Sustainable Management of Fisheries Resources of the Bay of Bengal

Support to Sustainable Management of the Bay of Bengal Large Marine Ecosystem Project

Bangladesh Fisheries Research Institute

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Sustainable Management of Fisheries Resources of the Bay of Bengal

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Foreword

The marine fisheries sector has been recognized as an important part of the economy of Bangladesh. Fish production from Bay of Bengal (BoB) marginally increased over the last 10 years but its relative share in fisheries production has declined. Bangladesh's coastal waters contain diverse fisheries resources, with 475 species of finfish including the cartilaginous fishes - sharks, skates and rays. The majority of the commercially targeted stocks are reported to be over-exploited and there were significant declines in catches during last decades.

In the Bay of Bengal, both industrial and artisanal fisheries exploit coastal and offshore marine fisheries resources without any management plan. This is due to the non-availability of scientific information and difficulties in implementation of management strategies. Fishing in the absence of proper information on the status of stock is leading to over-exploitation of inshore and under exploitation of offshore fishery resources.

The Bay of Bengal is one of the world's 64 Large Marine Ecosystems (LMEs). The Bay is bounded by eight countries like Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand. As the BoB 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 to resolve the existing problems. Eight marginal countries of the BoB have already realized that they need closer link and cooperation for sustainable management of the fisheries resources of the BoB and its large marine ecosystem. Thus, FAO conducting a GEF financed regional project "Sustainable Management of the Bay of Bengal Large Marine Ecosystem (BOBLME)" project in 8 countries.

The present publication is an outcome of preliminary country status report on BoB, presented in different national and regional workshops. I would like to thank those contributing in this report and also the "Support to BOBLME project" for bringing out this publication.

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Acronyms and Abbreviations

BFDC	Bangladesh Fisheries Development Cooperation
BFRI	Bangladesh Fisheries Research Institute
BoB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem
BOBP-IGO	Bay of Bengal Programme-Inter Governmental Organization
CCRF	Code of Conduct for Responsible Fisheries
CPUE	Catch Per Unit Efficiency
DoE	Department of Environment
DoF	Department of Fisheries
ECFCP	Empowerment of Coastal Fishing Communities for Livelihood Security Project
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ESBN	Estuarine Set Bag Net
FAO	Food and Agricultural Organisation of the United Nations
FD	Forest Department
FRSS	Fisheries Resource Survey System
GEF	Global Environment Facility
GoB	Government of the People's Republic of Bangladesh
ICZM	Integrated Coastal Zone Management
IUCN	The World Conservation Union
MCS	Monitoring Control & Surveillance
MFO	Marine Fisheries Ordinance
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
NEP	National Environment Policy
NGO	Non Government Organisation
PL	Post Larvae
POPs	Persistent Organic Pollutants
UNDP	United Nations Development Programme

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Bangladesh coastal and marine fisheries, and environment

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1. General Context

The coastal and marine fishers of Bangladesh lands around half a million tons of fish a year involving by about one million people operating an estimated 22,500 non-mechanized and 21,400 mechanized fishing boats and also a significant industrial trawler fleet targeting shrimp and finfish on the continental shelf. This production is only 20% of the national fish production. The potential of the coastal fisheries sector has not been rationally harvested. Rather the resources have been over-exploited and as a result the fish stocks have declined.

The combined impact of the destructive fishing of the shrimp PL fishery, the ESBN fishery and the shrimp trawl fishery which target for post larvae of tiger shrimp (*Penaeus monodon*), juveniles of miscellaneous marine fauna and the spawning adult shrimps respectively, have greatly destabilized the coastal fisheries resource base. The increased pressure within the marine fisheries

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sector has led to artisanal fisheries being too non-remunerative for the fishers to survive. This has been well documented in the marine fisheries sub-strategy as a serious concern and prioritized for immediate attention to address the process restoring and sustaining the fish stocks for livelihoods and food security for future generations. Penaeid shrimp stocks, especially the tiger shrimp are under pressure from multiple fishing sectors and consequently there is a risk of depletion that may impact not only upon the livelihoods of the coastal fishers but the whole coastal shrimp sector. If this happen it would have a catastrophic effect on the country's economy.

The fisheries sector review (Banks 2003) have emphasized a continued decline in yields from the majority of these coastal fisheries. The Department of Fisheries (DoF) undertook review of the sector while producing a '*marine fisheries sector sub-strategy'* (DoF 2006) as part of a wider *National Fisheries Strategy* and action plan. In this sub-strategy, the need for major changes in the institutional setup was incorporated in future action plans.

Realizing the crisis of the sub-sector and the need for strengthening, the government in 2005 has delegated the power of implementation of the respective rules under the Marine Fisheries Ordinance (MFO) to the DFOs of the coastal districts. But in absence of technically capable marine fisheries staff at district and Upazila levels, the system did not work. In spite of the fact that the concerned agencies and the policy makers are aware of the problem, the coastal marine fisheries has gone uncontrolled, except some limited interventions, and this has worsen the crisis the sector is facing today. A political commitment in this matter is needed in order to properly address the crisis and sustainably manage the valuable fisheries resources and the livelihoods of the poor who rely upon these resources. This can be a lesson from the successes made so far in the Hilsa resources management where the political will was the most important driving force.

Following serious conflicts in the sector during 2006-2007, however, the Ministry of Fisheries and Livestock (MoFL) requested the WorldFish Center to undertake a study and suggest measures to mitigate these conflicts and also to suggest the precautionary approaches to management in line with the FAO/UN Code of Conduct for Responsible Fisheries (FAO-CCRF). Following this, the study conducted by WorldFish Center has not only

confirmed that the fish stocks are still in the process of decline, it has rather emphasized that the rate of decline has been faster during the last few years (WorldFish Center 2008). The report added that if unchecked, it is highly likely that recruitment of many key commercial species will collapse, having a substantial impact on all coastal fisheries and the livelihoods and food security. It is greatly reducing their ability to withstand shocks; something that will be more necessary in this era of climate change.

In 1995, the FAO published its Code of Conduct for Responsible Fisheries (CCRF), detailing principles and criteria for responsible fishing. It serves as a reference document to assist signatories in developing national policies for sustainable fisheries and supporting these with robust legal and institutional frameworks. However, despite being a signatory, Bangladesh is yet to implement its own Code of Conduct. There is however institutional capacity limitations while there have been efforts taken recently but have not continued. This is principally because the line agency has not been much persuasive and the development partners have shown virtually no interest in this field of marine and coastal fisheries.

2. Marine and Coastal Ecosystem

2.1 Physical environment

Bangladesh has a land area of 144,000 km^2 and is bounded by India on the West, North and Northeast, by Myanmar on the East and Southeast, and by the Bay of Bengal on the South. The countries exclusive economic zone (EEZ) spans 164,000 km^2 and the shelf area covers roughly 66,440 km^2. The coastal waters are very shallow, with depths less than 10 m covering 24,000 km^2. The shelf area down to about 150 m appears to be very smooth with very few obstacles to bottom trawling. The continental edge occurs at depths between 160 m and 180 m. Its slope is very precipitous and thus, it appears presently not possible to trawl in waters deeper than 180 m.

Primary production in the Bay of Bengal is known to be high during the northeast monsoon. Coral reefs are quite limited off Bangladesh due to high

river discharge and turbidity. Four species of *Acropora* and ten other coral reef genera have been reported from off shore islands. Seafronts of newly formed islands and some low lying coastal areas are often carpeted with sea grass.

a. Ecosystems

i. Brackishwater estuaries

Along the coast, an estimated 2.6 million ha of low-lying land are subject to tidal inundation. Most of the flood plain of this area is empoldered. Tidal action is strong in this area. Depending on seasonal variation in salinity, different brackish as well as marine fish species are available. Some migratory species like river shad hilsa and freshwater giant prawn *golda* are also available. Most of the polders are under paddy and tiger shrimp *bagda* culture by making large *ghers*. This area is characterized by low saline regime due to freshwater run off during the summer monsoon. This salinity increased during winter months and in some places rise beyond 20 ppt and intrudes into the coastal zone as aggravated by the low flow of the rivers. This area is the meeting point of three different ecosystems dominated by brackishwater species e.g. small clupeids, *Acetes* shrimps, gobeids etc. While largely serves as the nursery as well as spawning ground for marine and freshwater fish/shell fish respectively.

ii. Mud flats of Sundarbans mangroves

Freshwater supplied by the rivers from the upstream and marine water available from tidal action makes the Sundarbans a transitional and unique fisheries habitat. Rivers, estuaries and regular flooded lands are the main habitats for fish in the Sundarbans. It has been used as breeding and nursery ground for a wide range of fish species of fresh tidal saline and marine environment (Hoq 2003). Presence of high ichthyoplankton indicates it as a breeding and nursery ground of fishes and shellfishes. Marine fishes spawn in areas where salinity ranges between 1 and 26 ppt, stays for a few months and return to the sea with the onset of monsoon. Juveniles of many marine species of prawns and fishes, various sciaenids, ribbon fishes etc. migrate for feeding

into the lower zone of the estuary during winter and summer months and return to the sea with the onset of monsoon.

iii. Near-shore ecosystems

Coastal ecosystems provide many vital ecological and economic services, including shoreline protection, productive commercial and sport fisheries, and nutrient cycling. Key nearshore ecosystems such as sea grass meadows, marshes, and mangroves are particularly valued for their extremely high productivity, which supports a great abundance and diversity of fish as well as shrimp, oysters, crabs, and other invertebrates. Because of the abundance of juvenile fish and shellfish they contain, near-shore ecosystems are widely considered 'nurseries'. The nursery role of coastal estuaries and marine ecosystems is well accepted by all people, and it is often cited to support protection and conservation of these areas. Mangrove ecosystem is directly linked with the enhanced productivity of the nursery ground for marine fish and shellfish fauna.

iv. Critical habitat

The most critical habitat in the marine ecosystem is the spawning ground of penaeid shrimp which usually lye between the 50 and 80 m. depth contour, depending upon the distance from the shore line as well as the position in relation to the disposal path of the major river system. Indiscriminate fishing on the penaeid shrimp by the shrimp trawler fleets during the peak spawning periods particularly during December – March (the most critical month being mid January to mid February). The salinity during the peak spawning time varies from 20 – 35 ppt in the area. The other critical habitat include the off shore island, littoral and sub littoral zones down those islands where overfishing/destruction on corals, bivalves, seaweeds etc. are regularly done by local inhabitants.

Coastal shrimp aquaculture is a continuously expanding activity in the zone alongside the capture fisheries. Salinity appears to be the most dominant attribute which controls and directs the capture as well as the culture fisheries. The salinity tolerance of different species of fish/shrimp are different. This

difference is also applicable to some of the species of fish/shrimp at different stages of their life cycle.

b. Hydro-morphology

Three of the main subcontinent's rivers- the Ganga, Brahmaputra and Meghna drain vast areas of India, Bangladesh, Nepal and the Himalayas. These rivers and their tributaries converge in Bangladesh, carrying approximately 85 per cent of the total water volume which reaches the Bay of Bengal from Bangladesh. This freshwater runoff is a dominant feature that influences the dynamics of the coastal and marine environment. The discharges show distinct seasonal fluctuations. Freshwater run off can reach up to 195,000 m^3/s in the monsoon period creating riverine water conditions during the post-monsoonal season (September and October). From January to June the balance is restored to create estuarine conditions (Mahmood *et al*.1994).

i. Natural and man-made coastal hazards

The Bangladesh coast is the most hazardous coast in the world in terms of the number of people who suffer from various types of environmental hazards every year. The dimensions of these rivers and their drainage basins are disproportionately large compared to the small area of Bangladesh. Seasonal variation in precipitation, and in the intensity and amount of discharge cause the flood flow in Bangladesh. Compared to past, the same amount of water can cause intensive flooding in the country. The annual flood situation, especially in the low lying coastal districts, has further deteriorated following the damming, Farakka barrage, the diversion of the upstream flow of the Ganges inside India. Now, less water flows from India into Bangladesh during times of drought, in summer months, and more is released during flood season which causes severe flooding. A regional plan would be necessary to mitigate the flooding problem.

ii. Shoreline erosion

The upstream diversion of the Ganges water and consequent reduction of sediment influx to the coastal areas have triggered many other secondary environmental hazards: shoreline erosion, submergence of coastal areas

(especially the western parts of the delta which are drained by the Ganges and its distributaries), salinity intrusion, erosion of the riverbanks of other rivers (such as the Bramhaputra, Meghna, and Tista) due to disequilibrium in the hydrodynamic system, interruption of the navigation system in the coastal areas, drawdown in the groundwater levels, and many others. Some of these hazards, namely the coastal cyclonic surges, and tornadoes are caused by natural processes. Others, like coastline and river banks erosion, coastal submergence, floods, drawdown in groundwater levels, salinity intrusion, and gradual fall in water levels of the rivers are caused by a combination of natural processes and human interference with nature.

iii. Sediment transport and salinity intrusion

Most of the man-made coastal hazards in Bangladesh have been triggered or accelerated by the upstream diversion of the Ganges inside India. The fluvial sediment supply to the coastal areas is a prerequisite to and a primary cause of any delta building process. The Ganges contributes about 67% of the total suspended sediment load in Bangladesh. The upstream diversion of the Ganges has reduced the sediment contribution by 30% . As a result, the once prograding delta is now experiencing coastal submergence due to transgression caused by a reduction in sediment supply combined with the ecstatic sea level rise and local subsidence.

The diversion of the Ganges flow by the damming of the upstream region and consequent reduction in the annual sediment supply from 2.4 billion tons/year to 1.8 billion tons/year, have not only retarded delta progradation but also have threatened the existence of the delta, the homeland for about 30 million people of the coastal districts of Bangladesh. Thus, better understanding of their nature is necessary to plan the land and water resources wisely while safeguarding the quality of the environment.

The present suspended sediment load, 1.8 billion tons/ year, is still sufficient for the delta to keep pace with rising sea level, provided the rate of sediment accumulation can be increased. Calculations of sediment budget and accumulations show that 30% of the present suspended sediment influx to the coastal areas is capable of aggrading an area of 30,000 km^2, the area of the

entire coastal districts of Bangladesh, when sea level rises at a rate of 1 cm/year, the EPA (Environmental Protection Agency of the U.S.A. (Khalequzzaman 1988) predicted rate for the next century.

vi. Sea water temperature

Surface water temperature varies in different months from 22.80^0C to 32.90^0C. The highest sea surface temperature (SST) is reported in September and the lowest during January and February. The vertical temperature distribution showed a subsurface maximum at about 10-30 m depth due to cooling of the surface layer and the depth of the thermocline varies from 30-70 m depth (Mahmood *et al*.1994).

c. Biological environment

The coast as a whole is dominated by soft substrate ecosystems that are biological productive, providing critical ecological habitats like mangroves, algal beds, salt marshes, sandy beach and mudflats (Kabir *et al.* 2004).

Mangroves serve as the transitional zone between the terrestrial and marine environment and are suitable feeding, breeding and nursery ground for various marine, estuarine and freshwater fishery resources. These areas are critical for providing nursery grounds of larval and juvenile stages of finishes, shrimps, crabs and cockles. The net-like spread root system of the mangrove acts as a coastal stabilizer and binders of sediment and thus aids in preventing erosion in the mangrove areas. Despite their obvious ecological benefits, mangroves throughout the region are under increasing threat from human activities such as deforestation and shrimp culture practice.

i. Key commercial fish stocks

A number of surveys have been conducted since 1958 in the marine waters of Bangladesh. Most of these were exploratory surveys, looking at fisheries feasibility. Some surveys were conducted to assess the standing stock of the marine resources, in particular demersal species. However, very little research has been conducted on the assessment of pelagic resources.

ii. Demersal finfish

Three surveys (FAO/NORAD/BGD 1979-80; BGD 1983 and FAO/BGD 1984-86) gave estimates of demersal standing stock between 150,000-160,000 t within the exploited 10 – 100 meter shelf area (Saetre 1981, Khan *et al.* 1983, Lamboeuf 1987). An additional 100,000 t of fish stock is available within the 24,000 km^2 open brackishwater area between the shore line and 10 m depth (Saetre 1981). In terms of species of commercial importance, stocks of croakers and catfishes were approximately 40,000 t, threadfin bream was 7,000 t and Bombay duck was 1,000 t respectively (Lamboeuf 1987).

The total production from all sources of marine and brackishwater fisheries has been estimated to be 264,000 t (Khan 1994). The drift gillnet fishery and the ESBN fishery account for the bulk of the production, followed by the MSBN and trawl fisheries, accounting for 136,000 t, 73,000 t., 26,000 t and 17,000 t respectively (Khan and Latif 1997).

iii. Maximum Sustainable Yield

Using the results of the stock assessment studies it was possible to calculate the fisheries potential for demersal fish. The results indicated that 40,000 to 55,000 t of demersal finfish can be harvested annually from the offshore fishing grounds lying 10100 m depth zones. This potential could be calculated for penaeid shrimp on the basis of biological information. The results indicted that 7,000 – 8,000 t can be harvested annually (Khan *et al.* 1989). The stock contributed around 10% of the total production from all fisheries during 2005-06. Of these, 7% were mature adults caught by trawlers; 85%, were caught in set bag nets and were mainly pre-juvenile and immature individuals; and the remaining 8% came from trammel net and other fisheries. (Penn 1983, White and Khan 1985).

iv. Pelagic finfish

Acoustic estimates of the biomass of pelagic fish over the shelf covered were: 38,000 t in November-December 1979; and 76,000 t in May 1980. The part of the shelf in Bangladesh inside 10 m depth which could not be covered by the

surveys is very extensive: about 7,000 nmi^2. If it is assumed that the density of pelagic fish here was the same as in the area between 10 and 100 m depth (about 9,400 nmi^2) where the pelagic fish was observed, then raised totals of 66,000 t in November-December and 133,000 t in May would represent the whole Bangladesh shelf. These are likely to be underestimates because of the generally negative bias of this first generation of acoustic equipment (Dr. Fridtjof Nansen 1979). Another survey conducted during 1979 recorded eight species of tuna and skip jack from Bangladesh water (Khan 1996) but the abundance was not studied. It was however recommended that an experimental tuna fleet may be worth to try (Khan and Latif 1997).

d. Socio-economic environment

The coastal zone of Bangladesh is comprised of 19 districts that contain a mixture of very old settlements and new land developments. Originally the area was part of different kingdoms that were ruled by different dynasties, which consequently shaped the social fabric of the respective populations.

According to a 2001 population census, the coastal zone of Bangladesh has a population of 35.1 million, 28 percent of the total population. From 1991-2001 this population increased exponentially by 1.36 percent annually. This was lower than the national rate of 1.48%, something that was indicative of the net out-migration from the coastal zone to other areas. In spite of this population density remained high at 743 people/km^2.

The natural system of the coastal zone generates a multitude of natural resources. Some are renewable (freshwater, soil, forest, salt, wind, solar energy, wildlife, etc) and some are non-renewable (oil/gas, sand, minerals, space, etc). In rural areas, agriculture laborers comprise the largest livelihood group in terms of number. At least one in every three rural households lives on agriculture labor. Among the non-farmers (those whose principal occupation is not agriculture), fishers are the single largest group. In urban areas, the majority of people serve as laborers in both the formal and informal sectors or are engaged in a wide range of self-employment activities (PDO-ICZMP 2004).

Using socio-economic indicators to compare the situation in coastal zones with the country as a whole, they would appear fairly evenly matched. Marked differences do exist for some indicators however. Within coastal zone if we compare three wider regions, Chittagong-Cox's bazaar, Noakhali-Barisal and Khulna it can be seen that the people of Chittagong-Cox's bazaar zone have more financial solvency and a higher literacy rate than the other areas, both of which are continuing to increase.

e. People and livelihood

Employment and income: Marine fisheries contributes at least 20% of total fish production in Bangladesh, > 90% of which comes from artisanal fishing, with approximately 500, 000 people fully and directly dependant on the sector (Ahmad 2004). Representative information about the employment and income of coastal community members involved in the marine fishing sector is extremely limited and tends to focus on regions rather than the whole coastline. The CPUE data collected for Chittagong and Cox's Bazaar implies that the yield for all fishing groups (MSBN, ESBN, SMD & LMD) has declined in terms of fish available for trade or consumption. In conjunction with the CPUE findings, the decreases in maximum size of key species indicates the lesser values the fishers will receive for their catches.

The combination of decreased yield and value of catch will almost certainly lead to reduced earnings in the Chittagong and Cox's bazaar fishery, therefore, destabilizing the livelihoods of those who are fully dependent on fishing. However, a full analysis of fishing related livelihood impacts would need to be investigated to make any definitive statements.

Access to fisheries: Traditionally coastal fisheries were the domain of low caste Hindus, a culturally distinct and economically disadvantaged group. In recent decades, more and more landless and unemployed Muslim farmers have taken up fishing as an occupation. In the absence of any effective institution for sustainable use of resources, these new entrants have tended to adopt fishing practices that test the limits of the fishery's regenerative capacity, and have in many instances occupied choicest locations, often displacing the traditional fishers.

Food security: Up-to-date information on fish consumption is not available, however, research conducted during 2003 stated that per capita food supply from fish and fishery products was 11kg/per person, which represented 7% of total protein supply (EarthTrends 2003). These consumption patterns do not reflect the inter-gender differences that exist within coastal fishing communities. Females, including pregnant females, nursing mothers and children, are especially vulnerable to malnutrition; a gap that has increased since the 1990s. Within Bangladesh, women bear a disproportionately large share of the country's poverty and food insecurity (USAID 2006). Following table highlighted the hazards and impacts on coastal livelihood.

Table 1. Hazards vulnerabilities and community impacts

Hazards	Vulnerable areas	Community impacts
Cyclone and storm surge	Islands, exposed upazilas	Widespread deaths and livelihood destruction
Land erosion	Meghna and other estuaries, islands and coastal rivers	Displacement of people up to 10-14 times within a lifetime
Flood	Exposed upazilas	Lives, households and assets lost
Drainage congestion	Khulna, Jessore, Noakhali	Crop loss through soil infertility, drinking (both human and livestock) water contamination
Salinity intrusion	Western exposed upazilas	Crop loss through soil infertility, drinking (both human and livestock) water contamination
Drought	Satkhira	Lives lost, crops and aquaculture damage/loss
Earthquake	Chittagong	Lives, households and assets lost
Global warming: Sea level rise	Exposed upazilas and islands	Mass-displacement of people

Source: Ahmed (2005)

Alongside the physical hazards that are faced by coastal communities, there are a number of social factors that increase their vulnerability. These include:

- Widespread poverty, limited livelihoods opportunities (especially outside agriculture) and poorly developed economic linkages

- Poor levels of service provision that lead to further isolation of many coastal areas
- Inequality within social networks, promoting the existence of a social elite and power imbalances
- The prevalence of informal loaning systems and piracy that increase risks to fishers' livelihoods

Adaptive capacity: The effects of the vulnerabilities mentioned above are experienced throughout coastal communities but vary greatly depending on localities, occupational groups and gender. Most coastal households face multiple vulnerabilities which compound each other in terms of both the impact of specific events and the capability to recover from these events when they do strike. For example, the poor infrastructure and remoteness of many coastal localities means that the immediate impact of a major hazardous event is likely to be more severe and relief efforts are hampered. Subsequently, when the survivors are rebuilding their livelihoods after the disaster, poor access to market, credit and other services, institutional weaknesses and the deterioration of the coastal resource base delay and hamper the recovery process.

