Coastal Resources Management, Policy and Planning In Bangladesh

Md. Masudur Rahman, Zubair Ahmed Chowdhury and Md. Nasir Uddin Sada
Department of Fisheries
Bangladesh

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Abstract

This paper reviews the coastal fishery resources of Bangladesh emphasizing the coastal environment, capture fisheries and management issues relative to the sector. Bangladesh's Exclusive Economic Zone (EEZ) covers an area of about 166 000 km^2. This area has abundant natural resources such as fish, shrimps, crabs and other marine products. Shrimp and fish trawling is the most important economic activity in this area. The fishery sector makes a significant contribution to the national economy in terms of foreign exchange, income generation and employment. It is very important in nutrition, especially in providing animal protein. In 1997 - 99, the marine fisheries sector contributed 22% of the total fishery production of 1 373 000 t. However, the resources are being destroyed in many ways. The fisheries resources have declined and fishers are getting poorer. The decline is partly due to estuarine set bag net, push net, and beach seine fishing, which result in recruitment over-fishing. A multiplicity of factors adversely affect the coastal fishery resources of Bangladesh.

Various laws, ordinances and acts have been formulated to manage the fisheries resources and to protect the coastal zone environment. Most of the laws have been amended to meet current needs. However, marine fisheries are not being well-managed because the laws are not properly implemented, due to a shortage of man power, lack of infrastructure and funds. Moreover, there are legislative and communication gaps between the law-enforcing agencies. In addition to sectoral issues, a number of cross-sectoral issues such as pollution and habitat destruction impact the coastal zone and the long-term sustainability of coastal fishery resources. The main objectives of coastal fisheries management in Bangladesh should include the following: (1) rational utilization of resources; (2) protection/conservation of the environment or habitat; (3) maximization of the benefits from utilization of the resources within sustainable limits; (4) minimization of conflicts among users; (5) promotion of equity in sharing benefits from utilization of the resources; (6) reduction of poverty among small scale fishers; and (7) promotion of alternative livelihood opportunities for fishers.

Introduction

Bangladesh is a South Asian Country of 147 570 km^2 situated between India and Myanmar and bordered by the Bay of Bengal in the south. It is located between latitude 20° 34' and 26° 38' North and longitude 88° 01' and 92° 41' East (Fig. 1). The country is divided into six administrative Divisions, Rajshahi (Northwest), Dhaka (Center), Khulna (Southwest), Chittagong (Southeast), Barisal (South) and Sylhet (North East). Each division is further divided into districts (*Zilla*), which consist of *Thanas*, or police stations, as administrative units. There are 64 *Zilla* and 640 *Thanas* with 85 650 villages. Although one of the most densely populated countries of the world, it has abundant natural resources such as the Sundarbans, the world's largest single compact mangrove forest; an intricate network of rivers with rich fish habitats, a vast communications network and ample fertile lands to grow crops. It also has promising gas reserves to meet the increasing energy needs.

Bangladesh declared an Exclusive Economic Zone (EEZ) of 200 nautical miles (370 km) in 1974. As a result, an area of about 166 000 km^2 is now under the economic jurisdiction of the country for exploration, exploitation, conservation and management of its living and non-living resources. Several surveys have been conducted by national and international agencies to assess and estimate the marine fisheries resources potential of Bangladesh since 1958. Most of these surveys were of an exploratory nature and repeatedly targeted the demersal fishery resources. These surveys gave good information on the standing stocks of demersal finfish and shrimp. However, no detailed surveys were conducted for pelagic fishery resources.

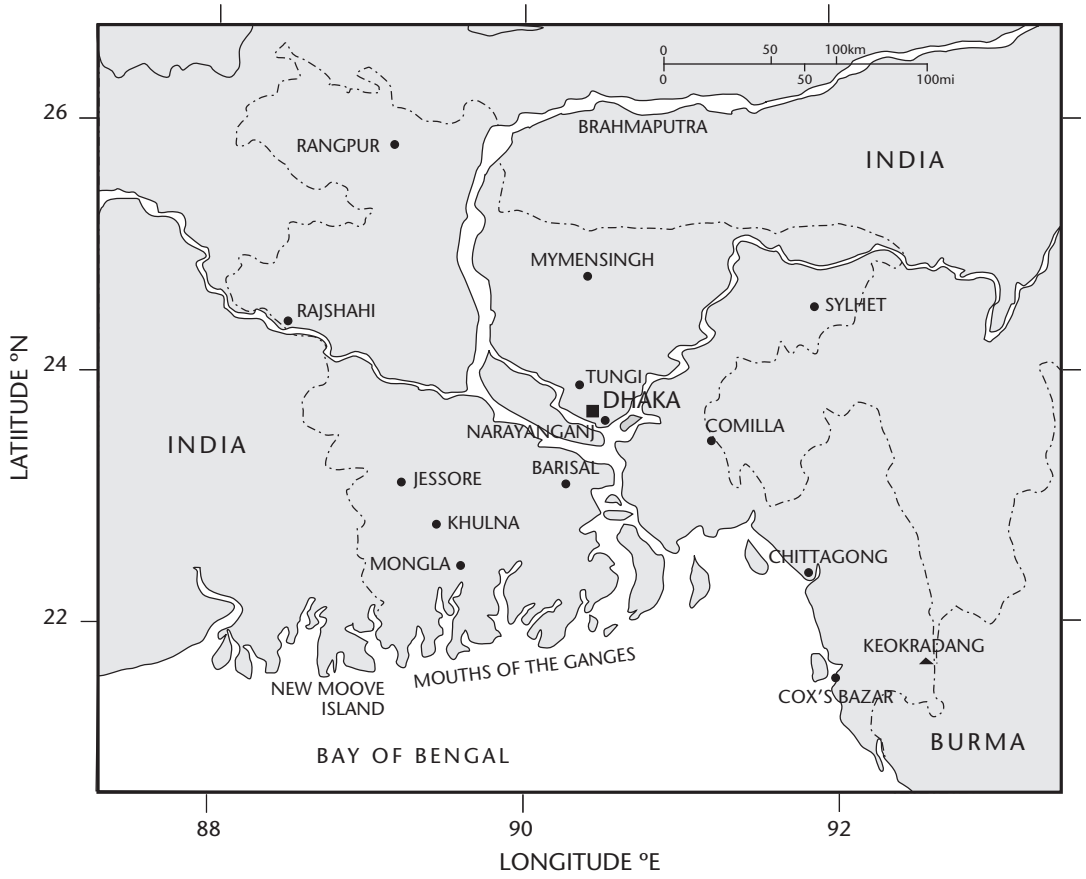

Fig. 1. Map of Bangladesh.

The freshwater area is being reduced by encroachment for agricultural production, and fish habitats and routes of migration have altered due to various water resources development activities. Therefore, it is difficult to fulfill the minimum protein requirement of the teeming millions from the freshwater sub-sector alone. Greater priority has always been accorded to freshwater fisheries as reflected in the large number of fisheries development projects implemented since independence, despite the fact that the marine fisheries sector provides the majority of foreign exchange earnings.

The fisheries sector in Bangladesh plays an important role in the national economy in terms of foreign exchange earning, income generation, employment and providing nutrition. It contributes nearly 4.2% of the national GDP, 7% to the agricultural GDP and 7.6% of the country's total export earnings. It provides full-time employment for 1.2 million professional fishers and 11 million part-time fishers, or about 10% of the total population.

The fisheries sector provides about 80% of the animal protein consumed in Bangladesh. But, in spite of continuous increases in fish production, it has not been able to cope with the demands of the fast growing population. The country's fish production increased from 640 000 t (metric tonnes) (inland 545 000 t, marine 95 000 t) in 1975 - 76 to 1 373 000 t (inland 1 079 000 t, marine 294 000 t) in 1996 - 97. However, per capita daily fish consumption decreased from 33 g to 20 g.

At present the marine fisheries sector contributes about 22% of the country's total production despite a reasonable marine and brackish water area under the EEZ. The strategic development of this sector has not been properly implemented. Rather, because of unplanned and irrational increases in fishing effort, many of the marine fish and shrimp stocks have already declined. As a result, coastal fishing has become non-remunerative and fisherfolk are getting poorer, thus putting more and more damaging pressure on the resources. This may give the impression that marine resources exploitation has become saturated, but the practical situation is different. We are destroying the resources in many ways.

The marine and brackish water fish production has increased yearly and accounts for about 95% of the total marine landings. However, knowledge on catchability, exploited size range, mortality rates and the optimum fishing efforts required to exploit these resources are inadequate for management.

While there is strong and continuous competition for demersal fin fish and shrimp between the shrimp trawl industry and the traditional artisanal fishing operations within the 100 m isobath, demersal resources beyond 100 m and the pelagic waters beyond 40 m are not being harvested to their potential. Various exploratory surveys and research data show that considerable resources are available for harvesting in these areas, particularly the pelagic resources such as mackerels, tunas, sharks, anchovies, sardines and cephalopods. Planning for the development of these resources is lacking, but this could be the most effective means of boosting fish production to reach the national target.

Coastal Environmental Setting

Planning Area

Bangladesh is endowed with a vast area of marine, brackish and inland waters having great fisheries potential. The Republic has a 710 km long coastal line on the southern zone of the country (Fig. 1), from the mouth of the Naf River in the southeast, to the mouth of the Raimangal River in the southwest, and approximately one million hectares of territorial waters extending 19 km seawards. The nation's EEZ extends 200 nautical miles (nm) seawards encompassing an area of 166 000 km^2. Details are given in Table 1.

The continental shelf of Bangladesh covers an area of 66 440 km^2, of which 37 000 km^2 are no deeper than 50 m (Table 2). Fleets of motorized small scale fishing craft, using gear such as set bag nets

Table 1. Total marine water area of Bangladesh

Marine water area	Area (km^2)
Base line from the coast line to 10 fathom	25 140
Territorial waters up to 12 nm from the base line	9 060
EEZ (200 nm from the base line including territorial water)	140 860
Total sea water area	166 000

Source: Fisheries Information Bulletin, GOB 1986.

Table 2. Area of the shelf of Bangladesh.

Depth Zone (m)	Area (km²)
Up to 10	24 000
10 - 24	8 400
25 - 49	4 800
50 - 74	5 580
75 - 99	13 410
100 - 199	10 250
TOTAL	66 440

Source: Saertre 1981.

(*behundies*), trammel-nets, beach seines, long-lines and gillnets operate in these areas. The substrate to 40 m is mostly alluvial silt and mud. Sand bottom occurs in deeper waters.

The coast of Bangladesh forms a part of the massive Gangas-Brahmaputra-Meghna delta. The coastal zone is characterized by sprawling estuaries, dense mangrove forests, islands and coral reefs. The great rivers empty into the large estuary at the apex of the Bay of Bengal, carrying large quantities of nutrients that mix with large quantities of organic and inorganic elements derived from the decomposition of litter of mangroves. Endowed with a warm tropical climate and high rainfall, the coastal waters are further enriched with nutrients from land that enable them to support a wide biotic diversity and rare endemic genetic material.

Biophysical Environment

A large proportion of the shelf of Bangladesh is shallower than 10 m, covering about 24 000 km^2. The shelf area down to about 150 m appears to be very even; obstacles hazardous to bottom trawling were only observed in two areas at depths more than 60 m in the northern part of Swatch of No-Ground and at depths more than 100 m southwest of St. Martin's Island. The continental edge is at depths of 160 - 180 m. The slope is very precipitous and it seems impossible to carry out bottom trawling in waters deeper than 180 m. The areas under different depth zones are given in Table 2. The oceanic large scale surface currents are generally wind-driven. The surface circulation is generally clockwise from January to July and counter-clockwise from August to December in accordance with the reversed monsoon wind systems.

The coastal zone consists of the complex delta of the Ganges-Brahmaputra-Meghna (GBM) river systems. Much of the country is drained by these rivers, constituting one of the largest river systems in the world, with their origins in the Himalayas and the Khasi-Jainta Hills in the north of the country. The estimated annual sediment load of 2.5 billion tonnes is dumped in Bangladesh. These sediments are subject to coastal dynamic processes activated mainly by river flow, tide and wave action, leading to erosion and accretion in the coastal zone.

During flooding, the rivers also transport massive amounts of suspended sediment loads, of the order of 13 million t·day^{-1}, into the Bay of Bengal. About 80 - 90% of the suspended sediment is transported during the monsoon season. This is calculated at some 1 500 million tonnes, of which only a small portion is deposited in the flood plains or in the lower delta; most of it is flushed out into the deeper parts of the Bay (Eysink 1983).

A number of studies have been made on the morphological changes and sedimentation in the coastal and offshore areas of Bangladesh. Pramanik (1983) made a detailed analysis of over 44 000 km^2 of the coastal zone for the period 1972 - 79, taking full advantage of the synoptic view provided by Landsat data. The coastal region of Bangladesh is divided into three broad regions, the Eastern Region, the Central Region and the Western Region. The Eastern Region paralleling the young folded hills of the Chittagong area is the site of a 154 km long sandy beach, the Central Region is the locale of active delta building processes, while the Western Region is a region of active subsidence due to compaction of sediments. A study on the application of satellite data from 1960 - 84 found that both erosion and accretion are prominent in the coastal zone with an overall seaward extension of the delta.

The surface water temperature of the Bay of Bengal varies from 17° C to 33° C. The surface water salinity varies from 18 to 37%. The bottom water salinity ranges from 28 to 39%. The depth to the thermocline is usually 30 - 40 m in summer and about 70 m during winter. Strong haline stratification was observed in the northern part, while in the more offshore areas the upper layer was more homohaline down to the thermocline. There was usually a slight increase in salinity towards the surface in the upper 20 - 30 m.

Oxygen concentrations varied from 4.8 ppm at the surface and 4.0 ppm at 35 m. The oxygen content decreased rapidly with depth within the upper part of the thermocline. The isoline for 1 $ml \cdot L^{-1}$ was situated at about 80 m in summer compared to about 20 m shallower in winter. The deep layer oxygen content decreased to less than 0.2 $ml \cdot L^{-1}$. There seemed to be a minimum in the vertical oxygen distribution between 200 and 400 m. pH values vary from 8.6 to 8.7 near St. Martin's Island.

The planktons are the most diverse group of organisms in the ocean. Some good information on estuarine and marine planktons of Bangladesh is available (Das and Das 1980). Two maximum areas of plankton density were observed on the continental shelf of Bangladesh, one along the eastern coast from Cox's Bazar to St. Martin Island and another in the northern part of Swatch of No-Ground (Saetre 1981).

Total phytoplankton counts have been estimated in the range of 2 100 - 22 479 $cells \cdot L^{-1}$ in the neritic water off the southeast coast (Noori 1999), depending on seasonal and regional environmental variables.

Very little is known about the hydrological features of the water bodies of the Bay of Bengal. Generally, in the inshore water near estuaries the turbidity is very high due to heavy run-off from the major rivers while the offshore waters are clearer. A maximum secchi disc reading was recorded at 27 m in offshore waters.

Critical Coastal Habitats

St. Martin's is the only coral reef island in Bangladesh. Locally known as Jinjiradwip, this gradually decaying island (Anwar 1988) is about 10 km south of the mainland. It is about 8 km long in an approximate north-south direction and has a maximum width of 1.6 km (in the north). Its area is a little over 7.5 km^2 (Haque et al. 1979).

There is little information on Bangladesh offshore corals. Haider and Mahmood (1992) recorded four species of the genus ***Acropora*** (*A. pulchra, A. horrida, A. humilis* and *A. variabilis*) from the reefs at St. Martin's Island. Additionally, coral of ten more genera, namely *Stylocoeniella, Pocillopora, Stylophora, Porites, Pavona, Favia, Favites, Pseudosiderastrea, Goniastrea* and *Monstastrea*, under six families, have been recorded (Mahmood and Haider 1992).

Mangroves, locally known as *sundarban* or *peraban,* play a vital role in the national economy. Besides being a source of different renewable resources, they also serve as buffer zones against cyclones and tidal surges. The coast supports about 587 400 ha of natural mangroves (Mahmood 1986) and a further 100 000 ha of planted mangroves.

The densest mangrove block, the Sundarbans (beautiful forest), is situated in the southwest, mostly in Khulna District. It covers an area of 577 040 ha (FAO 1984), one third of which comprises tidal channels. It is not only the largest single forest resource in the country, but also the largest single compact mangrove resource in the world.

The natural mangroves of the country are being destroyed by ecological changes caused by biotic factors and salinity increases due to reduced waterflows because of the by construction of dams, barrages and embankments. An estimated 40 - 45% of the two major species of the Khulna Sunderbans forest reserve declined in this way between 1959 and 1983. The worst form of destruction has been going on in Chakaria, Cox's Bazar, due to the uncontrolled expansion of coastal shrimp farming. The beautiful Kewa forest of the Jaliardwip on Naf River has been cleared for conversion into shrimp ponds (Mahmood 1995).

Information on seagrass beds is lacking. *Halodule uninervis* has been reported from the sandy littoral zone around St. Martin's Island (Islam 1980). The seafronts of newly formed islands (*chars*), as well as some low-lying coastal areas, are often carpeted with seagrass.

Seaweeds are found in the littoral and sub-littoral zones of St. Martin's island. According to Islam (1976), 133 species of marine algae have been recorded in Bangladesh, especially from St. Martin's island, and 138 species of algae have been recorded in the eastern part of Bangladesh (Zafar 1992). Ten species are very common, namely; Green algae (*Caulerpa sertularioides, C. racemosa* and *Entromorpha* sp.), Brown algae (*Hydroclathrus clathratus* and *Sargassum* sp.)*, Red algae (*Gelidiella tenuissima, Helimenia discoide, Hypnea valentiae*, H. pannosa** and *Gelidium pusillum*).

* Common species.

Watersheds

Bangladesh is the combined delta of three major river systems, the Ganges, Brahmaputra and the Meghna. Additionally, a number of large and small rivers with their tributaries and branches criss-cross the country. Of these, 54 are shared with India. All these rivers have extensive flood plains along both banks. The estimated total area under flood plains is 2 832 792 ha. These remain inundated at depths ranging from very shallow (0 - 30 cm) to deeply flooded (> 1.8 m) during the monsoon season. Within the flood plains, there are deep depressions, locally termed *beels*. The permanent *beels* retain water year-round while the seasonal ones dry out during the peak of the dry season (March and April). The deeply flooded areas in the north-east of the country are known as haors.

Besides the flood plains and *beels*, another set of large water bodies known as *baors* or oxbow lakes occur largely in the districts of Jessore and Kushtia in the southwestern region. The *baors* are bends of meandering rivers, which have become cut off from the main river courses and have little or no connection with the open water system.

A large hydro-electric reservoir was created in the Chittagong Hill Tracts by building a dam across the Kharnaphuli River at Kaptai in the 1950s. This reservoir, popularly called Kaptai Lake, covers an area of 68 800 ha. It is not connected with the remainder of the open water system of the country.

In addition to the above, the country has an estimated 1 288 222 man-made ponds and ditches which together provide a total water area of about 215 000 ha.

The country has 25 000 km^2 of intertidal lands, which provide temporary nursery and feeding grounds for the fry and post-larvae of various species of finfish, shrimp or prawns during the tidal inundation. Extensive traditional brackish water aquaculture is carried out in intertidal areas in the southeastern and southwestern regions of the country (MPO 1987). Areas under rivers, beels, flood plains, oxbow lakes, ponds and brackish water farms in the coastal areas are shown in Table 3.

Table 3. Areas of different types of inland water-bodies.

Water-bodies	Area (Hectares)
A. OPEN INLAND WATERS (Sub-total)	4 920 316
1. Rivers	479 735
Ganges	27 165
Padma	42 325
Jamuna	73 666
Meghna upper	33 592
Meghna lower	40 407
Other rivers and canals	262 580
2. Estuarine area	551 828
Sub-Total	1 031 563
3. Beels and Haors	114 161
4. Flood plains	2 832 792
5. Kaptai Lake	68 800
6. Polder/Enclosure	873 000
B. CLOSED WATERS (Sub-total)	361 841
1. Ponds and Ditches	215 000
2. Baors (Oxbow lakes)	5 488
3. Shrimp farms	141 353
GRAND TOTAL	5 282 157

Fishery Resources and Potential

Demersals

A number of surveys have been conducted since 1958 in the marine waters of Bangladesh. Most of these surveys were of an exploratory nature and oriented to studies of fishing feasibility. However, some surveys were made to assess the standing stocks of the marine resources, particularly the demersal fish and shrimp resources.

The demersal fish assessment survey results vary to a great extent. West (1973), through a desk study, estimated the standing stock of demersal fish at 264 000 - 374 000 t and the maximum sustainable yield (MSY) at 175 000 t. Saetre (1981) estimated the MSY at 100 000 t, on the basis of data collected by the R.V. Dr. Fridtjof Nansen survey during

1978 - 79, and Khan (1983) estimated that 40 000 - 55 000 t of demersal finfish could be harvested annually from the offshore fishing grounds. This includes some part of the shallower zone within 10 - 100 m. The potential yield was estimated at 47 500 - 88 500 t within the 10 - 200 m isopleths (Lamboeuf 1987).

The finfish species that are presently exploited are mainly demersal, shallow water estuarine species, but include a few pelagics. Most are common to both artisanal and industrial fisheries. About 100 species are taken, of which the commonest are as follows: ***Pampus argenteus*** (Silver pomfret) *Pampus chinensis* (Chinese pomfret), *Pomadasys hasta* (Lined silver grunter), *Lutjanus johni* (Red snapper), *Polynemus indicus* (Indian salmon), *P. paradiseus* (Paradise threadfin), *Eleuthero nema tetradactylum* (Four-finger threadfin), *Leptu-racanthus savala* (Ribbonfish), *Arius* spp. (Catfish), *Johnius argenteus* (Sillver pennah croaker), *Otolithes maculates* (Blotched tiger toothed croaker), *Nemipterus japonicus* (Japanese threadfin bream), *Upeneus sul- phureus* (Goatfish), *Saurida tumbil* (Lizardfish), *Ilisha filigera* (Bigeye Ilisha), *Sphyraena barracuda* (Great barracuda), *Muraenesox telabonoides* (Indian pike conger), *Harpadon nehereus* (Bombay duck), *Lates calcarifer* (Sea perch or Sea bass), *Sillago domina* (Ladyfish) and *Epinephelus lanceolatus* (Grouper).

Pelagics

Detailed surveys for pelagic fish resources have not yet been carried out in Bangladesh waters. However, some information is available from the demersal fish surveys. Saetre (1981) estimated the standing stock of pelagic fish at 60 000 - 120 000 t during the R.V. Dr. Fridjof Nansen survey in 1979 - 80, through an acoustic study, but it was suggested that this might be an underestimate.

In 1979, a Thai-Bangladesh joint survey cruise with the R.V. Fishery Research No. 2 found a good abundance of large pelagics such as tuna and tuna-like fish and sharks in Bangladesh waters. A number of species available on the continental shelf of Bangladesh are either not exploited or are taken only as incidental catches by the bottom trawl, shrimp trawl or drift gillnet fisheries. The most important species are *Euthynnus affinis* (Eastern little tuna), *Katsuwonus pelamis* (Skipjack tuna), *Thunnus obesus* (Bigeye tuna) *Thunnus tonggol* (Longtail tuna), *Auxis rochei* (Bullet tuna), *Auxis thazard* (Frigate tuna), *Scomberomorus guttatus* (King mackerel), *S. commerson* (Spanish mackerel), *Rastrelliger kanagurta* (Indian mackerel) and *R. brachysoma* (Short-bodied mackerel).

Other pelagic fish that appear as by-catch include four species of sardine (mainly *Sardinella gibbosa* and *S. fimbriata*), thirteen species of sharks and rays (mainly *Scolliodon sorrakowa, Carcharhinus menisorrah, Sphyrna blochii, Dasyatis uarank*), thirteen species of carangids (mainly *Decapterus maruadsi, Megalaspis cordyla* and *Atropus atropus*) and six species of clupeoids (mainly *Chirocentreus dorab*).

Shrimps

Few surveys were conducted for assessing the standing stock of penaeid shrimp and there are large variations in the estimates, ranging between 1 000 and 11 000 t. West (1973) reported a standing stock of shrimp of 11 000 t and an MSY of 9 000 t. However, his estimates were criticized by several authors (Saetre 1981; Penn 1983; Rashid 1983; White and Khan 1985).

Later Penn (1983) estimated the standing stock of shrimp at 2 000 - 4 000 t and an MSY of the same amount, on the basis of commercial shrimp trawl data. This result agrees with the studies carried out later by the DOF. The standing stock estimates varied from 1 500 t to 4 000 t (White and Khan 1985; Mustafa et al. 1985). The MSY of shrimp was estimated at 4 000 - 4 300 t (Mustafa and Khan 1993) annually within < 30 m, on the basis of commercial trawl data. Khan et al. (1989) estimated the MSY at 7 000 - 8 000 t annually.

Most of the shrimp species taken are common to both artisanal and industrial fisheries. The industrial fishery harvests mostly the adult phases and the artisanal fishery takes pre-adults, post-juveniles and juveniles. This is because the early phases of their life cycles are spent in the brackish water estuaries.

The major exploited shrimp species are as follows: *Penaeus monodon* (Giant tiger shrimp), *P. semisulcatus* (Green tiger shrimp), *P. japonicus* (Kuruma shrimp), *P. indicus* (Indian white shrimp), *P. merguiensis* (Banana or White shrimp), *Metapenaeus monoceros* (Brown or Speckled shrimp), *M. brevicornis* (Brown or Yellow shrimp), *M. spinulatus* (Brown shrimp), *M. affinis* (Brown or Jinga shrimp), *Parapenaeopsis sculptilis* (Pink or Rainbow shrimp), *P. stylifera* (Pink or Kkiddi shrimp), *P. hardwikii* (Pink or Spear

shrimp), *Parapenaeopsis uncta* (Pink or Uncta shrimp), **Solenocera crassicornis* (Mud shrimp) **Acetes indicus* (Paste shrimp), **Macrobrachium rosenbergii* (Giant river prawn) **Palaemon styliferus* (Roshna prawn), and **Alepheus euphrosyne* (Nymph snapping shrimp). *Penaeus monodon* is the most targeted species and fetches a very good price both in local and international markets. The values of the species more or less follow a descending order according to the list. However, the highest contribution (63%) to total production is made by *M. monoceros,* the Brown shrimp.

The non-penaeid shrimps appear in the coastal estuarine areas at certain stages of their life cycle. The caridean shrimps are typically freshwater living animals, while *Acetes indicus* (a sergestid shrimp) is an exclusively brackish water species that is abundantly exploited by the artisanal fishery.

