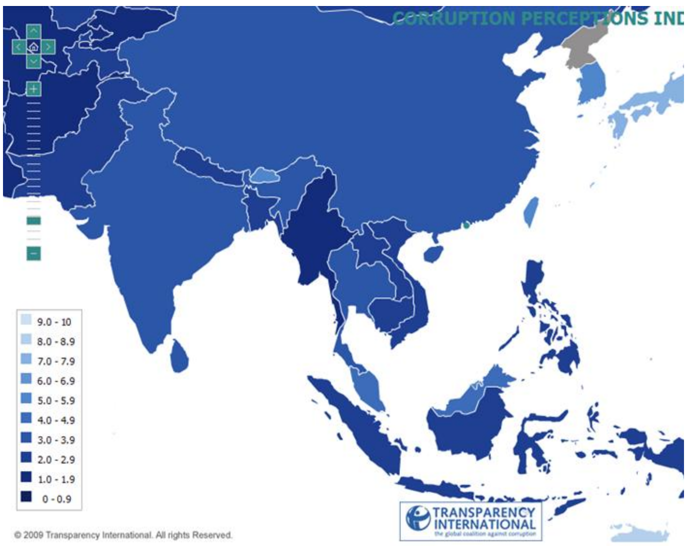
57. In this TDA it is not possible to cover all characteristics of government interventions in coastal communities around the BOBLME and, therefore, four aspects have been selected which are illustrative of the key challenges. These relate to (i) corruption, (ii) take up and implementation of new policies and measures, (iii) subsidies and infrastructure support, and (iv) the social protection services that may be critical in supporting livelihood change.

## Corruption

58. The world's oceans support economic activities on a vast scale, and the need to rehabilitate and protect their common wealth and productivity has led the international community to focus intensely on how oceans are used and governed. Intrinsically linked to this recognition is the need to ensure greater responsibility and accountability by all individuals and private companies involved in accessing the coastal marine resources (FAO 2008).

**Table 2.9: Transparency International's Corruption Perceptions Index 2010. 10 = least corrupt (light blue); 0 = most corrupt (dark blue); values in brackets indicate World rank.** *Source: Transparency International (2010)*

| Country (rank) | CPI 2010 |
|---|---|
| Denmark, New Zealand, Singapore (1 equal) | 9.3 |
| Malaysia (56) | 4.4 |
| Thailand (78) | 3.5 |
| India (87) | 3.3 |
| Sri Lanka (91) | 3.2 |
| Indonesia (110) | 2.8 |
| Bangladesh (134) | 2.4 |
| Maldives (143) | 2.3 |
| Myanmar (176) | 1.4 |




59. More broadly and also taking account of the potential for endemic corruption in resource-based industries, sustainable management outcomes (including poverty reduction and alleviation, improved food security, stronger economic development and growth, and greater access to public services) depend to a large extent on concurrent improvements in public governance.

60. Table 2.9 shows that the BOBLME region overall can improve in terms of Transparency International's Corruption Perceptions Index (CPI). The CPI measures the perceived levels of public sector corruption in 180 countries and territories. The CPI is a composite index, based on 13 different expert and business surveys. Malaysia (ranked at 56) is the highest (or least corrupt)

country within the BOBLME with Maldives (130), Bangladesh (139) and Myanmar (178) lying within the bottom 50 countries worldwide.

### Implementation of laws and policies

61. BOBLME countries are governed through a range of different systems. Despite their differences, all the governments of the region are eager to promote economic growth and development, including through increased exploitation of living resources. As a result, all the region's governments have been keen to see increased marine and freshwater fishery production (including aquaculture) and have expended considerable funding in an attempt to make this happen. Most countries have legislation and policies in the different sectors (see next Section for details), 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 are aggravating some of the problems.

62. 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 can also be constrained by weak governance, especially at the local level and insufficient human capacity and government funding for enforcing laws and regulations.

63. In instances where the existing legislation and regulations are adequate, enforcement is impeded by a number of factors, including weak institutions, 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. A related gap is the generally inadequate penalties imposed for violations of marine living resource and critical habitat laws. The inadequacy of penalties arises partly from the fact that in many of the BOBLME countries, the laws in place have not been updated since the 1980s. These laws need to be improved, revised and updated.

64. Together with an often confused policy environment, the services provided to coastal communities can be limited. This is particularly so in the western and northern shores of the Bay of Bengal, where the absence of supportive institutions increases the vulnerability of coastal fishing communities to changes, such as illness and natural disasters (Townsley, 2004).

### Subsidies and infrastructure support

65. Public funding assistance to the fisheries sector has taken the form of subsidies and grants, construction of infrastructure (ports, ice machines, etc.), establishment of government-owned fishing companies, and concessions to foreign fishing vessels. Much of this funding has come from aid sources or in the form of concessionary loan finance from multilateral banks (Preston, 2004).

66. One of the most striking features of 'fisheries development' in some BOBLME countries (particularly Sri Lanka and India) is the extent to which the government subsidizes fishers, including industrial, commercial and artisanal operators. Cheap gear and equipment, artificially high product prices, credit facilities and cash subsidies are incorporated into subsidized boatbuilding and marketing operations, as well as welfare schemes aimed at fishermen and fishing communities (Preston, 2004. Commercial and industrial fishing fleets in particular are already overcapitalized, and subsidizing fishers or fishing operations allow them to keep on fishing even when catches have declined to very low levels, thus increases the chances of serious overfishing and consequent stock collapse.

### Social protection measures

67. Formal social protection measures, by providing additional income to the poor, and maintaining their food intake and access to education and health services, can play a key role in

sustainable development of coastal communities. They also have the potential to benefit aquatic resources by removing the need for poor people to move into fisheries as a last resort in tough times, and by giving people the confidence and certainty needed to make longer term investment decisions about taking up opportunities to move out of fisheries.

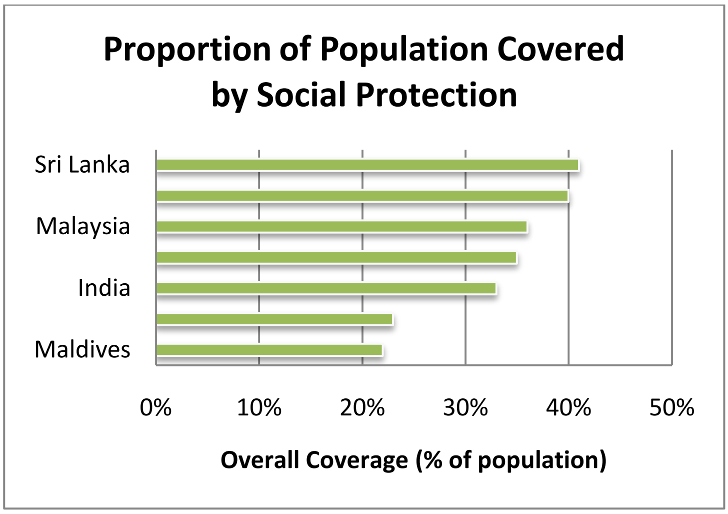



**Figure 2.9. Proportion of BOBLME population covered by social security**

**Table 2.10: Social Protection in the BOBLME countries.**

| | Sickness | Poverty | Health | Education | Employment | Transfers | Child |
|---|---|---|---|---|---|---|---|
| **Indonesia** | X | | | | | X | X |
| **Malaysia** | X | X | | | X | X | X |
| **Thailand** | X | X | X | | X | X | X |
| **Bangladesh** | X | X | X | X | X | X | |
| **India** | X | X | X | X | X | X | |
| **Sri Lanka** | X | X | X | X | X | X | |
| **Maldives** | X | X | | X | | X | |

*Source: ADB (2010)*

68. The BOBLME countries offer a range of social protection measures, which are shown in Table 2.10. However, in many cases these measures are not sufficiently funded, coherent or extensive enough to protect the vulnerable populations. Indeed the rates of coverage are among the lowest in the world (Fig. 2.9[5]).

[5] Social Protection Coverage indicator (SPCOV) has been formulated to represent the coverage of social protection. It is based on assessments related to each different type of social protection measure and then combined to give a figure that is indicative of the % of targeted people actually receiving the benefits from social protection. See (Baulch, et al. 2008)

69. For example, the index shows that less than a quarter of the target populations for social protection in Bangladesh and the Maldives actually have access to those benefits. Often, where social safety nets do exist they are biased towards the formal government sector leaving many without basic services and rights (ADB, 2010).

### 2.3.5 Vulnerability to Change in Coastal Communities

70. An important feature of coastal and marine livelihoods in the Bay of Bengal, especially on the Western and Northern shores of the region, is their acute vulnerability to major shocks from natural disasters. Poverty tends to increase vulnerability, and reduce resilience and longer term adaptive capacity. As is demonstrated in Table 2.8 the BOBLME countries have over 50% of the worlds coastal poor.

71. People's livelihoods are complex and the livelihood strategies that they adopt are influenced by many factors. When considering the vulnerability of people in coastal communities it is important to recognise that their livelihood strategies are influenced by many changing factors such as health, education, land tenure, wider environmental issues, relationships with government and support agencies and food security are also important. These are often of greater significance than immediate natural resource related concerns, especially after a disaster, but they will often impact upon how people can utilize natural resources in their livelihood strategies.

72. Some of the key elements of vulnerability of the coastal communities in the BOBLME were identified as part of an FAO regional consultation on disaster risk management in fishing and fish farming communities in Asia and the Pacific by (Campbell, 2010). They include: inherent vulnerability; hazards and disasters; and climate change. These elements are further influenced by a range of social and economic changes that are affecting the BOBLME nations. These elements are described below:

#### Inherent vulnerability

73. The coastal zone of the BOBLME is a very dynamic environment. The daily tidal changes in the coast and the seasonal weather patterns are regular factors affecting this dynamism; in addition it is also subject to the changing patterns of river flows and surface water run-off from the land, which often affect the state of the near-shore ecosystems and the services that they provide. The impacts of these regular changes are being exacerbated by long-term trends such as resource degradation, pollution and climate change. It is often the hostile nature of these aquatic environments that create opportunities for the poor. The remote and inhospitable nature of these environments, often with poor communications and poor market access, makes for a less than welcoming environment, which, whilst tolerated by the poor, are often unacceptable to better-off operators who may prefer to seek opportunities in lower risk and higher return environments (Campbell, et. al., 2006).

#### Hazards and disasters

74. Coastal communities in the BOBLME are exposed to a variety of hazards and disasters. They are most directly impacted by events such as tsunamis, storm surges and coastal flooding. More indirectly, droughts and other events can cause mass migration of people into areas normally occupied by fishing and fish farming communities and can interact directly with them through competition for resources. Biological disasters, such as the colonization of non-local species in coastal areas, for example crown-of-thorns starfish on reefs or disease amongst farmed fish and shrimp, can have devastating effects on local resources and livelihoods.

75. Asia has the highest number of disasters of any region. In recent years, major events have included the Orissa Super cyclone in India in 1999, the Indian Ocean Tsunami of 2004, Cyclone Sidr in Bangladesh in 2007, Cyclone Nargis in Myanmar in 2008, and the floods in Pakistan in 2010. While statistics show that the number of disasters isn't significantly increasing (according to the Annual Disaster Statistical Review 2009 (Vos et. al., 2010), as populations in the coastal zone are increasing (see Fig 2.6) more people are exposed to natural hazards.

#### Climate change

76. The Intergovernmental Panel on Climate Change (IPCC) predicts an increase in global temperature, and an increase in sea surface temperature, rising sea levels, increased precipitation, increased likelihood of severe weather events for much of the area of Asia where fisheries are important (Parry et al., 2007). The impacts of climate change on the ecosystem services provided by the BOBLME are likely to impact people in many different ways. Some examples identified by Campbell (2010) include:

- changes in fish abundance and distribution are likely to affect their availability to local fisheries and may result in migration of fishers;
- changes in distribution of bait fish will compromise people's abilities to participate in commercial fisheries (such as tuna);
- for some people, their traditional knowledge will become redundant as species compositions change, for others that traditional knowledge will provide the means to adapt;
- storms are likely to damage fishing boats, fish cages, fish drying racks, landing infrastructure and houses;
- changes in weather patterns will affect traditional fish processing methods especially where sun is used to dry fish. In some locations this may be of benefit for processors, in other locations poor weather in glut fish landing seasons will affect drying rates with the potential for substantial losses; and
- changes in access roads to markets where unusual flooding or heavy rains occur.

## Social and Economic Changes

77. This vulnerability of the coastal communities around the BOBLME is further exacerbated by a diversity of pressures from the changes happening in the wider economies and societies both globally and within the BOBLME nations. Examples of such changes include:

78. *Fuel Prices Fluctuations:* Oil prices more than trebled between 2002 and 2008 when they soared to nearly $150/barrel in the July and then fell again to $50/barrel in November 2008. Such fluctuations not only affect all major investment decisions globally, but they also affect the costs of harvesting and marketing different aquatic resources. Such uncertainty can be very difficult to deal with.

79. *Oil Exploration and Exploitation:* The Bay of Bengal is reputed to be one of the major hydrocarbon-rich and world-class gulf basins such as the Gulf of Mexico, Persian Gulf and the Bohai Bay in China. While oil will bring a wealth of opportunities to the nations surrounding the BOBLME it does bring many risks to both the coastal communities and the environment. Experiences from other parts of the world have indicated that oil exploitation can lead to a wide range of issues, including conflicts with fishers and coastal communities, transboundary conflicts between governments, diversion of government focus from all other uses, and influx of job seekers to coastal area.

80. *Increased Coastal Development:* Poor communities are often at risk of being displaced from the coastal spaces they have occupied, to make way for tourism, ports, urban growth, industry, intensive aquaculture, airports, special economic zones (SEZs), and top down conservation projects. Where people don't have clearly defined rights for their houses and land or for their access to aquatic resources their ability to resist - or at least be compensated for - such changes is greatly reduced.

81. *Global Economic Crisis – 2008:* While many of the impacts of this crisis may not yet have filtered down to the coastal communities of the BOBLME, the slowdown in growth and contraction of exports could have adverse consequences for the development of the coastal zone. In past crises the increased levels of industrial unemployment has lead to workers moving into agriculture (and potentially fisheries) (ADB, 2009). Falling remittances as unemployment grows in developed

countries and pressure on aid budgets may either reduce aid flows or change their nature (ODI, 2010).

**Box 1: Sailing to nowhere – A Cambodian migrant's tale**

*Nang, aged 25, is a Cambodian fisherman from Banteay Meanchey province. He has very little formal education and, following the advice of some friends, decided to leave Cambodia in early 2004 to work in neighbouring Thailand to support his family. He was recruited by a Cambodian broker (mekhal) who came to his village and promised him a job in the construction industry in Thailand paying up to THB 4,500 (USD 128) per month. The broker's fee, payable in advance, was THB 3,000 (USD 85). Nang borrowed the money for the broker's fee from relatives, and he was then taken to the Thailand border, where the broker helped him cross the border into Thailand unlawfully for an additional fee of THB 200 (USD 6).*

*Once in Thailand, he was taken to Patnam in Samut Prakan province, where he was kept in a guesthouse for several days before being told that there was no job in construction and that he would have to work on a fishing boat. Nang believes that the broker sold him to the captain of the fishing boat for THB 5,000 (USD 150). According to Nang, the conditions onboard his boat, which sailed towards Indonesian waters and remained there for six months, were extremely harsh. The crew had to work day and night for three days before having a day to rest, and was continually harassed and threatened by the captain. Nang was never allowed to leave the boat.*

*Eventually the boat docked in Ranong on the Thai-Myanmar border, where the Cambodian crew was replaced by a crew from Myanmar prior to moving into that country's waters. Nang was paid a total of THB 2,000 (USD 57) for six months of work. With no travel documents and unable to afford transport back to Cambodia, let alone the sum of THB 6,000 (USD 171) demanded by a broker to help him return home, Nang realized that it was only a matter of time before he would be picked up by the Thai police as an irregular migrant. On the advice of other Cambodian fishermen stranded in Ranong, he signed up with another Thai fishing boat and was given forged papers identifying him as Thai.*

*In August 2004, while fishing illegally in Indian waters, the boat was intercepted by the Indian navy and escorted to Port Blair in the Andaman and Nicobar islands. The entire crew was jailed, but after six weeks the Thai owner of the vessel arrived to stand bail and obtain their release. The Thai crew immediately left India, leaving Nang and the other Cambodians to fend for themselves. Nang was then taken to the Port Blair Immigration Police Centre and held there for three months. When the case was finally heard in court, he pleaded guilty to entering India unlawfully and was sent to an internment camp, where he remained for two years. In March 2007, working with the Cambodian and Indian governments, the International Migration Organization (IOM) was able to at last repatriate Nang from Port Blair to his home province of Banteay Meanchey.*

*Source: IOM (2008)*

# 3. LEGAL, ADMINISTRATIVE, POLITICAL CONTEXT AND CONSTRAINTS

## 3.1 Introduction

82. The implementation of BOBLME activities and reform agenda need to be assessed against the overall legal, administrative and political context and constraints of the BOBLME countries individually and collectively. The regional context is particularly important because the BOBLME countries share the same marine environment; consequently, national activities have transboundary impact.

83. There is considerable variance in the legal, administrative and political situation across the eight BOBLME countries. Some of the countries have federal systems of government and others are unitary States. Some are republics and some are monarchies. Despite these variations, however, administrative structures and national marine conservation and utilization legislation share similar characteristics and constraints.

84. In recent years, many of the BOBLME countries have made substantial progress in improving their national domestic policies, legal and institutional frameworks to achieve the sustainable management of the BOBLME. However, the effectiveness of these efforts has been hampered by a number of constraints.

85. These constraints can be summarized into four broad categories: (a) legal and policy; (b) institutional; (c) fiscal; and (d) community participation and public awareness.

86. In most of the BOBLME countries, the lack of institutional capacity to implement policies and enforce regulations is strongly linked to financial constraints, and the failure to mobilize grassroots participation. The effective enforcement and implementation of the best of laws and policies necessitate tremendous fiscal resources which most of the BOBLME are not in a position to muster. The effort required to deal with the immense transboundary issues with respect to the BOBLME is beyond the means of any one country, which are saddled with their own respective domestic socio-economic concerns. There is thus a need to strengthen institutional capacity and improve integration and coordination between national and local government units and to tap community-based participation toward achieving BOBLME conservation and management objectives.

## 3.2 International and domestic legal context

### 3.2.1 International agreements

87. First and foremost, the effectiveness of BOBLME activities and reform agenda need to be analyzed against international marine conservation and sustainable resource conservation standards and principles. Some of these international instruments are legally binding and require ratification and legislative implementation at the national levels; whilst others are non-binding policy documents but require domestic policy or legal implementation. Tables 3.1 and 3.2 provide a list of the major international instruments whose implementation at the national level will support the achievement of the BOBLME objectives. The Tables also evaluate the status of these instruments in the BOBLME countries.

88. Of particular importance in the context of the BOBLME Project is the FAO Code of Conduct for Responsible Fisheries (Code of Conduct) which provides principles and standards applicable to the conservation, management and development of all fisheries, including the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management. The Code of Conduct is supported by the FAO Compliance Agreement and specific International Plans of Action which require the development and implementation of corresponding national plans of action.

89. Collectively, these binding and non-binding international instruments provide the framework for the implementation of sustainable and responsible fishing practices and sound marine environmental management, including better management of fisheries, protection of migratory and threatened species, ecosystem and biodiversity protection and marine pollution prevention.

90. Most of the BOBLME countries are parties to major international agreements pertaining to biodiversity and protection of ecosystems ( Table 3.1), including, the United Nations Convention on the Law of the Sea,[6] Convention on Biological Diversity,[7] the Cartagena Protocol on Biosafety to the Convention on Biological Diversity.[8] Except for the Maldives, all BOBLME member countries are parties to the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention);[9] and the Convention on International Trade in Endangered Species of Wild Fauna and Flora.[10] All BOBLME countries are also parties to key international instruments concerning the protection of the atmosphere such as the United Nations Framework Convention on Climate Change[11] and the Kyoto Protocol to the United Nations Framework Convention on Climate.[12]

91. Only a few of the BOBLME countries have ratified the UN Fish Stocks Agreement[13] and none have accepted the FAO Compliance Agreement (Table 3.2).[14] Only a few BOBLME countries have developed national plans of action to implement the various FAO International Plans of Action, namely on capacity, seabirds, sharks and illegal, unreported and unregulated (IUU) fishing.

92. A major gap in the BOBLME is the lack of widespread ratification of international agreements pertaining to marine pollution prevention. None of the BOBLME countries are party to the Convention for the Prevention of Marine Pollution from Land-Based Sources,[15] nor the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention).[16] Among the BOBLME countries, only Malaysia is party to the International Convention on Civil Liability for Bunker Oil Pollution Damage,[17] and only India, Malaysia and the Maldives have ratified the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (Fund Convention).[18]

---

[6] United Nations Convention on the Law of the Sea, concluded on 10 December 1982, entered into force on 16 November 1994, 1833 UNTS 3; 21 ILM 1261 (1982).

[7] Convention on Biological Diversity, concluded on 05 June 1992, entered into force on 29 December 1993, 1760 UNTS 79; 31 ILM 818 (1992).

[8] Cartagena Protocol on Biosafety to the Convention on Biological Diversity, concluded on 29 January 2000, entered into force on 11 September 2003, 2226 U.N.T.S. 208; 39 ILM 1027 (2000).

[9] Convention on Wetlands of International Importance especially as Waterfowl Habitat, concluded on 29 January 2000, entered into force on 11 September 2003, 2226 U.N.T.S. 208; 39 ILM 1027 (2000).

[10] Convention on International Trade in Endangered Species of Wild Fauna and Flora, concluded on 03 March 1973, entered into force on 01 July 1975, 27 UST 1087; TIAS 8249; 993 UNTS 243.

[11] United Nations Framework Convention on Climate Change, concluded on 09 May 1992, entered into force on 21 March 1994, 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992).

[12] Kyoto Protocol to the United Nations Framework Convention on Climate, concluded on 11 December 1997, entered into force on 16 February 2005, UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997; 37 ILM 22 (1998).

[13] United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, concluded on 04 August 1995, entered into force on 11 December 2001, 34 ILM 1542 (1995); 2167 UNTS 88.

[14] The Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, unanimously approved, subject to acceptance, at the 27th Session of the Conference of the FAO in November 1993, entered into force on 24 April 2003.

[15] Convention for the Prevention of Marine Pollution from Land-Based Sources, concluded on 04 June 1974, entered into force on 06 May 1978, 1546 UNTS 119; 13 ILM 352 (1974); UKTS 1978, No. 64.

[16] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, concluded on 29 December 1972, entered into force on 30 August 1975, 26 UST 2403, 1046 UNTS 120, 11 ILM 1294 (1972).

[17] International Convention on Civil Liability for Bunker Oil Pollution Damage, concluded on 23 March 2001, entered into force on 21 November 2008, IMO LEG/CONF.12/19; OJ 2002 L 256/7.

[18] International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, Brussels, 1971.

**Table 3.1: Status of Major Environmental Treaties of BOBLME Countries**

| Country | Law of the Sea Convention (LOSC) | Convention on Biological Diversity (CBD) | Convention on International Trade in Endangered Species (CITES) | Convention on Migratory Species (Bonn Convention) | Ramsar Convention on Wetlands of International Importance (Ramsar) | Stockholm Convention on Persistent Organic Pollutants | UN Framework Convention on Climate Change (FCCC) and Kyoto Protocol | Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal | UN Fish Stocks Agreement | FAO Compliance Agreement | Fund Convention | International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indonesia | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | ✓ | × | ✓ (Annex I – II) |
| Malaysia | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ (Annex I,II, V) |
| Thailand | × | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | ✓ | × | ✓ (Annex I & II) |
| Myanmar | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | × | ✓ | × | ✓ (Annex I & II) |
| Bangladesh | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | ✓ | × | ✓ (Annex I – VI) |
| Sri Lanka | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | × | ✓ (Annex I – V) |
| India | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ (Annex I – V) |
| Maldives | ✓ | ✓ | × | × | × | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ (Annex I,II, V) |

✓ State Party

× Non-State Party

**Table 3.2: Adoption of International and National Plans of Action by BOBLME Countries**

| Country | IPOA-Seabirds | NPOA-Seabirds | IPOA-Sharks | Sharks-plan | IPOA-Capacity | NPOA-Capacity | IPOA-IUU | NPOA-IUU |
|---|---|---|---|---|---|---|---|---|
| Indonesia | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| Malaysia | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ |
| Thailand | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Myanmar | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Bangladesh | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |
| India | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Sri Lanka | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |
| Maldives | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✗ |

✓ for the IPOA columns indicate participation during the 23rd and 24th FAO Committee on Fisheries meetings when the IPOAs were adopted.

93. The participation of BOBLME countries in many relevant international instruments, as shown in Tables 3.1 and 3.2, demonstrate significant levels of commitment to address cross-cutting issues of transboundary concern. However, many of these international commitments remain to be implemented in domestic legislation.

94. The Environmental Performance Index (EPI) (EPI, 2010) provides a benchmark of the environmental performance of a country's policies. The 2010 EPI ranks 163 countries on 25 performance indicators tracked across ten well-established policy categories covering both environmental public health and ecosystem vitality. The performance of the BOBLME countries in the 2010 EPI was very low; with the highest-ranked BOBLME country being Maldives at 48 and the lowest-ranked being Bangladesh at 139. Despite the comprehensive scope of the EPI, there is still the need for a study assessing how BOBLME member countries meet their nationally-set environmental objectives and how these objectives fulfill their international obligations and commitments.

### 3.2.2 Domestic legislation

95. While there is considerable variance across the BOBLME countries in regard to their respective political, legislative and administrative structures, they have all enacted a number of legislations that seek to regulate activities in the BOBLME to ensure that the marine living resources and critical habitats of the BOBLME are afforded a certain level of protection. The existing legal and policy framework among the BOBLME countries dealing with coastal and marine resource management and sustainable use of the BOBLME are, in general, comprehensive in their content and coverage. However, they are fragmented, sectoral in scope, and not effectively implemented. Table 3.3 provides a summary of relevant national legislation of the BOBLME

countries. The laws can be classified into three broad categories, namely: fisheries management and development, marine biodiversity protection and marine pollution.

96. Analysis of the laws of individual BOBLME countries in the context of achieving the objectives of the BOBLME reveals that many of the laws do not embody modern management concepts reflected in international instruments and sustainable marine environmental management practices. Major gaps relate to ensuring the objectives of long term sustainable use, the precautionary approach and ecosystem approach to underpin governmental actions in the marine sector.

97. There is a complex suite of laws and regulations on, e.g., aquaculture, coastal zone management, environment, capture fisheries, forests, pollution, critical habitats and certain defined commercially attractive and/or endangered species. The domestic legal and administrative structures are largely sectoral, uncoordinated and need to be simplified, streamlined and harmonized in order for national and regional efforts to manage the BOBLME to be effective. Other major constraints are insufficient budgetary commitments, and lack of community stakeholder consultation and empowerment.

98. Some legislation exists to protect the BOBLME to a certain extent from the main forms of pollution, although it is largely in the form of controls on effluent discharges. Even if these controls are rigorously enforced (which they tend not to be; see also institutional root causes), controlled discharges can still destroy an ecosystem if there are enough of them. The effluent control approach also does not take into account the effect of combinations of pollutants on ecosystems, or whether ecosystems are already polluted, physically damaged or otherwise stressed (e.g., by floods). A further inadequacy of pollution-specific legislation in the region is the absence of the "polluter-pays" principle and other penalties severe enough to ensure that breaking the law is a serious economic cost of doing business (i.e., it is more expensive to break the law than to comply with it).

**Table 3.3: Marine-related legislation of BOBLME countries**

**Indonesia**

- Act concerning Indonesian Waters (No. 4 of 1960), 1960.
- Act No. 9/1985 Fisheries Act
- Fisheries Law No. 31/2004, 2004.
- Act No. 9/1990 concerning Tourism
- Law 23/1997 regarding Environmental Management.
- Act on the conservation of biological resources and their ecosystems (Act No. 5 of 1990)
- Law No. 24/1992 regarding Spatial Planning
- Presidential Decree No. 196/1998 regarding the Agency for the Control of Control of Environmental Impact
- Environmental Impact Act No. 21/1992 regarding Maritime Transportation
- Government Regulation No. 60/2007 regarding the conservation of fishery resources, 2007.
- Regulation of the Minister of Finance No. 113/PMK.04/2007 regarding the exemption from import duty on the import of sea products caught by permitted catching instruments, 2007.
- Regulation of the Minister of Finance No. 105/PMK.04/2007 regarding the exemption from import duty on the import of parent stocks and seeds for the establishment and development of farming, breeding, or fishery

industry, 2007.

- Law No. 16/2006 on Agricultural, Fishery and Forestry Extension System, 2006.
- Government Regulation No. 15/2002 concerning fish quarantine, 2002.
- Decree of the Minister of Agriculture No. 646/KPTS/KP.150/7/1996 re establishment of a team for fostering and controlling the supply of fishing vessels, 1996.
- Joint Decree of the Minister of Agriculture and the Minister of Communications No. 492/Kpts/IK.120/7/1996 and No. SK.1/AL.003/PHB-96 of 4 July 1996 re the simplification of licensing for fishing vessels, 1996.
- Joint Decree of the Minister of Agriculture and the Minister of Communications No. 493/KPTS/IK.410/7/96 and No. SK.2/AL.106/PHB-96 of 4 July 1996, re the operation of fishing ports as fishing infrastructures, 1996.
- Decree of the Minister of Agriculture No. 805/Kpts/IK.120/12/95 on the stipulation on the use of fish-carrying vessels, 1995.
- Decree of the Minister of Agriculture on appointing a port as a fishing base for chartered foreign flag fishing vessels for fishing in the EEZ (No. 144 of 1993), 1993.
- Decree relative to Licenses for any Foreigner or Foreign Corporate Body to Catch Fish in Indonesian Exclusive Economic Zone (No. 475/Kpts/IK.120/7/1985), 1985.
- Decree of the Minister of Agriculture on the Determination of Total Allowable Catch in the Indonesian Exclusive Economic Zone (No. 473a/KPTS/IK 250.6/1985), 1985. Fisheries Law (No. 9 of 1985), 1985.
- Regulations on Fishery Resource Management in the Indonesian Exclusive Economic Zone (EEZ) (Government Decree No. 15 of 1984), 1984.
- Presidential Decree regarding Seafarming Development in Indonesian Waters (No. 23 of 1982), 1982.
- Decree No. 608/Kpts/Um/9/1976 on the delimitation of fishing lanes for vessels owned by state fishing entities, 1976.
- Decree No. 607/Kpts/Um/9/1976 on Fishing Lanes, 1976.
- Decree of the Minister of Agriculture on the Fishing Areas for Sea-bed Trawlers (No. 609 of 1976), 1976.
- Decree No. 123/Kpts/Um/3/1975 establishing the size of mesh in the purse seine nets used for fishing certain fish species, 1975.
- Decree No. 1 of the Minister of Agriculture on the Conservation of the Riches of the Fish Resources of Indonesia, 1975.
- Decree No. 561 of the Minister of Agriculture on the Utilization of the By-products of Fisheries, 1973.
- Foreign Ships - Innocent Passage in Indonesian Waters (Govt Decree No. 36 of 1962), 1962.

