सत्यमेव जयते

National Mission for Clean Ganga
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation
Government of India

BIOLOGY AND FISHERIES OF HILSA SHAD IN GANGA RIVER BASIN

JULY 2020

Prepared by

cGanga
Centre for Ganga River Basin Management and Studies

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National Mission for Clean Ganga (NMCG)

NMCG is the implementation wing of National Ganga Council which was setup in October 2016 under the River Ganga Authority order 2016. Initially NMCG was registered as a society on 12th August 2011 under the Societies Registration Act 1860. It acted as implementation arm of National Ganga River Basin Authority (NGRBA) which was constituted under the provisions of the Environment (Protection) Act (EPA) 1986. NGRBA has since been dissolved with effect from the 7th October 2016, consequent to constitution of National Council for Restoration, Protection and Management of River Ganga (referred to as National Ganga Council).
www.nmcg.in

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the ægis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this it is also responsible for introducing new technologies, innovations and solutions into India.
www.cganga.org

Acknowledgment

The document on the focal species "Hilsa" was compiled through comprehensive review on the current level of knowledge on various aspects of Hilsa fish and assessed how current legislation and policy is affecting the species conservation and management approaches by the members of team cGanga. The document was completed in April 2020 and has been finalised following a peer review process by the expert members of Wildlife Institute of India (WII), Dehradun (Dr. K. Sivakumar, Scientist F), ICAR-Central Inland Fisheries Research Institute, Barrackpore (Dr. Archan Kanti Das, Principal Scientist & In-Charge) and Indian Institute of Technology Roorkee (IITR), Roorkee formerly University of Roorkee (Dr. R.P. Mathur, Former Professor). Their helpful comments are gratefully acknowledged along with those of many people who contributed to the photographs and images for this document.

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Biology and Fisheries of Hilsa shad in Ganga River Basin by cGanga and NMCG

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PREFACE

NATIONAL RIVER Ganga has been at the centre of the government's multi-decadal efforts to restore and conserve degraded Indian rivers. The Ganga River Basin Management Plan (GRBMP) submitted to the National Mission for Clean Ganga (NMCG), Government of India in the year 2015 by a Consortium of 7 IITs ("Indian Institute of Technology"s) set a clear direction and action-framework for this purpose, but progress on its implementation was tardy, partly due to the GRBMP recommendations being broad-based strategic measures to some extent. Therefore, after the Centre for Ganga River Basin Management and Studies ("cGanga") was created through a Memorandum of Understanding between MoWR, RD&GR (now Ministry of Jal Shakti), Government of India and IIT Kanpur in April 2016, cGanga conducted many field and in-house studies as well as workshops and consultations with stakeholders, executive bodies, monitoring agencies and experts on various components of GRBMP and its implementation. Based on these activities over the past few years, a clearer understanding emerged on some of the major implementation challenges of GRBMP, especially the difficulty in restoring a very large and complex river system like River Ganga. This led to a more refined and detailed strategic implementation procedure that combines robust scientific method with a Socio-economically, culturally and administratively aligned policy framework.

One of the most important missions of GRBMP was that of Ecological Restoration. This is because it was realized during the preparation of GRBMP that the ecological health of River Ganga would be the best indicator of her wholesomeness rather than piecemeal assessment of hydrological, water quality or geomorphological characterization of the river. As a vibrant ecosystem of ancient origin, the river's biodiversity would be the most complete indicator of her overall status. It is for this reason that it was ardently hoped that GRBMP would be implemented speedily to revive the vibrant River Ganga teeming with life. And it is for the same reason that the separate compilation for each focal species is planed which not only covers the biology of the organism i.e., fish, turtle, gharial, dolphin but also its historical and current status in terms of abundance and distribution; major threats; conservation measures, formulated guidelines, current and future policies by state and central authorities and challenges for scientific understanding. The periodic coverage of the focal species in river Ganga is necessary to decipher overall improvements or decline in the river habitat conditions within the Ganga River Basin.