Other Resources

Other than the demersal, pelagic and shrimp species, the coastal fishery resources comprise fifteen species of crabs (mainly the Mud crab, *Scylla serrata, Charybdis cruciaia, Neptunus pelagicus, Paratelphusa lamelliformis*), five species of lobsters (mainly *Panulirus polyphagus* and *P. versicolor*), three species of cephalopods (mainly *Sepia officinalis* and *Loligo* spp.), six species of oysters (mainly *Crassostrea madrasensis* and *Placuna placenta*), one species of green mussel (*Mytilus edulis*), three species of clams (mainly *Anadara granosa*) and one species of sea cucumber.

Socioeconomic Background

Demography

The population of Bangladesh was estimated to be 111.40 million in 1991 (BBS 1997). The urban population was 20.1%. The annual intercensal growth rate of the population, estimated by using the adjusted population of the 1991 census, was 2.1 %. Assuming the median variant of declining fertility and mortality, the country was expected to reach a population of 129.6 million by 2000 A.D. A country-wide intensive family planning measure is aimed at reducing the growth rate. The density of the population was approximately 647 km^{-2} in 1981 and increased to 755 km^{-2} in 1991. The sex ratio of the population is 106 males per 100 females. There were 19.4 million households in the country distributed over 59 990 revenue villages (mauzas).

Bangladesh already has the highest population density in the world and it is assumed that the population will be doubled within the next 35 years. Restraining population growth has therefore been one of the Government's highest priorities. So far it has been remarkably successful. Population growth slowed during 1974-84 and in the early 1990s the average annual growth rate fell from 2.8% to 2.1%. Fertility fell steeply between 1975 and 1990 and the average number of births per woman dropped from 7.0 to 4.6. Even more remarkably, between 1971 and 1990, contraceptive use increased from 3% to 40%.

Income, Labor and Employment

People are Bangladesh's greatest resource. However, if they are to exploit their full potential, their energy and skills must be channeled to productive work. Only about 2% of the work-force is officially unemployed, though in reality many employed may do useful work only for a few hours a day. Most workers cannot survive without an income and must seize every opportunity, however fleeting or poorly paid. If the criterion of under-employment is working less than 40 hours per week, the figures are sobering; 18% of the work-force is under-employed.

The greatest employment challenge is in the rural areas. Around 80% of workers in the rural areas are employed in agriculture, forestry or fisheries and the demand for their labor has been rising to some extent. High-yield varieties (HYVs) of rice and wheat are more labor intensive than the traditional varieties and the modernization of agriculture has also helped increase non-farm employment. This has stimulated inter-regional trade. Between the early 1960s and 1984 - 85, the marketed surplus of rice, for example, increased from 10% to nearly 40%, generating greater employment in trade and transport. Between 1976 and 1985 the volume of freight traffic increased by 5% per year.

Freshwater fisheries are also a major employer. Most of the rural population do some fishing but around 2 million people derive most of their income from fisheries-either in catching, packaging, transporting or marketing.

* Non-penaieds.

While job opportunities have been increasing somewhat, they are still outpaced by the growth in the labor force. This is not because the proportion seeking work (the participation rate) has gone up: it has remained steady in recent years, at 83% for men and 68% for women. The problem is that the rural population has increased at around 2.3% per cent annually.

Unable to find sufficient work, about 1% of the rural population migrates annually to urban areas. Between 1981 and 1991 the urban population increased by 5% per year and rural-urban migration was responsible for two-thirds of this growth.

The limited opportunities for employment and earning have also encouraged many Bangladeshis to work abroad, the majority of them in the Middle East and Southeast Asia. During 1992 - 93, 237 779 workers left; nearly half of them were destined for Saudi Arabia. Their annual remittances of about $1 million are a valuable source of foreign exchange.

Health and Nutrition

Health

Medical services have been increasing gradually as the government continues to expand the health services at the grassroots level. Some steps are being taken to strengthen the system. First, the Government is directing more resources to health. Between 1986 and 1993, it increased health expenditure in proportion to the revenue budget from 2.6% to 4.9%. Despite increasing demands from the wealthy for more sophisticated medical facilities, the Government also redirected funds more towards primary health care. Over the same period, the proportion of the total health budget going to primary health care rose from 32% to 50%.

However, Government health services are still not adequate. Equipment is antiquated and poorly maintained. The distribution of drugs and other essentials is erratic. Even where primary health care workers are available and willing to visit villages, they can be frustrated by lack of transport.

Life expectancy at birth in Bangladesh is low. Poverty, poor sanitation, malnutrition and a host of other health hazards continue to take their toll. Better living conditions would certainly raise health standards. Many of the major killers such as diarrhoeal disease and acute respiratory infection could be brought under control by an efficient basic health service and better health practices.

Nutrition

The first nutritional census of the country was done over 30 years ago. A survey conducted by the World Bank in 1997 (see Khan et al. 1998) showed that two thirds of the population received insufficient food. A person requires 2 039 calories·day^{-1}, but per capita daily calorie in rural areas was 1 892 and in the urban areas it was 1 779. The survey showed that although the urban people spend more, they get fewer calories than the village people. During the 1960s the average calorific intake was 2 118 (Khan et al. 1998).

According to the WB survey, women and children are the most deprived section. While pregnant women and lactating mothers need nutrition most, they get the least. The survey also showed that of the total population, only 26.5% obtained the required calories. Forty-four per cent of people get less than 80% of calories required.

As the pregnant women get fewer calories, their babies are born malnourished. Sixty per cent of the babies between 6 and 71 months get less food than required. This keeps most Bangladeshi children short in height and underweight. Malnutrition also slows down their mental growth and causes diseases like arthritis, anemia and night blindness.

The food supply in Bangladesh has increased in recent years. Rice production has risen significantly, though at the expense of nutritionally important foods such as beans, pulses and those rich in Vitamin A. At present, the per capita calorie consumption is only around 80% of the level recommended by the WHO. This is not entirely because people are poor. Recent studies have shown that malnutrition can be improved by adopting healthy feeding habits and better distribution of family food supply. Many low cost products like pulses and beans can be supplemented for expensive meat or fish to ward off malnutrition.

Education and Literacy

Education

In 1993, the government made primary education compulsory throughout the country and created a National Plan of Action and set ambitious targets

for primary education. By the year 2000 it aimed to raise the gross enrollment rate to 95% and the completion rate to 70%.

Despite the priority given to the education sector, the education system is not yet producing an adaptable, creative work-force. Teaching has largely been by rote. Staffing is inadequate, materials are scarce and classrooms are crowded and dilapidated. The education system has not been able to attract students, as many parents and children regard school as unattractive or irrelevant to their daily lives. Attendance in primary education is no more than 50% and completion only 40%.

For many children the basic problem is poverty - their families are trapped in a vicious intergenerational cycle of deprivation and ignorance. A Dhaka child can earn 40 - 50 Taka per day just by scavenging for waste paper. Breaking out of this cycle will demand a determined national effort.

Literacy

In Bangladesh a person aged > 7 years who can write a letter is considered to be literate . The average rate is 32.4%; male literacy rate is 38.9% and female literacy rate is only 25.4%. There is a gross inequality in geographical pattern. Generally, coastal districts and the Chittagong Hill Tracts show proportionately higher literacy rates, whereas districts in north Bengal show medium and lower rates. The pattern is partially correlated with the pattern of population density (Khan et al. 1998).

Environmental Awareness

Children in the rural areas learn to swim as soon as they can walk. Bangladesh from one perspective is a vast and beautiful water garden; but from another it is one huge drain.

Heavy rainfall and floods regularly replenish the underground aquifers. In most parts of the country the water-table is only around 8 m below the surface. If people use river or surface water they are taking a great risk, since much of it is contaminated by faeces. Faecal contamination is probably the country's most severe environmental hazard. Groundwater extracted through tube wells using hand-operated suction pumps have been found to be contaminated with arsenic and pose a serious health risk (Islam et al. 2000).

Two-thirds of the rural population either defecate out in the open or use unhygienic latrines that release waste into rivers or ponds. This represents a major health hazard: some 80% of disease is related to unclean water and poor sanitation.

There are a number of other poverty-related environmental issues such as deforestation. The forested area has dropped by over half in the last 20 years and now covers less than 8% of the country. The standing volume of the two main species in the Sunderbans mangrove forest has declined by about 45% since 1959. Deforestation has immediate social and economic costs.

Agriculture development may also lead to groundwater pollution through intensive use of fertilizer, and to a lesser extent pesticides - though these impacts and the effects of multicropping on the organic content of the soil have yet to be closely investigated.

The leather and textile industries, which are among the country's most important export prospects, already account for half the 900 identified polluting industrial plants - chiefly affecting the rivers in Chittagong, Dhaka and Khulna. The Hazaribag area of Dhaka has 250 leather factories, which dump toxic effluents into the Buriganga River.

Local communities and NGOs are now more aware of potential dangers from industrial processes or large scale development projects and have become increasingly vocal.

A Ministry of Environment and Forests, and within it a Department of the Environment, exists to assess the environmental impact of development projects and to monitor industrial pollution. However, this has yet to exert any influence on sustainable human development.

According to some projections, global warming, could cause the sea-level to rise by 100 cm and up to 18% of the country would be permanently submerged.

Level of Urbanization

Although Bangladesh is one of the least urbanized countries, it has some serious urban problems. The capital, Dhaka, is one of the fastest growing cities in the world. Urbanization is not due to regional development, but the result of huge migration of

the unemployed rural population in search of job opportunities. There are 107 urban centers in the country. The majority of the towns are local markets with some administrative functions.

In 1961, slightly more than 5% of the population lived in the urban areas, but by 1991 22% of the population was urban. Most urban migrants have limited skills and are often unable to gain entry into the formal sector job market. The consequence has been an explosion of slum and squatter settlements amidst mass poverty and gross inequality.

According to a survey conducted by the Asian Development Bank (ADB) and the Planning Commission, Government of Bangladesh, in 1995 - 96 61.3% of the urban population fell below the absolute poverty line while 40.2% fell below the hard-core poverty line. Only 18% of the urban poor own the plot of land that they occupy. The situation is extreme in the case of Dhaka, with only 3.2% owning their plots, with the reverse situation in the small towns where nearly 90% own their plots. A higher portion (26%) of households own the house they live in, the reason being the many have built their house on land they do not own. At least 9% are squatters and the proportion in Dhaka is 18.5% (Khan et al. 1998).

Economy and Major Development Patterns (Khan et al. 1998)

In the decades since independence, economic growth has averaged 4% per year. This might seem respectable for a country born from the devastation of war and regularly buffeted by natural disasters. However, it is low by the standards of many Asian neighbors and not nearly enough to have a serious impact on poverty. If poverty is to be reduced significantly in the coming decades, economic growth will need to be closer to 7% per year.

In 1993, Bangladesh ranked 147 out of 173 countries in the UNDP Human Development Index - a reflection of low life expectancy, low educational attainment and low GDP per capita. The poverty situation improved somewhat in the 1980s. Between 1983 - 84 and 1988 - 89, in the rural areas the proportion below the poverty line (consuming less than the recommended intake of 2 122 calories•day^{-1}) fell from 57% to 48% - and in the urban areas from 66% to 44%. In the case of the "hard-core poor" (consuming less than 1 805 calories•day^{-1}) the trend is not consistent. The proportion did fall between 1983 - 84 and 1985 - 86 (in the rural areas from 38% to 22% and in urban areas from 35% to 19%), but between 1985 - 86 and 1988 - 89 it rose again to 30% in the rural areas and 21% in the urban areas.

The Government has taken a number of measures to stimulate the economy and in macro-economic terms it has been very successful. Between 1990 and 1992, it reduced the fiscal deficit as a proportion of GDP, from 7.8% to 5.2% and the current account deficit fell from 6.9% to 2.3%. Over the same period, inflation fell from 9.3% to 5.1% and by the end of 1993 was down to 1.3%. This kind of stabilization lays an essential foundation; now the challenge is to build the framework of a more productive and dynamic economy.

The Government is also financing more of its own development expenditure. Until recently the Annual Development Plan was entirely financed from aid; now the Government contributes around 25%.

The Government has taken a number of useful measures to stimulate the private sector. The Government has liberalized some elements of its macro policy framework, and has developed an inter bank foreign exchange market. Bangladesh's nominal rates of protection are roughly double those of the successful countries of East Asia.

Fisheries Sector

Fisheries

Agriculture is the main occupation, employing 68.5% of the labor force. This sector directly contributes around 35% to the GDP. Bangladesh is rich in fish resources. The fisheries sector plays a very important role in the socio cultural and economic life. In 1992 - 93, the fisheries sector contributed 4.2% to the GDP. Within the agricultural sector, fisheries accounted for 13.8% and export earnings amounted to Taka 7 003 million equal to about 7.6% of the country's total export earnings. In 1997 - 98, export earnings amounting to Taka 13 878 million constituted about 5.9% of the country's total export earnings (DOF 1999). Although the quantities are low, fish provides about 80% of the total animal protein intake.

Infrastructure

Fish Landing Facilities

Fishers operating small traditional craft usually

land their catch on the coast. Most places do not have facilities for berthing, ice and chilling. The fish traders usually transport ice from distant places and often the use of ice is not adequate. A large number of fish traders own motorized fish transportation boats wherein they carry ice and collect catches from the fishers operating in rivers and estuaries. These traders bring collected fish to landing centers in large cities. Most of the traditional boats fish inshore and stay out for one or two days and do not use ice to preserve the fish.

The Bangladesh Fisheries Development Corporation (BFDC) operates six fish landing centers in the coastal districts, at Chittagong, Cox's Bazar, Khulna, Barisal, Patherghata and Khepupara, and four fish landing centers in the inland districts, at Ranagamati, Kaptai, Rajshahi and Daborghat. All these centers are provided with landing platforms, auction halls, ice plants, cold storage, drinking water and accommodation for fish traders. The only fish harbor in the country developed by BFDC is located at Chittagong, near Chittagong port, on the north side of the Karnaphuli River. The facilities of this harbor include a spillway to accommodate vessels up to 35 m, a warehouse, workshop, boat building yards and ancillary facilities, an ice plant, cold storage, freshwater supply, auction hall and a fish meal plant. It also houses a Marine Fisheries Training Institute to train personnel for fish trawlers. At present the berthing facilities have become very limited owing to heavy siltation of the harbor mouth and basin due to erosion of the left bank of the river and regular dredging is required. Fishers' co-operative societies also operate a major fish landing center in Chittagong, but it has neither modern nor hygienic facilities. One such landing center is operated by an NGO (CARITAS) at Chittagong. Private fishing vessels use the mooring facilities, created by the Chittagong Port Authority in the midstream of the Karnaphuli River. For using these facilities the boat owners have to pay a charge of US$ 100 per day. Some private trawler companies have their own landing facilities.

Ice-making and Cold Storage Facilities

There is no recent information on the supply of ice. In 1992 - 93 there were 217 ice plants (block and flake) with a combined daily capacity of 4 405 t, located in the coastal districts of Chittagong, Barisal, Cox's Bazar, Patuakhali, Pirojpur, Khulna, Bagerhat and Noakhali.

The supply of ice is limited, particularly during the peak fishing season, and the supply of ice is generally adequate in only 8 out of 18 wholesale markets. Shortage of ice during the peak season is reflected by the price charged. In Chittagong, prices varied between Taka 10 and Taka 330 for a 125 kg block, depending on demand.

Other Infrastructure Facilities

These include two dock-yards, 7 fish/shrimp training centers, 113 fish hatcheries, 1 public and 43 private shrimp hatcheries, 4 private fish meal plants, 5 public and 31 private prawn hatcheries; 2 public shrimp demonstration farms, 20 public shrimp service centers, 7 fisheries research stations or substations and 1 public surveillance check point.

Fish Processing Plants

There are 123 fish processing plants, of which 87 are located in the coastal districts of Chittagong, Cox's Bazar, Khulna, Satkhira, Bagerhat and Patuakhali. For all these plants, a total requirement of around 156 000 t of raw materials is needed, but only about 22 000 t are available and these processing plants are utilizing only 13 - 15% of their capacity. Only 40% of the plants are currently operational at that capacity level and the others have either closed down their operations or are have been declared as "sick industries".

Boat-building Facilities

Construction of traditional boats is carried out at many places along the coast. Four boat-building yards are owned and operated by the private sector and are located at Anowara, Kalurghat and Patharghata in Chittagong and in Cox's Bazaar. The boats constructed in these yards range in size from 9 m (22 hp) to 16 m (110 hp). There are eight engine repair workshops near the landing terminals, six owned by BFDC, one owned by the Christian Council for Development of Bangladesh (CCDB) at Cox's Bazar and one owned by Bangladesh Jatio Matshyajibi Samabay Samity (BJMSS) at Chittagong.

Net-making Facilities

Most of the nets used by small scale fishers are hand-braided by the fisherfolk. BJMSS owns and operates a net factory at Chittagong which produces 27 000 kg of nylon nets per year. The other net factory is located at Comilla and is owned and

operated by BFDC which has an installed capacity of 41 000 kg of nets. Two new net factories, each with a production capacity of 100 000 kg•year^{-1}, are under construction by BFDC at Chittagong and Khulna.

Fishers and Fishing Households

Fishers belong to the poorest of the poor in Bangladesh. They are mostly illiterate. Since fishing is considered to be a low-class profession, fishers are looked down upon socially. The fishing communities are not conscious of their rights and are not well organized, because they lack both education and leadership. They harvest fish at the risk of their lives even in inclement weather. Family members depend fully on the head of the family, but many of them are only part-time fishers. A few of the fisher families earn a secondary income from poultry, vegetable gardening and fish farming.

Artisanal fisheries range from localized subsistence fishing to intensive mobile fishing operations using simple craft and traditional gear. Seasonality and unstable catch composition are characteristics of the capture fisheries. Inadequate infrastructure and supporting service and lack of proper marketing and distribution, also contribute to high variations in activity.

Traditionally, marine fishing was practiced at a subsistence level by the *jaladas* of the Hindu community. However, with the increased commercialization of marine fisheries and the decrease in land assets because of population pressure, a large number of Muslim fishers took up fishing as a full-time job. Most of the motorized small scale fishing boat owners are now Muslims who hire Hindu or Muslim fishermen as crew, mostly on a catch-share basis. The profit-sharing arrangement varies from area, the type of fishery and the fishing season. For instance, in Chittagong and Cox's Bazar, 60% of the value of catch, after covering the operational cost, goes to the boat and gear owner. The remaining 40% is distributed among the hired crew, the share of each crew member depending on the type of functions performed. These may include catching, drying, transporting and support services such as cooking (Hannan 1996).

Fishing is a major economic activity in the coastal areas. Considerable changes have taken place in the traditional structure of fisheries, with many Hindu fishers migrating to India over the last decades. This, in conjunction with increased population pressure and steady contraction of fisheries resources, has resulted in significant changes in the social groups involved in fisheries.

In 1974 - 75, a survey indicated that 250 000 people were engaged in marine and estuarine fisheries. In 1980 - 81 the total number was estimated at 412 000 while in 1983 - 84 the number was estimated at 515 000, indicating an annual increase of 8%. However, the numbers are confusing because the marine fishing village survey of 1983 - 84 found 105 000 active fishers in the coastal area (Draft Master Plan 1998).

A major problem of the different surveys is the definition of "fishers" and it is likely that sometimes "fishers" and the "total household of a fishing family" are mixed up. This is illustrated in Table 4a, where the results of the marine fishing villages survey of 1983 - 84 are summarized. The total number of households with fishing as a major occupation was estimated at 60 500, comprising about 360 000 family members. The active number of fishers from these households, however, was estimated at 105 000 using 15 000 boats. The largest numbers of fishers are living in Chittagong, Cox's Bazar and Laksmipur district.

A comparison of villages or *thanas* surveyed in 1983 - 84, 1990 and 1997 are presented in Tables 4b and 4c. The average annual increase of different parameters is shown in Table 4d.

In 1984 - 85 a survey indicated that 123 562 fishers were engaged in marine artisanal fisheries, and the total number of coastal households was estimated at 70 193. This is shown in Tables 5 and 6 (DOF 1985).

According to the Bureau of Statistics the number of fishers in the coastal region was 507 788 and in the inland waters 768 632 in 1988 - 89. The yearly statistics of fishers in the inland and the other sectors from 1972 - 73 to 1988 - 89 are given in Table 7.

Table 4a. A summary of the results of the marine fishing village survey in 1983 - 84.

District	Marine village HH	Marine village population	Fishing HH	Fishers	Boats	Fishing HH in marine village (%)
Barisal	4 531	25 096	113	177	44	249
Bhola	24 193	85 415	3 176	3 999	417	1 313
Borguna	28 375	159 675	3 389	6 135	924	1 194
Chittagong	102 365	6,4 462	18 191	31 344	5 694	1 777
Cox's Bazar	87 572	585 156	15 980	28 831	2 869	1 825
Feni	8 104	49 291	442	605	30	545
Jhalakati	14 119	70 710	756	1 511	254	535
Khulna	11 479	69 210	1 484	2 668	846	1 293
Laksmipur	18 052	102 358	5 376	12 502	1 276	2 978
Noakhali	35 271	199 818	6 349	7 937	944	1 800
Patuakhali	33 010	185 773	3 177	6 324	991	962
Pirojpur	19 854	113 338	1 668	2 834	567	840
Satkhira	3 217	18 803	162	300	60	504
TOTAL	390 142	2 309 105	60 263	105 167	14 916	1 545

Source: Draft Master Plan 1998.
Note: HH = households

Table 4b. Comparison of frame survey results for marine fishing villages, 1984 and 1990.

Thana name & survey year	Fisher households	Total fisher household members	Total fishers	Fisher households (%)	Fishers (%)	No. of boats
Pathuakhali - 1983	1 180	6 844	1 886	2.0	1.0	435
Patuakhali - 1990	3 182	22 274	4 773	6.0	2.0	N/A
INCREASE (fold)	2.70	3.25	2.53	3.0	2.0	
Mirzaganj - 1983	232	1 392	316	1.0	0.0	91
Mirzaganj - 1990	988	5 928	N/A	5.0	N/A	N/A
INCREASE	4.26	4.26		4.7		
Kalapara - 1983	435	2 610	726	2.0	1.0	163
Kalapara - 1990	2 293	20 840	N/A	9.0	N/A	961
INCREASE	5.27	7.98		5.0		5.9
Galachipa - 1983	1 066	6 289	2 861	3.0	1.0	302
Galachipa & Dasmina -1990	6 848	41 082	N/A	17.0	N/A	1 380
INCREASE	6.42	6.53		6.4		4.6
Barguna - 1983	739	4 360	1 333	2	1.0	192
Barguna - 1990	675	4 050	N/A	2	N/A	N/A
INCREASE	0.91	0.93		0.9		

Table 4b. Comparison of frame survey results for marine fishing villages, 1984 and 1990. (continued)

Thana name & survey year	Fisher households	Total fisher household members	Total fishers	Fisher households (%	Fishers (%)	No. of boats
Patharghata-1983	1 851	11 106	3 336	9.0	3.0	477
Patharghata-1990	3 930	23 580	5 700	20.0	5.0	N/A
INCREASE	2.12	2.12	1.71	2.22	1.7	
Bamna-1983	348	2 018	643	16.0	5.0	119
Bamna-1990	190	1 140	N/A	2	N/A	206
INCREASE	0.55	0.56		0.10		1.7
Betagi-1983	210	1 197	419	3.0	1.0	47
Betagi-1990	1 200	6 642	N/A	7.0	N/A	235
INCREASE	5.71	5.55		2.2		5.0
AVERAGE ANNUAL INCREASE	0.54	0.61	0.21	2.68	0.2	0.7

Source: Draft Master Plan 1998.
Note: N/A = Not available.

Table 4c. Comparison of frame survey results of marine fishing villages, 1984 and 1997 - 98.

	Char Montaz	Nijum Deep	Bara Baishia	Vhar Majid	Kukri Mukri	Urir Char	Avg. annual increase
No. HH 84	121	99	221	N/A	542	497	
No. HH 97	288	1083	150	720	935	2031	
% increase	2.38	10.9	0.7		1.72	4.09	0.30
Tot Pop 84	883	721	1381	N/A	2875	3828	
Tot Pop 97	2081	5719	921	4241	4936	10195	
% increase	2.36	7.93	0.7		1.72	2.66	0.24
No. fish HH 84	45	81	136	N/A	N/A	N/A	
No. fish HH 97	107	569	33	7	168	63	
% increase	2.39	7.02	0.24				0.25
% fish HH 84	37	82	62	N/A	N/A	N/A	
% fish HH 97	37	53	22	1.0	18.0	3.0	
% increase	1.0	0.6	0.36				0.05
Fishers 84	65	131	290	N/A	N/A	N/A	
Fishers 97	298	824	65	20	452	87	
% increase	4.9	6.3	0.23				0.28
Boats 84	25	11	31	N/A	N/A	N/A	
Boats 97	76	N/A	N/A	N/A		N/A	
% increase	3.0						0.23

Source: Draft Master Plan 1998.
Note: N/A = Not available.

Table 4d. The average annual increase in population, fishers and fishing boats in the coastal belt, 1984 - 98.

	Annual increase ratio	Increase since 1984
No. of households	0.30	4.27
Total population	0.24	3.30
No. fishing households	0.44	6.20
Total Fishers	0.25	3.47
Total boats	0.47	6.65

Source: Draft Master Plan 1998.

Table 5. The number of marine artisanal fisher in households villages 1984 - 85.

District	No. of Marine fishing villages	No. of Marine fisher households				No. of Joint Management Units
		Total	Fishery management households		Fishery laborer households	
			with boat	without boat		
Bangladesh	869	70 193	12 442	7 317	50 434	1 744
Chittagong	171	21 101	4 621	2 667	13 813	253
(CTG. South)	(104)	(15 521)	(2 551)	(1 789)	(11 181)	(232)
(CTG. North)	(67)	(5 580)	(2 070)	(878)	(2 632)	(21)
Cox's Bazar	251	21 545	2 242	1 799	17 504	746
Noakhali	64	10 714	1 525	1 236	7 953	228
Borisal	137	8 059	1 673	753	5 633	219
Patuakhali	200	7 128	1 639	622	4 867	297
Khulna	46	1 646	742	240	664	1

Source: Survey results of 1984 - 85, FRSS (Fisheries Resources Survey System) DOF.

Table 6. The number of marine artisanal fishers and fishing boats in 1984 - 85.

District	No. of Marine Fishers				No. of Marine Fishing Boats		
	Total	Fishery management households		Fishery laborer households	Total	With engine	Without engine
		with boat	without boat				
Bangladesh	123 562	21 172	11 189	91 201	17 331	3 317	14 014
Chittagong	36 623	6 886	3 614	26 123	6 400	1 128	5 272
(CTG. South)	(24 804)	(2 267)	(1 749)	(20 788)	(3 785)	(1 114)	(2 671)
(CTG. North)	(11 819)	(4 619)	(1 865)	(5 335)	(2 615)	(14)	(2 601)
Cox's Bazar	39 829	3 636	3 143	33 050	3 911	1 822	2 089
Noakhali	17 350	2 169	1 762	13 419	2 039	179	1 860
Barisal	12 616	2 810	1 091	8 715	1 933	81	1 852
Patuakhali	14 176	4 383	1 113	8 680	2 142	98	2 044
Khulna	2 968	1 288	466	1 214	906	9	897

Source: Survey results of 1984 - 85, FRSS DOF.