**Malaysia**

- Malaysian Maritime Enforcement Agency Act, 2004.
- Environmental Quality Act, 1974.
- Exclusive Economic Zone Act, 1984.
- Merchant Shipping Ordinance, 1952.
- Merchant Shipping (Amendment and Extension) Act, 2007.
- Protection of Wildlife Act, 1972.
- Fisheries Act 1985 (No. 317 of 1985), 1985.

| |
|---|
| • Waters Act, 1920 (as amended 1989)<br>• Fisheries (Prohibited Areas) Regulations, 1994.<br>• Fisheries (Riverine) Rules, 1990.<br>• Fisheries (Maritime) (Licensing of Local Fishing Vessel) Regulations 1985, 1985.<br>• Fisheries (Prohibition of Method of Fishing) Regulations 1980, 1980. |
| **Thailand**<br>• The Fisheries Act (1947, as amended in 1953 and 1985)<br>• Wildlife Conservation and Protection Act (1992)<br>• Enhancement and Preservation of Natural Environmental Quality Act (1992)<br>• Regulation of the Department of Fisheries on the Application and Permission for Aquaculture in Public Fishing Grounds (1990)<br>• National Park Act (1961, as amended)<br>• Navigation in Thai Waters Act (1913, as amended).<br>• Regulation of the Fisheries Department on the application for a license for overseas fisheries b.e. 2532, 1989.<br>• Act Governing the Right to Fish in Thai Fishery Waters (B.E. 2502), 1939. |
| **Bangladesh**<br>• Territorial Waters and Maritime Zones Act, 1974 (Act No. XXVI), 1978.<br>• The Bangladesh Environment Conservation Act, 1995<br>• The Bangladesh Wild Life (Preservation) Order, 1973<br>• The Embankment and Drainage Act, 1952 (East Bengal Act)<br>• The Environment Conservation Rules, 1997<br>• The Environment Court Act, 2000<br>• The Environment Pollution Control Ordinance 1977<br>• The Ground Water Management Ordinance, 1985<br>• Water Development Board Act, 2000<br>• The Marine Fisheries Ordinance, 1983<br>• The Marine Fisheries Rules, 1983<br>• The Private Fisheries Protection Act, 1889<br>• The Protection and Conservation of Fish Act, 1950<br>• The Fish and Fish Products Ordinance, 1983;<br>• The Tanks Improvement Act, 1939<br>• Bangladesh Merchant Shipping Ordinance, 1983 (No. XXVI of 1983) |

- Protection and Conservation of Fish Act, 1950 (East Bengal Act XVIII of 1950)
- Fisheries Research Institute Ordinance, 1984 (Ordinance No. XVL of 1984), 1984.
- Protection and Conservation of Fish Rules, 1985.
- Bangladesh Fisheries Development Corporation Act, 1973.
- Government Fisheries (Protection) Ordinance, 1959 (E.P. Ordinance No. XXIV of 1959), 1959.
- The Inland Shipping Ordinance, 1976

**India**

- Territorial Waters Continental Shelf Exclusive Economic Zone and other Maritime Zones Act, 1976
- Environment (Protection) Act, 1986
- Environmental Impact Assessment Notification, 1994.
- Water (Prevention and Control of Pollution) Act, 1974 (as amended)
- Water (Prevention and Control of Pollution) Cess Act, 1977 (as amended)
- Guidelines for Sustainable Development and Management of Brackish Water Aquaculture, 1995.
- Hazardous Wastes (Management and Handling) Rules (1989, as amended)
- Wildlife (Protection) Act (1972, as recently amended in 2003)
- Biological Diversity Act, 2002.
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987
- Coastal Aquaculture Authority Rules, 2005.
- Marine Products Export Development Authority Act, 1972 (Act No. 13 of 1972), 1972, 1986.
- Maritime Zones of India (Regulation of Fishing by Foreign Fishing Vessels) Rules, 1982.
- Maritime Zone of India (Regulation of Fishing by Foreign Vessels) Act, 1981 (Act No. 42), 1981.

**Sri Lanka**

- Aquaculture (Monitoring of Residues) Regulations 2002, 2002.
- Aquaculture Management (Disease Control) Regulations 2000, 2000.
- National Institute of Fisheries and Nautical Engineering Act (No. 36 of 1999), 1999.
- National Aquaculture Development Authority of Sri Lanka Act, No. 53 of 1998, 1998.
- Fish Products (Export) Regulations, 1998.
- Export and Import of Live Fish Regulations, 1998, 1998.
- Fish Processing Establishments Regulations, 1998, 1998.
- Aquaculture Management Regulations of 1996, 1996.
- Fishing Operations Regulations of 1996, 1996.

- Inland Fisheries Management Regulations of 1996, 1996.
- Fisheries and Aquatic Resources Act 1996 (No. 2 of 1996), 1996.
- Madel (Beach Seine) Fishing Regulations 1984, 1984.
- National Aquatic Resources Research and Development Agency Act 1981 (No. 54 of 1981), 1981.
- Foreign Fishing Boat Regulations, 1981, 1981.
- Sri Lanka Ports Authority Act (No. 51 of 1979), 1979.
- Inland Water Fishing Regulations, 1978, 1978.
- Proclamation of the President delimiting the breadth of the maritime zones (unofficial title), 1977.
- Spiny Lobster and Prawn (Shrimp) Regulations, 1973.
- Fisheries Regulations, 1941, 1968.

**Maldives**

- Maritime Zones of Maldives Act No. 6, 1996
- Navigation Act (Law No. 69/78)
- Mandate of the Ministry of Transport, Environment and Construction -138/2009/34 (2009)
- Customs Control over International Ships in Ports Act (Law No. 62/78),
- Police Act (Law No. 5/2008) (2008)
- Levy of Fees of Maritime Vessels Act (Law No. 19/83)
- National Security Service and Coast Guard Act (Law no. 1/2008)
- Navigational Lights Act (Law No. 65/78)
- Outwards Clearance Permit for Ship Embarking on International Voyage Act (Law No.61/78)
- Port Dues Act (Law No. 66/78)
- Regulation for Vessels Navigating within the Maritime Zones, (1999)
- Ship Levies Act (Law No: 19/83)
- Ship Station License Act (Law No. 36/78)
- Ship Wrecks and Collision within Maritime Zones of Maldives act (Law No:7/96),
- Ships Engaged in International Import/ Export Trade other than Ships Granted Diplomatic Immunity Act (Law No. 63/78)
- Fisheries Law of the Maldives (Law No. 5/87), 1987.
- Environment Protection Law of 1993
- Law No. 1/74 relating to Fishing in the Lagoons of Maldives (enacted 1374 Hejira, amended by laws 19 of 1971 and 22 of 1975), 1975.
- Regulations for Issuing the License to Fish in the Exclusive Economic Zone of the Republic of Maldives, 1986.

99. At the local level, where community-based management or co-management is being developed, specific devolution of power and authority from higher levels of government down to locally constituted bodies is necessary. These bodies may range from local authorities or communities, to committees made up of a representative selection of stakeholders in the resources or the habitats. This in turn requires enabling legislation at the national or state level, coupled with appropriate local by-laws that give effect to the co-management arrangements and adequate consultation and participation.

100. In a number of critical areas, there is absence of any legislation, policies or strategies. For example, there is inadequate legislation to protect the BOBLME from principal forms of land-based pollution, a key priority area identified as a BOBLME transboundary environmental problem which needs to be addressed in a coordinated manner across national and supra-national institutions. Another noticeable common trend in the BOBLME is that often, even where legislation is in place, it has ambiguous, overlapping, or conflicting provisions. There are often no enabling subsidiary rules or regulations to implement the laws.

## 3.3 Institutional arrangements

101. In each of the BOBLME countries, a number of institutions exist at the national and provincial levels. However, the form and type of institutional arrangements with authority to implement BOBLME objectives vary widely. Table 3.4 shows the institutional arrangements in each of the BOBLME countries with actual or potential responsibility for the BOBLME.

**Table 3.4: Ministries, Departments and Agencies with marine and environment functions among BOBLME countries**

| Country | Ministries, Departments and Agencies |
|---|---|
| Indonesia | • Ministry of Marine Affairs and Fisheries<br>o Agency for Marine and Fisheries Research, Ministry of Marine Affairs and Fisheries<br>• Ministry of Environment<br>• Department of Agriculture<br>• Department of Forestry<br>• National Coordinating Agency for Survey and Mapping (BAKOSURTANAL).<br>• Meteorological and Geophysics Institute of Indonesia (BMG).<br>• Agency for the Assessment and Application of Technology (BPPT). |
| Malaysia | • Federal Department of Fisheries<br>• Department of Environment<br>• Ministry of Agriculture and Agro-based Industry<br>• Fisheries Development Authority of Malaysia<br>• Fisheries Research Institute Malaysia<br>• Fisheries Development Authority of Malaysia |
| Thailand | • Ministry of Natural Resources and Environment<br>o Department of Fisheries |

| | |
|---|---|
| | ◦ Department of Marine and Coastal Resources<br>◦ Department of Water Resources<br>◦ Office of the Natural Resources and Environmental Policy and Planning<br>◦ Department of Environmental Quality Promotion<br>◦ Pollution Control Department<br>• Ministry of Agriculture and Cooperative |
| Myanmar | • Department of Fisheries<br>◦ Marine Fisheries Resources Survey and Research Unit<br>• Hotel and Tourist Department<br>• Forest Department |
| Bangladesh | • Ministry of Fisheries and Livestock<br>◦ Department of Fisheries<br>◦ Bangladesh Fisheries Research Institute<br>◦ Bangladesh Fisheries Development Corporation<br>◦ Marine Fisheries Academy<br>• Ministry of Environment and Forest<br>◦ Department of Environment<br>• Ministry of Water Resources |
| India | • Department of Agriculture & Cooperation<br>• Department of Animal Husbandry, Dairying & Fisheries<br>• Department of Agricultural Research & Education<br>• Ministry of Food Processing Industries<br>• Department of Ocean Development<br>• Department of Bio-Technology<br>• Indian Council of Agricultural Research<br>• Central Institute of Brackishwater Aquaculture<br>• Central Inland Fisheries Research Institute<br>• Central Institute of Freshwater Aquaculture<br>• Central Institute of Fisheries Technology<br>• Central Marine Fisheries Research Institute<br>• Central Institute of Fisheries Education<br>• National Bureau of Fish Genetic Resources |

| | |
|---|---|
| | • National Research Centre on Coldwater Fisheries<br>• Fishery Survey of India<br>• Integrated Fisheries Project<br>• Central Institute of Fisheries, Nautical & Training<br>• Central Institute of Coastal Engineering for Fisheries<br>• Coastal Aquaculture Authority |
| Sri Lanka | • Ministry of Fisheries and Ocean Resources<br>  ○ Coast Conservation Department<br>  ○ Department of Fisheries and Aquatic Resources<br>  ○ National Aquatic Resources Research and Development Agency<br>  ○ Marine Pollution Prevention Authority<br>  ○ Ceylon Fisheries Harbours Corporation<br>  ○ National Aquaculture Development Authority<br>• Ministry of Environment and Natural Resources<br>  ○ Central Environment Authority<br>  ○ Department of Wildlife<br>  ○ Department of Forests<br>• Ministry of Tourism<br>• Ministry of Science and Technology<br>• Ministry of Plantation, Infrastructure and Construction<br>• Ministry of Irrigation and Water Management<br>• Ministry of Provincial Councils and Local Government<br>• Provincial Ministry of Local Government, Education, Industries and Environment |
| Maldives | • Ministry of Fisheries Agriculture and Marine Resources<br>  ○ Marine Research Centre<br>• Ministry of Environment Energy and Water<br>• Ministry of Tourism |

102. As a result of the many different institutions that exist with overlapping mandates and jurisdiction, responsibility and accountability among different levels of government they are not always clearly assigned or delineated, which may lead to conflict among agencies and confusion among stakeholders. This can have a negative impact on the management of the BOBLME resources. At the grassroots level, the lack of local community stakeholder consultation and involvement in planning, decision-making, implementation and

enforcement undermine effective implementation by responsible agencies. There is thus a need for continuous coordination and collaboration between agencies, and between the central government and the various sub-national units in order to ensure sustainable conservation and management of the BOBMLE. Institutional arrangements, in order to be effective, necessitate that enforcement powers are assigned to clearly identified agencies, fines and other penalties are specified and act as deterrents, and monitoring is promoted to ensure compliance.

103. The lack of clarity with regard to responsibility and accountability resulting from overlapping institutional mandates also gives rise to levels of corruption. The performance of the BOBLME countries in the Corruption Perception Index which measures the perceived level of public-sector corruption is indicative of the need to address wider issues of governance, including corruption. (See Socio-economic characteristics for more detail)

### 3.3.1 Decentralized Governments

104. A noticeable trend in the BOBLME member countries is a move towards decentralized administrations which vary across the BOBLME countries. The exercise of administrative authority is complicated in the BOBLME countries because of the overlapping and uncoordinated powers and functions of national, state and local governmental bodies. Central, state and local governments in the BOBLME countries are often hampered by poor unified planning and inadequate communication, including information exchange. While there is, by and large, inadequate capacity at all levels; this is most serious at the local governmental level, which generally lacks the capacity for managing multiple-use, multiple-stakeholder activities in the BOBLME region. Table 3.5 presents the sub-national administrative mechanisms in place in the BOBLME member countries.

**Table 3.5: Sub-national Government Systems in BOBLME Countries**

| Country | Local government levels |
|---|---|
| Indonesia | • 4 out of 33 provinces (Aceh, North Sumatra, West Sumatra and Riau) are part of the BOBLME.<br>• Provinces subdivided into regencies (*kabupaten*) and cities (*kota*), further subdivided into subdistricts (*kecamatan*), and into village groupings (either *desa* or *kelurahan*), which all have their own local governments and parliamentary bodies.<br>• The modern administration is supported by the traditional *gotong royong*, or mutual responsibility and cooperation system, based on village councils led by a headman |
| Malaysia | • 8 out of 11 peninsular states (Perlis, Kedah, Pulau Pinang, Perak, Selangor, Sembilan, Melaka and Johor) are on the BOB.<br>• 9 states have hereditary rulers and four are led by governors appointed by the hereditary rulers. Each state also has a state parliament.<br>• All states except Perlis (which is too small) are divided into varying numbers of districts, each headed by a district officer<br>• Beneath this are local, municipal and city councils |

| | |
|---|---|
| Thailand | • 75 provinces, called *changwat*, each under the control of a governor appointed by the national government.<br>• 877 districts, called *amphoe*, controlled by appointed district officials<br>• More than 7255 communes, called *tambon*, and 69,307 villages, known as *muban*. |
| Myanmar | • 14 regions, 7 of which are states of ethnic minority groups; and 7 administrative divisions occupied by the Burmese majority -- Kachin State, Kayah State, Kayin State, Chin State, Sagaing Division, Taninthayi Division, Bago Division, Magway Division, Mandalay Division, Mon State, Rakhine State, Yangon Division, Shan State, Ayeyawady Division<br>• Division, Township, and Village Law and Order Restoration Councils control local government;<br>• Regional commanders have considerable autonomy over their districts |
| Bangladesh | • 7 administrative divisions, three of which are adjacent to the BOB (although all are linked to it via the river and the coastal watershed)<br>• Divisions subdivided into districts (*zila*), which are further subdivided into subdistricts (*upazila* or *thana*) |
| India | • 4 states (West Bengal, Orissa, Andrha Pradesh, Tamil Nadu) are on the BOB.<br>• 2 Union Territories (Andaman and Nicobar Islands, Pondicherry) are in or adjacent to the BOB. These are administered collectively by a governor appointed by the head of state.<br>• Various urban and rural administrative bodies |
| Sri Lanka | • 9 provinces each headed by a directly elected provincial council -- Central, Eastern, North Central, Northern, North Western, Sabaragamuwa, Southern, Uva, and Western<br>• 25 administrative districts, which are further subdivided into divisional secretariats<br>• Other local government units include 12 municipal councils and 39 urban councils |
| Maldives | • 7 provinces – Upper North, North, North Central, Central, South Central, Upper South and South<br>• Local councils and island administrations |

105. Decentralized and participatory models of governance ensure local cultural and political autonomy, bring the government closer to the people, mobilize local resources, enhance sub-national units and institutions, and encourage grassroots community citizen participation in public administration. The move to decentralized

governance across the BOBLME countries also provides unique opportunities for states/provinces to implement and enforce legislation and policies in the BOBLME.

106. At the same time however, decentralized administration in the BOBLME countries comes with a number of constraints in terms of administrative, fiscal and logistical implementation as well as efficient delivery of public services. Decentralized administration raises an important issue of the capacity of the sub-national units to enforce nationally-set rules and regulations. By and large, the success of decentralization depends on the skills, education and motivation, equipment and financial resources of the local government units.

### 3.3.2 Traditional systems and customary rights

107. The recognition of traditional systems and customary rights through mechanisms such as customary marine tenure and community-based management have proven to be successful in managing marine living resources and improving the livelihoods of traditional fishermen, as well as the management and conservation of marine resources. Among the BOBLME countries, local customary management practices which regulate the use, access, and transfer of resources have been developed through generations of human interaction with the environment. These are often distilled from indigenous ecological knowledge and are culturally embedded in customary land and sea tenure institutions.

108. The implementation of customary marine tenure, practices and traditional knowledge is exemplified in the BOBLME region in various forms such as temporary closure of particular areas to fishing (i.e. closed for several months to provide supplies of fish for a feast) or permanently (where spirits reside, for example); limiting who can harvest certain species, using certain gears, fishing in certain areas; and restricting the quantity of a harvest. However, with colonization and adoption of western cultures, community-based management and co-management schemes have weakened. Where they still exist, the adoption of such approaches into the domestic legal framework and resource management practices of the BOBLME countries should be encouraged and promoted as a positive step towards ensuring the sustainable management of the BOBLME.

### 3.3.3 Community participation and public awareness

109. Community participation in one form or another in coastal and marine living resource management is generally accepted as a fundamental and practical way to promote compliance with laws and regulations and to ensure the sustainability of marine living resources.

110. At present, the opportunities for stakeholder participation in the BOBLME are limited under existing laws, regulations and policies and their own low level of capabilities. There is a need to strengthen, improve and further expand avenues for increased participation of all major stakeholders at the regional, national and local levels in coastal environment and resources conservation and management of the BOBLME. In order to strengthen the participation of the community stakeholders, appropriate policies, laws and regulations would need to be put in place. The capacity building of stakeholders themselves should be made a separate goal in itself which could be achieved through the development of training and information transfer projects as well as institutional arrangements which will allow for standard participation. The involvement and participation of all relevant stakeholders in establishing a transparent and practicable management of the BOBLME should be ensured, and not merely limited to perfunctory consultation.

111. At the regional level, broad and enduring partnerships among and within the BOBLME countries and with key regional/international agencies and donors should be built in order to achieve a coordinated implementation process which will harness the comparative advantage of the respective co-financing institutions. In light of the size and complexity of the BOB, achieving a high degree of regional cooperation with a large number of government agencies, many of which would likely be directly involved in project implementation, will ensure long-term viability of BOBLME projects and activities.

# 4. ASSESSMENT OF MARINE LIVING RESOURCES AND THE ENVIRONMENT

## 4.1 Overexploitation of marine living resources

112. The term “marine living resources” in this TDA covers (i) fish[19] that support important fisheries in the BOBLME, (ii) marine biodiversity, and (iii) vulnerable and endangered species. In all consultations with BOBLME countries leading up to the development of the TDA, the impact of fishing on the marine living resources was a common concern. "Fishing" in this context comprises the harvesting or other extractive use(s) of naturally occurring marine living resources irrespective of their phylogenetic classification and include, *inter alia*, adults, juveniles, eggs and miscellaneous parts of fish, invertebrates, plants and other organisms that rely on the marine environment for some part of their life cycle.

113. As described in Section II, the fisheries of the BOBLME are of great socio-economic importance to the countries bordering the BOBLME and provide for direct employment of over 2 million fishermen. Fisheries of the BOBLME catch a wide range of species, including sardine, anchovy, scad, shad, mackerel, snapper, emperor, grouper, tuna, shark, ornamental reef fish, shrimp, bivalve shellfish and seaweed (Preston, 2004).

### 4.1.1 Current production and value

114. The current estimated production for the BOBLME (statistics for year 2008) is approximately 6 million tonnes valued at USD 4 billion (SAUP, 2010) and (FAO Fishstat, 2010). The various sources of production figures (Food and Agriculture Organization of the United Nations (FAO), Sea Around Us Project (SAUP), and country statistics year books) present the data in different ways and it is difficult to derive a definitive figure, although a comparison of the different sources all gave an estimate of around 5 million tonnes in 2006 (Table 4.1). In countries where only part of their seas is covered by the BOBLME, it is also difficult to apportion the catch to only those areas – rough estimates were necessary as explained in Table 4.1.

115. The national statistics and the FAO records that are derived from these refer to landings recorded by each of the BOBLME countries. SAUP estimates differ in that they are (i) allocated to fishing ground at capture, not the place of landing, (ii) based on best available data sets, and (iii) in the case of India a based on “reconstructed” catches that include missing data and discards.

116. For example, although Thailand recorded a total landing of about 850,000 tonnes landed in Thailand, much of this is taken from the EEZs of other countries, and according to SAUP (2010), only 200,000 tonnes is taken from the Thailand EEZ (Andaman Sea). SAUP and FAO also point out that the catch recorded in each country is probably an underestimate as it often does not include (i) all the catch taken by the small-scale fisheries, (ii) IUU catch, and (iii) discarded catch. Thus, the total catch and value of the BOBLME is probably considerably larger than that reported here.

117. As well as estimating the amount of fish actually taken in each EEZ, SAUP (2010) also estimates the catch of each fishing country in the BOB, regardless of where the fish is caught. Myanmar is the top fishing nation with a total catch of 1.472 million tonnes in 2006. India was second, followed by Thailand and Bangladesh (Fig. 4.1).

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

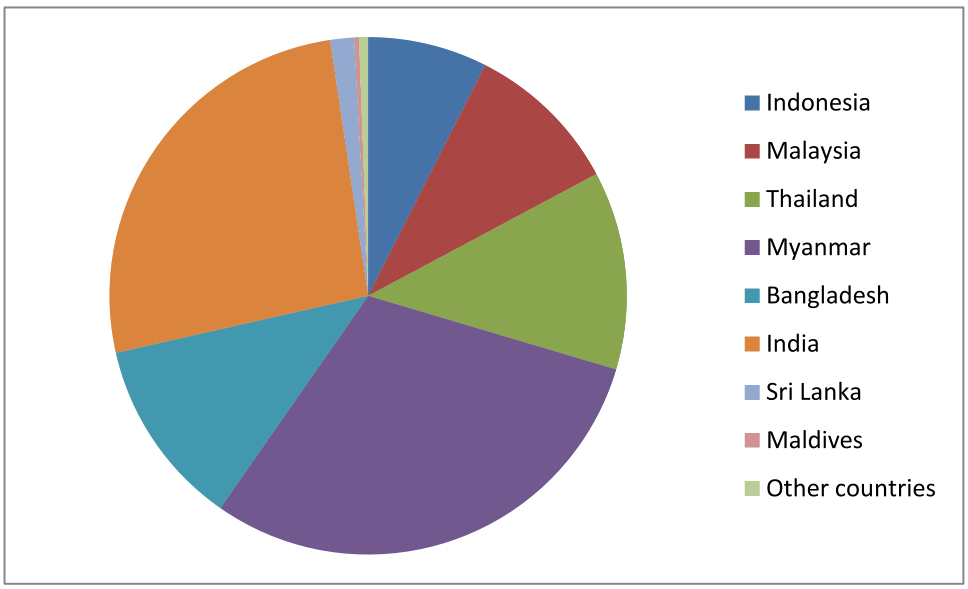
**Table 4.1: Estimates of marine production and value for each country of the Bay of Bengal, 2006.**

| | Indonesia* | Malaysia | Thailand | Myanmar | Bangladesh | India** | Sri Lanka | Maldives | Total* |
|---|---|---|---|---|---|---|---|---|---|
| **FAO statistics** | | | | | | | | | |
| **Tonnes ($10^3$)** | 569.5 | 586.7 | 867.9 | 1,375.7 | 479.8 | 991.5 | 239.3 | 184.2 | 5,295 |
| **Country statistics** | | | | | | | | | |
| **Tonnes($10^3$)** | 571.1 | 640.0 | 891.4 | 1,380.0 | 486.0 | 919.9 | 216.0 | 184.2 | 5,289 |
| **Sea around us Project (Production in BOBLME country EEZs)** | | | | | | | | | |
| **Tonnes ($10^3$)** | 365.3 | 465.4 | 206.8 | 1,838.2 | 555.0 | 1,183.2 | 144.0 | 40.2 | 4,798 |
| **USD ($10^6$)** | 159 | 572.0 | 175.0 | 1,270.0 | 127.0 | 993.9 | 131.0 | 74.5 | 3,581 |

*Indonesia FAO and SAUP figures based on 50% of FAO fishing area 57 landings. National landings based on Fishery Management Area (FMA) 571 plus 50% of 572

** SAUP data for India's Nicobar and Andaman Islands corrected from 2001-06 from India's National Yearbook statistics

*Source: SAUP (2010), FAO Fishstat (2010) and Country statistics and yearbooks (2007).*




*Source: SAUP (2010)*

**Figure 4.1. Catches by fishing nation in the Bay of Bengal, 2006.**

### 4.1.2 Catch and fleet characteristics

#### Catch profile

118. Fisheries in the BOBLME target a wide range of species that include sardines, anchovies, scads, shads, mackerels, snappers, emperors, groupers, congers, pike-eels, tunas, sharks, ornamental reef fish, shrimps, crabs, lobsters, octopus, gastropod and bivalve shellfish, sea cucumbers and seaweeds. Over 40% of the 2008 catch from the BOBLME (2.8 million tonnes) as classified by FAO Fishstat, is designated as "Marine fish not identified elsewhere" ("nei"), while a further 26% (1.7 million tonnes) falls into the three 'miscellaneous' categories used by FAO, based on International Standard Statistical Classification of Aquatic Animals and Plants which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. The imprecise nature of the data introduces considerable unreliability into any conclusions that may be drawn from them. However, it is apparent that pelagic fish make up a large proportion of the catch (Table 4.2). Of the properly defined species categories, "tunas, bonitos and billfishes" and "herrings, sardines, anchovies" are the most important, making up about 17% of the catch. However, it is likely that a significant proportion of the tuna catch is taken outside the BOBLME proper, for example by Indonesian vessels fishing in the wider Indian Ocean.

**Table 4.2: Major species groups contributing to fishery production in BOBLME countries (percentage), 2008, based on International Standard Statistical Classification of Aquatic Animals and Plants**

| Country | Marine fish "nei" | Herrings, sardines, anchovies | Miscellaneous pelagic fishes | Miscellaneous demersal fishes | Miscellaneous coastal fishes | Shrimps, prawns | Squids, cuttlefish, octopus | Shads | Tunas, bonitos, billfish | Sharks, rays, chimaeras | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Indonesia | 3.3 | 20.7 | 23.3 | 3.2 | 16.4 | 6.3 | 2.3 | 0.2 | 13.2 | 2.9 | 10.8 |
| Malaysia | 34.5 | 2.2 | 31.2 | 1.1 | 9.0 | 8.1 | 5.0 | 1.8 | 3.3 | 1.0 | 3.4 |
| Thailand | 45.6 | 8.6 | 16.4 | 1.3 | 13.7 | 2.6 | 4.8 | - | 2.6 | 1.1 | 2.1 |
| Myanmar | 97.9 | - | - | - | - | 2.0 | - | - | - | - | 0.1 |
| Bangladesh | 35.9 | - | - | - | 11.2 | - | - | 40.0 | 0.3 | 1.0 | 10.7 |
| India | 28.3 | 8.5 | 10.0 | 3.0 | 25.1 | 8.6 | 1.4 | 1.7 | 5.1 | 5.0 | 3.4 |
| Sri Lanka | 4.5 | 23.5 | 10.3 | 4.5 | - | - | 0.2 | - | 48.7 | 1.6 | 2.2 |
| Maldives | 11.8 | - | - | - | - | - | - | - | 87.7 | 0.4 | 0.1 |
| BOBLME | **42.6** | **8.4** | **12.6** | **1.7** | **11.3** | **4.5** | **1.8** | **3.6** | **8.5** | **1.9** | **3.1** |

*Source: FAO Fishstat (2010)*

119. Considerable country differences exist, both in terms of detailed reporting and in major groups caught. Countries closer to the open Indian Ocean catch more tunas, bonitos and billfish, especially Sri Lanka and the

Maldives (Table 4.3). Hilsa shad (mainly *Tenualosa ilisha)* is a dominant part of the catch in Bangladesh and is the most important single species identified in the statistics and also is probably an important component of Myanmar. On the eastern coast (Indonesia, Malaysia and Thailand), Indian mackerels (mainly *Rastrelliger kanagurta*) and Indian scad (*Decapterus russelli*) are the most abundant single species identified, while on the western coast (India, Sri Lanka and the Maldives), skipjack tuna *Katsuwonus pelamis* is the most important single species identified.

**Table 4.3: Major species and species groups contributing to fishery production in the eastern, middle and western BOBLME (*Source: FAO Fishstat (2010)***

| Eastern BOB | | Middle BOB | | Western BOB | |
|---|---|---|---|---|---|
| Marine fishes nei | 577,425 | Marine fishes nei | 1,822,987 | Marine fishes nei | 320,029 |
| Indian mackerels nei | 176,410 | Hilsa shad | 200,100 | Clupeoids nei | 96,992 |
| Indian scad | 64,124 | Marine crustaceans nei | 53,206 | Skipjack tuna | 81,335 |
| Threadfin breams nei | 37,258 | Bombay-duck | 36,980 | Penaeid prawns | 62,277 |
| Croakers, drums nei | 35,619 | Natantian decapods nei | 33,000 | Croakers, drums nei | 62,110 |
| Anchovies, etc. nei | 30,197 | Sea catfishes nei | 20,534 | Sea catfishes nei | 61,203 |
| Sardinellas nei | 30,120 | Sharks, rays, skates, etc. nei | 4,767 | Sharks, rays, skates, etc. nei | 57,655 |
| Natantian decapods nei | 29,321 | Jellyfishes | 2,410 | Ponyfishes(=Slipmouths) nei | 47,800 |
| Torpedo scad | 28,973 | Seerfishes nei | 1,559 | Percoids nei | 45,605 |
| Sergestid shrimps nei | 25,851 | Indian threadfin | 1,040 | Yellowfin tuna | 43,118 |

*Source: FAO Fishstat (2010)*

120. The Indian Ocean in general, and the BOBLME within it, differs from other oceans of the world in that production from artisanal, small-scale fisheries equals or exceeds that from industrial, large-scale fisheries. In Bangladesh, for example, less than 5% of marine landings are estimated to come from industrial fishing activities, with the rest being produced by artisanal fishers (Hossain, 2003). In Thailand, although the quantity of fish caught by the small-scale subsector is only about 15%, it is of much higher value than the catch from larger vessels, especially trawlers, which is now composed of a high proportion of low value small/trash fish. The Maldives is an exemption with a modern fleet of relatively large pole-and-line tuna vessels.

121. A characteristic of artisanal fisheries in the BOBLME countries is the low volume of discards, because almost all components of the catch are consumed or used for animal feed. Fish constitute a generally affordable source of protein in the BOBLME countries, and most of the inshore catch is used for local or domestic consumption, contributing significantly to dietary health and food security, particularly in coastal areas.

122. (SAUP, 2010) have attempted to increase the range of species identified by extrapolating from countries where better statistics are available and also inferring catches from gear type used. Based on 2000 data,

medium pelagics (39 to 89 cm) were the dominant group in all countries, thereby supporting the findings from FAO Fishstat[20].

## Fishing fleet profile

123. There are at least 412,500 fishing vessels operating in the BOBLME (Table 4.4). This is probably an underestimate, as many countries only report registered vessels and many small vessels remain unregistered. Of the 412,500, about 34% were non-motorized (for example, small-scale dugout canoes), and 34% were outboard powered (including long-tail powered boats as well as modern outboards). Inboard driven fishing vessels range from <5 GRT to in excess of 200 GRT, although most are in smaller categories.

**Table 4.4: Best estimate of the number of fishing vessels operating in the BOBLME countries. Trawlers are included in the total**

| | Year | Inboard | Outboard | Non-motorized | Total | Trawlers |
|---|---|---|---|---|---|---|
| **Indonesia* [1]** | 2008 | 30,320 | 14,900 | 24,895 | 70,115 | - |
| **Malaysia[2]** | 2008 | 7,865 | 10,027 | 98 | 19,998 | 3,098 |
| **Thailand[3]** | 2007 | 1,744 | 17,954 | 1,458 | 21,156 | n/a |
| **Myanmar[4]** | 2008 | 2,087 | 14,289 | 15,219 | 31,595 | n/a |
| **Bangladesh[5]** | 2006 | 21,433** | | 22,527 | 43,236 | 122 |
| **India**[6]** | 2005 | 21,450 | 46,182 | 77,563 | 145,195 | 9,391 |
| **Sri Lanka[5]** | 2008 | 4,749 | 39,104*** | | 43,853 | n/a |
| **Maldives[5]** | 2008 | 907 | - | 24 | 931 | - |
| **Total** | | **90,555** | **142,456** | **142,738** | **412,521** | |

*Indonesia statistics refer to FMA 571 plus 50% of FMA 572

**Both inboard and outboard combined

***India classifies boats as (i) mechanised, (ii) motorized and (iii) non-motorized. For convenience categories (i) and (ii) were re-classified as "inboard" and "outboard", respectively

*** Both outboard and non-motorized combined

*Source[1]. SEAFDEC (2009), Source[2]. Abu Talib (pers comm) Source [3].Panjarat, 2008), Source [4]. Country update, BOBLME Project, Source [5]. FAO Country profiles(2010),Source [6].CMFRI (2006),*

124. The fishing vessels in BOBLME countries are mostly small-scale in nature but there has been a large increase in the numbers of various categories of trawlers targeting primarily shrimp and demersal fish by-catch and purse seiners targeting pelagic fish. Some countries provide statistics on the catch by different fishing gear. Small-scale fisheries in the region use gill nets, trammel nets, purse-seines, beach seines, push-nets, various kinds of fixed nets and traps, troll lines, pole-and-line gear and longlines (not to mention dynamite and cyanide) to target a wide range of species. In Aceh, Indonesia, where trawling has been banned since 1980 (some illegal

[20] SAUP (2010) data sets contain an error after 2001 – the Indian production was incorrectly entered, distorting many extrapolations after this date

trawling still occurs), the main gears used are gill nets and hook and lines. In other BOBLME countries, a much larger portion of the catch comes from trawling and purse seining (for example, about 80% in West Coast Malaysia in 2006 (Anon, 2007) and 95% in the Andaman Sea, Thailand (SEAFDEC, 2009). Maldives is an outlier with most of its catch coming from pole-and-line fishing for tuna, mainly skipjack.