These vulnerabilities affect different households differently in an asset-dependent way. The poorer the asset base of a household the more they have to forego potentially profitable but risky opportunities.

Alternate livelihood: Alternative income generating opportunities of the coastal fishing communities are very limited. Their main source of income is still fishing and fisheries related activities. However, as resource bases become more fragile, there is a need to increase the access to incomes from alternative sources outside fisheries though such employment opportunities are very limited (Khan *et al.* 1994) but still possible, given the social dynamics and responsible development. The UNDP supported FAO/DoF project on ECFC has some successes reported.

As a predominant number of coastal inhabitants are poor, their asset base and ability to take risks through diversifying their income is limited. For this reason, micro-credit opportunities has been provided in order to support the

empowerment of target fishing communities. These grants are offered by a number of NGOs such as BRAC, CODEC, DEEP and Proshika, with the aim of encouraging social and economic empowerment of the communities through capacity building that would enable communities to address their problems and needs, look for opportunities, assess their resource constraints and introduce various economic and community welfare activities.

3. Fisheries Activities

3.1 Status and trends of key fisheries

The present total fish production in Bangladesh is 2.56 MT of which marine fisheries contributes around 19.41 %. Of this about 90 % is landed by artisanal fishers. The sector has an estimated 22,500 non-mechanized and 21,400 mechanized fishing boats. There are more than 100 industrial trawlers engaged in harvesting demersal fish and shrimp resources. Management of coastal fisheries in Bangladesh has focused predominantly on industrial trawler fleets, with limited attention being paid to other sectors. This has led to uncontrolled expansion of fishing effort, which has resulted in the crisis the sector is facing today.

The number of privately owned boats built up rapidly from only 4 trawlers operating in 1978 to about 100 by early 1985 and subsequently a total of 250 licenses were issued for importation of trawlers into Bangladesh (White and Khan 1985). Following this increase it was felt that the number of trawlers should be reduced to encourage sustainable exploitation of the resources. Trawlers fleets were reduced to 72 and joint ventures between Thailand and Bangladesh were stopped. However, after 2003 some additional licenses were issued for mid water and offshore pelagic and mid-water fisheries resources exploitation.

i. Industrial trawl fisheries

At the present there are 42 shrimp trawlers and >80 finfish trawlers in operation. These vessels use outriggers and operate two to four nets at a time, using modern shrimp trawl nets with the cod-end having a mesh size of 45

mm and a head rope length of 15-26 m. Finfish trawlers range from 28.0 to 30.5 m and mostly carry out single trawls using high opening bottom trawl nets with 60 mm mesh size at the cod end. Almost all trawler vessels are equipped with modern navigation, communication and fish finding equipment.

Trawl fishing has officially been restricted from operating within the 40 m depth contour. However, they are found operating even up to a depth of 10 m. The key shrimp and fish species that are exploited by the trawl nets are *P. monodon, P. merguiensis, P. indicus, Metapenaeus monoceros, M. brevicornis,* hairtail, pomfret, goat fish, cat fish, croakers, Bombay duck and lizard fish.

The CPUE of shrimp (kg/day/shrimp trawler) has steadily decreased since the early nineties and the CPUE has decreased by about 50% (Fig. 1). The effort has not changed considerably since early nineties but still catch is comparatively low. High levels of discarded finfish were reported, reaching up to 35,000 t (Khan and Latif 1996) which have reduced to around 35% of the total catch (WorldFish Center 2008).

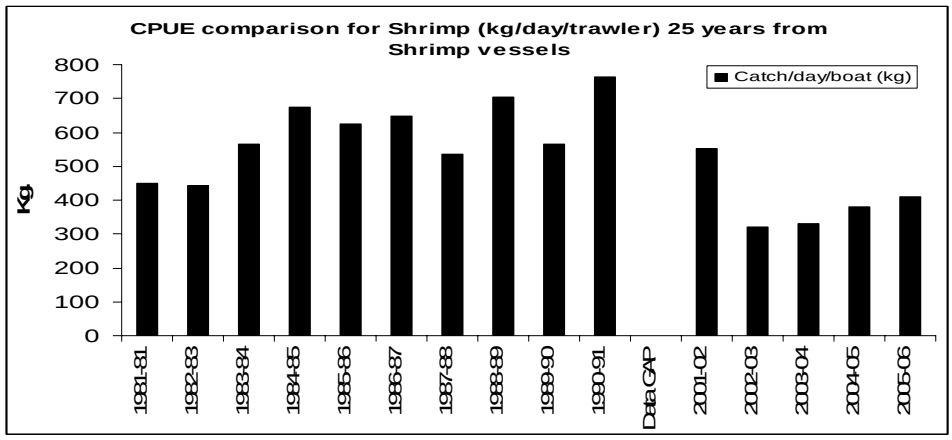

Fig. 1. CPUE of shrimp trawler fleet for last 25 years, since 1981.

Over the last 10 years shrimp trawl fishery catches have shown shifts in species composition. From a sample of shrimp trawler data that was logged between 1996 and 2006 it was found that tiger shrimps have gradually

reduced until 2005, after which there was a small increase. Brown shrimps increased between 1996 and 1999 but dropped again but decreased the following year, showing, again a small increase in 2006. White shrimps were more or less steady, and miscellaneous shrimp species decreased between 1998 and 2005 but increased this year. The total catch rate of shrimps in the shrimp trawlers dropped down by about 30% from the level of 2001, after which they stabilized.

Fishing effort in the finfish trawlers has approximately doubled since the nineties. This includes the trawlers fishing without a license but with a court verdict. Using data adapted from Marine Survey Unit DoF, it can be seen that over the last five years the catch rate of croakers, pomfrets and Bombay ducks are dominating. Catfish and other miscellaneous species have, however, showed an increasing trend. Overall finfish catch seems to be steady, but there has been a shift in the commercial species.

Over the last 20 years there have been a big shift in the composition of catches of the of finfish trawlers. Catches in 1984/86 showed that the major commercial were white grunters, croakers, catfish, breams, snappers and hairtails. Since 2005/06 these have mostly been replaced by the low valued species like crab juveniles and the Bombay ducks (Fig 2).

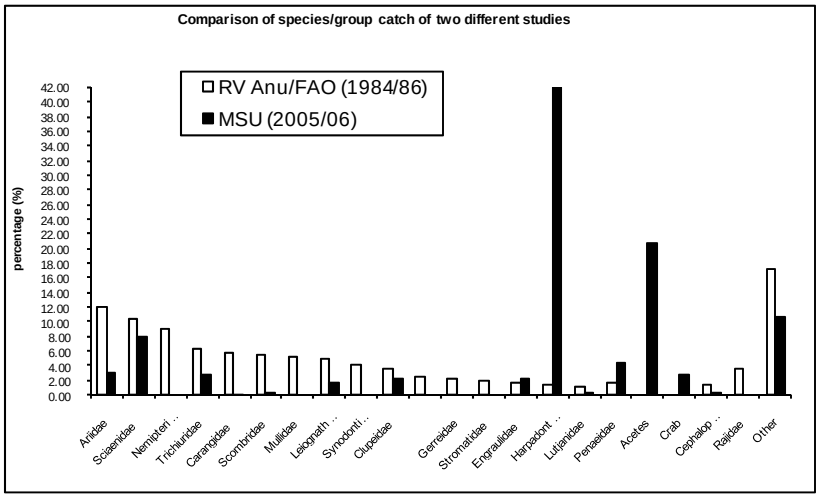

Fig. 2. Bottom finfish trawl catch composition (1984-86 and 2005-06)

Mechanized commercial fisheries: Artisanal fishing operations in the estuaries and coastal waters used to be carried out by traditional craft until the mid 1960s. Two organizations, the Bangladesh Fisheries Development Corporation (BFDC) and the *Bangladesh Jatio Matshyajibi Samabay Samity* (BJMSS) started the process of mechanization of fishing boats by importing and introducing marine engines. There are five different types of gillnet (i.e. drift gillnet, fixed gillnet, large mesh gillnet, bottom set gillnet and mullet gillnet), two types of set bagnet (estuarine set bagnet and marine set bagnet). Trammel net, bottom longlines, beach seine and many other nets are also used throughout the coast and estuaries.

There are 20 species of sharks (10 species), skates (2 species) and rays (8 species) were recorded at the landing centers from April 2006 to February 2007. Shark landings (a relatively new venture over the last 10 years) at the Chittagong and Cox's Bazar coast have shown a sharp and serious decline, from approximately 2300 t in 2001-02 to only 500 t in 2005-06. In 2006, the highest catch was in June and was 81.935 m, the lowest catch was in August 2006 and was 4.458 t. The increase in effort in Bangladesh's shark fishery has been met by a steady decrease in the length of the sharks that are being caught and their catch rates. This is a clear indication that over exploitation occurring. At present there is no legislation and management measures in place to protect the shark fishery (Ahmed 2007). There is also a lack of detailed catch information but it can be seen that composition has shifted and rays are the main species caught (70%). One species, *Carcharhinus melanoptera* is found in the red list (IUCN 2000).

Large Mesh Drift Gill Net (LMD): Landing data for large meshed drift gill nets (LMDs) that are targeting *Polynemus indicus* (Indian salmon), long jew fish and sharks are also showing a declining trend in the catch per boat per day. However, because of the size of the fishes being caught this fishery still appeared to be operating at profit. Detailed species catch composition data is not available to understand any specific species shifts. However, it is evident from other studies that the Indian salmon catch is declining rapidly towards extinction.

Combined catches from different types of gill nets: Over the last five years there has been a serious decline in the CPUE (catch/boat/day), from about 700 kg in 2001-02 to less than 100 kg in 2005-06, recorded at landing sites along

the coasts of Chittagong and Cox's Bazar . These boats use a mix of different types of fishing gears (SMD, LMD, Shark nets, Rocket nets etc.) and target species such as grunter, hilsa, Bombay duck, jewfish, mullet, shrimp, mackerel, crabs etc.

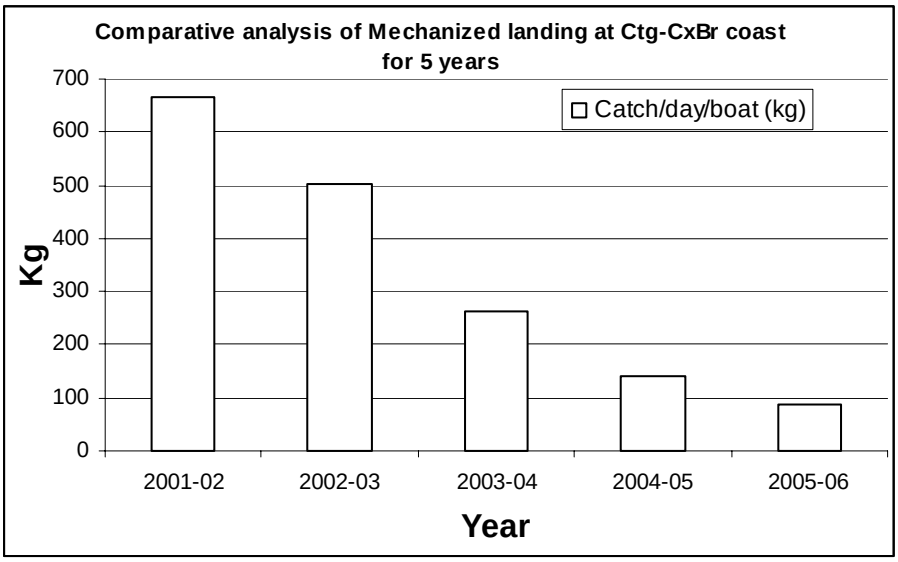

Fig. 3. Daily catch rate for mechanized gillnet vessels. **(**Source: WorldFish Center 2008)

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Mechanized boats are also adopting new fishing gears. An example of this is the rocket net, which is essentially modified version of the mullet gill net, using a monofilament gill net with <50 mm mesh. This was initially a successful gear, catching large amounts of finfish per day that reached weights of up to 90 kg. However, fish catches have since decreased to weights of 30 kg. The introduction of new techniques indicates that resource constraints and overcapacity are pushing fisher to try new and more extreme measures to catch a depleting resource base.

Marine set bag fisheries: Marine set bag nets (MSBNs) operate in deeper waters. They are 18 – 40 m in length, with an opening mouth of 10 – 29 m and cod end mesh size 12 – 25mm. Both mechanized and non-mechanized crafts use MSBNs. There was a total of 3,086 MSBN in 1985, 5,400 in 1987-

88, 3,852 in 1991, and 21,000 in 2001-02. Of the species caught by MSBN most of the fish and shrimp species were pre adults and adults. There does not appear to be a significant change in the size ranges of the target species during the periods observed. Catch rate (kg/haul) decreased by 50% between 1985 and 2002-04. Generally there is no discard as all are partially used for human consumption or dried for poultry/fish feeds.

Owners of MSBN employ crews on hire basis and sometimes on share basis. Traditionally this tends to be arranged before starting of the fishing season. Initially boat owners bear the operational cost and continue with sale proceeds.

Longline fisheries: The bottom long line fishery was introduced in late 1960s and became popular in mid 1970s with encouragement from overseas buyers. Long lines are used within 10 – 30 m depth ranges. A total 2,641 long line fishing vessels are used, which use 24,614 long lines. There are different types: jewfish LL, and misc. fish LL, which mainly catch are croakers. The common species targeted by long lines are- *Pennahia argentata*, *Johnius belangerii, Protonibea diacanthus*, *Otolithoides pama*. These long lines operate in the south of Chittagong, Noakhali, and Patuakhali and south-west of Cox's Bazar.

Trammel net fisheries: Trammel nets are three paneled bottom set gill nets with outer 1.8 m, panels of large meshes (265 mm) and an inner loose 2.25 m panel with small mesh (50 mm). These nets are operated using an 8 – 10 m long, open wooden dinghy-type, non mechanized sail boat. Catch rate and production: catch rate (kg/boat/day) showed an increasing trend, with annual production estimated at 1,754 t from 400 units during 1989-90. However, it was shown that despite higher effort trammel net catch rate decreased in Cox's Bazar coast (DoF 2006).

ii. Non-mechanized artisanal fisheries

Estuarine set bag net: Currently there are 11,674 vessels used in the ESBN fishery, and several are operating without boats; more densely operated in the Patuakhali-Barisal sea coasts and estuaries using fine meshed nets targeting juveniles of miscellaneous fish and shrimp species (Rashid 2001).

ESBN fishery has shown a major shift from commercial to non-commercial species. In 1993 185 species or groups of species of fishes and shellfishes were recorded. These included 15 penaeid shrimps, 3 non-penaeids, 9 freshwater prawn, 3 crabs, 3 mollusks, 90 pelagics, and 62 demersal finfishes (Islam *et al.* 1993). In this fishery there does not tend to be any discard fish as all are partially used for human consumption both fresh and dry and others are dried for poultry/fish feeds and in frequent cases the catch is brought home rotten and unsuitable for human consumption.

The length of landed fish has reduced for a number of species, but in some instances has also increased (Bombay duck, croakers and some small penaeids). Islam *et al.* (1993) estimated approximately 54,000 t of ESBN production during 1989/90. The level of production is said to have increased during 2001/02 to 2005/06 (DoF 2006). In spite of these increases, CPUE has drastically declined to a totally non-remunerative situation for the fishers to survive.

Shrimp Post-larvae (PL) collection: Three types of nets are used in this fishery the push net, drag net and all made of finest mesh mosquito net. It has proved to be highly damaging to biodiversity and wild fish stocks, in particular the fixed bag net. The rate of damage is 1:34 in the SE and 1:360 in the SW coast against each tiger shrimp (*P. monodon*). Reasons behind its damaging nature are that it restricts recruitment of the fish and shrimp PL to migrate to the sea for completion of life cycle by catching between 80 and 90% of the PL that come into the estuarine nursery areas (Khan 2002). This was however a popular fishery, prior to the 2002 ban, the number of people involved in this fishery was approximately 185,000.

According to Khan (1999) about 2,035 million *bagda* PL (*P. monodon*) were annually collected by the shrimp seed collectors in the whole coastal region of

Bangladesh to support coastal shrimp farming industry. It comprised only less than 1% of the total larvae catch. The rest of the catch, which is composed of other shrimp species, fin fishes and zooplankton were thrown on the sandy beach to die. This process of indiscriminate killing of other aquatic organisms was estimated to be about of 200 billion a year. It is therefore, safe to conclude that the coastal aquaculture industry relies to a very large extent on wild-caught larvae that have a severe damaging impact on the resource base as well as on food chain and biodiversity.

There are 2,082 crafts and 30,643 gears are involved in other fisheries including beach seine, cast nets, traps and harpoons. These tend to be used for subsistence fishing, although a few do serve for part-time fishing by the fisherfolk living along the sea coast. These gears produce 3,789 t of fish/shrimp but their catch rates and production have been reduced by about 50% over five years. In term of impact, beach seines is damaging fish stocks to a similar extent as ESBN.

4. Fisheries Management

Management of marine and coastal fisheries has virtually gone uncontrolled. However some limited interventions in industrial trawler operation and to some extent on the hilsa fisheries this has gone on without any real control and management over the vast coastal area that needs devoted management program. On the other hand the monitoring control and surveillance (MCS) in the coastal fisheries is concentrated only in the surveillance of the industrial trawl fishery which produces <10% of the catch and the artisanal fishery that produces >90% are still beyond the management MCS. This has lead to an uncontrolled expansion of the fishing effort, particularly in the artisanal fisheries sector which has resulted in the crisis the sector is facing today. The exact status of the crisis is not known, as no recent surveys have been undertaken. Estuarine bag set nets fishermen have also voiced their concern and have stated that to ensure a catch they have put in more nets with smaller mesh sizes.

Presently, however, the shrimp hatcheries have demonstrated their ability to fulfil the demand of shrimp seeds for the farming industry, but the farmers still prefer to a large extent on the wild seeds and as a result the wild seed collection is still in progress, at a lesser degree indeed. The government of Bangladesh has, however decided recently to ban this fishing practice in order to save the natural fish stocks. But this ban is not fully effective as yet.

i. Harvest limits and capacity control

In the case of finite marine fisheries resources, it is normal to limit the fishing effort or landings from different métiers. For key stocks this can include the setting of harvest rules that limits the annual catch to within sustainable limits, with a quota that is shared between the different metiers fishing for the same species. At present there are no such limits for marine species such as the penaeid tiger shrimp, hilsa, Indian salmon, croakers or pomfret. With the exception of the trawl fishery, there are few input controls in terms of vessel and gear numbers – essentially they are open access fisheries that can expand unrestricted.

ii. Regulation

Marine fisheries management is based around the *Marine Fisheries Ordinance* (1983). This is implemented by the Marine Fisheries Wing (MFW) of the Department of Fisheries, empowering MFW to make rules covering licensing, catch reporting and the declaration of marine reserves. This is supported by a series of rules *(*Marine Fisheries Rules, 1983) and supplemented periodically by further legal rulings that are published in the Bangladesh Gazette. These might cover anything from changes in licensing fees to new technical instruments such as minimum gear specifications or change of fishing practices.

The MFO (1983) is applied between (i) the baseline (10 fathoms or 18.29 m) and 40 m (for the artisanal fishery) and (ii) beyond the 40 m depth contour (industrial fisheries).). However, Habib (1999) argues that certain activities by traditional fishermen inside 18 m are covered by the MFO, as are prohibitions covered in the Maritime Zones Act 1974 and Coast Guard Act 1994. The distinction is that any specific provisions, which are contained

within the MFO but are also required inside 18.29 m depth, have to be specified through the issuance of a notification. For the management of the trawl fisheries the Government has limited the number of trawlers to 73 which are allowed to operate in the EEZ of Bangladesh (Rahman 2001).

Coastal waters (together with inland waters) are also covered by the *Protection and Conservation of Fish Rules* (1985). This regulation refers to methods of fishing, fish species that cannot be caught during a particular season, mesh size of fishing nets, prohibition of landing and carrying fish of a certain size.

In summary, whilst there are some broad technical instruments governing mesh sizes and minimum size restrictions, the absence of fishing capacity controls, harvest limits and by-catch controls have contributed to the difficulty in managing marine capture fisheries and controlling the evident slide into the overfishing of key stocks.

iii. Institutional capacity building

One major weakness to the Bangladesh management system and it potential evolution is the lack of institutional support within Bangladesh. There are no recognized gear technologists, and the existing assessments of the state of the stocks are very rudimentary (and without definitive conclusions). Most of the historic recommendations for restrictions show a distinct lack of awareness of stock recovery rates, and a lack of awareness of the ability to alter means of application of fishing techniques. Action is required therefore, for considerable institutional strengthening in this sector.

iv. Monitoring, control and surveillance

With the possible exception of the industrial trawl sector, the MCS system is non-existent. It is also impractical, given the size of the fleet, to contemplate extending resources to a dedicated MCS unit. A more practical approach would be to deploy a more limited MCS unit in the coastal ports, but to rely heavily on stakeholder management. The village community structure should theoretically provide the basis for this in respect to artisanal vessels. The

other groups, particularly the commercial trawlers, appear to be quite individualistic and highly nomadic. In ideal situation MCS should focus on a combination of control scenarios – licensing by the authority and monitoring of gears and landings at designated ports. The prospects for co-operative/stakeholder policing in this sector are perceived to be poor, but given the practicalities, there are no alternative strategies, which might be considered.

Under the above circumstance, the immediate requirement is to undertake a development project (and establish as a routine institutional programme) as proposed below, in order to salvage the marine fisheries sector from possible future extinction and conserve the livelihoods (particularly the artisanal fisheries in the shallow coastal areas and hence the deep sea fishing) in one hand, and to enhance fish production and revenue earning from the deeper part of the EEZ on the other hand. Capacity and infrastructure/logistics of the MCS agencies including the BFRI, DoF, Coast Guard need to be strengthened and particularly concentrated and decentralized to the western part of the coast. This is a long discussed and agreed problem and the marine fisheries sub-strategy has also emphasized on this but no solutions have come out as yet. This needs to be seriously addressed and political commitment is vitally necessary in this situation.

v. Conflict resolution

Conflict is principally caused by the zoning disagreement by the big vessels claiming that GoB knowledge diffusion process is weak and questionable;

- Trawlers reportedly disturb spawning beds of important shrimp and fin-fish. These often operate in shallower water and restrict fishing operations of mechanized boats
- Collection of brood shrimp for hatcheries by shrimp trawlers is not considered as a viable and sustainable method that has overfishing impact and can be better replaced by mechanized trammel nets
- ESBN operators complain that other boats damage their nets. They request Government to demarcate and specify areas of operation of their boats. It is presently demarcated but this demarcation is not obeyed by the parties.