Table 7. Number of fishers in Bangladesh during the period from 1972 - 73 to 1988 - 89

Year	Fishers		
	Inland	Marine	Total
1972 - 73	650 000	210 000	860 000
1973 - 74	660 000	220 000	880 000
1974 - 75	600 000	200 000	800 000
1975 - 76	600 000	200 000	800 000
1976 - 77	618 000	206 000	824 000
1977 - 78	709 000	290 060	999 060
1978 - 79	716 970	312 000	1 028 970
1979 - 80	723 781	334 000	1 057 781
1980 - 81	695 000	411 995	1 106 995
1981 - 82	700 500	439 669	1 140 169
1982 - 83	705 950	456 950	1 162 900
1983 - 84	707 000	463 000	1 170 000
1984 - 85	715 000	450 000	1 165 000
1985 - 86	719 000	475 000	1 194 000
1986 - 87	735 177	485 687	1 220 864
1987 - 88	751 718	496 615	1 248 333
1988 - 89	768 632	507 788	1 276 420

Source: BBS 1997.

During the short winter season, fishers migrate along the coast, i.e. from Chittagong district to the Sunderban region (Dubla) and from the adjacent *thanas* of the Sunderbans. Many of the fishers of the Chittagong district switch to river fishing during the off-season.

Professional, Business and Industry Groups

The fisheries sector employs about 1.2 million people who are directly or indirectly dependent on fishing, fish farming, fish processing, etc., which is about 10% of the total population of the country (Hussain 1995). About 685 000 are inland full-time fishers, 412 000 are marine fishers, about 5 - 6 000 are in the processing industry (both regular and casual) and about 87 000 are in shrimp farming, fry collection, crab and frog collection, dry and dehydrated fish industry and in fish carrier boats.

In 1995, about 60% (768 000) of fishers were in inland fisheries. In inland capture fisheries, the number of fishers increased by 6% from 1979 - 80 to 1988 - 89, but in the same period the marine fishers increased by 50% (Islam 1995).

Marine fisheries are dominated by small scale fishers. They contribute about 96% of the total marine catch and employ 497 000 full-time and 252 500 part-time fishers (Chong et al. 1991).

Institutional and Legal Framework

Fisheries-related Policies

The Constitution

The Constitution provides for an unicameral legislature, which is called Jatiya Sangsad. It consists of 300 members directly elected by adult franchise. The members of Jatiya Sangsad elect another 30 female members. Jatiya Sangsad is the national parliament and is vested with all powers under the Constitution to make laws for the country.

Legislation

Various laws have been enacted for the management and conservation of fish and fisheries. Much of the legislation was enacted during the British colonial period. Most of these laws have been amended to meet modern requirements.

Development Plans

The development of the fisheries sector is undertaken through five-year plans. The Fifth Five-year Year Plan (1997 - 98 to 2001 - 2002) targeted the following items for development:

- Socioeconomic development of fisher folk;
- Open water fisheries development;
- Shrimp culture development in both fresh and brackish water;
- Intensive fish culture development;
- Management and conservation of open inland fisheries and marine fisheries;
- Strengthening of extension service;
- Strengthening of the Fisheries Resources Survey System (FRSS);
- Strengthening of fish inspection and quality control services;
- Development of unexploited fisheries.

The first five-year plan (FFYP 1973 - 78) was developed by the Planning Commission in November 1973. This was followed by a two-year plan (TYP 1978 - 80). The second (SFYP), third (TFYP) and fourth (FFYP) five-year plans were implemented during 1980 - 85, 1985 - 90 and 1990 - 95, respectively. The broad objectives and targets of all the development plans have been similar i.e. increasing fish production for domestic consumption and export, generating employment opportunities, improving socioeconomic conditions of fisher folk and conserving the resources. Fish production targets of the plans are given below.

Plans	Target '000 t	Production achieved '000 t
FFYP (1973 - 78)	1 020	643
TYP (1978 - 80)	808	646
SFYP (1980 - 85)	1 000	774
TFYP (1985 - 90)	1 000	856
FFYP (1990 - 95)	1 200	1 173
TYP (1995 - 97)	1 370	1 307
FiFYP (1997 - 02)	2 075	–

The financial allocation for fisheries development during the plans has always been inconsistent with

the present contributions and further development potential. The rate of utilization of funds available has also been low, as shown below:

Plan	Allocation (Taka in million)	Actual utilization (Taka in million)	% Utilization
FFYP (1973 - 78)	485	190	39
TYP (1978 - 80)	440	386	88
SFYP (1980 - 85)	1 743	1 583	90
TFYP (1985 - 90)	3 500	1 400	40
FFYP (1990 - 95)	7 500	3 000	40
FiFYP (1997 - 02)	5 862	–	–

The main objectives of the Fifth Five-year Plan (FiFYP) were to develop and strengthen fisheries research and development and management and extension activities aimed at increasing fish production with the following objectives:

- To increase fish production and improve nutritional level;
- To generate additional employment opportunities in fisheries and ancillary industries to help poverty alleviation;
- To improve the socioeconomic conditions of fisher folk, fishers, fish farmers and others engaged in the fishery sub sector;
- To increase export earning from shrimp, fish, fish products and GD;
- To improve environmental conditions and public health;
- To improve the biological and institutional management mechanisms for judicious use of fisheries resources; and
- To strengthen research, extension, management and coordination in order to transfer technology and encourage production activities in the private sector and to ensure sustainable development of fisheries resources, particularly utilizing the water resources of the vast flood plains.

Open-water Fisheries Development

Bangladesh has vast inland open water resources. In order to increase production three strategies were planned. These were: (i) to conserve resources through rigorous implementation of Fish Acts and Ordinances and through motivation of fishers; (ii) to establish fish sanctuaries; and (iii) to increase production by massive stocking of fast-growing carp. Construction of fish passes in flood control and irrigation embankments was also planned.

Closed-water Culture Fishery Development

There are over 1.3 million ponds covering an estimated area of 147 000 ha, some 6 000 ha of ox bow lakes and over 130 000 ha of shrimp farms. The production of freshwater ponds is only 1.4 $t \cdot ha^{-1}$ and of brackish water shrimp farms only 160 $kg \cdot ha^{-1}$. Experimentation by the Fisheries Research Institute and demonstration by the Department of Fisheries has shown that pond production can be increased up to 3.7 $t \cdot ha^{-1}$. If successful, planned extension programs could increase the present pond production from 195 000 t to at least 600 000 t in a 10-year period.

Brackish Water Aquaculture Development

There are an estimated 143 000 ha of coastal land under brackish water shrimp culture. The strategy for development of this sub-sector is to improve the infrastructure, ensure quality seeds, feeds and other inputs, ensure security and provide technical advice and training for the farmers on improved scientific farming systems. With better support and increased resources, a level of production of 400 $kg \cdot ha^{-1}$ can be realized. Semi-intensive farming areas identified will be developed with appropriate inputs.

Marine Fisheries Development

Marine fisheries resources have been under pressure from over-fishing in some areas particularly the inshore and the coastal areas. The detrimental effects of estuarine set bag nets and shrimp larval collection nets have to be reduced through motivation, awareness building and by providing the fisher folks with alternate income sources. Although the demersal stocks are considered to be over-fished, the pelagic resources, such as tuna, tuna-like fish and sharks, are still under-exploited in some areas. Many non-traditional resources like seaweeds, oysters, clams, squids and cuttlefish have scope for expansion. Trash fish, which is discarded by the commercial shrimp trawlers, could be utilized if appropriate uses could be found.

Post-harvest Technology and Marketing

It is believed that 30 - 33% of all fish caught becomes unfit for human consumption. This economic waste could be reduced by better handling, processing, transportation and marketing. The appropriate infrastructure facilities, such as cold storage, ice plants, insulated and refrigerated systems and markets, have to be built and appropriate training provided to reduce these losses. The marketing system must be adjusted to expanding export demand for quality frozen fish, expanding domestic demand for quality fresh and frozen fish and coping with large seasonal fish catches in areas far from the main markets and fish landing centers.

Peoples' Participation in Fisheries Development

Fisheries development is the result of the concerted effort by governmental, non-governmental and private organizations, fisher folk and fish traders. A strong and effective linkage system must be developed among these parties for implementation of a participatory plan for fisheries development. Participation is recognized as an essential part of the planning and development process, which helps to increase access to and maximize the utilization of services. Therefore, participatory planning that has been started recently should involve the members of communities of fishing, farming, trading, marketing and who, as a community, know and accept responsibility for their own development. They will develop their own resources to meet their needs. This requires personal as well as government endeavor, institutions and organizations. The primary focus is to put the people in control of their own problems, resources and activities accordingly to their priorities.

The major constraints are:

- Flood control and irrigation embankment are reducing the available habitat of fish and shrimp and are obstructing their migratory routes and destroying their breeding habitat.
- Pond culture developments are affected by multi-ownership and multiple uses of ponds, and also by lack of technical knowledge and necessary inputs.
- Unplanned brackish water shrimp culture is responsible for mangrove destruction, and is creating conflicts among the paddy farmers and shrimp farmers. The problem of disease and lack of proper infrastructure and necessary materials is hampering its overall development.
- The marine fisheries sector is constrained by the lack of manpower and infrastructure facilities. There is also lack of proper management policy. Many under-utilized and unutilized resources are not being exploited due to the lack of appropriate technology and technical knowledge.
- Pollution from pesticides and agricultural wastes are destroying the ecology of fish habitats and reducing the natural recruitment of fish and shrimp.

Administrative Orders, Regulations and Ordinances

There are many ordinances governing the management and conservation of the fisheries resources in the country (See Appendix I). Most of them are concerned with the freshwater fishery resources. The most comprehensive legislation dealing with the management and conservation of the marine fisheries resources are the Marine Fisheries Ordinance and the Marine Fisheries Rules.

National and Sub-national Fisheries Institutions

Fisheries Administration and Agencies

The formulation of policies on fisheries management remains primarily under the control of the Ministry of Fisheries and Livestock headed by a Cabinet Minister. The major responsibilities of the Department are as follows:

- Assisting the Ministry in formulation of policies on fisheries management and development.
- Surveying and estimating of available resources.
- Management and conservation of fisheries resources, including enforcement of fisheries legislation, rules and orders.
- Formulation and execution of fisheries development projects.
- Demonstration, extension, technology transfer and training related to aquaculture and fisheries management.
- Ensuring quality of exportable fisheries products and issuing certificates in accordance with fish inspection and quality control rules.
- Monitoring of artisanal and marine industrial fisheries, including surveillance of fishing operations in coastal waters.

The existing organizational structure of the DOF is based on the findings and recommendations of a Committee named the "Matin Committee". The DOF is headed by the Director General, who is supported by three Directors; one for marine fisheries, one for inland fisheries and another for the Fisheries Training Academy, Savar, in Dhaka. The Director (Marine) takes care of all functions of marine resources surveys, enforcement of laws and licensing. The Director (Inland) is responsible for administration, finance, training, fish culture, extension activities and management of field offices. He also looks after completed field based projects included in the revenue budget. There are two Principal Scientific Officers, one for the Fisheries Resources Survey System (FRSS) and another for Quality Control.

The field level set-up consists of Deputy Directors in five Divisions, Marine Fisheries and Quality Control Officers, 64 District Fisheries Officers and 456 *Thana* Fisheries Officers. In addition there are 103 Farm Managers and other officers in the Training Institute and the Marine Survey and Management Unit.

The total staff of the DOF under the revenue budget is 3 863. The Marine Wing of DOF is located in Chittagong. According to provisions of the Marine Fisheries Ordinance and Marine Fisheries Rules, the Marine Wing of the DOF issues licenses and monitors operations of fishing vessels. In addition to the Ministry of Fisheries and Livestock, other ministries or agencies directly or indirectly involved in fishery activities are the Ministry of Lands, for leasing of public open water bodies or *jalmahals*; the Ministry of Industries for licensing and promotion of fish processing industries and trawler industries; the Ministry of Commerce for export of fishery products and import of fishery equipment; the Ministry of Irrigation Water Development and Flood Control for the development for embankments and water control; the Ministry of Local Government and Rural Development for registration of fishers' cooperative societies and the Ministry of Environment and Forest for management of water bodies within the Sunderbans Forest Reserve and conservation of mangrove ecosystems.

Mandate of DOF

This covers the following:

Transfer of technology:

- Extension services on aquaculture and management.
- Training and advisory services on aquaculture and management.
- Advisory services to provide credit for fisheries.
- Dissemination of modern technology on aquaculture, fisheries management and hatchery operations.

Conservation of fisheries resources:

- Enhancement of fisheries through conservation and management of fisheries resources.
- Enhancement of fisheries rules and regulations.

Quality control of fish and fishery products:

- Ensuring quality of fish and fishery products and issuance of health certificates for exportable fish products.
- Enforcement of inspection and quality control rules for fish and fish products.

Others:

- Advising the Government in the formulation of policies related to fisheries.
- Collection of data on the fisheries and their compilation, editing and publication.
- Planning, formulation, implementation, monitoring and evaluation of fisheries development projects.
- Socioeconomic uplift of fishing communities.
- Poverty alleviation through fisheries activities.

Other Fisheries Institutions

Bangladesh Fisheries Development Corporation (BFDC)

The BFDC was established in 1964 with a view to promoting the fishing industry, particularly in the marine sector. Activities of the Corporation include the following:

- operating a number of fish and shrimp trawlers.
- managing some large water bodies, such as Karnaphully Reservoir (68 800 ha), the canal and Gulsan Lake.
- undertaking marketing of fish in Dhaka by transporting fish from Chittagong, Rangamati, Cox's Bazar, Jossore and other places.

- operating wholesale fish markets and sale centers in Dhaka and other cities.
- processing shrimp and finfish and undertaking limited export of products.
- operating a number of fish landing centers and three fish net factories.

Fisheries Research Institute (FRI)

The FRI was established in 1984 as an autonomous body under the administrative control of the MOFL. The mandate of FRI is to plan and undertake adaptive research programs for inland, coastal and marine fisheries and develop suitable technology for use of fish farmers and fisheries managers. The Institute has research facilities at four stations, namely the Freshwater Aquaculture Station at Mymensingh, the River Research Station at Chandpur, the Brackish water Station at Paikgacha and the Marine and Technology Station at Cox's Bazar.

Marine Fisheries Academy (MFA)

The academy was established in 1973 to develop qualified manpower such as skippers, gear technologists, engineers and fish processors for the fishing trawlers. At present, the Academy works under the direct control of the MOFL.

Other Institutions Involved in Fisheries and Coastal Zone Management

Fisher Folk's Organizations

There are three fisher folk's organizations in Bangladesh, as shown below:

- Bangladesh Jatio Matshyajibi Samabay Samity (BJMSS) established in 1960.
- Bangladesh Jatio Matshyajibi Samity (BJMS) established in 1986.
- Bangladesh Jatiotabadi Jele Dal (BJJD) established in 1993.

The last two societies were established at the national level under different governments. These societies do not have access to societies at the field level. The BJMSS is the apex society registered with the Department of Cooperatives, which has 88 central and 4 243 primary societies.

Non-governmental Organizations (NGOs)

Many NGOs are working with the fisher folk in the inland and marine sectors. Most of the NGOs in the coastal areas are engaged in socioeconomic development. They mostly work to improve living standards by educating people on sanitation, health and nutrition and also providing them with some facilities. Many provide fishers with credit for engaging in fishing or other non-fishing activities. The notable NGOs working with the coastal fisher folk are CODEC, CARITAS, ASA and OXFAM. The NGOs working with the coastal fisher folk have formed an organization called COFCON to coordinate development activities in coastal areas.

Involvement of Agencies

The involvement of different agencies in the administration, management and development of fisheries is shown in Figure 2.

Financing Institutions Relevant to Fisheries Activities

Donors like IDA (Institute of Defense Analysis), ADB (Asian Development Bank), UNDP (United Nations Development Programme), FAO (Food and Agricultural Organization), DfID (Department for International Development), IFAD (International Fund for Agricultural Development), Danida (Danish Development Assistance), CARE (Co-operative for American Relief Everywhere), EU (European Union), USAID (United State Agency for International Development), CIDA (Canadian International Development Agency) and the Ford Foundation are involved in Bangladesh's fisheries sector with the stated aim of increasing fish production and improving fisheries management. These donors fund studies, research, institutional development and pilot activities. They show concern for the rights of the fishers and their role in management. Among the donors, the World Bank takes the leading role.

The financial banks are also related to fisheries as they advance loans for fish culture activities. Many banks also fund shrimp culture and the fish processing industry. The notable banks are the Khrishi Bank and the Sonali Bank.

Ministry	Department / institution	Involvement
Ministry of Fisheries and Livestock (MOFL)	Department of Fisheries (DOF)	Administration, management and development, extension and training, conservation of resources, enforcement of fishery laws.
	Bangladesh Fisheries Development Corporation (BFDC)	Exploitation and marketing
	Fisheries Research Institute (FRI)	Research, training and extension.
Ministry of Land (ML)	Land Administration Board (Land Reforms Division)	Leasing of public water bodies above 20 acres.
Ministry of local Government Rural Development and Co-operatives (LGRDC)	Bangladesh Rural Development Board (BRDB)	Fisheries component of integrated rural development.
	Registrar of Co-operative Societies	Registration and supervision of fisher's co-operative societies.
	Bangladesh National Fishermen's Co-operative Societies (BJMSS)	Operation of ice-plants import of fishing gear.
	Co-operative Banks	Financing of fisher's co-operatives.
	District parishad	Management of water bodies above 20 acres.
	Thana parishad	Management of closed water bodies below 20 but above 3 acres.
	Union parishad	Management of water bodies below 3 acres, and with rent earlier fixed at Taka 5000 (as of February 1987).
Ministry of Irrigation, Water Development and Food Control (MIWDFC)	Bangladesh Water Development Board (BWDB)	Leasing of reservoir and irrigation channels.
Ministry of Forest and Environment (MFE)	Forest Department (FD)	Exploitation and control of Sundarban-based fisheries loan.
Ministry of Finance (MF)	Bangladesh Krishi Bank (BKB)	Administration of fisheries loan.
	Commercial banks	Administration of fisheries loan.
	Economic Relations Department (ERD)	Administration and co-ordination of foreign assistance for fisheries development.
Ministry of Planning	Planning Commission (planning)	Project evaluation and approval.
Ministry of Shipping	Mercantile Marine Department	Registration of fishing vessels/boats.
Bangladesh of Transport and Communication (BT and C)	Bangladesh Railway (BR)	Leasing of reservoirs and canals on railway land.
Ministry of Defense (MD)	Bangladesh Navy (BN)	Leasing of water bodies in the naval area: Patrolling Exclusive Economic Zone (EEZ) to prevent intrusion of foreign fishing vessels.
Ministry of Commerce (MC)	Department of Commerce	Leasing of fish processing plants.
Ministry of Foreign Affairs (MFA)	EEZ of Bangladesh	Exclusive Economic Zone (EEZ) negotiations.
Ministry of Education	Bangladesh Agricultural University	Higher fisheries education; extension and training.
	Other universities	Fisheries-related education.
NGO affairs Bureau	Various non-governmental organisation (NGOs)	Development activities in the fisheries sector by arrangement with other agencies.

Fig. 2. Involvement of Government of Bangladesh agencies in administration management and development of fisheries.
Source: Kutty et al. 1991.

Research and Training Facilities and Opportunities

Apparently, the marine sector has been a lower priority area in the fisheries development program. Before starting commercial exploitation by deep sea trawlers and mechanized boats, several surveys were conducted in the Bay of Bengal starting in 1958, to evaluate the abundance and promote the exploration of marine fishery resources. The most important findings obtained from the various surveys were as follows:

- Identification of the major fishing grounds in Bangladesh marine areas, covering an area of over 16 000 km^2.
- Identification of shelf area of over 40 000 km^2 and estimation of fishery biomass at depths ranging from 10 to 200 m.
- Estimation of the standing stock and MSY of demersal fish and shrimp.

However, to date no proper assessment of pelagic resources has been made.

The Marine Fisheries Research, Development and Management Project at Chittagong, with a substation at Cox's Bazar, was functional under FAO/UNDP assistance during 1984 - 85, when assessments of demersal stocks were done. During the second phase of the project, aspects of artisanal fisheries were studied with technical and financial support from the Bay of Bengal Programme. The resource survey component of the DOF, provided data to compile the official fishery statistics. However, these are qualitatively and quantitatively unsatisfactory and need to be improved. The former Marine Fisheries Survey Project of the DOF also carried out similar programs and undertook research studies in a particular area for only as long as necessary to acquire data for some intended stock assessment. However, complete baseline information on the different parameters of the marine fisheries is lacking.

The Fisheries Research Institute (FRI) was established in 1984 with four research stations; the Freshwater Station at Mymenshingh, the Riverine Station at Chandpur, the Brackish water Station at Paikgacha, Khulna and the Marine Fisheries and Technological Station (MFTS) at Cox's Bazar. The Marine Station was based in the compound of the former Marine Fisheries Research and Development Project. As a government policy decision, the facilities, man power and equipment of that project were to be transferred to the FRI to initiate marine fisheries research in the country. However, this did not happen as planned and the DOF handed over only a part of the building and the staff quarters to the FRI in 1991. The FRI then initiated establishment of its station (MFTS) with limited research activities on mariculture of shrimp and finfish, planktonic mass culture, Artemia biomass production, transportation of live shrimp and the development of fish and shrimp feed formulation. Unfortunately because of lack of personnel, funding and facilities, no research could be undertaken on productivity, stock assessment and catch monitoring.

Training

The Department of Fisheries operates three training institutes for training of fisheries workers and fish farmers and one training academy for in-service training of governments officers. Officers also get foreign training offered by various developed countries, but the officers are not always posted to the sectors for which that they are trained. Government fisheries officers need more training in order to understand fish stock assessment and management.

Coastal Capture Fisheries in Focus

Capture Methods by Sector

Fishing Craft

Fishing operations in the estuaries and coastal waters used to be carried out by traditional craft until the mid - 1960s. From 1966, two organizations, namely the Bangladesh Fisheries Development Corporation (BFDC) and the Bangladesh *Jatio Matshyajibi Samabay Samity* (BJMSS) started the process of mechanization by importing and introducing marine engines. A frame survey of traditional and mechanized boats was carried out by the Fisheries Resources Survey System (FRSS) of the Department of Fisheries (DOF) in 1984 - 85 and according to that survey a total of 17 331 boats were in operation in the marine artisanal fishery, of which 3 317 were mechanized. The distribution of these boats by District is given in Table 6. It is known that the number of boats has substantially increased since 1985, but no substantive data are available. According to an estimate by Nuruzzaman (1991), there were 20 000 traditional and 12 700 motorized boats in the estuaries and coastal waters.

More recently, the Coastal and Marine Fisheries Strengthening Project of the DOF reported a total of 50 530 artisanal boats, of which 28 700 are non-mechanized and 21 830 are mechanized, including 3 317 that are registered as mechanized boats.

Traditional Boats

Three types of traditional boats exist in the country. These are plank-built *dhingi, chandi* and *balam* (dug-outs). Characteristics of these boats are given in Table 8.

Mechanized Boats

Mechanized boats of 7 - 8 gross tonnage are powered by 9 - 33 hp engines and have 6 - 10 crew. Most land 2 - 3 t per 4 - 6 day trip.

Trawlers

In additional to the artisanal fishing fleet, commercial fishing is undertaken by a fleet of 44 shrimp and 15 finfish trawlers. Most of the shrimp trawlers are 30 - 40 m long with 450 - 750 hp engines and have 20 - 25 crew. They are mostly double riggers with cod-end mesh sizes of 45 - 50 mm. The shrimp trawlers operate around 180 days per year and land a daily average catch of 610 kg shrimp and 350 kg of white fish. The overall lengths of finfish trawlers range from 28 to 30 m. All are stern trawlers with cod-end mesh sizes of 60 - 65 mm.

Artisanal Fishing Gears

The major gear employed in the estuaries and coastal areas are gillnets, set bag net (SBN), trammel-nets, long-lines and beach seines. Some are operated by boat and some without boats. The types and numbers of gear in operation in the different areas during 1984 - 85 are given in Table 9.

Table 8. Characteristics of traditional and motorized fishing fleet of Bangladesh.

Type of boat	Length of craft (m)	Width (m)	Depth (m)	Number of crew	Propulsion	Cost ('000 taka)	Fishing gear used
A. Traditional							
Dinghi	6 - 7	1.0 - 1.2	0.9	1 - 2	Oar/sail	10 - 15	Gillnets/long lines
Chandi	10 - 15	1.4 - 1.8	1.0	7 - 15	Oar/sail	20 - 30	Gillnets
Balam (medium)	10 - 15	1.5 - 2.0	1.2	10 - 15	Oar/sail	35 - 40	Gillnets
Balam (large)	15 - 20	2.0 - 2.5	1.2 - 1.5	20 - 30	Oar/sail	45 - 60	Gillnets/SBN*
B. Motorized							
Cox's Bazar type Modified	12 - 14	3.0 - 3.2	1.2 - 1.5	8	22 - 33 hp	140 - 180	Gill/SBN*
Cox's Bazar type *Chandi*	12	30	12	6	22 hp	–	Gill/SBN*
Chandi	12 - 13	1.6 - 1.8	1.0	10	9 hp	50 - 60	Gillnets
Longliner	6 - 7	1.0 - 1.2	0.9	6	10 - 15 hp	40 - 50	Long line

Source: Ameen 1987.
Note: * SBN = Set bag net.

Table 9. Type and number of gear in operation in the coastal district of Bangladesh in 1984 - 85.

Gear type District	Gillnet	Set bag net	Long-line	Cast-net	Seine-net	Misc.	Total
Chittagong	1 744	5 952	534	–	60	82	8 372
South	1 118	2 374	186	–	10	–	3 688
North	626	3 578	348	–	50	82	4 684
Cox's Bazar	1 964	2 346	1 115	1 342	346	109	7 222
Noakhali	1 234	461	88	8	24	–	1 815
Barisal	880	795	265	3	22	120	2 085
Patuakhali	1 059	1 500	70	–	10	–	2 639
Khulna	8	1 561	12	–	96	–	1 677
Total Number	6 889	12 615	2 084	1 353	558	331	23 810

Source: Survey results of 1984 - 85, FRSS DOF.

Gillnets

Gillnets include five different types, namely: drift, fixed, large, bottom-set and mullet gillnets. Most are drift gillnets with an average mesh size of 100 mm operated within 20 - 40 m depth and catch mostly *Hilsa*. Skipjack tuna, mackerel and shark are incidental catches. The nets are made of nylon twine and tire cord and are operated by mechanized boats. The large mesh (180 - 200 mm) gillnets are used for catching Indian salmon, sea bass and groupers (BOBP 1985). The number of gillnets in 1984 - 85 was 6 889 (DOF 1985).