125. Despite predictions to the contrary, and significant subsidies provided to support larger-scale activities, the importance of the region's small-scale fisheries has continued to increase in recent years and artisanal craft are ranging over progressively larger areas. Over time, the size and number of motorized vessel has increased, while that of the non-motorized vessels has either declined or remained static. An example of this trend is given for the Province of Aceh in Indonesia (Fig. 4.2).

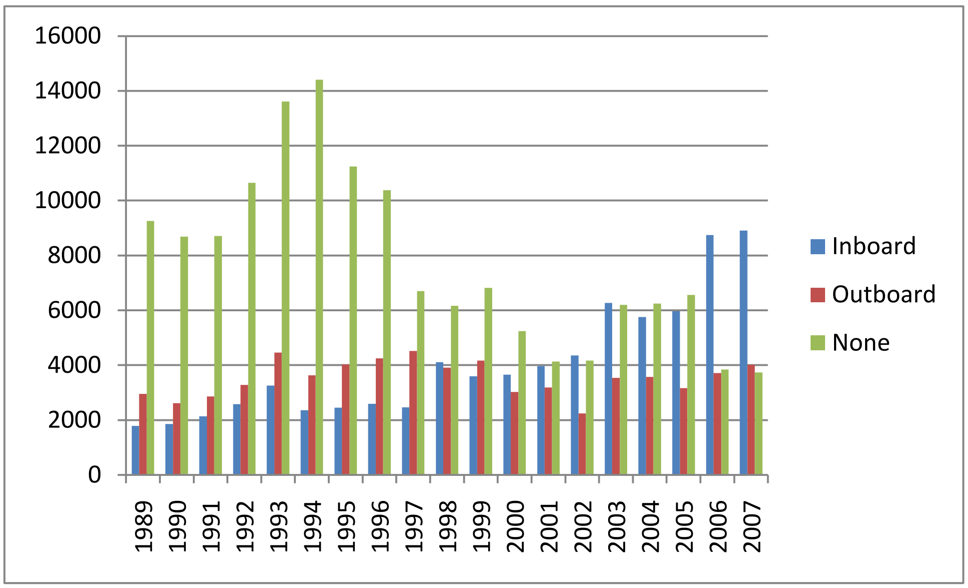



**Figure 4.2. Trends in the number of non-motorized vessels, vessels powered by outboard and inboard motors, Aceh Province, Indonesia 1998-2007.**

### 4.1.3 Status of marine living resources

126. Increasing numbers of fishermen and of fishing vessels of various categories as well as their greater fishing power, including the widespread adoption of fish aggregating and attracting devices in concert with purse seines, have all contributed to dramatically increased fishing pressure on limited fishery resources.

127. A number of indictors all point towards overexploitation of the marine living resources, especially in coastal inshore waters. These indicators include:

1. Stagnating production from marine waters in many of the BOBLME countries;
2. Changes in species composition and "fishing down the food chain";
3. Catches equal to or greater than estimated potential yields;
4. Assessments of exploitation of major fish groups and selected stocks;
5. Quantities of juvenile fish taken; and
6. Anecdotal information from fishermen on catch and profit trends.

## Stagnating catches in many BOBLME countries

128. With the exception of Myanmar and Bangladesh, the catch of marine fish in the BOBLME countries has either been static or declining over the past decade (Fig. 4.3). The most obvious decline has been in the Thailand Andaman Sea landings that declined from 909,500 tonnes in 1998 to 735,300 in 2008. In Malaysia, catches levelled off as earlier as 1990 and remained static until 2006 (a slight increase has been recorded in 2007 and 2008). On the western side of the BOB, catches in India and Sri Lanka have been relatively static since the late 1990s, although India has shown a recent small incease. Most of the tsunami affected countries (Indonesia, Thailand, India and Sri Lanka) show a decreased catch in 2005 but a quick rebound back to previous levels in 2006.

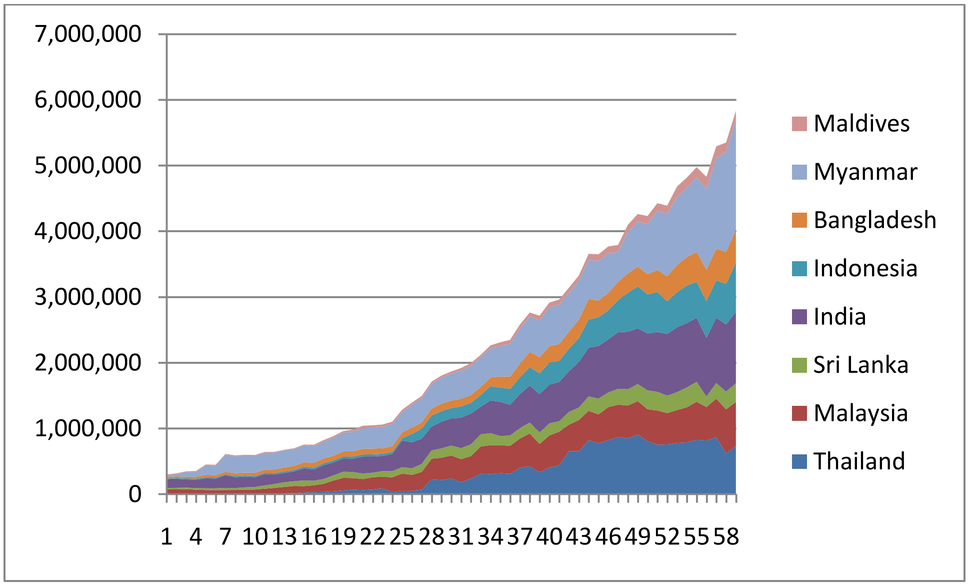



**Figure 4.3. Catches of marine fish from BOBLME countries, 1950 to 2008.** ***Source: FAO Fishstat (2010)***

129. The exceptions to the stagnating trend in Bangladesh and Myanmar need comment. Both these countries provide the least detailed statistics, so it is difficult to examine which fish are contributing the increases. The increase in Myanmar is particularly spectacular, increasing from 681,000 tonnes to 1,679,010 tonnes over the last decade. This amounts to an average increase of almost 10% per year. It is difficult to understand this increase when landings in Thailand, which catches a significant proportion of its catch in Myanmar waters, declined over the same period. The statistics of Myanmar (and Bangladesh) require further verification.

## Changes in species composition and "fishing down the food chain"

130. Although difficult to detect from gross statistics where many species are grouped as "nei", all the evidence points towards considerable shifts in the species composition in the landings from BOBLME countries. This is evident in Fig. 4.4 that shows the changes in major ISCAAP groups over time. The proportion of demersal fish; sharks, rays, chimeras; shrimps, prawns; and herrings, sardines, anchovies declined while that of shads (mainly hilsa shad); squids, cuttlefish, octopuses; and tunas, bonitos, billfishes increased.

131. Along with these changes in catch, fishermen have been fishing further away from their homeports and landing places. This is expressed as a "FIB" index by SAUP (2010) and shows a steady increase throughout most of the development of the BOBLME fishery (Fig. 4.5). Interestingly, the last 5 years index has been relatively flat suggesting that the expansion may have finished.

132. Changes in species composition are often associated with a change in the underlying ecosystem. When larger, longer-lived predators are removed (for example sharks and rays) the overall trophic level of the system

declines as the proportion of prey species increases. SAUP (2010) demonstrates this trend by a decline in the mean trophic level for the BOBLME over the time span of the fishery (Fig. 4.6).

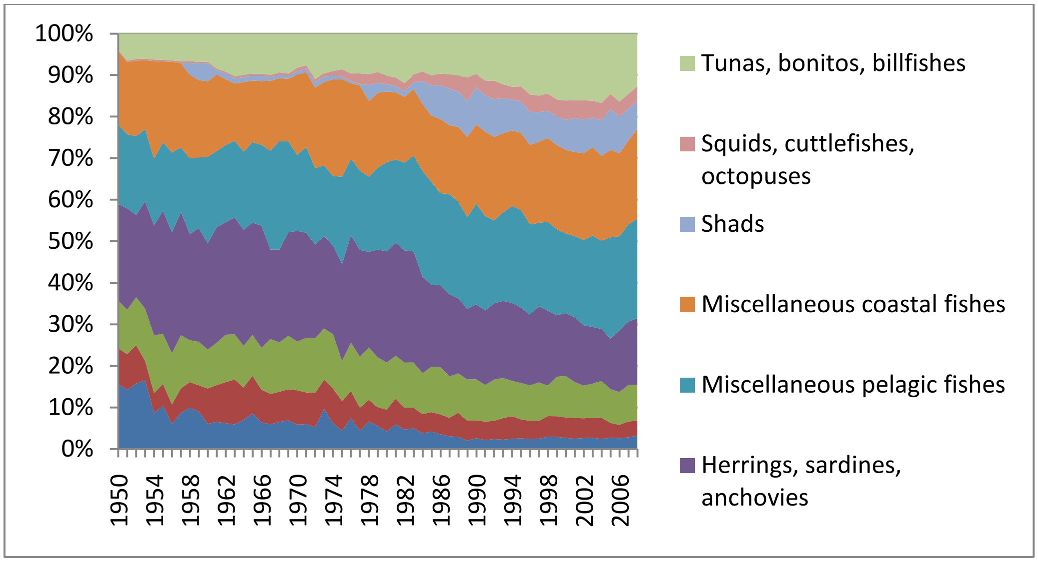



**Figure 4.4. Changes in the composition of landings from FAO Fishing Area 57 from 1950 to 2008. *Source: FAO Fishstat (2010)***

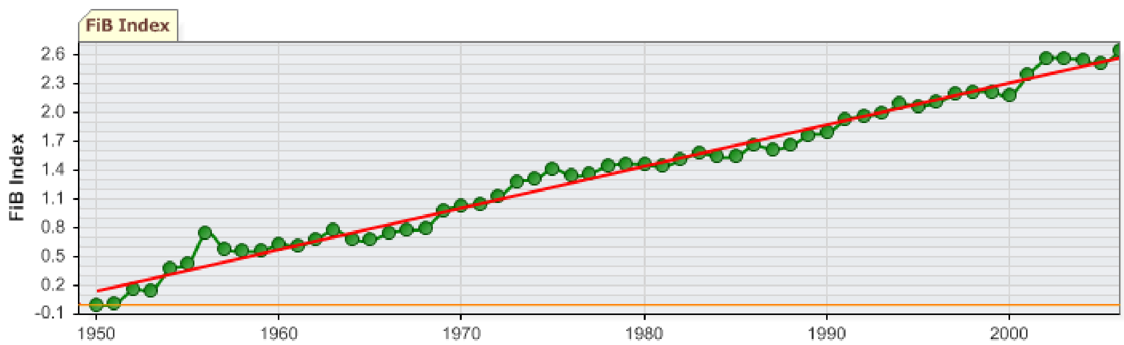



**Figure 4.5. FIB index that demonstrates the offshore expansion of the fisheries in the BOBLME. *Source: SAUP (2010)***

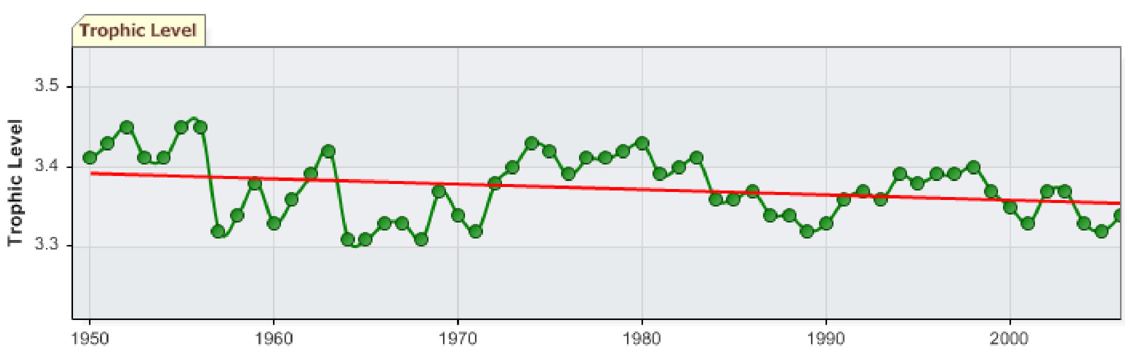



**Figure 4.6. Changes in the mean trophic level of the BOBLME as calculated from changes in the species composition of catches, 1950 to 2006. *Source: SAUP (2010)***

## Actual catches versus potential yield estimates

133. The comparison of actual yields with "potential yields" is a commonly used indicator of the status of marine living resources in BOBLME countries. However, these comparisons can be misleading as the potential yield is often calculated from different sources of data and are often based on a number of assumptions that are not clearly identified or substantiated. Early "potential yields" were often based on research surveys where the biomass of fish was calculated from the swept area of the survey and multiplied up to the EZZ as a whole. The potential yield was estimated as a proportion of the biomass (often 0.5). More recently, acoustic surveys have been used to estimate pelagic biomass. Some BOBLME countries updated their "potential yield" estimates by modelling the trends in the catch and effort of major species and species groups and calculating the maximum sustainable yield (MSY) from production models. With expansion of fishing grounds (as demonstrated in the previous section), catches and catch rates can increase, but not necessarily indicating changes in the MSY. However, because this indicator is commonly used, an attempt was made to find the most recent estimate of the potential yield and compare that with maximum catch in the past and current catches (Table 4.5).

134. Over all BOBLME countries, the current yield exceeds the sum of the potential yields, indicating that as a region, the fishery is overexploited. Within this overall assessment, however, there are many country and species differences - it appears that some resources and areas may still have room for development (e.g. small pelagic resources off the coast of Sumatra), but the overall message is that these are exceptions, not the rule. It is also difficult to see how different target groups can be developed without adding to the overall increase in fishing effort and capacity.

135. The outliers in the magnitude of the potential yield can also be seen. The potential yield/km$^2$ of the different EEZs averages 2.6 tonnes/km$^2$ with Bangladesh's estimate of 5.73 tonnes/km$^2$ lying well outside this average. This may indicate the differences in methods used to estimate potential yields, as described above. However, when these potential estimates are compared with the estimated primary production of the waters of each country, it is Indonesia that is an outlier with a very high potential yield compared with its primary productivity.

136. Several countries have adopted policies to expand fishing to offshore areas based on these types of estimates. Recent analyses have shown that offshore areas are much less productive than the inshore areas, and in many cases, the promised resources are not there in sufficient abundance to make fishing viable (APFIC, 2009). As shown in the next section, this also applies to the highly migratory tuna of the region.

## Stock assessments

137. Some BOBLME countries, notably Malaysia and India, conduct routine stock assessments to guide management. Some countries, notably Myanmar, have very little information on the status of their stocks.

138. (APFIC, in press) has collated stock assessments at the species group level (e.g. large demersals, small pelagics) from scientists in each country. These show that a large number of the groups in the region are either overfished or fully fished, especially in eastern BOBLME countries (Table 4.6 and Fig. 4.7). There are also a large number of groups that are scored as moderately fished (i.e. little room for development).

139. Underfished stocks are mainly confined to Bangladesh, and given the lack of assessments in this country, these are questionable. Both large and small demersal fish are overfished in a majority of the areas where assessments have been carried out. The status of large and small pelagics is more variable with most recorded as overfished or fully fished, although some are still moderately fished. The stocks of anchovies and sardines are fully fished in a majority of the assessed fisheries in the BOBLME.

**Table 4.5: Estimates of the potential yield (PY) (1,000 tonnes), PY per area of EZZ (PY/km²), PY per unit of primary productivity (PY/mgC) and actual yield (both peak landings and 2008 estimates) and the difference between current landings and PY for BOBLME countries.**

| | Potential yields (PY) | | | | | | Landings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Demersal | Pelagic | Others | Total | PY/ $km^2$ | PY/ mgC | Peak landing | Landings 2008 | Difference |
| **Indonesia**[1] | 235.4 | 1067.8 | 29.7 | 1332.9 | 2.72 | 2405 | 887.6 | 830.3 | -502.6 |
| **Malaysia**[2] | 155.5 | 62.0 | | 217.5 | 3.16 | 159 | 677.1 | 669.7 | 452.2 |
| **Thailand**[3] | 159.2 | 200.8 | | 360.0 | 4.04 | 507 | 909.6 | 753.3 | 393.3 |
| **Myanmar**[4] | | | 1050.0 | 1050.0 | 2.02 | 1117 | 1679.0 | 1679.0 | 629.0 |
| **Bangladesh***[5] | | | 939.5 | 939.5 | 5.73 | 550 | | 497.6 | -441.9 |
| **India**[6] | 413.6 | 500.5 | 263.0 | 1177.1 | 0.92 | 1163 | 1085.9 | 1085.9 | -91.1 |
| **Sri Lanka**[7] | 80.0 | 170.0 | | 250 | 0.48 | 411 | 303.2 | 285.0 | 35.0 |
| **Total** | | | | **5327.0** | | | | **5800.8** | |

*Source[1] Duta (pers comm); Source[2] Abu Talib (pers comm.; Source[3]. Panjarat (2008); Source[4] FAO Country profiles (2010); Source [5] APFIC (in press); Source[6] GOI (2007); Source[7] Blindheim & Forn, (1980)*

140. Large migratory tuna need to be assessed at the regional level. The Indian Ocean Tuna Commission (IOTC) provides regular status reports based on national inputs. In 2009, the Scientific Committee (IOTC, 2009) assessed that yellowfin tuna was overfished, bigeye tuna, swordfish and albacore were fully fished, and skipjack tuna were showing signs of possible overfishing in some areas. The status of the billfishes was uncertain.

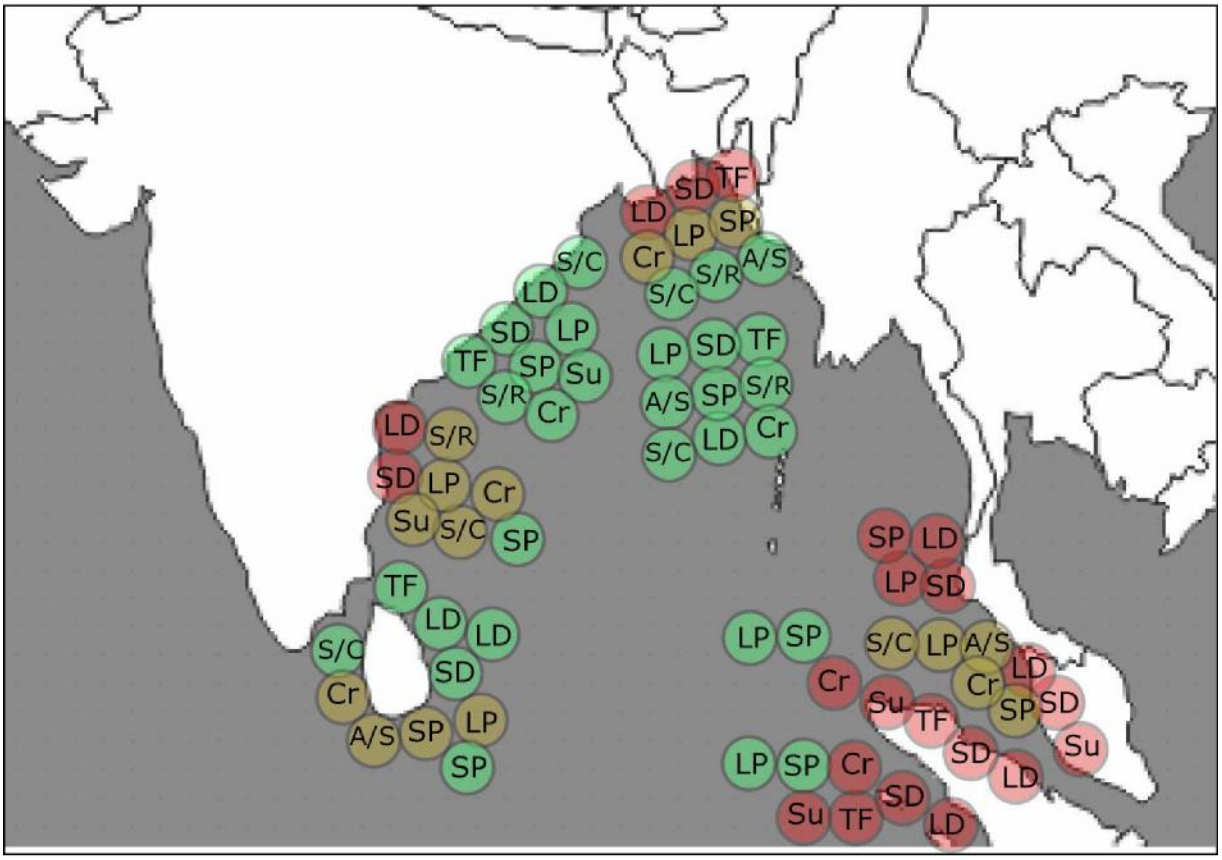
141. Surimi is becoming a more important product in the region and is based on catches of species that previously had little commercial value such as threadfin bream (*Nemipterus spp*), big eye (*Priacanthus spp*) and lizardfish (*Saurida spp*). These species are assessed as overfished in Malaysia and the east coast of Sumatra, fully or moderately fished in India and the west coast of Sumatra. The stocks of crustaceans are scored as fully fished in the majority of the assessed fisheries, whereas squids/cuttlefish have some areas fully fished whereas others are moderately fished. Interestingly, scientists assess small low value/trash fish as overfished in waters <40m in Bangladesh and fully to overexploited in Indonesian waters (Table 4.6).

**Table 4.6: Fishery/stock assessments for the assessed Bay of Bengal fisheries areas: Depleted (D); Overfished (O); Fully (F), Moderately (M); Underfished denotes no data available. Several values indicate range of reported values (e.g. several sub areas).**

| | Indonesia | Malaysia | Thailand | Bangladesh | India | Sri Lanka |
|---|---|---|---|---|---|---|
| **Large demersal** | F/O, F/O | O | O | O, F | O/F, M | M, U |
| **Small demersal** | F/O, F/O | O | O | O, M | O, M | M |
| **Large pelagic** | M,M | F | O | F, U | F, M | F |
| **Small pelagic** | M,M | F | O | F, M | M,M | F, M |
| **Anchovy/Sardine** | | F | | M, U | | F |
| **Trash fish /low value fish** | F/O, F/O | | | O, U | nd, M | M |
| **Surimi species** | F/O, F/O | O | | | F, M | |
| **Shark/rays** | | | | M, U | F, M | |
| **Squids/cuttlefish** | | F | | U,U | F, M | M |
| **Crustaceans** | F/O, F/O | F | | F, M | F, M | F |

Note: This table presents indicative status for species groupings. Terminologies for level of exploitation vary between countries as do the methods of assessment, date of last assessment and the geographic scope of those assessments.

*Source:* APFIC (in press)




| | | | | |
|---|---|---|---|---|
| **LD** | Large Demersals | **TF** | Trash fish /low value fish | Depleted / Overfished |
| **SD** | Small Demersals | **Su** | Surimi species | |
| **LP** | Large Pelagics | **S/R** | Sharks/rays | Fully fished |
| **SP** | Small Pelagics | **S/C** | Squid / cuttlefish | Moderately / Under fished |
| **A/S** | Anchovy / Sardine | **Cr** | Crustaceans | |

**Figure 4.7. Indicative fishery/stock assessments for the assessed fisheries areas. Green = underfished, yellow = fully fished and red = overfished.**

*Source: APFIC (in press)*

## Trawl surveys

142. India, Malaysia and Thailand (Andaman Sea as well as Gulf of Thailand) undertake regular surveys with dedicated research vessels. In Thailand (Andaman Sea), trawl surveys have been conducted since 1966. The catch rate declined steadily from 1966 to 1972 (Fig. 4.8), indicating an early decline in the abundance of demersal fish in the area during a time of heavy fishing pressure that coincided with introduction of trawling to Thailand from the Philippines by a joint Thai-German Government initiative in the early 1960s. Parallel industrial-scale developments were also stimulated at this time, most notably in Indonesia and the Malay Peninsula.

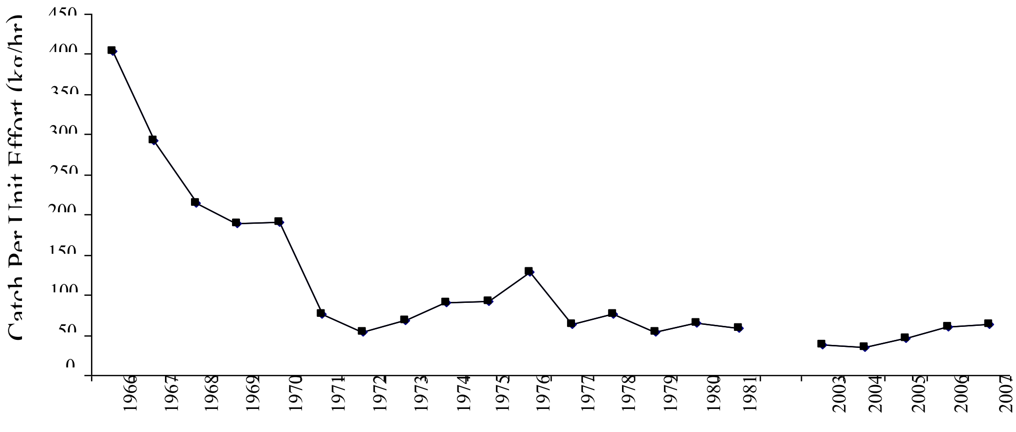



**Figure 4.8. Catch rate (kg/hr) of the total fish taken in the standard bottom trawl of the research vessel in the Andaman Sea from 1966 to 1981 and 2003 to 2007.** ***Source: Nootmorn (pers comm.).***

143. In Malaysia, the average catch rate in the coastal zone of the northern area of the west coast of Malaysia reduced from 74.5 kg/hr in 1971-72 to only 22.7 kg/hr in 1991 and further down to 18.6 kg/hr in 1997. This is a reduction of 75% over the period considered. Further south, the average catch rate of 67.2 kg/hr in 1971-72 was reduced to 21.00 kg/hr by 1991 – a reduction of 69% (Abu Talib, et al., 2003).

144. The Fish Survey of India started surveys in 1946 and currently deploys several vessels undertaking regular surveys along the east coast of India. Unfortunately, no long-term time series seems to have been attempted, but would give very interesting results on the status of marine resources in India.

## High proportion of juvenile fish

145. In many fisheries of the region, there is little control on the mesh size of the fishing gear used, and the proportion of juvenile fish is very high. Juveniles of more highly-priced fish, if left to grow would fetch much higher prices in the market. Low value/trash fish caught mainly by trawlers in the BOBLME is composed of an assortment of juveniles of commercial and non-commercial fish species, and small, more productive fish species. In Thailand between 18% and 32% of low value/trash fish are juveniles of commercially important fish species. During 1995-1999, low value/trash fish production of trawl fisheries composed of at least 35 species, 9 of them were small species and the other 26 species were juveniles of high value fish (9 pelagic species and 17 demersal species). Other aquatic species such as cuttlefish, shrimp (incl. sergestid shrimp), and crab are also taken. There were 14 species of low value/trash fish from push net fisheries, i.e., 3 species of small fish and 11 species of juveniles of high value fish (5 pelagic species and 6 demersal species) (Kaewnern & Wangvoralak (2004). Large volumes of low value/trash fish are taken in Thailand, Malaysia, India, Bangladesh, and presumably Myanmar.

146. In India, detailed studies have been carried out on the fish taken by trawlers that landed their fish in Mangalore-Malpe (CMFRI, 2006) (Table 4.7). Over 50% of the trawl catch, nearly 60% of the purse seine catch, and over 30% of the fish taken by ring seines were juvenile fish.

**Table 4.7: Percentage juveniles caught in a survey of commercial trawlers, purse seiners and ring seiners in Mangalore-Malpe, Orissa, India 2005**

| Trawlers | Total catch | Juvenile catch | Per cent |
|---|---|---|---|
| Hairtails | 11970434 | 5314873 | 44.4 |
| Groupers | 4641669 | 3717683 | 80.1 |
| Threadfin bream | 1144722 | 915777 | 80.0 |
| Tongue sole | 1340807 | 474109 | 35.4 |
| Herring, scads and hilsa | 625265 | 393492 | 62.9 |
| Oil sardine | 717544 | 171493 | 23.9 |
| Lizard fishes | 206967 | 82787 | 40.0 |
| Drums and croakers | 239892 | 81329 | 33.9 |
| Pony fishes | 103207 | 35489 | 34.4 |
| False trevally | 1108998 | 26815 | 2.4 |
| Mackerel | 58212 | 19431 | 33.4 |
| Anchovy | 667 | 217 | 32.5 |
| | **22158384** | **11233495** | **50.7** |
| **Purse seiners** | | | |
| Oil sardine | 4617881 | 2664517 | 57.7 |
| Torpedo scad | 1161987 | 730890 | 62.9 |
| | **5779868** | **3395407** | **58.8** |
| **Ring seiners** | | | |
| Oil sardine | 957643 | 316980 | 33.1 |
| Indian mackerel | 8330 | 1166 | 14.0 |
| | **965973** | **318146** | **32.9** |

Source: CMFRI (2006)

147. Some other fishing gears are also very non-selective. In Bangladesh, bag net fisheries trap a large number of juvenile fish on the tidal flows in estuaries (Mazid & Rahman, 2005). Lift net fishing gears in Indonesia is

another gear that is singled out as catching large numbers of juvenile fish, especially the mobile lift net that can be operated from a fishing vessel (Purnomohadi, 2003).

148. No detailed analyses of the impact that this practice is having on the resources, neither in terms of growth overfishing that is affecting the economics of the fisheries nor recruitment overfishing that is damaging to the stocks, in the BOBLME has been undertaken. However, based on studies elsewhere, killing fish before they have a chance to breed is very damaging.

### Anecdotal evidence from fishers

149. There are consistent fisher's reports on declining catches, catch rates and profits, increasingly long distances needed to fill up the boat with fish, and the need to adopt more effective and destructive gears (e.g. ring seines). This has been accompanied by a diversification of fishing effort to focus on low value species, migration of fishers from their homes to other places to fish (e.g. fishers from Andhra Pradesh migrating seasonally to Gujarat in India), and increasing dependence on cheap foreign labour as crews e.g. Thailand. Along many coastlines and ports one can observe idle boats and idle fishing crews, deteriorating state of the vessels and scrapping of some boats.

150. There is also increased competition for fish by buyers, especially at landing sites and increased conflicts between different vessel and gear types.

### 4.1.4 Status of coastal aquaculture

151. Shrimp farming has been practiced for more than a century for food and the livelihood of coastal people in some Asian countries, such as Indonesia and Thailand. The giant tiger prawn was originally harvested together with other shrimp species from traditional trapping-growing ponds or as a significant by-product of extensive milkfish ponds. Following on from research into breeding in Taiwan Province of China (POC), extensive and semi-intensive farms were commercially established in Thailand, in the early 1970s, after the first success in breeding giant tiger prawns at Phuket Fisheries Station in 1972. Taiwan POC was the leading producer for several years, but after a viral disease wiped out the industry there, Thailand, encouraged by extremely high prices in the Japanese market due to supply shortages, replaced the world's leading producer of farm-raised giant tiger prawns in 1988. Later, the culture of this species spread throughout southeast and south Asia, as it can grow up to a large size with high value and demand in the international market.

