# Ecosystem Health and Management of Pollution in the Bay of Bengal, Bangladesh

Support to Sustainable Management of the BOBLME Project
Bangladesh Fisheries Research Institute

*SBOBLME Pub./Rep.3*

# Ecosystem Health and Management of Pollution in the Bay of Bengal

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# Ecosystem Health and Management of Pollution in the Bay of Bengal

(*Based on workshop held on 12 June 2010 at Chittagong*)

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# Foreword

As the Bay of Bengal is a large marine ecosystem and stands by seven other countries, the management of its living resources and its habitats is not only lies responsibility with Bangladesh but also an exclusive task for all the neighboring countries. So, eight marginal countries of the BoB have already realized their need closer link and cooperation for sustainable management of the environment and fisheries resources of the BoB and its large marine ecosystem. One of the major component of BOBLME project is Maintenance of Ecosystem Health and Management of Pollution. The objective of the component is to support activities leading to an agreed on set of environmental indicators to measure the health of the BOBLME and development of a regional collaborative approach to identifying important coastal water pollution issues and to develop remedial strategies.

The marine fisheries sector of Bangladesh has so far been remained as a low priority area in the overall fisheries development programme of the country. Other issues of ecosystem health that are common throughout the coast are: environmental stresses on the water quality; the degradation of habitats that support fisheries; and the use of fishing gear that may affect the long-term sustainability of the fisheries resources. High levels of pesticides and chemicals are found along the coastal waters and sediments, especially near cities and ports. Other than this, huge population burden and associated poverty, unsustainable fishing practices and a decline in income from fisheries are contributing to crisis generation. None of the ship breaking yards in Chittagong currently have an environmental clearance.

This publication is the outcome of a workshop held at Chittagong, to review the environmental aspects of the Bay of Bangladesh water. The report will be helpful for multi-sectoral users to understand environmental scenario of the Bay of Bengal.

**Dr. Md. Gulam Hussain**
Director General
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# Acronyms and Abbreviations

| | |
|---|---|
| BELA | Bangladesh Environmental Lawyer's Association |
| BFDC | Bangladesh Fisheries Development Cooperation |
| BFRI | Bangladesh Fisheries Research Institute |
| BIMSTEC | The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation |
| BoB | Bay of Bengal |
| BOBLME | Bay of Bengal Large Marine Ecosystem |
| BOBP-IGO | Bay of Bengal Programme-Inter Governmental Organization |
| BOD | Biological Oxygen Demand |
| CCRF | Code of Conduct for Responsible Fisheries |
| CPUE | Catch Per Unit Efficiency |
| DoF | Department of Fisheries |
| DoS | Department of Shipping |
| EEZ | Exclusive Economic Zone |
| EPA | Environmental Protection Agency |
| EQS | Environmental Quality Standard values for Bangladesh |
| ESBN | Estuarine Set Bag Net |
| FAO | Food and Agricultural Organisation of the United Nations |
| GEF | Global Environment Facility |
| GoB | Government of the People's Republic of Bangladesh |
| IMO | International Maritime Organization |
| IUCN | The World Conservation Union |
| IUU | Illegal, Unreported, and Unregulated |
| MCS | Monitoring Control & Surveillance |
| MMD | Mercantile Marine Department |
| MoEF | Ministry of Environment and Forest |
| MoFL | Ministry of Fisheries and Livestock |
| MSBN | Marine Set Bag Net |
| MSY | Maximum Sustainable Yield |
| NGO | Non Government Organisation |
| POPs | Persistent Organic Pollutants |
| TED | Turtle Excluder Device |
| UNDP | United Nations Development Programme |
| VMS | Vessel Monitoring System |
| VTMS | Vessel Tracking and Monitoring System |

# Contents

# Workshop Report

## The Workshop

The workshop was held in the Conference Room of Hotel Lords Inn, Chittagong on 12 June 2010. The workshop was organized by the Bangladesh Fisheries Research Institute in collaboration with the Support to Sustainable Management of the Bay of Bengal Large Marine Ecosystem (BOBLME) project. A total of 60 participants from Research Institute, Government and Non-government Agencies, Universities actively participated in the day-long workshop.

## Opening Ceremony

The workshop was inaugurated by Mr. Muhammad Shamsul Kibria, Joint Secretary, Ministry of Fisheries and Livestock and Member, Project Steering Committee, BOBLME Project. Mr. Md. Mahabubur Rahman Khan**,** Director (Marine), Department of Fisheries was present as Special Guest. The welcome address and introduction of the workshop was given by Dr. S.U. Ahammed, Director (Research and Planning), BFRI. The Inaugural session was chaired by Dr. M.G. Hussain, National Coordinator, BOBLME- Bangladesh and Director General, BFRI.

## Technical Session

The technical session was chaired by Dr. M.G. Hussain, Director General, BFRI. The technical session started with presentation of paper (1$^{st}$ paper) from the Institute of Marine Science and Fisheries, Chittagong University by Prof. Dr. Md. M. Maruf Hossain. Prof. Hossain presented the current status of *Marine pollution in the Bay of Bengal and sustainable management*, which included presentation on *Ship breaking* *activities: threats to coastal environment and fish biodiversity - needs sustainable management*. Following the key-note presentation, *Coastal pollution issues in relation to water quality criteria and remedial strategies in the Bay of Bengal* (2nd paper) was presented by Dr. Md. Shahab Uddin, Chief Scientific Officer, Marine Fisheries and Technology Station, BFRI, Cox's Bazar. The 3rd paper on *Marine fisheries resources and its management policies in the Bay of Bengal* was presented by Dr. Md. Sharif Uddin, Assistant Director, Marine Fisheries Wing of the Department of Fisheries, Chittagong. The 4th paper on *Environmental impact on hilsa (Tenualosa ilisha) fisheries in the coastal belt of Bangladesh* was presented by Dr. Md. Anisur Rahman, Senior Scientific Officer, Riverine Station, BFRI, Chandpur. The last presentation (5th paper) was from COAST by Md. Shafiuddin on *Coastal aquaculture and alternative livelihoods in Bangladesh*, which included presentation on *Seagrasses community of Bangladesh*.

After presentation of all the papers the floor was opened for open discussion. After through and thread-bare discussions the following recommendations were adopted by the participants of the workshop.

# Summary of Recommendations

- Most of the pollution study on the Bay of Bengal focused Chittagong coast which could not represent the BoB Bangladesh coast. Detailed study on entire Bangladesh coast should be undertaken on priority basis.
- Land-based pollution should be minimized through imposing proper regulations and recycling of waste materials.
- Sources of harmful chemicals in the BoB water should be identified and proper awareness should be developed on toxic effects of chemicals.
- Specifically the sources of pollution, quantity, and their causes should be identified and possible management measures should be developed.
- Standard and uniform data on pollution status of the BoB should be developed and compared the data of neighboring regional sources.
- Research should be undertaken to know the bioaccumulation and relation of pollution with estuarine and brackishwater fisheries.
- Reliable statistic on fish catch, landing, species composition and seasonality should be generated for sustainable management of the BoB.
- Ships and other transports should not be allowed to dispose their pollutants like ballast water, oil etc. in the BoB coast.
- Propriety right of fishers' community on the BoB resources should be established.
- Capacity building of the BoB's fishers should be developed and integrated for resources management and protect environmental degradation.
- Saint Martin's Island of the BoB should be declared as Marine Protected Area and proper steps should be taken to maintain it.

# Marine pollution in the Bay of Bengal and sustainable management

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## Introduction

Bangladesh comprises a land area of 144,054 km$^2$, with a population of more than 150 million. It is bounded by India on the West, North and Northeast, by Myanmar on the East and Southeast; and the Bay of Bengal on the South. According to the International Hydrographic Bureau (IGBP 2003), the southern boundary of the Bay of Bengal (BoB) extends from Dondra head at the south end of Sri Lanka to the northern tip of Sumatra roughly along 5ºN latitude. The BoB may thus be said to lie between 5ºN and 20º30' N latitude and 800E and 95º E longitudes. The total area of the Bay is 2.2 x 106 km$^2$ (Salek and Yasuda 1995). Most of the country is low lying about 10 m above the mean sea level (Mahmood *et.al.* 1994). The Southern most part of Bangladesh is bordered by about 710 km long coastal belt of the BoB, which has the continental shelf of up to 50 m depth with an area of about 37,000 km$^2$. The (EEZ of Bangladesh lies from the base line to 200 nautical miles seaward.

The Bangladesh coastal zone includes coastal plains island, tidal flat, estuaries, neritic and offshore waters. It extends to the edge of a wide (about 20 km) continental shelf .The river net work, estuarine system and the drainage basin of Bangladesh cover also Myanmar, in addition to India, Nepal, Bhutan and China. The land area of the coastal zone is about 421,54 $km^2$. The Marine and coastal capture fisheries sector of Bangladesh is the only primary source of income and nutrition for over 484,000 households and 2.7 million family members in the coastal region of Bangladesh (ICZM 2003).

## Overview of sources of pollution

### *Land based pollution*

Municipal wastes comprise household (domestic), commercial, industrial, agricultural, street sweeping, construction debris and sanitation residues etc. The cities and human settlements in the coastal areas of Bangladesh do not have domestic waste treatment facility and therefore effluents either directly or indirectly find their way untreated into the rivers and hence ultimately to the Bay of Bengal. The two populous coastal cities, namely; Chittagong and Khulna have the prime role in the contamination of the marine environment by municipal wastes, which are discharged in the Karnaphuli and Passur rivers respectively. The largest and most populous capital city, Dhaka, although far away from the coast have also its contribution in this regard. It produces huge amount of domestic sewage and solid wastes, which mainly enter the tidal river Buriganga flowing in to the Bay of Bengal. According to 'Waste Concern' report in 2002, the amount of daily produce of wastes was 17,000 tons. According to World Bank, the amount of waste in 2025 will be 470,64 tons, which is 3 times more than the present load (Waste Concerns 2000).

The rivers, including the Karnaphuli and Passur, directly receive raw excreta daily from dense populations living on both sides of Chittagong and Khulna towns. Every day a considerable amount of blood and intestines of slaughtered animals from the Firringee Bazar slaughter house of Chittagong find their way into the River Karnaphuli and hence to the Bay of Bengal. The most common system currently adopted for the disposal of solid wastes is to dump huge quantities of the collected solid wastes on the outskirts of town ships as landfill, creating a breeding ground for houseflies and mosquitoes. The decomposition process pollutes the area emitting poisonous and obnoxious smells. The major channels which carry domestic wastes and spread into the coastal city areas causing pathogenic microbial pollution and serious health hazards during the rainy season and flood periods severity is more in the Bay (Mahmood *et. al.* 1994).

**Table 1.** Sources of pollutions

| Point Sources | Non-Point Sources |
|---|---|
| • Sewage outfall<br>• Industrial outfall<br>• Agriculture (husbandry)<br>• Sediment mobilisation<br>• Litter<br>• Aquaculture<br>• Land clearance<br>• Reclamation | • Aquaculture<br>• Agriculture (cropping)<br>• Run-off<br>• Storm surge<br>• Ground water<br>• Tide<br>• Flood<br>• Atmospheric emission<br>• Transport |

## *Status of solid waste in Bangladesh*

The Dhaka City Corporation (DCC) is responsible for solid waste Management (collection, transportation, disposal and treatment of solid waste) in the metropolitan area. It was estimated that approximately 3500 tons (Bhuiyan 1999) of solid waste are generated everyday in Dhaka city from various residential commercial, industrial activities with the per capita generation of about 0.5 kg/day (Kazi 1998). DCC can manage only about 55% of generated solid waste with its current manpower and financial capacities (Bhuiyan 1999). As per recent projections, waste to be generated by every person in Dhaka City during 2010 and 2020 would amount to 0.75 kg and 1.0 kg, respectively. Hospitals, clinics and diagnostic center usually do not maintain safe management of wastes generated from their establishments. The hazardous wastes are discharged at the city corporation’s storage waste bins, which are then mixed up with domestic solid waste and disposed at the commons dumping place.

**Table 2.** Total urban solid waste generation in Bangladesh

| Year | Total urban population | Urban population (%) total | Waste rate (kg/cap/day) | Total waste generation (Ton/day) |
|---|---|---|---|---|
| 1991 | 208,72204 | 20.15 | 0.49 | 9873.5 |
| 2001 | 288,08477 | 23.39 | 0.5 | 11,695 |
| 2004 | 327,65152 | 25.08 | 0.5 | 16,382 |
| 2025 | 784,40000 | 40.0 | 0.6 | 47,064 |

Source: Iftekhar and Hashmi (2006).

- Waste generating sources: domestic, commercial, industrial, street sweeping, health care facilities (hospitals and clinics) etc.
- Waste generation rate: 0.5 kg/capita/day
- Collection efficiency by formal systems: 40% - 50%
- Recycling by informal systems: 10-15%
- Self-disposal/illegal dumping (uncollected): 35%-50%
- Solid Waste Management cost: 5-20% of the total annual budget.
- Residential areas generate approx.: 60% of wastes.

***Industrial pollution***

Bangladesh is considered as one of the most polluting countries due to unplanned and uncontrolled industrial management practices and discharge of untreated effluents. Total of 26,446 industrial units of which 1,200 are polluting industries fewer than 13 categories. In all these industries employ about 1,15,6204 persons (SEHD 2002).

- Main polluting zones are Dhaka (Tejgaon, Hazaribag, Demra, Tongi, Joyadevpur, Narshindi, and Narayanganj),
- Chittagong (Kalurghat, Nasirabad, Sholashahar, Patenga, Kaptai, Bhatiary, Barabkunda and Fauzdarhat) and
- Khulna (Shiromoni, Khalishpur, Boyra and Rupsha).

### *Solid waste management*

When we think about waste management then we have to consider the things: reduce, reuse, recycle, recovery, stabilization, solidification, sanitary landfill, secure landfill and high temperature incineration. Stabilization is a process where additives are mixed with waste to minimize the rate of contaminant migration from the waste and to reduce the toxicity of waste. Solidification is a process employing additives by which the physical nature of the waste is altered during the process. Stabilization technologies can be applied in land disposal and site remediation. Stabilization and Landfill known as one of the cost effective treatment for inorganic waste. Major identified waste related problems are:

- Wastes being generated from industries are polluting the surrounding environment at different level (water, air and land).
- Financial expenditure increased to control waste and environment pollution due to use of old and backdated technology, use of old equipment up to their maximum ability, etc. intend of not using modern method.
- No initiatives from government provide financial support and other incentives for setting up plant for treatment of chemicals those come from industries and factories.