Set Bag Nets

These are fixed nets with rectangular mouths that are kept open by two vertical bamboo poles. The nets taper from the mouth and end in a bag of fine (5 - 18 mm) mesh. There are two types, the estuarine set bag net (ESBN) and the marine set bag net (MSBN). In 1989 - 90 there were 12 561 ESBN (Islam et al. 1993) and 3 852 MSBN (Quayum et al. 1993). The ESBN are operated in depths of 3 - 10 m. The gear is considered destructive since it catches juveniles of a large variety of shrimp and finfish species. The marine set bag nets are large with a somewhat bigger mesh size and are operated during the dry season in 10 - 30 m from island bases and catch similar species to the ESBN, but mostly at pre-adult sizes.

Trammel-nets

These are three-layered bottom gillnets targeted at penaeid shrimp, but they also catch valuable finfish species. In 1989 - 90, 400 nets were in use (Islam and Khan 1993). Their operation is concentrated along the Cox's Bazar-Teknaf coast. The mesh size at the inner wall is 40 - 45 mm and the gear is ope-rated by row boats in 5 - 15 m.

Bottom Long-lines

Bottom long-lines are operated at 20 - 30 m, 20 km offshore, mainly from Cox's Bazar. About 2 084 units were engaged in coastal areas in 1985 (DOF 1985). They are operated by 6 - 16 hp mechanized boats. The targeted species are jewfish (croakers), but other species such as Indian salmon, catfish, threadfin and groupers are also captured.

Beach Seines

Beach seines are used throughout the country but are concentrated in the Teknaf-Cox's Bazar area. There were 558 nets in 1984 - 85 (DOF 1985). Since the mesh size is small (12 mm in the middle) and the area of operation is shallow, they mostly catch young and juvenile jewfish, anchovies, clupeoids and small shrimp.

Shrimp Seed Collection Gear

Fine-meshed push-nets, fixed bag nets and drag-nets are used in all areas for harvesting of post-larvae *Penaeus monodon*. In the process of collection, large numbers of the larvae and juveniles of other species of shrimp and finfish are destroyed. It was estimated by the DOF/BOBP survey between November 1989 and October 1990 that 292 397 people, including women and children, are involved in the collection of shrimp seed and 228 658 gear of different types are used in this fishery (Paul et al. 1993).

Catch and Catch Rates

Historical Catches and Landings

Fish production increased from 815 000 t in 1986 - 87 to 159 900 t in 1989 - 99. The fish production from different sources between 1990 - 91 and 1998 - 99 is given in Table 10.

Historical Effort Information

Motorized traditional boats: Marine fishing with motorized boats was practically unknown before 1960. Mechanization of fishing boats and fish carrier boats started in 1957 - 58 and was subsequently taken up through the co-operative sector and the Fisheries Development Corporation (Shahidullah 1983). In 1966 - 67 a FAO-Sida project began motorizing traditional Cox's Bazar type boats with 12 hp petrol outboard engines. Subsequently, these were replaced by inboard marine diesel engines of 15 - 35 hp. The boats are 12 - 14 m long and use mainly gillnets, but also operate *behundi* and/or *funda* nets (BOBP 1985). During 1 or 2 months of the year these boats stay on the Kalidaha fishing ground or off Dubla Island. They carry up to 100 gillnets with a total length of 1 400 m (Mohiuddin et al. 1980). The number of crew per boat is generally 8 - 10.

After independence the mechanization of fishing boats continued rapidly. From 1975 to 76, a modified Cox's Bazar type was built in a boatyard set up at Chittagong under a Danida-aided boat building and motorization project. The boats are 12 m long of 5 GRT and are powered by a 22 hp marine inboard diesel engine and have a crew of six (Ameen 1987). The characteristics of the traditional and motorized fishing fleets are shown in Table 11.

Shahidullah (1983) noted that the number of mechanical boats registered with the Marine Mercantile Department of the Ministry of Shipping was 1 030 in 1976 - 77, which rose to 1 400 in 1979 - 80 and 2 643 in 1982 - 83. However, a large number operated without registration. Nevertheless, it was estimated that about 2 500 - 3 000 boats were engaged in fishing in the sea. The Third Five-Year Development Plan also estimated that the small scale fishing fleet consisted of 12 000 boats of which about 3 000 were mechanized.

Table 10. Fish production from different sources from 1990 - 91 to 1998 - 99.

Year	Total production (t)	Total marine production (t)	Industrial production (t)	Artisanal production (t)
1990 - 91	895 935	241 538	8 760	232 778
1991 - 92	952 079	245 474	9 623	235 851
1992 - 93	1 020 654	250 492	12 227	238 265
1993 - 94	1 090 610	253 044	12 454	240 590
1994 - 95	1 170 365	264 650	11 715	252 935
1995 - 96	1 257 940	269 702	11 959	257 743
1996 - 97	1 306 739	274 704	13 564	261 140
1997 - 98	1 473 673	283 673	15 673	268 000
1998 - 99	1 598 900	291 900	15 900	276 000

Sources: FCS, DOF 1990 - 91 to 1995 - 96.

Table 11. Annual shrimp catch and effort of shrimp and fish trawlers during the period from 1981 - 82 to 1997 - 98.

Fishing season	Standard effort (days)			Shrimp catch (t)			Catch per unit effort kg·fishing day^{-1}
	Shrimp trawler	Fish trawler	Total	Shrimp trawler	Fish trawler	Total	
1981 - 82	2 987	795	3 782*	1 340	357	1 697*	449
1982 - 83	4 510	2 514	7 024	2 004	1 116	3 120	444
1983 - 84	6 087	3 575	9 662	3 441	2 020	5 461	565
1984 - 85	6 267	1 892	8 159	4 239	1 279	5 518	676
1985 - 86	5 941	502	6 444	3 716	318	4 034	626
1986 - 87	6 449	479	6 928	4 178	310	4 488	648
1987 - 88	6 239	344	6 583	3 339	184	3 523	535
1988 - 89	6 615	330	6 945	4 661	232	4 893	705
1989 - 90	5 460	86	5 546	3 086	48	3 134	565
1990 - 91	4 437	62	4 499	3 384	47	3 431	763
1991 - 92	–	–	6 122	–	–	2 902	474
1992 - 93	–	–	7 065	–	–	4 188	593
1993 - 94	–	–	7 169	–	–	3 480	485
1994 - 95	–	–	6 761	–	–	2 416	357
1995 - 96	–	–	7 394	–	–	3 588	485
1996 - 97	–	–	7 107	–	–	3 536	497
1997 - 98	–	–	7 491	–	–	2 444	326

Sources: Khan et al. 1997.
Note: * Estimated fishing effort and production were considered unreliable.

Offshore trawler fishing: Commercial trawling, mainly for demersal finfish, in offshore waters began in 1972 with the introduction of 10 trawlers (Rahman 1999). After the discovery of commercial shrimping grounds in 1976 - 77, some Bangladeshi entrepreneurs and foreign firms became interested in trawl fishing, particularly for shrimp. The GOB subsequently recognized deep sea fishing with trawlers as an industry.

For the acquisition and importation of trawlers, some Bangladeshi firms obtained trawlers with financial credit from various banks, others under Joint Venture Schemes in collaboration with foreign trawling companies. Permission was also accorded to bring trawlers on charter with foreign collaboration. Trawlers charted by Bangladeshi firms were later converted to *pay as you earn* (PAYE) schemes, in which local firms entered into agreements with foreign trawler suppliers to make payment of the cost of trawlers over 5 - 7 years through yearly installments from the earnings of their exports. However, it was observed that in joint venture and PAYE schemes, the ownership and fishing operations remained under the management of foreign trawler suppliers; even the expert crews were also foreigners. Most of the catches of PAYE scheme trawlers were directly exported to Thailand. The local subsidiary companies worked only as agents and earned some money without any investment of their own (Shahidullah 1986).

After the confirmation of the presence of the exportable varieties and quantities, trawling for

penaeid shrimps was introduced in 1978. From 4 shrimp trawlers operating in 1978, the number went up to around 100 in 1984 (White and Khan 1985). Meanwhile, there was a large increase in demersal finfish trawlers due to joint ventures, reaching 137 in 1980 - 81, after which joint ventures were terminated temporarily until January 1985 when the Department of Industry provided licenses for 250 vessels, of which around 100 became operational. In 1985 a reduction in fishing effort was suggested and the fleet stabilized. Currently there are 44 shrimp trawlers and 15 demersal finfish trawlers. The effort in the trawl fishery during the last two decades has been around 5 000 - 7 000 standard fishing days, producing 2 500 - 5 500 t of shrimp (Table 11).

Catch Composition Trends

The catch composition in gillnets during 1982 - 85 is shown in Table 12. The table indicates that the percentage composition of commercial fish such as pomfret, Indian salmon and seabass were declining during 1982 - 85.

The percentage catch composition of the fish trawler F.V. Mitali for demersal fish in 1991 and 1998 and in shrimp trawlers from 1987 - 88 to 1997 - 98 are shown in Tables 13 and 14, respectively. Table 13 shows that the percentage composition of commercially important demersal finfishes like pomfret, jewfish, grunter and snapper were declining from 1991 to 1998. Table 14 shows changes in the percentage composition of commercial shrimps during 1987 - 98.

Table 12. Percentage composition of gillnet catch at Chittagong from mechanized boats during 1982 - 85.

Local name	English name	Scientific name/ Family	Percentage composition			
			1982	1983	1984	1985
Hilsa	River shad	*Hilsa ilisha*	67.7	71.0	72.6	76.2
Poa/Kala datina	Jewfish/croaker	*Sciaenidae*	1.9	3.5	3.0	2.6
Katamach/Gongra	Cat fish	*Tachysuridae*	5.9	4.0	3.8	3.4
Rupchanda	Pomfret	*Stromateidae*	4.2	5.0	2.6	1.5
Lakhua (Lakya)	Indian Salmon	*Polynemus indicus*	2.3	1.5	2.0	1.0
Bhetki/Koral	Giant Seaperch (Sea bass)	*Lates calcarifer*	0.9	1.5	2.0	1.3
Maitta, Champa, Bom-maitya, etc.	Tuna and Mackerel	*Scombridae*	15.6	11.5	12.0	11.0
Skates and Rays	String rays	*Dasyatidae*	1.5	2.0	2.0	3.0

Source: Shahidullah 1986.

Table 13. Percentage species composition of fish trawler F.V. Mitali in 1991 & 1998.

1991		1998	
Pomfret	2.28	Pomfret	1.06
Jewfish	18.48	Jewfish	11.61
Snapper	1.36	Snapper	0.35
Grunter	1.76	Grunter	0.63
Catfish	16.15	Catfish	17.41
Ribbon fish	9.28	Ribbon fish	8.07

1991		1998	
Eel	1.40	Eel	0.99
Pama Croaker	0.62	*Nemipterus* spp.	0.89
Sea perch/Sea bass	0.52	Red fish	11.86
Mixed	3.59		
Others	44.50	Others	47.10

Source: Rahman 1999.

Table 14. Percentage species composition of shrimp trawler from 1987 - 88 to 1997 - 98.

Years	*P. monodon*	*P. indicus*	*M. monoceros*	Small mixed shrimp
1987 - 88	17.30	8.10	52.30	21.30
1988 - 89	11.27	6.90	65.40	16.43
1989 - 90	15.80	6.50	57.50	20.20
1990 - 91	9.79	2.79	72.08	15.34
1991 - 92	18.80	7.60	63.60	10.00
1992 - 93	12.30	7.70	60.60	19.40
1993 - 94	8.91	13.33	50.86	26.90
1994 - 95	12.49	8.01	55.70	23.80
1995 - 96	7.91	9.15	57.85	25.09
1996 - 97	9.58	6.25	59.83	24.39
1997 - 98	8.61	5.44	55.49	30.46

Source : Rahman 1999.

Economics of Coastal Capture Fisheries

Disposition and Value of Catch

Most of the marine catches are marketed fresh. Some are frozen for export, some are dried and a small portion is salted. The facilities are very poor and large portions of the catch are spoiled due to lack of ice or proper processing. There is also a lack of knowledge about sound post-harvest practices.

Catches of most of the ESBN are taken in remote locations and are disposed of locally for human consumption. The catches are of low quality as most of the fish stay in the cod-end for a long time before they are collected by the fishers. The catches, being mostly the juveniles of commercial fish and shrimp, are of low economic value. Some of the Bombay duck and jewfish are collected by fish traders to be taken to wholesale markets. Fishers also take some of the good catches to wholesale markets in the cities.

The MSBNs are usually operated from the offshore islands. Most of the catch is dried but some of the quality fish and shrimp are transported to the cities to be processed for export. There is a seasonal stake-net fishery along the coast of Chittagong. This fishery is operated from July to September. During the season huge quantities of *Hilsa* are harvested; much more than the fishers or fish traders can handle. Large quantities of partially rotten fish are salted at this time and, consequently, the quality is very low.

The beach seine fishery is operated along the coast of Chittagong and Cox's Bazar. This fishery catches mostly juvenile fish and shrimp. As a consequence they fetch very low prices and are seldom transported elsewhere and are usually marketed fresh.

The long-line fishery in the Cox's Bazaar area is wholly oriented towards export. Almost all the jewfish caught by the long-lines are dried using proper scientific methods. The traditional method of drying is not used during processing and as such the quality of the product is very good.

The drift gillnet fishery uses mainly two types of nets: viz. the small-mesh drift-nets for catching *Hilsa* and the large-mesh net for catching Indian salmon and large croakers. The *Hilsa* are marketed fresh and transported to most parts of the country. Some of the *Hilsa* is exported fresh to India with ice and yet others are frozen, to be exported to the Middle East or Europe. The croakers and the Indian salmon caught by the large mesh gillnet are sold fresh in the cities.

The shrimp caught by the shrimp trawlers are processed onboard into different grades. They are exported mainly to Japan. A small quantity of fish cought by the shrimp trawlers are exported, the rest are sold fresh to the local market. A large quantity of fish caught by the shrimp trawler is thrown overboard because it is of low value or the crew has little time to handle the catch or there is a lack of space in the fish hold. It is assumed that the amount of discards may be up to 80% of the actual catch, which is equivalent to 30 - 35 000 t annually. The freezer trawlers refrigerate the fish in gunny bags that are stacked one upon the other in the fish hold. These fish get crushed under their own weight and hence fetch low prices. The fish trawlers keep quality fish on ice to be sold to the local market and a few companies export frozen fish to external markets. Some jewfish are taken by the dry fish exporters at Cox's Bazar. The values of the catches of different fisheries are shown in Tables 14 - 20.

Table 14. Average monthly prices (Taka·kg^{-1}) of species groups at different stations for ESBN catches during 1989 - 90.

Species	Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mixed shrimp and fish	Maiskhali	30	30	25	20	–	15	30	27	27	30	30	30
	Kumira	24	22	25	25	25	35	27	18	20	15	17	26
	Hatia	17	19	18	18	–	21	25	23	21	28	24	15
	Khepupara	20	25	23	20	15	22	23	14	20	12	15	18
	Morrelganj	15	20	25	24	19	18	22	30	24	18	30	11
	Kaliganj	30	22	30	40	30	20	25	23	20	30	25	26
Penaeus monodon	Maiskhali	–	–	–	–	–	200	250	–	38	80	–	–
	Kumira	–	–	–	–	–	–	–	–	–	–	–	–
	Hatia	–	–	–	–	–	–	–	–	–	–	–	–
	Khepupara	–	25	–	–	210	22	140	–	–	–	–	–
	Morrelganj	–	–	–	–	250	175	–	–	–	250	–	230
	Kaliganj	–	220	210	230	230	–	160	200	260	–	–	40
Macrobrachium rosenbergii	Maiskhali	–	–	–	–	–	–	–	270	50	150	150	–
	Kumira	–	–	200	–	–	–	–	–	–	–	–	–
	Hatia	–	–	–	–	–	–	–	–	120	130	–	–
	Khepupara	60	50	–	–	60	–	–	60	–	140	–	–
	Morrelganj	–	–	–	–	280	282	–	–	220	220	124	138
	Kaliganj	–	–	–	160	–	–	150	150	150	–	130	60
Metapenaeus monoceros	Maiskhali	–	40	–	–	–	–	–	40	–	–	–	–
	Kumira	–	–	–	–	–	–	–	–	–	–	–	–
	Hatia	–	–	35	–	30	–	–	–	–	–	–	–
	Khepupara	–	–	–	–	–	–	–	–	–	–	–	–
	Morrelganj	–	–	–	–	80	–	–	–	50	–	–	–
	Kaliganj	–	–	–	–	–	–	–	–	–	–	–	–
M. brevicornis	Maiskhali	–	40	–	–	–	–	–	–	–	–	–	–
	Kumira	–	–	–	–	–	–	–	–	–	–	–	–
	Hatia	–	–	–	25	–	25	–	–	–	–	–	–
	Khepupara	–	–	–	–	–	–	–	–	–	–	–	–
	Morrelganj	–	–	–	–	–	–	–	–	–	–	–	–
	Kaliganj	–	–	–	–	–	–	–	–	–	–	–	–
Acetes spp.	Maiskhali	7	–	–	–	7	8	–	6	7	8	7	–
	Kumira	6	7	7	8	8	7	–	5	5	6	6	6
	Hatia	3	5	–	–	–	–	–	–	–	–	–	4
	Khepupara	–	–	–	7	4	–	–	–	–	–	4	4
	Morrelganj	–	4	4	8	4	–	–	–	–	–	–	–
	Kaliganj	6	4	5	8	4	4	–	4	4	–	–	4

Source: Islam et al. 1993.

Table 15. Monthly average price (Taka·kg^{-1}) of selected species or species groups in the beach seine catch at two stations of Teknaf in Cox's Bazar during 1988 - 89.

Species name	Station*	Mar. 88	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. '89	Feb.
Shrimp (Mixed)	1	–	–	–	–	–	–	–	–	9	13	13	13
	2	10	10	9	8	–	–	8	8	9	–	–	–
Penaeus indicus	1	–	–	–	–	–	–	–	–	18	20	20	20
	2	20	18	18	18	15	–	–	15	15	18	–	–
Metapenaeus monceros	1	–	–	–	–	–	–	–	–	18	20	20	20
	2	20	18	18	15	–	–	15	15	18	20	20	20
Croaker	1	–	–	–	–	–	–	–	–	10	13	13	13
	2	13	10	10	10	–	–	10	10	10	–	–	–
Ribbonfish and Sillago (Whiting)	1	–	–	–	–	–	–	–	–	10	13	13	13
	2	10	10	10	10	–	–	10	10	10	–	–	–
Bigeye Ilisha and Threadfin Bream	1	–	–	–	–	–	–	–	–	10	13	13	13
	2	13	10	10	10	–	–	10	10	10	–	–	–
Grey Mullet and Pomfret	1	–	–	–	–	–	–	–	–	15	20	20	20
	2	20	15	15	15	–	–	15	15	15	20	20	20
Other clupeids & Engraulids (Anchovy)	1	–	–	–	–	–	–	–	–	9	10	10	10
	2	10	9	9	9	–	–	9	9	9	–	–	–
Mixed finfish	1	–	–	–	–	–	–	–	–	8	10	10	10
	2	8	8	8	8	–	–	8	8	8	–	–	–
Trash fish *(Tricanthidae Tetraodontida)*	1	–	–	–	–	–	–	–	–	2	2	2	2
	2	2	2	2	2	–	–	2	2	2	–	–	–
Crab and cuttlefish	1	–	–	–	–	–	–	–	–	2	2	2	2
	2	2	2	2	2	–	–	2	2	2	–	–	–

Source: Chowdhury et al. 1993.
Note: * 1. Coast Station; 2. Estuary Station.

Table 16. Value of dried fish/shrimp and gross earnings at Sonadia (Taka·haul^{-1}) for MSBN catch.

Month		September		October		Novem-ber	December		January	February		March	
Name of spp./Group	Price Tk·kg^{-1}	Wt.**	Value***	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value
Pomfret	85	-	-	0.95	80.75	1.20	102.00	–	–	0.05	4.25	–	–
Ribbonfish	22	1.59	34.98	5.11	112.42	6.47	142.34	3.35	73.70	0.21	4.62	0.71	15.6
Bombay Duck	25	9.97	249.25	0.70	17.50	0.88	22.00	19.48	487.00	13.57	339.25	4.47	111.75
Anchovy	15	9.97	149.55	19.06	285.90	24.01	360.15	11.63	174.45	7.45	111.75	4.47	67.05
Croaker	15	25.39	380.85	0.91	13.65	1.15	17.25	1.66	24.90	2.72	40.80	11.38	170.70
Mixed shrimp	25	8.39	209.75	12.30	307.50	15.50	387.50	2.81	70.25	1.08	27.96	3.76	94.00
Misc.	7	9.45	66.15	1.18	8.26	1.49	10.43	0.02	0.14	1.28	8.96	4.23	29.61
TOTAL		64.76	1090.53	40.21	825.98	50.70	1041.67	38.95	830.44	26.36	536.63	29.02	488.73
Hauls·day^{-1}			4		4		4		4		4		4
Fishing day·month^{-1}			9		18		22		22		20		9
Gross earning ·month^{-1}·net^{-1}			39 259.08		59 470.56		91 666.96		73 078.72		42 930.40		17 594.28

Source: Quayum et al. 1993.

Note: ** Wt. = weight as kg·haul^{-1} **Dried weight = 60 per cent of wet weight.**

***** Value in Taka·haul^{-1}** **All shrimp prices are dried shrimp rates.**

Table 17. Price (Taka·kg^{-1}) of wet shrimp and dry fish from the MSBN Fishery in different areas (1991).

Name of the species/group										
Name of area	White shrimp	Brown shrimp	Pink shrimp	Sergestid shrimp	Silver pomfret	Bombay duck	Ribbon fish	Croaker	Anchovy	Mixed fish
Sonadia	46	28	27	11	84	27	27	17	18	17
Mohipur	45	33	25	9	84	32	29	14	16	14
Dubla	32	14	16	9	84	32	29	15	15	13

Source: Quayum et al. 1993.

Table 18. The quantities of dried croaker exported, the total value and the value per kg from 1986 - 87 to 1990 - 91.

Year	Exported amount (kg)	Value (US$)	Price·kg^{-1} (US$)
1986-87	135 704	612 197	4.51
1987-88	185 516	685 186	3.69
1988-89	845 192	4508 405	5.33
1989-90	1 152 700	5 ,321 978	4.33
1990-91	1 087 718	3 882 927	3.57

Source: Quality Control Laboratory, Chittagong.

Table 19. Wholesale rate (US$·kg^{-1}) of commercial shrimp at BFDC market, Chittagong from 1991 - 93.

Sl. No.	Species (with Grade)	1991 - 92 Value US$·kg^{-1}	1992 - 93 Value US$·kg^{-1}
1	Tiger		
	0 - 5	19.45	23.19
	6 - 8	19.39	23.33
	8 - 12	17.34	20.44
	13 - 15	13.28	14.22
	16 - 20	9.50	12.27
	21 - 25	7.64	9.97
	26 - 30	6.50	–
	Mix	–	4.04
2	Flower Tiger		
	8 - 12	–	19.01
	13 - 15	–	13.00
	16 - 20	–	11.10
	21 - 25	–	9.00
3	Brown		
	21 - 25	7.28	8.02
	26 - 30	6.62	7.07
	31 - 40	5.09	5.87
	41 - 50	4.70	5.08
	51 - 60	4.38	4.64
	61 - 70	3.81	3.81
	71 - 90	3.01	3.21
	91 - 110	2.30	2.40
	Mix	2.17	2.14
4	White		
	8 - 12	–	17.50
	13 - 15	16.50	16.42
	16 - 20	13.86	15.19
	21 - 25	10.70	11.67
	26 - 30	9.57	10.21
	31 - 40	7.79	8.55
	41 - 50	6.20	6.84
	51/60	5.50	5.20
	Mix	2.22	3.80
5	Misc.		
	Red	2.05	2.14
	B.P., G.B.	–	2.00
	Black	2.11	2.07
	Yellow	–	2.00

Source : BFD.

Table 20. Wholesale rates (Taka·kg^{-1}) of commercial fishery at BFDC Market, Chittagong during 1992 - 93.

Species	Value (Taka·kg^{-1})
Chinese Pomfret	114.59
Silver Pomfret	90.37
Salmon big	80.36
Salmon medium	50.00
Salmon small	31.00
Golden Jew big (Croaker)	48.33
Golden Jew small (Croaker)	28.71
Black Jew big (Croaker)	46.85
Black Jew small (Croaker)	28.09
Black Pomfret	46.22
Hilsa	28.00
Hatirkan (Spade fish)	40.00
Long Jew big (Croaker)	31.62
Red Snapper	32.86
Silver Jew big (Croaker)	38.92
Silver Jew small (Croaker)	22.64
Small Jew	15.40
White Grunter	30.98
Lady fish	22.21
Spotted Jew (Croaker)	32.70
Mackerel	18.45
Chapakari (Queenfish)	20.99
Pangash	30.00
Choika (Big eye ilisha)	17.74
Eel	28.00
Cat Big	15.59
Bombay Duck	12.81

Source: BFDC.

Costs and Returns

ESBN Fishery

A survey of the ESBN fishery was conducted from 1989 to 1990 (Islam et al. 1993). Six sampling stations representing 710 km of the coastline were selected, Maiskhali, Kumira, Hatia, Khepupara, Morelganj and Kaliganj. The nets for sampling purposes were classified into four sizes, based on the measurement of the mouth openings: G1a, G1b, G1c and G1d.

The G1a net (width of mouth < 6 m and area of mouth < 15 m^2) was used in four areas (Kumira, Hatia, Khepupara and Kaliganj), and had an annual net profit per gear ranging between Taka 24 969 and 33 342. The highest net income was from Hatia (over 11 months of operation) and the lowest was from Kumira (over 12 months of operation). In Kumira, hired labor was used and the total cost was higher than in Hatia where the labor was mostly provided by members of the owner, households. The average net income (in Taka) per active fishing month ranged from Taka 2 080 to 3 745. The highest net income was from Khepupara and the lowest was from Kumira.

The G1b class nets (mouth 6 - 10 m wide and area of mouth 15 - 50 m^2) were operated at all six stations and the annual net income per gear ranged from Taka 19 540 to 95 739. Maiskhali recorded the highest income and Kaliganj the lowest income over the operations. Morrelganj had the highest operational cost using hired labor, and gave a Taka 370 814 net profit. The average net income per active fishing month was highest for Maiskhali, (Taka 9 573) and the lowest for Kaliganj (Taka 2 171).

The G1c class net (with width of mouth 10 - 15 m and area of mouth 50 - 90 m^2) was operated in three stations (Maiskhali, Khepupara and Morrelganj), and had the highest net annual income per gear of Taka 179 159 over 11 months of fishing, while Khepupara exhibited the lowest income of Taka 37 278 in 12 months. Maiskhali recorded the highest income per active fishing month which is Taka 16 287 and the lowest was recorded for Khepupara, Taka 4 142.