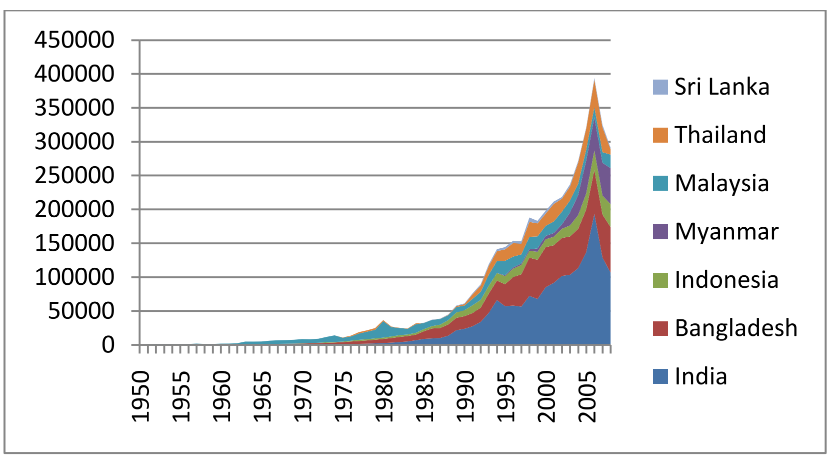



**Figure 4.9. Trends in aquaculture production, 1950 to 2008.** ***Source: FAO Fishstat (2010).***

152. Without reverting to state/provincial statistics, marine and brackish water aquaculture from the BOBLME is difficult to estimate. In the FAO global database (FAO Fishstat, 2010) values are given for the countries as a whole (except India, which is divided into east and west). A very rough estimate of production for 2008 was

300,000 tonnes. In 2008, the greatest production came from India, followed by Bangladesh, Indonesia, Myanmar, Thailand, Malaysia and Sri Lanka.

153. Commercial aquaculture started rather slowly throughout the 1970s and 1980s but took off rapidly in the 1990s and early 2000s (Fig.4.9). The largest production for the region as a whole was in 2006. Production in Indonesia and Bangladesh has continued to increase while that of Thailand, India and Sri Lanka has declined in recent years. Production in Malaysia has always been more variable but has also shown a levelling off since 1995. Myanmar has recorded tremendous growth, increasing from 5,000 tonnes in 2000 to 53,000 tonnes in 2008.

154. Taking the countries as a whole (except India), the giant tiger prawn is still the main species cultured, followed by whiteleg shrimp. However, there is a considerable variation among countries and there have been rapid shifts in species in recent years. Blood cockles have been a major crop of Malaysia and are still dominant, although there has been a major surge in banana prawns in recent years. Whiteleg shrimp culture started in Indonesia and Thailand in 2003 when the species was introduced (both legally and illegally) from South America because of its superior resistance to disease. In Thailand, whiteleg shrimp is now the major product, although its production also plummeted in 2008 (from 98,000 tonnes in 2007 to 13,000 tonnes in 2008). Fish culture is still relatively small but is becoming increasingly important in Thailand, Malaysia and India.

### 4.1.5 Key marine species

#### Sharks

155. Sharks are either targeted in commercial and artisanal fisheries, or caught as bycatch, in all BOBLME countries. Many of the larger species are slow growing (therefore reach sexual maturity only after a number of years) and produce relatively few offspring. There is widespread concern among biologists and fisheries managers that the resource is easily overfished and many species are already considered to be threatened. In response to global concerns about the status of sharks, Member Countries of FAO adopted an International Plan of Action (IPOA) in 1999 to ensure the conservation and management of sharks and their long-term sustainable use. Part of the IPOA was a request for countries to develop National Plans (NPOAs) and Regional Plans, where appropriate. This has been achieved by Malaysia and Indonesia and a draft developed by Thailand. To assist in developing these plans the Bay of Bengal Intergovernmental Organisation (BOBP-IGO) has organised two Regional Consultation on the Preparation of Management Plan for Shark Fisheries; the last being in the Maldives, August 2009. In this meeting, the Maldives, Sri Lanka, India and Bangladesh all proposed a “road map” for completing national plans. A draft regional Plan of Action was also discussed.

156. Detailed statistics on shark catches are poor in the BOBLME countries. No data are available for Myanmar but the total catch of all sharks recorded for the other 7 countries in 2008 was 100,031 tonnes. Peak catches, around 120,000 tonnes occurred in the late 1990s and early 2000s. Species details are only available for Indonesia since 2005.

157. Despite including three of the world’s largest shark fishing nations, management of shark fisheries within the region is almost non-existent. Most countries have regulations pertaining to general fishing (e.g. registration of vessels), but have no specific regulations for elasmobranchs, or elasmobranch fisheries. The exceptions to this are India and the Maldives. Nine species of sharks and rays, including the whale shark *Rhincodon typus*, are protected in India and the landing of these species is banned. The Maldives have instituted regulations restricting exports (including a ban on export of ray products), establishing protected areas and protecting *R. typus*.

158. While many of the exploited species cross national boundaries there are no mechanisms in place for joint management of stocks. The Indian Ocean Tuna Commission (IOTC) has agreed to act as a regional data

depository for oceanic shark catch data; however, this relies on national authorities to submit the data and at the moment this is not occurring as it should be.

### Hilsa

159. Hilsa shad has been chosen by the BOBLME project as a key species because of its importance in the eastern countries (it is the national fish of Bangladesh) and because hilsa is a single stock that is probably shared across India, Bangladesh and Myanmar.

160. Hilsa landings in Bangladesh ranged between 1.44 million and 2.9 million tonnes with an average of 2.11 million tonnes during 1983-84 to 2007-08. The average landings from inland and marine sectors were 79,152 and 131,371 tonnes during this period. The total hilsa landings from Bangladesh waters have not decreased over this period, moreover the production has increased substantially in the recent past years due to the adoption of different management interventions for this fishery since 2003. During the last two decades hilsa production from inland waters declined about 12 percent with an increase of about 2 times from the marine sector. The number of marine fishing boats and gears has increased about 4 times since 1984-85 resulting in tremendous fishing pressure in the marine sector. In addition, the intensity of marine catches have increased due to the introduction of nylon twine and mechanized boats. In India, the marine catch of hilsa is around 35,000 tonnes. The marine catch of Myanmar is increasing significantly in the recent years, but data are lacking.

161. The BOBP-IGO is also assisting BOBLME countries and held a Regional Consultation on Preparation of Management Plan for Hilsa Fisheries in February, 2010. Bangladesh scientists have undertaken several stock assessments of hilsa in Bangladesh based on analysis of large samples of fish length frequencies. Although only one of these analyses adjusted the data for net selectivity, they all point to the hilsa population in Bangladesh being overexploited and that fishing mortality needs to be reduced by at least 10% if maximizing biological yield is the overall objective or be reduced to as little as 33% of the existing levels if maximizing economic yield is the objective (Mome & Arnason, 2007).

162. None of these stock assessments have led to a change in Department of Fisheries' policy or management of fishing effort in Bangladesh. Further assessment and expansion of the current approach of restricting catch during critical spawning periods and spatial closures for juvenile fish (jatka) are required. In India there is currently no control on fishing effort, small size mesh nets are widely used to catch jatka and similar-sized juveniles of many species. Limited studies on Indian hilsa suggest that it is overexploited. India has a proposed a management plan that identifies many very valuable management actions. However, many of the timelines suggested have already past.

163. There is very little information on the hilsa fishery in Myanmar. There also appears to have been no scientific studies of hilsa in Myanmar. Thus the knowledge base and technical resources available to undertake management of the fishery in Myanmar is probably less than in other BOBLME countries.

### Indian mackerel

164. Indian mackerel (mainly *Rastrelliger kanagurta*) occurs along the coast of all BOBLME countries. However, detailed catch data are not available for Myanmar or Bangladesh. Catches are usually recorded as *Rastrelliger spp*. and combined with *R. brachysoma*. The total landings of *Rastrelliger* spp for the BOBLME countries without Myanmar or Bangladesh, was 195,000 tonnes and that reported separately as *R. kanagurta* was 45,500 tonnes in 2008, with the largest catch coming from Malaysia and Thailand (FAO Fishstat, 2010). (SAUP, 2010) estimated that in 2006, *R. kanagurta* catch was 71,800 tonnes and that of mackerels other than *R. kanagurta* was 129,200 tonnes (total of 231,000 tonnes).

165. Little is known of the current status of Indian mackerel. One study carried out in India (Noble, et al. 1992) indicated that *R. kanagurta* was overexploited on the east coast in the late 1980s, and recommended a reduction of fishing effort of 38%. (Joseph & Jayaprakash, 2003) concluded that for the east coast of India, the

problem was not as severe as that in the west coast, where large numbers of juveniles are taken indiscriminately by large seine gear. In the Java Sea (to the south of the BOBLME), Cardinale et al. (2009) assessed that the biomass of Indian mackerel had been reduced to levels between 3 and 19% of the maximum observed biomass in the 1990s.

### 4.1.6 Biodiversity, endangered and vulnerable species

166. Marine ecosystems across the globe are experiencing declining biodiversity, with largely unknown consequences. Recent studies have suggested that these declines are increasingly impairing the ocean's capacity to provide food, maintain water quality and recover from perturbations (Worm, et al., 2006). Tropical oceans typically enjoy high diversity and it is this characteristic that has allowed these ecosystems to provide more services with less variability than more temperate systems in the past.

167. The global and regional importance of the rich coastal and marine genetic, species, ecosystem and process biodiversity of the BOBLME is well recognized (see, e.g., (Kelleher, et al., 1995)). Table 4.8 shows the wide range of species in the BOBLME region's biodiversity that are currently at risk (list is not an exhaustive list).

**Table 4.8: Examples of threatened or endangered species in the BOBLME**

| Common name | Scientific name |
|---|---|
| **Fish** | |
| Horseshoe crab | *Limulus spp* |
| Whale shark | *Rhincodon typus* |
| Marine catfish | genus Tachysurus and genus Osteogrenousus |
| White fish | *Lactarius lactarius* |
| Flat head | *Platycephalus maculipinna* |
| Threadfin | *Polynemus indicus and P. heptadactylus*, |
| Sciaenid | *Pseudosciaena diaqcanthus* and *Otolithoides brunneus*, |
| Perch | *Pomadasys hasta* |
| Eel | *Muraenosox spp.* |
| Seahorse | *Hippocampus spp* |
| Bêche-de-mer | *Holothuria scabra* |
| **Molluscs** | |
| | *Xancus pyrum, Cypraea talpa, C. serpentis, Pinctada fucata, Chicoreus ramosus, C. virgineus, Conus amadis, C. textile, Strombus canarium, Murex adustus, M. haustellum, Velluta lapponica* |
| **Marine worm** | |
| Enteropneust | *Ptychodera flava (Balanoglossus)* |
| **Mammals** | |
| Sea cow or manatee | *Dugong dugon* |
| Gangetic dolphin | *Platanista gangetica* |

| | |
|---|---|
| Irrawaddy dolphin | *Orcaella berivostris* |
| Finless porpoise | *Neophocaena phocaenoides* |
| Royal Bengal tiger | *Panthera tigris* |
| Fishing cat | *Felis viverrina* |
| Jungle cat | *Felis chaus* |
| **Reptiles** | |
| Loggerhead turtle | *Caretta caretta* |
| Green turtle | *Chelonia mydas* |
| Leatherback turtle | *Dermochelys coriacea* |
| Hawk'sbill turtle | *Eretmochelys imbricata* |
| Olive ridley turtle | *Lepidochelys olivacea* |
| River terrapin | *Batagur baska* |
| Estuarine crocodile | *Crocodilus porosus* |
| Marsh crocodile | *Crocodilus palustris* |
| Water monitor lizard | *Varanus salvator* |
| **Birds** | |
| Oceanic teal | *Anas gibberfrons albogularis* |
| **Mangroves** | |
| | *Sonneratia caseolaris, S. apetala, Avicennia marina, A. officialis, Suaeda maritima, S. monoica,Rhizophora apiculata, R. annamalayana , Bruguiera cylindrica, Ceriops decandra, Aegiceros corniculatum, Acanthus ilicifolius, Lumnitzera racemosa* |

*Source: Preston (2004)*

168. The list of species recently declared to be extinct in the Sundarbans alone (Hossain, 2003) also already includes mammals, birds and reptiles. That list is probably not exhaustive either, as our knowledge of the full diversity of the Sunderbans is poor.

### 4.1.7 Restoration of marine living resources

169. The fisheries sector in the BOBLME can contribute much more to the BOBLME economy, especially pro-poor growth and improved livelihoods through better management of the resources. Fisheries currently trap millions of people into a downward spiral of low profits, few assets, marginalization, increased poverty, poor health and lack of any viable alternatives.

170. However, current policy directions and management objectives often focus mainly on increasing production. Rather than improving the situation, these objectives are often the main cause of the poor state of the sector. A paradigm shift to focusing on increasing the social and economic benefits of fishing and marketing, especially pro-poor growth, is needed.

171. A recent analysis across the world's fisheries, including 10 LMEs (Worm, et al., 2009) shows that many fisheries have been overexploited, but through better management some are rebuilding. For small-scale fisheries in a developing country, the example of depleted fish stocks on Kenyan coral reefs is cited, where a network of closed areas and the exclusion of highly unselective beach seines were implemented in cooperation with local communities. This led to a recovery of the amount of fish and the size of fish on the reefs that translated into steep increases in fishermen's income, particularly in areas that had both gear restrictions in place (Fig. 4.10).

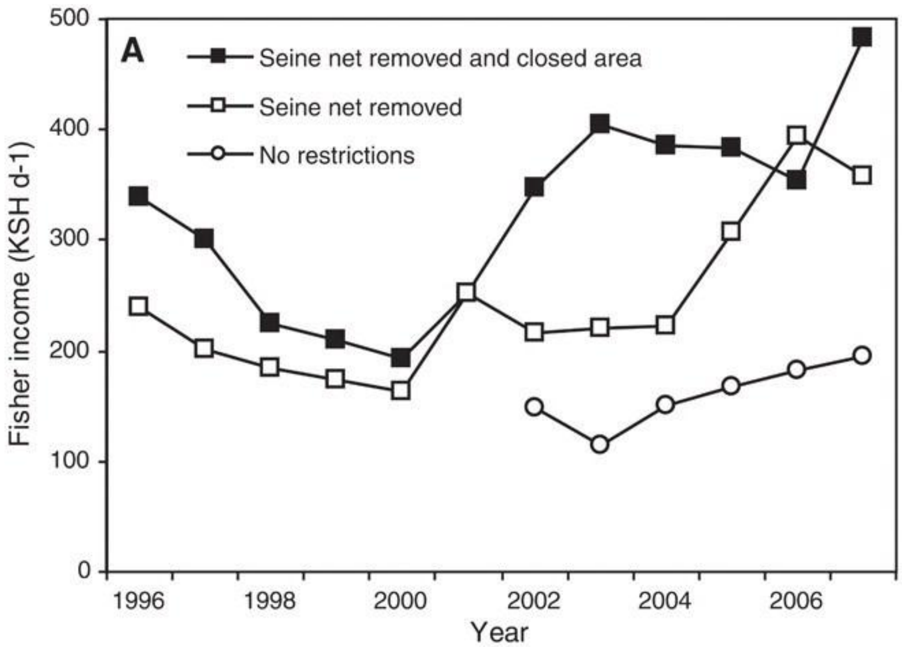



**Figure 4.10. Increase in fisher's income in a small-scale reef fishery in Kenya following management interventions.** ***Source: Worm, et al. (2009)***

172. Fisheries management is very weak in the BOBLME with very few viable co-management systems in place. Major stakeholders need to be more involved in introducing responsible fisheries and link to the wider government initiatives/policies aimed at improved welfare and social support. Partnerships between governments (at all levels) and major stakeholders hold the key to improving the management of the resources and securing the potential social and economic benefits that are on offer. This will require human capacity building at all levels, development of institutions that engender trust and true participation of all stakeholders in the development and implementation of new policies and reforms.

## 4.2 Degradation of critical habitats

173. In the context of the sustainable management of a LME, (Angell, 2004) defined a critical habitat as one whose services are necessary to the LME's sustainability. e.g., by providing centres of biodiversity and sources of food, serving as breeding, feeding, nursery and refuge areas, moderating the influence of nutrients, sediments and pollutants from land, supporting coastal and offshore productivity, and protecting the coast from the effects of storms and floods. The assessment of "criticality" would include the habitat's exceptional ecological value and/or its being at risk in terms of imminent threats, inherent vulnerability, and/or rarity. The three critical habitats – mangroves, coral reefs and seagrass all satisfy the criteria for "criticality" locally and regionally and some have already achieved formal recognition of global significance. They are all highly productive and often interdependent, such that degradation of one may adversely affect the other two.

### 4.2.1 Mangroves

#### Importance of mangroves

174. Mangroves occur in all BOBLME countries and account for 11.9% of the world's mangroves. Few valuations of the economic value of mangroves have been conducted in the BOBLME but (Gunawarden & Rowan, 2005) estimated that the Rekawa mangrove lagoon system in Sri Lanka was worth US$217,600 per year based on the income derived from forestry, fisheries and the services of erosion control and buffer against storms, and existence, bequest and option values to local communities. Another study showed that converting mangroves to aquaculture in Southern Thailand resulted in a net loss when the value of timber, charcoal, non-timber forest products, offshore fisheries and storm protection were taken into account (cited in Conservation International, 2008).

175. Mangroves form an ideal habitat for the life stages of many animal species and are critical for supporting offshore fish populations and fisheries (Blaber, 2009). Above the water, mangrove trees and canopy provide important habitat for a wide range of species. Below the water surface, plants and animals such as algae, tunicates, sponges, and bivalves grow on mangrove roots. The soft substratum in the mangroves is a habitat for a wide variety of species, while the space between roots provides shelter and food for motile fauna such as shrimps, crabs, and fishes. Mangrove litter partly supports an intricate food web together with plankton, algae and microphytobenthos.

176. Nagelkerken, et al. (2008) reviewed the habitat function of mangroves. They concluded that evidence for linkages between mangroves and offshore habitats by animal migrations is scarce but highly needed for conservation and management purposes. Some examples do exist in the literature but more studies are needed. Many of the fish caught for sustenance or commercially have part of their life cycles in the Matang mangroves in Malaysia (Sasekumar, et al., 1994). There were 119 species of fish and 9 species of shrimp captured in mangrove inlets and creeks in Selangor, Malaysia, the majority of these were juveniles. Many of the juvenile fish and shrimp species moved out of the mangrove and became commercially important, clearly demonstrating that mangroves support fisheries by providing habitat and food. It is well known that mangroves in Australian tropics are used as nursery areas by postlarval and juvenile banana prawn *Penaeus merguiensis* (Vance, et al., 1990) and that fish moved into mangrove at high tide (Vance, et al., 1996). Laedsgaard & Johnson ( 2001) found that there were more juvenile fish in artificial mangrove structures with fouling algae than in seagrass beds, artificial mangrove structures without fouling algae or bare sand. As the fish grew they moved to more open areas in response to changes in diet, foraging efficiency and vulnerability to predators.

177. Although mangroves have been widely promoted for the purpose of reducing the impact of large storm surges and tsunami (Danielson, et al., 2005) this is still controversial. A recent review (Feagin, et al., 2010) suggests that we should not assume that the science on short-period wave attenuation supports the conclusion that vegetation can reduce the effects of storm surges or tsunamis. Mangroves grow in areas of relatively low energy, and are by definition protected from high energy impacts.

178. A significant percentage of the people in coastal communities are traditionally dependent on mangroves for their domestic needs and livelihoods, such as for firewood and timber and for catching fish, shrimp, crabs and worms. Aquaculture practices in BOBLME countries still rely on wild-collected stock including collection of brood stock and trash fish used for food for the cultured animals and much of this is associated with mangroves. Exploitation of prawns, crabs and mollusks that are associated with mangroves has a total global value of about US$4 billion per year.

#### Status of mangroves

179. The most recent analysis of the status of mangroves in the BOBLME has been carried out by Giri, et al. (2008). In 2005 there were approximately 16,500km$^2$ of mangrove forest remaining in the region (compared

with 157,000km$^2$ in the South China Sea). The largest percentage of the remaining mangrove forest areas was located in Myanmar, followed by Bangladesh, India Thailand, Malaysia, Indonesia and Sri Lanka (Table 4.9). Mangroves in the Maldives occur mainly on the northern atolls of this island chain (Spalding et al. 2010). The species composition and vegetation structure are unique and these are the only atoll islands with mangroves in the world.

**Table 4.9: Area of mangroves in countries around the BOBLME**

| | % World | km$^2$ | % BOBLME |
|---|---|---|---|
| **Indonesia** | 0.5% | 682 | 4.1% |
| **Malaysia** | 0.5% | 706 | 4.3% |
| **Thailand** | 1.2% | 1,689 | 10.2% |
| **Myanmar** | 4.0% | 5,514 | 33.5% |
| **Bangladesh** | 3.2% | 4,388 | 26.7% |
| **India** | 2.5% | 3,377 | 20.5% |
| **Sri Lanka** | 0.1% | 104 | 0.6% |
| **Maldives** | <0.1% | 0.95 | 0.01% |
| Total | **11.9%** | **16,460** | |

*Source: Giri et al. (2008)*

180. The largest expanse of mangrove forests is in the Sundarbans (along the border between Bangladesh and India); the Ayeyarwady Delta, Rakhine, and Tahinthayi (Myanmar); Phang Nga and Krabi (Thailand); and Matang (Malaysia).

181. 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 (Table 4.10). 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 main reason for the decline is the leveling off of aquaculture expansion in all the countries except Myanmar and Indonesia. Losses in India and Bangladesh occurred during the earlier part of the period and the present areas of mangrove in those countries have remained comparatively unchanged over the last five years.

182. A similar situation occurred in Thailand where mangroves are no longer cleared as extensively as before. Past losses in the Thailand Andaman coast, where 80% of the original mangrove remains, are not as great as along the coast of the South China Sea where it amounted to in excess of 80% of the original area. The present areas of mangrove in Indonesia and Malaysia bordering the Bay of Bengal are comparatively small compared to the areas of this habitat bordering the South China Sea (6,758km$^2$ ha in Indonesia and 5,321km$^2$ in Malaysia). In the case of Malaysia some 400km$^2$ of mangrove is contained in the Matang forest in Perak State, which is 57% of the Malaysian mangrove in the BOBLME. This area is managed as production forest on a 30 year cycle with a consequent reduction in diversity of both the flora and fauna, *Rhizophora* now dominating much of the cropped area, which has been sustainably harvested for over 100 years.

**Table 4.10. Change in mangrove cover from 1975 to 2005 in BOBLME countries**

| | 1975 | Present | Area lost | % loss | Annual rate (Km$^2$/year) |
|---|---|---|---|---|---|
| **Indonesia** | 1,012 | 682 | 330 | 32.6% | 11 |
| **Malaysia** | 929 | 706 | 223 | 24.0% | 7 |
| **Thailand** | 2,095 | 1,689 | 406 | 19.4% | 14 |
| **Myanmar** | 8,515 | 5,514 | 3,001 | 35.3% | 100 |
| **Bangladesh** | 4,481 | 4,388 | 93 | 2.1% | 3 |
| **India** | 3,718 | 3,377 | 341 | 9.2% | 11 |
| **Sri Lanka** | 240 | 104 | 136 | 156.7% | 5 |
| **Maldives** | n/a | 0.9 | n/a | n/a | n/a |
| **Total** | 21,008 | 16,460 | 4,530 | 21.6% | 151 |

*Source: Giri et al. (2008)*

183. It can be seen from Table 4.11 that the major cause of loss of mangrove has been conversion to agriculture (82%) and to aquaculture (12%). It is important to recognise that conversion of mangrove to agricultural land basically occurs on the landward side of mangrove habitats where the soil salinity is generally lower than on the seaward side. Mangrove that has already been converted to agricultural purposes is generally unavailable for mangrove replanting due to the continued growth of human populations in the countries concerned that place food security high on the national policy agenda.

184. Conversion to aquaculture, in contrast, tends to occur in the more brackish reaches on the seaward side of these ecosystems since the waterlogged soils in the lower zones of mangrove communities tend to be acid sulphate soils that require extensive treatment and large inputs of freshwater if they are to be used productively for agriculture. In both of these major causes of conversion it is important to distinguish between losses due to production for national consumption and production for export since these two purposes of production have different underlying drivers and are generally undertaken by different sectors of society with consequent differences in terms of the accrual of costs and benefits of interventions designed to reduce such production. Production for subsistence and national use is generally in accordance with national policies aimed at achieving food security and the units of production tend to be small whilst commercial production for export is usually larger scale, requires substantial capital investment and the beneficiaries are often not local communities.

185. At the local level, both deforestation and forest regeneration occurred with varying intensities, with localized hotspots of rapid change. Major reforestation and aforestation areas are located on the south-eastern coast of Bangladesh, and in Pichavaram, Devi Mouth, and Godavari in India.

**Table 4.11 Causes of mangrove conversion (area converted km²) by country, 1975-2005**

| | Aquaculture | Agriculture | Urban | Other |
|---|---|---|---|---|
| **Indonesia** | 209.6 | 106.3 | 14.2 | 0 |
| **Malaysia** | 16.1 | 96.1 | 45.3 | 65.6 |
| **Thailand** | 168.2 | 203.0 | 7.1 | 27.5 |
| **Myanmar** | 68.7 | 2930.4 | 0.7 | 1.3 |
| **Bangladesh** | 10.7 | 71.9 | 0 | 10.5 |
| **India** | 75.5 | 171.8 | 1.7 | 91.8 |
| **Sri Lanka** | 1.3 | 125.6 | 0.3 | 9.0 |
| **Total** | 550.0 | 3704.9 | 69.2 | 205.5 |
| **Total (percent)** | 12% | 82% | 2% | 5% |

Source: Giri et al. (2008)

186. In addition to the loss of mangrove habitat as a consequence of land use changes, degradation of remaining mangrove habitat is occurring as a consequence of various anthropogenic activities including both subsistence and commercial levels of exploitation. Mangroves even when under some form of nominal protection serve as a source of timber, fuel-wood, charcoal, thatching materials and food (including fish and shrimp). More recently the capture of shrimp and fish fry for aquaculture ponds has increased whilst the harvest of crabs for small scale commercial purposes is widespread. The impact of subsistence and small scale commercial exploitation of mangrove resources increases with the continuing growth of coastal populations and consequent increase in demand for fuel and food. The importance of this cause of degradation varies considerably from location to location reflecting local population densities, the extent of the mangrove areas and demands from outside the area.

187. In addition to direct anthropogenic drivers of mangrove degradation indirect causes of mangrove degradation are found in cases where the flow of freshwater into the rear of the mangrove ecosystem is reduced or stopped altogether as a consequence of dams and barrage construction and diversion of water for irrigated agriculture. Such reductions in flow result in increased intrusion of saline wedges further inland than in the past and alter the species composition of the landward zone of the mangrove system. Extensive salinisation combined with high evapo-transpiration rates result in degradation of the mangrove and formation of salt flats which can and often are used for salt production. Alteration of freshwater inputs causes changes in the zonation and species composition of the mangrove community with the more salt tolerant species coming to replace those dependent on low salinity. In addition to altering the input of water to mangrove systems, dams and barrages trap sediment (and nutrients) which in turn has consequences for the mangrove community. Where depositional shorelines are sinking relative to mean sea level, mangrove communities help to maintain coastal stability through trapping sediments in and around their prop roots and pneumatophores. By trapping sediment the mangrove soil surface accretes vertically; and where sufficient sediment inflows occur the mangrove community may prograde seaward. In cases were sediment inputs are reduced or cut off altogether the relative sea level may continue to rise and seaward mangrove communities may die as a consequence of ‘drowning’ of

the breathing roots. This is accompanied by saline intrusion landwards and a shift in the zonation of the mangrove communities reflecting new tidal inundation regimes. Clearly, under conditions of a continuing rise in global mean sea level the maintenance of sediment inflows is a vital necessity if the mangrove community is to continue to exist. The mangroves of the Sundarbans are considered severely degraded (Wilkie, et al., 2003) with significant reduced forest cover, and it seems likely that changes in freshwater and sediment flux have played a part in the process.

188. In India, although the main cause of loss is from conversion to agriculture from 1975 to 2005, a dramatic example of clear-felling of mangroves occurred in the Godalvi estuary, located in the northernmost end of the Cauvery delta. From 1935 to 1975 about 500 ha of mature mangrove forest of the Pichavaram wetland was clear-felled by the government management agencies for revenue generation.

**Table 4.12: Major mangrove forests in the BOBLME** (Modified from Angell, 2004**)**

| Country | Area , km$^2$ | Status | Condition |
|---|---|---|---|
| **Indonesia** | | | |
| Aceh | 594[11] | | 70% to shrimp ponds |
| North Sumatera | 868[11] | | Threatened |
| Riau | 2,399[11] | | Threatened |
| West Sumatera | 365[11] | | 53% destroyed |
| **Malaysia** | | | |
| Perlis | 1 | | |
| Kedah | 80[10] | 99% forest reserve | Degraded |
| Penang | 6 | | |
| Perak | 435[10] | 78% forest reserve | Sustainable harvesting |
| Selangor | 151[10] | 76% forest reserve | Degraded |
| Negri Sembilan | 2 | | |
| Melaka | 2 | | |
| Johor | 167[10] | 68% forest reserve | Degraded |
| **Thailand** | | | |
| Ranong, Pangnga, Phuket | 707[9] | 15% protected, 82% under management | Recovering, |
| Krabi, Trang and Setun | 1058[9] | | |
| **Myanmar** | | | |
| Rakhine | 229[8] | Nominally protected | Threatened |
| Ayeyarwady | 275[8] | Nominally protected | 10.6% reserved forest, remainder threatened |

| | | | |
|---|---|---|---|
| Tanintharyi | 224[8] | Nominally protected | Threatened. Rate of decrease 2.4% per annum. |
| **Bangladesh** | | | |
| Sundarbans | 4016[5] | Reserved forest | Threatened |
| Chokaria | 182 | Converted to shrimp farms | ≈ 100% Destroyed |
| Aforestation/reforestation | 1043[6] | Plantation | 575 $km^2$ in good condition |
| **India** | | | |
| Sundarbans | 9630[1] of which 4263 $km^2$ are mangroves | Biosphere Reserve | Threatened |
| Bhitarkanika | 675 [2] | Sanctuary | Now 25% of sanctuary.[7] |
| Coringa | 101[2] | Reserve Forest | Threatened |
| Pichavaram | 11[2] | Reserve Forest | Stable |
| Vedharanyam Mangrove Swamp | 17.3[2] | Wild life sanctuary[2] | Threatened. 40% degraded |
| Nicobar Islands | 2,450[13] | | |
| Andaman Islands | 966 [3,4] | Timber extraction banned | Threatened |
| **Sri Lanka** | | | |
| Batticaloa | 16 [12] | | Undisturbed |
| Mullaitivu | 10[12] | | |
| Jaffna | 11[12] | | 52% Reduction |
| Puttalam | 5[12] | | 85% Reduction |
| Other, Kipparatota, Hikkadawee | 19[12] | | Degraded |
| **Maldives** | | | |
| Scattered | Not available | Not protected | Threatened |

[1] Includes core area, manipulation zone and restoration zone. Core area is 1692 $km^2$ (Sampath 2003) [2] Sampath 2003 [3] Only a small portion is protected, but the entire area has been proposed as a Ramsar site.

*Sources: National reports Op.Cit),Source[4]* Kumar (n.d.), Source[6] *Choudhury 2003 Source[7] www.indianjungles.com; Source[8] Jagtap, (1992)*

189. The agencies believed that mangrove plants would regenerate naturally in the clear-felled areas. The clear-felling and subsequent exposure of the mangrove wetland caused subsidence of sediment in the clear-felled areas causing the topography to become trough-shaped and tidal water entering into this trough-shaped portion became stagnant. Evaporation of stagnant tidal water increased the soil and groundwater salinity to a level which was lethal to mangrove species and was the main cause of degradation of the Pichavaram mangrove wetland (Selvam, et al., 2003).

190. Angell, (2004) provided more in-country detail, mainly from information provided in the national reports (Table 4.12). Note that some of the estimates of mangrove areas differ from that estimated by Landsat imagery by Giri et al. (2008). This is due to both difference in definitions and also techniques used to estimate areas.

191. Most of the mangrove forests in the BOBLME are either already degraded or threatened. Some mangroves are under various forms of government protection in all the BOBLME countries, except Maldives, although, as pointed out by Ali (2004), the importance of its mangroves is recognized there as well.

192. Arguably the Maldives have the most to lose if the islands' mangroves are lost. The Maldives, particularly the northern atolls have luxuriant mangroves; however, the islanders are unaware of their value to the islands' ecosystems and in preventing erosion and enhancing sedimentation. Island reclamation particularly Male atoll, has resulted in considerable erosion due to removal of mangroves (Jagtap & Untawale, 1999).