This needs to be reviewed with scientific evidences and support and informed knowledge in order to get full participation

- ESBN operate in large numbers in estuaries and river mouths and block/ restrict entry and movement of mechanized boats. Off-shore vessel owners complains that these vessels are restricting the fish to recruit in the fishing ground.
- Although Marine Fisheries Rules regulate areas of operation of a number of boats these do not specify or demarcate those for artisanal boats
- Indiscriminate way of catching brood tiger shrimp for hatcheries, by the trawlers competes with the people who depend on the same stock.

vi. Management issues

- Management of marine fisheries is highly focused on activities of industrial trawl sector. Currently the management is done by the limited resources of the marine wing based in Chittagong.
- There is no management and monitoring of artisanal sector which operate from Barisal, Bhola, Patuakhali, Barguna and other areas where fishing pressure is increasing alarmingly.
- The process of licensing is handicapped and is applicable only to boats with registration and fitness certificate issued by MMD.
- No effective co-operation and participation of the fishing community in limiting fishing effort to sustain the fishery.
- Present management system does not consider creation of awareness of the fishing community about the need for conservation of resources.
- Community participation in management planning and implementation is totally absent

5. Inter-agency Coordination

i. Inter-agency management issues

Mercantile Marine Department of the Ministry of Shipping has the mandate to register and provide fitness certificates to fishing boats which has limited

operational base in Chittagong and Khulna and are unable to register vast majority of boats that operate from all over the coastal regions which in turn limits the DoF to bring all the vessels under licensing system. DOF hardly any access to Sundarbans fisheries since Forest Department (FD) exercises sole authority to manage the fishery. Essentially the FD management is only devoted to revenue collection by providing unlimited permits for resources exploitation from the Sundarbans Reserve Forest (SRF). Joint management would be effective. There is no practical linkage between DOF and Coast Guard for use of their manpower and logistics for enforcement of regulatory measures in the coastal waters. Technical as well as administrative partnership with different agencies/institutions e.g. MoWR, MoEF, CEGIS, IWM, BFRI, BFDC etc. is needed.

ii. Monitoring, control and surveillance and catch monitoring

The ability to monitor and control fisheries - that is to monitor fishers' compliance with harvest limits, technical regulations and other fisheries rules as opposed to scientific catch monitoring - is an essential prerequisite to effective fisheries management. In the absence of any capacity or harvest limits there is an insufficient regulatory framework on which to target MCS activities. As such, with the possible exception of the trawl fishery, and to some extent the Hilsa fishery the marine capture fisheries MCS programme and capacity of the line agency is extremely limited at present.

The last comprehensive fish and gear census was undertaken by DoF over 1995-2000 (Rashid 2001). In terms of catch assessment, FRSS is responsible for monitoring coastal artisanal catches. The large number of landing points[1] and their wide geographic spread and the poor communication in many coastal districts, combined with the limited human resources allocated to catch monitoring, suggest that considerable improvements need to be made before these figures can be considered as a robust management tool. However it is important to stress that this situation should not be considered and excuse for a lack of management action, but more the development of immediate strategies to overcome data limitations and the longer-term development of a practical and robust fisheries information system.

[1] There are 192 landing stations for the commercial gillnet fisheries alone (Banks 2003)

iii. Sundarbans mangrove- wetland ecosystem: Issues for conservation and management

The SRF nursery ground is essential for the survival of the millions of poor people (fishers, traders, processors etc) who derive livelihoods directly or indirectly from the Bay of Bengal coastal fisheries. The aquatic ecosystem in and around the SRF is in fragile condition, due to over-exploitation of the natural resources. Various types of fishing gears operated in the shallow waters with very small mesh sizes create obstacles to the completion of lifecycle processes of the fish and shrimp populations. The SRF wetland serves as the nursery ground for marine fish populations, where serious growth overfishing along with the apprehension of the depletion of the marine fish stocks has been reported by some authors (Hoq 2007). Salinity intrusion has occurred over the last few years (mainly due to reduced water flow in the up-stream rivers), which might have influenced in shifting the nursery ground towards the upstream and thereby making it more vulnerable to the over fishing.

The outcome of this is the degradation of aquatic environment and loss of biodiversity. Livelihoods and food security of the poor artisanal fishers is negatively impacted by these activities. These issues and the impacts have, however been recorded earlier by a number of authors, but not in a comprehensive manner that can help policy decisions. In particular the problem of salinity intrusion and its added impact in further intensifying the vulnerability of fish stocks and biodiversity has not been studied before, for which the present extent of the problems and the impact on the fishery and the environment and the consequent impact on the livelihoods of the poor coastal artisanal fishers is not known to the science till date.

The fishing effort goes uncontrolled; all activities in the SRF area is under the control of Forest Department (FD) who has virtually no capacity nor any plan for management of fisheries; on the other hand the DoF has hardly any access to management of the fisheries resources in the Sundarbans area. This is an interdepartmental and interministerial issue to seriously consider if the fishery resources of the Bay of Bengal and the livelihoods and food security has to be sustained for food security.

Due to the institutional problems, as stated above in addressing the problems by any institution or agency, while the problem is acute in nature and related to the long term livelihoods and food security of millions, the nation can not afford to ignore the issues but to take necessary measures without further delay.

The MFO (1983) designates the Director of DoF's Marine Wing in Chittagong as responsible for implementing the ordinance and "responsible for management, conservation, supervision and development of marine fisheries" (Part II, Art. 5). However the ability of the coastal districts to manage marine fisheries is extremely limited, both in terms of numbers and skill sets – at present the District Fisheries Officers and their staff tend to be inland fisheries and aquaculture specialists. There has been a recent move to provide marine specialists to coastal districts to assist the coastal District Fishery Officers (DFOs) who have been delegated by the government in 2005 to exercise the power of MCS under the rules of the MFO 1983 as a part of decentralization strategy, but this has yet to materialize.

In terms of managing the coastal fishing fleet, a further complication is that the capacity of the *Marine Mercantile Department* (MMD) is also poor – this has hindered the registration of fishing vessels and their subsequent licensing for fisheries purposes. At present, only half the commercial fleet and under ten percent of the entire fishing fleet is registered and licensed (Banks 2003). Again a recent proposal to provide a 'one stop shop' where prospective applicants can both register their vessels and obtain fishing licenses at a single point at District level has yet to develop on the ground. Without the ability to understand the nature and capacity of the different fishing métiers, it will be impossible to strategize, target and control fishing effort at a local level.

Fisheries management, from sectoral strategy development to the monitoring and control of fishing activities, is essentially top-down in Bangladesh. This immediately raises limitations in terms of the equity of benefits flowing for the fishery as well as the ability to manage and operate the fisheries at ground level with limited resources. For the small-scale fisheries that compose most of the coastal fisheries sector, there is great potential to develop community-based and co-management strategies to engage a wider range of stakeholders in management.

6. Issues and Challenges

i. Fishing down the food chain

Penaeid shrimp decline: catches of adult penaeid shrimps as broodstock for the coastal aquaculture industry have declined in terms of CPUE (50% reduction since 1987) and size (22% reduction over the past five years). This has resulted in the trawl industry expanding its operations into inshore waters (i.e. from the 40 m depth contour to as shallow as 10 m) to maintain catches. The industry apparently cites a change in the salinity regime for a shift in shrimp to shallower water, but any scientific validation in favour of this could not found.

Relative benefit of the shrimp and finfish trawler catches and the ecosystems costs and impacts on small-scale fishers: the shrimp and finfish catches have declined in both absolute terms as well as in terms of their overall contribution of catch (less than 4% of national shrimp production in 2005 compared to 20% in 2002) and foreign earnings to the country. Furthermore, the bottom trawl fishery is damaging to the benthic habitats and has very high discard rates. There is therefore an argument that the benefits of trawling are increasing limited and accrue to a small number of people whilst the ecological costs are high and will impact many small-scale fishers. Given that the trawl industry is artificially supported through subsidies, its true economic value is doubtful and needs careful examination. Regarding the role of the trawl industry in *P. monodon* broodstock collection, it is thought that this could be transferred to a trammel net fishery that is much more selective and has lower shrimp mortality rates. The attention of the large vessels should be diverted to the resources in the waters deeper than 100 m where the resources like large pelagics are reportedly abundant.

Declining numbers of high value finfish from gillnet and other commercial fisheries: The declining CPUE (650 kg/day/boat in 2001-02 to under 100 kg/day/boat in 2005-06) from small mesh gillnet vessels targeting hilsa, skipjack tuna and mackerel is alarming. One target species of the large mesh gillnet– the Indian salmon (*Polynemus indicus*) – is now almost extinct in Bangladesh waters. Whilst these nets are reasonably selective, the number

of fishers has expanded enormously from 6,389 in the late 1980s to 26,169 in 2000, yet the annual catch per vessel dropped from 41 t to 7 t over the same period (Banks 2003). The catch rate from marine set bag nets has also dropped from 85 kg per haul in 1985 to 24 kg/haul over 2002-2004. Meanwhile the number of units expanded from 3,086 to 21,000 units.

High degree of non-selectivity of many artisanal fishing methods: Some widely used fishing techniques such as estuarine set bag nets, push nets and bag nets have extremely high catches of juvenile finfish and crustaceans. Many of these are driven by the demand for wild post-larvae (PL) for coastal aquaculture, despite a government ban and increasing hatchery production. In the SW districts of coastal Bangladesh, for every one PL caught, 360 organisms are discarded with unknown mortality – this is likely to have a significant impact on recruitment of migratory species and their predators. The number of ESBNs used have expanded from 11,674 in 1989 to 53,540 in 2001 whilst catch rates have dropped from 18 kg/haul in 1987 to under 10 kg/haul in 2007 (WorldFish Center 2008).

ii. Changing behaviour of the fishing practices

The catch rate of more valuable demersal species such as croakers and pomfrets has declined against a gain in less valuable, small species such as Bombay duck and *Acetes* shrimp. In addition, the biodiversity has also declined – in 1984-86 surveys there were 20 species contributing to the main catch, whilst in 2005-06 this has declined to 12. This indicates that the more valuable and longer-lived species are being fished out and being replaced by smaller, short-lived pelagic fish (Fig. 4). A recent report in *Science* (Jørgensen *et al*. 2007) suggests that these shifts are difficult to reverse and have long-term implications for ecosystem structure and function – and their human dependents.

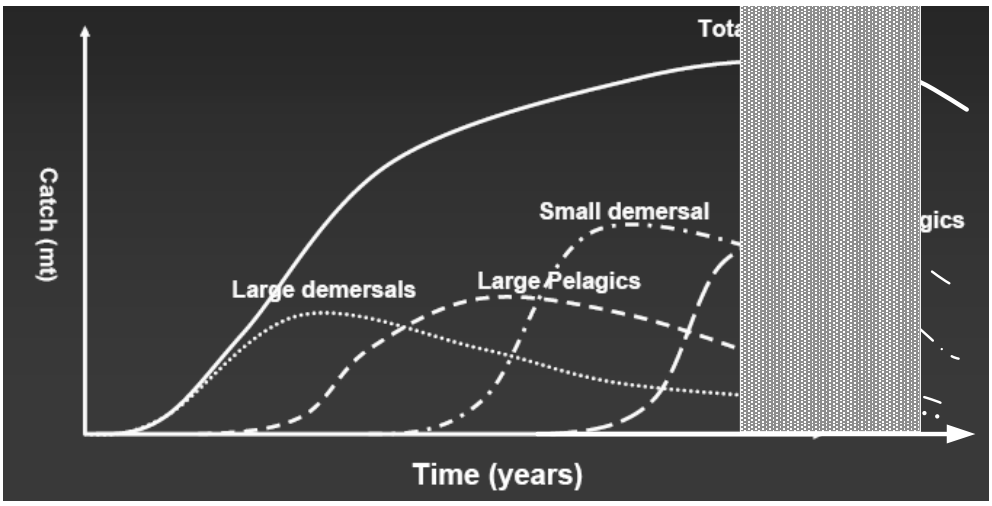

Fig. 4. Fishing down the food chain – perceived status of marine fisheries in Bangladesh. (Source: Funge-Smith 2007)

iii. Longer-term developmental issues

Unlimited and expanding fishing capacity: Since the publication of the last Marine Fisheries Ordinance in 1983, there has been little real change in the fisheries management regime, either in terms of the technical measures adopted nor the rules and regulations being applied. This situation has been complicated by the strong trawl fishing lobby that has resisted a number of attempts at regulation. This needs to be reviewed urgently and make amendments based on present knowledge (including the zoning) and the efforts are controlled to a reasonable limit.

Low level of monitoring, control and surveillance: The ability of DoF to enforce fisheries regulations is limited by the geographic isolation of many coastal fishing communities, a lack of physical assets such as patrol boats and a chronic shortage of trained manpower.

Stock assessment: No detailed stock assessments for key commercial species have been undertaken since 1993. Key stock condition indicators need to be identified to enable the preparation of *Fisheries Management Plans*. In the

meantime, practical indicators need to be developed with currently available data and conservative target and limit reference points set.

Co-management: Community-based management has proved to be successful in the inland fisheries of Bangladesh and both regional and international experience suggests that models could be adapted for use in the coastal fisheries. In this reference can be made to the case study of the ECFC project.

Marine protected areas: Establishment of fish sanctuaries and maintenance through community based organizations have been quite successful in the inland open water bodies. In the same line of concept marine protected areas (MPA) need be established in the critical areas e.g. spawning grounds, nursery grounds.

National Fisheries Strategy & Action Plan: Many of the issues summarized are well known. The 2006 *Marine Fisheries Sector Sub-strategy* responds to many of these, and the 1998 *National Fisheries Policy* is soon to be updated. There is now a real opportunity to address these issues and to ensure a sustainable contribution to coastal livelihoods and national food security.

7. Conclusions and Recommendations

The marine fisheries policy requires updating to reflect both the precautionary approach as well as the ecosystem approach that recognizes that fisheries will impact the structure, function and biological diversity of the wider ecosystem (and *vice versa*). Other policy areas that need greater emphasis include minimizing inter-sectoral resource and spatial conflicts, the development of co-management and community-based fisheries management (CBFM) and other approaches to reduce the vulnerability of small-scale fishers. In addition to the recommendations embedded in the text, the following are the key recommendations for precautionary management:

- The preparation of individual 'Fisheries Management Plans' for key commercial species (or multi-species) fisheries considering the multi-fleet dynamics of fishing behaviour.

- Whilst fisheries management needs to be precautionary in the face of scientific uncertainty, it is important that long-term fisheries management needs to underpinned by robust information and research, with an upgrade of the FRSS urgently required for coastal and marine fisheries
- Fishing capacity and effort needs to be limited for all coastal and marine fisheries. This will require the licensing and registration of all mechanized fishing vessels and limits set on their overall capacity and individual effort as part of the FMPs
- There is an urgent need for improved gear technology and development in Bangladesh. This will allow the gradual replacement of all non-selective gears with more sustainable methods that will still provide a reasonable living. This development will have to be matched with changes in the results and regulations governing gear specification and use, as well as the ability to enforce these.
- A needs assessment for a cost-effective monitoring, control and surveillance (MCS) system is urgently needed. It is suggested that the landings of the larger mechanized vessels is restricted to certain designated ports to focus MCS activities, that the logbook scheme is made more robust and extended to the large mechanized gillnet vessels. For artisanal fisheries, the development of community-based policing as part of co-management is considered the most cost-effective solution.
- The capacity of DoF to implement the *Marine Fisheries Sector Sub-strategy* needs to be substantially improved, including the development of a Marine Fisheries Directorate that can target all the coastal areas of Bangladesh, as well as the development of a cadre of qualified marine Fisheries Officers who can take fisheries management down to the District and even Upazila level.

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2

Marine fisheries resources of Bangladesh: Stock status and management issues

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1. Introduction

Fisheries sector plays an important role in the economy in terms of nutrition, income, employment and foreign exchange earnings of Bangladesh. The sector is contributing 5.71% of the total export earning and 4.92% to the GDP, while about 12 million people are directly or indirectly involved in this sector with an annual increase of labour employment by about 3.5% (Ahmed 2005). In 2007, total fish production of the country was 2.56 million tons of which 2.06 million tons came from inland source and the remaining only 0.50 million tons obtained from the marine sector (DoF 2009). Within the marine sector, artisanal fishery contributed about 0.46 million tons and industrial trawlers contributed only 0.03 million tons. As a single species, Hilsa (*Tenualosa*

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ilisha), the national fish accounts nearly half of the total marine catches, and 12-13% of the total fish production of the country.

The southernmost part of Bangladesh is bordered by about 710 km long coastal belt of the Bay of Bengal, which has the continental shelf of up to 50 m depth that constitutes an area of about 37,000 km^2. The Exclusive Economic Zone (EEZ) of Bangladesh lies from the base line of the 710 km coastal belt to 200 nautical miles, having an area of about 164,000 km^2 is now under economic jurisdiction of the country for exploration, exploitation, conservation and management of its marine resources.

As a whole, the total fish production, especially from culture and marine sector is increasing each year being 1.4 million tons in 1997-98 and 1.9 million tons in 2001-02 and 2.56 million tons in 2007. However, due to the rapid population increase without keeping pace with the fish production, the per capita consumption of fish has dropped from 33 g in 1963-64 to 20.5 g in 1989-90 as against the recommended level of 38 g per capita per day. Recently the per capita fish consumption has increased to 26 g but still it is much below the recommended level. This role of fish in the life of people is likely to diminish in the foreseeable future and scientists and dieticians believe that better health of the people of Bangladesh can be ensured quickly and economically through greater production and capture of fish.

On the other hand, the production of marine fish has increased steadily for the last few years, indicating a viable alternative for more and more fish production to meet the demand of the vast population of the country. However, the marine ecosystem, especially the mangrove habitat, is under threat due to the rapid expansion of coastal shrimp farming and pollution.

Therefore, it is not too late to come forward to develop comprehensive marine fisheries management policy considering biological, environmental and socio-economic issues to get maximum sustainable production of marine resources to feed the ever-growing vast population in this area and at the same time to protect our large marine ecosystem without breaking its natural harmony. In

this connection, implementation of ecosystem approach to fisheries and aquaculture development in the APFIC region could be the most vital option.

Different steps have been undertaken by the government and non-government organizations for poverty alleviation, employment generation and export earning through boosting fish and shrimp production from culture and capture sector, management of open-water resources, infrastructure development, human resources development, sanctuary establishment and need based technology dissemination in Bangladesh. Nonetheless, ever neglected marine sector needs more attentions for sustainable utilization of its valuable resource.

2. Major fisheries and management

There are four major fishing grounds in the marine water of Bangladesh. The **South Patches** and **South of South Patches** lies between 20° 50'N to 21° 40'N latitude and 91° 00'E to 91° 50'E Longitude, covering an area of about 6200 km². The **Middling** fishing ground situated between 20° 50'N to 21° 20'N latitude and 90° 00'E to 91° 00'E longitude that covers an area of about 4600 km². Finally, the **Swatch of no ground** lies between 21° 00'N to 21° 25'N latitude and 89° 00'E to 90° 00'E longitude, which covers an area of about 3800 km² (Shahidullah 1983).

2.1 Major fishery resources

The marine capture fisheries of Bangladesh exploit a complex, multi-species resource, and a single trawl haul, for instance, usually catches over a hundred of species (White and Khan 1985). Total species of finfish, shrimp, seaweed, crabs, lobster, mollusks, coral, starfish, cuttle fish, squid, snakes, turtles, crocodile and mammals were recorded as 475, 36, 13, 15, 5, 301, 4, 3, 2, 2, 4, 4, 1 and 11, respectively (Khan 2005, DOF 2008). Besides, there are hundreds of other invertebrates. The sector is subdivided into industrial and artisanal fisheries. The industrial fishery based on trawl (shrimp trawl and fish trawl)

fishery. Out of the total 127 trawlers, 45 are shrimp trawlers and the remaining are finfish trawlers (DOF 2008).

A number of studies (particularly demersal trawl surveys) to examine the development of potential and status of these resources were conducted in the 1980s, but no recent assessment is available. In the case of trawlable stocks (dominantly demarsal), estimates of standing stocks vary widely, from the 40000 – 55000 t to 260000 – 370000 t (Penn 1983). However, the consensus based on the reassessment of these and related studies was a trawlable standing stock of 150,000 – 160,000 t in the coastal water of Bangladesh, of which about 53% (85400 t) consists of commercially important demersals, and about 16% (257,00 t) consists of commercially important pelagics (Lamboeuf 1987, Khan *et al*. 1997).

Important individual fish families are Ariidae, Sciaenidae, Nemipteridae, Trichiuridae, Carangidae, Scombridae, Mullidae, Leiognathedae, Synodontidae and Clupeidae. These ten fish families contributed about 56 – 75% of the biomass (Lamboeuf 1987). The family/group wise standing stocks are presented in Table 1. The most abundant groups are catfishes (Ariidae) 11.99%, croakers (Sciaenidae) 10.37% and threadfin bream (Nemipteridae) 9%. Other dominated fish families were Pomadasyidae, Gerridae, Stromateidae, Priacanthidae, Gerridae, Penaedae, Engauridae, Caphalopoda, Harpadontidae and Lutjanidae.

Table 1. Estimated biomass by family/group of marine fish in Bangladesh

Family/Group	Common name(s)	Biomass (t) (Relative abundance in parenthesis)
1. Sciaenidae	Croakers	20,670 (12.8%)
2. Ariidae	Cat fishes	18,729 (11.6%)
3. Nemipteridae	Threadfin breams	7117(4.4%)
4. Carangidae	Jacks, Scads	5039(3.2%)
5. Mullidae	Goat fishes	4,811 (3.0%)
6. Synodontidae	Lizard fishes	4,663 (2.9%)
7. Trichiuridae	Hairtail/Ribbon fishes	4,043 (2.5%)

8. Leiognathidae	Pony fishes	3,998 (2.5%)
9. Pomadasyidae	Grunters	3,415 (2.1%)
10. Clupeidae	Sardines, Shads	3,109 (1.9%)
11. Scombridae	Mackerels, Tunas	1,836 (1.1%)
12. Priacanthidae	Bullseyes	1,433 (0.9%)
13. Stromateidae	Pomfrets	1,348 (0.8%)
14. Cephalopods	Squid, Cuttle fishes	1,296 (0.8%)
15. Engraulidae	Anchovies	1,082 (0.7%)
16. Gerridae	Silver-biddies	959 (0.6%)
17. Harpodontidae	Bombay duck	783 (0.5%)
18. Lutjanidae	Snappers	356 (0.2%)
19. Rajidae	Skates, rays	6,714 (4.2%)
20. Others		69,679 (43.3%)
Total		161,080 (100%)

Commercially harvested important some finfish are: Jewfish/croakers (*Johnius* sp., *Otolithus* sp.), pomphrets (*Pampus* sp), mackerals (*Scomberomorus* sp./*Rastrelliger* sp.), tunas (*Euthynnus affinis*) catfish (Ariidae), carangids (Scad, Trevally), clupeids (anchovy, sardine), sharks, skates & rays and shrimps (Penaeidae).

Studies on shrimp stocks suggested a maximum sustainable yield of about 7,000 – 8,000 t of penaeid shrimps (Khan *et al*. 1989). Among the penaeid shrimps *P. monodon*, *P. semisulcatus*, *Metapenaeus monoceros*, *Parapenaeopsis stylifera*, *P. sculptilis* and *Solenocera indica* were the major contributor and brown shrimp *M. monoceros* contributed about 56% of the total shrimp catch. Tiger shrimp *P. monodon* is the main commercial species because of its price and export value, but a declining trend was evident with an average of 4.5 kg/hr until 1984 and 3.7 kg/hr thereafter – approximately 17% decline between 1980/81 and 1990/91 (Mustafa and Khan 1992).

2.2 Fishing gears

Numerous gears are used to exploit multi species marine resources in Bangladesh. Artisanal small scale fisheries contribute 95% of the total marine catch, which includes gillnets, set bagnet (*behundi* net), seine net, push net, hook and line, trammel net, etc. Large scale industrial fisheries (trawl fishery) contribute 5% of the total marine production. This includes large trawlers that specially fished for penaeid shrimps. Table 2 gives a summary of the fishing gear used in the country, together with their target species/group and depth of operation.