The G1d class nets were used only at Morrelganj and the annual net profit per gear was Taka 20 517 for four months of fishing the estuary. The average net income per active fishing month for Morrelganj was Taka 5 129.

In most stations there were two peaks in income - one in May/June and the other in November/ December. These correspond with the beginning of the Southwest monsoon and the Northeast monsoon, respectively. In Maiskhali, whenever crew were engaged, they were paid Taka 400 - 600 per month and provided with free food. In Kumira and Khepupara crews were paid Taka 600 - 1 000 and 250 - 600 Taka per month, respectively. The value of food provided was Taka 450 - 500 per month per ESBN unit. Other operational costs are minimal; most of the craft used in this fishery are non-motorized and generally family members are engaged as labor (Islam et al. 1993).

Beach Seine Fishery

A survey of the beach seine fishery was conducted in 1988 and 1989 (Chowdhury et al. 1993). Two stations at the Naf River estuary and the Teknaf coast were selected. The beach seine owners earned less income in the Naf River estuary than on the Teknaf coast and their maximum gross earnings were Taka 21 253 in October, with a net profit of Taka 3 855. Their minimum gross earnings were Taka 10 242 in March with a net profit of Taka 185. Seasonal gross earnings per unit were Taka 113 029 over seven active fishing months and the net profit to the owner was Taka 15 083.

Owners of gear on the Teknaf coast earned a reasonable income from their fishing units during most months of the year. The highest monthly gross earnings were Taka 101 433 per unit, with a profit of Taka 30 589 in December and the lowest monthly gross earnings were Taka 12 262, with a net profit of Taka 859 in February. Gross earnings per unit were Taka 171 619 during a season of four active fishing months, while the total profit to the owner during this period was Taka 44 292.

The gross revenue on the Teknaf coast was Taka 16 150 while on the Naf river estuary it was Taka 42 900. The average monthly net income on the Naf River estuary was Taka 2 160 and on the Teknaf coast it was Taka 11 070. The average income per month to fishers was Taka 446 at the Naf River estuary and Taka 2200 on the Teknaf coast.

Most beach seines and boats are owned by *bahardars*, better-off people belonging to the fish landing localities. The fishers get paid on a share basis after incidental expenses, generally small amounts, are deducted.

When net revenue from each haul exceeds Taka 400, one third of it goes to the owner of the unit and the remaining two-thirds is equally distributed among the fishers. If the gross revenue is between Taka 200 and 400, a fixed amount of Taka 200 is shared among the fishers and the rest of the money goes to the owner. When gross revenue falls below Taka 200, all of it is distributed equally among the fishers, without anything going to the owner. The beach seine fishing communities generally follow this traditional sharing system.

MSBN Fishery

A study on the MSBN fishery was conducted during 1983 - 86 at three fishing areas: Sonadia, Mohipur and Dubla (Quayum et al. 1993).

An owner of an MSBN and supporting craft is locally known as a *bahardar*. He organizes the fishing units and may use his own craft and gear or, sometimes, hires craft and other equipment for the fishing season.

At Sonadia, remuneration is based on a share system, but in Mohipur and Dubla both share and wage systems are observed. One or a combination, of the two systems is applicable in all three areas. In the share system, the net income is divided into 74 shares and distributed among *bahardar* and the crew. The total share of *bahadar* is 33 and for the crew is 41.

The *bahardar* generally bears all expenses and these are deducted from gross revenue before the net revenue is shared. A typical operation unit comprises two motorized craft (one usually rented) and one rented non-motorized craft. These are used to operate 15 set bag nets. The operational cost includes hire of two craft, craft and gear repair, fuel, food, firewood, utensils, bamboo mats, drying racks, and jute piling.

Trammel-net Fishery

A survey of the trammel-net fishery along the southeast coast of Bangladesh was undertaken during 1989 - 90 by Islam and Khan (1993).

Most trammel-nets and boats are owned by *bahardars*. The fishers are paid on a share basis, after deducting incidental expenses, which are generally small amounts. If the owner is also a member of the crew, he gets an extra crew share. There are also a few cases of fishers jointly owning a set or sets of gear and one or more supporting craft.

When the net revenue from the landed catch exceeds Taka 500, 50% goes to the owner of the gear and craft and the remainder is divided equally among the fishers. If the gross income is between Taka 200 and 500, then a fixed amount of Taka 200 is shared among the fishermen and the rest of the money goes to the owner. When gross revenue falls below Taka 200, all of it is distributed equally among the fishers, without any payment to the owner. This is a traditional sharing system.

In most months, the *bahardars* earn a good income from this fishery, with maximum earnings in December and a minimum in March. The gross income of a boat per day during the study varied from Taka 128 to 3 896, with the average gross revenue per boat per day being Taka 1 036. The deductible expenses being very small, the net revenue would be almost equal to the gross revenue.

The average annual gross earnings per boat were Taka 143 664 in seven fishing months and the annual income of the owner, after deducting the fixed costs (including depreciation, repair and maintenance cost of craft and gear - about Taka 9 000) was Taka 59 437. The operational costs are generally incidentals such as tobacco and minor food items. During the period of the study, the trammel net fishery was profitable in all months except in March, when there was a loss due to a decline in the catch rates of the more valuable species.

The monthly average income per fishers ranged from Taka 2 000 to 7 000 and the highest income was Taka 15 000 in December.

Bottom Long-line Fishery

A study of the long-line fishery was conducted during 1990 - 91 at Chittagong (south), Cox's Bazar, Noakhali and Patuakhali (Haque et al. 1993).

During the survey, a cost and earning analysis (Table 21) showed that the variable cost of the fishery is composed of the fuel, food, bait, salt, repairs and replacement of lost or damaged gear. The price of bait is 35 - 45 Taka·kg^{-1}. The cost of craft and gear are Taka 2 500 000 and 4 000, with average lives of 15 years and 1 year, respectively. The estimates of the costs and earnings for a unit during a whole fishing season are given in Table 22, from

which it appears that the monthly average income per fisher is Taka 1 309 for the lean season (1-day trips) and Taka 2 848 for the peak season (4-day trips).

After deducting the variable cost from the gross revenue, the balance is shared on the basis of eight shares for the craft owner, two for the head fishers and one each for the nine crew members.

Major repairs and maintenance of the boat and gear, about 200 Taka•month^{-1}, are borne by the boat owner. Therefore, after deducting the depreciation and maintenance cost, the boat owner gets 8 804 Taka•month^{-1} in the lean season and 20 909 Taka•month^{-1} in the peak season.

The fish are sold to the factory with the swim bladder intact and the fishermen do not get any additional payment for this. The dried swim bladders of the Silver Pennah Croaker and Belanger's Croaker are worth 200 Taka•kg^{-1} and that of the large Spotted croaker 1 000 Taka•kg^{-1}. The factory owners sell these to middlemen linked with the export of this product - "isinglass".

Table 21. Cost and earning analysis of the bottom long-line fishery for Croaker and the average income to owner and crew member per trip in 1991.

Period	Duration of trip (days)	Avg. value of catch (Tk)	Avg. bait cost (Tk)	Avg. fuel cost per trip (Tk)	Food cost per trip (Tk)	Salt cost per trip (Tk)	Additional cost (Tk)	Net hooks (Tk)	Crew revenue (Tk)	Skipper boat (Tk)	Boat share (Tk)
Aug., Oct. & Feb.	1	4 796	700	1 700	500	–	500	1 396	73	146	587
Nov. - Jan.	4	–	18 136	700	2 000	2 000	800	600	12 036	633	1 266

Table 22. Cost and earnings of a bottom long-line unit, for the whole 1991 season (Values are in Tk.).

	Variable Cost	Depreciation & maintenance	Salaries/ shares	Total cost	Total revenue	Profit to owner
Peak season Nov. - Jan. (3 months)	82 350	5 775	93 984	182 109	244 836	62 727
Lean season Aug. - Oct. (2 months)	122 400	3 850	28 798	155 048	172 656	17 608
**Annual	204 750	9 625	122 782	337 157	417 492	82 335

Note: ** "annual" means one season, i.e. the 5-month fishing period.

a. Depreciation of fixed cost/month = Tk. 1 390 + Tk 335 = Tk 1 725

b. Variable cost/month = Tk. 61 200 (for day trip)
= Tk. 27 450 (for 4-day trip)***

c. Gross revenue/month = Tk. 86 328 (for 1-day trip)
= Tk. 81 612 (for 4-day trip)

d. Profit/month = Tk. 25 128 (for 1-day trip)
= Tk. 54 162 (for 4-day trip)

***** Variable costs are less for a month with a 4-day trip because there are fewer trips per month, resulting in fuel cost being substantially less for approximately the same number of fishing days.**

Incomes and Sharing Arrangements

Traditionally, all kinds of fishing were practiced at subsistence level by the *jaladas* of the Hindu community. However, with increasing demand and commercialization of inland and marine fisheries and decreases in land assets due to population pressure, large numbers of Muslim fishers took up fishing as a full-time job. Most of the small scale fishing boat owners, either motorized or non-motorized, are now Muslim, who hire Hindu and Muslim fishers as crew, mostly on a catch share basis.

Most of the boat owners do not go to sea. They provide the mechanized boat, gear and other necessary fishing materials and the crew work as actual fishers and undertake various responsibilities.

The income-sharing arrangement between boat owner and crews varies from area to area and depends on the type of gear used and the fishing season. For instance, in Chittagong and Cox's Bazar, 60% of the value of the catch, after covering the operational costs, goes to the boat owner and the remaining 40% is distributed among the hired crew. The share of each crew member depends on the functions performed by him (Rahman 1993). These may include catching, drying, transporting and support services, such as cooking.

Very few surveys have been conducted on small scale marine fishing. Thomson et al. (1993) made a socioeconomic survey on estuarine set bag net fishers. Islam and Elahi (1993) studied the socioeconomic condition of different categories of small scale marine fishers involved in fishing with gillnets, long-lines and set bag nets. A fishing team usually consists of one head mazhi, one assistant head mazhi, one driver and 12 to 15 unspecialized fishing laborers.

Annual fishing activities are divided into three subperiods. The high activity period (AP) comprises the months of September to November, the medium AP comprises the months of December to March, and the low AP five months from April to August. The rainy season, June and July, is the slack period for fishing. There is little variation of employment during the activity period among different categories of fishers.

The head *mazhi*, assistant head *mazhi* and laborers spend more than 90% of their time on fishing. The boat owners and other fishers, such as cooks, helpers, net makers, repairers, are relatively less involved with fishing. The boat owners' second most important job is business, while other fishers are involved with different occupations for varying periods. Thomson et al. (1993) indicated that 35% of the fishing community were involved in productive activities; 37% were children below the age of 10, and 28% did not have any employment. There was a high rate of dependence on the income-earning members.

The different categories of fishers earned about 90% of their income from fishing. Other sources such as agriculture or business did not contribute much. The assistant head *mazhi* earned more than 99% of their income from fishing. Business was the second most important source of income in the case of boat owners, head *mazhi* and other fishers.

The annual income levels and their differences among different categories of fishers are considerable. The annual income of a boat owner is about Taka 461 304, but the fishers get Taka 13 568 annually. The average annual per capita income of different categories within fishing households also varies significantly.

Household expenditures were divided into five categories, of which four relate to basic human needs: food, clothing, education and medication. The boat owners used more than 56% of expenditure on non-basic items, while fishers used most of their income on the basic items. Food is the single most important expense. This conforms with the Engel Law that expenditure on food varies inversely with income. While boat owners spend 34% on food, fishers use more than 82%. The boat owners have substantial savings whereas the other fishers have none.

Fleet Operational Dynamics

Bangladesh started fishing with a fleet of 10 trawlers and 200 motorized boats just after independence. The number of trawlers more than doubled to 21 in a year and then increased to 26 two years later. The numbers of trawlers changed abruptly in the early 1980s and reached a maximum of 73 in 1984. The number then fell gradually and stabilized at a little more than 50. The current number of trawlers is 59, of which 44 are shrimp trawlers and the others are fish trawlers. The operational fluctuations of different trawlers and boats between 1972 - 73 and 1988 - 99 is shown in Table 23.

Table 23. Number of fishing crafts from 1983 to 99.

Years	Trawlers				Boats		
	Shrimp	Fish	Mixed	Total	Non-mechanized	Mechanized	Total
1972 - 73	N/A	N/A	N/A	10	N/A	200	–
1973 - 74	N/A	N/A	N/A	21	N/A	276	–
1974 - 75	N/A	N/A	N/A	21	N/A	1 000	–
1975 - 76	N/A	N/A	N/A	26	N/A	1 000	–
1976 - 77	N/A	N/A	N/A	26	N/A	1 050	–
1977 - 78	N/A	N/A	N/A	26	N/A	1 100	–
1978 - 79	N/A	N/A	N/A	26	N/A	1 200	–
1979 - 80	N/A	N/A	N/A	26	N/A	1 300	–
1980 - 81	N/A	N/A	N/A	24	N/A	2 000	–
1981 - 82	N/A	N/A	N/A	35	N/A	2 050	–
1982 - 83	N/A	N/A	N/A	53	N/A	2 100	–
1983 - 84	27	46	N/A	73	743	3 347	4 090
1984 - 85	30	37	N/A	67	14 014	3 317	17 331
1985 - 86	35	10	N/A	45	14 014	3 317	17 331
1986 - 87	31	10	8	49	14 014	3 317	17 331
1987 - 88	35	10	7	52	14 014	3 317	17 331
1988 - 89	35	10	7	52	14 014	3 317	17 331
1889 - 90	40	9	4	53	14 014	3 317	17 331
1990 - 91	41	15	N/A	56	14 014	3 317	17 331
1991 - 92	37	14	N/A	51	14 014	3 317	17 331
1992 - 93	37	12	N/A	49	14 014	3 317	17 331
1993 - 94	40	11	N/A	51	14 014	3 317	17 331
1994 - 95	43	14	N/A	57	14 014	3 317	17 331
1995 - 96	41	12	N/A	53	14 014	3 317	17 331
1996 - 97	41	14	N/A	55	N/A	N/A	N/A
1997 - 98	48	13	N/A	61	N/A	N/A	N/A
1998 - 99	44	15	N/A	59	N/A	N/A	N/A

Sources: BBS 1997; Frame survey 1984 - 85; Rahman 1995 and FCS. DOF 1983 - 84 to 1995 - 96.
Note: N/A = Information not available.

Fish Marketing, Post-harvest Handling and Storage Facilities

Marketing of Fish

Bangladesh has around 111 million people. At a standard consumption rate of 20 kg•capita^{-1}•year^{-1}, about 2.2 million t of fish would be needed annually. However, the present production of 1.62 million t of fish provides only 8 kg•capita^{-1}•year^{-1} (Hussain 1995). The entire production of marine, estuarine and freshwater fish is easily marketed domestically in Bangladesh, except for a very small quantity of selected species of finfish. People of Bangladesh like to eat fresh fish. Chilled fish are also marketed in large quantities in the towns and cities. However marketing of frozen fish is negligible in the absence of customer preferences and cold-chain marketing developments. Utilization and marketing distribution of fish is around 70% fresh and chilled fish, 25% dried and other forms of locally processed fish, including fermentation and the rest are frozen products. The total production of about 100 000 t of live crustaceans, mainly shrimp and prawns, about 19 000 t (headless; equivalent to 36 000 t live weight) is exported and the remaining 64 000 t, mostly of smaller sizes and non-exportable quality is marketed domestically (Hussain 1995).

Domestic Marketing Situation

As there is a large gap between supply and demand, fish marketing is very easy. All types of fish, irrespective of cost, are easily sold, due to the presence of a heterogeneous mixture of buyers. High cost fish like carp, catfish and other live-fish from inland waters and marine pomfret, Indian salmon, snapper, grunters and eel, are either sold to the affluent or are processed for export. Mixed fish are usually sold to the vast majority of the people, those of the low-income groups. Owing to high domestic and international demand, the prices of exportable species have increased several-fold.

The marketing of fish is generally conducted by fish traders, either individually or as groups, or by Fish Trader Associations or Fishers' Cooperative Societies. Almost all fish markets operated by them are ill-managed and unhygienic. There is no proper handling, washing, cleaning, icing or re-icing of the fish. They care very little for post-harvest management of the resource, being more interested in earning more revenue at the cost of the fishers and the consumers. Most fish markets managed by fish traders in cities, district towns and rural areas have no modern infrastructure facilities, not even over head shelters. In the villages, fish is directly landed on the soil and in bamboo baskets and sold by auction, before being transported to cities and towns for retailing.

City markets built by municipal corporations or municipalities offer better facilities, but are not managed according to any standards. Municipal fish markets are usually a part of the general market. The Local Government Ministry is now constructing small fish markets in the rural areas through the Local Government Engineering Department. These provide better facilities for rural fish marketing. There are no special or modern fish landing centers run by the municipalities or by the private sector.

The BFDC is the only organization which has constructed modern fish harbors and fish landing centers in such coastal areas as Chittagong, Cox's Bazar, Barisal, Khepupara, Patharghata and Khulna. It has also constructed commercial fresh fish landing centers in Rangamati, Kaptai, Rajshahi and Daborghat. These landing centers provide modern and hygienic facilities for the fishers and fish traders and there are facilities for berthing, landing, auctioning, cold storage, freezer storage and transport. Post-harvest resource management is properly taken care of only in these centers. But fishers and fish traders are not interested in utilizing these modern facilities due to ignorance and self-interest. As a result, fish landing centers in Barisal, Khepupara and Patharghata have not been started as planned.

Marketing Systems of the Fish Trade

Four levels of domestic markets or marketing systems are observed in the distribution channels of the fish trade in Bangladesh (Hussain and Uddin 1997). These are the primary, secondary, higher secondary and final consuming markets (Fig. 3).

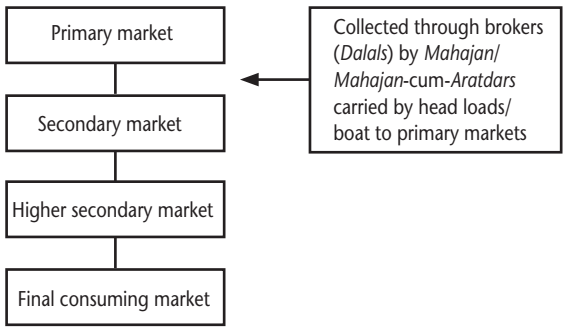

Fig. 3. Four levels of domestic fish market in Bangladesh. Source: Hussain and Uddin 1997.

Primary Market

This is a marketing place at the landing point, usually in a rural area. Fish collectors or assemblers, commonly known as *mahajans* or *aratdar* procure fish from the catchers, with the help of local brokers called *dalals*, who get a commission from the *mahajan*. Part of the catch is also locally sold by the catchers, farmers or local retailers.

Secondary Market

The collectors bring the fish from the primary markets to the landing *ghats*, usually to the nearest *thana* market or to a place well linked by rivers, roads or rail transport. The mahajan sell the fish to the distributors known as *beparies*, generaly with the help of the *aratdars*, the commission agents.

Higher Secondary Market

The *beparies* transport the fish to the nearest city or town markets by rail or boat. These are the main distribution markets and here the *beparies* sell the fish to another set of distributors known as *paikars*, again with the help of *aratdars*.

Final Consuming Markets

On purchasing the fish from the higher secondary market, the *paikars* sell the fish to the retailers. There are two channels of retailing. The urban retailers sell the fish in the urban markets in permanent stalls or set out with the fish on their heads or in tricycle (rickshaw) vans to sell them. Other retailers take the fish to the suburbs or to villages.

In the course of marketing at all these levels, the collector or distributor carries out the function of handling, cleaning, sorting, icing, preservation and transportation at his own cost as far as possible. Expenses on such accounts are deducted from the bills of sellers.

Major Fish Markets and Landing Centers

Major coastal fish landing centers are located at Chittagong, Cox's Bazar, Teknaf, Shaparir Dhip, Kutubdia, Hatiya, Sandip, Sitakunda, Laxmipur, Hajimara, Rangamati, Bhola, Dauladia, Charfessan, Patuakhali, Galachipa, Khepupara, Mohipur/Kuakata, Barguna, Patharghata, Khulna, Bagerhat, Parerhat, Satkhira, Barisal and Chandpur . Most of the catches from the Bay of Bengal are landed at these centers and *Hilsa* is the main species landed (Hussain and Uddin 1997).

Trade flow

Trade flow or movement of marine fish for domestic consumption originates from Cox's Bazar, Chittagong, Barisal, Khulna, Bagerhat, Parerhat, Chandpur and many other coastal landing centers. After meeting local needs, the surplus fish is sent to the major markets, principally Dhaka, Sylhet and Rajshahi.

Marketing Channels

Almost all fish trade for the domestic market passes through the channels described above. The market structure varies from area to area, but in general terms is as illustrated in Figure 3.

While the four levels of markets are the normal trade channels, there is sometimes variation between locations and type of fishers. Sometimes fishers and fish farmers bypass these channels and sell fish directly to the secondary markets, this being most commonly practiced by the mechanized boat operators at the coastal fish landing centers.

Marketing Margins

The fishers' shares and marketing margins in fish sold in Dhaka and Pabna in 1981 were analyzed for freshwater fish like *Hilsa* (river shad), *ruhi* (carps) and *singhi (Heteropneustes fossilis)* and the following were the results (Hussain and Uddin 1997):

Fisher's share in consumer price	: 51 - 63%
Middleman's share in consumer price	: 37 - 49%
Expenses	: 12 - 24%
Net income after expenses	: 24 - 26%
Share of collectors	: 14 - 35%
Share of distributor	: 16 - 20%
Share of retailer	: 5 - 10%

The fisher's share and marketing margin of marine fish sold in Chittagong and Cox's Bazar were as follows:

Fisher's share	: 60 - 63%
Middleman's share	: 40 - 37%

Breakdown of Middlemen's Margins

Marketing costs	: 21.7 - 22.2%
Quality/weight loss	: 1.6%
Net income	: 13.3 - 16.1%

Existing Auction System

Most of the auctioning is carried out by auctioneers, locally called *aratdars*. They follow a price incremental system.

As soon as the fishers land the fish in the market, the *aratdar* takes care of landing, handling, sorting and auctioning by species and size groups. Even though an open bidding system is the most prevalent one, there are other types of price-fixation systems followed by some traders' associations in selected markets. In general, the sales systems are as follows:

Open Bids

Auctioneers call out the bid by the bidders loudly in the presence of the buyers. The incremental system is followed. It is the most competitive form of auctioning and ensures a better price for fishers. It takes place at all levels of fish marketing, except retailing. The auctioneer gets a 3 - 5% commission on sales value plus his actual expenses.

Syndicate-controlled Price Fixing

In fish landing centers in the coastal areas, especially in Cox's Bazar, Chittagong and Barisal, the private auctioneers in some markets have formed associations called "syndicates", which fix the price of fish either in the evening or on the next day, after disposing of local demand. They send the excess fish, properly iced and packed, to distant landing cities or district markets to another set of local *aratdars*, who receive the fish and auction it locally. The fishers, thus, do not know, nor are they able to know, what the auction value was for their fish, neither do the buyers know the beach price. After disposal of the fish, the inland *aratdar* sends information about the price obtained to the auctioneers at the landing centers. The latter collectively fix prices as they wish. This system works on faith and mutual trust only. The fishers are bound to follow the system, since they are tied to the auctioneer by credit given to them. There is plenty of room for malpractices in this system.

Limited Bidding

In this system, the auctioneer fixes the price by negotiation or partial bidding, usually in the absence of the seller. The auctioneer does not make loud calls, but whispers the price to the intending buyers. He then decides the highest price and awards the fish to the so-called highest bidder. This system is also flawed but since both seller and buyer are tied to each other by advances or credit, there can be no protest.

Through Tender

In the case of trawler catches, the owners sometimes sell the fish through tender. In smaller landing centers or production areas, fish is also sold by negotiation between the local buyer and seller. Retail prices are always fixed by negotiation in the private sector. In department stores, however, prices are fixed.

Marketing Infrastructure

Landing facilities and wholesale fish markets are not well developed. Inland fish landing centers are entirely run by the private sector and this sector also dominates coastal landing centers in many places. These centers are not developed due to the indifference of the private sector.

The Government, through its Ministry of Fisheries and Livestock and the BFDC, established a fish harbor in 1972 for deep sea trawlers of 25 - 30 m length. It also established, with Japanese assistance, a modern fish-landing center in Chittagong for the 2 000 to 3 000 strong mechanized fishing fleet operating from that area. This center started operation in August 1994 when about 45 000 t of fish were expected to be landed. BFDC also established fish landing centers at Cox's Bazar, Khulna, Barisal, Khepupara and Patharghata along the coast and at Rangamati, Kaptai and Daborghat (Sylhet) inland. Additional modern fish landing centers and wholesale fish markets are planned by the Government.

Fishers' cooperative societies also run a major fish-landing center in Chittagong, but it has neither modern nor hygienic facilities.

Fish landing centers run by the fish traders are of very poor standard and need improvement. In most cases there are no auction sheds, no packing sheds, no landing terminals, no gangways, no pontoons and no proper drainage or hygienic facilities.

Wholesale fish markets in almost all cities and towns are operated by the municipalities concerned under the Ministry of Local Government. The landing and wholesaling facilities in the municipal mar-

kets are generally inadequate for handling a highly perishable commodity like fish.

In major cities like Dhaka, Chittagong, Khulna and Rajshahi, as well as district towns, the retail markets are managed by the municipalities. Conditions in these markets are also not adequate in respect to sales areas, parking, sanitation, water supply, drainage, cleaning and washing, maintenance and repairs. A few new markets are, however, exceptions. The BFDC runs a modern fish distribution and retail center in Dhaka, with half a dozen modern fish shops and fifty rickshaw vans that sell fish from door to door. A few modern retail fish shops have also been established by private sector entrepreneurs in Dhaka.

Ice Plants and Cold Storage

There has been much improvement in the ice supply during recent years. Many ice plants have been established in Cox's Bazar, Chittagong, Khulna, Barisal, Khepupara, Patharghata and other small fish landing areas along the coast. The number of ice-plants, with their daily production capacity, in the major fish landing centers are listed below (1993 figures):

Name of center	Number	Capacity ($t \cdot day^{-1}$)
Chittagong	68	1 055
Cox's Bazar	30	642
Barisal	39	1 654
Khulna	60	660
Bagerhat	21	180
Mongla	5	34
Parerhat	4	55

Most mechanized fishing boats carry ice and land fish properly iced. There is no shortage of ice supply in these centers for the marine fishery. During peak *Hilsa* catches, which coincide with the full moon and the "dead" moon periods (a short period of 3 - 4 days during the monsoon months of May to October every year) shortages of ice sometimes occur. The average price per block of ice, weighing about 140 kg, varies from Taka. 40.00 to 100.00 depending on fish landings. The average price is around Taka 600 per t. The BFDC has established 14 ice plants in its ten coastal fish landing centers, with a daily ice-making capacity of 260 t (210 t block ice + 50 t flake ice), a chill room capacity of 615 t and an ice storage capacity of 670 t. Cold storage for ice and chilled fish has not received proper attention from the private sector.