### Restoration and management of mangroves

193. Total mangrove ecosystem management entails managing the mangroves for silviculture, aquaculture, and ecosystem services, such as coastal protection. The broader context of management of mangroves and their diverse benthos is reviewed in (Ellison, 1998). He reassesses the relative merits of management focussed on short term economic gains and suggests that managing for ecosystem services may ultimately preserve benthic biodiversity in mangrove ecosystems.

194. The Matang Mangrove Forest Reserve in Perak State in Malaysia is of considerable economic importance and an example that could be followed by other BOBLME countries. It was gazetted in 1906 as a forest reserve and has been managed sustainably ever since. The area is a major supplier of seafood to the local and international market. Revenue from forestry was about US$12 million in the late 90s. The value of the shrimp and fishing industry in the area was at least US$48 million and US$60 million, respectively, in 1994 (Sasekumar, 1994).

195. Of the three critical habitats described here, mangroves are the easiest to restore. Abandoned shrimp farms can best be restored by opening the walls and allowing propagules to settle in the bare areas (Lewis, 1998). Remote sensing techniques have been used to assess and monitor the effectiveness of mangrove restoration and conservation programmes where physical monitoring is difficult (Selvam, et al., 2003) and to monitor conversion of mangrove to shrimp ponds and abandoned ponds back to mangrove (Jayanthi, et al., 2007).

196. Restoration should be carried out where substrates and other conditions are suitable. Care should be taken that intertidal mudflats that never carried mangroves are not used as mangrove planting areas because they appear to be easy to plant. These mudflats themselves are important coastal habitats (Ertemeijer & Lewis, 1999) and restoration of mangroves should not be at the expense of intertidal mudflats. Community groups are ideal for providing the labour for planting mangroves and large areas with many seedlings can be planted (Ertemeijer & Bualuang, 1998). Unfortunately, it is usual to plant single species (Fig. 4.11), which results in the function and form of the new mangrove forest not being returned. Practical guidelines to mangrove restoration are given in Giesen, et al. (2006) and Field (1996).

197. In the Pichavaram mangrove in India**,** remote sensing has shown that mangrove cover increased by 90% from 1986 to 2002 after revegetation and some channels were dug to assist water flow (Table 4.13).

198. There are many examples of restoration projects in BOBLME countries. In Thailand, the Ecological Mangrove Restoration (EMR) Project is managed by Mangrove Action Project (MAP) which has developed a unique mangrove rehabilitation method to restore mangrove forests. This method of Ecological Mangrove Restoration (EMR) supports the idea of returning the natural forest biodiversity that was lost rather than create a tree plantation of one or several species. EMR results in a higher biodiversity of mangrove forests.

**Table 4.13: Change in Pichavaram mangrove before and after restoration**

| Class | 1986 ha | 2002 ha | Change h |
|---|---|---|---|
| Dense mangrove | 325 | 411 | +86 |
| Young mangrove More than 3 years old | 0 | 117 | +117 |
| Young mangrove Less than 3 years old | 0 | 90 | +90 |
| Degraded | 375 | 65 | —310 |

*Source: Selvam, et al. (2003)*

199. Despite these successes, there have been numerous failures of coastal mangrove restoration projects post-tsunami due to planting of inappropriate species, in inappropriate locations, and a lack of understanding of the restoration site itself.

**The Mangrove Action Program has a number of projects to restore mangroves in BOBLME countries (MAP, 2010).**

**Figure 4.11. Restoration of single species mangrove in an abandoned shrimp pond.**

**Box 4. 1 Degradation of mangroves**

Although just outside of the BOBLME, the largest shrimp farm in the world in Lampung, southern Sumatra is a good case study. Approximately 1,860km$^2$ of mangrove was converted to ponds. The ponds stretched along the coast for 60 km and reached about 4 km inland (see photo). In 1996 it produced 19,854 tonnes of shrimp worth $US 167 million.


**Google Earth photo of the shrimp ponds at Lampung**

The farm was supported by the BDNI, World Bank and Export-Import Bank of Japan. The company was the sole supplier of feed, fry, power and other basics and took a huge cut from the farmers' income. Farmers had to borrow to stay afloat and account status for farmers was refused. However, shrimp proved to be temperamental to grow. Early harvests were poor and even when harvests were good the company took more from the farmers. Clashes between the company and farmers have been common and the overall future of the venture is in doubt.

*Source: Far Eastern Economic Review 30 May 2000). http://www.gtenterprise.com.dipasena*

### 4.2.2 Coral reefs

#### Importance of coral reefs

200. Like mangroves, coral reefs also occur in all countries. Globally, they are well known for their high productivity and rich biodiversity and as a source of beauty but they also provide many services to the communities that live on or near coral reefs. Coral reefs support a variety of human needs, and are important for subsistence and commercial fisheries, tourism, shoreline protection, and potentially yield compounds that are important in the development of new medicines. Economic valuations of coral reefs in the BOBLME are not available, but globally, coral reefs are estimated to be worth US$29.8 billion, based on tourism (32%), fisheries (19%), coastal protection (3%) and biodiversity (18%) (Cesar, et al.,2003). Although coral reefs cover less than 1% of the Earth's surface, they are home to 25% of all marine fish species.

201. The large river flows, monsoonal runoff from the land and strong currents that cause turbidity render much of the BOBLME not suitable for corals. Corals, therefore, 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. However, although limited in their distribution, these reefs are vitally important for the communities that depend on them.

## Status of coral reefs

202. The major coral reefs in the BOBLME occur in the Maldives, the Andaman and Nicobar Island, Myanmar and Andaman Sea area of Thailand. There are also extensive reefs in the Gulf of Mannar, and fringing and patch reefs elsewhere in India, Sri Lanka, Malaysia and Indonesia. Limited coral communities occur around St. Martin's Island in Bangladesh.

**Table 4.14 Area of coral reefs in countries around the BOBLME**

| | % World | km2 | % BOBLME |
|---|---|---|---|
| **Indonesia** | 0.7% | 1,848 | 8.2% |
| **Malaysia** | 0.1% | 284 | 1.3% |
| **Thailand** | 0.3% | 853 | 3.8% |
| **Myanmar** | 0.9% | 2,559 | 11.3% |
| **Bangladesh** | - | - | 0.0% |
| **India** | 2.6% | 7,392 | 32.7% |
| **Sri Lanka** | 0.3% | 853 | 3.8% |
| **Maldives** | 3.1% | 8,813 | 39.0% |
| **Total** | **8.0%** | **22,602** | |

Note: Andaman and Nicobar Island account for 88% of India's coral reefs

Source: Percentages from SAUP (2010), areas from UNEP (2007)

203. The total area of reef has been estimated as 22,600km$^{2}$, with the largest area in India (mainly Nicobar and Andaman Islands), followed by Maldives, Myanmar, Indonesia, Sri Lanka, Thailand, Malaysia and Bangladesh (Table 4.14)

204. Coral reefs in South Asia suffered large scale bleaching in 1998 with an enormous reduction in coral cover. Up to 90% mortality was observed in the Maldives, but there was much less bleaching in the Gulf of Mannar and the Andaman and Nicobar Islands (Wilkinson, 2008). Some recovery has occurred but further damage with sea temperature rises will occur. One of the major hazards after bleaching is that alga turfs and macroalgae will grow back faster than the zooxanthellae, causing the coral to die. These coral turfs are often assisted by nutrients from runoff from the land and overfishing of the herbivores which previously controlled coral turf growth.

205. Coral reef recovery following the 1998 bleaching was variable. Some areas show relatively good recovery, whereas in other areas there are indications of a phase shift, with algal growth smothering corals. Minor coral bleaching was also observed in 2003 and 2004 in the Maldives, Sri Lanka, on the Indian side of the Gulf of Mannar and on St. Martin's Island in Bangladesh, with almost 100% recovery within months. A renewed massive coral bleaching event is in progress in mid-2010, thought to be linked to the late onset of the southwest monsoon.

206. By 2004, many of the reefs of the region were still struggling to recover from the mass bleaching mortality in 1998, partly due to high levels of other stresses. While reefs not affected by the bleaching mortality remain in relatively better health, they are also often under threat from human activities. There are clear signs of over harvesting of fish and other reef resources such as sea cucumbers, chanks and spiny lobsters. Effects of over-fishing and destructive methods to collect reef resources, e.g. bomb fishing and mining, are clearly evident on reefs close to larger human settlements, resulting in reduced coral cover and ecosystem productivity. New or rapidly growing markets, including tourism and marine aquarium fish collection were affecting the reef resources, e.g. reef fish and lobster populations were depleted. Reefs in the Maldives and Sri Lanka were mostly recovering well from earlier plagues of crown-of-thorns starfish (COTS). There were no obvious signs of large-scale perturbations.

207. Table 4.15 shows that most of the coral reefs in the BOBLME are either already degraded or threatened, despite many being under various forms of governmental protection. Ocean acidification, higher than normal sea surface temperatures, human impacts such as declining water quality and over fishing are reducing coral reef resilience to environmental change, changing reef structure, coral abundance and community composition.

208. With the loss of coral cover the biodiversity supported by the coral reefs is at risk. The productivity of the coastal fisheries supported by the coral reefs is thought to be declining as the reefs deteriorate. Bait fish for commercial tuna pole-and-line fishing are caught over coral reefs (Blaber, 2009). This author describes the connectivity of coral reef fish, larvae and pelagic reef-associated fish.

**Table 4.15: Summary of coral reef status in the BOBLME (Modified from Angell (2004)**

| Country | Site | Area km$^2$ | % live coral cover | Major threats |
|---|---|---|---|---|
| **Indonesia** | Riau<br>*Central Tapanuli including *Karang Island<br>*Nias and South Nias<br>*Mentawai | 521 km$^2$<br>12 km$^2$<br>10 km$^2$ fringing & patch<br>240 km$^2$ Fringing, patch & shoal | 67% to 98% of reefs have been degraded<br>12%–69%good–poor condition<br>Good to poor<br>3%–52% | Mining, sedimentation, destructive fishing methods<br>Trawling, blasting. Thai fishing in 1998<br>Blasting, cyanide, trawling, fish traps, mining<br>Blasting, cyanide, trawling, overfishing |
| **Malaysia** | P. Langkawai,<br>P. Sembilan,<br>P. Pangkor,<br>Port Dickson<br>(P. Segantang,<br>P.Lembu, P.Kaca) in the P. Payar Marine Pk | Fringing<br>Fringing<br>Fringing<br>Fringing<br>Fringing<br>Fringing | Threatened 61%<br>Threatened<br>Degraded<br>Degraded<br>74%<br>!2–18% | Destructive fishing, land reclamation, shipping accidents.<br>Boats and shipping<br>Protected area, but potential threat from tourist development |
| **Thailand** | BOBLME area of Andaman Sea Similan Islands, Surin Islands, | Fringing/<br>78.6 km$^2$ | Good, 12% ; fair,34%;<br>poor,27%;<br>very poor 23% | Destructive fishing, crown-of-thorns, bleaching, sedimentation, storms, tourist development |
| **Myanmar** | Mergui Archipelago<br>Burma Banks<br>Rakine area<br>Tanintharyi | Fringing 1,700 km$^2$<br>Barrier<br>Fringing<br>Fringing | Unknown<br>Supposed to be good.<br>Unknown | Blast fishing<br>Tangled nets, blast fishing<br>Coastal pollution, poor fishing practices<br>Coastal pollution, poor fishing practices |
| **Bangladesh** | St. Martins Island (Narikel Jinjira) | Patch | 7.6% coverage on SE coast | Coral mining, sedimentation, overfishing, pollution from sewage and waste |
| **India** | Gulf of Mannar Marine Biosphere Reserve<br>Mahatma Gandhi Marine | Fringing and patch<br>66.5 km$^2$<br>Fringing | 3 to 52% | Intensive trawling, coral mining, blast fishing, overfishing of reef resources. |

| | | | | |
|---|---|---|---|---|
| | National Park, Andaman and Nicobar Islands | and patch | 17.5 $km^2$<br>10% to 85%, varies among park islands | Siltation |
| **Sri Lanka** | Bar Reef Marine Sanctuary<br>Kapparatota<br>Talawila in NW<br>Aranwala & Kirawella in S<br>Jafna Peninsula | Patch<br>Fringing<br>Fringing<br>Fringing<br>Fringing | Almost 100% mortality from coral bleaching, well recovered by 2008. | Bleaching, destructive fishing, anchoring, sediment and coral rubble |
| | Kandakuliya | Fringing | New growth after bleaching, but destroyed by Halimeda | Bleaching, destructive fishing, anchoring, quarrying for lime |
| | Hikkadua Marine Sanctuary | Fringing | Decreased from 47% live coral coverage to 12% after bleaching. | Sedimentation, anchoring, pollution, uncontrolled tourist activity, mining |
| | Weligama | Fringing | Decreased from 92% to 54% after bleaching | Sedimentation, pollution, uncontrolled tourist activities, anchoring. |
| | Rumassala | Fringing | Decreased from 45% to 23% after bleaching. Some restoration efforts | Blasting, |
| | Great Basses and Little Basses Reef Marine Sanctuaries in south east | Barrier | Un-degraded | Overfishing |
| **Maldives** | Nation wide | 26 atolls, 1200 coral islands, 202 inhabited. | High coverage up to 70% but coral bleaching caused losses up to 90% in 1998 recovering now. | Coral mining, oil pollution, tourist & domestic waste, overfishing, bleaching, sea level rise |

Source: National reports op.cit; (Spalding, et al., 2001); (Wilkinson, 2008); (Bayu, (2009), (Mollah, 1997),(Haida, 2008), (Lim, 1990); (Hoon, 1997)

209. Corals in most shallow reef areas of Sri Lanka were destroyed in 1998 due to bleaching caused by high water temperatures associated with the ‘El Nino’ Southern Oscillation (ENSO) effect. Coral reefs at depths of 3–5 m lost most of their live coral from the northwest to the east coast except near Trincomalee. Since then, coral species at different locations have shown varied levels of impact and recovery from the bleaching event. Bleached corals have been recorded even at 42 m depth off the east coast, although almost all bleached corals at depths below 10–15 m recovered after about six months. A cause for concern is that at many locations the dead corals in shallow waters have been covered by rapidly growing algae, tunicates and invertebrates such as corallimorphs. This may inhibit the reestablishment of live coral (Rajasuriya, et al., 2000).

210. The Andaman Sea coast is the coral reef area in the Bay of Bengal for Thailand, with a total area of 78 $km^2$ of primarily fringing reefs ranging from near shore to offshore areas (Changsang, et al., 1999). The 1998 bleaching event did not appear to affect reefs in the Andaman Sea (Spalding, et al., 2001). These reefs are an important resource for tourism in Thailand. However, rapid coastal development on the Thai Andaman Sea coast over the past three decades has led to degradation of coastal resources. Although development has increased economic growth of the country and income of the population, it has also affected the physical environment and socio-economic condition of coastal communities.

211. Myanmar has some of the region's most pristine reefs, but reef status is difficult to determine due to a lack of baseline information. Its reefs probably typify the past experience of most other reefs in the BOB. The consensus is that the coral reefs of Myanmar are generally in very good to excellent condition. However, there are growing concerns that destructive fishing is increasing rapidly, including trawling and longline fishing near reefs, and blast fishing. There is also evidence of damage by fishing devices such as tangled nets. 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 coral reefs of Myanmar are currently threatened for the following reasons: there is a lack of legislation; local government enforcement and scientific capacity is weak; many NGOs cannot operate coral reef programs in Myanmar; and over-exploitation of reef resources and coastal development are increasing. Urgent action is needed to prevent the coral reefs of Myanmar from declining to unsustainable levels.

212. St Martin's Island (Narikel Jinjira) is the only place where coral grows in Bangladesh; however its problems are common throughout the BOBLME. Its total area is only 12 $km^2$ and corals suffer from runoff of market and domestic waste including sewage, exposure to sedimentation, and collection of benthic animals such as sea cucumbers, mollusks and coral for tourists. Boat moorings damage seagrass and corals and rock weighted gill nets also take their toll on coral reefs. More information about the corals of St Martin's Island and their connectivity to corals of Myanmar and the mainland of Bangladesh is required.

213. In western Sumatra there are two protected areas that consider coral reefs: Pulau Weh near Aceh has fringing reef while there is about 85 km of barrier reef 20 km off the west coast of Aceh and Kepulauan Banyak. There is also the Mentawai Island chain and barrier reefs with a combined length of 660 km along the west coast of Sumatra. These have been rarely studied or mentioned in reviews (Spalding, et al., 2001).

214. Among the major findings of (Wilkinson, et al., 2006) were that damage to coral reefs resulting from the tsunami in the BOBLME were patchy, site dependent and heavily influenced by environmental condition. Most of the damage was due to sediment and coral rubble and from debris washed from the land. The Indian Ocean tsunami caused very limited damage to the coral reefs of western Thailand with negative impacts being greater in the north than in the south. The major damaging effects included overturning of massive corals, broken branching corals and smothered coral tissues by sediment in Aceh. Most of the coral reefs in the BOBLME escaped serious damage and are expected to recover in 5–10 years. The damage at Aceh in northern Sumatra was the heaviest, but even here land-sourced debris was the main cause. In the northwest of Simeuleu Island, corals were lifted 1–2 m above sea level. The greatest impacts of the 2004 tsunami on coral reefs in Sri Lanka were observed on the shallow coral habitats of the east coast whilst the north-western coastal reefs were undamaged (Rajasuriya , 2005).

215. In Myanmar, prior to the tsunami, the best accounts of the coral reefs were from anecdotal reports by recreational divers visiting the Burma Banks and the Myeik Archipelago on live-aboard dive boats operating out of Thailand. After the tsunami Tun & Heiss (2006) reported that the tsunami caused minimal to no damage to the coastline of Myanmar or to the coral reefs in the Myeik (Mergui) archipelago.

216. Baseline quantitative data of reefs in northern Sumatra, Indonesia is comparatively limited, both before and after the Indian Ocean tsunami. In the aftermath of the tsunami, long term reef monitoring was recognized

as a priority, and monitoring was carried out on Pulau Weh and Aceh Islands. Natural coral recruitment was observed to take place two years after the tsunami, especially on rocky substrates in shallow waters. However, rubble substrates in deeper waters prevent recruitment due to post settlement mortality of the recruits (Rudi, et al., 2008).

217. Long-term monitoring studies in Thailand suggest that coral reefs which were not affected by the tsunami are in good condition and currently show as high a coral cover as ever recorded during the last 25 years. Such background conditions, together with sustained coral growth rate and high regeneration potential, should aid recovery of most damaged locations over the next 3–5 years (Satapoomin, et.al, 2006).

### Management and restoration of coral reefs

218. The reefs in Thai waters (Surin Islands National Park, Similan Islands and the Adang Rawi Islands of Tarutao National Park) have been monitored under a long term monitoring programme (Phongsuwan, et al., 2008). Results indicate that reefs in the Andaman Sea are resilient to natural stress and damage; the reefs did not suffer extensive damage from the bleaching event in 1998 in comparison to reefs in, e.g. Maldives (Zahir & Rasheed, 2005) and Sri Lanka (Rajasuriya, 2002). However reefs close to tourist development areas show signs of degradation (Phongsuwan, et al., 2008). Throughout the region there are tourist operators that are diligent in their control of clients in diving on coral reefs but tourists often do not consider the impacts of their activities.

219. Thailand and the Maldives are probably the leaders in controlling and managing the activities of tourists in the BOBLME corals. In Thailand “Green Fins" asks a network of dive operators to offer tours according to a set of environmentally-friendly guidelines. The dive operators will assist in surveying and keeping track of information on their customers’ knowledge of and behavior in the sea. In addition, the dive operators may help with monitoring coral reefs when they take customers on dive trips. The "Green Fins" initiative will strengthen the involvement and role of dive operators as an important stakeholder and partner in the protection, conservation and sustainable use of coral reefs, and will raise the environmental awareness for coral reefs. To support the "Green Fins" initiative, capacity building activities and training workshops will be organized as needed. “Green Fins” is sponsored by Thomson Reuters, Siam Cement Group and the Siam Commercial Bank. This is a good example of private-public partnership and is participated in by UNEP and the Thai Department of Marine and Coastal Resources. (/www.greenfins-thailand.org/greenfins/index.php?m=aboutus)

220. It may be necessary to apply concepts such as: ecosystem engineering, where the influence of autogenic and allogenic “engineering species” over abiotic variables and their consequent effects on biotic communities may facilitate ecological restoration; concepts learned from “silvicultural systems” to enhance biological diversity through the improvement of structural heterogeneity, species mixture, and vertical structure variation; edge effect, patch size, and perimeter-area ratio; concepts well established in silviculture literature, that have dramatic impacts on community characteristics. All these measures and costs should be considered when initiative restoration approaches are to be made.

221. There are many attempts at coral restoration in the BOBLME countries; for example, in Indonesia an experiment compared three different low-cost, locally available treatments: rock piles, cement slabs pinned to the rubble, and fishing net pinned to the rubble. Significantly greater recruitment occurred on the rock and cement experimental treatments compared to the bare, untreated rubble (Fox, et al. 2000). Many of these experimental methods have been considered successful but less success has occurred once wide scale projects are implemented. Other important concerns are of course the cost per area restored.

### 4.2.3 Seagrass

#### Importance of seagrass

222. Seagrass are areas of great biodiversity and are the nursery areas for many commercial fish and crustaceans. They support adult fish, molluscs and crustaceans used for food and either fished or gleaned by local communities. They are better known as the feeding grounds of green sea turtles (Chelonia mydas) and dugongs (Dugong dugon). They are also known to stabilise coastal sediments, and trap and recycle nutrients. Like coral reefs they are also important sources of food and income for some coastal communities. Gleaning on seagrass beds by local communities occurs for molluscs, seahorses and sea cucumbers, some of which are destined for the export market.

#### Status of seagrass

223. The tropical Indo-Pacific region has a large data gap in seagrass abundance and distribution. Few regional maps exist and little is known of the great biological diversity living in them. The BOBLME region has the highest number of seagrass species (Waycott, et al., 2009). In this global review, the authors refer to a global loss of seagrasses, but not specifically to the BOBLME region nor do they show any evidence one way or another for seagrass loss in this region. They do however correctly state “given the rapid population growth and development pressures in the Indo-Pacific, there is a pressing need to acquire more data on seagrass extent in this important region to aid in evaluating the status of seagrasses”.

224. The information provided by this section is based on the information from the World Atlas of Seagrasses (Green & Short, 2003), and the Country Reports and National Reports. It appears that seagrass beds remain the least well-studied of the three critical habitats addressed here, as earlier noted by (Holmgren, 1994).

225. Many of the BOBLME region's seagrass beds are known to be either already degraded or threatened. The biodiversity supported by the seagrass beds is known to be also at risk, especially with regard to endangered species such as marine turtles, dugongs and seahorses, although little quantitative information is available (Table IV.16). The productivity of the coastal fisheries supported by seagrass beds is also thought to be declining as the seagrass beds degrade and disappear.

226. Of all the countries in the BOBLME, Thailand has the most research on seagrass. This was probably brought about by the seagrass beds at Trang having the largest number of dugong in the region and the interest in this endangered mammal (Mukai, et al., 1999). The area of seagrass along the Andaman Sea coast was described by Changsang & Poovachiranon (1994). In Thailand, as in other BOBLME countries, because of the poor knowledge of seagrass ecology and distribution, seagrass beds suffer strong abuses. The five of the most serious threats to seagrass globally—overexploitation, physical modification, nutrient and sediment pollution, introduction of non-native species, and global climate change are all major threats in the BOBLME except for invasive species about which little is documented.

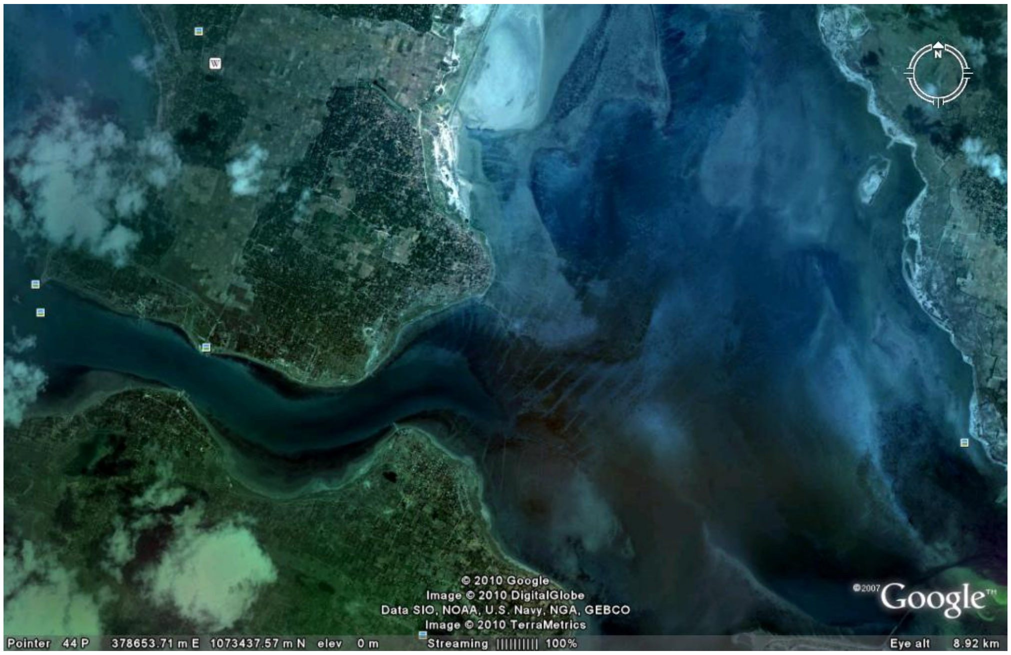



**Figure 4.13. Trawler marks in seagrass bed at Karainagar on Hunativu Island at Jaffna, Sri Lanka**

227. Pushnet and trawler fishing (Fig. 4.13) tear up underground rhizomes and gleaning by local communities for molluscs, seahorses and sea cucumbers reduces biological diversity and can damage the seagrass by trampling.

228. Details of known seagrass beds and their status are given in Table 4.16.

## Restoration of seagrass

229. Seagrass is generally difficult to restore, but it will grow from seeds or vegetative propagules. Much work has been carried out on seagrass restoration in temperate areas in Australia and the USA but little is reported from the BOBLME. Community groups in this region are the most likely groups to attempt to restore seagrass and their reports on their work are not often available in a public forum. Community groups do try restoration of seagrass usually using *Enhalus acoroides* as this is a large plant and easily cut up from donor beds. The problem with getting vegetative propagules from donor beds is that the donor beds are then damaged and take time to recover. One of the problems of restoration is that the seedlings and vegetative propagules do not rapidly stretch out their rhizomes to attach successfully to the substrate and they are often washed out. Success is usually gauged on coverage or density but function is often ignored. The economics of seagrass restoration is discussed in (Fonseca, et al., 2000) who describe a way of calculating the ecological function value compared to the restoration cost and the intrinsic recovery value. Once the countries of the BOBLME realize the importance of seagrass they will investigate restoration techniques, build the knowledge base of coastal communities and promote seagrass restoration and conservation.

**Table 4.16: Status of Seagrass Beds in BOBLME**

| Country | Site | Status | Species Reference | Major threats |
|---|---|---|---|---|
| **Indonesia**[1] | Palau Weh, Sunda Strait | Patches offshore islands of w Sumatra | | Runoff, siltation, poor fishing gear |
| **Malaysia**[2] | Langkawi<br>Port Dickson to Malacca | Patches in sheltered silt free areas | | Tourists, runoff.<br>Sand mining, oil spills |
| **Thailand**[3] | Trang<br>Ko Talibong<br>Ranong | 18 $km^2$<br>7 $km^2$<br>1.2 $km^2$ | | Push nets, mining, land development, destruction of mangroves |
| **Myanmar**[4] | Myeik Archipelago<br>Rakhine<br>Tanintharyi | Good condition, areas not known | | Blast fishing, siltation |
| **Bangladesh**[5] | Bakkhali estuary | Areas not known | | Siltation, overfishing |
| **India**[6] | Andaman and Nicobar Islands<br>Gulf of Mannar & Palk Bay | 8.3 $km^2$ Patchy & mixed<br>30 $km^2$ | | Siltation<br>Dredging, pollution, siltation |
| **Sri Lanka**[7] | Estuaries,<br>Kalitiya to end of Jaffna Peninsular | Degraded<br>Good | | Eutrophication, siltation, poor fishing gear |
| **Maldives**[8] | Most atolls on lee side. | No real survey done | | Tourists, building sand, |

*Source[: 1,2,3,7 & 8] Green & Short (2003); Source[4] Novak et al., (2009); Source[5] Abu Hena (2007), Kanal & Short (2009); Source[8] Jagtag & Untawale (1999)*

## 4.3 Pollution

230. Pollution can be defined as the human introduction into the environment of substances or energy resulting in adverse environmental impacts. Contaminants, on the other hand, are substances or energy introduced into the environment by human activities that may or may not have adverse effects on the environment.

231. The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) that was agreed to by governments to prevent the degradation of the marine environment as a result of marine activities on land identifies eight major categories of contaminants (not listed in priority order):

- Sewage
- Persistent organic pollutants (POPs)
- Radioactive substances
- Heavy metals
- Oils (hydrocarbons)
- Nutrients
- Sediment mobilization
- Litter

232. Sewage is a complex and variable mixture that can contain all of the other contaminant categories identified by the GPA, so it can be problematic to treat it as an individual contaminant. The analytical framework used in the TDA has, therefore, been modified to consider separately two types of contaminants that are invariably associated with untreated or inadequately treated domestic sewage: sewage-borne pathogens and biodegradable organic matter, or organic load. Other contaminants that can occur in domestic or industrial wastewater are considered under the respective GPA contaminant category. Radioactive substances are not included in the TDA because available information does not indicate that contamination of the marine environment with radioactive substances is a significant problem in the BOBLME. Thus, the TDA of pollution in the BOBLME is based on the following contaminant categories:

- Sewage-borne pathogens
- Organic load
- Solid waste/marine litter
- Nutrients
- Oils (hydrocarbons)
- Sediment mobilization
- Persistent organic pollutants (POPs) and Persistent toxic substances (PTSs)
- Heavy metals

233. GESAMP (1990), in the first global estimate of sources of marine contaminants, estimated that 77% of all contaminants reaching the global ocean are produced by land based activities (44% via runoff and land-based discharged, and 33% via atmospheric transport and deposition). It is now widely accepted that up to 80% of anthropogenic contaminants entering the marine environment are derived from human activities on land. Table summarises the relative importance of land- and sea-based sources in the BOBLME, which is discussed further under the individual contaminants below. It is clear that, except for oil, land-based sources dominate pollutant inputs in the BOBLME.

### 4.3.1 Sewage-borne pathogens

234. "Sewage" is a generic term that in different contexts may be used to refer specifically to human waste or more broadly to include other types of wastewater or even any form of liquid effluent, domestic, agricultural, or industrial. In the framework of the GPA, "sewage" refers to domestic wastewater, or domestic sewage. Shipping and small vessels may discharge sewage but sea-based sources of domestic sewage in the Bay of Bengal are insignificant relative to land-based sources.

235. Sewage is the main source of human parasites and disease-causing microorganisms, or pathogens, in the marine environment, as well as a major source of organic matter, nutrients, and suspended solids. Excreted pharmaceuticals such as antibiotics and endocrine disrupting compounds derived from contraceptives are of concern in some parts of the world. Available information does not allow evaluation of the significance of these contaminants in the BOBLME region.

236. Domestic sewage may also contain significant amounts of POPs, metals, and oil, but usually when industrial wastewater, urban runoff, and/or agricultural waste streams are mixed with the domestic wastewater stream.

**Table 4.17. Relative importance of land-based and sea-based sources of the contaminant categories considered in the TDA.**

| Contaminant category | Relative importance of land-based sources | Relative importance of sea-based sources |
|---|---|---|
| **Domestic sewage (pathogens and organic load)** | Overwhelmingly dominant | Minor |
| **Solid waste/marine litter** | Overwhelmingly dominant for solid waste in general<br>Unknown for marine litter | Unknown for marine litter<br>Discarded fishing gear a particular concern |
| **Nutrients** | Overwhelmingly dominant | Minor |
| **Oil** | Uncertain, likely to be 20-50% | Uncertain, likely to be 50-80% |
| **Sedimentation** | Essentially a land-based issue | Insignificant, dredging for navigation can be locally significant |
| **Persistent organic pollutants (POPs)** | Overwhelmingly dominant | Minor |
| **Heavy metals** | Overwhelmingly dominant | Minor, except for organotins |

237. The level of sewage treatment is poor in all the BOBLME countries (Kaly, 2004), and most domestic sewage s discharged with no or ineffective treatment. An estimated 90-95% of domestic sewage in South Asian countries is discharged untreated (UNEP/DA, 2009). Almost all domestic sewage in Sumatra is discharged without treatment (Purnomohadi, 2003) and a large volume of sewage is also discharged untreated or partially treated in the other Southeast Asian countries bordering the BOBLME (UNEP/COBSEA, 2009). Despite investment in sewage treatment facilities in the 1990s, only about 53% of the population in Malaysia was serviced by sewage treatment by the mid-1990s, and this has declined since (Omar, 2003). Even when sewage treatment is available, it is often inadequate. Effluent from sewage treatment plants is still the main source of organic loading in Malaysian rivers, for example (see Section 2).