**Fig. 1.** Chittagong City Corporation (CCC) Garbage Treatment Plant, Bangladesh.

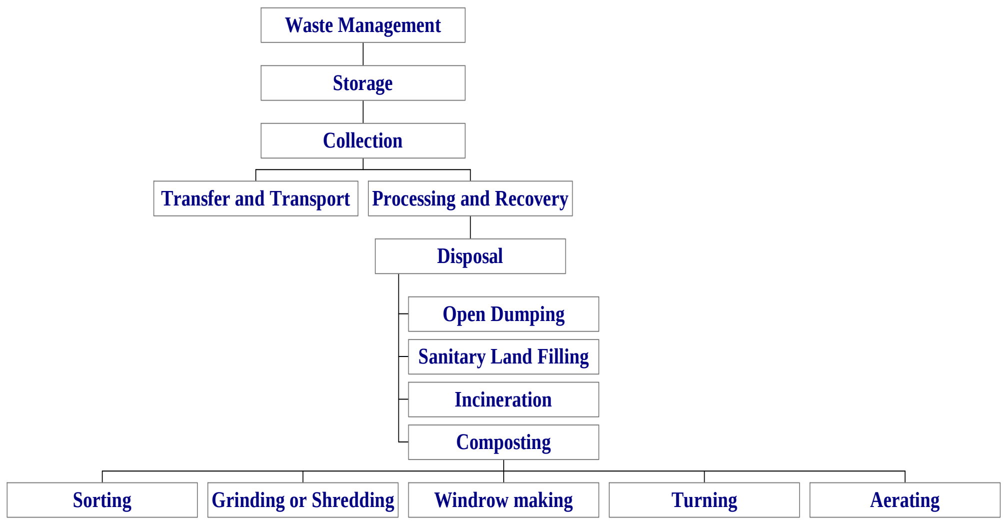


**Fig. 2.** Management Process of Solid Wastes in India.

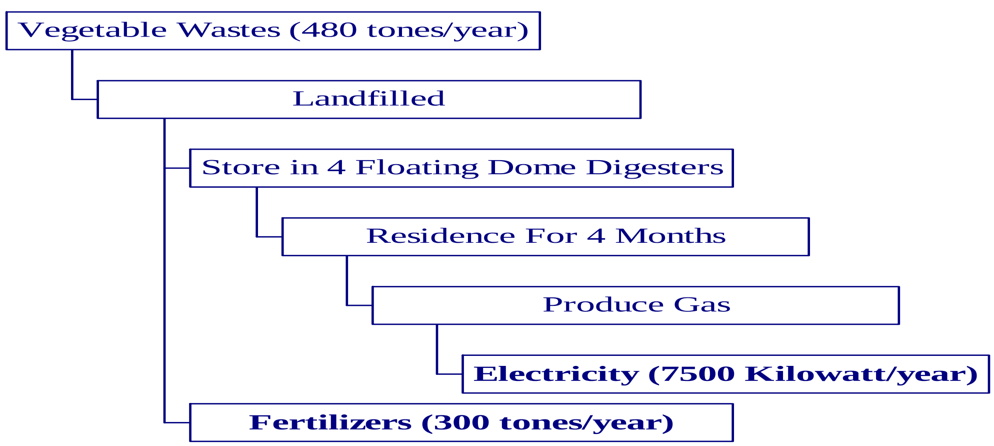


**Fig. 3.** Medium scale biogas and compost production from market garbage in Colombo, Sri Lanka

**Fig. 4.** Garbage Processing Floating Dam Digester in Sri Lanka.

**Major industries and their pollutant contribution**

- Principal polluting industries are paper and pulp, textile (dyeing and printing) and the tanneries and they possess the top position on the basis of high pollutant contribution;
- Sugar, food, fish and distilleries are also responsible for considerable waste load.
- The polluting industries discharge their liquid effluents and solids wastes into the adjacent canals, rivers, estuary and finally into the Bay of Bengal.
- The effluents are ammonia, chromium and other heavy metals from fertilizer and tanneries, phenols from pulp and paper, refinery, plastic, pharmaceuticals and paint industries. There are also other acids, alkalis, organic and inorganic waste materials.

**Table 3.** Characteristics of industrial liquid wastes of Bangladesh

| | (a) Max. conc. among 17 textile | (b) Max. conc. among 16 tanneries | (c) Max. conc. among 3 Paper & pulp industries | (d) Effluent standard for surface water |
|---|---|---|---|---|
| Parameters (mg/l) | Textile waste Water (a) | Tannery waste water (b) | Pulp and paper waste water (c) | Effluent standard (d) |
| $BOD_5$ | 8,100 | 36,000 | 600 | 50 |
| COD | 17,100 | 56,400 | 1700 | 200 |
| Suspended solids | 15,221 | 7,498 | 2,024 | 150 |
| Nitrate | 200 | 700 | - | 10 |
| Chloride | 80,000 | 62,500 | 5,900 | 600 |
| Chromium | 0.47 | 3,818 | - | 0.5 |
| Sulfide | - | 1,500 | - | 1.0 |

Source: Unnayan Shammannay (2003)

## Ship breaking activities in Bangladesh

The ship breaking activities of Bangladesh began in 1969. It has earned a good reputation for being profitable but at a great environmental cost. Various refuse and disposable materials are being discharged and spilled from scrapped ships and often get mixed with the beach soil and sea water which in turn has a negative impact on our coastal environment and biodiversity.

**Fig. 5.** Ship breaking activities contaminate the coastal soil and sea water.

## Oil pollution and oil spill

Oil spills in the BoB as well as along the river navigation route may happen along the coast and the Sundarbans by flowing water. At both Chittagong and Mongla ports, there is also risk of collision between vessels and of grounding due to engine breakdowns, navigational error or dragging of anchors. Other risk of marine pollution considered here are illegal disposal from ships, waste water from industries, farming, domestic waste water etc. The operational oil spill arises from the ships and land sources and the spilled quantity may not exceed 2,500 t/yr in Bangladesh (Table 4).

**Table 4.** Operational oil spill from land and ship sources in the Bay of Bengal, Bangladesh

| Sources | Location and Operation | Quantity (tons/Yr.) | Remarks |
|---|---|---|---|
| Land sources | ERL, Oil depots, Power Station (oil), and other oil handling facilities on land | 200-300 | Excluding loading/unloading operation from /to ship |
| Ship sources | Ship breaking area | 500 | Sitakunda area, Chittagong |
| | Loading/unloading | 100-200 | > 40,000 times/yr. |
| | Deballasting | 600 - 1,200 | 0.02 % remaining |
| | Debilging | 100 -200 | 0.2% discharged |
| | Other routine operations | -100 | Bunkering |
| **Total = 1,500 – 2,500 t/yr** | | | |

Source: Alam (2004).

## Agricultural pollution

Pesticides have been used in farming in Bangladesh since 1957. In 2009 about 45,172.43 tons of pesticides were used, as compare to 22,115.85 tons in 2004, which is more than double yearly consumption rate within 5 years (BBS 2009). If an estimated ¼$^{th}$ of all these pesticides used reaches the coast (Hossain 2004), the amount of yearly pesticide load entering into the Bay of Bengal would be about 112,293 tons. Fertilizer use is also thought to be increasing, as in BBS (2008) import of fertilizers (Urea, TSP and SSP) for the year 2002-03 was only 8,42,000 metric tons, whereas in 2003-04, 2004-05 and 2005-06, it was 2,021,000 mt, 2,531,000 mt and 2,234,000 mt respectively i.e. usage pattern is more than 2.5 times higher than that of 2003. Though, there are no estimates of how much of the fertilizers used would find their way to the sea, but certainly a significant portion of excess and unutilized fertilizers from agricultural lands finally finds their way into the Bay and contributes to chemical pollution in terms of nutrients and pesticides.

**Pollutants from aquaculture activities**

- Despite being a major export item, shrimp culture industry is categorized as "Amber–B" from its pollution point of view
- Wastes dumping from the shrimp 'ghers' and hatcheries, shrimp and fish processing centers to the adjacent coastal water bodies is a threat to the environment.

**Major pollutants and its impacts**

**a. Liquid:** Oil, lubricants, grease, TBT.

***Harmful effects***

- Coating and asphyxiation,
- Reduction of light intensity and oil coating inhibits photosynthesis; reduce exchange of oxygen and carbon dioxide,
- Damage of bird population, coating the feathers by oil, causes buoyancy and insulation losses.

***Acute toxicity***

- Sometimes spillage may cause wide spread mortality amongst the population of fish, worms, crabs and mollusk.

**b. Metals:** Mercury, copper, lead, Cd, As, Fe, etc.

***Harmful effects***

- Mental disorders, nervous system break down (e.g. Minamata disease, Arsenocosis),
- Anemia, kidney disorder, sterility and carcinogenic.

**c. Gaseous:** $CO_2$, CO, $SO_2$ ,$Cl_2$ ,$NH_2$, Acid fumes, Isocyanide

***Harmful effect***

- Increases of toxic gases in air,

- Adverse impact on human beings (e.g. Asthma and other respiratory diseases).

**d. Solid:** PAHs, PCBs, PVC, plastics, glass wool, asbestos, etc

***Harmful effect***

- PAHs: Cause malignant tumors, interfere with enzymatic breakdown affecting the lungs, stomach, intestines and skin. Highly toxic and bio-accumulate in the environment.
- Dioxins: Carcinogenic, can suppress the immune system. Suspected of pre- and post-natal affects on children's nervous system.
- PCBs: Have been linked to cancer, liver damage, reproductive impairments and system damage. Highly biomagnified and persistent in the higher trophic level of marine food chain.

**e. Harmful Microbes:** Pathogenic bacteria and viruses and its adverse impacts on fishery resources and human health.

**Existing policies and legislations for pollution control in Bangladesh**

**The Environment Protection Acts and Rules**

- Water Prevention and Control of Pollution Act, 1974
- Environmental Conservation Act, 1995 (Amendment 2002)
- Environmental Conservation Rules, 1997
- Environmental Court Act, 2000 (Amendment 2002)
- The Forest Act, 1927 (Amendment 1990, 2000)
- Biosafety Guidelines of Bangladesh, 2007
- National Biodiversity Framework, 2007

**Water quality standards**

- National Water Policy (NWP), 1999
- National Policy for Safe Water Supply and Sanitation (1998)
- National Water Management Plan (NWMP), 2001

**Agro-chemical pollution control**

- National Agriculture Policy, 1999
- Pesticides Law, 1985

**Coastal Zone Policy and Strategy, 2005**

- Solid waste management ordinance, 2010
- Ship breaking and hazardous waste management rule, 2010
- Biosafety ordinance, 2010
- ECA management Ordinance, 2010
- Durable development and tourism policy of St. Martin Island 2010
- Guidelines on environmental management, Waste treatment and workers occupational safety and health (OSH) for ship breaking yards in Bangladesh, 2010.

**What are the problems?**

a. **Land based**

- Lack of co-operation and coordination among the Municipality, DoE, Public Health and the relevant organizations;
- Lack of treatment facilities;
- Implementation of rules and guidelines;
- Lack of implementation of rules and imposing penalty;
- Population pressure;
- Lack of awareness;
- Environmental Impact Assessment (EIA) not done properly;
- Weak infrastructure and technically skilled people is limited in the DoE, local govt. authorities (municipal corp., public health dept. port authority etc.).

**b. Sea based**

- Lack of oil spill contingency plan;
- Oil pollution from ship and ship breaking activities;

- Lack of implementation of rules and penalty (Marine Pollution ordinance) and non-ratification of laws;
- Lack of awareness;
- Poor port and harbor management;
- Lack of cooperation among the enforcement authorities;
- Lack of technology/data on impacts on aquatic biota, oil and natural gas exploration;
- EIA not done properly;
- Few alternatives (TBT used in boat, vessels, ship to protect from antifouling organisms).

**Recommendations**

**A. Land based pollution**

- Disposal of wastes should be dealt by both public and private sectors (perhaps under govt. license).
- Support service from the govt. should be provided to the stakeholders to take responsibility of their wastes and participation in waste minimization.
- New regulations have to be made, so that they fit into an existing frame works of laws on municipal wastes, chemicals and pesticides.
- Systematic study on the sources, fate, and extent of current industrial/agricultural/municipal effluents dumping in the water body and assessment of overall impacts on aquatic life as well as human health should be started soon.
- Integrated land use planning and land zoning should be made.
- Vessels causing marine pollution by spill, over-flow or dumping of oil or oily sludge etc. will be liable and to be prosecuted under Bangladesh Marine Pollution Ordinance.
- The ship breakers must obtain NOC from the authority before the ship being dismantled. A longer stretch along the sea shore is in no way justified for continuation of ship breaking business, rather a “certain isolated and protected scrapper’s yard should be selected by the competent authority.

**B. Sea Based pollution**

- Research is utmost important on the fate and effect of photo-transformation by-products of oils (PAHs) and its impacts on biota.

- Port reception facilities and treatment of ballast water and bilge (engine wastes) to be created without any delay.
- Involvement of relevant national and international organizations (IMSF,CU; SPARRSO, EGIS, IMCO, IMO, ICZM, Bangladesh Navy, Marine Academy, Port authority, Coast Guard, etc.), scientists and marine engineers are needed to combat marine pollution.
- Finally, an ‘Oil Pollution Model’ should be build for regional management of oil pollution in the Bay of Bengal.

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# Ship breaking activities: threats to coastal environment and fish biodiversity

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## Introduction

Of the approximate 45,000 ocean-going ships in the world about 700 (1.55%) are taken out of service every year (FIDH 2002). At the end of their sailing life, ships are sold so that the valuable steel- about 95% of a ships' mass can be recovered. Until the 1960s, ship breaking activity, considered as a highly mechanized operation, was concentrated in industrialized countries- mainly the United States, the United Kingdom, Germany and Italy. From early 1980s ship owners are sending their vessels, to maximize profits, to the scrap yards of India, China, Pakistan, Bangladesh, the Philippines and Vietnam where health and safety standards are minimal and workers are desperate for work (Hossain 2009). Though 79 nations in the past decade had some form of ship recycling activity, the Asian ship breaking yards, which took off in the 1980s, now account for over 95% of the industry. At present, Alang, Sosiya, Gujarat, India is retaining its position as the world's largest scrapping site for ocean ships, accounting for an average of 70% of tonnage and an average of 50% of worldwide demolition sales. Bangladesh is the second country, after India, in terms of volume of recycling (Hossain 2009).

- Of the approximate 45,000 ocean-going ships in the world about 1.55% is taken out of service every year for scrapping.
- Asian ship breaking yards account for over 95% of the industry. Bangladesh is the $2^{nd}$ country, after India, in terms of volume of ship recycling.
- Health and safety standards are minimal in ship scrap yards of India, China, Pakistan, Bangladesh, the Philippines and Vietnam and workers are desperate there for work.

In Bangladesh ship breaking activities initiated in 1969 but the sector experienced a boom in the 1980s. As developed countries like the United Kingdom, Spain, Scandinavian countries, Brazil, Taiwan, South Korea wanting to get rid of an industry which was not in compliance with the new environmental protection standards, Bangladeshi industrialists took the opportunities allured by huge profit. Businessmen involved in the industry imported more and more ships and Bangladesh began to play a preponderant role bit by bit. As a result within short period Bangladesh established monopoly in the international market of big ship scrapping. Statistics show that about 52% of big ships are dismantled in Bangladesh (DNV 1999). There are 24 ship breaking yards in Bangladesh and the area extends over 14 km along Fauzdarhat to Kumira coast of Chittagong (YPSA 2005).

**Economic benefit of SBA**

Ship breaking activities hold potential as it creates economic opportunities for thousands of laborers and contribute to the economic growth of regions in need of private sector investment. To the extent possible 100% of the ship is recycled (Fig. 1). Ship breaking activities is of great importance in national economy of Bangladesh as it saves a lot of foreign exchange by reducing the import of steel materials. Ship scrapping supply raw materials to the steel mills, steel plate re-manufacturing, asbestos re-manufacturing, lubricating, oil regeneration and other industries. Bangladesh Government earns annual revenue of about Tk.700 core from ship breaking each year by imposing duties (7.5%), yards tax (2.5%), etc. Ship breaking activities offers direct employment opportunities to about 25,000 people. Moreover, another 200,000 people are also engaged in different business related to ship breaking activities (YPSA 2005). Bangladesh needs 8 million tons of building materials per year in which mostly needed materials is iron and ship breaking activities is supplying 60-70% iron materials of the country (Ronning 2000), though exact statistics are not yet known. Along the road from Chittagong to Dhaka several shops display various materials of ship breaking products.