Drift gill nets are dominated in the inshore areas and specially used to catch hilsa. There are two types of set bagnets, the larger one operated in the deeper areas with an average depth of 10 to 30 meters and smaller one in the estuaries area as well as in the river, where tidal effect is high. Hook and line fishing is seasonal and limited to the winter season when the sea become calmer. Most of the fisher fished for croakers, catfishes, groupers, skates, rays, sharks, Indian salmon, etc. Most of the seine nets are operated at the very near shore and used for small fishes.

Table 2. Fishing gear used in the coastal/marine water in Bangladesh with target species and depth of operation

Fishery/Gear	Target species/group	Depth of operation (m)
A. Industrial		
1. Shrimp trawlers	Penaeid shrimps	40 – 100
2. Fish trawlers	Pomfrets, Grunter, Croakers,	40 – 100
B. Artisanal	catfish, Indian salmon, Jew	
1. Gillnet	fish, Ribbon fish, etc.	
a. Drift gillnet	Hilsa shad (*Tenualosa ilisha*)	down to 30
b. Fixed gillnet	-do-	8 – 10
c. Large mesh driftnet	Sharks	down to 30
d. Bottom setnet	Indian salmon	down to 80
e. Mullet gillnet	Grey mullet	5 – 10
2. Set bagnet		
a. Estuarine set bagnet	Shrimps, Croakers, Ribbon	5 – 10
b. Marine set bagnet	fish, Bombay duck, Clupeids,	

c. Large mesh set bagnet	Anchovies, etc. -do-	
3. Trammel net	Sea bass (*Lates calcarifer*)	10 – 30
4. Bottom longline	Shrimps, Croakers, Catfish	10 – 30
5. Beach seine	Croakers	10 – 30
6. Char pata net	Clupeids, Croakers,	8 – 10
7. Cast net	Anchovies, Ribbon fish.	down to 10
8. Push net	Shrimps	down to 10
9. Fixed bagnet	Shrimps	down to 10
10. Dragnet	Shrimp larvae (*P. monodon*)	down to 5
	-do-	down to 2
	-do-	

(Source: Khan *et al*. 1997)

Mainly motorized wooden boats of different sizes are used for fishing in the deeper region and smaller manual boats are used in the shallower coastal region. The number of crafts and gears are increasing day by day. These boats operated almost round the year. However, during monsoon (June-August) and during the bad weather condition, only a few boasts operate along the near-shore area.

2.3 Management practices

In Bangladesh artisanal, as well as industrial fisheries exploit coastal and offshore marine fisheries resources without any appropriate management plan. This is due to the non-availability of scientific data and difficulties in implication of management strategies. Under the present level of exploitation it is realized that most of the fishing gears are harmful to the growth, regeneration and maintenance of balance to the biological cycle of the marine population and there is some indications that our coastal fish stocks are overexploited year by year. Therefore, it is necessary to assess precisely the extent of fishing pressure and the level of exploitation by different gears in order to estimate the impact on the sustainable management.

The Marine Fisheries Ordinance 1983, after several amendments, has got 22 rules and regulations, is the main legal instrument for the management purpose. The rules restricted different depth zones, mesh sizes, fish sizes,

seasons and areas for different fisheries which could be more than enough, if implemented properly. The MCS operations are so poor; most of the rules are not enforced properly. Recently the government has formulated the National Fisheries Policy and National Fisheries Strategy, after implementation of those fisheries sector, hopefully will be able to overcome its many constraints.

2.3.1 The National Fisheries Policy

The management of fishery resources in Bangladesh is guided and regulated by the National Fisheries Policy of 1998. It spelled out the country's objectives in fisheries: to increase fish production, alleviate poverty, improve the conditions of fishers, provide animal protein, strengthen foreign currency earnings through export, and promote ecology, biodiversity and public health. Key aspects of the policy are:

- Procurement, preservation and management of fisheries resources in the open water bodies.
- Fish culture and management in closed freshwater bodies.
- Culture of shrimps in the coastal regions.
- Exploitation, conservation and management of marine fisheries resources.

Policy for marine fisheries development

- Conduct survey on marine resources assessment and extend the information to marine resource exploiters.
- Utilization of trash fish.
- Provide alternate employment for fishermen during fishing holiday.
- Regulate industrial and artisanal fishery to reduce over-fishing for sustainable production.
- Strengthen research for marine fisheries development.
- Prevent indiscriminate exploitation of marine fish.
- Control marine pollution by dumping of harmful chemicals and radio-active materials in the sea.

2.3.2 The National Fisheries Strategy

On the light of the National Fisheries Policy, a pathway to achieve the objectives of the policy, several strategies for every sub-sector were formulated in 2006 by the Department of Fisheries. The strategies outline management approaches for implementing the National Fisheries Policy, taking into account likely changes in the fisheries scenario over the next 10 years. The National Fisheries Strategy evolved through a series of studies, papers, discussions and meetings represent one of the largest, widest and most significant consultative exercises of its kind ever undertaken in Bangladesh fisheries. The strategy includes strategies and action plans for eight sub-sectors. Common to the National Fisheries Strategy and the sub-strategies is a core of central principles and themes– such as decentralization, people's participation, poverty alleviation, gender equity. The strategy was also guided by the Government's Poverty Reduction Strategy Paper, and by a number of international agreements signed by the government.

2.3.3 Hilsa Management Action Plan

Hilsa is the most important single species fishery and the national fish of Bangladesh. It accounts for nearly half of the total marine catches, and 12 – 13% of total fish production and about 1.0% of GDP. The average annual production of hilsa is about 3.0 million tons. At present 50 – 60% of global hilsa catch is reported from Bangladesh waters, 20 – 25% from Myanmar, 15 – 20% from India other 5 – 10% from other countries. A comprehensive action plan for its management has already been formulated by Bangladesh Fisheries Research Institute (BFRI) and being implemented by Department of Fisheries (DOF). Politicians are also willing to provide necessary support for its implementation. Inter-ministerial cooperation also obtained in implementation of the plan. The plan includes juvenile protection, breeding ground protection, nursery ground protection, etc. Govt. allocated about US$ 0.29 million for alternate livelihood, i.e. cage culture and other activities of hilsa fishers during fishing ban period. Impacts of the implementation of the plan are becoming visible, as the abundance of *jatka*, the juvenile hilsa

recorded 35% more than previous years. Overall hilsa production has also been increased by 40% more than previous years.

Implementation of Hilsa Management Action Plan

Implementation of hilsa action plan has been initiated since 2003 with the view to protecting *jatka* (young hilsa) properly. This action plan specified the activities to protect *jatka*, developed the implementation strategy, ascertained responsibility of relevant agencies and target community and fixed specific timeframe for implementation. The action plan involved variety of activities, these are as follows:

- District administration/Ministers/Public representatives involvement
- Awareness creation through public media
- Enforcement of fish protection and conservation act
- Establishment of hilsa sanctuary
- Ten days fishing ban in major spawning grounds
- Alternate livelihood for *jatka* collectors

Special operation for jatka protection and conservation

Juvenile hilsa (up to 23.0 cm size) catch, transportation, marketing, selling and possessing have been banned between 01 November and 31 May every year in Bangladesh under the Protection and Conservation of Fish Act-1950.

- Involved different agencies in *jatka* protection program (MoFL, DoF, Navy, Coast Guard, Upazila Administration, District and Upazila level officers of DoF)
- Introduction of fund allocation for special campaign for *jatka* protection programme
- Special Task Forces formed by the DoF, District and Upazila Administration
- Implementation of awareness building programme
- Rehabilitation and alternative income generating activities for *jatka* fishers

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 in October. So, catch of hilsa has been banned each year in the following major spawning grounds during the highest breeding time (15-24 October).

2.3.4 Integrated coastal resource management

The strategy includes an effective regulation of the artisanal and trawl fisheries for sustainable production. Policy for development and conservation of aquatic habitat and fish biodiversity are also included in this strategy.

2.4 Institutions involved

Ministry of Fisheries and Livestock is primarily responsible for controlling the administration and management of fisheries resources. Under this ministry, three different organizations i) Department of Fisheries (DOF), ii) Bangladesh Fisheries Development Corporation (BFDC) and iii) Bangladesh Fisheries Research Institute (BFRI) are working on different aspects. The department of Fisheries is mainly responsible for the implementation of fish laws and regulations. BFDC is mainly promoting fishing industry, landing and processing & preservation facilities. BFRI is mainly working on research and development of technologies and management suggestions.

3. Data availability

In Bangladesh, getting comprehensive and reliable fishery data, especially for marine fishery is a serious problem. Only some gross catch statistics are

available for different groups. Among the large number of marine species, species wise catch and effort statistics are roughly available for hilsa. For other species, only roughly estimated (eye estimation) values for different group (e.g. pomfrets, mackerels, croakers, shrimps, herrings, sharks, etc.) are available in some extent. Data collection system is also unreliable and most of the time it is not very much useful for scientific purposes. As a result, the species wise information necessary for filling the supplied format could not be made possible (except for hilsa). Therefore, more reliable and more stratified data collection methods need to be used for each of the commercially important species.

4. Resource management issues

The demersal resources of the country, which constitutes the coastal shrimp/finfish fishery occupying different ecosystems such as estuaries, inshore and offshore waters, are well established in these different environments. The goal of managing the shrimp/finfish fishery is to attain the greatest overall benefit for the nation on the basis of maximum sustainable yield (MSY) as modified by relevant economics, social and ecological factors. Penaeid shrimps are widely distributed in the offshore water of the Bay of Bengal, and trawl fishery is exclusively limited to between the 30 and 80 m depth contour. Among the shrimp species brown shrimp *M. monoceros* is the dominant contributor, but tiger shrimps (*P. monodon* and *P. semisulcatus*) are the higher priced and hence mostly sought target species (Mustafa *et al.* 1987). However, declining trend of the availability of the target species has been reported in the offshore trawl catch.

For conservation and sustainable exploitation of the fishery, scientific management based on ecosystem considerations is a very important issue, but proper management and utilisation of fishery resources in developing countries are in general hindered by lack of appropriate information about the ecosystem components. Quantitative assessment of trophic interactions in the Bay of Bengal has important implications for the understanding and management of multi-species fisheries, as fish yields are the result of energy flows.

Main issues concerning marine fisheries

- Expansion of institutional capabilities to plan and implement developmental activities is necessary.
- Stock assessment and feasibility survey in the inshore and offshore pelagic resources in order to explore under-exploited fisheries resources like mackerel, tuna, swordfish, billfish, etc.
- Development of community based integrated management policy for artisanal fisheries.
- Continuous monitoring of the marine fisheries resources to identify new fishing grounds, and to determine the maximum sustainable yield (MSY) of different species.
- Assessment of trophic interactions in the Bay of Bengal, which has important implications for the understanding and managing multi-species fisheries, as fish yields are the result of energy flows.
- The pollution discharged through the major rivers is to be quantified and management system should be developed before releasing to sewerage and industrial pollution in the sea.
- For the stock assessment and oceanographic studies in the Bay of Bengal, a well equipped research vessel and an on-station oceanographic research laboratory needs to be established
- Licensing system of artisanal and industrial fishing unit should be intensified so that all the fishing units can bring under licensing policy. This will also facilitate to collect basic information on the fishing and fisheries resources of the Bay of Bengal.
- Withdrawal/improvement of destructive fishing gears and development environment friendly sustainable fishing mechanism should be developed.
- Export oriented ornamental fishery, seaweed and shells might be assessed and utilized.
- Provision should be developed to conduct EIA before giving permission for any major activities like drilling for oil & gas exploration and establishing deep sea port.

- Strengthening catch and effort data collection system and establishment of an online national and regional comprehensive database that would be necessary for scientific fisheries research, emphasizing marine sector.

5. Conclusions and Recommendations

From the above background information the following areas of marine sector are prioritized where national, regional and international organization may help:

- Assessing and utilizing underutilized important pelagic resources, like mackerels, tunas, sword fish, billfish, sharks, etc.
- Strengthening catch and effort data collection system and establishing an online national and regional comprehensive database that would be necessary for scientific fisheries research, emphasizing marine sector.
- A regional technical advisory committee on fisheries may be formed to suggest management strategy of the fisheries resources of the Bay of Bengal to be implemented by the member countries individually and jointly.
- Regional co-operation through–training and exchange visit on good practices, bilateral discussions over issues of conflicts and follow-up actions through regional workshops should be strengthened.
- A regional research vessel with expert in resource assessment may provide help to the member countries by rotation for assessment and sustainable utilization of the marine resources.
- Exchange of technical know-how among the member countries in the field of processing, product development and quality control of marine fishery products and by-products.

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3

Impacts of climate change on coastal and marine fisheries resources in Bangladesh

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1. Introduction

Bangladesh is a South Asian country with an area of 147,570 sq. km. and a population of 156.0 million with annual growth rate of 1.29%. The country is located between 20^{o} to 26^{o} North and 88^{o} to 92^{o} East. It is bordered on the west, north and east by India, on the southeast by Myanmar and on the south by the Bay of Bengal. On the other hand, is situated at the interface of two contrasting settings with the Bay of Bengal and the North Indian Ocean to the south and the Himalayas to the north. Bangladesh has a humid, warm, tropical climate; having mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October). Most of the country has an elevation of less than 10 meters above sea level. The major rivers systems are Ganges-Padma, Brahmaputra-Jamuna and Meghn that flow from the Himalayan Mountain into the Bay of Bengal. These three giant rivers form the main frame on which the latticeworks of relatively smaller rivers are attached.

Adapted from a paper submitted in *Bay of Bengal News* from an invitation of Director, BOBP-IGO, Chennai, India.

Bangladesh is widely recognized to be one of the most climatically vulnerable countries in the world (Table 1). The country suffers from many climate dependent natural hazards, such as: droughts, cyclones, much of the country routinely inundated during the summer monsoon season. High population density and poverty increases the country's vulnerability to these natural hazards. The country's population is projected to grow to over 200 million by 2050 (WB and BCAS 1998). High population density implies that more people live in areas vulnerable to climate change, and therefore could limit the capacity of people to move in response to this situation.

Table 1. World major climate vulnerable countries
(Deaths/100,000 people exposed to floods or cyclones)

Floods			Tropical cyclones		
1	Venezuela	4.9	1	Bangladesh	32.1
2	Afghanistan	4.3	2	India	20.2
3	Pakistan	2.2	3	Philippines	8.3
4	China	1.4	4	Honduras	7.3
5	India	1.2	5	Vietnam	5.5
6	Bangladesh	1.1	6	China	2.8

Source: UNDP (2004)

Climate change is a long-term phenomenon and the scenario for Bangladesh developed under United States Country Study Program and World Bank Study. Potential effects of climate change are considered for the period 2030 and 2050 (Table 2).

Table 2. Climate change scenarios for Bangladesh in 2030 and 2050

Year	SLR (cm)	Temperature increase (^{0}C)	Precipitation fluctuation compared to 1990 (%)	Changes in evaporation
2030	30	+0.7 in monsoon +1.3 in winter	-3 in winter +11 in monsoon	+0.9 in winter +15.8 in monsoon
2050	50	+1.1 in monsoon +1.8 in winter	-37 in winter +28 in monsoon	0 in winter 16.7 in monsoon

Source: UNFCCC (2002)

According to IPCC (2001), the following changes related to Bay of Bengal have been observed in Bangladesh in climate trends, variability and extreme events:

- Average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998.
- The annual mean rainfall exhibits increasing trends and decadal rain anomalies are above long term averages since 1960s.
- Serious and recurring floods have taken place during 2002, 2003 and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclones formation in Bay of Bengal has increased.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland along tributary channels during the dry season.

2. The Coastal and Marine Environment of Bangladesh

The Bay of Bengal, the marine area of Bangladesh is characterized by a semi-enclosed tropical basin. The coastline of the country comprises about 710 km extending from the tip of Teknaf in the south-east to the south-west coast of Satkhira. As a result, along with 710 km coast line an area more than 166,000 km^2 falls under economic jurisdiction of Bangladesh for exploration, exploitation, conservation and management of its marine resources. The country's shelf area covers roughly 66,000 km^2 and coastal waters are very shallow with less than 10 m depth covering about 24,000 km^2. The entire shelf area of Bangladesh (up to 200 m depth contour) covers about 70,000 km^2. The shelf area remains down to about 150 m depth, appears to be very smooth to bottom trawling, while the continental edge occurs at depths between 160 m and 180 m, where the bottom is very precipitous and thus trawling is not possible in this area (Khan *et al*. 1997).

2.1 Major fishery resources

A number of surveys have been conducted to assess the standing crop of the marine resources (West 1973, Saetre 1981, Penn 1982, Lamboeuf 1987, Khan

2000). All the surveys were confined to the demersal fisheries stocks. As shown in Table 3, the results of the surveys vary to a great extent. No direct survey has been conducted on the estimation of pelagic resources. During R.V Dr. Fridtj of Nansen" survey (Saetre 1981), the pelagic fish stock was estimated as 90,000 – 160,000 MT through an acoustic study. The current consensus based on the reassessment of the previous and related studies showed a trawl able standing stock of 150,000 – 160,000 MT in the coastal water of Bangladesh of which about 53% comprising of commercially important demersal fishes and about 16% consists of commercially important pelagic fishes (Lamboeuf 1987, Khan *et al*. 1997).

Table 3. Standing stock (MT) of demersal, pelagic fish and shrimp of the Bay of Bengal

Demersal fish	Pelagic fish	Shrimp	Authors
264,000-373,000	-	9,000	West (1973)
160,000	90,000-160,000	-	Saetre (1981)
200,000-250,000	160,000-200,000	4,000-6,000	Penn (1982)
188,000	25,600	-	Lamboeuf (1987)
176,160	-	857	Khan (2000)

The marine capture fisheries of Bangladesh consist of complex, multi-species resources. This sector contributes about 20% of the total fish production (2.44 million tons) of Bangladesh. The marine fisheries sector of Bangladesh is divided into two sub-sectors- industrial and artisanal. The average of last ten years' production shows that the industrial fishery based on trawl fishery (shrimp trawl and fish trawl) contributes only 6.3% of the total marine production and the artisanal small scale fisheries contributes 93.7% of the total marine landing (Table 4). There is lacking of data on sustainable harvest of marine fisheries resources. Besides, due to poor socioeconomic conditions and lack of alternate income source of fisher folk, maintaining sustainable harvest of resources has become very difficult.

Table 4. Production (MT) fish from the marine water Bangladesh

Year	Industrial	Artisanal	Total
1997-1998	15,273 (5.60)	257,545 (94.40)	272,818
1998-1999	15,818 (5.11)	293,979 (94.89)	309,797
1999-2000	16,304 (4.88)	317,495 (95.12)	333,799
2000-2001	23,901 (6.30)	344,596 (93.70)	379,497
2001-2002	25,165 (6.06)	390,255 (93.94)	415,420
2002-2003	27,954 (6.47)	403,954 (93.53)	431,908
2003-2004	32,606 (7.16)	422,601 (92.84)	455,207
2004-2005	34,114 (7.18)	440,483 (92.81)	474,597
2005-2006	34,084 (7.10)	445,726 (92.90)	479,810
2006-2007	35,391 (7.26)	452,047 (92.74)	487,438
Average	26,061 (6.30)	376,868 (93.70)	404,029

*****The figures in parenthesis indicate percent of total

3. Climate Vulnerability

3.1 El Nino and La Nina

Although no direct correlation has been found between the Southern Oscillation and consequent temperature anomaly in the oceanic systems and the extreme weather events in Bangladesh, some studies report that the El Nino Southern Oscillation events influenced the record breaking floods of 1987, 1988 and 1998 (Chowdhury 1998). The rapid transformation of La Nino from El Nino phase in early monsoon in 1998 is said to have influenced high rates of precipitation over the entire GBM catchment basin. As a result, after a prolonged dry season, the wettest monsoon came along with extremely high levels of precipitation eventually resulting in the deluge of the century. Such global events could, therefore, intensify some of the extreme climate change related weather events even further.

3.2 Flooding

Analysis of past floods suggests that, about 26 percent of the country is subject to annual flooding and an additional 42% is at risk of floods with

varied intensity (Ahmed and Mirza 1999). A 10% increase in monsoon precipitation in Bangladesh could increase runoff depth by 18 to 22%, resulting in a seven fold increase in the probability of an extremely wet year (Qureshi and Hobbie 1994). Alam *et al* (1999) reported that, by the year 2030, an additional 14.3% of the country will become extremely vulnerable to floods, while the already flood-vulnerable areas would face higher levels of flooding. It is also reported that, even if the banks of the major rivers are embanked more non-flooded areas will undergo flooding by the year 2075.

3.3 Cyclones and storm surges

Tropical cyclone hits Bangladesh, on an average, every 3 years. These storms generally form in the months just before and after the monsoon and intensify as they move north over the warm waters of the Bay of Bengal. They are accompanied by high winds of over 150 kph and can result in storm surges up to seven meters high, causing extensive damage to the rural houses and high loss of life to humans and livestock in coastal communities. The storm surges are higher in Bangladesh than in neighboring countries because the Bay of Bengal narrows towards the north, where Bangladesh is located. In recent years, general cyclonic activity in the Bay of Bengal has become more frequent, causing more roughness in the sea that can make life difficult for fishermen and small craft to use for fishing in the sea.

Although there is some uncertainty about the IPCC forecasts on the timing and severity of these impacts, the directions of change are clear. Changes in rainfall patterns and in the frequency and severity of tropical cyclones, hurricanes and storm surges are likely to happen rapidly and quickly (and may be recently happening already with Cyclone *Sidr* in Bangladesh and Cyclone *Nargis* in Myanmar happening within six months of each other). Other changes such as sea level rise are likely to be seen only after 20 years, possibly longer.

3.4 Siltation

The oceanographic feature of the northern Bay of Bengal is being stricken by siltation. It has some influence on the fishery ecology of the estuarine and near shore water body of Bangladesh. Since prehistoric times Bangladesh has been

one of the areas of most active sedimentation in the world. Denudation of Himalayas resulted in the formation of the world's largest delta, which is still active at a rate of about 70 cm per one thousand years (Curray and Moore 1971). The Ganges-Brahmaputra river-system brings this sediment down and drains into the Bay of Bengal. The Meghna system seems to be filtered while passing through the depressions (haors) of sylhet basin and contributes less to the process. A total of 6 million cusecs of water carrying an estimated amount of 2,179 million metric tons of sediments is being carried down to the sea each year by the Ganges-Brahmaputra river system (Curray and Moore 1971).

The accretion-erosion process of the islands like Hatyia, Sandwip and Bhola of Bay of Bengal estuary has indication of strong sedimentary process in the vast GBM estuary, which constitute about 12800 km^2 of inshore fish habitat, (West 1973). Due to heavy siltation in the near shore regions, has a direct impact on continual change in the habitat; especially on the bottom topography is subjected to continual alteration. Extensive rate of erosion in Hatyia, Sandwip, Bhola and Noakhali in the recent past (few decades) must have altered the bottom condition of the habitat, which might have substantial effect on the fish community particularly, the demersal stock. Sedimentary processes might have influences on the fish ecology of the estuarine and near shore waters of Bangladesh.

3.5 Sea level rise

Another critical variable that determines the vulnerability of Bangladesh to climate change impacts is the magnitude of sea level rise. There is no specific regional scenario for net sea level rise, in part because the Ganges-Brahmaputra delta is still active and the morphology highly dynamic (Agrawala *et al*. 2003). The country is highly vulnerable to sea level rise, because it is a densely populated coastal country of smooth relief comprising broad and narrow ridges and depressions. World Bank (2000) showed 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100; affected 2%, 4% and 17.5% of total land mass respectively. At present expected rates, this situation will occur in about 150 years from now.