238. Sewage has been assessed as the highest-priority contaminant in the marine environment globally (GESAMP, 2001). Not surprisingly, given the large human populations and low levels of treatment in the region, sewage is a high, if not the highest, priority in the BOBLME countries. (Kaly 2004) ranked sewage as the number one pollution priority on the basis of the BOBLME national reports, and domestic sewage has also been identified as a major pollution problem by recent assessments of the South Asian Seas and East Asian Seas (UNEP/COBSEA, 2010).

239. All of India's major rivers are polluted (UNEP/DA, 2009), and high biological oxygen demand (BOD) and coliform bacteria counts show that sewage is the main source of pollution in both Indian rivers and coastal waters (CPCB, 2008; Sampath, 2003). Coastal impacts from urban waste, dominated by sewage, are very important in most of the major river basins of South Asia flowing into the Bay of Bengal, including the Mahanadi, Godavari, Krishna, and Cauvery systems of Peninsular India, the Ganges-Brahmaputra-Meghna (GBM) system shared by India and Bangladesh, the Karnafuli in Bangladesh, and the Ayeyarwadi in Myanmar (Ramesh *et al*., 2009). Ramesh *et al*. (2009) assessed water pollution from municipal waste in the Walawe system in Sri Lanka to be of minor importance and confined to local urban areas. Nonetheless, sewage pollution is a problem in Sri Lankan coastal waters near cities and tourist areas (Joseph, 2003). Despite the relatively high proportion of the population serviced by some level of sewage treatment in Malaysia, more than half of water quality samples from coastal waters in the Andaman Sea and Straits of Malacca exceed Malaysian standards for contamination by sewage bacteria (Figure 4.), and effluent from sewage treatment plants remain the largest source of organic loading in Malaysian rivers (see Section 2). Although Thai waters in the Andaman Sea are generally relatively clean, bacterial pollution from sewage is a problem in concentrated tourist areas (Juntarashote, 2003).

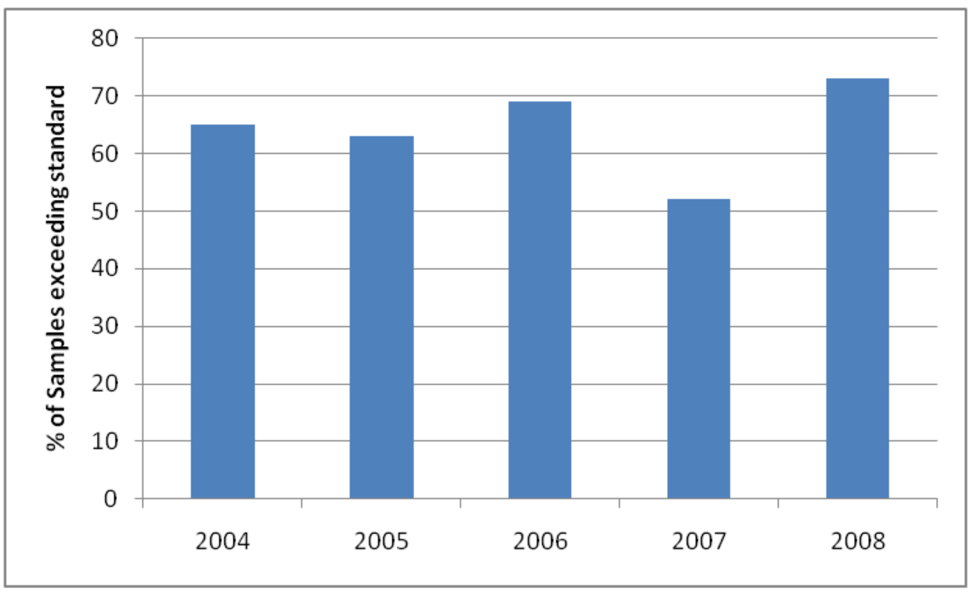



**Figure 4.14. Percentage of marine water quality samples from the west coast of peninsular Malaysia exceeding the Malaysian Interim Marine Water Quality Standard for coliform bacteria of 100 MPN/100ml from 2004-2008.** ***Source: DoE (2005-2009).***

240. Domestic sewage contains a broad range of disease-causing organisms, including viruses, bacteria, protozoans, and worms (Chia, 2000). Sewage pollution in marine waters results in an estimated global burden of disease from respiratory and gastrointenstinal infections, as well as hepatitis, of about 3 million disability-adjusted life years (DALYs), comparable to the disease burden from major diseases including syphilis, trachoma, schistosomiasis, and nematode infections (Shuval, 2003, WHO, 2008). Although reliable data are not available for the BOBLME region, the human health impacts of sewage pollution of coastal waters are likely to be

substantial given widespread sewage pollution and the large coastal population. High levels of sewage bacteria in estuaries and coastal waters near concentrated urban areas are reported in the national reports of Bangladesh (Hossain, 2003), India (Sampath, 2003), Malaysia (Omar, 2003), Sri Lanka (Joseph, 2003), and Thailand (Juntarashote, 2003). Food poisoning is often associated with cultured bivalves in Malaysia (Omar, 2003), and a high proportion of the offshore marine catch in Sri Lanka is contaminated with sewage bacteria (Joseph, 2003).

### 4.3.2 Organic Load

241. Domestic sewage, industrial effluents, agricultural waste, and aquaculture all contribute loads of biodegradable organic matter to the environment, but sewage is probably the dominant contributor in the BOBLME. BOD is an accepted indicator of organic loading on aquatic environments. Sewage probably far outweighs industrial effluents in terms of BOD generation. Figure shows estimated BOD generated by domestic sewage and industrial effluents based on the World Bank's World Development Indicators (World Bank, 2001, 2006, 2010). In terms of the initial generation of organic load, domestic sewage clearly dominates over industrial generation.

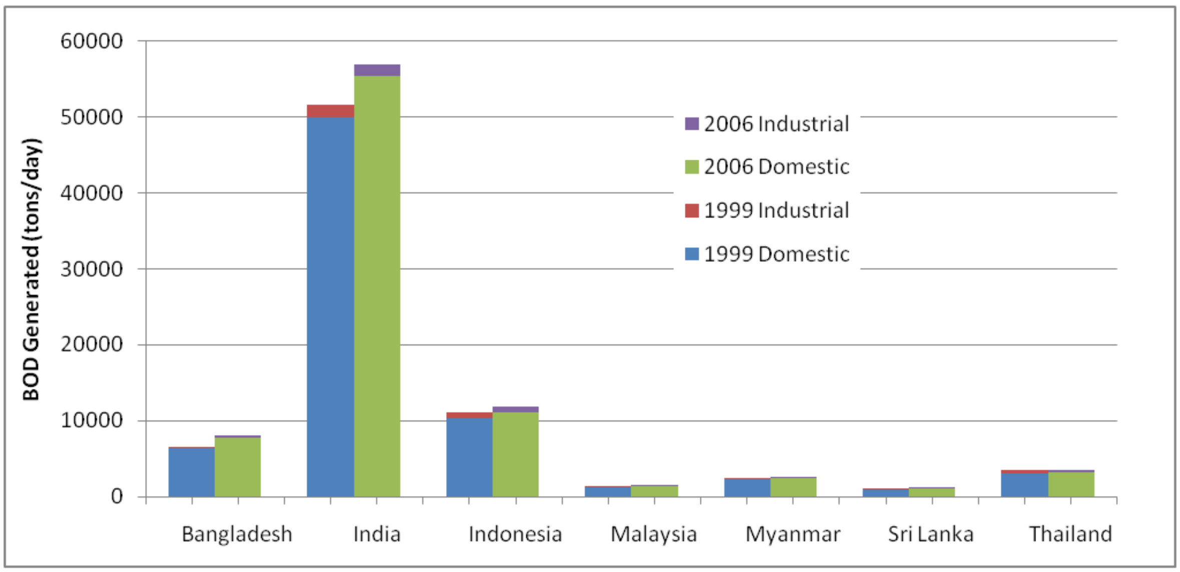



**Figure 4.15 Estimated daily generation of BOD from domestic sewage and industrial effluents in BOBLME countries in 1999 and 2006.** *Source: Domestic sewage generation is estimated using the World Health Organization estimate of 0.05 kg/d/person (Economopoulous, 1993). Estimates of population and industrial BOD generation are from World Bank (2001, 2006, 2010). Data are not available for Maldives.*

242. The relative contribution of different sectors to the industrial component of BOD generation varies markedly among countries (Figure 4.16).

243. The data presented in Fig. 4.16 are national estimates and not specific to catchments in the BOBLME, and reflect waste generation rather than inputs to the marine environment. Nonetheless, the figure is likely to be generally indicative of the situation in the BOBLME. If anything, the relative contribution of industrial effluents may be reduced by a somewhat higher level of treatment in comparison to domestic sewage. Large industries often have waste treatment systems, as is the case in India (Sampath, 2003). An estimated 25% of industrial effluent in South Asian countries is treated before discharge, compared to 5% of domestic sewage (UNEP/DA, 2009). Nonetheless, treatment of industrial wastewater is minimal in some countries, such as Indonesia (Purnomohadi, 2003) and Sri Lanka (Joseph, 2003), and even with treatment industrial sources of BOD can be locally dominant because the effluent concentrations and volumes of these point sources can be high.

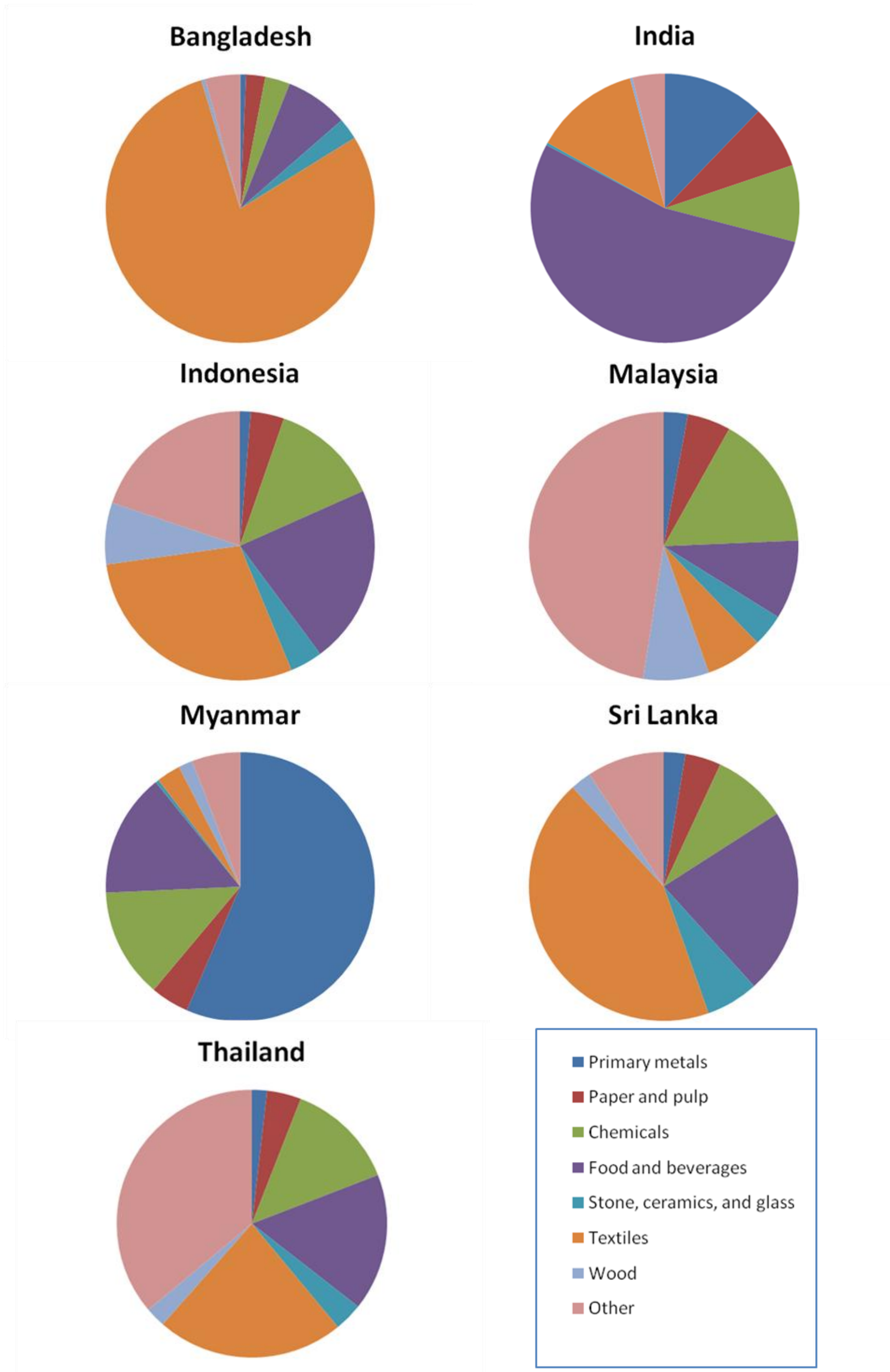



**Figure 4.16. Percent contribution of different industry sectors to industrial BOD generation in 2006. Source: World Bank (2010).**

244. Agriculture is a significant contributor to organic pollution in some BOBLME countries, for example through runoff of animal wastes and discharges from agricultural processing industries. Regional statistics on the agricultural contribution to organic load are not available, but it is higher than the industrial contribution at least in Malaysia, where pig farms and agro-based industry are the second and third largest sources of BOD

discharge into rivers even though they represent a much smaller number of individual sources than manufacturing industries (Figure and Figure 4. 4.18). Nevertheless, BOD discharges of treated and partially treated sewage from sewage treatment plants far outweigh the agriculture contribution. It should be noted that the sewage contribution represented in Figure 4.17 includes only sewage treatment plant effluents, and not discharges of untreated sewage.

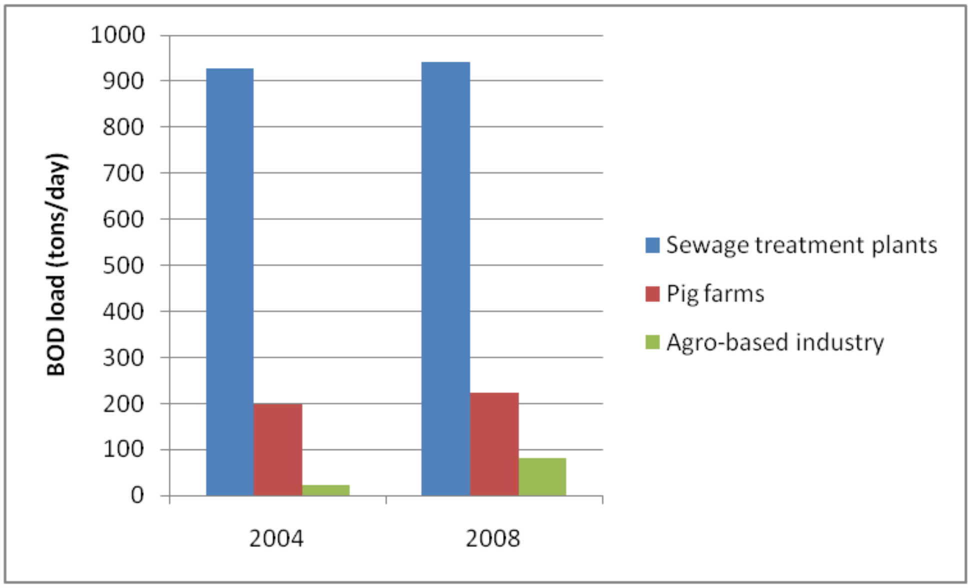



**Figure 4.17. BOD discharges from sewage treatment plans, animal farms (pig farms), and agro-based industry in Malaysia in 2004 and 2008. BOD discharges from manufacturing industries were less than from agro-based industry.** ***Source: DoE (2005, 2009).***

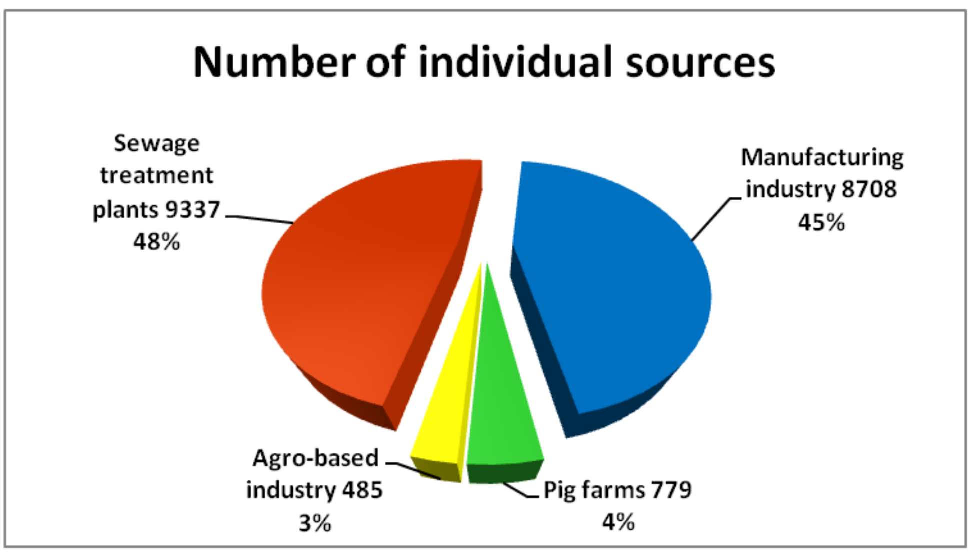



**Figure 4.18. Number of individual sources of BOD discharges to Malaysian rivers and coastal areas by source category in 2008.** ***Source: DoE (2009).***

245. In addition to sewage and agriculture, aquaculture facilities have been identified as a significant local source of BOD in Bangladesh (Hossain, 2003), India (Sampath, 2003), Malaysia (Omar, 2003), and Sri Lanka (Joseph, 2003).

246. The decomposition of organic matter in the marine environment can lead to oxygen depletion, or hypoxia, if the organic load exceeds the assimilative capacity of the receiving waters. Low levels of dissolved oxygen have been observed in proximity to large BOD sources in several countries, generally in estuaries, lagoons, and near-shore coastal waters, with impacts decreasing offshore (Hossain, 2003; Sampath, 2003). Hypoxia from organic loading may be acute, but in general is probably localised around sources, although it might also contribute to the risk of increasing basin-scale hypoxia driven primarily by agricultural and other sources of excess nutrients (see Section 4).

### 4.3.3 Solid Waste/Marine Litter

247. The national reports of all countries ranked solid waste from domestic (including medical waste) and industrial sources as a high priority, and the Maldives as the highest priority (Ali, 2003). Urban areas and industries generate large amounts of solid waste, but reliable statistics on the quantities generated are unavailable. Much of the solid waste is not managed, but is dumped haphazardly, including into waterways. Solid waste management systems that do exist are often unable to deal with the waste load. Dhaka is able to manage only about 55% of its municipal solid waste, for example (Hossain, 2003), and only 60% of domestic solid waste in India is collected. Even when solid waste is managed, waste from landfills often reaches the environment as a result of inadequate management or landfill capacity, or flooding (Kaly, 2004; UNEP/GPA, 2006). Landfills may also leach toxic substances and other pollutants.

248. Solid waste includes a very wide variety of materials. Much of municipal solid waste is food waste and other degradable material (UNEP/GPA, 2006), and industries such as jute, fish and shrimp landing and processing, and slaughter houses also generate large amounts of organic waste that may cause oxygen depletion of the water column and sediments as well as health hazards. Medical wastes such as used hypodermic syringes and dressings are also a health risk. Industry generates large amounts of inorganic solid waste. Some 65% of industrial solid waste in India is inorganic material such as blast furnace slag and fly ash, for example (Sampath, 2003), and about a third of the solid waste generated in Male is construction waste (Ali, 2003). The textile industry generates large amounts of solid waste, in the form of fabric offcuts, in Sri Lanka (Joseph, 2003). Ship breaking is a significant source in India and Bangladesh (UNEP, 2009) adding also to other pollutant categories. Non-degradable solid waste often causes severe habitat damage via burial and smothering.

249. Many components of solid waste are relatively immobile, so that impacts are localised although they can be severe and widespread. Plastic waste is of particular concern because plastics persist in the environment for long periods, and are transported for long distances in the ocean. Plastics are the main component of marine litter, and have widespread effects on fauna that consume or become entangled in plastic litter (UNEP, 2009).

250. The relative importance of land-based and sea-based sources of marine litter is unknown, both in the BOBLME and globally. A 1995 assessment (NRC, 1995) concluded that shipping is the source of almost 90% or marine litter. Studies in Australia and the Republic of Korea, on the other hand, indicate that up to 80% comes from land-based sources. There are almost no reliable data regarding the sources, quantities in the environment, distribution, composition, or impacts of marine litter in the BOBLME (UNEP, 2008, 2009).

251. Derelict fishing gear is one component of marine litter and debris that is of concern in the BOBLME and unquestionably from sea-base sources. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) causes damage through physical damage in coral reefs, seagrass beds, and other habitats, through entanglement of marine fauna, and through “ghost fishing”, in which derelict nets or traps continue to capture and kill fish and other marine fauna. Thailand identifies ALDFG as the component of marine litter with the most serious impacts (UNEP, 2008).

### 4.3.4 Nutrients

252. Excessive inputs of nutrients to marine systems can lead to eutrophication, or excessive primary production that can result in overgrowth of coral reefs by algae, harmful algal blooms (HABs), the formation or expansion of low-oxygen (hypoxic) zones when phytoplankton biomass decays and consumes oxygen, and other problems. Nitrogen is usually the nutrient of most concern because nitrogen availability typically limits primary productivity in coastal marine systems.

253. Domestic sewage, runoff of fertilizers and animal manure from agriculture, and some industrial effluents all contribute to anthropogenic nutrient inputs to the BOBLME. Aquaculture is an important source in some areas (Hossain, 2003; Omar, 2003; Joseph, 2003; Sampath, 2003). Large amounts of nitrogen also enter the BOBLME from the atmosphere as a result of fossil fuel combustion and industrial and agricultural atmospheric emissions. Fertilizers are the largest source of dissolved inorganic nitrogen (DIN) in the GBM system and most east Indian watersheds (Dumont *et al*., 2005). In most other areas bordering the BOBLME, natural nitrogen fixation remains a dominant source (Dumont *et al*., 2005), but human activities still contribute large amounts (Kaly, 2004). Sea-based sources do contribute nutrients via waste discharge and atmospheric emissions from fuel combustion, but it can safely be assumed that sea-based sources of nutrients are negligible in comparison to land-based sources.

254. Despite high levels of anthropogenic nitrogen generation in watersheds linked to the BOBLME and enormous river discharge, river inputs of DIN remain relatively low (Naqvi *et al*., 2006, 2010). The effects of anthropogenic nutrient inputs on the BOBLME are poorly studied (Hossain, 2003; Kaly, 2004). All of the BOBLME national reports recognise risks associated with increasing nutrient inputs, and several identify problems of eutrophication in coastal wetlands and estuaries, but the available data do not indicate that there are widespread increases in the frequency or severity of HABs in coastal or offshore areas, or that the naturally occurring hypoxic zone in the Bay of Bengal (see below) is expanding or intensifying.

255. Nutrient inputs are, however, increasing. Fertilizer use appears to be generally increasing regionally (Fig. 4.19), and inputs from sewage will also increase with population growth without compensatory improvements in sewage treatment. The Global Nutrient Export from Watersheds (Global NEWS) model projects the northern Bay of Bengal as one of the world's areas of greatest increase in DIN export between 2000 and 2030 in one of the scenarios used in the Millennium Ecosystem Assessment, the Global Orchestration scenario (Seitzinger *et al*., 2010), although the predicted increase is less under other scenarios (Seitzinger *et al*., 2010). The north-western BOBLME is also expected to experience among the world's greatest increases in atmospheric inputs of nitrogen from 2000 – 2030 (Duce *et al*., 2008; Figure 4.21).

256. There is scientific consensus that anthropogenic increases in nutrient inputs to coastal areas are associated with increases in the frequency, severity, and duration of HABs (Heisler *et al*., 2008) but present understanding is inadequate to predict the effects of the expected increases in nutrient inputs on HABs in the BOBLME.

257. Present understanding of the Bay of Bengal is also inadequate to predict the effects of increasing nutrient input with regard to hypoxia. Hypoxia is often defined as a dissolved oxygen concentration of less than 2 ml/L, below which physiological and behavioural effects in fishes and invertebrates are observed (Diaz and Rosenberg, 1995). The Bay of Bengal has a persistent offshore oxygen minimum zone (OMZ) with less than 0.5 mg/L dissolved oxygen between about 100 and 600 m depth (Helly and Levin, 2004), and dissolved oxygen levels below 1 ml/L are reached at a depth of 80 – 100 m in the northern Bay of Bengal (Hossain, 2003). The entire outer continental shelf of the Bay of Bengal is subject to hypoxic conditions from the OMZ (Levin *et al*., 2009). The OMZ is considered to be a natural feature of the Bay of Bengal, as opposed to the coastal hypoxia due to eutrophication that has occurred in many other ocean areas (Helly and Levin, 2004; Diaz and Rosenberg, 2008). It is thought that hypoxia has not developed on the inner shelf in association with large rivers such as the BGM

and Ayeyarwadi because of the relatively limited input of DIN and a lack of upwelling (Naqvi *et al*., 2006, 2010). Hypoxic deep water is, however, known to seasonally intrude onto the continental shelf of Myanmar (Myint, 2003).

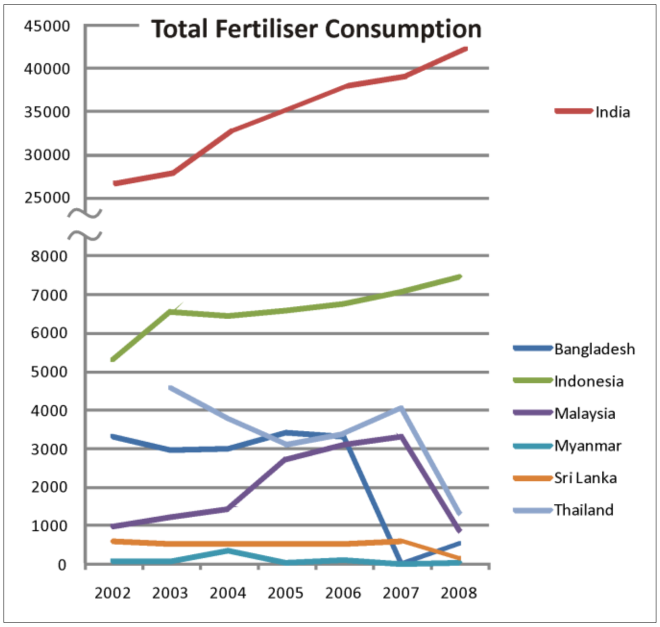



**Figure 4.19. Trends in total fertilizer consumption 2002 – 2008 in the BOBLME countries, except the Maldives. The apparent declines in Thailand and Malaysia in 2008, and in Bangladesh in 2007 and 2008, may reflect changes in reporting rather than in actual fertilizer use.** ***Source: FAOStat statistical database, (viewed 20/8/10).***

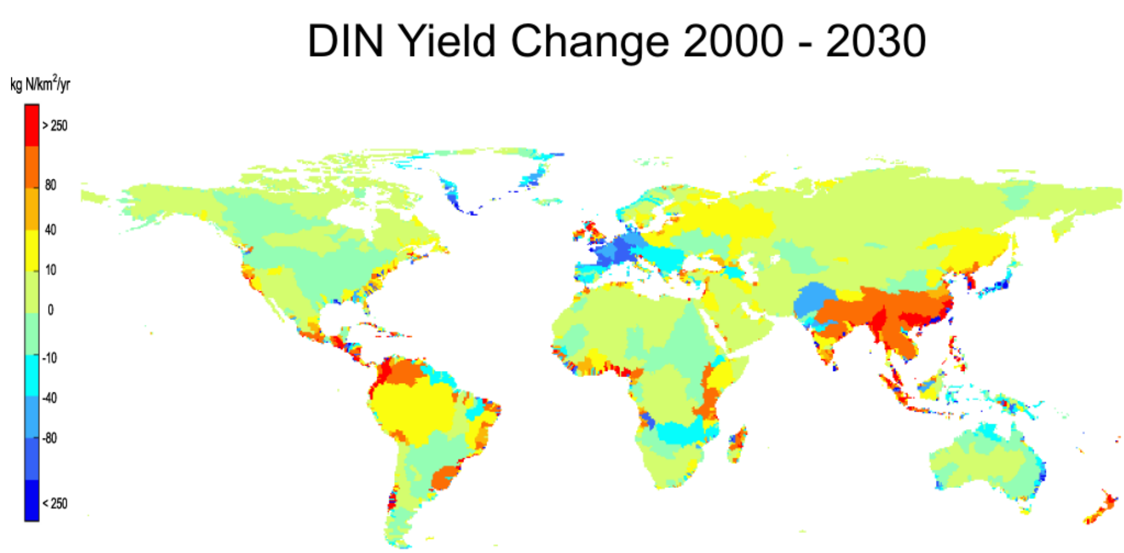



**Figure 4.20. Predicted change in the generation of dissolved inorganic nitrogen (kg N/km$^2$/yr) in watersheds between 2000 and 2030** ***(adapted from Seitzinger et al., 2010)***

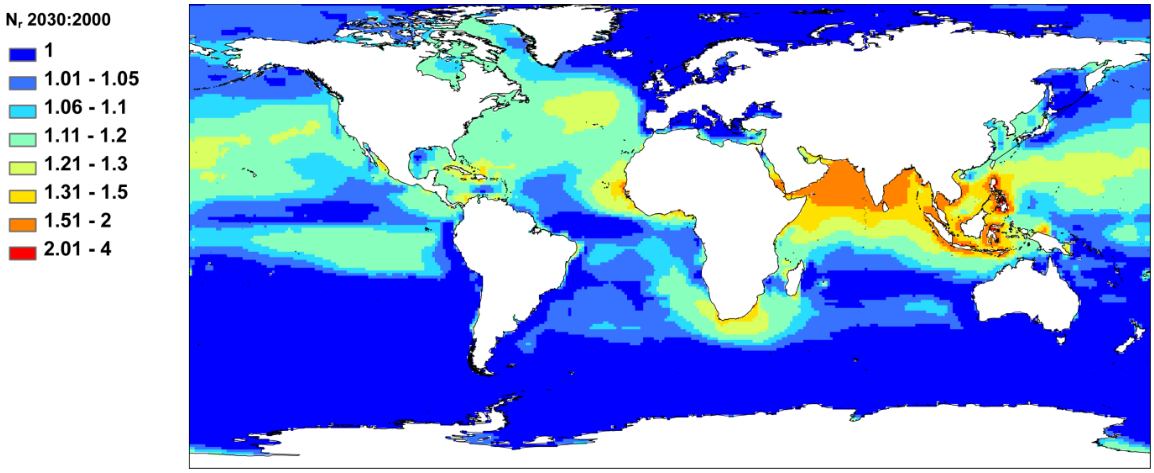



**Figure 4.21. Increase in atmospheric nitrogen deposition between 2000 and 2030, shown as the ratio of predicted deposition in 2030 to deposition in 2000.** ***Source: Duce et al. (2008).***

258. The continued resilience of the BOBLME with regard to hypoxia in the face of continued increases in nutrient inputs is uncertain. Rabelais *et al*. (2008) note that the Bay of Bengal is an open system compared to other ocean areas that receive high nutrient inputs, lacking physical features such as shallow sills or narrow entrances that restrict water exchange and the replenishment of oxygen. This exchange will determine the system's response to increased nutrient inputs (Rabelais *et al*., 2008). The development of coastal hypoxic zones or a shoaling of the deep-water OMZ that leads to widespread intrusion of hypoxic water onto the shallow shelf as has been observed on the Oregon shelf of the northeast Pacific in recent years (Chan *et al*., 2008), could have significant impacts on ecosystems and fisheries of the BOBLME. It should be noted in this regard that global warming may lead to a general decline in marine dissolved oxygen concentrations (Keeling and Garcia, 2002; Levin *et al*., 2009). Furthermore, the development of coastal hypoxic zones due to eutrophication in other parts of the world has typically lagged behind increased nutrient inputs by a decade (Diaz and Rosenberg, 2008), so even present nutrient inputs could still lead to increasing hypoxia in coming years.