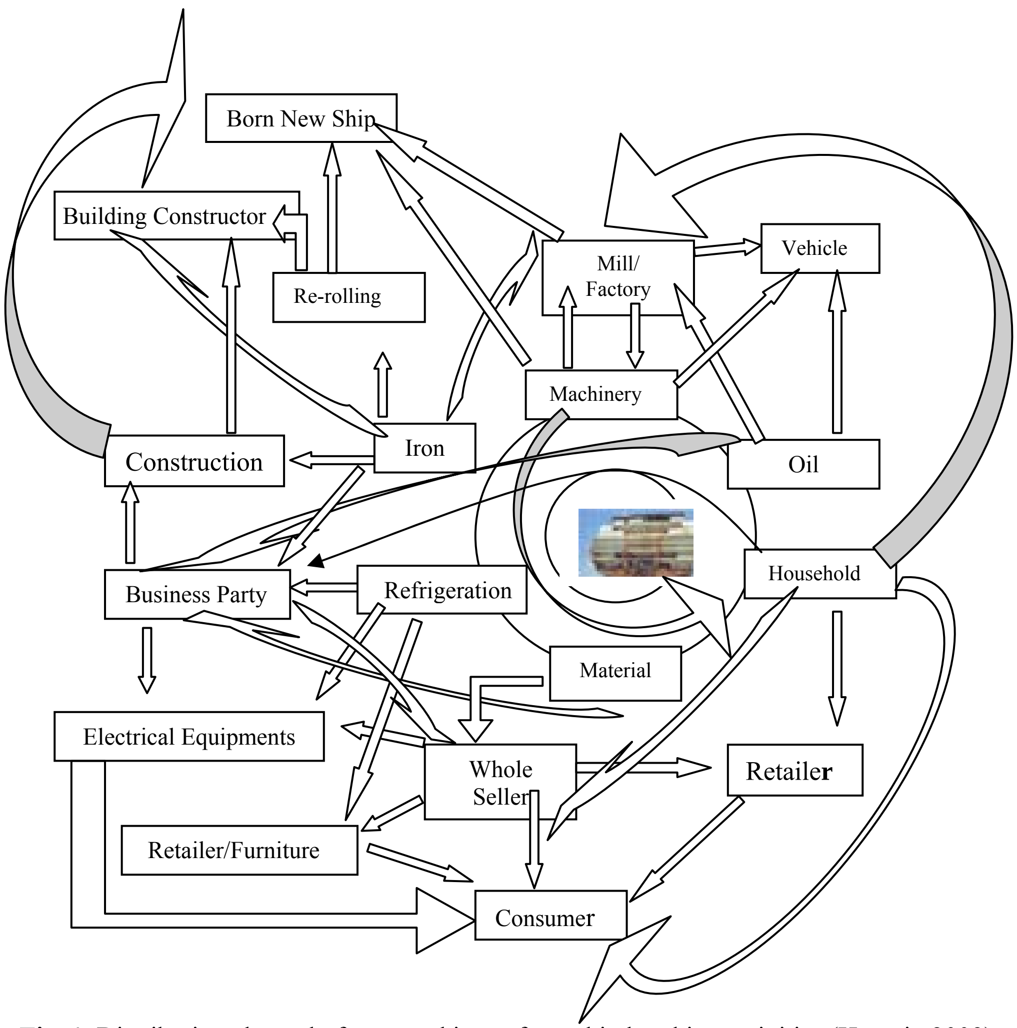


**Fig. 1.** Distribution channel of scrapped items from ship breaking activities (Hossain 2009).

Field investigations and laboratory analysis were carried out to study the present status of ship breaking activities in Sitakunda coastal area of Chittagong during June 2005 to December 2008 and extensive literature surveys as well as a general Google scholar search were also done for further materials.

## Hazards involved in ship breaking activities

Though ship breaking has earned a good reputation for being profitable in developing countries but it bothers least about the environment and human health hazards (Table 1). Depending on their size and function, scrapped ships have an unloaded weight of between 5,000 and 40,000 tones (an average of 13,000+), 95% of which is steel, coated with between 10 and 100 tones of paint containing lead, cadmium, organotins, arsenic, zinc and chromium. Ships also contain a wide range of other hazardous wastes (Tables 2 and 3), sealants containing PCBs; up to 7.5 tons of various types of asbestos; several thousand liters of oil (engine oil, bilge oil, hydraulic and lubricating oils and grease). Tankers additionally hold up to 1,000 cubic meters of residual oil. Most of these materials are already defined as hazardous waste under the Basel Convention. In Asia, old ships containing these materials are being cut up by hand, on open beaches, under inhumane working conditions (Fig. 2).

**Fig. 2.** A usual picture of inter-tidal area where cargo ships wait for dismantling.

- Scrapped ships have an unloaded mean weight of 13,000 tones of which 95% is steel, coated with 10-100 tones of paint containing lead, cadmium, organotins, arsenic, zinc and chromium.
- Ships also contain a wide range of other hazardous wastes, sealants containing PCBs; up to 7.5 tons of various types of asbestos; several thousand liters of oils and greases.
- Tankers additionally hold up to 1,000 cubic meters of residual oil.
- Most of these materials are already defined as hazardous waste under the Basel Convention.

**Table 1.** Common hazards those are likely to cause work-related injuries and death, ill health, diseases and incidents among ship breaking workers (ILO 2003)

| | |
|---|---|
| **Serious Accident Hazards** | |
| Fire and explosion: explosives, flammable materials | Falls from height inside ship structures or on the ground |
| Being struck by falling objects | Struck by moving objects |
| Caught in or compressed | Slipping on wet surfaces |
| Snapping of cables, ropes, chains, slings | Sharp objects |
| Handling heavy objects; Access in progressively dismantled vessels (floors, stairs, passageways) | Oxygen deficiency in confined spaces. Lack of PPE, housekeeping practices, safety signs |
| **Hazardous Substances** | |
| Asbestos fibers, dusts | PCBs & PVC (combustion products) |
| Heavy and toxic metals (lead, mercury, cadmium, copper, zinc etc.) | Welding fumes |
| Organometallic substances (tributylin, etc.) | Volatile organic compounds (solvents) |
| Lack of hazard communication (storage, labeling, material safety data sheets) | Inhalation in confined and enclosed spaces |
| Batteries fire-fighting liquids | Compressed gas cylinders |
| **Physical Hazards** | |
| Noise | Vibration |
| Extreme temperatures | Poor illumination |
| **Mechanical Hazards** | |
| Trucks and transport vehicles | Shackles, hooks; chains |
| Scaffolding, fixed and portable ladders | Cranes, winches, hoisting & hauling equipment |
| Impact by tools, sharp-edged tools | Lack of safety guards in machines |
| Power-driven hand tools, saws, grinders and abrasive cutting wheels | Poor maintenance of machinery and equipment |

| Biological Hazards | |
|---|---|
| Toxic marine organisms | Animal bites |
| Risk of communicable diseases transmitted by pests, vermin, rodents, insects and other animals that may infest the ship | Infectious diseases (TB, malaria, dengue fever, hepatitis, respiratory infections, others) |
| **Ergonomic and Psychological Hazards** | |
| Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload | Mental stress, human relations ( behavior, alcohol and drug abuse, violence) |
| Long working hours, shift work, night work, temporary employment | Poverty, low wages, minimum age, lack of education and social environment |

**Table 2.** Waste components that may be on board of the vessel

| Wastes | Products where waste may be found |
|---|---|
| Unsorted waste batteries | Portable radios, torches |
| Waste non-halogenated organic solvents | Solvents and thinners |
| Waste halogenated organic solvents | Solvents and thinners |
| Wastes from the production, preparation and use of pharmaceutical products | Miscellaneous medicines |
| Wastes from the production, formulation and use of biocides and phyto-pharmaceuticals, including waste pesticides and herbicides which are off-specification, outdated, or unfit for their originally intended use | Insecticide sprays |
| Wastes from the production, formulation and use of links, dyes, pigments, paints, lacquers, varnish | Paints and coatings |
| Waste consisting of or containing off specification or outdated chemicals | Consumables |
| CFC (R12-dichlorodifluoromethane, or R22-chlorodifluoromethane) | Refrigeration devices such as water coolers and small freezer units. Styrofoam |
| Halons | Firefighting equipment |
| Radioactive material | Liquid-level indicators, smoke detector, emergency signs |
| Micro organisms/ sediments | Ballast water systems |
| Fuel oil, diesel oil, gas oil | Ballast water systems (including tanks) |

**Table 3.** Wastes and substances that may be inherent in the vessel structure

| **Wastes** | **Waste-location on the ship** |
|---|---|
| Antimony | Alloys with lead in lead-acid storage batteries, solder |
| Beryllium | Hardening agent in alloys, fuel containers, navigational systems |
| Cadmium | Bearings |
| Lead | Connectors, couplings, bearings |
| Tellurium | In alloys |
| Antimony compounds | Fire retardation in plastics, textiles, rubber etc. |
| Cadmium compounds | Batteries, anodes, bolts and nuts |
| Lead compounds | Batteries, lead and chromate paint, paint coatings, cable insulation, lead ballast, generators, and motor components |
| Arsenic: arsenic compounds | Paints on the ship's structure |
| Mercury; mercury compounds | Thermometer, light fittings, electrical level switches, mercury in fluorescent light tubes, fire detectors, and tank-level indicators |
| Hexa-valent chromium compounds | Paints (lead chromate) on the ship's structure |
| Waste zinc residues | Anodes (Cu, Cd, Pb, Zn) |
| Waste lead-acid batteries, whole or crushed | Batteries: emergency, radio, fire alarm, start up, lifeboats |
| Glass waste from cathode-ray tubes and other activated glasses | TV and Computer screens |
| Asbestos | Thermal insulation, surfacing material, sound insulation, hanger liners, mastic under insulation, cloth over insulation, cable, lagging and insulation on pipes and hull, adhesive, gaskets on piping connections, and valve packing |
| Mineral oils unfit for their originally intended use. | Hydraulic fluids, oil sump (engine, lubricant oil, gear, separator etc.) oil tank residuals (cargo residues) |
| Non-halogenated organic solvent | Antifreeze fluids |
| Polychlorinated biphenyl (PCBs), Polychlorinated terphenyl (PCT), Polychlorinated naphthalene (PCN) or Polybrominated biphenyl (PBB) or any other polybrominated analogues of these compounds | Capacitors in light fittings, PCB in oil residuals, gaskets, couplings, wiring (plastics in the ships' structure) cable insulation, transformers, capacitors and electronic equipment with transformers and Capacitors inside, oil-based paint, anchor windlasses, equipment for cargo handling |

| | |
|---|---|
| | (such as crane and pump arrangements), sealing materials and glues used in windows, electrical components in powering systems and in electric lighting including fittings and heat exposed electrical components (condensators). Also in rubber products such as hoses, plastic foam insulation, cables, silver paint, habitability paint, felt under septum plates, plates on top of the hull bottom, and primary paint on hull steel |
| Waste of explosive nature | Compressed gases (acetylene, propane, butane), cargo residues (cargo tanks) |

Source: UNEP 2002, ILO 2003, OSHA 2001

There is no disagreement in home and abroad that ship breaking is a high-risk industry. By any standards, the demolition of ships is a dirty and dangerous occupation. The hazards linked to ship breaking broadly fall into two categories: intoxication by dangerous substances and accidents on the plots. Explosions of leftover gas and fumes in the tanks are the prime cause of accidents in the yards. Another major cause of accident is the fall from the ships (which are up to 70 m high) of laborers who work there with no safety harness. Other accidents include workers being crushed by falling steel beams and plates, electric shock, etc. (FIDH 2002). The unskilled workers carry metal plates, metal bars or pipes on their bare heads or shoulders, start walking in synchronized steps with the rhythm of the singers call up to a definite destination and then pile up metal plates in stack yards or load them on trucks (Fig. 3).

**Fig. 3.** Cutting of large metal into pieces.

**Pollutants discharged from ship breaking**

The ship breaking activities is a threat to both terrestrial and marine environment as well as to the public health as it a mini version of city and discharges every kind of pollutants a metropolis can generate like liquid, metal, gaseous and solid pollutants.

***Persistent Organic Pollutants (POP's)***

Persistent Organic Pollutants (POP's) are chemicals that are highly toxic, remain intact in the environment for long periods, become widely distributed geographically, bioaccumulate through the food web, accumulate in the fatty tissues of living organisms and pose a risk of causing adverse effects to human population, wildlife and the environment. There has been a realization that these pollutants, upon exposure to human, can cause serious health effects ranging from increased incidence of cancers to disruption of hormonal systems (Kibria *et al.* 2009). Ship breaking activities is a potential source of lethal POP's.

***Polychlorinated Biphenyl Compounds (PCBs)***

The analysis of soil from a steel plate re-processing site of Chittagong ship breaking yards on ∑PCBs (7 toxic congener's $PCB_{28}$ –$PCB_{180}$) found that the amount varied from 1.444-0.2 mg/kg in dry weight (DNV 2001). However, over the last 10-15 years in Bangladesh, as in other developing countries, the usage of capacitors, transformers and other PCB's containing products from dismantling of old ships and other sources has increased many folds; and there is no legislation to control or manage the old stocks of PCB containing products in Bangladesh. That is the real danger or risk for PCB contamination in marine biodiversity (higher trophic level) and human health for Bangladesh and certainly the contamination of PCBs will be more in the years ahead (Hossain 2002, Kibria *et al.* 2009).

***Dioxins***

Dioxins are known human carcinogen, is created when chlorine products like PCBs (Polychlorinated Biphenyls), PVC are made or burned. Dioxins are the most toxic substances that humans have ever released into the environments. Burned in open fires on the ship breaking yards, dioxins are constantly inhaled by the workers. In most western countries the emissions of dioxins are strongly reduced. A UN-treaty in 2001 on POP's banned dioxins worldwide (Kibria *et al.* 2009).

***Polyvinyl Chloride (PVC)***

In the shipwrecks, lots of equipment and materials are made of PVC. PVC poses serious threats to environmental health at every stage of its existence (production, use and disposal). At the end of its life, PVC waste creates intractable disposal problems because; it is expensive and unsafe to burn. It releases hazardous chemicals into groundwater and air when buried, and is not so easily or cheaply recycled. Degraded PVC releases volatile organic chemicals such as 3-ethyl-1-hexanol and 1-butanol, into air causing asthma; among the other dangers when PVC burns in open fires are dioxin generation - the formation of hydrochloric acid mist and the generation of thick, choking smoke.

***Polycyclic Aromatic Hydrocarbons (PAHs)***

Hs are released during torch cutting and afterwards when paints continue to smolder or when wastes are deliberately burned. About 250 PAHs are known. Some harmful PAHs are Naphthalene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo (a) anthracene, Chrysene Benzo (k) fluoranthene, Benzo (a) pyrene, Benzo (ghi) perylene, Indenopyrene. The health hazards from PAHs comes from directly inhaling fumes, during torch cutting, smoldering of paints and burning of wastes. PAHs accumulate in dusts and sediments, and tissues of life forms. As a result they are available for uptake either through inhalation, dermal contact or via the food chain.

***Organotins***

Organotins are nerve toxins that accumulate in the blood, liver, kidneys and brain. Some notorious organotins are Tributyltin (TBT), Triphenyltin, Dibutyltin, Dicyclohexyltin, Diphenyltin, Tricyclohexyltin (Kibria *et al.* 2009). Analysis of soil from a steel plate re-processing in Chittagong ship breaking area found

Monobutyltin (MBT) ranging from 1.9 to 0.72 mg/kg, Dibutyltin (DBT) from 2.4 to 1.38 mg/kg and Tri-butyltin (TBT) from 25.0 to 17.0 mg/kg, all in dry weight (DNV 1999). Tributyltin (TBT) is an aggressive biocide (kills living organisms) that has been used in anti-fouling paints since the 1970s. Concerns over toxicity of these compounds (some reports describe biological effects to marine life at a concentration of 1 nanogram per liter) have led to a world-wide ban by the International Maritime Organization (IMO) in 2003.

***Asbestos***

Asbestos is important components used in ships as heat insulator. During scrapping worker as well as surrounding environment become vulnerable to the impact of asbestos. Exposure to asbestos fibers (even in very low concentrations) especially through inhalation may cause cancer. On the ship breaking beaches of Asia, asbestos fibers and flocks fly around in the open air. Men handle asbestos insulation materials with their bare hand.

***Heavy metals***

Heavy metals are found in many parts of ships such as in paints, coatings, anodes and electrical equipments. Exposures can result in lung cancer, cancer of the skin, intestine, kidney, liver or bladder. It can also cause damage to blood vessels.

**i) Mercury**: Mercury, a highly toxic heavy metal exists in various forms including metallic mercury, inorganic and organic mercury compounds. Research studies show that contamination brought about by natural and man-made activities is clearly a growing problem today. The level of mercury found in the soil of ship breaking area of Chittagong ranges from 0.8 mg/kg to 3.0 mg/kg, where the background value is only 0.1 mg/kg in dry weight (DNV 2001).