Freezing Plants and Frozen Storage

Bangladesh has developed a big shrimp processing industry. There were 115 processing plants by 1993 - 94, having a total daily capacity of 800 t of shrimp or fish or approximately 180 000 t annually, on the basis of 220 days of operation per year. As against this installed capacity, shrimp for export amounts to only around 40 000 t live-weight or about 25 000 t headless weight. Capacity utilization for shrimp freezing was only 19 per cent in 1992 - 93. As a result, most shrimp processing plants are either lying idle or have diversified into finfish processing and freezing for export and domestic marketing. Of the 115 plants, only four are in the public sector (BFDC) and have a daily freezing capacity of 61 t (49 t blast freezing + 12 t freezing) and 1 380 t of frozen storage capacity. BFDC plants are mainly used as service facilities by the private sector exporters.

Trawler Based Shrimp Processing Plants

Shrimp trawlers were introduced in 1978. By 1994, the fleet had grown to 48 shrimp trawlers with a daily freezing capacity of 108 t. These trawlers catch over 4 000 t of marine shrimp annually. Of the 48 shrimp trawlers, only two belong to the public sector (BFDC). There are also 4 white-fish trawlers belonging to the BFDC as against 16 in the private sector.

International Marketing and Exports

Exports of shrimp, fish and other fishery products were unusual before independence, but have increased many times in past years, earning more and more foreign exchange to minimize the national balance of trade.

The major export items are frozen shrimp, frozen fish, chilled fish, salted and dehydrated fish, dried fish, sharkfins and maws, crabs, tortoises and turtles. Small quantities of cephalopods such as squid and cuttlefish are also exported. Exports of fish and fishery products from Bangladesh are shown in Table 24.

Exports of Frozen Foods.

Frozen sea foods were 94.34% of the total exports of fishery products in 1992 - 93 and earned US$165.34 million. Other fishery products earned US$9.80 million (5.66% of exports). In the frozen foods sub-sector, frozen shrimp accounted for US$155.48 million (90.10%), frozen fish US$9.80 million (9.90%) and frozen frog legs had no earnings, since they were totally banned by the Government.

Table 24. Export of fish and fishery products from Bangladesh in t - their value in parentheses in million Taka.

Year	Commodity							% Of national export earnings
	Frozen shrimp/ prawn	Frozen fish	Dry fish	Salted/ Dehyd. Fish	Turtle/ Crab/ Tortoise	Shark fin/ fish-maws	Total	
1981 - 82	6 903 (904.4)	631 (41.8)	39 (03.6)	123 (13.1)	2 358 (134.6)	63 (12.9)	10 117 (1 110.4)	8.84
1982 - 83	9312 (1 499.4)	1 279 (77.0)	79 (08.3)	128 (12.8)	2 357 (143.4)	64 (17.6)	13 219 (1 758.5)	10.88
1983 - 84	8818 (1 555.0)	2 817 (141.7)	74 (08.6)	283 (32.1)	2 935 (217.7)	43 (13.0)	14 970 (1 968.1)	9.89
1984 - 85	12 682 (1 994.5)	3 297 (147.7)	47 (05.5)	382 (36.6)	1 790 (127.0)	108 (21.2)	18 306 (2 332.5)	9.66
1985 - 86	13 631 (26 93.1)	5 017 (365.0)	786 (100.6)	422 (49.5)	3 142 (346.8)	50 (12.5)	23 048 (3 562.5)	14.65
1986 - 87	16 275 (3 417.5)	4 046 (354.1)	402 (49.0)	295 (38.4)	2 629 (346.6)	114 (34.9)	23 761 (4 240.5)	12.99
1987 - 88	15 023 (3 611.7)	4 191 (283.5)	475 (66.9)	372 (48.1)	3 232 (484.8)	130 (46.2)	23 423 (4 541.2)	11.93
1988 - 89	15 386 (3 820.5)	2 427 (225.9)	567 (138.9)	293 (41.2)	2 978 (464.7)	68 (27.7)	21 719 (4 718.9)	11.51
1989 - 90	17 505 (4 143.1)	3 484 (255.8)	1 278 (234.0)	161 (14.4)	876 (112.4)	35 (28.0)	23 339 (4 787.7)	9.62
1990 - 91	17 985 (4 512.2)	5 702 (414.0)	427 (57.5)	1 194 (139.5)	723 (105.8)	78 (37.2)	26 109 (5 266.2)	8.64
1991 - 92	16 730 (4 557.3)	2 604 (301.0)	892 (141.1)	80 (13.9)	1 709 (176.1)	65 (54.1)	22 080 (5 243.5)	6.91
1992 - 93	19 224 (6 040.3)	2 704 (383.1)	1 042 (122.6)	599 (98.4)	2 800 (216.0)	239 (142.5)	26 608 (7 002.9)	7.57
1993 - 94	22 054 (7 877.3)	3 125 (511.8)	2 473 (418.3)	50 (10.6)	4 088 (363.7)	45 (27.9)	31 835 (9 209.6)	9.12
1994 - 95	26 277 (10 456.7)	9 267 (1 802.6)	521 (83.9)	649 (153.5)	4 760 (406.7)	212 (166.0)	41 686 (13 069.4)	9.38
1995 - 96	25 225 (11 063.9)	8 827 (1 766.2)	182 (30.5)	436 (114.7)	4 203 (392.0)	56 (42.1)	38 929 (13 409.4)	8.44
1996 - 97	25 742 (11 889.1)	8 754 (1 767.4)	427 (79.2)	561 (138.1)	5 952 (614.8)	113 (85.5)	41 549 (14 574.1)	7.75
1997 - 98	18 630 (11 814.8)	8836 (1 516.6)	233 (31.1)	1 106 (264.3)	1 198 (143.4)	155 (107.9)	30 158 (13 878.1)	5.93

Source: DOF 1999.

Exports of Other Fishery Products

This sub-sector constituted only 5.66% of the total exports of the sector during 1992 - 93, comprising dried fish (1.80%), salted and dehydrated fish (1.45%), sharkfins and fish maws (2.10%), crabs (0.84%) and tortoises and turtles (0.14 %).

The major export market for frozen shrimps are USA (38.33%), EU (34.49%), Japan (9.88%) and Germany (10.66%). During 1991 - 92 exports of frozen shrimp to world markets were as follows:

USA	38.33%
Germany	10.66%
Japan	9.88%
EU	36.495
Belgium	15.24%
UK	12.79%
Netherlands	5.54%
Italy	1.86%
Denmark	0.53%
Spain	0.30%
France	0.16%
Norway	0.07%
ASEAN/FEA	4.12%
Singapore	2.95%
Malaysia	0.76%
Taiwan	0.29%
Hong Kong	0.10%
Thailand	0.02%

The major export markets for frozen frog legs during 1991 - 92 were USA (92.03%), Belgium (4.49%) and Canada (3.48%). Export of frog legs was totally banned by the Government from 1992 to 93, in order to preserve the environment. The major export markets of this product during 1991 to 92 are given below:

UK	56.18%
Germany	0.22%
USA	4.11%
Japan	2.00%
Netherlands	0.38%
S. Arabia	6.24%
Oman	6.24%
UAE	6.21%
Qatar	2.95%
Kuwait	2.32%
Bahrain	0.24%
Singapore	5.75%
Hong Kong	3.96%
Malaysia	2.70%
Brunei	0.01%
Taiwan	0.18%

The major markets for dried fish during 1991 - 92 were as follows:

ASEAN	88.0%
Hong Kong	66.49%
Singapore	13.59%
Middle East	0.66%
UAE	4.405%
Oman	3.22%
Bahrain	1.83%
Kuwait	0.55%
Qatar	0.43%
S. Arabia	0.23%
EU	8.75%
UK	8.70%
Germany	0.05%

The only market for salted and dehydrated fish was Hong Kong in1991 - 92. During 1990 - 91 the major markets were Hong Kong (76.69%), Japan (11.77%), Singapore (4.75%), USA (4.64%), UK (1.21%), Malaysia (0.54%) and Belgium (0.40%).

Major markets for shark fins and fish maws in 1991 - 92 were Hong Kong (71.69%), Singapore (23.65%), UK (4.40%), Thailand (0.18%) and Malaysia (0.04%).

The major markets for crabs during 1991 - 92 were Singapore (72.18%), Malaysia (9.12%), Taiwan (8.78%), Hong Kong (6.63%), Qatar (1.51%) and UK (1.01%).

Major markets for tortoise and turtles in 1990 - 91 were Singapore (79.28%), China (1.70%), Japan (10.14%), Hong Kong (3.04%), UK (3.13%), Korea (2.42%) and USA (0.29%). This changed during 1991 - 92 to Singapore (34.13%), China (27.82%), Japan (18.62%), Hong Kong (10.48%), Spain (4.75%) and Kuwait (94.21%).

Assessment of Exploitation Status

Biological Status

The Estuarine Set Bag Net (ESBN) Fishery

Detailed catch assessment and biological information on the pattern of exploitation by this fishery is available (with DOF) and it is evident that this fishery is most destructive (Islam et al. 1993 and Khan et al. 1994). Table 25 shows the natural mortality, fishing mortality and exploitation pattern of the 19 most significant species in the ESBN fishery, covering three different ecosystems.

It can be seen in Table 18 that the species of brackish water origin, *Acetes indicus* (the sergestid shrimp), *Raconda russeliana* and *Setipinna taty* are underfished to some extent, while almost all species of marine and freshwater origin which visit the brackish water area for nursery and breeding purposes are seriously over-fished (growth over-fishing). It is observed that all the shrimp are caught by this gear before the adult stage and thus affect the spawning process. For instance it can be seen in Figs. 5 and 6 that the ESBN, push-nets and beach seines harvest members of the same population at sizes much lower than the size at first maturity. As a result about 99 percent of the population do not get a chance to participate in the spawning process.

The Push-net Fishery

More than 2 035 million post-larvae of Tiger shrimp (*P. monodon*) are collected annually by push-net, which is only a little over one percent of the total catch of the push-net fishery (Paul et al. 1993). The rest of the catch is thrown on the sand to die, which is equivalent to about 200 billion post-larval shrimp, and fish larvae and zooplankters. This is serious growth over-fishing.

Beach Seine Fishery

Annual production of the beach seine fishery was estimated at about 7 320 t. of which most of the catches were pre-juveniles and juveniles of jewfish, anchovies, clupeoids and penaeid and caridean shrimp. As a result all the catches by this net do not get a chance to join the spawning process.

Trammel-net Fishery

Trammel-nets only operate on the Teknaf coast on a limited artisanal scale. This is a selective gear and biological studies show that the exploitation rate is below the optimum level, that the size at first capture is above the minimum and that overall exploitation by this gear appears to be biologically and economically rational and socioeconomically acceptable.

Exploitation by Semi-industrial Fisheries

There are no reports on over-fishing of *hilsa* in the marine ecosystem, but juveniles are exploited seriously in the riverine system. The bottom longlining and marine set bag net fishing with mechanized boats do not appear to be causing over-fishing, but fishing for spawning *hilsa* is a concern for management. Over-fishing of adult Indian salmon and long jewfish by large mesh drift-nets occurs in shallow waters off Cox's Bazar.

The Industrial Trawl Fishery

The effort in the trawl fishery during the last two decades has varied around 5 - 7 000 standard fishing days (Table 12), to produce 2 500 - 5 500 t of shrimp. The MSY of penaeid shrimp is 7 000 t and the optimum effort for producing this amount is 7 000 - 8 000 standard days. In some years effort was around the level of MSY. Some effort was lost due to a major cyclone in April 1991. Thereafter, shrimp production was much below the MSY level.

Table 25. Population parameters of some species common in the catch of estuarine set bag net in Bangladesh.

Species	L_∞ (cm)[a]	K (year^{-1})	M (year^{-1})	F (year^{-1})	L_c (cm)[b]	E = (f/z)
Shrimp						
Penaues monodon	31.36	0.720	1.423	8.377	13.792	0.855
Penaues indicus	22.84	0.550	1.303	3.700	5.919	0.740
Metapenaeus monoceros	19.77	0.437	1.167	3.652	5.860	0.758
Metapenaeus brevicornis	15.57	0.310	0.997	4.235	4.809	0.809
Metapenaeus spinulatus	20.06	0.390	1.079	5.900	5.292	0.845
Parapenaeupsus sculptitis	16.90	0.760	1.752	4.150	15.300	0.703
Parapenaeupsus stylifera	14.37	1.660	3.062	3.000	2.800	0.495
Acetes indicus	5.00	0.730	2.401	1.100	2.036	0.314
Macrobrachium rosenbergii	35.54	0.340	0.841	1.960	7.341	0.700
Palaemon styliferus	15.37	0.630	1.591	3.200	3.736	0.670
Fish						
Raconda russeliana	23.62	0.430	1.099	2.100	2.931	0.657
Setipinna taty	21.27	0.530	1.284	0.800	15.796	0.281
Stolephorus tri	16.83	0.650	1.586	9.000	3.351	0.850
Harpadon nehereus	34.90	0.380	0.909	3.750	6.273	0.805
Lepturacanthus savala	93.00	0.290	0.579	2.620	22.600	0.819
Eleatheronema tetradactylum	38.08	0.100	0.850	3.500	5.300	0.866
Polynemus paradiseus	21.63	0.520	1.276	4.724	2.699	0.787
Sillago domina	43.26	0.380	0.856	2.700	13.057	0.759
Sillago sihama	27.36	0.390	0.993	3.000	5.100	0.751

Source: Khan et al. 1997.

Note: [a] = Asymptotic total length in the Von Bertalanffy growth equation.

[b] = Mean total length of first capture.

But if the shrimp catch of artisanal gear operated in more than 10 m depth is considered, the total shrimp production becomes more than the MSY level. At present, there are 59 trawlers (44 shrimp and 15 finfish), which give a total annual effort of about 7 000 standard days. However, shrimp production has not increased accordingly.

Finfish landed by the trawler fleet is in the range of 8 000 - 12 000 t, which is only 20% of the actual catch, while 80%, equivalent to 35 - 45 000 t (White and Khan 1985), is discarded at sea. Even if the discarded amount is considered as production, the MSY is being achieved. If the finfish catch (35 000 - 50 000 t) of artisanal gear operated in more than 10 m is included, the production exceeds the MSY level. The MSY is 48-88 000 t within the 10 - 200 m zone (Lamboeuf 1987) whereas Khan et. al. (1997) reported an MSY of 40 - 50 000 t within this zone. The tiger shrimp *(P. monodon)* is the targeted species and has been over-exploited (Table 26) by the trawl fishery.

Tuna and Other Pelagic Fish

While there is strong and continuous competition

in the demersal and shrimp trawling industry within the 100 m isopleth, as well as in the traditional artisanal fishing areas, the resources of other areas such as those beyond 100 m depth and the surface areas of 40 m depth are not being harvested. Exploratory survey and research information shows that substantial resources are available in these areas, particularly pelagics such as mackerels, tuna and skipjack, shark, anchovies and sardines. These large pelagic resources are partly exploited as by-catch of the *hilsa* gillnets and some of the small pelagics are harvested as by-catch of the trawlers.

Economic Status

A "long-term prediction" analysis was done with a view to finding the comparative economic gain from the trammel, trawl and ESBN fisheries if only one was allowed to operate and the others were suppressed, or vice versa if only the ESBN is suppressed and the others are allowed to operate as they are.

The analysis indicated that if the trawl fishery is kept and all other interactive fisheries (but not push-net) are suppressed, there would be substantial gain in weight and about a 300% gain in value of the catch. There would be a 250% gain in value of the catch in the trawl fishery if the ESBN fishery was not in operation.

On the other hand, trammel-nets showed an extremely high gain (by about ten times) in revenue when all fisheries (including trawlers, but not the push-net fisheries) were suppressed, but a smaller gain in yield and a large gain in revenue (300%) if only the ESBN is suppressed (Khan and Latif 1995).

Table 26. Population parameters of trawl-caught species in Bangladesh.

Species of fish/shrimp	L_∞ (cm)[a]	K (year^{-1})	Z (year^{-1})	M (year^{-1})	F (year^{-1})	E = (f/z)	L_c (cm)[b]
Shrimp							
Penaeus monodon (F)	30.5	1.14	6.83	1.94	4.89	0.71	17.5
Penaeus monodon (M)	31.5	1.35	5.72	2.14	3.58	0.62	15.7
Metapenaeus monoceros (M)	15.7	1.60	5.89	2.91	2.98	0.50	8.9
Metapenaeus monoceros (F)	18.5	1.65	4.52	2.84	1.68	0.37	9.5
Fish							
Pampus argenteus	30.5	1.66	5.25	2.35	2.90	0.55	–
Upenaeus sulphureus	22.0	1.10	10.59	2.96	7.63	0.72	–
Nemipterus japanicus	25.0	1.06	3.75	1.94	1.81	0.48	–
Saurida tambil	39.0	0.97	2.54	1.66	0.88	0.35	–
Pamadasys hasta	57.0	0.38	1.61	0.81	0.79	0.51	–
Lepteuracanthus savala	105	0.85	2.06	1.33	0.73	0.65	–
Harpadon nehereus	38.3	0.42	1.54	0.94	0.6	0.38	–
Lutjanus johni	64.72	0.28	2.70	0.59	2.11	0.78	–
Arioma indica	22.0	1.12	5.53	2.10	3.43	0.62	–

Source: Khan et al. 1997.

Note: [a] = Asymptotic total length in the Von Bertalanffy growth equation.

[b] = Mean total length of first capture.

From the different analyses, it is evident that withdrawal of the ESBN fishery would not only maintain a healthier stock, but would give a substantial increase in economic returns. The push-net (larval) fishery was kept out of this analysis because necessary data were not available. However, since about 95% of the exploited population is taken by the larval fishery alone, the suppression of this fishery would definitely give a greatly increased economic return. This perception would lead fishery managers and planners to seek higher economic returns from the same stock by changing traditional fishing attitudes.

Management Issues and Opportunities

Fisheries Management Philosophy

Fisheries in Bangladesh have been considered a gift of nature, which everybody can harness for their benefit. However, the increase of fisherfolk and limited employment opportunities in the coastal areas has resulted in the entry of non-traditional fishers who have saturated the coastal areas with nets. This has resulted in the development of some highly destructive gear. Bangladesh fisheries thus face a grave situation. Although the biological solution to destructive practices calls for the total elimination of destructive gear, the Government has taken a cautious approach to the problem and has favored a participatory approach in the management of the fisheries. Interest in community-based fisheries management strategies has increased, giving more emphasis to motivation and awareness-building campaigns than to enforcement of legislation.

Fisheries Management Goals and Objectives

The main goal is the sustainable utilization of the coastal fishery resources of Bangladesh. Fisheries management has three main objectives, ecological, economic and social (Table 27).

These were finalized through joint discussion with participants from DOF, MOFL, FRI, universities, WorldFish and EGIS in a national workshop held during 3 - 5 October 2000 in Dhaka.

Ecological Objectives

These are divided into three branches: (a) rational utilization of the resources; (b) protection/conservation of the environment that sustains the resources and (c) biodiversity protection and conservation of endangered species. Rational utilization of the resources, including shrimps, demersal finfishes and shellfish, pelagic finfish and shellfish migratory species, other invertebrates and sea weeds. These resources should be exploited and utilized rationally. If any one type of resource is over-exploited while others are exploited at lower rates or are unexploited, the entire ecosystem will be depleted.

Protection and conservation of the environment include maintaining the ecological integrity of critical coastal habitat (mangroves, coral reefs). Coastal habitats should not be damaged by any agency and brackish and marine waters should not be polluted (Table 27).

Table 27. Goals/Objectives for the coastal fisheries management of Bangladesh.

Main goal: Sustainable utilization of the coastal fishery resources of Bangladesh	
Ecological objectives	Rational utilization of resources Demersals (shrimps and others) Pelagics Migratory species/straddling stocks Harvestable invertebrates Seaweeds Protection/conservation of the environment that sustains the resources Ecological integrity of critical coastal habitats (mangroves, coral reefs, etc.) Ecological integrity of marine waters Bio-diversity protection/Protection and conservation of endangered species
Economic objectives	Maximize benefits from the utilization of the resources within the limits of sustainable use Increase incomes of small scale fishers Improve the efficiency of input use
Social objectives	Minimize conflicts among resource users Promote equity in sharing benefits from the utilization of the resources Reduce poverty among small scale fishers Promote alternative livelihood opportunities

Economic Objectives

The objective is to maximize benefits from the utilization of resources, within the limits of sustainable use. The small scale fishers should get reasonable incomes from artisanal fishing and the fishing technology should be improved, but over-fishing must be avoided under all circumstances (Table 27).

Social Objectives

These include minimizing conflicts among resources users, promoting equity in sharing benefits from the utilization of the resources, reducing poverty among small scale fishers and promoting alternative livelihood opportunities for the fishers (Table 27).

Fisheries Sector Issues

The multiplicity of issues that impact the coastal fisheries in Bangladesh (Tables 28 - 31) were discussed with participants from DOF, MOFL, FRI, universities, WorldFish and EGIS in the national workshop held during 3 - 5 October 2000, in Dhaka. The consensus was that the coastal fish stocks and fisheries require improved management to sustain the resources and increase the benefits derived from them. The main issues (Tables 28 - 31) that require improved management are briefly described.

Table 28. Productivity efficiency issues, causes, effects and interventions.

Issue	Causes	Effects	Interventions
Stock depletion	Over-fishing on inshore stocks Growth over-fishing (small mesh size) Recruitment over-fishing/brood over-fishing Poaching Poor law enforcement Non-compliance with legislation or capability of the DOF/MOFL Lack of coordination among the government, NGOs, autonomous bodies, private organizations related to fisheries development/exploitation Lack of protection of the productive sensitive zones, i.e. Sunderbans areas	Reduced protein potentiality Reduced fish catch Reduced earning from fisheries Reduced employment opportunities Reduced business activities Seasonal succession disrupted Endangering/extinction of some commercially important species	Limited entry Effort reduction Implementation of legislation supported by motivational programs Management and action program should be participatory (presence of all stakeholders to be ensured) Build-up of information technology for sustainable development of aquatic resources Stocking of selected species from hatchery Creation of field/mobile licensing facilities Closed seasons/areas (during breeding season) for particular species Protect mangrove areas Extend MPA in coastal areas
Inappropriate exploitation patterns	Non-specificity of gear used; absence of gear for pelagic species	Unexploited resources Unequal exploitation of different species /populations	Needs immediate feasibility studies on pelagic fisheries Regulations regarding use of specific gear for particular populations
Technology	Lack of technology and manpower	Wastage of resources/over-exploitation	Technological/manpower development
Research	Lack of resources/infrastructure and planning	Absence of appropriate technology	Mobilization of sufficient funds and resources
Information - database on the catch production	Lack of awareness/facilities	Inability in interaction with other countries	Create facilities for information retrieval systems
Post-harvest losses	Trash fish - non-profitable Inadequate transport and preservation facilities Inappropriate marketing channels	Wastage of resources Local pollution Inbalance in food chain Loss of resources Deprived reasonable prices	Introduction of by-catch reduction device Other means of processing on board the vessel Develop preservation and other facilities like transport Introduction of appropriate marketing channel (elimination of middlemen)

Table 29. Environmental integrity issues, causes, effects and interventions.

Issue	Causes	Effects	Interventions
Over-exploitation of the stocks	Lack of awareness Lack of database	Stock depletion/low productivity	Enforcement of regulations on gear/ size/season. Awareness build up
Pollution from oil due to ship breaking/spillage and other sources	Lack of enforcement/tendency not to obey the regulations	Habitat degradation/stock depletion	Creation of awareness enforcement of regulations Valuation of habitats
Mangrove destruction	Lack of awareness/Lack of appropriate policy/Corruption	Habitat degradation	Framing of appropriate policies/ creation of awareness Enforcement of regulations Valuation of habitats
Siltation	Deforestation in the catchments areas/Corruption	Habitat degradation	Awareness building/enforcement of regulations Valuation of habitats
Waste dumping and leakage	Lack of enforcement of regulations/disobeying of regulations	Pollution/degradation of habitat	Enforcement of regulations/create facilities for waste receiving dumping/treatment Valuation of habitats
Rigging for oil exploration	Development of economy	Habitat degradation	Mitigation measures should be taken Monitoring program should be launched Valuation of habitats
Industrial wastage	Economic benefits	Habitat degradation	Appropriate mitigation measures should be adopted Valuation of habitats
Pesticides use	Economic benefits	Habitat degradation/health hazards	Appropriate mitigation measures should be adopted
Introduction of exotic species			Strict quarantine rules
Sewage disposal	Lack of enforcement/awareness	Habitat degradation	Enforcement of regulations/ awareness
Lack of monitoring program on water quality			Parallel monitoring (multi-agency)
Lack of an environmental section in DOF			Establish an environmental section in DOF
			Overall interventions: Eco-friendly environmental management measures should be adopted in all cases

Table 30. Distributional equity issues, causes, effects and interventions.

Issue	Causes	Effects	Interventions
Small /Large scale fisheries conflicts	Overlapping of interests	Over-exploitation of the resources	Awareness build-up in the stakeholders
Dadon System	Lack of credit for small holders	Economic exploitation of the fisherfolk, resulting increase in poverty	Creation of credit facilities for the poor fishers without collateral
Demarcation of sea/Species types/ Gear types/Seasonality	Lack of awareness/weak enforcement of the existing rules/tendency not to obey the existing regulations	Over-exploitation of the resources affecting interests/ low catch/low income	Awareness building, management and enforcement of regulations
Resource management conflicts in the Sunderbans area	Not managed by DOF	Resource depletion Poor management	Water bodies should be scientifically managed with the collaboration of DOF
Rehabilitation and IGAs for push-net fisheries and ESBN fisheries	Encouraging fishing with destructive gear	Destruction of resources	Closure of the fishery Provision of alternative livelihood

Table 31. Instutional efficiency issues, causes, effects and interventions.