### 4.3.5 Oil

259. All of the BOBLME national reports identify coastal oil pollution as a problem, with the Maldives considering oil pollution the top national priority (Ali, 2003). Oil is the third most common pollutant in Malaysian coastal waters, with 35 – 49% of coastal monitoring sites exceeding the Malaysian water quality standard for oil and grease over the period 2004-2008 (DoE, 2005, 2006, 2008), but in general there is little available information on the extent or impacts of oil pollution in the BOBLME.

260. Land-based sources of oil pollution in the BOBLME include municipal runoff as well as spills and operational discharges from coastal refineries and other petroleum infrastructure. Sea-based sources include tanker spills, operational discharges of bilge and ballast water, dumping of waste oil, spills during transfer and handling of oil cargoes, and operational discharges and spills from offshore oil and gas extraction. In Bangladesh and India, ship breaking is also a significant source of oil pollution in the vicinity of ship breaking activities (Hossein, 2003; Sampath, 2003).

261. Globally, estimates of the relative contributions of land-based and sea-based sources of oil pollution in the marine environment vary considerably. GESAMP (1993), for example, estimated that land-based runoff accounts for some 56% of oil inputs to the oceans (excluding natural seeps), while NRC (2002) estimated this contribution at 21%. In the BOBLME, the sea-based contribution could be toward the higher end of the global estimates given the high shipping traffic and large number of small vessels operating in coastal waters, but

quantitative estimates of the relative importance of land-based and sea-based sources of oil pollution are not available.

262. Of the sea-based sources, routine operational discharges are almost certainly more important than catastrophic oil spills, even though the risk of such spills is high due to the high volume of tanker traffic, particularly in the Straits of Malacca. Operational discharges account for about 80% of sea-based oil inputs to the marine environment in India, for example (Sampath, 2003). Some of these operational inputs come from large ships, in particular oily ballast water from tankers. Bangladesh allows the direct discharge of tanker ballast (Hossain, 2003). Where there are restrictions on oil discharge from ships they may be ineffective. For example, the Port of Colombo has receiving facilities for waste oil from ships, but the final disposal of this oil is unregulated (Joseph, 2003).

263. Sea-based oil discharges from small vessels are probably very important relative to discharges from large ships due to the vast number of small vessels operating in BOBLME coastal and river waters and a general lack of controls or waste oil reception facilities. At least 50% of oil entering the marine environment in India and Bangladesh comes from river craft and small steamers (UNEP/GPA, 2006), and it is highly likely that small vessels, particularly the dumping of waste oil from such vessels, are a major source of oil pollution in most other BOBLME countries.

264. Land-based sources of marine oil pollution are also probably mainly operational, such as the dumping of waste oil from vehicles, workshops, manufacturing facilities, and routine small spills at refineries and transfer facilities (Hossain, 2003; Joseph, 2003; UNEP/DA, 2009).

### 4.3.6 Sedimentation

265. The Bay of Bengal receives a huge sediment load from the BGM system, the Ayeyarwady, and several rivers in eastern India (Ramesh *et al*., 2009; UNEP/GPA, 2006). The high natural sediment load into the BOBLME has been increased greatly by human activities. This is primarily a result of agriculture, forestry, and other changes in land use, although sewage and other waste discharges can contribute large amount of suspended solids at a local scale (Kaly, 2004; Ramesh *et al*., 2009). Dredging for port development and navigation channels can also re-mobilise sediments at a local scale.

266. Elevated sedimentation can adversely affect sensitive ecological communities through a reduction of light penetration through the water column and smothering of benthic communities when suspended solids settle on the bottom. Coral reef and seagrass communities are particularly sensitive to these effects. Given the very high natural sediment loads in the BOBLME, the ecological communities in areas subject to large river inputs are generally sediment-tolerant. The effects of increased sedimentation are generally localised to areas where sediment inputs are naturally relatively low but have been increased by land-use change.

### 4.3.7 Persistent Organic Pollutants/Persistent Toxic Substances

267. The term “persistent organic pollutants” (POPs) is often used in a broad sense to refer to organic compounds that persist for long periods of time and undergo long-range transport in the environment, and are toxic to and tend to accumulate in the tissues of organisms. In recent decades, “POPs” has increasingly tended to refer specifically to compounds regulated under the Stockholm Convention on Persistent Organic Pollutants. The terms “persistent toxic substances” (PTSs) and “persistent, bioaccumulating, and toxic (PBT) substances” are often used to refer to organic compounds with the characteristics of environmental persistence, tendency for bioaccumulation, and toxicity, without reference to the status of the compounds in question as regards the Stockholm Convention. The TDA has been conducted in the context of PTSs.

268. The major sources of PTSs in the marine environment are agricultural pesticides, industrial processes, landfills, and waste burning. PTSs may also be present in sewage, sometimes from discarded household chemicals but more often when industrial waste streams are mixed with domestic sewage. This is likely to be

common in BOBLME countries where separation of waste streams is uncommon, especially from small industries. Domestic sewage treatment is often ineffective in removing many PTSs.

269. Little information is available on the quantities and trends of PTS emissions, levels in the environment, and ecological and human health impacts in the BOBLME region. Measurements of PTS concentrations in water, sediments, and organisms in the region are sparse, in large part because of limited capacity for laboratory analysis (UNEP Chemicals 2002, 2003).

270. Organochlorine pesticides used for agricultural and domestic purposes are one important source of PTSs in the environment, and moderate to high levels of organochlorine pesticides have been observed in the BOBLME (UNEP Chemicals, 2002, 2003). BOBLME countries have banned the use of most of these pesticides, although DDT is still used for malaria control. Although little quantitative information is available, levels of PTS pesticides in the region generally appear to be declining (Ramesh *et al*., 2009; Sampath, 2003; UNEP Chemicals, 2002, 2003). Some stockpiles remain (UNEP Chemicals, 2003), and organochlorine pesticides may still be in use in some areas. Ramesh *et al*. (2009) report that 79% of pesticides used in the Godvari basin are organochlorines, for example.

271. The levels and effects of PTSs produced as industrial chemicals are also poorly known, but considerable progress has been made in banning or regulating many of these chemicals. Industrial emissions of at least some PTSs, however, could be increasing given the growth of industry in the region and the chemical industry.

272. Polychlorinated dibenzo-p-dioxins (PCDDs) and Polychlorinated dibenzofurans (PCDFs), often referred to simply as “dioxins” and “furans”, have been identified as the PTSs of most concern to countries in the region. Dioxins and furans are unintended by-products of some industries including chloralkali, pulp and paper, and some plastics and chemicals manufacturing, as well as from the combustion of waste and biomass. The widespread open burning or low-temperature incineration of solid waste in the region is considered a potential major source of dioxins and furans (UNEP Chemicals, 2002, 2003).

273. PTSs are an issue of concern for the BOBLME countries given their persistence in the environment and potential impacts on organisms and human health. The lack of information regarding the levels and impacts of POPs in the environment is regarded as a serious information gap.

274. Minor amounts of PTSs are generated from sea-based activities including shipping and offshore oil and gas production, but land-based sources are overwhelmingly dominant.

### 4.3.8 Heavy Metals

275. Major anthropogenic sources of heavy metals in the marine environment include tanneries, fertilizer production, chloralkali plants, and the paint and textile industries. Ship-breaking activities can also be a source of heavy metals. As with PTSs, heavy metals may be present at high levels in sewage when industrial waste streams are mixed in.

276. Heavy metal pollution in association with industrial areas was identified in the national reports of Bangladesh, India, Indonesia, Malaysia, and Sri Lanka, but the extent of heavy metal contamination in the BOBLME is not known (Kaly, 2004). In most cases, heavy metal contamination is probably localised near the source, as most metals are not transported long distances in the marine environment (GESAMP, 2001). The exceptions are the volatile metals lead and mercury, which can be transported long distances in the atmosphere. Lead contamination of the marine environment is a decreasing concern because leaded fuels, a dominant source, are being phased out. Both lead and mercury are of particular concern in terms of toxic effects when complexed in organic form. Lead is added to fuels in organic form, and organomercury compounds are formed through biological transformation in sediments.

277. Data on the distribution, levels, or effects of organolead and organomercury compounds in the BOBLME are not available (UNEP Chemicals, 2002, 2003). Organolead compounds are probably of decreasing concern given the phase-out of leaded fuels, but there is increasing international concern about anthropogenic mercury contamination.

278. The sources of heavy metal contamination of the marine environment are overwhelmingly land-based, with the exception of tributyl tin, which has been widely used in antifoulant coatings for shipping and maritime infrastructure. The status of organotin contamination in the BOBLME has not been assessed regionally (UNEP Chemicals, 2002, 2003), but tributyl tin is being removed from use globally, so that organotin contamination can be expected to decline in coming years.

# 5. BACKGROUND TO TRANSBOUNDARY ISSUES

## 5.1 Overexploitation of marine living resources

### 5.1.1 Transboundary nature of fish

279. Many of the living marine resource stocks on which the BOBLME's fisheries are based traverse international boundaries of adjacent, and sometimes non-adjacent, countries and many of them are targeted by several BOBLME countries.

280. TableV.1 lists several important fishery species/species groups that range across BOBLME country borders. 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.

281. Smaller pelagic species, such as anchovies, herrings and shads, are not as mobile, but usually migrate through the coastal waters of two or more neighboring countries. Some small pelagic species, e.g., the rainbow sardine (*Dussumieria acuta*), are distributed along the coasts of all BOBLME countries; their range may extend well beyond the BOBLME.

282. Resources which appear to be sessile 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 thousands of miles from the place of birth to the place of adult settlement. Some demersal species, such as the sea catfish (family Ariidae) are also transboundary.

283. Unsustainable fisheries based on these shared or straddling stocks and unsustainable activities based on the critical habitats that support these stocks in one country may adversely affect recruitment that originates in another country but replenishes the stocks in the first country or vice-versa.

### 5.1.2 Transboundary nature of fishing

284. Based on known access agreements (both formal and informal), SAUP (2010) have estimated the origin of each country's landings (Table 5.2). This does not include IUU fishing in other countries' EEZs. According to SAUP, most BOBLME countries fish to some degree in other countries' EEZs. The most wide-spread fleet is that of Thailand fishing in Indonesia, Malaysia, Myanmar, Bangladesh, India (including Nicobar an Andaman Islands) and Sri Lanka. According to SAUP, only a small percentage of the Thailand catch is taken in the Thailand EEZ – much more is taken in Myanmar and Malaysian waters. This figure may overestimate the catch outside of the Thailand EEZ but in a well-researched study, published by the legal Office of the UN (Panjarat, 2008), was also highlighted the spread of Thai fishing in the BOBLME - 4,000 large Thai vessels operate in EEZs of other coastal States (mainly Myanmar and Malaysia), of which 2,000 have licenses.

285. 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 (Table 5.1). As in other parts of the world, foreign access was encouraged in many BOBLME countries, but as access was denied by the different countries, the activity of the different countries has also changed. Japan was the most active player in early years.

**Table 5.1: Examples of transboundary species/species groups in the BOBLME**

| Common name | Scientific name | Countries primarily concerned |
|---|---|---|
| Migratory tunas<br>e.g. Skipjack tuna<br>Yellowfin tuna,<br>Bigeye tuna | <br>*Katsuwonus pelamis*<br>*Thunnus albacores*<br>*T. obesus* | All |
| Coastal tunas<br>e.g. Frigate tuna,<br>Kawa kawa | <br>*Auxis thazard,*<br>*Euthynnus affinis* | All |
| Indian mackerel | *Rastrelliger kanagurta* | All |
| Short mackerel | *Rastrelliger brachysoma* | Indonesia, Malaysia, Thailand Myanmar and Sri Lanka |
| Spanish mackerel/seerfish | *Scomberomorus spp* | All |
| Oil sardine | *Sardinella longiceps* | India, Indonesia and Sri Lanka |
| Hilsa | *Tenualosa ilisha/toli* | All except Maldives |
| Bali sardinella | *Sardinella lemuru* | Thailand and Indonesia |
| Rainbow sardine | *Dussumieria acuta/elopsoides* | All, especially southern India/Sri Lanka |
| Indian pellona | *Pellona ditchella* | All except Maldives |
| Goldstripe sardinella | *Sardinella gibbosa/fimbriata* | All except Maldives |
| Indian scad | *Decapterus russelli* | All |
| Indian halibut | *Psettodes erumei* | India, Indonesia, Malaysia, Myanmar, Sri Lanka and Thailand |
| Bombay duck | *Harpodon nehereus* | India, Bangladesh, Indonesia, Malaysia and Myanmar |
| Black pomfrets | *Parastromateus niger* | India, Indonesia, Malaysia, Sri Lanka and Thailand |
| Sea catfish | *Arius maculates, A. thalassinum,* | All except Maldives |

*Modified from Preston (2004)*

**Table 5.2: Origin of catches by countries fishing in the BOBLME.**

| Country's EEZ | Country fishing: Indonesia | Malaysia | Thailand | Myanmar | Bangladesh | India | Sri Lanka | Maldives | Others |
|---|---|---|---|---|---|---|---|---|---|
| Indonesia | **71.0** | 26.3 | 9.1 | - | - | 2.2 | 2.7 | - | 3.3 |
| Malaysia | 17.1 | **61.9** | 23.3 | - | - | - | - | - | 57.6 |
| Thailand | 7.5 | 9.9 | **15.2** | 3.4 | - | 0.8 | 0.2 | - | 0.1 |
| Myanmar | - | 0.2 | 47.8 | **93.3** | 11.0 | 8.4 | 2.4 | - | 0.5 |
| Bangladesh | - | - | 1.7 | 3.0 | **83.3** | 1.6 | 0.7 | - | - |
| India | 3.8 | 1.0 | 2.5 | 0.4 | 5.8 | **77.0** | 63.7 | - | 3.0 |
| Sri Lanka | 0.5 | 0.6 | .5 | - | - | 8.7 | **30.3** | - | 1.9 |
| Maldives | - | - | - | - | - | 1.3 | - | **100.0** | 33.6 |

Source: SAUP (2010)

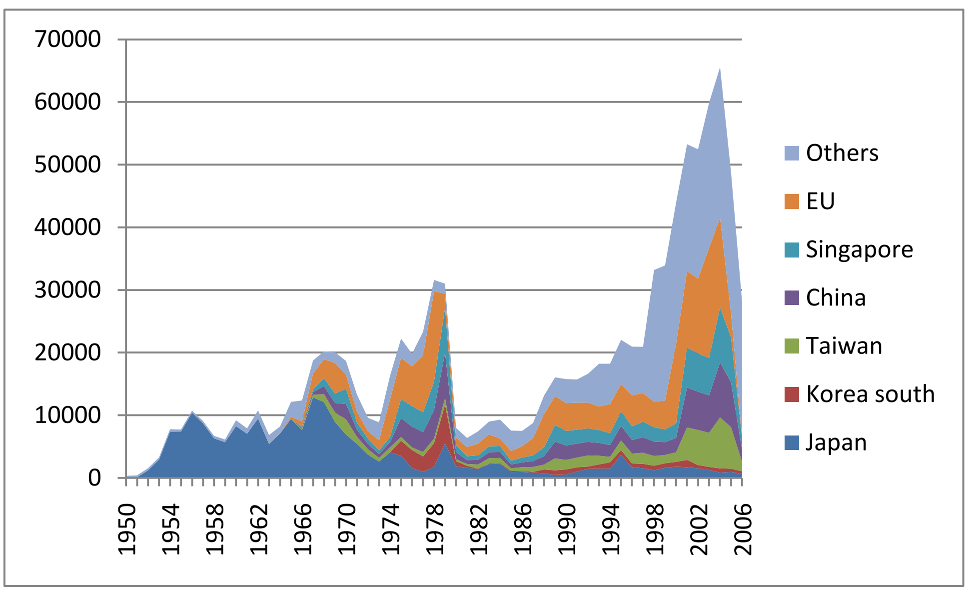



**Fig 5.1. Catches of fish by distant water fishing nations in the Bay of Bengal.** ***Source SAUP (2010)***

286. 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 by "other" countries.

287. Crews are also often shared across boundaries. This is particularly prevalent on Thai fishing vessels where many of the crew (apart from the Skipper and senior crew) is from Myanmar and some from Cambodia. The

Asia Foundation has recently reported the results of a survey (Anon, 2010) that identified and interviewed more than 60 Cambodian men who were trafficked onto Thai fishing boats since 2007.

288. 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 conclusions has been that IUU fishing is a major problem in the region, is costing the region's countries significant amounts in lost revenue and is resulting in overexploited fisheries and adverse social issues. It is important to separate IUU fishing issues into the following three categories because different regulatory and enforcement regimes apply to each situation. These categories are:

- national vessels in national waters,
- foreign vessels in national waters and
- vessels fishing on the high seas

289. Both the first two categories are transboundary in the BOBLME. The former because it is common across all countries and is a major loss of revenue from fishing, depletion to the resource and conflict it can cause to more law-abiding citizens and the latter because it is a shared problem in all BOBLME countries.

290. The major national IUU issues identified are reasonably consistent across the countries. In the national category, nationals using prohibited gears or methods are the main issue. In terms of foreign fishing, unauthorized incursions into their EEZs by foreign fishing vessels, which can be either commercial or industrial vessels from distant-water fishing nations or artisanal or commercial fishermen from one BOBLME country fishing in the waters of another is a concern shared by all countries.

291. A large proportion of the national fleets are not registered, and although this is not strictly IUU fishing in countries where there is no legal requirement to be registered, it is of regional concern. A robust and enforceable vessel registration and licensing system is a cornerstone of any programme to measure and therefore manage fishing effort and capacity.

### 5.1.3 Transboundary nature of markets

292. Despite its perishable nature, fish is the most traded commodity in the world (Fig. 5.2). World exports of fish and fishery products reached US$85.9 billion in 2006 (FAO, 2008).

293. 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. The fishery net exports of developing countries (i.e. the total value of their exports less the total value of their imports) continue to be of vital importance to the economies of many fish-exporting developing countries, including many BOBLME countries. They have increased significantly in recent decades, growing from US$1.8 billion in 1976 to US$24.6 billion in 2006. Growth is predicted to continue, but mainly in developing countries (Delgado, et al., 2002). Developing countries have gone 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 the 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.

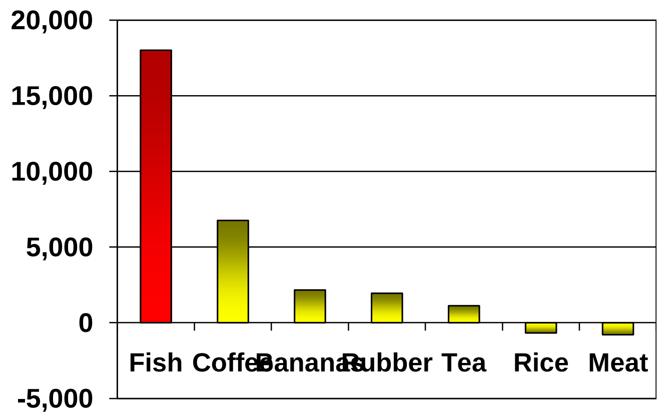



**Figure 5.2. Global trade in commodities from developing countries ($10^{-3}$ tonnes). Source: FAO**

294. 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.

295. 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".

296. Emerging markets for fish meal and surimi are also encouraging the capture of small low value/trash fish. The total production of trash fish is around 900,000 tonnes in the BOBLME (interpolating to countries where no data are available). Percentage composition of low value/trash fish ranges from 5.6% in Indonesia where trawling is banned to as much as 34.7% in Thailand where trawling is very active (APFIC, in press). In Thailand, low/value trash fish constitutes as much as 64% of the otter trawl catch.

**Table 5.3. Estimates of the catch of low value/trash fish and its percentage of the total catch in BOBLME countries. Nd = no data available**

| | Tonnes | % total catch |
|---|---|---|
| **Indonesia** | 34,500 | 5.6% |
| **Thailand** | 215,571 | 34.7% |
| **Malaysia** | 206,105 | 30.7% |
| **Myanmar** | Nd | |
| **Bangladesh** | 85,843 | 17.6% |
| **India** | 347,862* | 14-32%** |
| **Sri Lanka** | Nd | |
| **Maldives** | Nd | |

* Estimate for whole of India, ** Percentages for east coast of India, Source: APFIC (in press)

297. In countries where the demand for aquaculture feed is high, much of the small low value/trash fish are either converted to fishmeal and included in formulated aquaculture diets or fed directly into fish cages. Because of the demand and large quantities that the market can absorb, incentives to fish with non-selective small-mesh fishing gear is high. Increasing demands from aquaculture intensification in the Bay of Bengal region could start to drive direct targeting and mesh size reductions if onshore market expanded, as seen in the South China Sea region.

298. Threadfin bream, lizard fish, bigeye, croaker and goatfish are 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 tonnes, requiring approximately 262,500 tonnes of raw material (APFIC, in press). Many countries in the Bay of Bengal region do not produce surimi in significant quantities that implies that the facilities to produce surimi are not yet established (there is a technological lag). It may also be that fish is utilized directly for consumption and thus there is less pressure to process fish into surimi to increase utilization for human consumption (especially products of trawl fisheries). In countries where the facilities for surimi manufacturing exist, surimi species make up between 5% (Thailand) and 16% (India) of the total catch.

### 5.1.4 Transboundary constraints to better management

299. All the countries of the BOBLME are experiencing significant difficulties in implementing better fisheries management. Despite relatively good fisheries legislation and policies, best practice fisheries management is difficult to find. Malaysia and the Maldives, because of their smaller population and greater economic development probably lead the field, but here too there are problems. The main constraint is that the fisheries have either been controlled by traditional customary practices that have been eroded by the introduction of western-style government and bureaucracies or managed inadequately by central governments in an ineffective “top-down” approach. This “open access” nature of fishing has reached a point where countries have been hindered by an unwillingness or inability to bear the short-term social and economic costs of reducing fishing. Some local 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.

300. 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 to good management. This transboundary dimension of overexploitation of marine living resources sends a strong signal for countries in the BOBLME to cooperate and share experiences in meeting these challenges. The BOBLME project will be focusing on three key fisheries – sharks, hilsa and Indian mackerel.

## 5.2 Degradation of critical habitats

### 5.2.1 Transboundary nature of mangroves, coral reefs and seagrass

301. Mangrove forests are found in all the BOBLME countries and, in some, are of global importance in coverage. 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 by the Government of India.

302. Coral reefs are also found in all the BOBLME countries 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.

303. Seagrass is usually found on mud/sand flats or between coral and mangroves and, in some cases, considered a nuisance, e.g., outside Maldives hotels. Seagrass beds are found in all the BOBLME countries. However, information on their regional areal extent and actual degradation state is unavailable.

304. 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 priority: 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.

### 5.2.2 Coastal development

305. 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). Ports and harbours should be included in this category where they include industrial facilities (Kaly, 2004).

306. Tourism, too, 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.

307. Tourist activities and the consequences of running a tourism industry can have deleterious effects on reefs. Without education of divers and enforcement of regulations the coral damage will increase far beyond the ability of the corals to repair it. Boat anchors are very destructive and moorings are often badly placed. The Thai Government has rules for mooring at dive sites in the Andaman Sea, and it provides non-destructive moorings which volunteers and National Park wardens distribute in sensitive places. Trampling, touching and collecting curios from coral reefs are also highly damaging.

308. 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 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. The Sundarbans (West-Bengal) are designated as a UNESCO Biosphere Reserve and as a wetland of international importance under the Ramsar Convention. Loss of mangrove habitat and the corresponding loss of fish nursery area will be felt in both countries. The Sundarbans and the Maldives also share the importance for mangroves to give coastal protection against erosion and storm waves.

### 5.2.3 Transboundary trade

309. One of the common drivers of critical habitat degradation is the desire to boost export earnings and trade in the BOBLME countries. The best known example is the export of cultured shrimp with the concurrent destruction of mangroves (especially in the past). As the demand for shrimp and fish, locally and internationally, increases the temptation to exploit mangrove land by clearing and putting in shrimp farms increases. Once the shrimp farms have failed, due to acid sulphate soils, disease and overuse of antibiotics, they are turned into salt farms, abandoned or taken over by local people for a very basic form of rearing fish.

310. There are a many less well known impacts of transboundary trade on critical habitats. Trade in mangrove products (shrimp, charcoal, wood, honey etc) with countries nearby or globally is also having a major impact on

sustainability of mangroves. The aquarium and live fish trade also encourages local people to dynamite or poison reefs to capture fish. As China becomes more affluent this trend will increase unless strict regulations are enforced and alternative means of obtaining coral fish (both live food fish and aquarium fish) can be developed. Destructive fishing practices are also widespread across the BOBLME. One example is the stunning of fish by cyanide or blasting. The fish are caught and then revived for the live fish trade or aquarium trade. The values of these fish are very high so it is difficult to put an end to these practises. The Marine Stewardship Council (MSC) and the Marine Aquarium Council (MAC) are dedicated to introducing sustainable fishing in coral reefs, and with the aid of experts, it developed standards for sustainable fishing and seafood traceability The MSC-labeled seafood comes from, and can be traced back to, a sustainable fishery. Other destructive fishing methods impact the habitats. For example, foreign fishermen working for one night on a seagrass bed may wipe out the livelihoods of local people for weeks. Inappropriate fishing gear tears up underground rhizomes and push nets damage seagrass beds and also remove many animals.

311. Gleaning by local communities for molluscs, seahorses for Chinese medicine and sea cucumbers reduces biological diversity and can damage the seagrass by trampling. As the value of these products rises, more and more are taken from the seagrass beds. Even trade in sea urchins and starfish is taking its toll and trophic relationships may be broken.

312. Building materials such as lime, coral blocks and sand are taken from reefs and used illegally. Sometimes these building materials are taken to other countries that would not allow such practices. Trade in coral has been reduced by awareness campaigns and enforcement of regulations but it continues in many regions. 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, which entails the dredging of a canal to enable faster sea travel between the east and west coasts to prevent ships having to sail 1100 km around Sri Lanka is also of transboundary concern. The canal 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.

### 5.2.4 Pollution and introduced pests

313. Other transboundary threats 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. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is also a problem in smothering coral and ghost fishing. Herbicides enter coastal waters from spray drift, leaching, run-off and accidental spills. Macinnis-Ng & Ralph (2003) found that Atrazine, Diuron and Irgarol 1051 impacted seagrass but that Iragarol 1051 and Diuron severely affected plants although they recovered after exposure to Atrazine. The likelihood of oil spills is very high in the BOBLME but the contingency plans are unknown. Not much is known about introduced marine species. They are brought into countries on the hulls of ships, as ballast water or when exotic species are brought in for culture. It is difficult to decide whether a species is an exotic if a comprehensive inventory is not available for indigenous species.

### 5.2.5 Climate related events

314. A major shared transboundary dimension to critical habitat degradation is climate change. Obviously there will be many local differences in the effect of global climate change around the BOBLME, in the region as a whole it is predicted to result in (i) ocean acidification (ii) sea level change; (iii) rising sea surface temperatures; (iv) changes in rainfall (decrease in some areas and increase in others); and (v) possible increased frequency of storms and cyclones.

315. Relative sea level rise may be a threat to mangroves, especially in areas where sediment surface elevation is not keeping pace with sea level rise and there is limited area for landward migration. More research is needed to assess the likely impacts, although better management of mangrove resources, restoration programmes and increases in strategically designed protected area networks that include mangrove will help to mitigate any deleterious effects (Gilman, et al., 2007).

316. Global climate change may have number of deleterious effects on corals. Sea level rise may cause lack of light at deeper levels; sea temperature warming is associated with coral bleaching for which the consequences are dire if the bleached corals are prevented from growing their zooxanthellae by smothering by algal turf. 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.

317. Global climate change will also affect seagrass beds (Bjork, et al., 2008). Rising sea levels may adversely impact seagrass communities due to increases in water depths above present beds. The depth limit of seagrass is usually governed by light, and sea level rise will reduce light at the limiting edge and plants will die. It is possible that seagrass beds may move towards the shore, as long as there are no impediments to their expansion. Changed currents causing erosion and increased turbidity and seawater intrusions higher up on land or into estuaries and rivers will also favour land-ward seagrass colonisations. Changing current patterns can either erode seagrass beds or create new areas for seagrass colonization. Increased acidification of the sea (Doney, et al., 2009) may also be beneficial for seagrass. Most seagrass species use $HCO_3^-$ inefficiently but photosynthesis increases with increased dissolved $CO_2$ concentration.

## 5.3 Pollution

### 5.3.1 Transboundary nature of pollution

318. Pollution is potentially transboundary, however, two conditions need to be met before they can be considered strictly transboundary (i) the impacts of the contaminant/pollutant occur within the waters of a country that is not generating the contaminant or pollutant and, (ii) that the combined impacts are having a basin scale impact. In the BOBLME, with the possible exception of the long-term issue of expansion of bottom water anoxia in the upper Bay of Bengal, the threat from plastics and fishing gear, and 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, most issues are probably more of local concern.

319. However, these issues can be included as transboundary issues if the ecosystem degradation/loss contributes to a global environmental problem and finding regional solutions is considered a global environmental benefit. Some of the issues fall into this category.

320. Although some pathogenic bacteria and viruses can remain viable for up to several months in the marine environment, they are generally unlikely to be transported long distances from their point of discharge into the marine environment when the organisms are deposited in sediments and relatively immobile sewage-borne pathogens (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.

321. 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.

322. 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.

323. 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.

324. 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.

325. Many PTSs undergo long-range transport in the atmosphere or via other pathways. Therefore, PTSs are likely to have a transboundary distribution, both within or outside of the BOBLME. Because of the potentially serious consequences of these compounds, the lack of information regarding the levels and effects of PTSs in the BOBLME is a concern.

326. The bulk of riverine sediment inputs to the ocean settle out near the river mouth, so the effects of sedimentation are generally localised; even in the Ganges-Brahmaputra-Meghna system that is subject to high natural sediment inputs. Sedimentation is, therefore, may not have a strong transboundary dimension, in the strict sense. Most metals also remain localised near their source, the exceptions being mercury and lead. 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.

## 6. BIBLIOGRAPHY

Abu Hena, M. K. (2007). Seagrass Halodule pinifolia, H.uninervis and Halophila beccarii. In M. M. Rahaman, *Encyclopedia of flora and fauna of Bangladesh.* Dhaka: Asiatic Society of Bangladesh.

Abu Talib, A., Mohammad Isa, M., Saupi, M. I., & Yusof, Y. (2003). Status of demersal fishery resources of Malaysia. In G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R. A. Valmonte-Santos, C. Luna, et al., *Assessment, management and future directions for coastal fisheries in Asian countries* (pp. 83-136). Penang, Malaysia: WorldFish Center Conference Proceedings 67.

ADB. (2010). *Achieving the millennium goals in an era of uncertainty.* Manila, Philippines: Asia Development Bank - Asia Pacific Report.

ADB. (2009). *Key Indicators for Asia and the Pacific 2009.* Mandaluyong, Philippines: Asian Development Bank.

Ali, M. (2003). *National report of the Maldives.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Angell, C. L. (2004). *Review of critical habitats: Mangroves and coral reefs.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Anon. (2010). *Human traffickers target young Cambodian men for fishing industry.* Voice of America. www.Voanews.com.

APFIC. (2009). *FAO/APFIC/SEAFDEC Workshop on the assessment and management of offshore fisheries resources in south and southeast Asia, 17-19 June 2008, Bangkok, Thailand.* Bangkok, Thailand: FAO Regional Office for Asia and the Pacific. RAP publication 2009/13.

APFIC. (2007). Managing fishing capacity and IUU fishing in the Asian region. *Workshop Report. RAP publication 2007/18.* Bangkok, Thailand: Food and Agriculture Organisation of the United Nations.

APFIC. (2008). *Status and potential of fisheries and aquaculture in Asia and the Pacific 2008.* FAO Regional Office for Asia and the Pacific. RAP publication 2008/15.

APFIC. (in press). *Status and potential of fisheries and aquaculture in Asia and the Pacific 2010.* Bangkok: FAO Regional Office for Asia and the Pacific.