**ii) Lead:** Lead, a toxic heavy metal that accumulates in blood and bones after inhalation or ingestion. Lead may enter the human system mainly through inhalation but also through ingestion. Most of the lead that enters the human body accumulates in the bones. The concentration of lead in the soil found in the ship breaking area of Chittagong ranges from 4,232 mg/kg to 5,733 mg/kg where the background value is only 144.0 mg/kg, all in dry weight (DNV 2001).

**iii) Arsenic:** The environmental problems associated with arsenic, due to its toxicity are well known. Presently, arsenic is treated as a human carcinogen and environmental agencies are pressing for stricter consumption standards. Acute exposure to inorganic arsenic has serious adverse health effects. Studies of acute toxicity show that inorganic compounds are more potent than organic ones.

**iv) Chromium:** The level of chromium found in the soil of ship breaking area of Chittagong ranges from 507.0 mg/kg to 568.0 mg/kg, where the background value is 144.0 mg/kg, all in dry weight (DNV 2001).

**v) Other heavy metals:** Among the other heavy metals found in the ship breaking area of Chittagong are, Cu - ranges from 573.0 mg/kg to 1,211.0 mg/kg, background value only 51.0 mg/kg , Hg - ranges from 0.076 to 0.266 mg/kg background value 0.05 to 2.0; Mn - ranges from 1,792 to 2,321 mg/kg, background value 1,363 mg/kg; Zn - ranges from 2,929 to 5,888 mg/kg, background value 144.0 mg/kg, all in dry weight (DNV 2001).

**vi) Oil:** As a result of the breaking of the ship, oil residues and the other refuses are being spilled and mixed with water and keep floating on the water of the entire seashore. Islam and Hossain (1986) detected between 10.800 and 9.280 mg/l oil in water samples and Talukder and Khan (1994) detected 239.0 and 248.0 µg/l PHC (petroleum hydrocarbons) in sea water from the ship breaking area.

- Heavy metals (Hg, Pb, As, Cr, Cu, Zn, Mn) are found in many parts of ships such as in paints, coatings, anodes and electrical equipments. Exposures can result in lung cancer, cancer of the skin, intestine, kidney, liver or bladder. It can also cause damage to blood vessels.
- As a result of ship breaking oil residues and the other refuses including PHCs are spilled and mixed with water and keep floating on the water of the entire seashore.

## Research on Ship Breaking

Unfortunately very little and scanty research efforts have been conducted relating to the ship breaking activities. Khan (1994), Khan and Talukder (1993) and Islam and Hossain (1986) have carried out sporadic research focusing on the oil pollution and accumulation of trace metals. Later Hossain and Islam (2006) gave a comprehensive overview of the impact of ship breaking yards on the environment and the marine resources. Babul (2000) studied on the history, legal aspects, safety, economic and technical aspects of ship breaking yards. Irony is that in all the above mentioned studies, the issues of fish abundance and related impact on local fisher folks have been ignored. The overall effect of CPUE of fishing, impact on the fish diversity and income and livelihoods of fishers are yet to be known. Siddique (2004) tried to identify the impacts of ship breaking activity on marine fish biodiversity of the Bay of Bengal, Bangladesh. A recent investigation on water and sediment quality status were tested at 6 sampling sites in and around ship breaking area of Sitakunda, Chittagong (Fig. 4) and a comparison with previous data and Bangladesh standards can be seen in Tables 4 and 5 respectively.

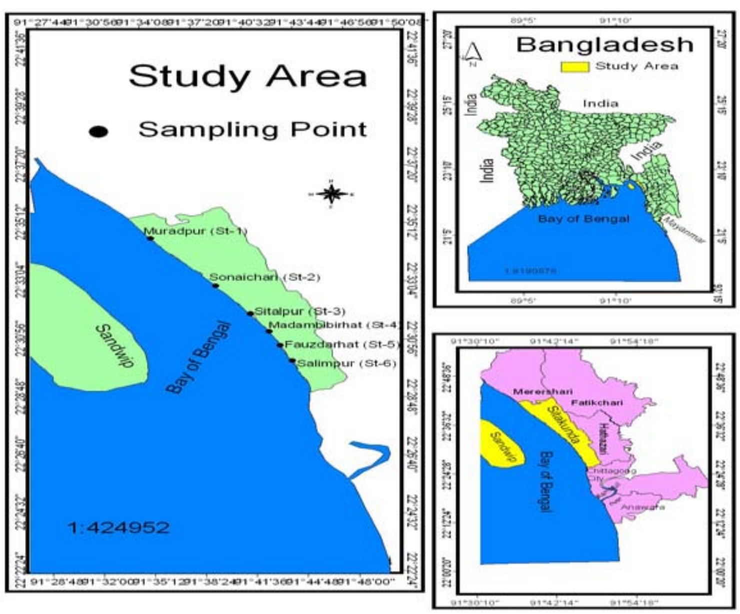


**Fig. 4.** Map showing Sitakunda coastal area of Chittagong and the selected sampling sites.

## Impacts of ship breaking

This study clearly shows that almost all the toxic metals in and around ship breaking area (St. 2 through St. 6) are quite high in concentration compared to relatively undisturbed area, the reference zone (St. 1). The results of the present toxic metal analysis in sediment also shows nearly 2-6 times higher contamination than that of the water samples from the investigated area (Table 5), with few exceptions and in maximum cases, exceeded the values for coastal water of Bangladesh (EQS 1991) and GESAMP values for coastal sediments.

**Table 4.** Physio-chemical properties of sea water and soil at ship breaking and reference area at Chittagong coast, Bangladesh

| Parameters | 1986 * | | 2007-2008 | | Bangladesh Standards | Remarks |
|---|---|---|---|---|---|---|
| | Ship breaking area (range) | Reference area (range) | Ship breaking area (St. 2-6) | Ref. area (St.1) (mean value) | | |
| Turbidity (JTU) | 690-723 | 470-475 | – | – | – | – |
| Transparency/ Secchi disc depth (m) | – | – | 0.38 | 0.63 | – | Both the area are highly turbid |
| Total Solids (mg/l) | 3678-4195 | 2284-2335 | ND | ND | – | Exceed the EQS value |
| Chloride (mg/l) | 460-502 | 785-789 | ND | ND | – | – |
| Water $P^H$ | ND | ND | 7.37-8.60 | 8.10 | EQS value is 6.9 | Exceed the EQS value |
| DO (mg/l) | 3.70-4.10 | 6.20-6.36 | 3.98-4.25 | 6.25 | Accepted value of DO in water is>5 | DO value below the standard for fisheries |
| BOD (mg/l) | 6.98-7.82 | 4.08-4.30 | 10.23-18.78 | 5.00 | <6 | BOD value of SB area exceed the value for fisheries |
| Total Hydro-carbon (mg/l) (Oil and grease) | 92.80-106.0 | – | 52.5-123.5 | 22.5 | 10 | Value of oil contamination level exceed the standard at all sites |

| | | | | | | |
|---|---|---|---|---|---|---|
| Organic Carbon (OC) | – | – | 0.511-1.215 | 1.26 | 1.42 | Due to low organic carbon & organic matters biomass productivity is also low |
| Organic matter (OM) | – | – | 1.02-1.83 | 2.4-3.2 | – | |

- : data not available; *: Islam and Hossain (1986). N.D. : Not detected.

**Table 5.** Comparison on the contamination level of toxic heavy metals in water and sediment at the coastal area of ship breaking and Reference zone (mean values).

| Level of heavy metals in coastal water and in sediment | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| parameter | 1986 * | | | | 2007-2008 | | | | Bangladesh Standards (EQS) (µg/ml) |
| | Ship breaking area | | Reference area | | Ship breaking area (St. 2-6) | | Reference area (St.1) | | |
| | Water (µg/ml) | Sedimt. (µg/gm) | Water (µg/ml) | Sedimt. (µg/gm) | Water (µg/ml) | Sedimt. (µg/gm) | Water (µg/ml) | Sedimt. (µg/gm) | |
| Fe | 36.02-41.26 | - | - | 0.20-2.92 | 15.75-20.32 | 28.32-74.9 | 7.52 | 19.995 | 0.02 |
| Cu | - | - | - | - | 0.235-0.645 | 2.32-3.962 | 0.075 | 0.289 | 0.005 |
| Zn | - | - | - | - | 0.112-0.189 | 1.890-2.701 | 0.092 | 0.968 | 0.05 |
| Cd | - | - | - | - | 0.038-0.059 | 0.09-0.182 | 0.0105 | 0.037 | 0.0005 |
| Cr | - | - | - | - | 0.3615-0.45 | 1.057-2.402 | 0.1575 | 0.447 | 0.0005 |
| Ni | - | - | - | - | 0.405-0.715 | 1.26-2.16 | 0.278 | 0.98 | 0.07 |
| Mn | - | - | - | - | ND | 0.505-0.87 | 3.02-3.20 | 0.235 | 2.45 |
| Al | - | - | - | - | ND | 0.074-0.471 | ND | 0.297 | 0.01 |
| Pb | - | - | - | - | 0.9-1.045 | 3.415-6.025 | 0.525 | 3.265 | 0.01 |
| Mg | - | - | - | - | ND | 3.06-4.28 | 5.89-12.215 | 2.355 | 3.605 |
| As | - | - | - | - | 0.031-0.038 | ND | 0.0065 | ND | <5 |
| Remarks: All most all the values of toxic metals in analytical water and sediment sample at the investigated area exceed the certified EQS values for coastal waters, with the exception of few values. | | | | | | | | | |

- : data not available; *: Islam and Hossain 1986; EQS: Environmental Quality Standard values for Bangladesh.

A recent study by Demaria (2009) on another major ship breaking site, Alang, Sosiya, Gujarat, India shows findings and reports, similar to those in the present study in ship breaking area of Chittagong, Bangladesh. According to Demaria (2009), ship breaking has substantially affected the ecosystem in Alang-Sosiya. System stress has led to a decline in biotic structure, such as decrease in biomass, abundance and species diversity with practically no vegetation along the intertidal zone of Alang ship breaking area (Tewari *et al.* 2001, Reddy *et al.* 2003). Mujamder (1997) has reported that, the sea of ASSBY has very poor biological production, with very low primary phytoplankton, pigment concentration, low zooplankton standing stock, very low macro-benthic standing stock and low numerical abundance of fish eggs and fish larvae. Fishermen report that, since ship breaking activity started, quantity, variety and size of the fish have decreased, taste has changed, while a number of species have disappeared compared to their earlier times, fish catches has decreased up to 50% (Demaria 2009).

**Table 6.** The fish species not found in SBN catches of ship breaking area during present investigation

| Scientific name | Local name | Scientific name | Local name |
|---|---|---|---|
| *Osteogeniosus staenocephalus* | Aspisoa katamach | *Sphyraena obtusata* | Khika mach |
| *Scolopsis vosmere* | Nemipscol mach | *Carangoides malabaricus* | Lohamuri mach |
| *Eleotris fusca* | Dora bailla | *Carangoides melampygus* | Bungda muri |
| *Uranoscopus guttatus* | Foton mach | *Sauridia elongate* | Tiktiki mach |
| *Dendrophysa russelli* | Kala poa | *Anodontostoma chacunda* | Koiputi mach |
| *Bahaba chaptis* | Chapti mach | *Pricanthus macracavthus* | Prica mach |
| *Pomadasys opercularis* | Grunti mach | *Pricanthus tayenus* | Prica mach |
| *Polynemus sextarius* | Kala tailla | *Cynoglossus macrolepidotus* | Lamba kukur jib |
| *Gobuis sadanandio* | Nandi bailla | *Arius thalassinus* | Kata mach |
| *Gobuis melanosoma* | Kalthu Bailla | *Apocryptes serperaster* | Dosa chau mach |
| *Sphyraena forstegi* | Khika mach | - | - |

Source: Metai and Hossain( 2007)

**Table 7.** Some of the commercial fish species found to be endangered and reduced in catch

| Scientific name | Local name | Scientific name | Local name |
|---|---|---|---|
| *Mugil cephalus* | Bata | *Polynemus paradiseus* | Hriska mach |
| *Gobuis melanosoma* | Baila | *Stromateus chinensis* | Foli chanda |
| *Gobuis sadanundio* | Baila | *Carangoides malbaricus* | Lahmuri mach |
| *Anodontostoma chacunda* | Koiputi mach | *Apocryptes serperaster* | Dora mach |
| *Arius thalassinus* | Kata mach | *Polynemus indicus* | Lakkha |
| *Lates calcarifer* | Bhetki | | |

### Finding of the study work

- This study clearly shows that concentration of almost all the toxic metals analyzed in ship breaking and its adjacent areas, both for water (11 metals) and soil (09 metals) are quite high as compared to relatively undisturbed area, the reference zone; and the concentrations of toxic metals in sediments of the investigated area shows clearly 2-6 times higher than that of the water of the investigated area and in most cases exceeded the certified values (EQS).
- This study also shows much higher concentrations of total hydrocarbon values in water and low levels of organic carbon and organic matters- the ingredient of productivity, in the intertidal zone of ship breaking area, than in the reference area.
- Study and catch statistics data (MFRMU 2007 ) show that abundance and fish species diversity in the coastal area of Chittagong significantly reduced and some 21 species, which were found earlier, are not available now (Table 6) along with a nos. of fishes seem to be endangered (Table 7).
- Recent indiscriminate cutting and clearance of mangrove forests in the coastal area of Sitakunda, for expansion of ship breaking yards, is not only a colossal loss of coastal habitat, aquatic resources and biodiversity, but will increase soil erosion, changes in sedimentation pattern and shore line configuration, vulnerability to cyclonic storms, tidal bore; and denudation of feeding, breeding and nursery ground for various estuarine, coastal and marine water fishery resources.

**Recommendations**

Considering the positive role of ship breaking in national economy ship breaking cannot be stopped rather than a sustainable approach should be taken to minimize the negative consequences of ship breaking activities in our coastal zone. However following steps may be taken for sustainable practices of ship breaking activities:

- Government should nominate a competent authority or authorities, as appropriate, which should, in consultation with the representative organizations of employers and workers, formulate, implement and periodically review a coherent national policy and principles for safe ship breaking. Such policy should include:
  - The control of the import and preparation of ships for breaking;
  - Employment and working conditions, occupational safety and health, workers rights and workers welfare;
  - The protection of both persons and the environment in the vicinity of a ship-breaking work site.
- Government should include this sector under the ministry of industry defined by the Factory Act, 1965 and formulate a policy so that worker's rights could be ensured and as well as it could be eco-friendly.
- Environment, human rights and economy, theses three things should be considered in formulating the public policy for this industry.
- A gas-free certificate must be obtained before any ship is broken. Oil must be removed and the oil tanks must be thoroughly cleaned either chemically or manually and the ship breakers must obtain a tank clearance certificate from the Mercantile Marine Department before the ship is broken.
- After making the ship gas-free (in true sense) it should be beached to scrap.
- Vessels must pump out maximum quantity of oil at the anchorage before beaching.
- All the oily sludge, rags, rust, sawdust, etc. must be removed and disposed of at a safer place.

- Vessels causing marine pollution by spill, over-flow or dumping of oil or oily sludge etc. will be liable to be prosecuted under Bangladesh Marine Pollution Ordinance.
- The ship breakers must arrange periodical inspection by a surveyor from the Department of Shipping for the purposes of supervision and control of pollution during ship breaking.
- The sea shall be kept undisturbed (nothing should flow in the sea water) as far as possible for healthy growth of fish and its food web.
- No ship breaking licenses should be issued to anybody unless he produced requisite permission showing that necessary lease of land had already been taken for the purpose.
- Fire stations and hospitals should be setup close by the ship breaking area as soon as possible for the welfare of the workers and avoiding severe loss by any accident.
- The ship breaking activities should be carried out in a planned and hygienic way. A layout could be designed before starting to break the ship.