Issue	Causes	Effects	Interventions
Inadequate institutional capacity to address fisheries management	Lack of an independent Marine Fisheries Department	Marine fisheries sector is not properly handled and monitored	Appropriate training programs Recruitment of needed manpower Establishment of independent Marine Fisheries Department and other infrastructure
Lack of scientific manpower with proper academic background	Lack of recruitment rules	Shortage of scientific manpower	Recruitment of adequate scientific manpower
Lack of proper training for scientific personnel	Training facilities are not organized	Personnel face difficulties in research and legislation	Introduction of proper training for scientific personnel
Lack of inter-agency coordination	Unclear responsibilities		Increase awareness among agencies regarding their roles and responsibilities Formulation and assignment of responsibilities by a central government agency/coordinating body Harmonize and simplify laws and regulations Promote dialogue/communication among agencies
Lack of infrastructure facilities and equipment	Due importance to marine fisheries sector not given	Marine fisheries resources are depleted	Infrastructure facilities should be created
Conflict between government and the marine fisheries industry, NGOs, fishing communities	Lack of awareness of better management policy	Marine fisheries management is not developed	Establish Marine Fisheries Department & reorganize the Ministry of Fisheries Increase participation of stakeholders
Irregular stock assessment/ monitoring	Lack of scientific manpower and logistic support facilities	Current information on marine fisheries resources lacking	Creation of facilities for bio-ecological research on marine fisheries resources
Lack of bio-ecological research on the commercial species of fish and shrimps	Lack of appropriate skilled scientific manpower and research facilities	Non-availability of knowledge of the bio-ecology and stock analysis of marine fishery resources	Creation of appropriate research facilities

Productivity and Efficiency Issues

Stock Depletion and Over-exploitation

The stocks of many species of marine shrimps and fish are declining due to growth over-fishing by estuarine set bag nets, push-nets and beach seines and to recruitment over-fishing by the trawler fleets. Problems are increased by poaching by foreign fishing trawlers, improper enforcement and implementation of laws, flouting of laws by trawl and artisanal fishers and lack of coordination among the government agencies, NGOs, autonomous bodies and private organizations.

Inappropriate Exploitation Patterns

Multi-gear, multi-species fisheries characterize the region and there are no specific gear types for particular species. For *Hilsa*, for example, the ESBN, MSBN and trawl-nets catch similar assemblages of species of demersal finfish and shrimp, but all species are not harvested at equal rates.

Technology

There is no specific technology for catching pelagic species, such as tuna and squid, or for other non-traditional fishery resources, such as cuttlefish, octopus, lobster and seaweeds.

Research and Database on the Catch

There is no database for catch and effort statistics and there is a lack of facilities for scientific research and a shortage of skilled scientific manpower.

Post-harvest Losses

The shrimp trawlers target only shrimp, but take substantial by-catch. The high-valued fin-fish are kept, but low-value trash fish are discarded. No facilities have been developed to transport the trash fish to markets and no marketing channels exist for these fish.

Environmental Integrity Issues

Pollution is increasing in brackish and marine waters due to pollutants from domestic, industrial and agricultural sources. Oil spills from ship breaking, spillage and other sources, waste dumping and leakage, sewage disposal, rigging for oil exploration, industrial wastage and pesticides are polluting marine waters and damaging habitats and stocks of aquatic resources. Mangrove destruction is leading to increased flooding, siltation and alteration of hydrological regimes that cause adverse impacts on coastal fishery resources. The degradation of mangroves, seagrasses and algal beds is apparent in coastal areas. All these impacts have repercussions on coastal bio diversity and on the productivity of coastal fishery resources.

Distributional Equity Issues

Small and Large scale Fisheries Conflicts

Fishing in areas less than 30 m deep is quite intense and competition between small scale artisanal and large scale trawl fisheries has increased in recent years resulting in high fishing pressure on the same resources. The trawl fishers should operate their gear beyond 40 m following the marine fisheries ordinance. The trawl fishers are not carrying out the restriction of area and season for conservation of the fishery resources and most of the artisanal fishers are not following the rules and regulations of mesh size of the gear. The instituation could be minimized by DOF/MOFL implementing the marine fisheries rules, supported by awareness building among the trawl and artisanal fishers and other stakeholders.

Rehabilitation and Income Generating Activities for PN and ESBN Fishers

Push-net, estuarine set bag nets and beach seines are destructive fishing methods and need to be banned. However, many thousands of full-time and part-time fishers are involved and alternative income generating activities are needed in the coastal zone.

Institutional Efficiency Issues

The lack of an independent Marine Fisheries Department has resulted in the marine fisheries sector not being properly managed. There is a shortage of scientific manpower due to a lack of proper recruitment rules. Training facilities are not well organized and the sector lacks infrastructure, equipment and funds because it has not been given due importance.

There are gaps in interagency coordination, conflicts between government and the fishing industries, the NGOs and the fishing communities, all resulting in mismanagement of fishery resources. The fisheries sector lacks current information on

the status of stocks and catch statistics and stock assessments have not been made because of the lack of skilled scientific manpower and logistic support.

Cross Sectoral Issues and Opportunities

Apart from these evident fisheries-specific issues, a number of cross-sectoral issues require attention for the long term sustainability of coastal fisheries. Table 32 summarizes the main activities and issues that impact the coastal zone and, ultimately, the coastal fisheries. The complex issues impacting the country's coastal zone require multiple, but integrated, interventions. Integrated coastal zone management (ICZM) requires increased support to resolve the impacts (both actual and potential) on the coastal ecosystems. Various ICZM initiatives in the country emphasize the need for improved collaboration and coordination among relevant government agencies (e.g. Ministry of Fisheries and Livestock, Ministry of Shipping, Ministry of Land, Ministry of Environment and Forests and the Ministry of Defense) as well as an upgrading of their capabilities to effectively resolve coastal zone impacts.

The Ministry of Industry is currently authorized to accord permission for acquisition of fishing trawlers in consultation with MOFL. The mechanized fishing vessels are registered with the Mercantile Marine Department (MMD). For patrolling of the EEZ, the DOF procured two modern gunboats and placed them under the operational control of the Bangladesh Navy.

Several NGOs and fishers cooperatives are involved in marine fisheries development activities in the country. Bangladesh *Jatiyo Matshyajibi Samabay Samity* (BJMSS), for example, had direct involvement in the marine fisheries development, but is now ineffective. Among the NGOs, CODEC, CARITAS and Proshika-MUK are directly involved in the development of the fisherfolk communities.

Table 32. Typical coastal transect showing the main activities and issues relevant to effective integrated coastal zone and coastal fisheries management in Bangladesh.

	Terrestrial			Coastal		Marine	
Major zones	**Upland slope (> 18%)**	**Midland (8 - 18% slope)**	**Lowland (0 - < 8% slope)**	**Interface (1km inland from HHWL* -30m depth)**	**Nearshore (30m - 200m depth)**	**Offshore (> 200m depth - EEZ)**	**Deepsea (beyond EEZ)**
Main resource uses/activities	Logging, mining, urban development agriculture	Logging, mining, urban development, industries, agriculture, brick/boulder, extraction	Logging, agriculture urban development, industries, tourism	Mangrove forestry, aquaculture, ports/marine transport, artisanal fishing	Artisanal fishing, commercial/ industrial fishing, marine transport, pearl collection	No fishing	Marine transport
Main environmental iissues/ impacts on the coastal zone	Siltation, erosion, flooding, agrochemical loading, water, pollution, toxic mine tailings	Siltation, erosion, flooding, toxic mine tailings	Siltation, erosion, flooding, agrochemical loading, sewage pollution, industrial pollution	Reduction of biodiversity, habitat degradation, over-fishing, beach erosion, organic loading, oil spills/slicks	Reduced biodiversity, over-fishing, oil spills/slicks, dumping of waste	Oil spills/slicks, dumping of waste	Oil spills/ slicks

Note: * Highest high water level.

As part of the global initiative taken by the coastal zone management subgroup (CZMS) of the Intergovernment Panel on Climate Change (IPCC), the Bangladesh Center for Advanced Studies (BCAS), in collaboration with Resource Analysis (The Netherlands) and Approach Consultants (Bangladesh), undertook a pilot study on the assessment of the vulnerability of coastal areas to climate change and sealevel rise. The results of the study were presented on behalf of the Ministry of Environment and Forestry, at the World Coast Conference. The objective of the study was to analyze the vulnerability of Bangladesh to sealevel rise and global climate change and to prepare a vulnerability profile. Other objectives included identification of the institutional strengths and weaknesses for implementing integrated coastal zone management (ICZM).

The study focused on assessing the primary physical effects of different scenarios in terms of changes in inundation, salinity intrusion and droughts, as well as cyclones and flash floods. The study revealed that there is clearly a need for integrated coastal zone management, both at the national and local levels.

The Environmental Survey and Research Unit (ESRU) of the Department of Geography, Dhaka University, is a research and study organization committed to gathering information useful for implementing projects of national importance. ESRU also assists development agencies in dealing with development oriented problems, in forms and means best suited to their needs. They have directed and participated in different projects financed by ADB, FAO, Ford Foundation, HABITAT, JICA, UNDP, UNFPA, USAID, World Bank and other organizations.

Recommendations for Immediate Government Action

- Additions of fishing boats and gear in coastal fisheries should be limited.
- Fishing effort should be reduced and all destructive gear like the estuarine set bag net, beach seine and shrimp fry collection nets should be gradually removed and replaced by non-de structive gear, provided that alternative income generating activities can be developed for those fishers who are fully dependent on these fisheries.
- Legislation for the artisanal and trawl fisheries, such as seasonal closures, area restrictions and mesh size regulations, must be properly implemented, supported by awareness building and motivational programs for coastal fishers, fishing vessel owners and other stakeholders.
- Pelagic fishery resources, like tuna and other non-traditional fishery resources, such as squid, cuttlefish, octopus, oysters, mussels, lobsters, crabs, sea cucumbers and seaweeds should be surveyed with a view to their exploitation in a sustainable manner.
- Improved fishing technologies for demersal fish and shrimp and for hilsa should be introduced.
- By-catch reduction devices should be introduced in the trawl fishery.
- The use of non-destructive gears, such as tram mel-nets, bottom set gillnets, bottom longlines and purse seines, should be promoted, through proper training and motivational programs for fishers.
- Improved fishing methods for pelagic fishery resources, particularly for tuna, should be introduced through training and extension programs.
- Regulations should be promulgated regarding the use of the gear with specific mesh sizes for selective harvesting of particular lengths or sizes of various species.
- Databases should be created on the catches of all fish stocks and on all relevant scientific information.
- Coordination between stakeholders should be increased to address the conflicts between government agencies and the marine fishing industry, NGOs and fishing communities, regarding marine fisheries management.
- Awareness building, communication, coordination and dialogue should be increased among agencies regarding their roles and responsibilities (assigned for marine fisheries management by the central government).
- Eco-friendly environmental management measures should be adopted in all cases.
- Multi-agency programs should be introduced for water quality analysis.
- Quarantine rules should be strictly followed by departments concerned regarding introductions of exotic species.
- The possibilities of stocking marine waters with selected, commercially-important species from hatcheries should be investigated.
- Mangrove areas should be protected and Marine Fisheries Department activities should be extended in the coastal areas.
- Appropriate mitigation measures such as awareness building and enforcement of regulations, should be undertaken to protect the marine

environment from pollution due to oil spills from ship breaking, spillage, oil exploration, industrial wastes, pesticide use, sewage disposal, waste dumping and leakage. Facilities should be created for waste treatment before dumping the waste into the marine waters and for receiving it waste from marine industries.
- An Environmental Section should be established in the Department of Fisheries.
- Sufficient funds should be allocated for marine fisheries surveys and research.
- Appropriate steps should be taken for man power development in the marine fishery sector.
- An independent Marine Fisheries Department should be established under the MOFL for proper and effective organizing, monitoring and regulating the overall activities in the sector.

Recommendations for Government Follow-up Action

- Closed periods during the breeding season and marine reserves for the conservation of gravid female shrimp and fish species should be established and implemented.
- Trash fish are to be utilized through shifting to carrier vessels with proper processing facilities on board. Appropriate marketing facilities should be introduced for trash fish.
- Appropriate research facilities should be created for bio-ecological research on marine fishery resources.
- Credit facilities on simple terms and conditions should be created for the poor fishers.
- Field-based mobile licensing facilities for fishing boats should be introduced.
- Appropriate policies for shrimp and fish farming should be made to protect the mangrove forests and regulations to conserve of mangrove forest should be enforced to check corruption.
- Water bodies of the Sunderbans (mangrove) areas should be scientifically managed with the collaboration of the Forest Department.
- Management and action programs for fishery resources conservation should be participatory, with the presence of all stakeholders ensured.
- Appropriate training programs should be introduced for scientific personnel, aiming at man power development.
- Scientific man power, with appropriate academic background, should be recruited by the Marine Fisheries Research and Surveying sector.

Recommendations for Regional Collaborative Efforts

- Marine infrastructure facilities in all member countries of the Indian Ocean Fishery Commission (IOFC) should be developed.
- International funding agencies may provide support for research in the area of exploration and exploitation of under-exploited or unexploited marine fishery resources.
- Governments of countries of the Indian Ocean rim should take necessary measures to prevent illegal poaching of fish by their vessels in the EEZs of other countries.
- Different by-catch reduction methods in trawl fishing should be investigated.
- Regional and national research collaboration should be promoted for increasing institutional capabilities and strengths and for providing information, training and advisory support to members of developing countries.
- Bilateral and multilateral cooperation should be promoted in managing, harvesting and utilizing straddling and migratory high seas fish stocks.
- The Indian Ocean Fishery Commission (IOFS) and other regional bodies such as the Indian Ocean Tuna Commission (IOFC), should take measures for the management and conservation of straddling or highly migratory fish stocks.
- Modern marine science technology should be disseminated to all countries of the Indian Ocean rim through different cooperative programs.
- The dumping of toxic wastes by industrially developed countries along the Indian Ocean should be prevented by building up public opinion and by monitoring the movement of vessels carrying toxic wastes.
- International cooperation by the IOFC, IOTC, IPFC, and the IPTP should be strengthened and made effective by more consultation and the establishment of a Secretariat for these organizations.
- Information networks should be established between the countries of the Indian Ocean rim to facilitate the easy flow of information and ideas which will help the conservation and management of aquatic resources.
- GOB should discuss with relevant international organizations, in the appropriate fora, the idea of initiating a United Nations Ocean Development Programme (UNODP) to overview the "Code of Conduct for Responsible Fisheries" internationally, to coordinate the rational development of ocean resources regionally, and to assist national endeavours in this respect.

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References

Ameen, M. 1987. Fisheries Resources and opportunities in Freshwater Fish Culture in Bangladesh. PAT.NRD-II / Danida, Noakhali, Bangladesh, 244 p.

Anwar, J. 1988. Geology of the Coastal area of Bangladesh: Recommendation for resource development and management. p. 36 - 66. *In* Proceedings, National Workshop on Coastal Area Resource Development and Management, Part -II.Organized by CARDMA (Coastal Area Resources Development and Management Association), Dhaka, Bangladesh.

Anon. 1992. The Dhaka courier. Vol. 8, No. 29 (February 21 - 27, 1992), Dhaka, Bangladesh.

Bangladesh Bureau of Statistics. 1997. Statistical Yearbook of Bangladesh. Ministry of Planning, Government of the People's Republic of Bangladesh.

BOBP (Bay of Bengal Program). 1985. Marine Small Scale Fisheries of Bangladesh: A general description. BOBP/INF/8/ (GCP/RAS/040/ SWE). Development of Small Scale Fisheries in the Bay of Bengal, Madras, India, 59 p.

Chong, Kee-chai, N. Islam and M. Begum.1991. Analysis of the constraints to and potentials and opportunities for expanded fish production in Bangladesh. Field Document on Institutional Strengthening in the Fisheries Sector, Bangladesh. Ministry of Fisheries and Livestock, UNDP,FAO,BGD/87/045/91/07, Dhaka, Bangladesh.

Chowdhury, Z.A., M.G. Khan and S.A. Quayum. 1993. The Beach Seine Fishery of Teknaf. p. 51 - 64. *In* Studies of interactive marine fisheries of Bangladesh. Bay of Bengal Program, BOBP/WP/89.

Chowdhury Q.1 1999: National Environmental Legislations. P. 145 - 161. *In* Bangladesh State of Environment Report 1998.

Das, N. G. and S. Das. 1980. Two Clanoid Copepods from the Karnaphully river estuary, Chittagong University Studies 11(4) : 41 - 47 p.

Draft Master Plan. 1998. Meghna Estuary study. Bangladesh water development board, Ministry of water resources. Vol. 6: Fisheries, DGIS/ Danida. 92 p.

Department of Fisheries. 1985. Report on the Frame Survey of the Marine Artisanal Fisheries in Bangladesh, 1984 - 85. Department of Fisheries, Dhaka, Bangladesh.

Department of Fisheries. 1990 - 91 to 1995 - 96. Fish Catch Statistics of Bangladesh, Bangladesh Fishery Resources Survey System. BFRSS, Department of Fisheries, Dhaka, Bangladesh.

Department of Fisheries. 1999. A Brief on the Department of Fisheries, Bangladesh. 65 p.

Eysink, W.D. 1983. Basic consideration on the morphology and land accretion potentials in the estuary of the Lower Meghna River. Land reclamation project. Bangladesh water development board. I.R.P. Technical report 15 : 39 p.

FAO. 1984. Technical Cooperation Program: Integrated Development of Bangladesh by FAO. Based on the work of H. R. Rabanal. Rome, FAO. TCP/BGD/2309 : 28 p.

Haider, S.M.B. and N. Mahmood. 1992. The Coral Genus Acropora (Scleractinia: Astrocoeniina: Acroporidae) in nearshore waters of the St. Martins Island, Bangladesh. Bangladesh. J. Zool.

Hannan, M.1996. Rural credit: An Assessment of Sources and Types available in Bangladesh. Information Bulletin 11, DFID/BOBP, Chennai, India, 62 p.

Hansen U.J. and M.G. Mustafa 1992. Survey to study the design, behaviour and performance of the set bagnet operated in the estuaries of Bangladesh. DIFTA, Danish Institute for Fisheries Technology and Aquaculture. Bay of Bengal Program, 28p.

Haque, M., M.A. Islam, S.T. Ahmed and S.M. Haque. 1979. Geology of the St. Martin's Island, Bangladesh. *J.Sci.Ind Res.* 2(B): 17 - 27 p.

Haque, Q.M., M.G. Khan, Z.A. Chowdhury and M.N. Sarker. 1993. The Bottom Longline Fishery for Croaker (Sciaenidae). p. 107 - 117. *In* Studies of interactive marine fisheries of Bangladesh. BOBP/WP/89.

Hussain, M.M. 1995. Status of development of the fishery and seafood processing industry in Bangladesh. p. 65 - 85. *In* M.A. Mazid, V.R.P.Sinha and M. Kamal (eds.) Proceedings of the seminar on Sustainable Development of Marine Fisheries Resources in Bangladesh, August 1994. Fisheries Research Institute, Bangladesh.

Hussain, M.M. and M. H. Uddin. 1997. Quality Control and Marketing of Fish and Products: Needs for Infrastructural and Legal Support. p. 231 - 272. *In* Report of the National Workshop on Fisheries Resources Development and Management in Bangladesh, Oct. - Nov. 1995, BOBP/REP/74, Madras, India.

Islam, A.K.M.N. 1976. Configuration to the study of the marine algae of Bangladesh, Biliopheta phycologica, J. Cramar Bend 19 : 253 p.

Islam, A.K.M.N. 1980. A marine angiosperm from St. Martins Island. Bangladesh *J. Bot.* 9(2) : 177 -178.

Islam, M.S., M.G. Khan, S.A. Quayum, M.N.U. Sada and Z.A. Chowdhury. 1993. The estuarine Set Bagnet Fishery. p. 19 - 50. *In* Studies of interactive marine fisheries of Bangladesh. BOBP/WP/89.

Islam, M.S. and M.G. Khan. 1993. The Trammel Net Fishery. *In* Studies of interactive marine fisheries of Bangladesh. p. 79 - 88. BOBP/WP/89.

Islam, M.S. and K.Q. Elahi. 1993. Small scale Marine Fisheries in Bangladesh : A Socioeconomic Analysis, Research Report No. 23. Bureau of Socioeconomic Research and Training, BAU, Mymensingh.

Islam M.R, R. Salminen and D.W Dahermo. 2000. Arsenic and other toxic elemental contamination of groundwater, surface water and soil in Bangladesh and its possible effect on human healthy. Environmental geochemistry and Health. Vol. 22 : No. 1 : 33 - 53 p.

Islam, M.S. 1995. Socio Economic status of Marine Fishermen and their upliftment. 58 - 64 p. *In* M.A. Mazid, V.R.P. Sinha and M. Kamal (eds.) Proceedings of the Seminar on Sustainable Development of Marine Fisheries Resources in Bangladesh, August 1994. Fisheries Research Institute, Bangladesh.

Kutty, M.N., A.A.K.M. Haque and S.R. Bhuiyan. 1991. Guidelines for Manpower Development Planning in the Fisheries Sector with Special Reference to Resource Type. BGD/87/045/91/12.

Khan, MG. 1983. Results of the 13th cruise (July '83) with the R.V. Anusandhani of the demersal fish and shrimp grounds of the Bay of Bengal, Bangladesh. Marine Fisheries Research, Management and Development Project. Chittagong, 25 p.

Khan, M.G.,M.G. Mustafa, M.N.U. Sada and Z.A. Chowdhury. 1989. Bangladesh Offshore Marine Fishery Resources Studies with Special Reference to the penaeid shrimp stock 1988 - 89. Annual Report Marine Fisheries Survey, Management and Development Project, GOB, Chittagong, 213 p.

Khan, M.G., M.S. Islam, M.G. Mustafa, M.N.U. Sada and Z.A. Chowdhury 1994. Biosocioeconomic assessment of the effect of the estuarine set bagnet on the marine fisheries of Bangladesh. BOBP Seminar, 12 - 15 January 1992, Cox's Bazar, Bangladesh, 20 p.

Khan, M.G. and and M.A. Latif. 1995. Potentials, constraints and strategies for conservation and management of open brackishwater and marine fishery resources. Paper presented at the National Seminar on Fisheries Resources Development and Management organized by MOFL, Bangladesh, with FAO and ODA, 29 October to 31 November 1995, Dhaka, Bangladesh, 19 p.

Khan M.G 1996. Bangladesh: Economy in the Far Esat and Australia. London. Europa publication.

Khan, M.G., M. Alamgir and M.N. Sada. 1997. The coastal fisheries of Bangladesh, 26 - 37 p. *In* G. Silvestre and D. Pauly (eds.) Status and management of tropical coastal fisheries in Asia. ICLARM Conf. Proc. 53, 208 p.

Khan, M.S., R. Ahmed, H. Rashid, M.M. Aktkah, M.A.Khan, M.Hossain, A. Chowdhury, P. Gain, S. Moral, P. Raj, F.M.A. Salam, R. Siddique, M. Farooque, R. Hasan, M.K. Majumder, M. Kamal, K.I. Omar, K. Gregow, F. Akhter, M.J. Abedeen, H. Shahriar, Y.S. A. Khan, S. Lipon, Q.A. Tahmina, R. Matin, S. Alam, U.K. Das, G.B. Mondal, G. Nandy, S.I. Chowdhury, A. Halim, H. Kabir and R.I. Sabuj. 1998. Philip Gain (eds.) Bangladesh Environment: Facing the 21st Century. Society for Environment and Humen Development (SEHD), Dhaka 1205, Bangladesh.

Lamboeuf, M. 1987. Bangladesh demersal fish resources of the continental shelf. Marine Fisheries Research Management and Development Project. FAO/ BGD.FE :DP /BGD /80/075, 26 p.

Mahmood, N.1986. On fishery significance of the mangroves of Bangladesh, p. 26 - 32. *In* N. Mahmood (ed.) Proceedings of the workshop on Coastal Aquaculture and Environmental Management, April 1995. Institute of Marine Science, University of Chittagong and Marine Fisheries Academy, Fish Harbor, Chittagong, Bangladesh.

Mahmood, N. and S.M.B. Haider. 1992. A note on Corals of the St. Martin Island, Bangladesh, Chittagong University Studies.

Mahmood, N., M.J.U. Chowdhury, M.M. Hossaine, S.M.B. Haider and S.R. Chowdhury. 1994. Bangladesh, p. 75 - 129. *In* An Environmental Assessment of the Bay of Bengal Region. BOBP/REP/67.

Mahmood, N. 1995. On the fishery significance of the mangroves of Bangladesh. Paper presented at the Workshop on Coastal Aquaculture and Environmental Management, 25 - 28 April 1995 Cox's Bazar. Institute of Marine Science, Chittagong University (IMS,CU). UNESCO.

Miah A.K. 1999. Bhumi Jarip O Bhumi Babostha Pana, 338 p.

MOEF (Ministry of Environment and Forest). 1992. Environment Policy 1992 and Action Plan. Government of the People's Republic of Bangladesh, 28 p. (In Bengali)

Mohiuddinn M.S, G. Kibria, M.M Hossain and L. Ali. 1980. Bangladesh Status Paper on Coastal Fishery Resources. Report of the consultation on stopck assesement for small scale fishery in the Bay of Bengal, Chittagong, Bangladesh. Bay of Bengal Programme, Madras, India.

MPO (Master Plan Organization). 1987. Coastal water culture fishery resources. Technical Report No. 19, March 1987.

Muminullah M. 1998. A Guide to the mines and minerals rules of Bangladesh. 52 p.

Mustafa, M.G., M. Humayun and S.C. Paul. 1985. Report on the results from the FAO 15th cruise of R.V. Anusandhani (Special Shrimp Curise Sep. - Oct. 1985). Marine Fisheries Research, Management and Development Project, DOF, Bangladesh, 50 p.

Mustafa, M.G. and Khan M.G. 1993. The bottom trawl fishery. *In*: Studies of Interactive Marine Fisheries of Bangladesh, BOBP/WP/89, 106 p.

Noori, M.N. 1999. An investigation on seasonal variation of micronutrients and standing crop of phytoplanton in neritic waters off the South East Coast of Bangladesh. University of Chittagong, 91 p. M.Sc. thesis, I (MS).

Nuruzzaman, A.K.M. 1991. Aquaculture in Bangladesh Challenges and opportunities. Paper presented at the commonwealth Senior Fishery officials (CSFO) held in Rome 1991, 13 p.

Penn, J.W. 1983. An assessment of potential yield from the offshore demersal shrimp and fish stock in Bangladesh waters (including Comments on the trawl fishery 1981 - 82). A report prepared for the Fisheries Advisory Service (Phase II) Project, Rome FAO.FI:DP/ BGD/81/034, Field document 4 : 22p.

Pramanik, M.A.H.1983. Remote Sensing application to coastal morphological investigations in Bangladesh. Jahangirnagar University, Savar, Dhaka, 227 p. Ph.D. thesis.

Paul S.C., Mustafa M.G., Chowdhury Z.A and Khan M.G. 1993. Shrimp seed collection. p. 3 - 17. *In* Studies of Interactive Marine Fisheries of Bangladesh. Bay of Bengal Programme. BOBP/WP/89.

Quayum, S. A., M. G. Khan, M.S. Islam, M.N.U. SADA and Z.A. Chowdhury. 1993. The Marine Set bagnet fishery. p. 65 - 78. *In* Studies of interactive marine fisheries of Bangladesh, Bay of Bengal Programme. BOBP/WP/89.