This document is prepared by dedicated members of cGanga through the gathering of information taken from the peer reviewed literature and unpublished databases, Government sponsored project reports, and research findings reported in Master's and PhD dissertations, analyses and discussions with various agencies and individuals.

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1.0 INTRODUCTION

Hilsa is a clupeid fish belonging to herring and shad family. It is a highly valuable fish for its flesh and flavor. It roams in coastal shelf, estuaries and fresh water rivers of South East Asia including Bangladesh, India and Pakistan (Dutta et al. 2012). It is the characteristic fish of lower estuarine stretch of river Ganga. The deltaic region of the Gangetic system in India and Bangladesh produces the highest yield of Hilsa fishery. The maximum deltaic share in terms of landings has been occupied by Bangladesh followed by India, Myanmar and Burma (Raja 1985; Dutta et al. 2012; IUCN 2014).

Hilsa is a prominent fish of lower Ganga River Basin (GRB) in nearshore coastal waters as well as fresh water zone across India and Bangladesh. West Bengal is one of the 11 states (Uttarakhand, Uttar Pradesh, Bihar, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, Jharkhand and West Bengal) in India under GRB through which the Ganga river and her tributaries flows. The 81% of the geographical area of West Bengal lies in GRB. Hilsa spawning grounds are well identified in the rivers i.e., Hooghly, Bhagirathi and Rupnarayan and many estuarine distributaries and creeks in the state (Ahsan et al. 2014). The overexploitation of the economic importance of Hilsa shad in the state compelled the West Bengal Fisheries Department to come up with the amendments under the West Bengal Inland Fisheries Act (West Ben. Act XXV of 1984) in April 2013 to protect Hilsa fishery and its breeding grounds (Hossain 2019). ICAR-NASF New Delhi has also sanctioned a multi-institutional research funding for "Stock characterization, captive breeding, seeds production and culture of Hilsa (*Tenualosa ilisha*)". Several scientific measures recommended as an outcome of this mega project (2013-2017) not only enhanced the genetic, physiological and morphological knowledge but also could be utilized as measures for alternate production strategy. This booklet briefly describes the fish biology and highlights fishery historical status in terms of catch, landings and distribution, current distribution range under GRB, major threats and conservation measures.

The overexploitation of the economic importance of Hilsa shad in the state compelled the West Bengal Fisheries Department to come up with the amendments under the West Bengal Inland Fisheries Act (West Ben. Act XXV of 1984) in April 2013 to protect Hilsa fishery and its breeding grounds.

Hilsa fishing operation (Photo Credits CIFRI Barrackpore)

2.0 HILSA BIOLOGY

The coastal waters, estuarine waters and rivers of tropical Asia are abode by 5 species of *Tenualosa* (*T. ilisha*, *T. toli*, *T. macrura*, *T. reevesii* and *T. thibaudeaui*). Scientific studies and communications reveal that all of these are on the verge of extinction due to

Images representing specimen of *Tenualosa ilisha*

A glimpse of the Hooghly river through Howrah bridge

the anthropogenic pressure (Das et al. 2017). *T. ilisha* is a national fish of Bangladesh and also known as iconic flagship species (IUCN 2014). Its life is more than 6 years. It is the characteristic fish of lower estuarine stretch of river Ganga.

SCIENTIFIC CLASSIFICATION

SUPER CLASS	**PISCES**
Class	Actinopterygii
Order	Clupeiformes
Family	Clupeidae
Genus	*Tenualosa*
Species	*Ilisha*

2.1 MORPHOLOGICAL CHARACTERS

The fish are silvery with stream lined spindle shape body. The dorsal and ventral profile equally convex. Frontoparietal striae weakly developed. Upper jaw has a distinct median notch. Belly with 30-33 scales. Caudal fin deeply forked as long as head. The lateral line with 37-47 scales. Gillrakers fine and numerous, about 100 to 250 on the lower part of the arch and also lack typical lateral line (Rahman et al. 2018). Teeth are unusually small.