Subsidence is also a considerable factor for sea level rise in Bangladesh. The Ganges and the Brahmaputra deliver approximately 1.6 billion tons of

sediment annually to the face of Bangladesh (Broadus 1993). These sediments compensate the natural compaction and subsidence of the delta and keep its size stable, relatively. So, sediment replenishment is considered to balance subsidence of the delta that results a net sea level rise (Agrawala *et al.* 2003). Besides ice melting and thermal expansion, area specific land subsidence and uplifting is an important factor for the sea level rise in Bangladesh.

4. Impacts of Sea Level Rise on the Coastal Ecosystem of Bangladesh

Salinity intrusion: The main impacts of sea level rise on water resources are fresh water availability reduction by salinity intrusion. Both water and soil salinity along the coast will be increased with the rise in sea level, destroying normal characteristics of coastal soil and water. A water salinity map for the period of 1967 and 1997 produced by Soil Resources Development Institute (SRDI 1998) shows that the problem is already on the way. A one meter sea level rise will expand the soil and water salinity area at a faster rate.

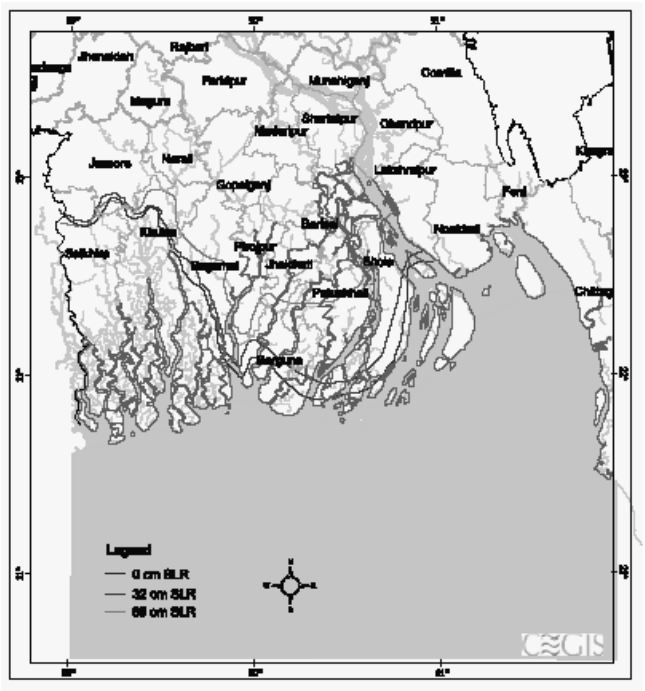

Fig. 2. Salinity ingress in southern Bangladesh due to different SLR.

Impacts on fisheries and aquaculture: Sea level rise would change the location of the river estuary, causing a great change in fish habitat and breeding ground. Penaeid prawns breed and develop in brackish water, where salt water and fresh water mixes. Sea level rise would turn this interface backward, changing natural habitat of prawn population. There are about 60

shrimp hatcheries and 120 shrimp processing plants in the coastal zone of Bangladesh. The hatcheries are located along the sea beach at Cox's Bazar. Favourable environmental condition and brood stock availability are the main reasons to set up hatcheries in that area. Some hatcheries have also started trial and experimental production in Chittagong and Satkhira coast. It is worthy to mention here that all the above districts are located in the coastal zone of the country. As the zone is vulnerable to sea level rise, shrimp hatcheries and shrimp fields are also vulnerable to the phenomena. However, sea level rise is helping shrimp farming by introducing salinity in the coastal area, but it is also harmful for other crops. If we consider another sea level rise phenomena, for instance flooding; it is doing massive harm to the sector by over flowing shrimp ponds and let the shrimps to set free in open water. In addition, high projected magnitude of sea level rise will inundate the present shrimp ponds and will destroy this prospective foreign exchange earning sector of Bangladesh (4.9% of total export). There are some areas in the coastal zone that are far from city or fisheries service centre and have no icing facilities. Fishermen of such areas dry fishes in open sunlight as a means of fish preservation. Dry fishes are rich in nutrient value and a popular dish among the coastal people, especially in the southeastern coastal zone. The dry fish industry will also be affected by anticipated sea level rise.

4.1 Climate change and the Sundarbans ecosystem

On the basis of different vulnerability indicators for accelerated sea level rise, WHOI (1986) produced a list of twenty-seven low-lying countries. The list was headed by Bangladesh and the Sundarbans, due to its location along the coastline, is most vulnerable. The Bay of Bengal acts as a funnel for storm events, creating the most severe storm surge problems in the world. Storm surges cause an elevation of sea level above the tidal height which, if they occur at spring tide inaxinia, have a devastating effect on a low-lying coast like that of Bangladesh. Predictions of the effects of global warming on Bangladesh are difficult to make because of the inherent dynamism of the environment.

Whatever the impacts of global climate change, the role of mangroves as a physical buffer against seawater inundation and coastal erosion is potentially very significant. It has also often been argued that mangroves mitigate the

impact of storms in coastal areas. Reports suggest that the effects of the storm surge in Bangladesh in 1970 may not have been so severe had large areas of mangrove not been cleared for agricultural purposes. It is difficult, however, to substantiate such claims quantitatively because of the lack of effective controls. Nevertheless, circumstantial evidence tends to support such claims with inundation being minimal in the area north of the Sundarbans when compared to other unprotected areas along the coast.

4.2 Climate change impacts on the Sundarbans

Climate change is expected to have a significant effect on the flow regimes of the major rivers in Bangladesh, including the Ganges. Since the viability of the Sundarbans rests on the hydrology of the Ganges and its tributaries, which supply the freshwater influx, climate change is expected to have significant impact on the Sundarbans. In addition to the altered hydrology, sea level rise will also have adverse impacts on the forest, directly through enhanced inundation and indirectly by enhancing saline intrusion in river systems. The climate change scenarios indicate that there is general agreement across climate models on increased precipitation during the monsoon season. Greater rainfall runoff would provide increased freshwater discharge in all the major distributaries of the Ganges supplying freshwater to the Sundarbans – the Gorai, the Modhumati and the Bhairab system on the Bangladesh side and the Hoogly on the Indian side. Simultaneously however, a rise in sea level would also occur under climate change which would cause increased backwater effect in the major distributaries of the Ganges and tend to push the saline front further inland. The final location of the saline front during the monsoon will, therefore, be the result of two opposing effects: enhanced freshwater flows and enhanced backwater effect, and is hard to predict precisely. The backwater effect would also reduce the discharge of freshwater flow from the northern reaches of the tributaries of the Ganges resulting in a relatively prolonged inundation of the forest land.

The Sundarbans will be completely lost with 1 metre sea level rise (World Bank 2000). Loss of the Sundarbans means great loss of heritage, loss of biodiversity, loss of fisheries resources, loss of life and livelihood and after all loss of very high productive ecosystem. Area of the Sundarbans, inundated by different scale of sea level rise, is shown in the Table 5.

Table 5. Fate of the Sundarbans with different sea level rise (SLR)

Sea level rise	Potential impacts
10 cm SLR	inundate 15% of the Sundarbans
25 cm SLR	inundate 40% of the Sundarbans
45 cm SLR	inundate 75% of the Sundarbans
60 cm SLR	inundate the whole Sundarbans
1 metre SLR	destroy the whole Sundarbans

Source: Sarwar (2005)

Environmentally protected areas are declared with a view to save the natural habitat and to save the biotic flora and fauna of the area. Considering the high biodiversity value of the Bangladesh coast, some parts of the zone are declared protected areas (Table 6).

Table 6. Protected areas in the coastal zone of Bangladesh

Type	Name	Area (ha)	Location	Effects of 1-m SLR
Reserved Forest	-	885,043	Khulna, Satkhira, Bagerhat, Bhola, Patuakhali, Noakhali, Chittagong, Cox's Bazar	Yes
National Park	Himchari	1,729	Cox's Bazar	No
	Nijhum dweep	4,232	Hatiya, Noakhali	Yes
Wildlife Sanctuaries	Sundarban east	31,227	Bagerhat	Yes
	Sundarban south	36,970	Khulna	Yes
	Sundarban west	71,502	Satkhira	Yes
	Char kukri- mukri	2,017	Bhola	Yes
	Chunati	7,761	Chittagong	No
Ramsar Site	Sundarbans	601,700	Khulna, Satkhira, Bagerhat	Yes
Environmental Critical Areas	Sonadia	4,916	Cox's Bazar	Yes
	Teknaf	10,465	Cox's Bazar	Yes
	St. Martin Island	590	Cox's Bazar	Yes
World Heritage Site	Wildlife sanctuaries of the Sundarbans		Khulna, Satkhira, Bagerhat	Yes
Marine Reserve		69,800	Bay of Bengal	Yes

Source: Islam (2004)

Sea level rise will decrease availability of light for corals, affecting photosynthesis process. Decreased rates of photosynthesis will decrease the growth of corals, causing destruction of St. Martin's island, the only highly productive coral island of the country.

4.3 Climate change impacts on the marine fisheries resources

Alteration of marine ecosystems due to climate change has direct and indirect adverse effect on fish flora and fauna for their reproduction, migration and survival. Reproduction in fish, as one of their important life history trait, is regulated by various exogenous and endogenous conditions. Therefore, reproductive cycle is a harmonious process interlinked with environmentally mediated routine of various aquatic ecosystems. In such case any adverse environmental condition might affect the natural reproduction process of marine fish population and ultimately hinder the recruitment in a stock through spawning. Similarly, fish migration might be hampered due to negative impact over the situation.

Hilsa (*Tenualosa ilisha*) or river shad is the national fish of Bangladesh. It contributes to 13-14% (290,000 mt, Tk 6,000 million, 1.3 % of GDP) of total fish production of Bangladesh. During last two decades hilsa production from inland water declined about 20%, whereas marine water yield increased about 3 times. Major hilsa catch has been gradually shifted from inland to marine water. Hilsa fish ascend for spawning migration from sea into estuaries and most of the river systems of Bangladesh. Where, all the essential exogenous semi-saline or freshwater ecological parameters trigger the reproduction of hilsa parental stocks. The river water nurses the millions of larvae where they grow and revert to juvenile and adult hilsa. At that stage they again migrate towards the sea. But the recent siltation problem on the upstream part of Padma and other river systems affected the normal course of spawning and migration of the fish. Recent study revealed that availability of hilsa stock is gradually declining in the Padma and Megna river catchment areas. As a result, the trend of hilsa production in the rivers has been decreased and alternatively, the production trend in marine water as mentioned above has comparatively been increased. Similar conditions might occur for other potential marine fish/shrimp species although no definite study had yet been carried out in Bangladesh.

5. Combating Climate Changes

In 2005, the Government of Bangladesh launched its National Adaptation Programme of Action (NAPA), in partnership with other stakeholders, which highlights the main adverse effects of climate change and identifies adaptation needs. The Climate Change Cell in Department of Environment (DoE) under the Ministry of Environment and Forests supports the mainstreaming of climate change into national development planning. The Meteorological Department and SPARRSO, under the Ministry of Defense, and the Flood Forecasting and Early Warning Centre of Bangladesh Water Development Board, under the Ministry of Water Resources, are two of the key institutions in this field.

To harness, guide and coordinate all the national and international responses and processes to integrate climate risk into development plans and processes, the government, through its DoE has recently launched the preparation of the Climate Change Policy and Action Plan for Bangladesh (CCPAP). This Plan will take a holistic, inclusive and comprehensive approach involving all stakeholders toward understanding climate risks and vulnerabilities and then responding to these through concerned sectors, agencies and stakeholders.

5.1 Adaptation measures in fisheries as prioritized in Bangladesh NAPA

- Promoting adaptation to coastal fisheries through culture of salt tolerant fish especially in coastal areas of Bangladesh.
- Adaptation to fisheries in areas prone to enhanced flooding in North East and Central Region through adaptive and diversified fish culture practices.
- Reduction of climate change hazards through coastal forestation with community focus.

5.2 Adaptation options for the climate changes

Adaptation seeks to reduce the adverse effects of sea level rise on living organisms, including human and the environment. The ability to adapt and cope is a function of wealth/income, technology, scientific and technical knowledge and skills, information, infrastructure, policy and management institutions and equity. Sea level rise adaptation can be addressed by changes

in policies that lessen pressure on resources, improve management of environmental risks, and enhance adaptive capacity. As most of the populations of the coastal communities of Bangladesh are fishermen and farmers, the adaptation options should be emphasized on these two sectors to overcome the problems of the anticipated issues. If we can implement different adaptation options of coastal fisheries, as shown in the following Causal Loop Diagram (CLD) (Fig. 3), we find that five loops may reinforce to increase the fisheries production. Foreign exchange earned by coastal fisheries could be invested for the development of coastal fisheries sector.

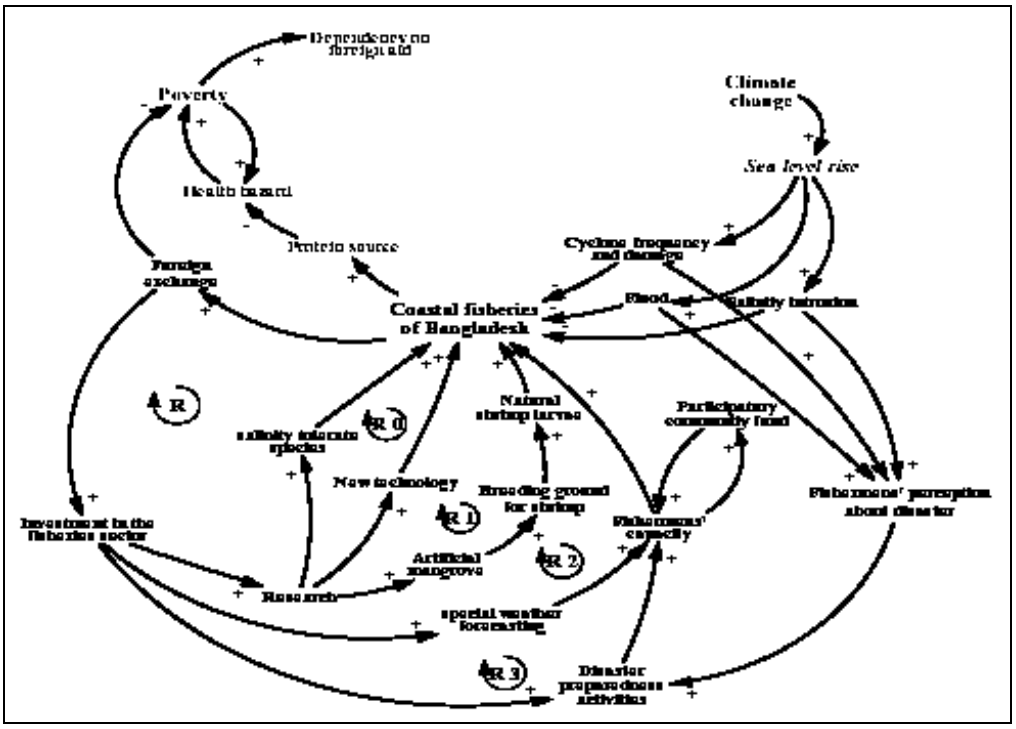

Fig. 3. CLD for the adaptation options of coastal fisheries with sea level rise. (Source: Sarwar 2005)

Coastal communities should be prepared to face these adverse situations by having disaster preparedness activities. Disaster preparedness activities include pre and post disaster activities, not only the duty during the disaster

event. Though, it is difficult to have a plan for any disaster before it has happened, it should be done ahead. The fishermen should be updated about the disaster and their duties to minimize the potential loss by the event. A disaster calendar should be prepared for the community, so that they can have a safe plan for fish farming. For example, most of the cyclones in the coastal zone occur in October and May; coastal district Noakhali is mostly heated by cyclone, which is almost the country's one-third; salinity is high in Khulna, Satkhira and Patuakhali districts could be considered in the proposed disaster calendar. Following the disaster calendar, fishermen can avoid the specified time period and the specific coastal district for fishing and fish farming. A disaster calendar that considers disaster intense time, disaster prone zone and salinity will help the fisher community to have a safe production and also safe harvest.

Weather forecasts in Bangladesh Radio and Bangladesh Television, whose target groups are mostly illiterate coastal farmers and fishermen, are developed and delivered by educated people in highly educated language. Weather forecasting should be in easy language, so that the target groups can understand it easily and completely and can react with the direction of the forecast. Besides forecasting, local radio station should broadcast special programmes that communicate coastal communities about different issues of sea level rise.

Efficient research can be conducted to develop or identify salinity tolerant species for the coastal fisheries sector. Species selection should be made for low, moderate and high saline environment. After selecting different species for different zones or saline environments, the fishermen should be trained about breeding and seed production techniques including cultivation and harvesting of the species. Research will also be conducted for new or advanced technologies for the sector. By cultivating salinity tolerate species and by practicing advanced fisheries techniques, coastal communities can adapt themselves with sea level rise, which is shown in the reinforcing loop of R and R0 of the CLD (Fig. 3).

The most useful adaptation aiming towards saving the Sundarbans from sea-level rise induced submergence would be to modify the threats of permanent inundation. Since most part of the projected sea level rise would occur from

tectonic subsidence, it would not be quite possible to stop the processes involved. However, efforts must be made to figure out ways to enhance sedimentation on the forest floor, by means of guided sedimentation techniques. If such approaches appear to be technically feasible and economically viable at a pilot level, efforts must be made to undertake projects in order to save the forest. Controlled and guided sedimentation will have a balancing influence on subsidence process and could help delay permanent inundation of the forest floor. The second most important adaptation strategy will be to reduce the threats of increasing salinity, particularly during the low flow period.

5.3 Future climate change strategy and action plan

The Government of Bangladesh is committed to increase the country's resilience to climate change; reduce the risks climate change poses to national development; and rapidly develops the country, following a low-carbon growth path. The NAPA, launched in 2005, provided a response to the urgent and immediate needs of adaptation and identified priority programmes. The CCPAP is a 10-year programme (2009 – 2018) to build the capacity and resilience of the country to meet the challenge of climate change. The CCPAP has been developed through a participatory process involving all relevant ministries and agencies, civil society, research organizations and the business community. Programmes funded under the Action Plan will be implemented by line ministries and agencies, with participation, as appropriate, of other stakeholder groups, including civil society, professional and research bodies and the private sector. The Ministry of Environment and Forests is currently working out the cost of implementing the ten-year Action Plan, in consultation with line ministries. The CCPAP included fisheries sector with the following programmes:

Table 7. The CCPAP of Bangladesh involving fisheries and biodiversity

Programme and time frame	Justification	Specific actions
The development of adaptation strategies in the fisheries sector (mid to long term)	Climate change is likely to adversely affect freshwater and marine fisheries resources in Bangladesh (e.g., the spawning of freshwater and marine species; water temperatures in fresh, brackish and marine waters are likely to increase; saline water is likely to extend further inland in the south of the country, which will change the existing aquatic ecosystems and production of fish in this zone; and turbulent and rough weather along the coast may prevail for longer durations adversely impacting on the livelihoods of fishermen). So, it is important that these potential impacts are identified and research and management strategies developed, tested and made ready, in anticipation of climate-related changes.	• Assess potential threats to fish spawning and growth of fish in the freshwater fisheries sector and develop adaptive measures, including fish farming and river based cage aquaculture etc. • Assess potential threats to fish spawning and growth of fish in the coastal zone and brackish water and develop appropriate adaptive measures and mariculture practices. • Assess potential impacts on the shrimp sector and develop appropriate adaptive measures and cultural practices. • Assess potential threats to the marine fish sector and develop adaptive measures to protect these resources
Monitoring of ecosystem and biodiversity changes and their impacts (mid to long term)	One of the objectives of the UNFCCC is to urgently reduce green house gas emissions, so that ecosystems and their flora and fauna have time to adjust to climate change. Salinity levels are also likely to increase significantly in the coastal belt. Mangrove ecosystems, which are already under serious stress for	• Set up a well-designed monitoring system to evaluate changes in ecosystem and biodiversity, covering all important and sensitive ecosystems. • Develop participatory monitoring systems by involving local trained people such as school

	anthropogenic reasons will suffer heavily due to further increases in salinity. These could alter the entire ecosystem of the Sundarbans and cause the extinction of some valuable fish/shrimp and other aquatic species. In view of these expected changes, a systematic monitoring mechanism should be put in place to assess the impact of climate change on ecosystems and bio-diversity. A participatory impact monitoring mechanism involving communities and academic experts will be designed. Pertinent physical, chemical and biological data will also be collected. The changes that take place in livelihood patterns due to ecological and biodiversity changes will also be assessed and policy recommendations and appropriate actions suggested.	teachers, communities and academic researchers. • Report changes in ecosystems and biodiversity and asses the implications, including those for the livelihoods of local people, and recommend adaptation measures.

6. Conclusions

Climate change impacts are really high for Bangladesh, though the country plays very little role in green house gas emissions, leading to climate change and sea level rise. By affecting different livelihood activities and important ecosystem of the country, sea level rise imposes a great threat to the existence of Bangladesh. Therefore, Bangladesh government needs to pay keen attention to these issues and should develop strategy to combat sea level rise impacts and thus safe the valuable resources and the people. It will not be

wise to think that sea level will not rise at all, or to wait to see what happens in future. So, development and implementation of adaptation policies and taking initiatives for mitigation measures are the right ways to respond to sea level rise impacts. It deserves research to find out the solutions of the potential problems, in practice and to develop salinity tolerant species both for agriculture and fisheries sectors.

Adaptation cost should be recovered from coastal resources using economic instruments. Research also needs to find out the way to save the country's protein source fish and wide range of biodiversity threatened by the upcoming constraints. Necessary assistance from the international communities is necessary in the form of technical and financial supports to combat the impacts of climate change on the country. Technical experts from international development organizations are also be required. Bangladesh is not self-sufficient to face such a large scale problem, either. So, global integrated initiatives should be taken to save the country to a greater extent.

In particularly for the marine environment, the main reasons caused by the climate change are the rise in sea water temperature, salinity and sea level, drop in sea surface pH, and changes in the current, upwelling, water mass movement, El Niño and La Nina events. Climate change would affect the distribution and abundance of marine fish species. Many of such fish species, for instance, have a narrow range of optimum temperatures related both to the species' basic metabolism and the availability of food organisms that have their own optimum temperature ranges. Depending on the species, the area it occupies may expand, shrink or be relocated with changes in oceanic conditions. No specific research has yet been conducted in these issues in Bangladesh and other nearby countries. Therefore, a coordinated long term research project(s) on impact of climate change in marine resources involving member countries having the common marine ecological conditions and interests need to be implemented in the Asia Pacific region.