Rashid, M.H.1983. Mitsui-Taiyo Survey 1976 - 77 by the survey research vessels MV Santamonica and MV Orion-8 in the Marine Waters of Bangladesh Research/Survey of Marine Fisheries Under the Directorate of Fisheries, Government of Bangladesh, Marine Fisheries Bulletin : 2.

Rahman, A.K.M. 1993. Socioeconomic Issues of the Fisheries Sector in Bangladesh. Paper presented in the workshop on Fisheries Socioeconomics and Marketing organized by South Asian Association for Regional Cooperation, Dhaka, 16 - 17 November 1993.

Rahman, M.M. and M.G. Khan. 1995. On the sustainable fishing effort for marine fishery resources management. Department of Fisheries. Fish Fortnight Bulletin: MOFL. 60 - 66.

Rahman, M.M. 1999. National Report on the Impact of Shrimp Trawl Fisheries on Living Marine Resources of Bangladesh. Report submitted to FAO, Rome.

Saetre, R.1981. Surveys on the Marine Fish Resources of Bangladesh, November - December 1979 and May 1980. Reports on Surveys with the R.V. Dr. Fridjof Nansen, Institute of Marine Research, Bergen, 67 p.

Shahidullah, M. 1983. Review of the exploratory surveys undertaken to assess the marine fisheries resources of Bangladesh and the present status of exploitation. Government of Bangladesh Directorate of Fisheries, Marine Fisheries Department, Chittagong. Document presented at the National Symposium on Agricultural Research Council BARC, 22 - 24 December 1983, 33 p.

Shahidullah, M.1986. Marine fisheries resources management in Bangladesh and current status of exploitation. Marine Fisheries Department, Chittagong, Bangladesh. Marine Fisheries Bulletin 3 : 26 p.

Thomson, K.T., M.D. Jahan and M.S. Hussain. 1993. The socioeconomic condition of the estuarine Set bagnet fisherfolk in Bangladesh. BOBP/WP/90. Madras, India.

West, W.Q.B.1973. Fishery resources of the upper Bay of Bengal. Indian Ocean Program. Indian Ocean Fisheries Commission, Rome, FAO, IOFC/DEV/73/ 28 : 44p.

White, T.F. and M.G. Khan, 1985. The marine fishery resources of Bangladesh and their potential for commercial development. Note presented to the National Seminar on Fisheries Management and Development in Bangladesh,14 - 17 January 1985, Dhaka, 4 p.

World Bank. 1991. Bangladesh Fisheries Sector Review. Document of the World Bank, FAP 12/13 project, Report No. 8830-bd.

Zafar, M. 1992. Study on some hydro-biological aspects of the South-eastern part of Bangladesh coastal water in the Bay of Bengal. Free University, Brussels, Belgium, 258 p. MS Thesis.

Appendix I. Administration Orders, Regulations for the Management and Conservation of Fisheries Resources in Bengal Bay

Coastal Zone Resources, Policies and Laws

Mangroves

The Sunderbans is a forest reserve. No cutting of mangroves and other trees is allowed without Government permission. Hunting has been banned in this area. However, illegal cutting of wood and poaching of wild animals has not been eliminated. Many of the planted mangrove forests in the Chokaria Sunderbans have been systematically cleared for shrimp farms despite the Government's restrictions. Although the policy and legislation exists to protect the mangrove the Government should be more vigilant to prevent the illegal poaching.

The Government policy and rules regarding mangroves are given below.

The Environment Conservation Rules (ECR), 1997 were promulgated in August 1997, making some vital provisions of the Environment Conservation Act fully operative. The Environmental Quality Standards (EQS) for air, water, soil, mangroves and shrimp culture have been set up. Some degree of ambiguity still exists regarding management in ecologically critical areas.

The National Conservation Strategy (NCS) was formulated in 1991. It identified 16 sectors covering major issues, their current status and strategic options. The following are relevant provisions in the NCS:

- Preservation of mangrove forests which provide nursery, food and shelter to shrimp and other estuarine living resources;
- The Sunderbans are to be managed in an integrated manner;
- Allocation of government-owned coastal land with suitable physical environment for shrimp culture and provision of technological support to farmers for intensive aquaculture. It will be made obligatory for shrimp farmers to grow mangrove forests around farms where such forest does not exist; and
- Establishment of shrimp hatcheries for production of juveniles and discouraging the wasteful method of trapping post-larvae and juveniles in open waters.

The National Fish policy of 1998 states that shrimp and fish culture cannot be developed by damaging the mangrove vegetation in coastal areas, that shrimp culture damaging mangroves will be banned and planting of mangroves will be compulsory between the shrimp farms and ponds and the banks of rivers.

Coral Reefs

No laws or acts have been enacted to protect the coral reef island of St. Martin. However, the government is studying the option of making the island and the adjacent areas a marine park in order to better manage and conserve it.

Endangered Wildlife

Many wildlife species have been exterminated in Bangladesh and many more are threatened with extinction. The country has lost 10% of its mammalian fauna, 3% of the avifauna, and 4% of the reptiles over the last 100 years. More than 50 species are critically endangered in Bangladesh, of which 23 species are already declared endangered in the Red Data Book of IUCN. These include elephant, tiger, wildcat, leopard, serao and dolphin among mammals; white-winged duck, comb duck, stork and crane, pheasant and partridge among birds; and crocodile, python, monitor lizard, river terrapin, roofed turtle, soft turtle and all marine turtles among reptiles.

There are specific laws to protect wildlife, which are described below:

The Bangladesh Wildlife (Preservation) Act, 1973 provides for the preservation, conservation and management of wildlife in Bangladesh. The earlier laws on wildlife preservation, namely, the Elephant Preservation Act-1879, the Wild Bird and Animals Protection Act-1912, and the Rhinoceros Preservation Act-1932 have been repealed and their provisions have been incorporated into this law.

The Act encompasses a range of different activities, including hunting and fishing, although the provision of greatest significance relates to the establishment of wildlife sanctuaries and national parks by the MOEF (Ministry of Environment and Forests). Such designations have enormous significance for the type of developments that may take place.

The main provisions are:

- The wild animals specified, as "game animals" shall not be hunted, killed or captured, save in accordance with the terms of a permit issued under this order.
- The wild animals specified in this order shall be known as "protected animals" and shall not be hunted, killed or captured save as otherwise expressly provided in this order.
- No person shall, with a view to carrying on a profession, trade or business, buy, sell or otherwise deal in wild animals, trophies or meat, or process or manufacture goods or articles from such trophies or meat unless he is in possession of a valid permit, issued for the purpose by an authorized officer.
- The government may declare any area to be a national park provided that the government may, for scientific purpose or for betterment of the national park or for aesthetic enjoyment of scenery or for any other exceptional reason, relax all or any of the prohibitions specified.

Article 23 (2) states that:
No person shall:

- Damage or destroy any vegetation in any wildlife sanctuary;
- Cause any fire in a wildlife sanctuary;
- Pollute water flowing in or through a wildlife sanctuary.

Contravention or attempts to contravene the various provisions of the law have been made punishable as specified in the law. This legislation does not provide scope for the creation of a strong organization, which can adopt appropriate measures to protect wildlife. Punitive provisions are not readily usable. The types of endangered and ecologically valuable animals or birds should be highlighted in the legislation. The government should have asked for active participation and specific action from local administration to protect wildlife. The law also does not prescribe seasons when certain animals/birds cannot be hunted or captured (Chowdhury 1999).

An executive order issued in June 1998 in relation to the Bangladesh Wildlife Preservation Order 1973 imposed a ban for five years on hunting any form of wildlife.

Fisheries Investment Policies

Bangladesh is keen to develop its fisheries potential and has thus identified major areas for investment though development projects. Private sector investments in commercial ventures are also welcome.

Identified fields of fisheries development projects of DOF include:

- Semi-intensive aquaculture technology development and extension service for ponds and other closed water bodies.
- Fisheries development in large water bodies such as beels and baors.
- Development of the socioeconomic conditions of the fishing communities.
- Fish culture development in flood control and irrigation projects areas.
- Paddy-cum-fish culture development and extension.
- Fish and shrimp culture development in the freshwater areas.
- Intensive fish polyculture development in the coastal districts where possible.
- Freshwater shrimp culture development and extension.
- Fisheries resources development, management and conservation in the Bay of Bengal.
- Demersal fisheries harvesting management and conservation in the Bay of Bengal.
- Pelagic fisheries resources harvesting technology development in the extensive economic zones of the countries sharing the Bay of Bengal.
- Shrimp hatchery technology development.
- Marine fisheries resources surveys to explore new commercial fishing grounds and for stock assessment and estimation of maximum sustainable yield (MSY).

- Support services for commercial oyster culture.
- Support services for infrastructure development of marine and freshwater shrimp culture in the private sector.
- Aquaculture development in derelict khas, ponds, ditches and freshwater bodies under the Pond Food for Work (FFW) program for landless and marginal farmers and rural unemployed youth.
- Implementation of inland open water hatchery management programs.
- Implementation of new fisheries management policy.
- Strengthening of extension and information services of the Department of Fisheries.
- Strengthening of fisheries resources survey systems and establishment of a databank.
- Strengthening and improving the fish inspection and quality control service of DOF.
- Modernization of the training infrastructure of the DOF and development of technical man power in both public and private sectors.
- Fish fry and fingerling stocking in open water bodies.
- Introduction of supervisory credit system through a loan guarantee fund scheme.
- Support services to implement aquaculture and fishery credit.

There are two sources of funding, viz. the Revenue Budget and the Development Budget. The Department of Fisheries had an annual revenue budget of Taka 277.9 million and a development budget of Taka 515.8 million•annum^{-1} during 1998 - 99. In order to implement the fisheries development programs, Taka 5 862 million was earmarked for the public sector during the Fifth Plan. Allocations by program are shown in Table 1.

In addition to the public sector allocation of Taka. 5 862 million, an amount of Taka 21 847 million was allocated for programs for fisheries development in the private sector, and for this purpose programs and projects were developed for implementation in the private sector with support and service from the public sector. Fish hatcheries, feed mills, fish culture, fish processing, fish preservation, fish production and export are some of the major areas for private sector participation.

Table 1. Allocation of funding to programs during the Fifth Plan, 1996 - 97.

Program	Allocation million Taka
Survey, investigation, feasibility study, research, etc.	400.00
Fisheries education, training, extension and community development	890.00
Culture and capture fisheries development (including inputs and water bodies development)	4 360.00
Fish landing, storage, processing, marketing, transportation, distribution	211.80
TOTAL	5 861.80

External Policies Affecting Fisheries

General Land Use

The following are relevant principles of settlement of the Non-agricultural *Khas* land under the Ministry of Land, according to the Non-agriculture *Khas* Land Management Act, 1995 (Miah 1999).

- The non-agricultural *khas* land can be leased to a Government office or organization on a payment basis, according to the market price of the land.
- The land can be leased for a religious place, orphanage or graveyard on the basis of 10% of the actual worth of the land.
- The land can be leased for educational purposes on the basis of 10% of the worth of the land.
- The land can be leased by the Government to rehabilitated peoples (5 per family) affected by disasters.
- The non-agricultural *khas* land can be leased for poultry or diary use outside the metropolitan and district towns.
- The government *khas* ponds and *jalmahal* (closed water bodies) will be leased on a long-term basis for scientific farming and fishing.
- Necessary land can be leased to foreign investors or companies to develop industries outside metropolitan areas, but land can be leased to develop hotels or motels of international standard (at least three stars) within metropolitan areas.
- Land can be leased to any person or any company for rubber plantations.

Effect of Policy on fisheries

In Bangladesh most of the water bodies in the inland sector are managed by the Land Ministry. There are serious anomalies in imposing the fisheries management and conservation legislation in the country. Most of the management endeavors are hampered because the water bodies are leased out without any control by the Department of Fisheries. Efforts to increase production by open water stocking have not been very successful due to this dual administrative arrangement regarding water bodies. As a result most of the water bodies leased out by the Land Ministry face total annihilation of the fish stocks by the lease holders who, in order to gain maximum benefit from the lease, totally drain the water body to catch all the fish. The coastal areas are also managed by multiple departments and ministries, which results in conflicting policies and measures. For example, the Sunderbans, which serve as the nursery ground of many marine fish and shrimp, are controlled and leased out by the Forest Department for fishing. The Forest Department does not consider the management aspects while allowing fishing. This results in the deaths of millions of fish fry and juveniles that, if conserved, would add substantially to the fish production.

Pollution and Environmental Protection

In tackling the environmental problems of the country, various environmental laws have been made from time to time. There are more than 200 sectoral laws that are in force dealing with environmental issues (Chowdhury 1999). They focus mainly on land use, air and water pollution, noise, toxic chemicals, solid waste, forest conservation, wildlife protection, mineral resources and coastal zone management. Laws now in force, such as the Forest Act of 1927, the Motor Vehicle Ordinance of 1939 and the Bengal Smoke Nuisance Act of 1876 were inherited. Others were enacted after 1947 due to changed scenarios. On the basis of the broad objectives of environmental laws existing in Bangladesh, the laws may be categorized as follows:

- Protection of environmental health;
- Control of environmental pollution; and
- Conservation of natural and cultural resources.

The National Environmental Policy (EP) of 1992 the marine environment of Bangladesh addresses (MOEF 1992). This was adopted by the Government as a significant component of an overall environmental strategy for multisectoral sustainable development. It specifically identified environmentally desirable policy suggestions for major development sectors, including agriculture, industry, health and sanitation, energy and fuel, water and irrigation, forests, wildlife and biodiversity, fisheries, livestock, food, transport and communication, coastal and marine ecosystems, industry, housing and urbanization, population, public awareness, education and research. The major objectives of the policy are as follows:

- Maintenance of the ecological balance and overall progress of the country through preservation and development of the environment.
- Protection of the country against natural disasters.
- Identification and prevention of all types of activities related to pollution and degradation of the environment.
- Ensuring environmentally sound development in all sectors.
- Ensuring sustainable, long-term and environmentally congenial utilization of all resources.
- Participation as far as possible with all international initiatives related to the environment.

For preservation of the coastal and marine environment, the EP stresses the following:

- Ensuring environmentally sound preservation and development of coastal and marine ecosystems and resources therein.
- Prohibiting all domestic and foreign activities causing pollution in coastal and marine areas.
- Strengthening research for the protection and development of the coastal and marine environment and resources.
- Keeping the fish catch from coastal and marine waters at the maximum sustainable level.

There are many other policy suggestions in the EP that are relevant to marine environment issues, e.g. ensuring a congenial environment for fisheries development and preservation of mangrove and other ecosystems. Reassessment of water development, flood control and irrigation projects having harmful impacts on fisheries, and doing EIA (Environmental Impact Assessments) before taking up new projects were stressed.

The EP recommends that all water bodies in Bangladesh be free from pollution and that industries take up pollution control measures gradually. It suggests a gradual ban on the establishment of any

new industry or the operation of any existing one whose produce is hazardous to the environment. Natural pest control, instead of using chemical pesticides, and the use of manure and agricultural wastes as fertilizers have also been suggested. In respect of an institutional framework, the Ministry of Environment and Forests (MOEF) is responsible for putting it in effect and conducting the inter-ministerial and inter-departmental coordination.

Another industrial policy enunciated in 1991 mentions the maintenance of environmental balance in industrialization and prevention of environmental pollution. The policy emphasized the need to develop industrial growth centers in appropriate locations to ensure environmentally sound industrialization. Existing industries are required to adopt anti-pollution measures within the time-frame to be specified by the government.

It is very significant that a national environmental policy has been formulated in Bangladesh where any industry, any ship or any township can freely dump wastes into the waters, no matter how dangerous or harmful it is to others. This situation has not only been due to the lack of policies, but also due to financial, technical, institutional, administrative and legislative weaknesses and gaps (Mahmood et al. 1994).

Environmental Quality Standards (EQS) for Bangladesh have been drafted, but have not yet been adopted. The scope of DOE's mandatory and DOE's administrative rights are ambiguous and undefined. It is not yet of adequate strength to obtain the needed data or provide the type of good judgement necessary to perform the job with objectivity. Often, industries refuse DOE personnel access to their plants. Sewage and municipal waste management from a water pollution control standpoint is not addressed in the EP. Legislative lacunae and ineffectiveness are still major problems in the country. The Water Supply and Sewerage Authority Ordinance, 1963, established executive responsibilities for WASA authorities. Nevertheless, there is no explicit mechanism for prosecuting WASA for failing to carry through with the assigned responsibilities. Therefore, gradual strengthening of all mechanisms through integrated efforts, actions and motivation is of prime importance.

Legislation Against Threats to the Marine Environment

National environmental legislation provides guidelines relating to the control of environmental pollution, conservation of natural resources and the protection of environmental health. About 45 laws in different areas, including the coastal and marine environment and resources, have a bearing on environmental issues. However, specific standards and enforcement mechanisms are lacking. In fact, there is no appropriate legislation for the protection of the marine environment and the related ecosystems of the country. As for other areas, the existing laws in this regard are also inadequate, contain glaring inconsistencies and are neither enforced nor enforceable due to institutional, technical, strategic and financial constraints. Most of the laws are outdated, inept and incoherent (Mahmood et al. 1994).

The legislative situation in respect to marine pollution can be gauged from the fact that, in 1989, Bangladesh failed to even file a case against a super oil tanker M.T. Filoti, after it was responsible for spilling about 3 000 t of crude oil in national waters. Bangladesh is still not a signatory to the Marine Convention of 1973, under which foreign ships can be sued for damages up to US$80 million for oil spills or dumping wastes (Anon 1992). To become a signatory to the Convention all ports, for instance, should have reception facilities for the treatment of ballast- and bilge-waters and other wastes from foreign ships and the country should have sufficient and competent coastguards to determine the exact nature of accidents at sea. Without coastguard patrols or other law enforcing agencies, punitive legal action is non-existent. Foreign ships discharge ballast- and bilge-waters and hazardous wastes at will. In 1988 - 89, a ship called the Falicia, carrying hazardous wastes, dumped its cargo in the Bay while traveling from Colombo to Singapore (Anon 1992). Bangladesh was not even in a position to determine if the wastes were dumped in its territorial waters or not.

Minerals

Bangladesh has a few proven mineral resources, but the country has enormous deposits of natural gas. To date, 17 gas fields have been discovered, from which natural gas is available for power-generation, industrial uses, etc. Fertilizer factories, including the petro-chemical complex operating at Ashuganj and others to be developed will use sizeable quantities of natural gas. About 1% of the gas reserve is currently being consumed annually. Coal deposits have been found and efforts are under way to exploit them with international assistance. There is a possibility of oil deposits in the country and efforts are being made for their exploration.

Limestone, the basic raw material for the production of cement, has been found in some places and cement factories are being set up for their utilization. Other minerals found include hardrock, lignite, silica sand and white clay.

Salt is not mined but is manufactured on a small scale at several thousand evaporation sites in the coastal areas of Chittagong and Cox's Bazar.

Extensive radioactive sand deposits have been found along the beaches from Kutubdia to Teknaf.

A survey estimates the reserve to be of the order of 0.5 million t of sand containing a significant amount of usable heavy minerals.

So far the Government policy regarding the exploitation of the mineral resources is to meet the growing domestic demand and thereafter seek exports. Natural gas is being used by some multi-national companies under joint ventures with the Government to produce fertilizer for export. Recent trends in the exploitation of the offshore gas field do not seem to significantly affect the fisheries. There is a rule on water purification under the Ministry of Energy and Mineral Resources, called the "Mines and Minerals Rules 1968 27L Water Purification" which states that "during exploration or the mining operation, if polluted waters erupts or if water is polluted in any way, measures shall be taken by the licensee or the leasee to purify it or to separate the harmful elements from the water so that no harm is done to the animals, fisheries, plants or agriculture or environment" (Muminullah 1998).

International and Regional Conventions

Bangladesh is a member of almost all the regional organizations and is active in the pursuance of eco-friendly fisheries, focusing on the conservation of the resources and preserving biodiversity. Bangladesh has actively supported the Code for Responsible Fisheries and the UN Conventions on Highly Migratory and Straddling Fish Stocks and has also signed Agenda 21 and has been actively fulfilling its obligations.

Foreign Trade Laws, Restrictions and Demands

There are a number of international laws and regional laws or measures that hamper fisheries activities. The ban on Bangladesh fishery products by the EU countries for the failure to meet their standard of Hazard Analysis Critical Control Point (HACCP) is one such example. This ban is gradually being overcome by improved management of the processing factories. There is a growing demand for Bangladeshi fishery products around the world. Many traditional fishery products are being exported to the developed countries to meet the demand of the migrants from this sub-continent. There are many trade barriers that come in the guise of other issues such as environmental issues which restrict trade. For example, the legislation imposed by the United States' Department of Commerce against shrimp caught in trawls without turtle exclusion devices.

Responsible International Trade

Bangladesh subscribes to the principles, rights and obligations established in the World Trade Organization Agreement as it pertains to trade in fish and fishery products.

Appendix II. Research Support for Marine Fisheries Development

Oceanography and Productivity

Almost no research appears to have been carried out on the oceanography and primary productivity of Bangladesh waters. Several fisheries resource surveys have gathered basic data on bathymetric as well as geographic distribution of various species, their catch rates and abundances, with particular reference to penaeid shrimp species, and some oceanographic data on temperature, salinity and Secchi disc readings.

Any form of rational fisheries management and development requires data on catch rates, species composition, location, seasonality and fishing gear, together with broad-based biological and Socioeconomic data. The most important areas of research are as follows:

- Oceanographic studies to understand the marine ecology of the area and assessment of primary and secondary productivity of the EEZ of Bangladesh.
- Studies on marine fish stock assessment to relate to marine productivity and marine fish landings.
- Research on methodologies for monitoring catches and fishing effort.
- Development of a catch monitoring system to assess the status of the resources and trends in landings.

Inshore Fisheries and Conservation of Exploited Resources

The inshore capture fisheries of Bangladesh are mainly artisanal, mostly with small non-motorized boats. They normally operate up to 40 m depth. Of the total fishery production the gillnet catch (composed mainly of *Hilsa* spp.) contributes 55%, while the estuarine set bag net (ESBN) contributes about 30%. Most of the catch of the ESBN are juveniles and a DOF/BOBP study in 1991 showed that the ESBN fishery is harmful to the resources and that fishing effort requires control. Before proper management measures are introduced, a better understanding of the issue is necessary to avoid any social tension and economic upset in the target populations. Research is needed to determine the scope of the problems and the ways to tackle them.

Increased yield of *Hilsa* spp. can probably be achieved through better management of stock. The most important strategy should be the extension of the marine fisheries management regime to cover the mechanized and artisanal fisheries. Revision of the Fisheries Ordinance 1983 in order to incorporate all types of gear used by artisanal fishers is necessary so that regulation of fishing effort may become possible. This was also reiterated by the FAO/TSS-Mission. Regulation would involve reduction of fishing effort and closing the fishery during the breeding season. The World Bank (1991) projected that improved management could increase the harvest by 25 000 t per year. Important research studies that are needed are as follows:

- Identification of over-exploited species and their management for conservation, particularly *Hilsa* and shrimp.
- Development of different models of community-level participation in conservation and management.

Offshore and Deep Sea Demersal Resources and Their Proper Exploitation

The Bangladesh offshore fishing fleet presently operates in the zone bordered by the 40 m and 100 m isopleths. Artisanal fishing craft normally operate within 40 m. However, there is a strong and continuous competition between the demersal trawling and artisanal fishing operations within 100 m depth. The most valuable penaeid shrimp species, *Penaeus monodon*, is showing a gradual decline due to over-fishing and inadequate recruitment because of intensive wild shrimp seed collection in the nursery grounds in the estuarine shallows.

If rational management of the exploited resources is not undertaken urgently, there is little prospect of increasing the catch of demersal species. On the other hand, there is untapped potential consisting of valuable pelagic fish species in the offshore areas beyond 100 m, as well as the surface area beyond 40 m. Various exploratory surveys have reported the availability of tuna, skipjack, mackerels, anchovies, sardines, sharks and cephalopods. At present these resources are being caught as by-catch of different gear types. Unfortunately, no real pelagic resources surveys have been made. According to the World Bank projection (1991), if fishing technologies improve, research requirements for this sector are as follows:

- Evolving suitable models for multi-gear-multi-species fisheries in order to forecast fish resources in time and space.
- Diversification of fishing methods to tap under-utilized species, particularly pelagics.
- Developing gear on the basis of fish behavioral studies.

Sea Farming

The farming of selected species appears to be desirable in order to utilize hitherto unexploited technology, for example, the culture of *Bhetki* or seabass *(Lates calcarifer)* and the mixed culture of mullet with shrimp. *Bhetki* is a relatively high-priced species and therefore very attractive for commercial-scale culture.

Mollusc and seaweed culture rank among those with the greatest potential for contributing to income improvement among coastal communities, with the least disruption of their traditional lifestyle. Cockles, clams and seaweeds need to be investigated and culture technology developed. Urgent research areas include the following:

- Development of methods for controlled reproduction of mullet and mass rearing of their larvae.
- Development of methods of mullet fry collection, identification, sorting and transport, pending the development of controlled reproduction and hatchery production of seed.
- Methods of monitoring health and disease problems of seabass and mullets and disease control.
- Documentation and evaluation of genetic resources of commercially important mollusc and seaweeds and development of routines for their culture, including site selection, seed collection, disease control and depuration.
- Diversification of mollusc and seaweed utilization through food product development.

Product Development, Processing and Marketing

Research support for product development from conventional and non-conventional species will have an impact on nutrition and income generation. A significant proportion of trawl by-catch is discarded in the sea. Some estimates suggest that discarded by-catch amounts to about 30 000 t annually. Cost-effective technologies need to be developed to fully utilize the by-catch.

Currently improved methods of fish fermentation are needed, as are investigations of the possibility of using enzymatic or bacteriological methods in the development of new products. Research is also needed to improve handling and processing methods, packing, storage, transport and marketing to improve the economics of operation, to reduce wastage and to improve quality, including hygiene and sanitation to safeguard public health. The important research areas are as follows:

- Development of techniques for processing by-catch and small pelagic fish for the preparation of improved quality *surimi* and other value added products.
- Screening of improved products both qualitatively and quantitatively, from by-catch and small pelagic fish.
- Experiments on deterioration of organoleptic quality of *Hilsa*.
- Studies on all stages of handling, transportation processing and preservation that affect the quality of *Hilsa* and shrimp.
- Studies on the bacteriology of *Hilsa* and shrimp preservation.

While taking into account likely future developments with respect to resource potentials, economic trends and social development, a number of issues need in-depth studies. These include national policies in respect of food production, improvement of the nutritional status of people, generation of employment, rural development, uplifting of women, reducing and erasing foreign debt, sectoral priorities, financing and credit from national sources and technical assistance and financial support from external sources. Only then will Bangladesh be able to formulate plans, programs and projects for the sustainable development of its marine resources.