2.2 HABITAT AND NICHE

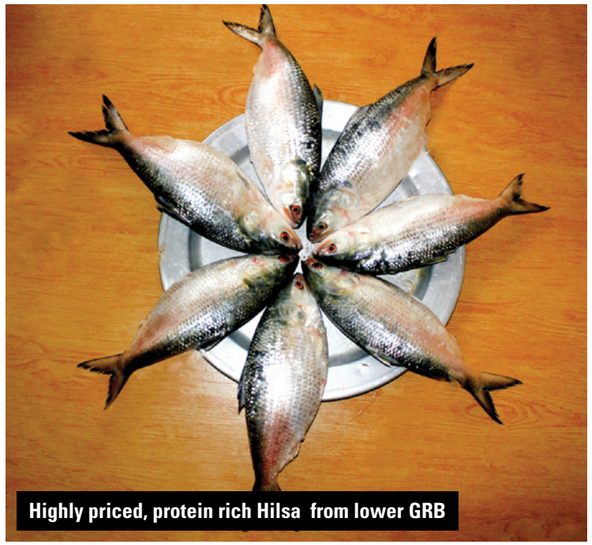
Hilsa is known to be a fast swimmer (Southwell and Prashad 1918). The fish is capable of covering as much as 70.8 km

Fishermen casting their nets in the river

in one day (Pillay et al. 1963). It is found to move on the sea surface whereas in the river they move at a depth of 14-18 m. However, on a cool or drizzly day, they may rise to 2 m from the surface (Mojumdar 1939). The ideal migration depth for stress free movement of brood stocks in Bhagirathi-Hooghly system was recorded as 18-20 m (IUCN 2014). While in winters when the size of migratory Hilsa is smaller, it passes through comparatively lower depth (av. 10 m). It is also observed that 4.0-4.5 m is

favourable depth from surface for migration of adult Hilsa in the rivers (IUCN 2014). During their upstream migration, the fish does not form dense shoals; but during winter months, they are found in very large shoals. Hilsa assemble in large numbers below dams or other obstructions on their way to their upstream migrations (Pillay and Rosa 1963). It also moves near the bottom of river and rise up to the surface when they meet dams or anicuts (Southwell and Prashad 1918). After spawning, Hilsa returns to the original habitat where they remain till the next breeding season. The males found to move on the surface and the females in deeper areas (Pillay 1958). July-September and January-February, the two periods where eggs, larvae and juveniles are found in the upper reaches of the river. Juveniles and young ones are reported in lower stretches in Ganga basin in the month of October-November and again during March. In the month from December-February young fish occupy the foreshore areas (Pillay and Rosa 1963). Hilsa prefers to reside in foreshore areas due to presence of sub-surface oxygen, strong tidal action, relatively low salinity, heavy siltation, high turbidity and rich growth of plankton (Pillay and Rosa 1963).

Fishing in lower stretches of Hooghly river. (Photo Credits CIFRI Barrackpore)


Highly priced, protein rich Hilsa from lower GRB

2.3 BREEDING

The Hilsa of Bay of Bengal and its estuaries and rivers are gonochoristic and anandromous (Blaber 2000). The male and female attain sexual maturity at the age of one year (Blaber and Mazid 2001). The males are comparatively smaller and slim than females (Jafri 1988). Fecundity is very high, ranges from 100,000 to 2,000,000. The greater the size of female the egg laying capacity is higher and vice versa. The breeding of Hilsa in the Ganga appears to be with the onset of the monsoon in July; with peak breeding from September-December (Motwani et al. 1957). Before the construction of Farakka barrage, the spawning area in the river Ganga was also marked between Patna and Allahabad by Motwani et al. (1957). Hilsa now breeds in the entire fresh water area thus there is a considerable extension of the spawning ground of Hilsa in the estuary during this period. This increase is largely due to the increased flow of fresh water into the estuary following construction. The higher rate of fresh water discharge into the Indian part of the rivers has significantly reduced the salinity downstream. As a result, the downstream zone becomes almost fresh water and therefore better for spawning. Nevertheless rainfall, salinity, turbidity and temperature play significantly in occurrence, distribution and the migratory behavior of estuarine fishes (Hilsa). Other factors such as light and depth of water are also contributing factors (Blaber 2000). A prolong spawning season (during August - March with peak in October- November and February-March) of Hilsa was also reported in the Hooghly estuary (De 1986; De and Saigal 1989; De et al. 1994; Bhaumik and Sharma 2011; Bhaumik 2013).