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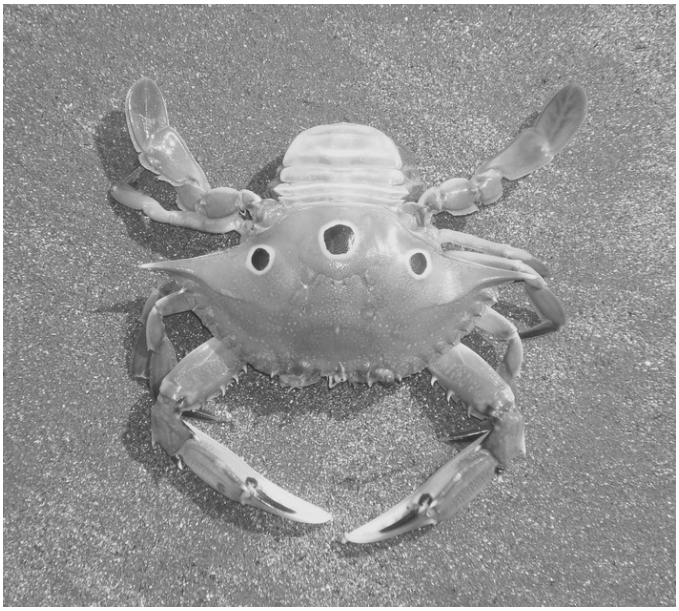

4

National Plan of Action for shark fisheries in Bangladesh

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1. Introduction

Shark is an important fishery in the costal areas of Bangladesh since time vogue. The tribal people eat shark meat both fresh and dried. Shark flesh is a high cost food in neighboring countries like Myanmar, Thailand, and China. Recently a considerable amount of shark product is exported from Bangladesh to these countries both in legal and illegal ways. Shark skin, teeth and jaws are used to prepare money bag, jewelery box, shoe, belt, etc. at home and abroad. Shark liver oil enriched with vitamin A and D and in the advanced countries it is extracted as vitamin A and D supplement for medicinal use. Shark fin are used to prepare special type of soup in the Far East countries including preparation of glue and gelatin. In fact, all parts of the fishes, the fins, skin, meat, liver, and teeth command high commercial value and have export potential. About 100 crore Tk is earned as foreign exchange from shark export in Bangladesh every year. In the recent times, due to technological innovations combined with expanding markets has led to an increased fishing effort of shark fishes from the marine water bodies.

Presented in the BOBP 2nd Regional Consultation on Preparation of Management Plan for Shark Fisheries. Organized by BOBP-IGO. 9-11 August 2009, Kulhudhuffushi, Maldives.

Shark fishing is banned under the Bangladesh Forest Act but there is no indication of shark banning in the Fisheries Act. So far, little initiative has been undertaken to implement the Forest Act or to manage the fishery either by the Department Forest or Department of Fisheries. As a result, the fisher catches shark indiscriminately both as targeted and non-targeted species and the traders allegedly encouraging shark trade.

The Department of Fisheries (DoF) recording the catches of shark following a catch assessment model developed in 1983-84 by establishing some sample villages. Since then, the model has not been revised or improved instead of major change in the sample villages and increase of fishing effort. As such dependable data of shark catches are absent. Meanwhile, catches of small size/juvenile sharks has increased with the decrease of large size shark and some species are rare in the catches and some has entered into the IUCN threatened and endangered list. In the above background National Plan of Action for Shark Fishery is urgently required for sustainable production of the fishes. To develop sustainable management development plan, detail information on catch and effort, fishing crafts and gears, stock and population structure, associated fisheries, including biological and environmental information are required. The present state of knowledge on Shark Fisheries is discussed below:

2. Present Status of Shark Fishery in Bangladesh

2.1 Abundance and distribution of Shark

The sharks are available throughout the entire coast of Bangladesh extending up to Myanmar and Indian border. They are distributed in the brackish water particularly in the Sundarbans, entire coastal line, off sea and deep sea areas. Occasionally sharks are also entering in to freshwater zone during the heavy run off in flood times.

2.2 Depth zone distribution

In the coast, their distribution ranges between 1.0 – 10 meters. In the Bay of Bengal demersal cruise no 3, caught 42.55% sharks in 10 – 20 meter depth, 21.12% sharks at 21 – 30 m depth, 3.10% at 51 – 100 m and 0.38% at 100 – 200 m depth ranges (White *et al.* 1985). The cruise no 4; caught 4.39% shark at 10 – 20 m, 4.5% at 21 – 30 m, 4.68% at 31 – 50 m and 2.9% at 51 – 100 m depth zones. From the above studies it appears that maximum numbers of sharks are dwelling and caught between 10 – 50 m depth zones.

2.3 Landing centers

The main landing centers of shark are situated at Cox's Bazar, Chittagong, Kuakata of Patuakhali district, Dublar Char Island, coast of the Sundarbans and Patharghata of Barguna district. The main drying yards are also located in the above areas.

2.4. Historical trends of shark catches in Bangladesh

The trends of shark catches and landings are shown in Fig. 1 (FRSS, 1985/86-2005/2006)

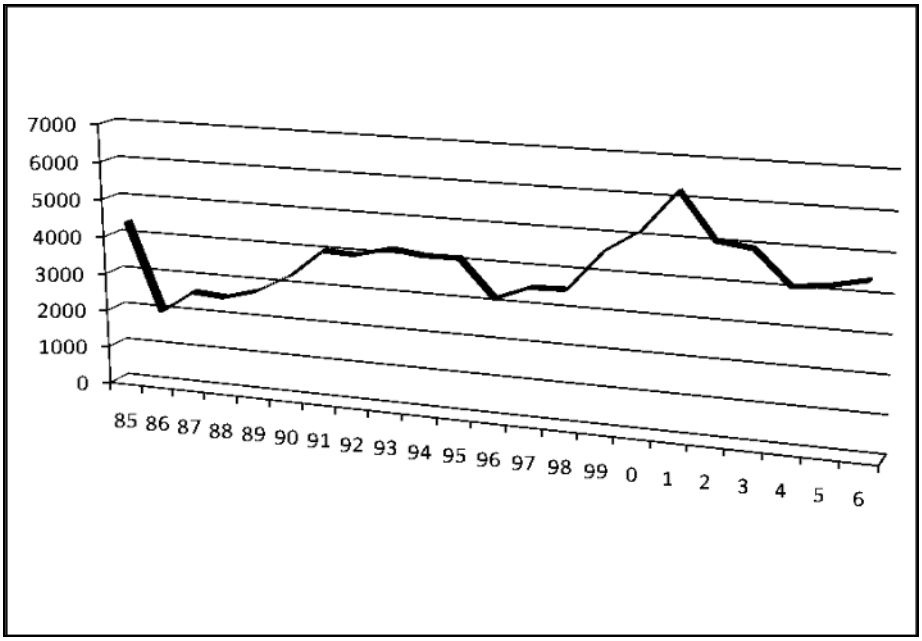

Fig. 1. Trends of shark catches and landings in Bangladesh.

During 1985/86 – 2005/06 shark landings ranged between 1,170 MT to 6,234 MT with an average of 4,000 MT. The highest landing was recorded in 2001 – 02 and the lowest in 1986-87. Since, 2001 – 02 the shark landings are decreasing rapidly and overall, the fishery is not stable in Bangladesh.

The catch assessment model of FRSS developed in 1983-84 by establishing some sample villages. Since then the sample village has not upgraded. A major change both in inland and marine sample villages was found under the hilsa studies (Haldar 2004). The shark catch data are also collected from the same sample villages. Thus, it is thought that the data that are collected for shark by FRSS are not much dependable. More over, species or group-wise data are absent in the FRSS system.

2.5 Species-wise contribution

A study was conducted at Cox's Bazar to determine the species composition of shark during January to December 2007 and from the study Kala hangar, *Charchahinus* sp. was the most dominant species followed by Hammer head *Scoliodon* sp., and Moisa *Chilosccyllium* sp (Roy *et al.* 2007).

2.6 Nets and gears used for shark catch

Sharks are caught in Bangladesh mainly as a by catch except a few boat has introduced into the fishery recently. The main crafts and gears are the gill net, large meshed gill nets (set and drift), set bag nets (ESBN and MSBN) hook and lines. Length and width of a shark net varies between 1,500 to 2,200 m and 10 to 15 m respectively and mesh size ranges between 40 to 52 cm. Mechanized boats are also used for shark fishing. Usually 10 to 12 crews are employed for fishing and a fishing cruise continues for 15 to 20 days.

2.7 Shark fishing season

The shark fishing season extends almost throughout the year but the main season is November to March and a peak is found in July (Fig. 2).

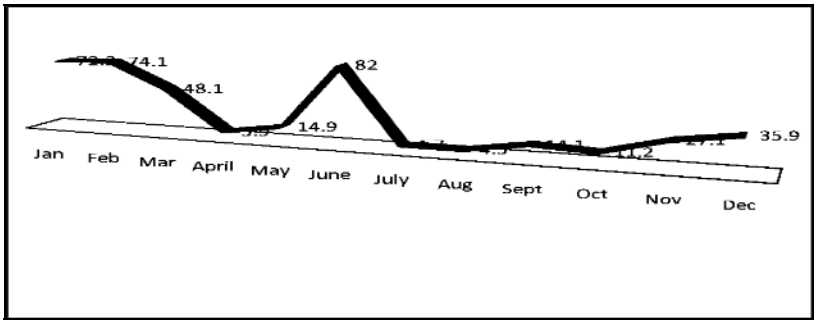

Fig 2. Peak season of shark harvest found in 2006.

2.8 Number and size of sharks caught in Bangladesh

The number and sizes of sharks caught in Bangladesh vary month to month of a year. Landings per month, % contribution to total landings by number and weight and individual average weight of sharks is given in Table 1. The average weight of the sharks ranged 0.72 to 9.20 kg and most of the small sized sharks caught during August to December. In Bangladesh comparatively smaller sizes of sharks are caught by the fishermen.

Table 1. Monthly catches of sharks, % contribution and average weight*

Months	Landings (Mt)	% contribution	Numbers caught	% of total number	Avg. Wt (Kg)
January	72.2	18.7	25016	15.4	2.88
February	74.1	19.2	14607	8.9	5.07
March	48.1	12.5	27629	16.9	1.74
April	5.9	1.53	654	0.4	9.02
May	14.9	3.87	8547	5.2	1.74
June	81.9	21.3	11755	7.2	6.97
July	4.7	1.2	4294	2.6	1.09
August	4.5	1.15	6126	3.8	0.72
September	14.2	3.7	9075	5.6	1.56
October	11.2	2.9	10498	6.4	0.11
November	27.1	7.1	23895	14.7	1.13
December	35.8	9.3	20792	12.8	1.72

*****Adapted following the data of Roy *et al.* (2007)

2.9 The price of shark products and export earnings

The present market price of shark meat (raw) varies between Tk. 70 – 100/kg and shark oil between Tk. 45 – 55/kg (1US$ = 70Tk.). Market price of different type and size of shark's fins at Cox's Bazar is furnished in Table 2.

Table 2. Market price of different type and size of shark fins

Size of fin (cm)	Price/set raw fins (In Tk.)	Price/set salted dry fins (In Tk.)
5-10	20.00	800.00
10-15	60.00	1,600.00
15-20	150.00	2,500.00
20-25	400.00	8,000.00
25-38	8,000.00	8,000.00
38-45	9,000.00	8,500.00
45-50	12,000.00	10,500.00
Above 50	16,000.00	11,000.00

The trend of shark product export from Bangladesh and foreign exchange earnings is shown in Fig. 3.

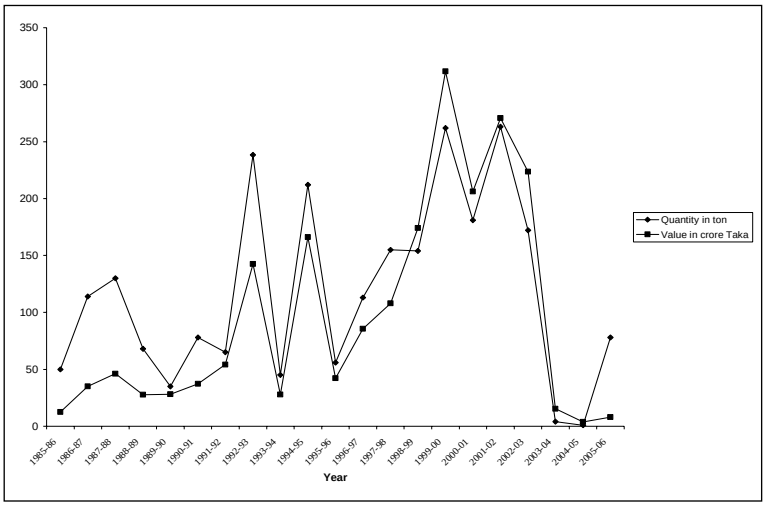

Fig. 3. Shark product export and foreign exchange earnings.

From the fig 3, it could be seen that the amount of shark product export from Bangladesh ranged 1.0 to 262 MT with an average of 100 MT during 1985/86 to 2006/07. The highest amount (262 MT) was exported during 1999/2000. The export earnings ranged between Tk. 80 to 3,110 million with an average of Tk. 850 million. The export earnings of shark products from Bangladesh are decreasing rapidly since the year 2003 – 04.

2.10 Species diversity of sharks in Bangladesh

As per FAO guideline (FAO 1984) the term shark includes all the species of sharks, skates, rays and chimeras (Class Chondrichthyes). In Bangladesh Hussain (1970), Quddus and Shafi (1983), IUCN (2000) and Roy *et. al.* 2007 discussed about the different species of sharks. The comparative number of different species of sharks, skates and ray found by different authors is presented in Table 3.

Table 3. Number of Shark, Ray and Skates reported by different authors

Author & Year	True Shark	Ray	Skates	Total
Hussain (1972)	-	-	-	56
Day (1978)	-	-	-	63
Quddus and Shafi (1983)	10	8	3	21
IUCN (2000)	35	18*	3*	56
Roy *et al. (*2007)	10	10	2	22

*Number to be confirmed further.

The number of species of sharks, skates as mentioned by the above authors varies. The highest number 63 was reported by Day 1981 followed by IUCN (2000). In the IUCN list, the Kala hangar *Carcharhinus limbatus* marked as vulnerable (VU) and Karat hangar *Pristis microndon* as endangered (EN) in the global status. Meanwhile, the scientific names of the different species has been changed and requires to be upgraded including publication of detail species profile in vernacular language for proper identification and management development of the fishery.

2.11. Trends of shark landings in BOBP-IGO countries

The trend of shark landings in the BOBP- IGO countries is shown in Fig 4. From the figure, it could be seen that the shark landings are decreasing rapidly in all the four member countries since, 2005. The sharks are highly migratory fishes. Thus for sustainable production of the fish in the region collaborative research and management initiative are required.

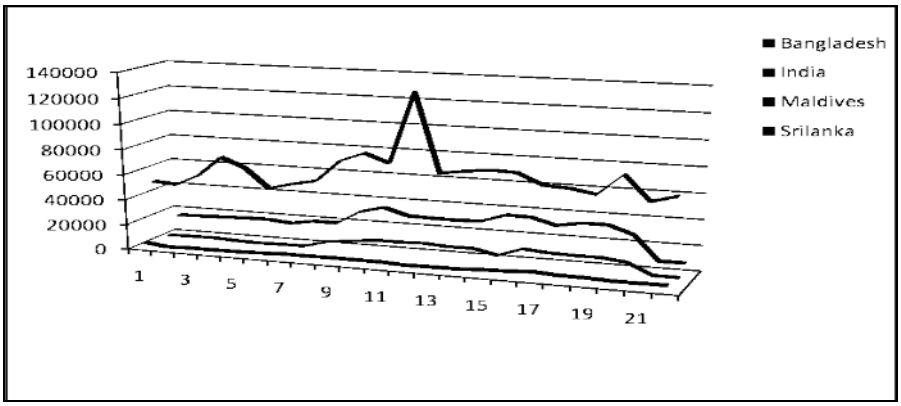

Fig 4. Trends of shark production in the BOBP-IGO countries.

3 Marine Fisheries Management Measures Proactive to Shark Fishery

So far, little initiative has been undertaken for the management conservation and development of shark in Bangladesh except ban of fishing in the Sundarban areas the under the Forest Conservation Act. But for the management of marine fisheries considerable management measures has been undertaken which are proactive to the shark fisheries. These are:

3.1 Limiting the fishing days for industrial trawlers

- Freezer trawlers are permitted to fish for 30 days.
- Non freezer trawlers are permitted to sail up to 15 days.

3.2 Measure to limit discard of by catch

- Shrimp trawlers must have at least 30% of fin fishes in the total catch.

3.3 Control of mesh size of different nets

- Mesh size of cod end of set bag net mandated at least 30 mm.
- Cod end of shrimp trawl nets mandatory to be 45 mm.
- Cod end of fish trawler net should be 60 mm.
- Mesh size of small meshed gill net should be 100 mm.
- Mesh size of large meshed gill net should be 200 mm.

3.4 Formulation of marine fish exploration guidelines for the industrial fishing fleet

- Formulated, publish to ensure proper exploitation of the fishery resources

3.5 Ban on throwing any fish into sea

- Government has restricted on throwing any catch of fish or any aquatic resources except turtle in the sea

3.5 Control of access to the fishing ground

In general, there is no control of access to the fishing ground for sharks except zone restriction, assurance of licenses and declaration of marine reserve for the marine fisheries resources.

3.6 Depth and area restriction

- Fish and shrimp trawlers are allowed to fish beyond 40m depth zone during high tide.
- Set bag net, hook, lines, small and large meshed gill net up to 40 m depth zone during high tide.

3.7 Restriction of industries trawlers license

- Government has restricted to issue of new licenses for any industrial trawler till proper survey of the EEZ are being done.

3.8 Encouragement to fish beyond 500m isobaths of EEZ

- Government has decided to encourage industrial fishing fleet to fish outside 500 m isobaths within EEZ in order to reduce pressure in the coastal fish population.

3.9 By-catch reduction, declaration of sanctuaries and closed season

For shark fisheries there is no sanctuaries or closed season and by catch reduction measures. But in general, the Government has declared four sanctuaries in the Bay of Bengal and four hilsa sanctuaries in the Lower Meghna river system.

4. Description of Prevailing State of the Shark Fishery and Constraints

The shark fishery bears significant potential to the economy and bio-essence of Bangladesh. But till date, not much cared. Thus no systematic research being carried out except a few sporadic studies on taxonomy and accordingly, important management initiatives not also undertaken. The prevailing state of the fishery and constraints towards sustainable management development is discussed below:

4.1 Shark stock and population

Till to date, stock assessment, population structure and biological studies are not being carried out in Bangladesh. Hence, the population parameters *viz*., the growth rate, mortality, exploitation rate, recruitment pattern, maximum sustainable yield and biomass including fishing effort, gear and mesh size selectivity etc. are not known. From the landing data of FRSS, it is seen that

the shark production is decreasing rapidly since 2002 – 2003. Recently 8 – 10 new shark targeted boats introduced in the fishery. Thus it assumed that the sharks are over exploited in Bangladesh.

4.2 Associated fisheries

Sharks are caught as by catch except the newly entered boats. The main catching nets and gears of sharks are the artisanal gill nets, large meshed gill net, ESBN, MSBN; trammel net, trawl nets and, hook and lines. The targeted species of small and large meshed gill nets are hilsa and Indian salmon respectively. ESBN and MSBN caught all the species those enter into the cod end. Thus it could be concluded that almost all the major fisheries are associated with shark. Detail investigation is required to specify the percent composition and contribution of catch by gear and net type used for shark catches.

4.3 Availability of data on catches efforts and landings of sharks

In FRSS catch assessment data, species diversity, % contribution of different species, changes in landing pattern etc. are absent. Likely, catch effort, exploitation level, vulnerability of the species, stock position and harvestable biomass etc. are also not available. For sustainable management and development of the fishery detail information on the above aspects are required.

4.4 Difficulties in species identification

The key features of identification of sharks are nostril, gill slits, spiracle, mouth position and various lengths and inter fins distances etc and different species of shark and rays are very similar to look at. So far standard and easy system for identification of different species not established. The local name of sharks varies from place to place and difficult to identify the different species at field level. Meanwhile, the scientific name and generic status of the sharks changed considerably by the Interventional Nomenclature and Fish-base authority since the pioneer work of Day (1981) and Quddus and Shafi (1983). Thus valid scientific name, standard local name with detail pictorial

species profile in vernacular language is required to develop for sustainable management, development and conservation of the fishes.

4.5 Insufficient biological and environmental data

Information on detail biology, abundance, distribution, migration pattern of sharks are very limited. Bangladesh being a deltaic country, the coastal and offshore region is changing continuously. Due to rapid industrialization and urbanization the coastal water is also polluting. The probable impact of climate changes on the fishery is not known. Thus for sustainable management and development of the fishery, knowledge on biology, stock assessment and probable impact of environmental and habitat changes are required.

4.6 Regional coordination

Regional coordination between the Bay of Bengal countries yet are limited particularly to the scientific research, data and information exchange. The sharks are highly migratory and high sea stock fish and become increasingly important both in domestic and international markets. As such significant amount of shark products are straddled through the trans-boundary movement from Bangladesh to neighboring in the recent years. The information on trans-boundary straddling of shark products is absent or scanty among the Bay of Bengal countries. To collect information on trans-boundary migration and straddling cooperation and linkages between the Bay of Bengal countries are urgently required.

5. Management Framework of the Shark Fishery

Absence of MCS and illegal, unreported and unregulated fishing causes both recruitment and growth over fishing of sharks in Bangladesh. Moreover, data and information about the fishery is very limited. Thus, foremost priority of management of the fishery should be accumulation of data and information and development of National Plan of Action (NPOA). Primarily the following management frame is thought for the development of the fishery (Table 4).

Table 4. Management Frame of Shark Fishery for Bangladesh

Sl. No.	Management issues	Address to the management issues	Implementing organization	Resource
1	Absence of adequate information and data about fishery and NPOA- Shark	Collection of data and information and formulation of draft NPOA- Shark	BFRI & DoF	BOBP-IGO
2	Finalization of draft NPOA- Shark	National workshop / Third RC-SF meeting	BOBP-IGO	-Do-
3	Mainstreaming and implementation of NPOA- Shark	Workshop, seminars, training	BFRI & DoF	-Do-
4	Assessment of impact of implementation of NPOA-Shark	DPP or TAPP under core/ donor assistance research programme	BFRI & IMSF	Govt. or Donor agencies
5	BOBP- IGO countries collaboration & cooperation	Signing of MOU & implementation of collaborative research	BOBP-IGO countries	BOBP-IGO/ SAARC forum

6. Contents of National Plan of Action for the Shark Fishery

6.1 Objective of the NPOA-Shark

The overall objective of the NPOA shark is the sustainable production and use, and conservation of species diversity through development and implementation of national plan of action.

6.2 Technical guidance of shark plan

The technical guidance required for development of management and implementations of the shark plan are as bellow:

6.2.1 Monitoring

In Bangladesh only catch or landing data are collected from some selected sample villages by the FRSS, DoF. Overall catch monitoring system is not

mainstreamed or not followed by DoF while at data collection. To improve catch monitoring system following measures could be undertaken:

- Mainstreaming of catch monitoring system into FRSS, DoF;
- Capacity building of resource survey official, FRSS, DoF;
- Awareness building of fishers, boat owners to allow data collection; and
- Registration and licensing of the boat, gear and vessels and compulsion of log book keeping by the boat/gear/vessel owner.

6.2 .2 Data collection and analysis

The Resource Survey Officer (RSO) capability is very limited for data collection, analysis and interpretation and awareness among the fishers, boat or vessel owners is poor.