Ashbolt, N. (1995). Human health risk from micro-organisms in the Australian marine environment. In L. P. Zann, & D. Sutton, *State of the marine environment report for Australia. Technical annex 2. Pollution. Great Barrier Reef Marine Park* (pp. 31-40). Canberra, Australia.

Baulch, B., Weber, A., & Wood, J. (2008). *Social protection index for committed poverty reduction.* Mandaluyong, Philippines: Asian Development Bank.

Bayu. (2009). *The stories of Indonesian coral reef ecosystem conservation.* Jakarta, Indonesia. 103pp: COREMAP II. Department of Marine Affiars and Fisheries.

Belkin, I. M. (2009). Rapid warming of Large Marine Ecosystems. *Progress in Oceanography* , 207-213.

Blaber, S. J. (2009). Relationship between tropical coastal habitats and (offshore) fisheries. In Nagelkerken, *Ecological connectivity among tropical coastal ecosystems* (pp. 533-564). Netherlands: Springer.

Blindheim, J., & Forn, L. (1980). *A survey of the coastal resources of Sri Lanka.* Colombo, Sri Lanka: Fisheries Research Station, Bergen. Report No.III.

BOBLME/REP/1. (2003). *Report of the first regional workshop of the Bay of Bengal Large Marine Ecosystem (2 volumes).* Pattaya, Thailand: Unpublished report at www.BOBLME.org.

BOBLME/REP/2. (2003). *Report of the preparatory meeting for the second Regional Workshop of the BOBLME Programme.* Penang, Malaysia: Unpublished provisional report at www.BOBLME.org.

BOBLME/REP/2RW. (2004). *Report of the second regional workshop of the BOBLME, Colombo, Sri Lanka, 25-29 October, 2004.* Colombo, Sri Lanka: Unpublished provisional report at www.BOBLME.org.

Brown, K., Daw, T., Rosendo, S., Bunce, M., & Cherrett, N. (2008). *Ecosystem services for poverty alleviation: Marine and coastal situation analysis.* Ecosystem Services for poverty alleviation (ESPA). Synthesis report funded by DFID.

Cardinale, M., Duto, N., & Hernroth, L. (2009). Reconstructing historical trends of small pelagic fish in the Java Sea using standardized commercial trip based catch per unit of effort. *Fisheries Research* , 151-158.

Cesar, H. J., Burke, L., & Pet-Soede, L. (2003). *The economics of worldwide reef degradation.* Zeist, Netherlands: Cesar Environmental Economics Consulting, Arnhem and WWF-Netherlands http:/assets.panda/downloads/.

Chan, F., Barth, J. A., Lubchenco, J., Kirincich, A., Weeks, H., Peterson, W. T., et al. (2008). Emergence of anoxia in the California Current large marine ecosystem. *Science 319:* 920.

Changsang, H., & Poovachiranon, S. (1994). The distribution and species composition of seagrass beds alaong the Andaman Sea coast of Thailand. *Phuket Marine Biological Center Research Bulletin, 59* , 43-52.

Changsang, H., Satpoomin, U., & Poovachiranon, S. (1999). *Maps of coral reefs in Thai waters. Volume2: The Andaman Sea.* Bangkok, Thailand (in Thai): Department of Fisheries.

Chavan, V. S., Jagtop, T. G., & Untawale, A. G. (1992). *Asia Pacific mangrove information network (APMIN) a conceptual model.* ISME Mangrove Ecosystems Technical Report, 5.

Chemicals, U. (2003). *Regionally based assessment of persistent toxic substances. Indian Ocean regional report.* Geneva, 93 pp: UNEP Chemicals .

Chemicals, U. (2002). *Regionally based assessment of persistent toxic substances. Southeast Asia and south Pacific regional report.* Geneva, 126 pp: UNEP Chemicals .

Chia, L. S. (2000). *Overview of Impact of Sewage on the Marine Environment of East Asia: Social and Economic Opportunities.* EAS/RCU Technical Report Series No. 15. 82 pp.

CMFRI. (2006). *Annual Report 2005-2006.* Kochi: Central Marine Fisheries Research Institute.

CMFRI. (2006). *Marine Fisheries Census 2005.* Kochi: Central Marine Fisheries Research Institute .

Conservation International. (2008). *Economic values of coral reefs, mangroves and seagrasses: A global comparison.* Arlington, USA: Centre for Applied Biodiversity Science, Conservation International.

CPBC. (2008). *Status of water quality in India – 2007.* Dehli, India: Central Pollution Control Board, Ministry of Environment and Forests. 96 pp + annexure.

Danielson, F., Soresen, M. K., Olwig, M. F., Selvam, V., Parish, V., Burgess, N. D., et al. (2005). The Asian tsunami: a protective role for coastal vegetation. *Science, 310* , 643.

Delgado, C. L., Wada, N., Rosegrant, M. W., Meijer, S., & Ahmed, M. (2002). *Fish to 2020: supply and demand in changing global markets.* Penang, Malaysia: IFPR/WFC www.worldfishcenter.org/pubs/fish-to-2020/fish-to-2020.htm.

DESA. (2010). *World Urbanization Prospects: The 2009 revision.* United Nations, Department of Economics and Social Affairs. http://esa.un.org/undp/wup/index.htm.

Deya, M., Rabb, M. A., Paraguasa, F., Piumsombunc, S., Bhattad, R., Alamb, M. F., et al. (2005). Fish consumption and food security: a disaggregated analysis by types of fish and classes of consumers in selected countries. *Aquaculture Econonics and Management. Vol. 9 (1 & 2)* , 89-111.

Diaz, R. J., & Rosenberg, R. (1995). Marine benthic hypoxia: A review of its ecological effects and the behavioural responses of benthic marine macrofauna. *Oceanography and Marine Biology: An Annual Review 33* , 245-303.

DoE (Department of Environment, Malaysia). (2005). *Malaysia environmental quality report 2004.* Kuala Lumpur, Malaysia: Department of Environment, Ministry of Natural Resources and Environment.

DoE (Department of Environment, Malaysia). (2006). *Malaysia environmental quality report 2005.* Kuala Lumpur, Malaysia: Department of Environment, Ministry of Natural Resources and Environment.

DoE (Department of Environment, Malaysia). (2007). *Malaysia environmental quality report 2006.* Kuala Lumpur, Malaysia: Department of Environment, Ministry of Natural Resources and Environment.

DoE (Department of Environment, Malaysia). (2008). *Malaysia environmental quality report 2007.* Kuala Lumpur, Malaysia: Department of Environment, Ministry of Natural Resources and Environment.

DoE (Department of Environment, Malaysia). (2009). *Malaysia environmental quality report 2008.* Kuala Lumpur, Malaysia: Department of Environment, Ministry of Natural Resources and Environment.

Doney, S. C., Fabry, V. J., Feely, R. A., & Kleypas, J. A. (2009). Ocean acidification: the other $CO_2$ problem. *Annual Review of Marine Science, 1* , 169-192.

Duce, R. A., LaRoche, J., Altieri, K., Baker, A., Capone, D. G., Cornell, S., et al. (2008). Impacts of atmospheric anthropogenic nitrogen on the open ocean. *Science 320* , 893-897.

Dumont, E., Harrison, J. A., Bakker, E. J., & Seitzinger, S. P. (2005). Global distribution and sources of dissolved inorganic nitrogen export to the coastal zone: Results from a spatially explicit, global model. *Global Biogeochemical Cycles 19* , GB4.

Dwivedi, S. N. (1993). Long-term variability in the food chain, biomass yield and oceanography of the Bay of Bengal Ecosystem. In K. Sherman, L. M. Alexander, & B. D. Gold, *Large Marine Ecosystems: Stress, Mitigation, and Sustainability.* (pp. 43-52). Washington, DC: AAAS Pres.

Dwivedi, S. N., & Choubey, A. K. (1998). Indian Ocean large marine ecosystems: Need for national and regional framework for conservation and sustainable development. In K. Sherman, E. Okewa, & M. Ntiba, *Large marine ecosystems of the Indian Ocean: Assessment, sustainability, and management.* (pp. 361-368). Cambridge, MA: Blackwell Science Inc.

Economopoulous, A. P. (1993). *Assessment of sources of air, water, and land pollution. A guide to rapid source inventory techniques and their use in formulating environmental control strategies. Part 1: Rapid inventory techniques in environmental pollution.*

Edeson, W. (2004). *Review of legal and enforcement mechanisms in the BOBLME region.* Unpublished report prepared for the BOBLME Programme. Unedited verion at www.BOBLME.org.

Ellison, W. (1998). Managing mangroves with benthic biodiversity in mind: moving beyond roving banditry. *Journal of Sea Research, 59* , 2-15.

EPI. (2010). *Environmental performance index*. Retrieved July 2010, from http://epi.yale.edu

Ertemeijer, P. L., & Lewis, R. R. (1999). *Planting mangroves on intertidal mudflats: habitat restoration or habitat conversion.* Proccedings of the Regional Seminar for East and Southeast Asia Countries. Ecotone VIII, Ranang and Phuket Provinces, southern Thailand 23-28 May 1999.

Ertemeijer, R. A., & Bualuang, A. (1998). Participation of local communities in mangrove forest rehabilitation in Pattani Bay, Thailand: Learning from success and failures. In *Strategies for wise use of wetlands: Best practices in participatory management. Proceedings of a workshop at the 2nd International Conference on wetlands and development (Nov, 1998)* (pp. 27-35). Dakar, Senegal.

ESCAP. (2009). *Key trends and challenges on international migration and development in Asia and the Pacific: findings from UN expert group meeting on International migration and development in Asia and the Pacific, 20-21 September 2008.* Bangkok, Thailand: United Nations Economic and Social Commission for Asia and the Pacific.

ESCAP. (2010). *Statistical Yearbook for Asia and the Pacific 2009.* http://www.unescap.org/stat/data/syb2009.

FAO Country profiles. (2010). *Food and Agriculture Organisation of the United Nations. Fisheries and Aquaculture. Geoinfo*. Retrieved July 2010, from http://www.fao.org/fishery/geoinfo/en

FAO Fishstat. (2010). *Fishstat plus: Universal software for fishery statistical time series. Version 2.3.2000*. Retrieved July 2010, from http://www.fao.org/fishery/statistics/software/fishstat/en

FAO. (2008). *State of the World fisheries and aquaculture.* Rome, Italy: Food and Agriculture Organisation of the United Nations.

FAO. (2009). *The state of food insecurity in the Wold economic crisis - impacts and leesons learnt.* Rome, Italy: Food and Agriculture Organisation of the United Nations.

Feagin, R. A., Mukherjee, N., Shanker, K., Baird, A. H., Cinner, J., Kerr, A. M., et al. (2010). Shelter from the storm? Use and misuse of coastal vegetation shields for managing natural disasters. *Conservation Letters, 3* , 1-11.

Field, C. (1996). *Restoration of mangrove ecosystems.* Yokohama, Japan: International Society for Mangrove Ecosystems.

Fonseca, M. S., Julius, B. E., & Kenworthy, W. J. (2000). Integrating biology and economocs in segrass restoration: How much is enough and why? *Ecological Engineeering, 15* , 227-237.

Fox, H. E., Pet, J. S., Dahuri, R., & Caldwell, R. L. (2000). Coral reef restoration after blast fishing in Indonesia. *Proceedings 9th International Coral Reef Symposium 23-27 October 200.* Bali, Indonesia.

GESAMP. (1993). Impact of oil and related chemicals and wastes on the marine environment. . *GESAMP Reports and Studies no. 50* , 180 pp.

GESAMP. (2001). Protecting the oceans from Land based Activities. Land-based sources and activities affecting the quality and uses of marine, coastal and associated freshwater environment. *GESAMP Reports and Studies No. 71* , 162 pp.

GESAMP. (1990). The state of the marine environment. *GESAMP Reports and Studies no. 39* , 111pp.

Giesen, W., Wulffraat, W., Zieren, M., & Scholten, L. (2006). *Mangrove guidebook for southeast Asia.* Bangkok, Thailand: FAO Regional Office for Asia and the Pacific. RAP Publication 2006/07.

Gilman, E. L., Ellison, J., Duke, N. C., & Field, C. (2007). Threats to mangroves from climatic change and adaptation options. *Aquatic Botany, 89.* , 237-250.

Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, T., et al. (2010). Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* , 1-6.

Giri, C., Zhu, Z., Tieszen, L. L., Singh, A., Gillette, S., & Kelmelis, J. A. (2008). Mangrove forest distributions and dynamics (1975-2005) of the tsunami-affected region of Asia. *Journal of Biogeoagraphy, 35* , 519-528.

GOI. (2007). *Handbook on Fisheries Statistics 2006.* New Delhi: Government of India, Ministry of Agriculture, Department of Animal Husbandsary, Dairying and Fisheries.

Green, E. P., & Short, F. T. (2003). *World Atlas of Seagrasses.* Berkley, USA. 298pp: UNEP World Conservation Monitoring Centre, University of California Press.

Gunawarden, M., & Rowan, J. S. (2005). Economic valuation of a mangrove ecosystem threatened by shrimp aquaculture in Sri Lanka. *Environmental Management 36* , 535-550.

Haida, T. (2008). *Saving the coral biodiversity on St Martin's Island*. Retrieved from http://www.groundreport.com/World/Saving-the-coral-biodiversity-of-St-Martins-island/2861723

Heisler, J., Gilbert, P. M., Burkholder, J. M., Anderson, D. M., Cochlan, W., Dennison, W. C., et al. (2008). Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae 8* , 3-13.

Helly, J. J., & Levin, L. A. (2004). Global distribution of naturally occurring marine hypoxia on continental margins. *Deep-sea Research Part I 51* , 1159–1168.

Holmgren, S. (1994). *An environmental assessment of the Bay of Bengal region.* Chennai, India. 258pp: BOBP/REP/67.

Hoon, V. (1997). Coral reefs of India: review of their extent, condition, research and management status. In V. Hoon, K.-C. Chong, R. Roy, R. Bierhuizen, J. Rubens, & H. Kanvinde, *Regional workshop on the conservation and sustainable management of coral reefs. Vol 1.* Rome, Italy: Food and Agriculture Organisation of the United Nations.

Hossain, M. M. (2003). *National Report of Bangladesh.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

IMM. (2003). *Coastal migration and mobility.* Exeter, UK: IMM Ltd. Coastal livelihoods information paper - from Sustainable Livelihoods Project funded by DFID Policy Research Programme.

IMM. (2005). *Understanding the factors that support or inhibit livelihood diversification in coastal Cambodia.* Exeter, UK: IMM ltd. Report from the sustainable coastal livlihoods project fund by DIFD policy reserach programme.

IMM/ICM. (2003). *Sustainable coastal livelihoods: Policy and coastal poverty in the western Bay of Bangal.* Exeter, UK: IMM Ltd. Report from the Sustainable Coastal Livelihoods Project funded by DIFD Policy Research Programme.

IOM. (2008). *World Migration Report.* Bangkok, Thailand: International Migration Organisation. http://www.iom.int/jahia/jsp/index.jsp.

IOTC. (2009). *Report of the Twelth Session of the Scientific Committee in 2009.* Victoria, Seychelles: Indian Ocean Tuna Commission.

Jagtap, T. G., & Untawale, A. G. (1999). Atoll mangroves and associated flora from Republic of Maldives, Indian Ocean. *ISME Mangrove Ecosystem Techical Report, 5* , 17-24.

Jagtap, T. G. (1992). Marine flora of Nicobar group of islands in the Andaman Sea. *Indian Journal of Marine Sciences 21* , 56-58.

Jayanthi, M. L., Gnanppazham, L., & Ramachandran, S. (2007). Assessment of impact of aquaculture on mangrove environments in the south east coast of India using remote sensing and goegraphical information system (GIS). *Asian Fisheries Science, 20* , 325-338.

Joseph, L. (2003). *National report of Sri Lanka.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Joseph, M. M., & Jayaprakash, A. A. (2003). *Status of expolited marine fishery resources of India.* Kochi, India: Central Marine Fisheries Research Institute.

Juntarashote, K. (2003). *National Report of Thailand.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Kaewnern, M., & Wanvoralak, S. (2003). *Overview of status and trends of 'trash fish' from marine fisheries and their utilization, with special reference to aquaculture.* Unpublished report to APFIC.

Kaly, U. L. (2004). *Review of land-based sources of pollution to coastal and marine environments in the BOBLME region.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLMME.org.

Kanal, A. H., & Short, F. (2009). A new record of seagrass Halophila beccarii Ascherson in Bangladesh. *CMU Journal of Natural Sciences, 8* , 201-206.

Keeling, R. F., & Garcia, H. E. (2002). The change in oceanic $O_2$ inventory associated with recent global warming. *Proceedings of the National Academy of Sciences 99* , 7848–7853.

Kelleher, G., Bleakley, C., & Wells, S. (1995). *A global representative system of marine protected areas: Volume III: Central Indian Ocean, Arabian Seas, East Africa and East Asian Seas.* Washington, D.C., USA: The World Bank.

Kumar, A. (2008). *"Oil poaching" Controversy in the Bay of Bengal.* South Asia Analysis Group.

Kumar, R. *Conservation and managemant of mangroves in India, with special reference to the state of Goa and the middle Andaman Islands.* Food and Agriculture Organisation of the United Nations. www.fao.org/docrep/x8080e/x8080e07.htm.

Laedsgaard, P., & Johnson, C. (2001). Why do juvenile fish utilise mangrove habitats? *Journal of Experimental Marine Biology and Ecology, 71 (3)* , 229-252.

Landscan. (2002). *Landscan 2002 global population database*. Retrieved July 2010, from www.ornl.gov/sci/gist/landscan

Levin, L. A., Ekau, W., Gooday, A. J., Middleberg, J. J., Naqvi, S. W., Neira, C., et al. (2009). Effects of natural and human-induced hypoxia on coastal benthos. *Biogeosciences 6* , 2063–2098.

Levy, G. (2008). Coral reef restoration through a two stepped "coral gathering" concept.[Abstract 541]. *Proceedings of the 11th International Reef Symposium, Jul 7-11, 2008.* Fort Lauderdale, Florida.

Lewis, R. R. (1998). *Key concepts in successful ecological restoration of mangrove forests.* Ranong, Thailand: Paper presented to the 2nd TCEP workshop 11pp.

Lim, L. C. (1990). *Carrying capacity assessment of the Palau Payer marine park, Malysia - BOBP.* www.fao.org/docrep/x5626e/x5626e07/htm.

Macinnis-Ng, C. M., & Ralph, P. J. (2003). Short-term response and recovery of Zostera capricorni photoynthesis after herbicide exposure. *Aquatic Botany, 76* , 1-15.

Maldives Ministry of Planning and National Development. (2010). Retrieved from http://www.planning.gov.mv/en/.

MAP. (2010). *Mangrove Action Project*. Retrieved August 2010, from http://mangroveactionproject.org/

Mazid, M. A., & Rahman, M. J. (2005). *Studies on the impact of marine set-bag-net (MSBN) on the marine fisheries resources of Bangladesh.* Cox's Bazaar, Bangladesh: Final Report, Bangladesh Fisheries Research Institute, Marine Fisheries & Technology Station.

Menge, B. A. (2008). Emergence of anoxia in the California Current large marine ecosystem. *Science 319* , 920.

Mollah, A. R. (1997). *Status of coral and associated resources in Bangladesh.* Rome, Italy: Food and Agriculture Organisation of the United Nations. Regional Workshop on Conservation and Management of coral reefs. http://www.fao.org/docrep/x5626e/x5627e08.htm.

Mome, M. A., & Arnason, R. (2007). *The potential of the artisanal hilsa fishery in Bangladesh: an economically efficient fishery.* Reykjavek, Iceland: The United Nations University.

Mukai, H., Aioi, K., Lewmanomont, K., Matsumasu, M., Nakaoka, M., Nojima, S., et al. (1999). Dugong grazing on Halophila beds in Haad Chao Mai National park, Trang province, Thailand -how many dugongs can survive? In I. Koike, *Effects of grazing and disturbance by dugongs and turtles on tropical seagrass ecosystems.* (pp. 239-254). Tokyo, Japan: Ocean Reserach Institute. University of Tokyo.

Myint, P. (2003). *National report of Myanmar.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Nagelkerken, I., Blaber, S. J., Boullon, S., Gree, P., Haywood, M., Kirton, M., et al. (2008). The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany 89* , 155-185.

Naqvi, S. W., Naik, H., D'Souza, W., Narvekar, P. V., Paropkari, A. L., & Bange, H. W. (2010). Carbon and nitrogen fluxes in the North Indian Ocean. In K. K.-M. Liu, *Carbon and nutrient fluxes in continental margins: A global synthesis* (pp. Pp. 180–192). New York: Springer-Verlag.

Naqvi, S. W., Naik, H., Jayakumar, D. A., Shailaja, M. S., & Narvekar, P. V. (2006). Seasonal oxygen deficiency over the western continental shelf of India. In L. N. Neretin, *Past and present water column anoxia* (pp. 195-224). NATO Science Series, IV.

Noble, A., Pillai, G. N., Kulkarni, G. M., Kurup, N. K., Reuben, S., Sivadas, M., et al. (1992). Assessment of mackerel stock along the Indian Coast. *Indian Journal of Fisheries 39 (3,4)* , 119-124.

Novak, A. B., Hines, E., Kwan, D., Parr, L., Tun, M. T., Win, H., et al. (2009). Revised ranges of seagrass species in the Myeik Archipelago, Myanmar. *Aquatic Botanay, 91.* , 250-252.

NRC. (1995). *Clean ships, clean ports, clean oceans. Controlling garbage and plastic wastes at sea. National Research Council. National Academy Press, Washington, D.C.* Washingto, D.C.: National Research Council. National Academy Press.

NRC. (2002). *Oil in the sea III: Inputs, fates and effects.* . Washington, D.C. 265 pp. : National Research Council. National Academy Press.

ODI. (2010). *The global financial crisis and developing countries.* London, UK: Overseas Development Institute: Phase 2 synthesis working group Paper 316.

Omar, I. H. (2003). *National report of Malaysia.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Ove, H. (1999). Climate change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research, 50* , 1323-1650.

Panjarat, S. (2008). *Sustainable fisheries in the Andaman Sea coast of Thailand.* New York: Division for Oceans Affairs, Office of Legal Affairs, the United Nations.

Phongsuwan, N., Chaimongkol, Y., Paokanta, S., & Areechon, P. (2008). Status of coral reefs in the Surin and Similan Archipelagos,Thailand. In D. O. Obura, J. Tamelander, & O. Linden, *Ten years after bleaching: Facing the consequences of climate cahnge in the indian Ocean. CORDIO Status Report 2008.* (pp. 3-10). Mambasa: CORDIO/Sida - SAREC. http://www.cordio.org.

Preston, G. L. (2004). *Review of the status of shared/common marine living resource stocks and stock assessment capability in the BOBLME region.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Purnomohadi, S. H. (2003). *National report of Indonesia.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Rabalais, N. N., Diaz, R. J., Levin, L. A., Turner, R. E., Gilbert, D., & Zhang, J. (2010b). Dynamics and distribution of natural and human-caused hypoxia. *Biogeosciences 7* , 585–619.

Rajasuriya, A. H., Zahir, H., Muley, B. R., Subramanian, R., Venkataraman, M. V., Wafer, S. M., et al. (2000). Status of corals in South Asia: Bangaldesh,India,Maldives and Sri Lanka. In C. Wilkinson, *Status of coral reefs of the world: 2000* (pp. 95-113). A GCRMN Publication.

Rajasuriya, A. (2005). Status of coral reefs in Sri Lanka in the aftermath of the 1998 coral bleaching event and 2004 tsunami. In D. Souter, & O. Linden, *Coral Reef Degradation in the Indian Ocean: Status Report 2005.* (pp. 83-96). Kalmar, Sweden: CORDIO. Departmant of Biology and Environmental Science, University of Kalmar.

Rajasuriya, A. (2002). Status report on the conditon of reef habitat in Sri Lanka. In O. Linden, D. Souter, D. Wilhelmsson, & D. Obura, *Coral reef degradation in the Indian Ocean: Status report 2002.* (pp. 139-148). Stockholm, Sweden: CORDIO.

Ramesh, R., Purvaja, R., Lakshmi, A., Newton, A., Kremer, H. H., & Wiechselgartner, J. (2009). *South Asia Basins: LOICZ Global Change Assessment and Synthesis of River Catchment - Coastal Sea Interaction and Human Dimensions.* LOICZ Research & Studies No. 32. GKSS Research Center, Geesthacht, 121 pages.

Reefbase. (2010). Retrieved August 2010, from Reefbase: htpp:/www.reefbase.org

Rosenberg, R., & Diaz, R. J. (2008). Spreading dead zones and consequences for marine ecosystems. *Science 321* , 926-929.

Rudi, E., Elrahimi, S. A., Irawan, S., Valentino, R. A., Surikatai, Yulizar, et al. (2008). Post tsunami status of coral reef and fish in northern Aceh. In D. O. Obura, J. Tamelander, & o. Linden, *Ten years after bleaching - facing the consequences of climate change in the Indian Ocean.* (pp. 151-160). Mombasa: CORDIO/Sida-SAREC. http//:www.cordio.org.

Salagrama, V. (2006). *Trends in poverty and livelihoods in coastal fishing communities of Orissa State, India.* Rome, Italy: FAO Fisheries Technical Paper 490.

Sampath, V. (2003). *National report of India.* Unpublished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Sampath, V. (2003). *National report of India.* Unpulished report prepared for the BOBLME Programme. Unedited version at www.BOBLME.org.

Sasekumar, A., Chong, C. V., Lim, K. H., & Singh, H. R. (1994). The fish community of the Matang mangrove waters, Malaysia. In S. Sudara, C. R. Wilkinson, & C. L. Ming, *Proceedings of the 3rd ASEAN-Australian Symposium on Living Coastal Resources, 16-20 May 1994* (pp. 457-464). Bangkok, Thailand.

Satapoomin, U., Phongsuwan, N., & Brown, B. E. (2006). A preliminary synopsis of the effects of the Indian Ocean tsunami on the coral reefs of western Thailand. *Phuket Marine Biological Center Research Bulletin, 67.* , 77-80.

SAUP. (2010). *Sea Around Us Project*. Retrieved July 2010, from www.searoundus.org

SEAFDEC. (2009). *Fishery Statistical Bulletin of Southeast Asia.* Bangkok: SEAFDEC.

SEDAC. (2010). *Population estimation service.* Socioeconomics data and Applications Centre: http://sedac.ciesin.columbia.edu/gpw/wps.jsp.

Seitzinger, S. P., Mayorga, E., Bouwman, A. F., Kroeze, C., Beusen, A. H., Billen, G., et al. (2010). Global river nutrient export: A scenario analysis of past and future trends. *Global Biogeochemical Cycles 24* , GB0A08, doi:10.1029/2009GB003587.

Selvam, V., Ravichandran, K. K., Gnanappazham, L., & Navamuniyammal, M. (2003). Assessment of community based restoration of Pichavaram mangrove wetland using remote sensing data. *Current Science, 85* , 77-80.

Shuval, H. (2003). Estimating the global burden of thalassogenic diseases: human infectious diseases caused by wastewater pollution of the marine environment. *Journal of Water and Health 1* , 53-64.

Spalding, M. D., Ravilious, C., & Green, E. P. (2001). *Atlas of Coral Reefs.* Berkley, USA: UNEP World Conservation Montoring Centre, University of California Press.

Spalding, M.D., Kainuma, M., & Collins, L. (2010). World Atlas of Mangroves. Earthscan London and Washington DC. 319p.

Staples, D. (2009). *Review of the preliminary framework Transboundary Diagnostic Analysis of the Bay of Bengal Large Marine Ecosystem Project.* Bangkok, Thailand: Unpublished report to the FAO/BOBLME Project Regional Coordinating Unit.

Townsley, P. (2004). *Review of the coastal and marine livelihoods and food security in the BOBLME region.* Unpublished report prepared for the BOBLME Progamme. Unedited version at wwww.BOBLME.org.

Townsley, P. (2004). *Review of the coastal and marine livelihoods and food security in the BOBLME region.* Unpublished report prepared for the BOBLME Progamme. Unedited version at wwww.BOBLME.org.

Transparency International. (2010). Retrieved July 2010, from http://www.transparency.org

Tun, K., & Heiss, G. (2006). Status of coral reefs in Myanmar: post-tsunami assessment. In C. Wilkinson, D. Souter, & J. Goldberg, *Status of coral reefs in tsunami affected countries: 2005* (pp. 79-84). Townsville, Australia: Australin Institute of marine Science.

UNDP. (2009). *Human Development Report 2009. Overcoming barriers: human mobility and development.* New York, USA: United Nations Development program.

UNEP. (2008). *Marine litter in the East Asian Seas Region.* Bangkok, Thailand: COBSEA Secretariat, United Nations Environment Programme. 62 pp.

UNEP. (2009). *Marine Litter: A Global Challenge. .* Nairobi, 232 pp: UNEP.

UNEP. (2007). *World Atlas of Coral Reefs.* http://www.unep-wcmc.org /marine/coralatlas/index.htm.

UNEP/COBSEA. (2010). *State of the marine environment report for the East Asian Seas 2009.* Bangkok, 156 pp: Ed. Chou, L.M., COBSEA Secretariat.

UNEP/DA. (2009). *South Asia Environment Outlook 2009.* UNEP, SAARC and Development Alternatives, 136 pp.

UNEP/GPA. (2006). *The State of the Marine Environment: Regional Assessments .* The Hague, 246 pp.: UNEP/GPA.

UNEP/SACEP. (2001). *State of the Environment, South Asia 2001.* UNEP, 154 pp.

UNDP. (2009). *World population prospects: The 2008 revision population database.* http:esa.un.org/unpp.

UNSD. (2010). *National accounts main aggregate database.* http://unstats.un.org/unsd/snaama/Introduction.asp.

US Energy Information Administration. (2010). *Complete energy outlook 2010.* Report #:DOE/EIA-0484(2010).

Vance, D. J., Haywood, M. D., & Staples, D. J. (1990). Use of a mangrove estuary as a nursery area by postlarval and juvenile banana prawns Penaeus merguiensis de Man, in northern Australia. *Estarine, Coastal and Shelf Science, 31* , 689-701.

Vance, D. J., Haywood, M. D., Heales, D. S., Kenyon, R. A., Loneragon, N. R., & Pendrey, R. C. (1996). How far do prawns and fish move into mangroves? Distribution of juvenile banana prawns Penaeus merguiensis de Man in a tropical mangrove forest in northern Australia. *Marine Ecological Progress Series, 131* , 115-124.

Verlaan, P. (2004). *Preliminary framework Transboundary Diagnostic Analysis of the Bay of Bengal Large Marine Ecosystem.* Chennai, India: BOBLME Programme.

Waycott, M., Duarte, C. M., Carruthers, T. J., Orth, R. J., Neenison, W. C., Olarnik, W. C., et al. (2009). Accelerating loss of seagrass across the globe threatens coastal ecosystems. *PNAS, 106 (30)* , 12,377-12,381.

WHO. (2008). *The global burden of disease: 2004 update.* Geneva, 146 pp.: World Health Organization.

Wilkie, M. L., & Fortuna, S. (2003). *Status and trends of mangrove area worldwide. Forest Resources Assessment Working Paper 63.* Rome, Italy: Food and Agriculture Organisation of the United Nations.

Wilkie, M. L., Fortuna, S., & Souksavat, O. (2003). *FAO's database on mangrove area estimates. Forest Resources Assessments Working Paper 62.* Rome, Itlay: Food and Agriculture Organisation of The United Nations.

Wilkinson, C. (2008). *Status of coral reefs in the world: 2008.* Townsville, Australia. 296pp: Monitoring Network and Reef and Rainforest Research Centre.

Wilkinson, C., Souter, D., & Goldberg, J. (2006). *Status of coral reefs in tsunami affected countries: 2005.* Townsville, Australia. 154pp: Australian Institute of Marine Science.

World Bank. (2001). *2001 World Development Indicators.* Washington, D.C., 396 pp.: The World Bank.

World Bank. (2006). *2006 World Development Indicators.* Washington, D.C., 402 pp.: The World Bank.

World Bank. (2010). *2010 World Development Indicators.* Washington, D.C., 464 pp.: The World Bank.

Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folkr, C., Halpern, B. S., et al. (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science 314 (5800)* , 787-790.

Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., et al. (2009). Rebuilding global fisheries. *Science 31, 324 (5940)* , 578-585.

Zahir, H., & Rasheed, A. (2005). Status of coral reefs of the Maldives: Recovery since the 1998 mass bleaching and the impacts of the Indian Ocean tsunami. In D. Souter, & O. Linden, *Coral reef degradation in the Indian Ocean. Status Report 2005.* (pp. 109-118). Stockholm, Sweeden: CORDIO.