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# Coastal pollution issues in relation to water quality criteria and remedial strategies in the Bay of Bengal

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## Introduction

The Bay of Bengal (BoB) is an arm of the Indian Ocean, 2,090 km long and 1,610 km wide, bordered on the west by Sri Lanka and India, on the north by Bangladesh, and on the east by Myanmar and Thailand, the Andaman and Nicobar islands separates it from the Andaman Sea, its eastern arms. The BoB occupies an area of 2,172,000 $km^2$. It is the largest bay in the world by area among 64 large marine ecosystems (LMEs). The bay receives many large rivers including the Ayeyarwady, Ganges-Brahmaputra, Mahanadi, Godavari, Krisina, and Kaveri all forming fertile and heavily populated delta. As a deltaic country, 100 crore tons of sediment settles every year to the coastal region of Bangladesh from the Himalya which has made the bay or coastal region a shallow sea. Among the important ports are Cuddalore, Vishakapatnam, Paradip, Kolkata, Mongla, Chittagong and Yangon.

From January to October, the current is northward flowing, and the clockwise circulation pattern is called the “East Indian Current”. The BoB monsoon moves in a northwest direction striking the Nicober Islands, and the Andaman Islands first at the end of May, then the Eastern Coast of India by end of June. A coastal zone is defined as the area on either side of any landmass where land, water (seawater and freshwater) and air interact (Lee *et al*. 1982).

The Bangladesh coastal zone has many unique ecosystems, ranging from estuaries to coral reefs, sea grass beds and mangroves. These ecosystems have become potential sources of revenue as ecotourism sites, in addition to fisheries, aquaculture, oil and gas, and various other types of development activities. Coastal zones have been much exploited for the establishment and growth of industry, resource, tourism and urbanization which have led to the evolution of the thriving economies, but the over-development of the coastal areas has also brought about a multitude of negative environmental impacts, such as the effects of improper industrial and human waste management, accelerated erosion and deposition, eutrophication, destruction of marine life and overall decrease in biodiversity (Fabbri 1998). In this day and ages to come, the sense of urgency for the sustainable development of natural resources is undeniably important.

Coastal waters are one of the nation’s assets, yet they are being bombarded with pollution from all directions. The heavy concentration of activity in coastal areas, combined with pollutants flowing from streams far inland and others carried through the air at great distances from their source are the primary causes of nutrient enrichment, hypoxia, harmful algal blooms, toxic contaminations, sedimentation and other problems that plague coastal waters. Not only do degraded waters cause significance ecological damage, they also lead to economic impacts due to beach closures, curtailed recreational activities and additional health care costs. Reducing water pollution will result in cleaner coastal waters, healthy habitats that support aquatic life and a suite of economical benefits.

**Program area for coastal/ marine pollution**

The problems of coastal/marine pollutions could be neutralized through a comprehensive program which includes these important components:

- Baseline and monitoring
- Water quality criteria establishment
- Identification of source, pathways, quantity of pollutants and
- Pollution control, abatement, and rehabilitation

So far, Bangladesh has not implemented the program in a systematic way. A few organizations are working on coastal pollution in an unplanned way. BFRI through its Marine Fisheries & Technology Station, Cox's Bazar is working for long on marine /coastal pollution in Chittagong and Cox's Bazar coast of the BoB based on which the data has been presented in this paper.

**Status of water quality in Chittagong and Cox's Bazar coast of the Bay of Bengal**

**Dissolved oxygen:** Dissolved oxygen is one of the important pollution indicators for the aquatic environment. Healthy dissolved oxygen level in any aquatic environment is around 5.0 mg/l which indicates that the environment is not polluted. Non-polluted surface waters are normally saturated with dissolved oxygen. Dissolved oxygen can be rapidly removed from the waters by discharge of the oxygen demanding wastes. Other inorganic reluctant such as hydrogen sulphide, ammonia, nitrites, ferrous iron and other oxidizable substances also tend to decrease dissolved oxygen in water. Low dissolved oxygen concentrations are generally associated with heavy contamination by organic matter. In such conditions dissolved oxygen totally disappears from the water. The study indicated that dissolved oxygen level at Laboni, Himchari, Sonapara and Teknaf point of Cox's Bazar coast were 7.52-8.50 mg/l, 8.24-8.60 mg/l, 8.02-8.69 mg/l and 8.01–8.50 respectively and at Bhatiari of Chittagong coast was 5.60–6.48 mg/l which can be considered as normal level (Fig. 1).

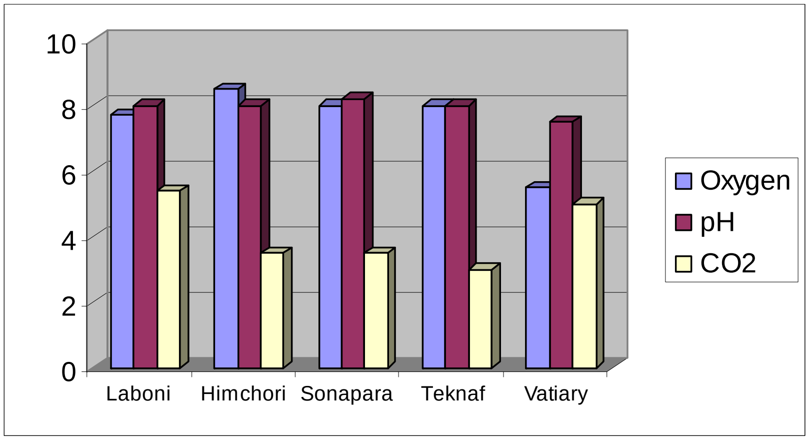


**Fig. 1.** Status of dissolved $O_2$, pH and $Co_2$ in Chittagong and Cox's Bazar coasts of the Bay of Bengal.

**pH:** The pH is one of the most characteristic features of water quality which controls the aquatic environment. All chemical and biological reactions are directly dependent upon the hydrogen ion concentration that is pH of the water system (Srinivasan 1967). Water pH is the measure of the intensity of alkalinity and measures the concentration of hydrogen ions in water. It does not measure total acidity or alkalinity (Bockris 1978). The pH of even natural water gets drastically changed with time due to the exposure to air, biological activity and temperature changes. The study showed that water pH level at Laboni, Himchari, Sonapara and Teknaf of Cox's Bazar coast were 8.00-8.50, 8.00-8.50, 8.30-8.50 and 8.10- 8.15 respectively and at Vatiari of Chittagong coast was 7.60–6.48 which is considered as normal level (Fig. 1).

**$Co_2$:** Carbon dioxide is the basis of all life on the earth although sometimes it may be considered as a troublesome substance. Without free carbon dioxide the basic food production by plants through photosynthesis is not possible. Bound and half -bound carbon dioxide have profound influence on the water quality. Respiration by organisms is an important source of free carbon dioxide. In unpolluted water body free carbon dioxide is found generally in small quantities. Free $Co_2$ concentrations of more than 20.0 mg/l may be harmful to fishes and even lower concentrations may be equally harmful when dissolved oxygen concentrations are less than 3.0-5.0 mg/l. The free carbon dioxide concentration becomes high in the early morning before sun-rise and lowest in the afternoon. The study indicated that free $Co_2$ at Laboni, Himchari and Sonapara of Cox' Bazar coast were 0.00-5.23 mg/l, 0.00-3.45 mg/l and 0.00-3.48 mg/l respectively and at Vatiari of Chittagong coast was 4.56–5.36 mg/l which is considered as within normal level (Fig. 1).

**Total suspended solids (TSS)**

TSS is solid materials, including organic and inorganic, that are suspended in the water. These would include silt, plankton and industrial wastes. High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. The combination of warmer water, less light and less oxygen makes it impossible for some forms of life to exist. Suspended solids affect life in other ways also. They can clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. Suspended solids can result from erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders, algal growth or waste water discharges. The study indicated that TSS of the Naf river and Bakkhali river of Cox's Bazar coast were 2.89-3.54 g/l and 4.89-4.32 g/l respectively and of the Karnophuli river of Chittagong coastwais 2.90–3.56 g/l which was within normal level (Fig. 2).

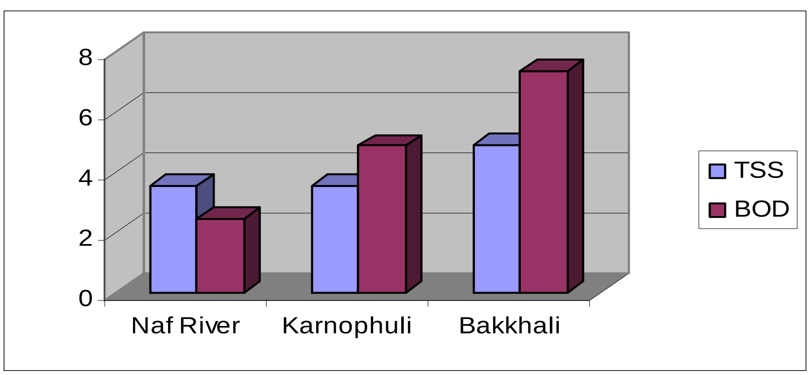


**Fig. 2.** Status of TSS and BOD in Chittagong and Cox's Bazar coasts of the Bay of Bengal.

## Biological oxygen demand (BOD)

BOD is one of the most common measures of pollutant organic materials in water. BOD indicates the amount of putrescible organic matters present in water. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water. Dissolved oxygen (DO) is consumed by bacteria when large amounts of organic matter from sewage or other discharges are present in water. DO is the actual amount of oxygen available in dissolved form in the water. When the DO drops below a certain level, the life forms in that water are unable to continue at a normal rate. The BOD test serves an important function in pollution control activities. It is a bioassay procedure that measures the amount of oxygen consumed by living organisms. The study indicated that BOD of the Naf river and Bakkhali river of Cox's Bazar coast were 2.47-2.65 mg/l and 4.42-7.35 mg/l respectively and of the Karnophuli river of Chittagong coast was 3.56 – 4.87 mg/l (Fig. 2).

## Total coliform bacteria (TCB)

Bacteria are unicellular organisms of different type. Some are beneficiary and some are harmful. Total Coliform bacteria of the Naf river and Bakkhali river of Cox's Bazar coast were 311-425 no/100 ml and >2,400 no/100 ml and of the Karnophuli river of Chittagong coast was 1280 - >2,400 no/100 ml (Fig. 3).

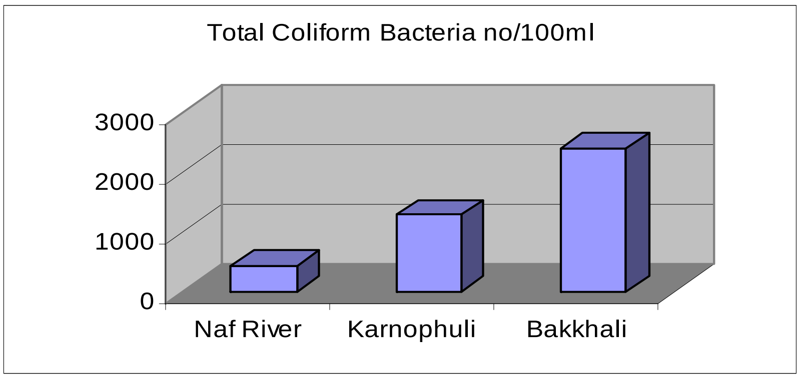


**Fig. 3.** Status of total coliform bacteria (TCB) in Chittagong and Cox's Bazar coasts of the Bay of Bengal.

**Temperature**

Water temperature is directly and closely related with air temperature but sometimes exceptions may occur when water temperature may be slightly higher than air temperature. The study showed that water temperatures of the Naf river and Bakkhali river of Cox's Bazar coast were 22.0- 28°C and 21.3–27.5°C and of the Karnophuli river of Chittagong coast was 22.8–27.0°C (Fig. 4).

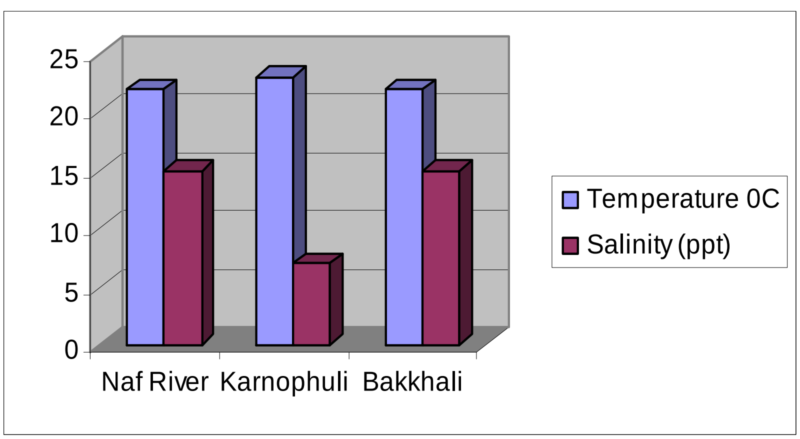


**Fig. 4.** Status of temperature and salinity in Chittagong and Cox's Bazar coasts of the Bay of Bengal

## Salinity

Salinity is an ecological factor of considerable importance, influencing the types of organisms that live in a body of water. The degree of salinity in oceans is a driver of the world's ocean circulation, where density changes due to both salinity changes and temperature changes at the surface of the ocean that produce changes in buoyancy, which cause the sinking and rising of water masses. Changes in the salinity of the oceans are thought to contribute to global changes in carbon dioxide as more saline waters are less soluble to carbon dioxide. The study showed that water salinity of the Naf river and Bakkhali river of Cox's Bazar coast were 15.0-27.0 ppt and 15.0–26.0 ppt and of the Karnophuli river of Chittagong coast was 7.0-13.0 ppt (Fig. 4).

## Oil and grease

Oil and grease is one of the main containment of the marine aquatic environment, hamper the primary productivity by limiting sun-light penetration in the aquatic environment. Usually when oil and grease spreads out in the aquatic environment it is difficult to diminish/destroy. The oil and grease level in the environment is considered as normal when the level is within 25.0 mg/l. In the study area, oil and grease was more in winter season than in monsoon season. During winter season, the study showed that oil and grease at Moheskhali channel, Kolatoli and Teknaf port were 180.0 mg/l, 20.0 mg/l and 250.0 mg/l respectively (Fig. 5).

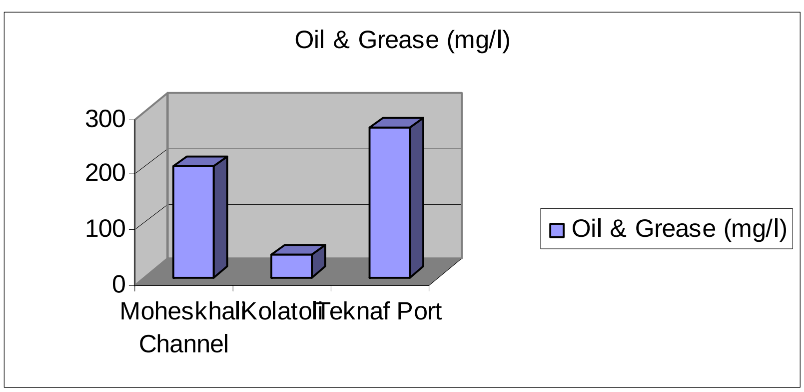


**Fig. 5.** Status of oil and grease in Cox's Bazar coast of the Bay of Bengal.

- Oil and grease is one of the main containment of the marine aquatic environment, it hampers primary productivity by limiting sun-light penetration in the aquatic environment.
- The oil and grease level in the environment is considered as normal when the level is within 25.0 mg/l.
- Heavy metals are natural components of the earth's crust and one of the important pollutants of water resources.
- Heavy metals are dangerous because they tend to bioaccumulate - an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment.