6. 2. 3 Research

Marine Fisheries & Technology Station (MFTS) of BFRI is designated for marine research of Bangladesh. The Institute of Marine Science & Fisheries under Chittagong University is responsible for education. Without research and scientific background the shark fisheries could not be developed and managed well. Thus the following actions could be undertaken for development management of sharks in Bangladesh:

- The detail species profile of the shark should be established with valid scientific and local names and determination of status in IUCN list of the threatened fishes;
- Assessment of trends of catches, landing, % composition and contribution, landing seasons, area etc;
- Assessment of nets and gears used for shark harvest, by catch assessment, mesh size and gears selectivity studies;
- Abundance and distribution (spatial, horizontal & vertical) of shark fishes;
- Biology including breeding & nursery grounds and migration/movement pattern, schooling etc:
- Predation rate of different size and age group of sharks ,prays and predator relationship;

- Development of marketing channel, export and assessment of trans-boundary straddling.

6.2.4 Implementation of management measure

The shark fisheries play an important role to the economy and export earnings of Bangladesh ranging Tk. 10.0 to 260.0 million. The estimated value of present shark production is about Tk. 500 million (@ Tk. 100/kg). But very little attention is provided to the fishery. Thus the Government should allocate funds for implementation of development and research activities. Some technical assistance and logistic support by the donor agencies could expedite implementation of shark management plan.

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5

Towards a collective action to meet the growing challenges of resource management and livelihoods of small scale fishers in the Bay of Bengal

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1. Resources and contribution

Bangladesh is lying in the delta of Ganges and Brahmaputra between the Hamalayan mountain and Bay of Bengal. Situated in the deltaic region and bounded in the south by the Bay of Bengal with a coastline of 714 km and an Exclusive Economic Zone (EEZ) of 164,000 km^2 of which the continental shelf takes up 44 percent. The country has a vast river network and a dynamic estuarine ecosystem. The coastal zone includes coastal plains, islands, tidal flats, estuaries and neritic and offshore waters. It houses several natural mangrove forest ecosystems including the Sunderbans that supports a rich diversified aquatic biota with breeding and nursing habitat of many marine and brackishwater species. Because of the tide and current pattern, the BoB has a peculiar wave action and remains very rough between May to August.

Presented in the 4th TAC meeting of BOBP-IGO. Organized by BOBP-IGO. 22-23 April 2009. Dhaka, Bangladesh.

The small-scale fishery has been passed on from generation to generation in the coastal waters which extend up to 200 m depth from the base line and cover an area of 55,400 km^2. The fisherman depends on fishing for their livelihood. With the rapid increase in fisherfolk population, fishing in coastal area has become difficult because of low catches and fishing rights conflicts. Fishermen are now opting to fish away from the coast. The marine sector of Bangladesh also offers additional 2.5 MT of raw salt production from the coastal traditional salt beds where approximate 0.04 m workers engaged themselves.

2. Issues and Problems of BoB Ecosystem

Two most important issues of the BoB related with resource management and livelihood are :

- Endangering marine habitats and ecosystem
- Natural disaster and climatic changes

2.1 Causes of habitat and ecosystem degradation

Marine habitats of Bangladesh are comprises of estuaries, mangroves, coral reefs, beaches, islands and offshore waters. In Bangladesh, national experts, development planners and government authorities first became conscious of the danger to the marine environment in 1979, when a national seminar on "Protection of the Marine Environment and the Related Ecosystem" was held in Dhaka under the joint sponsorship of UN/ESCAP, the Swedish Environment Protection Service (SEPS) and the then National Department of Environmental Pollution Central (at present Department of Environment). The causes of ecosystem and habitat degradation are:

- Flood control and drainage irrigation (FCDI) activities
- Construction of coastal embankment to protect land from saline water
- Destruction of mangrove-forests
- Pollution, siltation and geo-morphological changes etc.

2.2 Habitat destruction: The Sundarbans mangrove

- The Sundarbans– the immense tidal mangrove forest of Bangladesh is place where the mainland of Bangladesh meets the Bay of Bengal, making the area globally unique ecologically niche (IUCN 1994).
- The Sundarbans, the largest continuous mangrove forest in the world is located at the extremity of the Ganges river delta, i.e. the plain bordering the northern margin of the Bay of Bengal.
- The natural mangrove of Bangladesh include this Sundarbans and the Chakoria Sundarbans.

Because lack of proper conservation measures and policy guidelines on Sundarbans ecosystem, the forest become under serious threat of over-exploitation and where most of the causes are anthropogenic. Root causes of destruction of the mangrove habitat and its resources:

- Over exploitation of forest resources (beyond recovery)
- Human Settlements
- Indiscriminate fishing
- Expansion of commercial shrimp fishery
- Pollution by agro-chemicals, industrial effluence, oil pollution
- Salinization due to reduction in freshwater flow
- Effect of sea level rise etc.

2.3 Pollution

There are several sources of marine pollution in Bangladesh those can be broadly placed under two categories— land based pollution and sea based pollution.

2.3.1 Land based pollution

a. Municipal wastes: Recent estimate shows that about 150 tons of wastes are generated in Khulna city and 480 tons wastes generated daily in Chittagong

city– those directly or indirectly falls into the Bay of Bengal. Moreover, medical water from hospitals are sharps, pathological wastes, radio active wastes, genotoxic and cytotoxic wastes chemical wastes (daily deposition rate is about 3,000 kg).

b. Industrial pollution: The country has emerged as one of the most polluting countries due to unplanned and uncontrolled industrial management practices and discharge of untreated effluents. Bangladesh has a total of about 3,000 industrial units of which 1,500 are polluting industries under 13 categories Insoluble in-organics of those industrial pollution are:

- Mercury, lead, chromium, cadmium, Si, Al, Fe, Ca, Mg etc.
- Estimated pollution load of Bay of Bengal due to pesticide during 2006-07 is 6,020 MT which is $1/4^{th}$ of total pesticides use in the year.
- High BOD due to industrial pollution indicates oxygen depletion, endangering fish and aquatic species, de-oxygenation induced by toxic wastes is taking place in the sea.

c. Ship breaking activities: Ship breaking activities in Bangladesh began in 1969 and have increased after 1980 to meet the growing demand for scrap as raw materials for re-rolling mills and other purposes. Today there are about 250 entrepreneurs engaged in this business. Some impacts of ship breaking on physico-chemical properties of soil-water and fish are :

- Accumulation of metal fragments form deep layer in soil of affected areas.
- Higher iron content with thin layer of bruned oil and lubricants prevailed in soil and water.
- Accelerated the rate of see-shore erosion resulted higher sea water turbidity.
- Critical concentration of DO and higher BOD with an abundance of floating materials.
- Oil spillage cause serious damage to fish by reducing light intensity underneath the oil layer, inhibiting photosynthesis and reducing the exchange of oxygen and carbon dioxide across the air-sea interface as well as by acute toxicity.

- Growth and abundance of marine organisms is affected significantly by the high ammonia content.

2.3.2 Sea based pollution

a. Oil pollution: It is a potential threat to the coastal and marine environment. Results mainly from the crude oil transplantation systems, water-oil from ships and mechanized vessels, workshop refinery handling loss, dumping of ballast and bilge water etc. Besides this, in Bangladesh more than 50% of the marine oil pollution comes from urban activities and through river run off (UNEP 1986). According to UNEP (1986) crude oil and its derivatives are the worst pollutants that enter the coastal areas owing to crude oil transportation operation in and amount the ports of Bangladesh.

b. Persistent Organic Pollutants (PoPs): Since POPs are persistent chemicals, Bangladesh coastal wastes is likely to receive water born residues of pesticides and insecticides sprayed upstream, within as well as outside the territory of Bangladesh through a number of ways like evaporation, precipitation and run washing (Hossain 2003).

- An increasing global concern about the fate of POP's particularly; Organo Chlorine Pesticides (OCPs) and Poly Chlorinated biphenyl's (PCBs).
- Introduce into the marine ecosystem through drainage, evaporation and precipitation.
- Number of pesticides for agriculture use in about 350 MT (2007) and more than 100 of them are dangerous for public health in Bangladesh.
- It is assumed that at least 25% of the total amount of pesticide used in Bangladesh may reach the coastal water flowing through inland water distribution system.

2.4 Natural disaster

Bangladesh as a disaster prone country, so far more than one million people have been killed by cyclone since 1820. With the consequences of global warming and sea level rise the frequency of occurrence and threat, as well, has

increased to considerable label. The phonograph morphology and other natural condition have made her vulnerable to disaster and environment hazards (e.g. The magnitude of economic loss of 1991 cycle was of the order of 10 billion Taka and that of 1988 was 65 billion while the loss due to SIDR during 2007 was more than 150 billion). The major forms of disaster in Bangladesh are highlighted below:

- Normally about 18 percent or 26,000 sq.km. of geographical area of the country flooded each year, the inundated area during several floods may exceeds 36% or 52,000 sq.km. (about 60% of net cultivable area). The volume is 85% of total inflow.
- During flood period rainfall generates about 18,400 Mm^3 stream flow inside the country and all this water finally fall into the Bay of Bengal (MPO 1987).
- The coastal areas have been ravaged by tropical cyclones associated with tidal surge almost every year particularly in the pre-monsoon and post-monsoon month.
- Between the year 1900 to 2008, 62 damaging cyclones were reported.
- Land erosion in coastal river, sea wave and tide have significant socio-economic and environmental impact in Bangladesh.
- During the monsoon, the GBM system carry about 1.9 billion tons of silt per year causing sever turbulence in the rivers results in gradual undercutting of river banks.

2.5 Global warming and sea level rise

The concentration of greenhouse gases, such as carbon-di-oxide, methane and nitrous oxide in the atmosphere have been increasing steadily. If apparent that this increasing are due to human activities like, fossil fuel use, change in land use and agriculture. Ultimate impacts of global warming are:

- It is a scientific concern that much increase in greenhouse gas concentration should cause global warming which is responsible for sea level use (BUP 1993).

- According to BUP (1993), over the last 100 yrs, the broad region encompassing Bangladesh has warmed up by about 0.5^0C and 0.5 m rise in sea level in the Bay of Bengal.
- Persistent increase will be a rise in mean sea level as a result of thermal expansion of the upper layer of the Ocean. "It has been estimated that sea level is rising at the rate of about 1mm per year globally and this situation may give rise to a total rise of 60 cm by the year 2050 (BAPA 2001).
- Predicted loss of mangrove forests in Bangladesh by 50 – 79% by the year 2050 and 75 – 96% by the year 2100 (WHOI 1986).
- Due to 1 m sea level rise 64,000 hectare agricultural land may go under water (BCAS 1994).

Information regarding the extend of sea level rise in Bangladesh is very meager. However 5.2 mm/year of sea level rise is found in the south-western Khulna region of Bangladesh (BUP 1993) and may rise of 8.5 cm in this region by the year 2050.

3. Sustainable Management and Livelihood Approach

Other than the issues and problems of BoB discussed in the earlier chapters, there are many vital issues related to sustainable management of marine ecosystem resources and livelihood of fishers. Bangladesh is lacking behind in most of the management areas. This is because there is acute problem of planning at the top management level, lack of due emphasis, shortage of funding, inadequate effort, facilities and organizational set up. The main issues related to sustainable management and livelihood approach are:

- Institutional capacity building to enhance research and development activities.
- Feasibility survey (assessment) of inshore and offshore fishery resources to explore under exploited fishes (mackerel, tuna, etc.).
- Develop community based integrated management policy for artisinal fisheries.
- Determination of maximum sustainable yield for different species of fish.

- Coordinated research on oceanography, stock assessment, experimental fishing, survey of fishing, spawning and nursery grounds with the participation of all stakeholder.
- Banning on destructive fishing gears and development of environment friendly sustainable fishing mechanisms.
- Development of breeding and culture technology of important eurohaline fish species.
- Ensured utilization of underutilized and unutilized discard species and other valuable items (like sea weed, shell, ornamental species).
- Appropriate plan for management of shared stock and ecosystem.
- Consequence of global warming and sea level rise and its impact on food security and livelihood of millions of coastal fishers.

4. The National Fishery Policy'98 versus Marine Fisheries

According to the National Fisheries Policy adopted in 1998, marine fisheries sector has set out certain policies for the development of the sector. Unfortunately no initiative has yet been taken to formulate and implement the required regulatory and supportive policies. Policies under each are briefly as follows:

4.1 Policy on marine fisheries

Outlined policy on marine fisheries are:

- Conduct surveys on marine resources assessment and extend the information to marine resource exploiters.
- Utilization of trash fish.
- Provide alternate employment for fishermen during fishing holiday.
- Regulate industrial and artisanal fishery to reduce over-fishing for sustainable production.
- Strengthen research for marine fisheries development.
- Prevent indiscriminate exploitation of marine fish.

- Control marine pollution by preventing dumping of harmful chemicals and radioactive materials in the sea.

4.2 Policy on coastal and marine environment

Outlined policy on coastal and marine environment are:

- Ensure environmentally sound conservation and development of coastal and marine eco-systems and resources.
- Prevent all internal and external activities polluting the coastal and marine areas. Strengthening necessary research to preserve and develop coastal and marine environment and resources.
- Coastal and marine fish catch within tolerable limit (regeneration/re-spawning limits).

5. BOBP-IGO initiatives for Bangladesh

As per BOB-IGO activity report (Oct.'05 – Dec.'06), no specific activity was included in the agreed work plan for Bangladesh. In the following year, FAO/BOBP-IGO consultant was deployed to prepare a report on status of safety measures deployed in fishing boats and implementation of standards and regulations to safeguard the safely and health of small scale fishers.

As per activities report of April'07 – Marh'08), it is evolved that like other member countries Bangladesh has been receiving benefits of the south Asian component of he global project on "Safety at Sea for small Scale Fishers" (implemented by FAO-UN through BOBP-IGO from May'07). Under this project a national workshop was organized in Chittagong, Bangladesh on January 21 – 22, 2008. The workshop identifies information, service and policy gaps regarding sea safety issues and following that an action plan for pilot scale implementation was designed where Cox'zBazar of Bangladesh is included as an area of implementation. A first hand assessment on the performance was also done by FAO fishery expert during later part of January'08 covering some selected coastal areas of the southern districts like Ptuakhali, Kuakata, Barisal etc. The main objective of this visit was to assess

the fishing boats with respect to their construction, availability of communication and safety equipments and preparedness of the crew in safety aspects. Recently (mid April'09) the 2nd workshop on safety at sea held in Chittagong, Bangladesh.

Besides that a regional workshop on "Monitoring, Controlling an Surveillance (RW-MCS) for Marine Fisheries of the Bay of Bengal" was held at Chittagong on January' 08 and based on the views and comments of the reports of the member countries the workshop adopted the "Chittagong Resolution" which is a significant outcome of the workshop.

As per proposal of Bangladesh and under the agreed activities of BOBP-IGOs first TAC meeting, a consultation meeting was organized for Hilsa Fishery Management during mid March'08. The meeting come out with recommendation to initiate the preparation of a Management Plan for Hilsa Fishery covering Bangladesh and India. Subject to the concurrence of the GoB a follow up meeting on preparation of management plan for hilsa fishery is expected to be held in Bangladesh within short time.

5.1 Proposed issues of Bangladesh raised in previous TAC meetings

To find a common concept based on broad-based regional initiative and experiences that can be adopted to suit local situations to achieve the goal of managing fisheries resources in a sustainable way, during the last two TAC's held in Chennai, India and Colombo, Sri Lanka, Bangladesh raised the following priority matters for their inclusion in the agreed activity list of BOBP-IGO. These are:

- Preparation of directory of scientists of relevant subject and organization of the member countries.
- Joint effort for stock assessment of commercially important species;
- Maintenance of ecological balance;
- Conservation of biodiversity;
- Prevention of habitat destruction;
- Mari-culture of commercially important species;

- Control and prevention of shrimp disease;
- Improvement of research capabilities;
- Development of trained man power;
- Exchange of technical know-how among the member countries; and
- Joint management plan for hilsa fishery resources.

Keeping in consideration of the above matter, Bangladesh placed its future priorities in the 3rd TAC meeting on the following areas:

- Increase in member countries by including other littoral countries;
- Demarcation of EEZ of the member countries;
- Establishment of information network;
- Develop a fish data base;
- Establishment of strong MCS system;
- Development of calendar indicating species-wise no fishing period for selective common marine species of member countries and establishment of marine park;
- Conservation and restoration of marine habitats;
- Regional cooperation on weather forecast system;
- Provision for technological support
- Raising of common fund for sea safety implication;
- Banning on shrimp seed collection from coastal waters and use of ESBN;
- Training of cost guards etc.

5.2 SaS and MCS program in Bangladesh

In the Bay of Bengal Bangladesh, region three quarter of a year prevails rough weather condition where safety at sea particularly for coastal and marine fisher folks are an important issue of consideration. Loss of boats and gears and death of fishers are very common. A number of rules related to fishers safety and seaworthiness of fishing vessels are being implemented by Mercantile Marine Department (MMD) of Bangladesh. The Bangladesh Fishing Vessel Equipment Rules 2005 are a part of the Bangladesh Mercantile Shipping Ordinance, 1983.

The DoF is primarily responsible for managing marine fisheries resources. They generally issued license to those boats having registration certificates from the MMD. The Marine Fisheries Ordinance1983 and subsequent rules address issues like fishing effort and mesh size control, closed season, marine parks and sanctuaries, zoning of the fishing areas. But the ordinance does not exercise any matter relating to safety of fishers at sea.

Artisanal fishing operations of the estuaries and coastal waters used to be carried out by traditional crafts until the mid-1960's. The process of mechanization was started in Bangladesh during 1966 through Bangladesh Fisheries Development Corporation and the Bangladesh *Jatio Matshayjibi Samabay Samaity* with importation and introduction of marine engines.

There are three types of traditional boats like Dingi, Chandi and Balam. Based on the type, length of boat varies from 6 – 20 m and these are mainly used for ESBN and gill nets. Mechanized boats are operated by 9 – 47 HP engine with 6 – 10 crew on boat. Gross tonnage of he boats are 7 – 8 tons per trip (4 – 7 days). The gear mostly used with these boats are drift gillnets, *behundi* nets (MSBN) and long lines.

Artisanal fishing gear include those operated by mechanized, motorized and country boats. There are five different types of gill nets, three types of set beg nets, trammel net, bottom long line, beach seine and shrimp seed collecting gears. The ESBN are the most widely used and widely distributed artisanal fishing gear in Bangladesh like other neighbor countries.

6. Priority Issues of Bangladesh

Marin sector management related issues and problems are complex and in most of the cases, to get benefit, it is better to find out the way how to co-exist with rather to take any mitigation measure. The burning example is global warming and sea level rise issues. On the other hand, marine fisheries resource management and livelihood activities to a greater extend can be addressed through local legislation/acts and their strict implementation, by

developing suitable organizational set up with adequate trained and skilled manpower and well equipped facilities, and empowering coastal people to achieve the collective goals through social, educational, economic and political functions. However, BoB as a common property, to manage some of the issues and to improve the livelihood of million of fishers around the coast and their safety at sea, intergovernmental organizations like BOBP and similar other organizations has been playing vital role. On behalf of Bangladesh, a number of such issues were proposed and many of them taken under the activity list and where BOBP has been working on some issues like regional hilsa fishery management plan preparation, sea safety awareness activities and strengthening MCS activities through awareness and capacity building. In the present priority proposals, repetition of a number of issues are made with some new inclusions. Working nature and limitations of BOBP were also taken into consideration while preparing the list. The priority proposals of Bangladesh (for discussion in the 4th TAC meeting of BOBP-IGO) are presented in the following lists:

6.1 Strategic measure to co-exist with climates change and sea level rise

With global warming and as consequences of sea level rise water character, circulation pattern and dynamic features of ocean are likely to be affected along with effect on breeding behavior and life cycle of many species where no fruitful attempt can be made to mitigate the problems locally or regionally. Sea level rise due to global warming will cause change in economic activities of coastal dwellers along with erosion of shoreline, damaging house holds and livelihoods. A regional strategic plan particularly for the vulnerable countries need immediate attention so that the effected population can co-exist with this sorts of changes with all economic and livelihood activities.

6.2 Hilsa fishery management

As a transboundary issue, regional plan for hilsa fishery management activity need to be finalized immediately. In the preparation and implementation of the management plan, countries like Bangladesh, India and Myanmar can work jointly. Inter Govt. co-operation and responsibility should determined

specifically. Decision taken for involving Bangladesh and India in the previous TAC meeting may be amended by involving Myanmar as new member.

6.3 Stock assessment of marine fish species

For appropriate management of marine fishery resource, species wise stock size and this feeding and breeding behavior, migration and biology and population parameters of important stocks need to be assessed. Bangladesh is lacking behind in this respect. A regional effort in this aspect may help to prepare plan of management of marine fish resources. Existing legislation/acts may further be reviewed and updated under this attempts. This proposal was also raised in the 1st TAC meeting of BOBP-IGO where joint assessment of fish stocks through collaborative and participatory arrangements among member countries was proposed.

6.4 Institutional linkage develop and capacity building

Institutional linkage and information flow are of important techniques for bridging knowledge gap. In Bangladesh, measure for marine resource management and sea safety for coastal artisanal and small scale fishers are very weak and not well organized. To strengthen all these, institutional linkage and information flow along with awareness and capacity building program both for short and long term interventions are necessary.

6.5 Alternative livelihood for income generation and food security

Bangladesh is less experienced in mariculture. Having enormous culture potential species, application of those technologies can pave greater contribution for establishing food security, income generation. Employment opportunity during off seasons and nutritional contribution will also increase. Bangladesh can get technical assistance in this aspect through BOBP from other member/practicing countries. Commercial important sea weeds, pearl oyster, clams, lobster, mussel and crab culture can considered as important areas.

6.6 Strengthening capacity of BOBP-IGO

Marine resource management becoming a challenging job, where every year after new issues and threats are emerging. To deal with all these priority issues, BOBP would have to increase its man power particularly by including subject matter specialists, technologists and secretarial staffs, as well. Increased amount of fund from the member countries and financial assistance from the donor agencies may provide additional support. Other then the focal point and the TAC member, an unit of BOBP-IGO may be established in each country. The unit will be responsible for implementing recommendations as per work plan of BOBP-IGO under the control of HQ and this will serve as net work center for information flow and sharing of knowledge.

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Marine and coastal resources of Bangladesh: BOBLME project implication

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1. Introduction

The Bay of Bengal, the marine area of Bangladesh is characterized by a semi-enclosed tropical basin. The coastline of the country comprises about 710 km extending from the tip of Teknaf in the south-east to the south-west coast of Satkhira (Fig. 1). As a result, along with 710 km coast line an area more than 166,000 km^2 falls under economic jurisdiction of Bangladesh for exploration, exploitation, conservation and management of its marine resources. The country's shelf area covers roughly 66,000 km^2 and coastal waters are very shallow with less than 10 m depth covering about 24,000 km^2. The entire shelf area of Bangladesh (up to 200 m depth contour) covers about 70,000 km^2.

The marine capture fisheries of Bangladesh consist of complex and multi-species resources. This sector contributes about 19% of the total fish

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production (2.56 million tons) of Bangladesh. The marine fisheries sector of Bangladesh is divided into two sub-sectors- industrial and artisanal. The average of last ten years' production shows that the industrial fishery based on trawl fishery (shrimp trawl and fish trawl) contributes only 6.6% of the total marine production and the artisanal small scale fisheries contributes 93.4% of the total marine landing (Table 1). There is lacking of data on sustainable harvest of marine fisheries resources. Besides, due to poor socioeconomic conditions and lack of alternate income source of fisher folk, maintaining sustainable harvest of resources has become very difficult.