## Heavy metals

Heavy metals are natural components of the earth's crust and one of the important pollutants of water resources. They cannot be degraded or destroyed. To small extent, they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (Copper, Zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations, they can lead to poisoning. Heavy metals are dangerous because they tend to bioaccumulate. During winter season, the study showed that Lead (Pb) at Vatiari, Patenga, Chittagong port in the Chittagong coast were 0.136 mg/l, 0.062 mg/l and 0.00 mg/l and at Moheskhali channel in the Cox's Bazar coast was 0.174 mg/l respectively. Cadmium (Cd) of water were found to be 0.067 mg/l at Vatiari, 0.042 mg/l at Patenga, 0.042 mg/l at Chittagong port and 0.048 mg/l at Moheskhali channel in the Cox's Bazar coast. The study also showed that Zinc (Zn) at Vatiari, Patenga, Chittagong port in the Chittagong coast were 0.016 mg/l, 0.014 mg/l and 0.007 mg/l and at Moheskhali channel was 0.059 mg/l respectively (Table 1).

**Table 1.** Heavy metals status in water in Chittagong and Cox's Bazar coasts of the Bay of Bengal

| Heavy metal | Bhatiari | Patenga | Chittagong Port | Moheskhali Channel |
|---|---|---|---|---|
| Lead, Pb (mg/l) | 0.136 | 0.062 | 0.00 | 0.174 |
| Cadmium, Cd (mg/l) | 0.067 | 0.042 | 0.042 | 0.048 |
| Chromium, Cr (mg/l) | 0.055 | 0.044 | 0.042 | 0.060 |
| Zinc, Zn (mg/l) | 0.016 | 0.014 | 0.007 | 0.059 |

**Status of BOBLME countries in relation to water quality**

In consideration to water quality in the BOBLME countries, most of the countries have their own water quality monitoring systems. Bangladesh and Maldives don't have water quality monitoring system. Malaysia has national monitoring system for all the water bodies. Thailand has also coastal and sea water quality monitoring system two times in a year. There is no national monitoring system for water quality in India. Indonesia and Sri Lanka have national monitoring systems for water quality.

**Transboundary issues**

***Sea based pollution***

Among the most important transboundary environmental issues of the BOB is pollution. Although there are several legal instruments, both national and international, to combat pollution and environmental degradation, several key problems still exist and these include operational ship discharge and ballasting dumping and illegal sand mining. The Department of the Environment has an important role to play preventing all forms of pollutant discharge in Bangladesh.

***Nutrients***

Nutrient pollution is the most pervasive and troubling pollution problem. Although nutrients such as nitrogen (N) and phosphorus (P) are necessary to marine ecosystems in small quantities and human activities on the coast and inland areas have greatly increased the flow of nutrient levels. Nutrient pollution defies simple categorization and is difficult to control because it can come from point, non-point, and atmospheric sources, from near and far. The main sources include runoff from agricultural land, animal feeding operations and urban areas, discharges from waste water treatment plants and atmospheric depositions of chemicals released during fossil fuel combustion. The largest human activity related additions of nitrogen results from an increased use of inorganic fertilizers. Nutrient pollution leads to a host of ecological and economic impacts including fish kills due to oxygen depletion; loss of important and sensitive coastal habitats, such as sea grasses and sometimes toxic algal blooms and changes in marine biodiversity.

- Most of the countries have their own water quality monitoring systems. Among the BOBLME countries, Bangladesh and Maldives don't have water quality monitoring system.
- Pollution is the important transboundary environmental issues of the BOBLME.
- Nutrient pollution leads to a host of ecological and economic impacts including fish kills due to oxygen depletion; loss of important and sensitive coastal habitats, such as sea grasses and sometimes toxic algal blooms and changes in marine biodiversity.

**Enforcement and implementation of Environmental Regulations**
**The Environmental Conservation Act, 1995**

The act has empowered the Government to declare an area as an "Ecologically critical area (ECA)" if its eco-system appeared to be under serious threats of degradation or is degraded. The Environmental Conservation Rules, 1995 were passed subsequently under this act. In 1999, the Ministry of Environment and Forest declared seven areas as ecologically critical areas having effect in marine fisheries like Sunderbans, Cox's Bazar-Teknaf sea beach, St. Martin's Island, Sonadia Island. Later Sunderbans was withdrawn from the list and instead a 10 km extent outside of Sunderbans Reserve Forest was declared as ECA. In these ECAs, ban has been imposed on some activities including activities that may be harmful for fish and aquatic life.

Marine pollution has reached such a level that could create an unmanageable situation in the near future. Although Bangladesh is a party/signatory to a number of international conventions related to marine pollution, no comprehensive domestic legislation has been enacted yet on this issue. Environmental Conservation Act, 1995 does not cover all issues of marine pollution adequately. However, the Departmental of Shipping is in the process for formulating a draft Marine Pollution Act. This would be drafted jointly by experts of the concerned departments.

**Tsunami impacts**

Generally saying Tsunami- is the long wave of sea. Due to earthquake at the bottom of sea/ocean, large waves are created. Geologists opine that approximately one million times earthquake happen in the earth in a year majority of which occurs at the bottom of sea/ocean, on a scale of Richter scale within 4-5. When earthquake happens in the Richter scale of 8-10, water current speeds in at rate of 500-700 km/h, as a result huge water-flow, inundation, typhoon-like situation may happen in the coastal areas. Now is the question, what is the impact of Tsunami in the marine pollution of the sea/ocean? At the moment this is one of the researchable issues for the marine environmental researchers. A recent report of the WorldFish Center, Dhaka (personal communication) revealed that there were no significant differences in the physic-chemical properties of sea water before and after the Tsunami of 26 December 2004. Findings revealed that water temperature was around 27.3°C-28.5°C, Water salinity around 32.8-33.0 ppt and dissolved oxygen around 5.8-7.4 mg/l and water was opaque after the Tsunami.

**Global warming and sea-level rise**

Global climate change may compound pressure on marine and coastal ecosystems through the effects of warmer ocean temperature, altered ocean circulation patterns, changing storm frequency and rising sea level (Burke *et al.* 2001 and Kibria *et al.* 2010). According to the International Panel on Climate Change (IPCC) Third Assessment Report (2001), sea level will rise from 9.0 to 88.0 cm by the year 2100 as a result of the global warming. The rising sea levels will likely inundate coastal wetlands and other low-lying coastal lands, erode beaches, intensify storm surges and flooding and increase salinity of inland rivers and groundwater tables.

**Areas and level of actions needed**

- Strengthening institutional co-ordination and integration– National
- Policy development and implementation– National/ Regional
- Monitoring programmes (standard criteria, protocol, mussel watch)– National/ Regional
- Public awareness and advocacy– National/Regional
- Capacity building (human resource and Infra-structure)– National/Regional
- Waste management (Liquid and solid)– National/Regional
- Nutrient management– National/Regional/ Global
- Catchment to coast linkage– National
- Mapping and report card on state of the coast/health ecosystem– Regional
- Establishment of operational working group– National/ Regional

**Conclusions**

Coastal areas in Chittagong and Cox's Bazar coasts in the Bay of Bengal are not polluted in all places except for a few places. Pollution occurs by oil and grease and is more frequent in winter season than monsoon in some selective areas. BOBLME countries can initiate an unified water quality parameter criteria for monitoring from all coastal states which would help to understand the situation of every country easily. In these aspects, there is a need of long-term project by integrating eight countries.

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# Marine fisheries resources and its management policies in the Bay of Bengal

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**Fisheries resources and production potentials**

Bangladesh is located in the delta of three mighty rivers; the Padma, the Jamuna and the Meghna. The fisheries sub-sector in Bangladesh contributes 20.87% to the agricultural production and earns second highest (4.04% of the total) foreign exchange of the country. About 60 percent of the national animal protein consumption comes from the fish and fish products. Fish production of 2007-08 by resource type is shown in Table 1.

In these circumstances, the fisheries sub-sector has become a major target in the country's development plans and is being geared to meet the demand of increasing population through optimum utilization and development of aquatic resources on a sustainable basis. To harness the full potential from both inland and marine fisheries resources, various management regimes are being in place involving both private and public sector.

**Table 1.** Fish production by resource type (2007-08)

| Resource type | Water area (Hectare) | Production (Metric ton) | Catch/area (kg/he) | % of total production |
|---|---|---|---|---|
| **A. Inland Fisheries** | | | | |
| **(i) Capture** | | | | |
| 1. River & estuaries | 853,863 | 136,82 | 160 | |
| 2. Sundarbans | 177,700 | 18,151 | 102 | |
| 3. Beel | 114,161 | 77,524 | 679 | |
| 4. Kaptai Lake | 68,800 | 8,248 | 120 | |
| 5. Flood plain | 2,832,792 | 819,446 | 289 | |
| **Capture total =** | **4,047,316** | **1,060,181** | **-** | **41.36** |
| **(ii) Culture** | | | | |
| 1. Pond & ditch | 305,025 | 866,049 | 2,839 | |
| 2. Baor | 5,488 | 4,778 | 871 | |
| 3. Shrimp/Prawn farm | 217,877 | 134,715 | 618 | |
| **Culture total** | **528,390** | **1,005,542** | **-** | **39.23** |
| **Inland total =** | **4,575,706** | **2,065,723** | **-** | **80.59** |
| **B. Marine Fisheries** | | | | |
| (i) Industrial fisheries | - | 34,159 | - | |
| (ii) Artisanal fisheries | - | 463,414 | - | |
| **Marine total =** | **-** | **497,573** | **-** | **19.41** |
| **Country total =** | **-** | **2,563,296** | **-** | **100.00** |

## Policy directives to fisheries development

To develop this sub-sector the National Fisheries Policy–1998 was formulated keeping in view to enhance fisheries production and alleviate poverty through facilitating employment generation, ensuring supply of animal protein, achieving economic growth by exporting fish and fish products, maintaining ecological balance and conserving biodiversity.

**Marine Fisheries**

Of the total fish production in Bangladesh, marine fisheries contribute around 19.41% from its EEZ. The marine catch in Bangladesh was only 95,000 mt in 1975-76 and has increased to about 497,573 mt in 2007-2008. The coastal and marine fisheries historically offer the livelihoods of millions of Bangladeshi people. In the year 2007-08 total marine fish production was 0.5 million mt of which only 8% was trawl catch and 92% were from artisanal fisheries. Only one third of the EEZ is under fishing operation and the rest area of the deeper part of the EEZ needs to be explored.

Marine fisheries production in Bangladesh has shown a steady growth over the last years and landings have increased. In recent years, there has been a substantial increase in fishing effort, leading to overexploitation of coastal stocks, with a resultant decrease in CPUE. But there is a lack of clear idea about the standing stock. Some surveys were done involving R.V. Dr. Fridtjof Nansen (FAO/NORAD/BGD 1979-80) and R.V. Annusandhani (BGD 1983, and FAO/BGD 1984-86), which gave estimates of demersal standing stock within the exploited 10-100 m depth shelf area. But the data is now almost obsolete. There is no data on pelagic fish stock as a whole and for highly migratory fishes. After a long gap, a short survey from 25$^{th}$ October to 21$^{st}$ December 2008 was initiated under BIMSTEC (2008) to assess the potential of fishery resources in the BoB and to collect the biological data of fishes, including oceanic squids in the survey areas. The survey was limited only using pelagic long line, drift gill net and squid jigging to assess the stock of some highly migratory fishes, *viz*. tuna, mackerel, sardine etc. At present 155 industrial trawlers and about 43,000 mechanized and non-mechanized boats are engaged in fishing. Pelagic and deep sea resources are still untapped.

**Highlights of Bangladesh marine resources**

**A. Area**

| | |
|---|---|
| Coast line | : 710 km |
| Internal water (coast line to base line) | : 25140 sq. km |
| Territorial water (from base line up to 12 nm) | : 9060 sq. km |
| EEZ (from base line up to 200 nm) | : 1,40,860 sq. km |
| Continental shelf | : 66,000 sq. km |
| Total sea water (EEZ+Internal water) | : 1,66,000 sq. km |

**B. Species inhibited of fisheries importance (no.)**

| Species | Numbers |
|---|---|
| Fish | 475 |
| Shrimp | 36 |
| Sea turtles | 0 |
| Crab | 12 |
| Lobster | 05 |
| Snail and shell | 301 |
| Seaweeds | 50 |
| Oyster | 06 |
| Dolphin/whale | 11 |
| Sea cucumber | 33 |

**C. Main fishing grounds**

Identified four fishing grounds are:

| **Sl. No.** | **Name** | **Area** (Sq. km) | **Position** |
|---|---|---|---|
| 1 | South patches | 3,400 | From 10 km West of Cox's Bazar |
| 2 | South of south patches | 2,800 | From 5 km South West of Teknaf |
| 3 | Middling | 4,600 | From 30 km South of Hatiya |
| 4 | Swatch of no ground | 3,800 | From 29 km South of Dubla Island |

**D. Maximum sustainable yield (MSY) based on marine fish stock (R.V. Dr. Fridtjof Nansen (FAO/NORAD/BGD 1979-80) beyond 10 m depth zone**

| Resource | Stock (mt) | MSY (mt) |
|---|---|---|
| Shrimp | 2,000 – 4,000 | 7,000 – 8,000 |
| Demersal fish | 1,50,000–1,60,000 | 40,000 – 55,000 |
| Pelagic | 90,000 – 1,60,000 | Not determined |

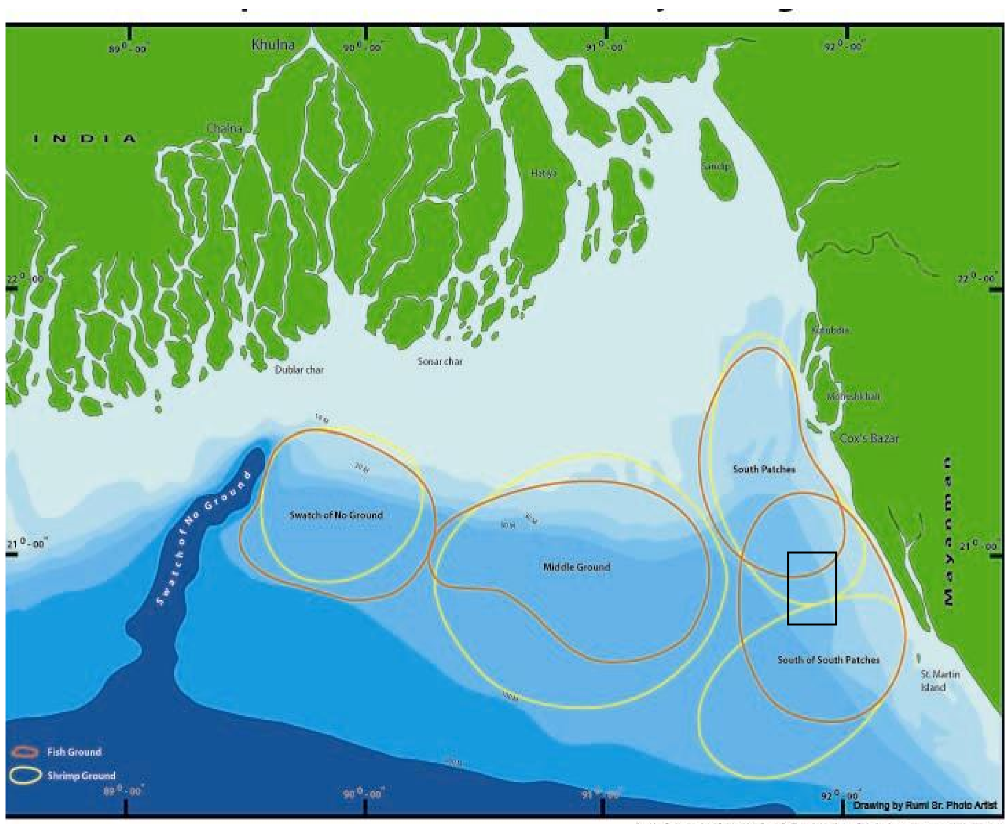


**Fig. 1.** Fishing grounds and marine reserves in the Bay of Bengal.

**Some Important commercial fish species in the Bay of Bengal**

The marine habitat houses many fish species, shrimps, lobsters, crabs and a number of other crustaceans and molluscs. Some of the important species exploited from the Bay of Bengal are:

1. *Pampus argenteus* - Silver pomfret
2. *Pampus chinensis* - Chinese pomfret
3. *Pomadasys hasta* - White grunter
4. *Lutjanus johini* - Red snapper
5. *Tenulossa* spp. - Hilsa shad
6. *Polynemus indicus* - Indian salmon
7. *Lepturacanthus savala* - Ribbon fish/Hair tail
8. *Arius* spp. - Cat fish
9. *Johnius belangerii* - Croaker
10. *Ilisha filigera* - Big eye ilisha
11. *Katsuwonus pelamis* - Skipjack tuna
12. *Euthynnus affinis* - Short tuna
13. *Thunnus maccoyii* - Southern blue fin tuna
14. *Penaeus monodon* - Giant tiger shrimp
15. *Penaeus semisulcatus* - Tiger shrimp
16. *Penaues indicus* - White shrimp
17. *Metapenaeus monoceros* - Brown shrimp
18. *Parapenaeopsis stylifera* - Pink shrimp

The fishing operations in the estuaries and coastal waters of Bangladesh were carried out by traditional craft till late 1960. Although the introduction of motorized fishing craft has gained momentum during the last decade but the bulk of the marine catch is still landed by non-motorized craft. Modern boats, nets and gears are essential for industrial and artisanal fishery management revolution. The country’s marine fishery may broadly be divided into Artisanal and Industrial fisheries.

**Artisanal fishery:** The artisanal fishery includes all the fishing activities other than industrial trawl fishery. A bulk number of mechanized and non-mechanized fishing boats are engaged in fishing in the BoB. There was no systematic census on the artisanal fishery since 1985. An update of the existing data was made through the “Strengthening of Marine Fisheries Management” project in 2000. The status of the marine craft and gears are as follows.

- No. of mechanized boats: 21,016
- No. of non mechanized boats: 22,120
- No. of gears
  Set bag net: 50,083
  Gill net : 1,06,316
  Push net: 18,775
  Drift net: 3,644
  Seine net: 1,949
  Others: 39,763

A large number of fishers operate gears without boat such as beach seine and cast net. A moderate number of fishers operate seine nets, estuarine set bag net (ESBN) and small long lines with non-mechanized boats.

**Mechanization of artisanal fishery**: Motorized boats with 12 HP outboard engines were introduced in 1966-67 by FAO-SIDA project under the Freedom from Hunger Campaign. Later, these were replaced by inboard marine diesel engines of 15-33 HP. A modified Cox's Bazar type boat has been built in Chittagong boatyard under DANIDA-aided boatbuilding and motorization project in 1975-76. It is 12 m long, powered by a 22 HP inboard diesel engine. Main types of fishing gears being used from the mechanized boats are, small meshed drift nets (SMD), large meshed drift nets (LMD), estuarine set bag nets (ESBN), marine set bag nets (MSBN) and long lines (LL).

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**Industrial fishery**: It primarily comprises of trawlers catching demersal fish and shrimps. Commercial trawling in the offshore waters started in 1972 with the introduction of seven trawlers. Towards the end of 1983, the effective number of trawlers in operation increased to 65, of which 47 were fish trawlers and 18 double rig shrimp trawlers.

At present 200 industrial fishing vessels are allowed to operate in the EEZ of Bangladesh. Out of these 155 are in operation and remaining 45 are under process of being operational. The fishing vessels in operations are shrimp trawler, white fish trawler, mid water trawler, demersal trawler, squid jigger and purse seiner. Last ten years marine fish harvest by industrial fishing trawler has been shown in Table 2.

**Table 2:** Marine fish harvest by industrial fishing trawlers during 1999-2009

| Year | Shrimp Trawler | | | | Fish Trawler | | | | Squid jigger | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nos. of trawler | Shrimp (mt) | Fish (mt) | Fishing days | Nos. of trawler | Shrimp (mt) | Fish (mt) | Fishing days | Nos. of jigger | Squid (mt) | Days |
| 99-00 | 44 | 2908 | 5372 | 7152 | 21 | 6 | 8017 | 2517 | | | |
| 2000-01 | 44 | 3155 | 4701 | 7289 | 31 | 17 | 16027 | 3871 | | | |
| 2001-02 | 44 | 3142 | 4459 | 6935 | 36 | 26 | 16586 | 4841 | | | |
| 2002-03 | 45 | 2455 | 5447 | 7069 | 42 | 22 | 19428 | 5414 | | | |
| 2003-04 | 45 | 3059 | 6034 | 7442 | 49 | 17 | 23207 | 6284 | | | |
| 2004-05 | 45 | 3272 | 5038 | 7866 | 68 | 38 | 25895 | 8535 | | | |
| 2005-06 | 41 | 3377 | 3544 | 7466 | 78 | 67 | 27096 | 11469 | | | |
| 2006-07 | 39 | 2138 | 3769 | 5919 | 88 | 36 | 29446 | 11462 | 1 | 33 | 146 |
| 2007-08 | 38 | 2579 | 2362 | 5969 | 95 | 41 | 29176 | 13368 | 2 | 91 | 225 |
| 2008-09 | 40 | 2877 | 2295 | 5956 | 101 | 55 | 30202 | 13825 | 4 | 156 | 388 |

**Legislation for marine fisheries management**

The Government of Bangladesh has promulgated the Marine Fisheries Ordinance 1983 for conservation, management and development of marine fisheries resources. Some of the important provisions in the Marine Fishery Ordnance 1983 and Rules thereof and in the subsequent amendments of the ordinance and rules are discussed below:

- **Licence for trawling:** All trawlers should have license for fishing in the territory of Bangladesh and should possess valid required certificate and display nationality sign through flag and suitable markings on the visible part of the vessel. Every fishing vessel should obtain pre-sailing permission for fishing from the Marine Fisheries Office.

- **Limiting the fishing days:** The shrimp trawlers and modern trawlers are permitted to fish for 30 days and ice trawler for 15 days limit in a cruise.
- **Discard of by-catch is banned**: The shrimp trawlers must have at least 30% fin-fish in the total catch for each trip. This measure was enforced in order to limit the discard of by-catch.
- **Control of mesh size:** Mandatory to use 45 mm and 60 mm mesh size at the cod end for the shrimp and fish trawl nets, respectively to facilitate the escape of small sized fish, shrimp and the juveniles of larger fish species. The use of a prescribed mesh size is also being ensured by random inspection of the industrial trawlers before and after every fishing trip. Bangladesh Navy and Coast Guards are deployed to enforce the ban and provisions of the law routinely.
- **Depth zone restriction of 40 m:** There are provisions for restricting the shrimp and fish trawlers for trawling within a 40 m depth zone to protect the nursery grounds of marine fish and shrimp and preserve the interest of artisanal fishers.
- **Formulation of marine fish exploration guidance:** Guidelines for the industrial fishing fleet have been formulated and published to ensure proper exploitation of the fishery resources.
- **Prohibited methods of fishing**: Fishing with any gear having mesh size smaller than the mesh size specified (above); fishing with any kind of explosives, poison and other noxious substances/chemicals and fishing with electrocuting the marine species of any type are entirely prohibited.
- **Compulsory use of TED:** Use of turtle excluder device (TED) in shrimp trawlers is mandatory.
- **Declaration of Marine Reserves:** To protect the marine habitat and the natural breeding grounds of marine resources Bangladesh government has declared a marine reserve in the Bay of Bengal on 29-10-2000. The area of the marine reserve is 698 sq. km, surrounded by the two fishing grounds namely middling and south patches.
- **Ban on shrimp trawlers:** Shrimp trawler is banned for operation during 15 January through 15 February considering the breeding period of shrimps.

- **Restriction on post-larvae (PL) collection:** Government has restricted PL collection in coastal areas in the year 2000, which was later reinforced in 2002.
- **Ban on throwing any fish into the sea:** Government has imposed restriction on throwing any catch of fish or aquatic resources except turtle in the sea.

- All trawlers should have license for fishing in the territory of Bangladesh and should possess valid required certificate.
- Shrimp trawlers and modern trawlers are permitted to fish for 30 days and ice trawler for 15 days limit in a cruise.
- Shrimp trawlers must have at least 30% fin-fish in the total catch for each trip.
- It is mandatory to use 45 mm and 60 mm mesh size at the cod end for the shrimp and fish trawl nets, respectively to facilitate the escape of small sized fish, shrimp and the juveniles of larger fish species.
- Industrial shrimp and fish trawlers are allowed only to fish at >40 m depths, while artisanal fishers are allowed to fish within 40 m depths.

**Potential for development of un-exploited resources and new interventions in marine fisheries**

A number of fish species have virtually remained unexploited or under-exploited, mainly because of the lack of knowledge and information on the availability of the sizes of different fish stocks and partly due to lack of technological developments for harvesting the untapped resources. Presently only one-third of the EEZ is covered by these fishing vessels. The extended fishing operation beyond the EEZ is needed and it is also possible to extend fishing operation beyond the EEZ, i.e. in the international waters. Entrepreneurship development initiatives are needed to get access to these development processes. To pursue the sustainable economic yield it is required to make a comprehensive survey of the total fishery resources in the BoB.

In the coastal parts of Bangladesh there are potentials to introduce mariculture and brackish water aquaculture as well. Introduction of new commercial species like sea cucumber, sea bass, grouper, milk fish etc. is needed for consideration in coastal aquaculture. Cage culture might be an option for further development of the marine fisheries aquaculture in Bangladesh.
For proper management of marine resources the following programs/activities need to be undertaken:

- Survey on demersal, pelagic and shrimp stocks
- Tuna fishery resource study in the EEZ
- Catch and effort statistics research
- Marine habitat protection and restoration
- Spawning and nursery ground identification
- Community based coastal resource management.

**Survey on Tuna fishery resources and its exploitation**

The last part of the EEZ of Bangladesh and adjacent international water is the migratory route of highly migratory fish like tuna, marlings etc. At present Bangladesh is in the pipeline for the membership for Indian Ocean Tuna Commission (IOTC). But we do not have sufficient information and are not in a position to exploit this resource though there is enough potential.

### Strengthening fisheries management in the coastal areas

Monitoring, control and surveillance (MCS) is an essential and integral component of fisheries management. The latest compliance method for surveillance is the Vessel Monitoring System (VMS) and Vessel Tracking and Monitoring System (VTMS) which needs to be introduced and established in the fishing vessels of the country. It is expensive as it needs help of satellite technology. This system is used as an effective management tool because of its capability to manage and control the activities of the intended vessels.

### Bangladesh in International Co-operation

A number of international agreements signed by the Bangladesh Government for proper management of marine resources – such as the Code of Conduct for Responsible Fisheries (CCRF) 1995, the 1982 UN Convention on the Law of the Sea (UNCLOS), the Ramsar Convention of 1971 for Wetlands Conservation, the UN's Millennium Development Goals, the Rio Declaration and Agenda 21 of 1992, the 1992 Convention on Biological Diversity. Bangladesh is the active member of BIMSTEC, BOBP-IGO and BOBLME.

### Conclusions

Marine fisheries sector in Bangladesh has come a long way. Once dominated by small-scale capture fisheries, later by aquaculture, it is now poised for more all-round development. Once unplanned, fisheries is now governed by a National Fisheries Policy-1998, detailing it through 8 strategies and then pointing specific development interventions through action plans for each of the strategy. Once driven largely by the Government, fisheries in Bangladesh are now moving toward an era of progress with private sector playing the leading role through private-public partnerships and linkages.

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# Environmental impact on hilsa (*Tenualosa ilisha*) fisheries in the coastal belt of Bangladesh

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## Introduction

Among other commercial important fishes, hilsa shad (*Tenualosa ilisha*) is the most important single species fishery and national fish of Bangladesh. It accounts for nearly half of the total marine catches, and about 12% of total fish production and about 1.0 percent of GDP. The average annual production of hilsa is 0.25 million tons, worth Tk. 50,000 million (@ Tk. 200/kg). The peak fishing season extends from July to March, with a major peak in September-October and a minor one during February-March. This fishery is artisanal and uses mainly drift and set gill nets from traditional non-mechanized and mechanized wooden boats. About 460,000 fishers of 148 Upazilas are directly employed in hilsa fishing with an indirect employment of about 2.5 million in the wider hilsa sector (trading, processing etc.). At present 50-60% of total hilsa catch is reported from Bangladesh, 20-25% from Myanmar, 15-20 % from India and rest 5-10 % from other countries (*e.g.*, Iraq, Kuwait, Malaysia, Thailand and Pakistan).

During last 10 years (1999 to 2008), industrial marine catch has increased about 116% whereas, artisanal catch has increased only 58% (FRSS, 2009), but development of this marine sector is vital in context of making a major impact on production and well being of the people of the country. Again, Hilsa is standing as the single largest species fishery contributing 11.13% of the total annual fish production of the country, then shrimp/prawn (8.70%), Bombay duck (*Harpondon nehereus)* (1.44%), jew fish (poa, lambu, kala datina etc.) (1.32%), sea cat fish (*Tachysurus* spp.) (0.80%), pomfret (rup, hail and_foli chanda*)* (0.65%) and sharks, skates and rays (0.19%) etc. Other than hilsa, there are many marine fish species remaining under-exploitation condition, need to assess the stock position and more exploitation can be done, there is a tremendous scope. Now the time has come to investigate in depth the environmental impact on hilsa (*Tenualosa ilisha*) and important fisheries of Bangladesh.

**Distribution of hilsa in the Bay of Bengal**

The details of marine distribution of hilsa in Bangladesh are not available. Although in earlier days, the marine hilsa catch was restricted in the coastline, it has now dispersed in the wider areas of the Bay of Bengal and extended up to 200-250 km from the coastline. Therefore, there is a chance of wider distribution of hilsa in the BoB due to increased fishing activity.

In inland waters, hilsa and *jatka* (juvenile hilsa) occurred in about 100 rivers, but at present their main concentration is in the lower Meghna, Tetulia, Arial kha and other major rivers of southern region and in their estuarine parts. The distribution of hilsa mainly depends on water flow and flooding of the rivers. In the years of heavy flood, they are also caught in the small channels and even sometimes in the floodplains. Considerable amount of hilsa are also caught in the lower Arial kha, Madhumati and Padma and a little in the Jamuna and Brahmaputra. During the last 10-30 years, hilsa fishery has been completely lost from about 35 rivers and in another 8-10 rivers hilsa are rarely caught. The estimated production loss from these rivers is about 20,000-25,000 mt and about 45,000-50,000 fishers have lost their works of hilsa fishing.

- During last two decades hilsa production from inland waters declined about 12% with an increase of about 2 times from the marine sector.
- During the last 10-30 years, hilsa fishery has been completely lost from about 35 rivers and in another 8-10 rivers hilsa are rarely caught.
- The marine catch of Myanmar is increasing significantly in the recent years.
- If proper protective and conservation measures are not undertaken for this fishery in inland waters, the area of hilsa catch may move further down and be restricted to the sea only.

**Some biological attributes of hilsa and exploitation level**

**Stock/Race of hilsa:** Earlier, there was a controversy as whether all hilsa (*T. ilisha*) stocks of Bangladesh are migratory or not. Many thought that there are three different hilsa stocks as regards to their migratory behaviour. (i) A migratory (anadromous) stock living in the foreshores of the Bay of Bengal, which migrate far upstream into the rivers for spawning. (ii) A stock which completes its' entire life cycle within the river system. It does not migrate to the sea. (iii) A marine stock living all its life in the foreshore of the sea and does not migrate to the river system (Quddus *et al.* 1984, Rahman 1997). Both genetic and otolith microchemistry data showed that hilsa from Southeast India and Myanmar were not significantly different from fish collected in coastal areas of Bangladesh and suggested that hilsa in the BoB are a single stock (Hussain *et al*. 1998). It may be concluded that hilsa in Bangladesh are a single population that is probably shared with India and Myanmar, and therefore this population needs tri-nation co-management as a single stock.