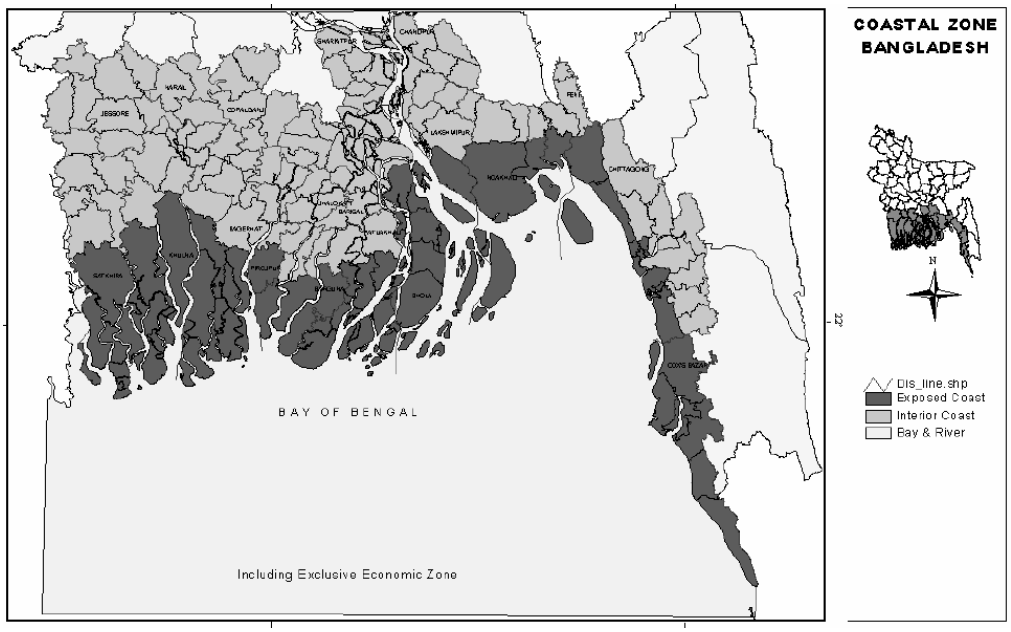

Fig. 1. Marine & coastal zone of Bangladesh.

Management of coastal fisheries in Bangladesh has focused predominantly on industrial trawler fleets, with limited attention being paid to other sectors. This has led to uncontrolled expansion of fishing effort, which has put forward the sector in crisis. Artisanal fishing has already become non-remunerative. The poor fishers are putting more and more nets of fine mesh to survive, which exerts excessive pressure on the fish stocks and increasingly catching less

valued and under-sized fish and as a result fish stocks are declining at an alarming rate.

Table 1. Production (MT) fish from the marine water Bangladesh

Year	Industrial	Artisanal	Total
1998-1999	15,818 (5.11)	293,979 (94.89)	309,797
1999-2000	16,304 (4.88)	317,495 (95.12)	333,799
2000-2001	23,901 (6.30)	344,596 (93.70)	379,497
2001-2002	25,165 (6.06)	390,255 (93.94)	415,420
2002-2003	27,954 (6.47)	403,954 (93.53)	431,908
2003-2004	32,606 (7.16)	422,601 (92.84)	455,207
2004-2005	34,114 (7.18)	440,483 (92.81)	474,597
2005-2006	34,084 (7.10)	445,726 (92.90)	479,810
2006-2007	35,391 (7.26)	452,047 (92.74)	487,438
2007-2008	34,159 (6.87)	463,414 (93.13)	497,573
Average	26,061 (6.59)	376,868 (93.42)	404,029

*The figures in parenthesis indicate percent of total

The declining CPUE (650 kg/ day/ boat in 2001-2002 to under 100 kg/ day/ boat in 2005 – 2006) from small mesh gillnet vessels targeting hilsa, skipjack tuna and mackerel is also alarming. One target species of the large mesh gillnet– the Indian salmon (*Polynemus indicus*)– is now almost extinct in Bangladesh waters. Whilst these nets are reasonably selective, the number of fishers has expanded considerably from 6,389 in the late 1980s to 26,169 in 2000, yet the annual catch per vessel dropped from 41 t to 7 t over the same period (Banks 2003). The catch rate from marine set bag nets has also dropped from 85 kg/haul in 1985 to 24 kg/haul by 2002 – 2004. Meanwhile the number of units expanded from 3,086 to 21,000 units (WorldFish Center 2007).

2. Management and Development Issues

Khan (2009) highlighted the following issues for the sustainable management and development of Bay of Bengal fish and fisheries.

2.1 Outdated fisheries management, regulation and rules

Since the adoption of the Marine Fisheries Ordinance in 1983, there has been little real change in the fisheries management regime, either in terms of the technical measures adopted nor the rules and regulations being applied. This situation has been further complicated by the resistance of different fishing association on a number of occasions.

2.2 Low level of monitoring, control and surveillance

The ability of Department of Fisheries (DoF) to enforce fisheries regulations is limited by the geographic isolation of many coastal fishing communities, a lack of physical assets such as patrol boats and a chronic shortage of trained manpower. The 2006 Marine Fisheries Sector Sub-strategy addresses many of these issues, and the 1998 National Fisheries Policy (NFP) is soon to be updated.

2.3 Fisheries and ecosystem management

The objectives of the NFP are to enhance fisheries production and achieve economic growth through earning foreign currency, although there is recognition of the need to "maintain ecological balance". These need to be updated to include a wider ecosystem approach and reflect the recently approved objective of the Marine Fisheries Sector Sub-Strategy (DoF 2006).

2.4 Resource allocation and access rights

The Marine Fisheries Sector Sub-Strategy emphasizes that a priority issue is to clarify whether fisheries resources should be used to maximize sustainable production or to provide employment and a sustainable livelihood to the largest number of resource poor people. This suggests that access rights for the artisanal sector in particular to be safeguarded through appropriate

management mechanisms, as well as the productive gillnet and emerging long line métiers, both of which operate at relatively small-scale but operate further offshore than the artisanal fisheries. It then presupposes that large-scale, industrial techniques *e.g*. trawling, purse seining should only be permitted if there is a sufficient and independent portion of the resource remaining in the sector.

2.5 Co-management of small-scale fisheries

One of the challenges to marine capture fisheries management is the potential contribution of decentralized co-management, especially for the small-scale fisheries elements of the sector. Community-based management has proved to be successful in the inland fisheries of Bangladesh and both regional and international experience suggests that such models could be adapted for their application in the coastal fisheries. This has been proved during implementation of the ECFC (FAO) project. Attempts are needed to develop and institutionalize the community-based fisheries management model (CBFM 2 Project of DoF/ WorldFish).

2.6 Fisheries research

Whilst the precautionary principle suggests a conservative approach to fisheries management in the absence of scientific information, targeted research should be conducted to ratify and refine decision-making as further information becomes available. Data compilation needs suitable for the recurrent, regular monitoring of the impact of fisheries on target stocks, dependant stocks and ecosystem components needs to be integrated into the upgraded Fisheries Resource Survey System (FRSS, DoF) statistical system. In particular, robust information on by catch, discards and waste need to be collected on a regular and systematic basis in this area.

3. Changes to legal instruments, policies, strategies, and plans, related to fisheries, environment, and coastal and marine resources

A good number of legislative instruments are in force in Bangladesh, which support marine fisheries directly or indirectly. These are the ordinances, Acts

or Rules published officially through various Ministries of Bangladesh Government over the decades. Some of the key legislations are described below:

3.1 The Marine Fisheries Ordinance, 1983

The base law and regulatory instrument for marine fisheries is the Ordinance of 1983. The Marine Fisheries Ordinance, 1983 covers the territorial waters and economic zone of Bangladesh as declared by the Government under the Territorial Waters and Maritime Zones Act, 1974, and any other marine waters over which it has, or claims to have, jurisdiction under law with respect to the management, conservation and development of the marine living resources. This law has authorized the Government to specify the types, classes and number of fishing vessels that can be deployed in Bangladesh waters having in regard to the requirement of fisheries management and development plans. Under Section 28 of the Ordinance the Government may declare any area of Bangladesh waters and an adjacent or surrounding land to be a marine reserve.

3.2 The Marine Fisheries Rules, 1983

The Marine Fisheries Ordinance, 1983 is applied through rules enacted in the same year as Marine Fisheries Rules, 1983 and amended in 1993. They regulate the issuance and conditions of fishing licenses for national and foreign fishing vessels, determining license conditions, allowed fishing gear, mesh size, etc. Licenses, unless determined otherwise in an individual license, shall expire on 31 December of the year of issuance. Allowed fishing areas are determined according to type of fishing gear used, for example, for fishing with set bag nets, up to 40 meters depth in marine waters at the high tide.

3.3 Key management measures related to fisheries in Bay of Bengal

- **Limiting the fishing days for industrial trawlers:** The freezer trawlers are permitted to fish for 30 days while non-freezer trawlers are permitted to sail for up to 15 days.

- **Measure to limit discard of bi-catch:** Shrimp trawlers must have at least 30 percent fish in the total catch. This measure was enforced in order to limit the discard of by-catch.
- **Control of mesh size:** Mandatory 45 mm mesh size at the cod end for the shrimp trawl nets has been enforced to facilitate the escape of small size fish, shrimp and the juveniles of larger fish. Since 2003, high profile drive against catching of jatka (hilsa fry) by small mesh nets called "Current Jaal" is ongoing during the period February to May every year.
- **Depth zone restriction of 40 m:** There are provisions for restricting shrimp and fish trawling within the 40 m depth zone to protect the nursery grounds of marine fish and shrimp and preserve the interest of artisanal fishers.
- **Declaration of hilsa sanctuary:** Four sites in the coastal area have been established as hilsa sanctuaries, where fishing is banned from 15 - 24 October every year during peak hilsa spawning season.
- **Restrictions on industrial trawler license:** Govt. has restricted the issue of fresh license for any industrial trawler till proper survey of the EEZ is being carried out.
- **Encouragement to fish beyond 500 m isobaths of EEZ:** Govt. has decided to encourage industrial fishing fleet to fish outside 500 m isobaths within EEZ, in order to reduce pressure in the coastal fish population.
- **Restriction on post larvae collection:** Govt. has restricted post larvae collection in coastal areas in 2000, which was later reinforced in 2002.
- **Ban on throwing any fish into the sea:** Govt. has imposed restriction on throwing any catch of fish or aquatic resource except turtle in the sea
- **Declaration of marine reserve:** Govt. has declared Middle Ground and South Patches in the Bay of Bengal as marine reserve.

3.4 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 appears 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 Forests (MoEF) declared seven areas as ecologically critical areas having effect in marine fisheries like Sundarbans, Cox's Bazar-Teknaf

sea beach, St. Martin's Island, Shonadia Island. Later Sundarbans was withdrawn from the list and instead outside of Sundarbans Reserve Forest a 10 km extent was declared as ECA.

3.5 Other key legal instruments / policies

- **The Territorial Waters and Maritime Zones Act, 1974 and the Territorial Waters and Maritime Zones Rules, 1977:** Under the Territorial Waters and Maritime Zones Act, 1974, various maritime zones like internal waters, territorial sea, exclusive economic zone and continental shelf were defined. Territorial Waters and Maritime Zones Rules, 1977 were enacted under the Act. It regulates the activities of foreign ships in territorial waters in the exclusive economic zone, etc.
- **The Bangladesh Merchant Shipping Ordinance, 1983:** In parallel with the Marine Fisheries Ordinance, 1983, Merchant Shipping Ordinance was enacted in the same year. Under the ordinance, requirement of registration and boat certification were made mandatory for fishing boats. It also has provisions for marking of fishing boats and certification of the skippers and drivers are made mandatory under the Ordinance.
- **Bangladesh Code of Conduct for Responsible Fishing:** In line with the FAO CCRF, a Code of Conduct for Responsible Fishing has already been drafted for Bangladesh for immediate implementation.
- **Bangladesh Coastal Zone Policy– 2005:** The Ministry of Water Resources has formulated a Coastal Zone Policy with a goal to integrate coastal zone management including the marine fisheries component. It also emphasizes on the ECAs and special measures to conserve natural environment of Sundarbans. Further, it also outlines the issue of marine pollution briefly.

The Marine Fisheries Ordinance/Rules recognizes that marine fisheries, at present, are mainly confined within a range of 40 m depth. In terms of targets, the policy aims at exportable surpluses rather than self -sufficiency. There is no upper-limit set for fish production. Quality, rather than marketable quantities, appears to limit demand. Export of turtles is being emphasized in this policy. This may conflict with conservation of endangered species of the government. NFP's aim to expand fisheries areas and integrate rice, fish and shrimp cultivation highlights the problem of benefiting farmers and fisher folk

simultaneously and may conflict with an ICZM approach in waterlogged areas. The NFP states that 'harvest of fish and shrimp by the trawlers in the shallow coastal areas (within 40 m depth) will be banned'. In addition, an assessment of present and planned measures to encourage fishing in the deep sea has to be made.

Pollution of the coastal and marine environment is one of the concerns in the coastal zone. The Bangladesh Navy and the Ministry of Shipping have allocated crucial tasks in management of the marine environment, such as: preventing and monitoring pollution in the territorial waters; to develop contingency plans; and to control waste disposal and oil pollution from ships (including licensing). The role of Bangladesh Navy for example, has become more crucial as the Government has declared an area as 'marine reserve' in the Bay of Bengal. The National Shipping Policy deals with many important issues like inland and coastal waterways, dredging and pollution on these waterways and even long-term river basin management. Through this policy, importance of ship breaking activities has been recognized along with the resulting concern of pollution. No direction has been mentioned regarding improvement of communication facilities with remote coastal islands.

4. Activities underway to improve regional, national and local fisheries management, resource conservation and critical habitat protection

The marine and coastal capture fishery is the primary source of income and nutrition for over 484,000 households in the coastal region. Full-time employment is thought to be almost 0.2 million people. In addition about 0.4 million poor men, women and children are involved in seasonal shrimp larvae collection. Unlike the inland fishery there is more of a commercial focus to the coastal and marine fishery. Access to most coastal and marine waters entails the use of a boat and, except for river mouths and estuaries, motorized boats are a requirement. The industrial trawl fishery can exploit deeper water fishery resources up to a depth of 50 – 200 m, and the prospects for exploiting the deepest waters have not been fully explored.

Worldwide, marine fishery resources are in decline, and those in Bangladesh are no different. The majority of opinion from fishers, fisheries professionals

and scientists, is that most inshore stocks are in decline or at best have reached their maximum sustainable yields, and that the peak of coastal and marine production was reached in the late 1990's. This is almost entirely the result of unregulated access and a lack of management controls. While pollution and illegal fishing by foreign trawlers operating in Bangladesh waters are certainly serious concerns, over-fishing still remains the main issue. Of particular concern has been the hilsa fishery, which accounts for much of the marine catch.

4.1 Fisheries management in the Sundarbans

The Sunderbans comprise the most important nursery area for the Bay of Bengal fisheries. It has been estimated that every hectare of mangrove generates upwards of 450 kg/ha of marine catch. The continued existence and functionality of the Sunderbans mangrove forest is of critical importance to the entire marine fishery of the Bay of Bengal. Through the Sundarbans Biodiversity Project (SBCP- an ADB supported project of MoEF) a management regime has been developed. This represents the first attempt at managing a coastal fishery in Bangladesh (Hoq 2007). Management of the Sundarbans reserve forest lies with the Forestry Department, under the auspices of the MoEF. Management practices within the Sundarbans are subject to specific protection orders, which prohibit access to specific areas at specific times of a year. Access to the Sundarbans is restricted by a permit system, allocated to specific vessels with a history of having fished in the zone.

4.2 Protection of coastal breeding and nursery areas

Bangladesh's coastal waters hold a wide diversity of fishery resources. There is a need to identify and protect breeding and nursery areas of commercially important fish species and prawns, as has taken place on an ad-hoc basis for the hilsa. Outside of the Sunderbans few effective protected areas exist.

The MoEF is responsible for coordination of the Government's Environment Policy of 1992, giving it overall responsibility for environmental pollution control, conservation of wildlife including waterfowl, responsibility for management of the country's various national parks and protected areas, and

implementation of the various international environmental treaties to which Bangladesh is a party. While having a general responsibility for conservation and the environment, the MoEF does not have a specific mandate in the area of aquatic resource protection. In general, these organizations lack the capacity and the in-house expertise to manage fisheries. However, the DoF, while having expertise in the areas of fisheries management and to a certain extent community management, lacks a background in protected area management.

4.3 Integrated coastal resource management

Based on the assessment of continuing decline in marine inshore resources, high poverty incidence in coastal regions, particularly among landless people dependent on the capture fisheries, and the critical need to manage and regulate the artisanal marine capture fisheries, the adoption of an Integrated Coastal Resource Management framework addressing poverty and the long-term viability of the coastal/marine ecosystem is recommended. Strategically, the support should be multi-sectoral and lead to livelihood diversification, reduced pressure on marine inshore resources, devolved and strengthened monitoring and law enforcement capacities, and effective participation of local communities in coastal resource management. This strategy could take place within the framework being developed by the Integrated Coastal Zone Management (ICZM) project.

4.4 Conservation of marine biological resources

According to the previous survey, the quantity of exploitable fish and shrimp has reached their maximum levels. Under these circumstances, strict decisions will be taken against increases of mechanised or non-mechanised boats engaged in fish harvest in the marine zones. This is required to keep the fish harvest at its maximum sustainable level. Behundi net's (set bag net) are destructive to fry and juveniles of shrimp. Their actual number and extent of destruction will be counted and analysed and conservation measures will be taken. Moreover, spawning grounds will be conserved to ensure natural breeding in the sea.. Appropriate preventive measures will be taken against dumping of hazardous chemicals and atomic wastes into the sea.

5. Activities relating to the mitigation of land-based pollution affecting the Bay of Bengal area

5.1 Pollutants discharged from ship breaking and their impacts

However, over the last 10 – 15 years in Bangladesh, as in other developing countries, the usage of capacitors, transformers & other Polychlorinated Biphenyl (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 year's ahead (Hossain 2002). As a result of the breaking of the ship, oil residues and the other refuses are being spilled and mixed with soil and water in the beach. Extensive human and mechanical activities accelerate the rate and amount of seashore erosion and results in higher turbidity of seawater. The fishery resources of the area seems to be affected by the ship breaking activities as revealed by increased fishing efforts, reduced species diversity, increased amount of trash fish (Siddiquee 2004). Present situation is certainly be more aggravated and need to be thoroughly investigated to know the real status.

5.2 Other sources of pollutants

Currently, the country's marine environment is being threatened by pollutants washed down directly from land and dumping as surface run off. In addition, a large number of up-stream rivers and waters that have their origin in the countries like India, Nepal, Bhutan and China ultimately empty into the Bay of Bengal with a colossal discharge of pollutants from different sources. In addition, rotten food grains, cement dust, fertilizer, torn bags, mats and broken dungarees are frequently dumped into the marine water near the port areas of the country. While the mentioned causes of marine pollution are internal in nature, there are as well the external sources of pollution to further aggravate the problem. Both land-based and coastal activities of the littoral countries contribute to marine pollution for reasons like dumping of solid waste, discharge of chemicals used in agriculture, drainage form port areas, deposit of domestic and industrial effluents, coastal construction and tourism activities

etc. In this respect, it is relevant to mention that because of the open nature of the ocean and continuous flow of currents (both clock and counter-clock wise), all the countries of the region feel the effects of pollution. As a result, the common interest in combating pollution should at least be guided by their concern for fisheries and other marine habit.

6. Changes to national data collection strategies and/or activities

The range and amount of information required to manage the fisheries sector as a whole cannot be collected by one agency alone. Many will collect the information for a unified objective as they follow similar governmental directives. Others however will have different objectives and these can provide useful checks to try and ensure that the information received is accurate and is not collected for gains such as to meet rewarded targets. At present no organized data collection system exists on marine resources. The FRSS under DoF mainly engaged in fish catch composition data based on landed records. However, the following agencies will be play key role in national data collection system.

DoF: For information on the fisheries sector DoF must play a critical role in monitoring the activities in the sector and collecting information from other key institutions. This information should also be widely disseminated so that others are able to benefit from it to improve their understanding of the sector and its management.

Local fishermen and communities: The principal person providing the information is the primary stakeholder. Information is traditionally collected from this source by interviews or surveys. However if suitably motivated they can also become a key collector of information through monitoring their own activities / catches.

Private sector exporters and traders: Records are kept for a number of reasons with the private sector. Some of these however can provide key insights into the industry. The also act as useful cross checks as their objectives for keeping the records are often different from other information collectors.

NGOs: Depending on their activities NGOs collect a range of information on community mobilisation, training, extension, credit disbursement. This information will be collected in a form to suit their requirements, but will also provide supporting material for activities within the sector.

Ministry of the Environment: The MoEF like DoF is understaffed to collect information pertaining to its mandate. However they are tasked with monitoring the environment and the status of the forests including the Sundarbans.

Ministry of Water Resources/BWDB: Since water is the key element for the sector, then information collected on this resource is vital for the fisheries sector. Issues such as water flows, dry and wet season water areas, siltation levels are vital for both the needs of the Ministry of Water Affairs and the fisheries sector.

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Coastal and Marine Ecosystem- Bangladesh: Basic Facts

	Bangladesh	Asia (excl. Middle East)	World
Coastal Statistics			
Length of coastline (km)	3,306	288,459	1,634,701
Percent of population within 100 km of the coast	55%	X	39%
Area of continental shelf (km^2)	59,638	5,514,288	24,285,959
Territorial sea (up to 12 nautical miles) (km^2)	40,257	5,730,868	18,816,919
Claimed Exclusive Economic Zone (km^2)	39,868	11,844,193	102,108,403
Area of mangrove forests (km^2)	4,403	40,330	169,452
Percent of mangrove forests protected	8%	27%	13%
Number of mangrove species	21	51	70
Number of sea grass species	19	27	58
Number of marine or littoral protected Areas	6	831	3,636
Wetlands of international importance, extent (km^2)	5,960	31,212	730,116
Fisheries Production			
Average annual capture (excludes aquaculture) in metric tons:			
Marine fish	497,573	36,516,371	84,411,066
Aquaculture production			
Total (includes freshwater)	1005,542	41,305,773	45,715,559
Total fish production (freshwater & marine)	2563,296	X	X
Aquatic plants	X	7,123,694	7,241,754
Fish Consumption and Trade			
Per capita food supply from fish and fishery products (kg/person)	17	18	16
Fish protein as a % of total protein supply	63%	10%	6%
Fishing Effort, both freshwater and marine			
People Employed in fishing and aquaculture (number)	30,80,000	28,890,352	36,116,329
Docked fishery vessels (number)	133	1,080,625	1,297,017

	Bangladesh	Asia (excl. Middle East)	World
Protected Areas			
Extent of Protected Areas by IUCN Category (000 ha)			
Nature reserves, wilderness areas, and national parks (categories I and II)	X	89,140	438,448
Natural monuments, species management areas, and protected landscapes and seascapes (categories III, IV, and V)	66	57,211	326,503
Areas managed for sustainable use and unclassified areas (category VI and "other")	0	57,878	692,723
Total area protected (all categories)	66	204,229	1,457,674
Marine and littoral protected areas	46	21,995	417,970
Protected areas as a % of total land area	0.5%	8.3%	10.8%
Number of protected areas	11	5,761	98,400
Wetlands of international importance (Ramsar Sites)			
Number of sites	2	98	1,179
Total area (000 ha)	606	5,641	102,283
Biosphere reserves			
Number of sites	X	55	408
Total area (000 ha)	X	X	439,000