**Movement and migration pattern:**. Most hilsa born in freshwater, live and grow in the sea and migrate to the upstream for breeding and feeding. The adults again return to the sea after spawning. The offspring of hilsa live in the rivers and streams for about 6-7 months and at the onset of monsoon, especially when the clear water of the rivers and streams began to get turbid, they migrate to the sea for maturation. After attaining maturity they again migrate to the freshwaters for breeding in order to complete their life cycle. It has been observed that in the Meghna river, *jatka* up to 13 cm remain in the upper part of the river and then they migrate to the deeper water. Earlier, the hilsa was considered as anadromous with two ecotypes- (i) a fluvial potamodromous and (ii) a marine type (Raja 1985).

Movement pattern studies of hilsa through otolith microchemistry also indicated that the fish move around in all three habitats, *i.e.*, from marine water to freshwater through brackish water and vice-versa. The resident stock never migrate to the sea and completes its' entire life cycle within the river system. But detailed studies, especially for juveniles and pre-adult hilsa, have not yet been done in Bangladesh. Now a days, it has been observed that migratory routes/channel of hilsa is being seriously hampered due to siltation and creation of merged and submerged islands in the main rivers, estuaries and in the coasts as well. This has happen due to global climatic change and other anthropogenic causes, which needs more research and attention to restore/rehabilitate their migratory routes.

**Spawning season and spawning grounds of hilsa:** Spawning of hilsa occurs almost throughout the year from upstream to the coast at Chittagong and even in the sea off the coast of Cox's Bazar. Gonado-Somatic Index (GSI) value showed that the peak spawning period is September-October with a minor peak in January-February. The frequency of spawning is still unknown. The spawning cycle of hilsa is closely synchronized with the lunar cycle and aggressive spawning is noticed during new moon and full moon. Spawning grounds of hilsa were identified by the occurrence of ripe and running (oozing) males and females and by catching hilsa larvae/fry with experimental fishing. The lower stretches and estuarine part of the Meghna river was found as the major spawning ground of hilsa in Bangladesh. Of these, (i) Kalirchar Island (down of Sandwip), (ii) Moulavirchar (south of Hatia), (iii) surrounding of Monpura Island (east of Bhola) and (iv) Dhalchar Island (Charfashion, Bhola) were found as the most significant areas of hilsa spawning (Haldar 2002).

**Natural and anthropogenic impacts of hilsa fisheries**

**Natural impacts:** Among the 230 rivers of Bangladesh, 54 including the big rivers *viz*. the Padma, Brahmaputra (Jamuna), Meghna, Surma, Kuhsiara and Karnaphuli have originated from Nepal and India and are flowing through Nepal, India and Bangladesh. Siltation is a serious threat to the inland fishery of Bangladesh. The Meghna river system are carrying considerable amount of silt and deposing into the BoB. Extensive erosion in the Hatiya, Sandwip, Bhola, Noakhali and various major rivers are continuously changing the river hydrology, bottom topography and are creating many merged and submerged islands. In Bangladesh, about 2,179 million tons of sediment is carried by the Ganges-Brahmaputra river system creating merged and submerged islands and changing ecology and blocking migratory routes of hilsa (Curray and Moore 1971).

**Anthropogenic impacts:** Due to the construction of different flood control drainage (FCD), flood control drainage and irrigation (FCDI) projects and barrages, water flow in Bangladesh has reduced considerably, and hilsa fishery has been affected severely. About 1,500 km streams and rivers of hilsa habitat in the upper region of the country have been lost (Haldar *et al*. 2001). The upper Padma and almost all of its branches and tributaries became shallow and some stretches have dried up completely. The hilsa fishery of a moderate magnitude that existed in the Kumar river (in Faridpur) is no longer available due to closure of Kumar river under Ganges-Kobadak project (Mahmood *et. al* 1994). Construction of the cross-dam in the mouth of the Feni river under the Muhuri Irrigation and Flood Control Project, has destroyed a commercial hilsa fishery of about 500 mt/yr (Haldar *et. al* 1992). Due to low discharge of water from the river Ganges and consequently heavy siltation in most of the rivers, the feeding, spawning, nursery and migratory routes/areas of hilsa have been reduced in the up streams.

Also, the hilsa fishery is suffering from serious recruitment over-fishing (indiscriminate catching of *jatka*) and growth over-fishing (indiscriminate killing of gravid brood). The fishing mortality has increased with decrease in size at first capture. Innumerable numbers of fishing gears are being used in inland as well as marine environment. Their exact number is unknown. Some gears are identified as illegal, which indiscriminately killing *jatka* of small sizes. Once *Jagot ber jal* (large beach seine net) was the principal gear, which captured about 80 percent *jatka* of the total catch. At present, small meshed *current jal*, *mosahri jal*, seine net, *behundi jal* (set bag net) and *char ghera jal* (fence like net operation around the char) are the most harmful gears that are being used illegally in the nursery grounds for capturing *jatka* of different sizes.

**Management measures on hilsa**

To sustain as well as to increase hilsa production, several management measures have been undertaken by the DoF based on the research findings of BFRI. Among the different attempts, conservation of *jatka* through declaring 4 fish sanctuaries in the major nursery and spawning grounds of river system and protection of berried hilsa catches for 10 days during the peak breeding season are the most important initiatives (DoF 2005-06).

**Implementation of Hilsa Fisheries Management Action Plan:** Implementation of hilsa fisheries management action plan (HFMAP) has been initiated since 2003 with the view of protecting *jatka* properly (BFRI 2004-05). This action plan specified the activities to protect *jatka*, develop the implementation strategy, ascertain responsibility of relevant agencies and target community and fix specific timeframe for implementation.

**Declaration of hilsa sanctuaries:** Four sites (Table 1) in the coastal areas of the country have been declared as hilsa sanctuaries under the for the effective conservation of *jatka* in the major nursery areas.

**Table 1.** Hilsa sanctuaries of Bangladesh

| Hilsa sanctuary area | Ban period |
|---|---|
| From Shatnol of Chandpur district to char Alexander of Laxmipur (100 km of lower Meghna estuary). | March to April |
| Madanpur/Char Ilisha to Char Pial in Bhola district (90 km area of Shahbajpur river, a tributary of the Meghna). | March to April |
| Bheduria of Bhola district to Char Rustam of Patuakhali district (nearly 100 km area of Tetulia river). | March to April |
| Entire 40 km stretch of Andharmanik river in Kalapara Upazila of Patuakhali district. | November to January |

**Conservation of gravid hilsa for uninterrupted spawning:** Every year the highest number of ripe and running hilsa are caught during 5 days before and 5 days after the full moon of Bara purnima (full moon of Durga Puja) in October (Ashwin-Kartik). So, catch of hilsa has been banned each year in the following major spawning grounds during the highest breeding time (15-24 October). The shape of the banned area is tetragonal, which has covered four major spawning grounds with an estimated area of 6,882 square kilometres (Table 2).

**Table 2.** Areas of hilsa catch ban during the highest breeding time

| Position | Area | Peak spawning period |
|---|---|---|
| North-east | Shaher Khali/Haithkandi point, Mirersharai | 15–24 October |
| North-west | North Tajumuddin/West Syed Awlia point | 15–24 October |
| South-east | North Kutubdia/Gandamara point | 15–24 October |
| South-west | Lata Chapili point/Kalapara | 15–24 October |

- Hilsa Fisheries Management Action Plan (HFMAP) has been initiated since 2003 toprotect *jatka.*
- Four sites in the coastal areas have been declared as hilsa sanctuaries under the "Protection and Conservation of Fish Act-1950" for effective conservation of *jatka* in the major nursery areas.
- Catch of hilsa has been banned each year in four major spawning grounds during the highest breeding time (15-24 October) in an estimated area of 6,882 square kilometers.

**Regional initiatives for hilsa management and conservation:** Hilsa is a common resource of the Bay of Bengal; and Bangladesh, India and Myanmar harvest 90-95 percent global hilsa, but there is no regional initiative for its management. Recent study indicated that hilsa of these regions belong to the same stock. Therefore, sustainable production of hilsa requires joint management of the stock. Areas of collaboration could be exchange/ sharing of information, collaborative research, abatement of pollution of the common rivers and sea, and finally development of regional management plans.

## Conclusions

Proper application of HFMAP, keeping the ecosystem of the BoB healthy and environment-friendly, would be helpful to obtain sustainable production of hilsa and to conserve biodiversity. The BOBLME program could initiate for TRI-COUNTRY partnership or cooperation development for sustainable management of this renewable hilsa, small pelagic fishes, sharks and similar commercial important fishes of the Bay of Bengal.

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# Coastal aquaculture- an alternative livelihood in Bangladesh

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Shafiuddin, M. 2010. Coastal aquaculture and an alternative livelihood in Bangladesh. pp. 77-82. *In*: M.E. Hoq, A.K. Yousuf Haroon and M.G. Hussain (eds.). 2011. *Eco-system Health and Management of Pollution in the Bay of Bengal*. Support to Sustainable Management of the BOBLME Project, Bangladesh Fisheries Research Institute, Bangladesh. 84 p.

**Introduction**

Some 60% of the world's population lives within 60 km of the sea and the social economic and environmental significance of the boundary between the land and ocean is now widely recognized. The ecology of coastal land and coastal waters provides numerous livelihood opportunities, encouraging concentrations of population and development activities in the coastal zone. The livelihoods of many people in coastal areas, particularly in Bangladesh, are based upon the exploitation of both terrestrial and aquatic resources. However, expanding markets have driven such exploitation to extremes, where levels of investment create imbalance between alternative uses for the same resource. In such circumstances, the poor can be made poorer. For that reason, the coastal poor people indeed need easily and available scientific technologies. This program of COAST Trust is taken for socio-economic benefits of the coastal poor people of Bangladesh.

COAST Trust project started to scale up and improve coastal poor peoples' livelihood condition using five appropriate technologies. The five occupational themes are mud crab fattening, seaweeds/seagrass harvesting and culture, molluscs culture, improved fish icing and pesticide and salt-free fish drying.

COAST Trust is working in 25 upazilas covering 7 Districts of the South-east coastal region of Bangladesh (Fig. 1). COAST works with more than 26,000 beneficiaries in the coastal region of the Bay of Bengal. But under this coastal aquaculture program the working area covers only 8 upazilas in 2 districts. Those are Teknaf, Cox's Bazar Sadar, Moheskhali, Chakaria, Pekua, Kutubdia upazilas of Cox's Bazar district and Bashkhali and Anowara upazilas of Chittagong district.

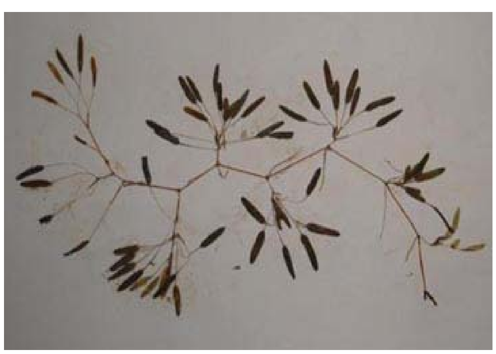
**Baseline data collection and group formation**

Primary baseline survey was conducted on current socio-economic status and livelihood practices of a representative 1,000 households (HHs). At group formation/organization stage, a total of 66 primary occupational groups (OGs), each having 15 to 20 HH members, was organized. During baseline study, all 34 OGs will be covered, but the total HHs covered will be 300 (50 HHs from both male and female OGs of each of three major community groups: Hindu jaladas, poor Muslim fishers and Adivashi fishers: 50x2x3). A simple database was developed using collected primary data, incorporating the secondary information already available within the NGOs and other agencies. This information will form the basis for later measures of improvement in livelihoods. If any pertinent information is missing, field staff will collect that, but this will be an absolute minimum and only where deemed essential by the majority of partners, for example to ensure groups are representative of poorest sectors of these marginalized communities.

**Summary of activities**

**Mud crab fattening:** Mud crab fattening in bamboo cages and earthen ponds are income generating activities. In this technology the wild collected soft shelled small crabs are put into bamboo cages for 10/12 days which are very low price in the market. Rearing for 10/12 days will make the soft shelled crabs as hard shelled which fetches high market price. In a single bamboo cage (7x3x1 ft) about 15-20 kg of soft shelled crab can be fattened and net profit would stand at Tk. 1,800-2,000/cycle of 10-12 days.

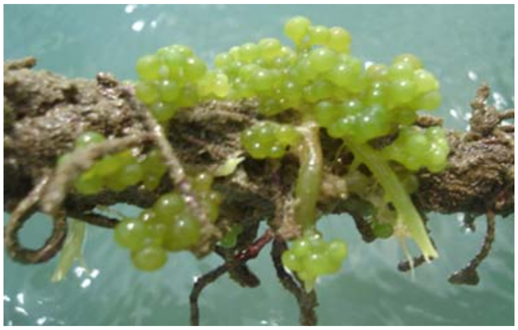

**Seaweeds/seagrass harvesting and culture:** Seaweeds are cultured in the coastal water using net and line culture methods. This is also a new technology developed by the Institute of Marine Science and Fisheries (IMSF) of the Chittagong University. There are about 60 species of seagrass around the world, of them five species are found in Bangladesh coast. The reported species of seagrass in Bangladesh coasts are: a) *Halodule uninervis* Ascherson, b) *Halophila decipiens* Ostenfeld, c) *H. pinifolia* Den Hartog, d) *H. baccerii* Ascherson and e) *Ruppia maritima* Linnaeus. In April 2010, this investigator found seagrass (*H. baccerii*) in the Naf river estuary of Bangladesh. Only two species (*Hypnea* spp. and *Caulerpa* spp.) are selected for culture. Seagrass is used in various purpose like human food, fin-fish and shell-fish feed and fertilizer, etc. Proximate compositions of seagrasses (*Halophila* spp.) have been shown that they were very nourishing food and it can be used as food ingredient for human being, fin fish and shell fish also without any risk.




Seagrass, *Halophila beccari*

Seagrass, *Halophila decipiens*

Seagrasses grow best in the quiet, protected waters of healthy estuaries and lagoons, often in beds, or meadows, that are easily delineated for classification as critical habitat areas. The migration of animals at various life stages from one ecosystem to another for feeding and shelter, coupled with currents that transport both organic and inorganic material from runoff and tidal flushing, ties the offshore coral reefs to near shore seagrass beds, and the seagrass beds to mangrove estuaries. They attract a diverse and prolific biota and serve as essential nursery areas to some important marine species. Seagrass meadows are also known to trap and bind sediments, thereby reducing particulate pollutants. Seagrasses have been known to serve as food for turtles since the time of Darwin. However, it was Petersen who first evaluated the contribution of the eelgrass to coastal fisheries. Seagrass beds serve as nursery, shelter and food for fish, invertebrates and dugong or sea cow. They also produce sediments and interact with coral reefs and mangroves in reducing wave energy and regulating water flow.



In order to effectively manage the seagrass resources, we need a better understanding of their ecology, their frailties and strengths, in the face of a rapidly deteriorating marine environment. The seagrass resources can help the national economy if we exploit rationally and conserve them.

**Molluscs culture:** Molluscs culture program is running in the coastal areas, especially in the St. Martin's Island, Teknaf, Moheskhali and Cox's Bazar Sadar, using rafts culture method. Molluscs meat and shell are sold in the market.

**Improved fish icing:** Improved icing is an income generating activities as well. In this program plain sheet ice boxes are used. Improved Fish Icing is running in the coastal areas especially in the St. Martin's Island, Teknaf, Moheskhali, Kutubdia, Banshkhali, Anowara and Cox's Bazar Sadar.

**Pesticide and salt-free dried fish:** Production of pesticide and salt-free dried fish is another income generating activities in the coastal areas. In this program beneficiaries produce pesticide and salt-free dried fish using ring and box tunnels. Pesticide and salt-free dried fish production programme is running in the coastal areas of the St. Martin's Island, Teknaf, Moheskhali, Kutubdia, Banshkhali, Anowara and Cox's Bazar Sadar.

## Conclusions

Bangladesh is a small but densely populated country in the world. About 55% of the populations live within 100 km of the coast of Bangladesh, most of them are very poor and live from hands to mouth. So it is not possible for the Government of Bangladesh to fulfill the demand and scarcity of food quickly. In this situation implementation of need-based appropriate technologies are needed for creation of new job opportunities for disadvantaged coastal people.

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