2.4 FOOD AND FEEDING

Hilsa intensively feed in the months of January to March (Pillay and Rao 1963). Its diet mainly composed of three groups, phytoplankton, crustaceans and plant debris. According to Dutta et al. (2013) the percentage composition of the food is organic debris (26.06±5.19 %), diatoms (31.22±11.97 %), other algae (12.41±2.62 %), and crustaceans (3.50±1.28 %). The sand grains (22.66±6.92 %) being obviously accidental inclusions with the debris.

2.5 MIGRATION

Hilsa species are anandromous experiencing both marine and fresh water life. It travels great distances and migrates up to 1,200 km inland through rivers for spawning. The upstream migration starts with the commencement of the south-west monsoon. The variations in the intensity of the monsoon rainfall during the breeding season cause considerable fluctuations in fish catches in different localities. The fish spends a part of its life in the sea not far from the shallow coastal belt (Day 1873). The general migratory pattern of adult Hilsa in the Ganga starts from May-June and they disappear by the second week of October (Naidu 1939). The mature Hilsa swarm upstream into the rivers during the flood season for spawning and also some young individuals travel far up before they become sexually mature. The spawning takes place in the tidal waters and in the middle reaches of the large rivers. The floods and sexual maturity induce the fish in the sea to undertake the upward migration (Hora 1941). Temperature, water current, velocity, and the volume of discharge are supposed to be the significant factors of Hilsa's movements from the sea to the estuary (Pantalu et al. 1966; Gopalakrishnan 1971). The full recruitment of juveniles to sea starts from the month of July and continues to January with a peak in October (Rueben et al. 1992). To know the source of Hilsa fishery in the upstream of the Farakka barrage, tagging experiments were carried out during 1993 and 1994 by De and Sinha (1997). The tagging experiments again conducted by De (2001) in Bhagirathi, Padma and Ganga river systems revealed that Hilsa could negotiate Farakka barrage only during flood season.

The long range of upstream migration reach of Hilsa was recorded upto Kanpur and Agra in Ganga and Yamuna systems, respectively. In river Yamuna, Hilsa found to ascend as high as Delhi

Under the influence of numerous factors responsible for drastically dwindled and ultimately extinction from several streams of GRB, Hilsa simultaneously forms three ecotypes (fluvial anadromous stocks; fluvial resident stocks; purely marine stocks) (Bhaumik 2015).

2.6 ECONOMIC, NUTRITIONAL AND ECOLOGICAL IMPORTANCE OF HILSA SHAD IN GRB

The Ganga-Hooghly and Brahmaputra-Padma drainage system of India and Bangladesh is a home of most abundant commercial fisheries of single species Hilsa (*T. ilisha*) in India, Bangladesh and Myanmar. Hilsa significantly contributes to the fisheries of the transition zone (Bhagirathi–Hooghly River). Its catch varies between 3.9-16% of the total catch of the estuary (Mathur et al. 2019). Other reports revealed that Hilsa accounts for about 20-25% of the total fish landing in the Hooghly-Bhagirathi river system (Bhaumik and Sharma 2012). The finding is also acquiescent to the finding that a significant share of the income of the fishers is also contributed by Hilsa shad in Hooghly-Bhagirathi river system (Roy et al. 2016). One of the major sources of fishermen's household family income is Hilsa fishery contributing 38.84% per annum. The trans-boundary Hilsa fish is not only associated with socio-economy of West Bengal, it is also associated with the cultural heritage of the Bengali people (Suresh et al. 2017). Its consumer preference is at the top position among the edible fishes due to its superb taste, mouth-watering flavour and delicate culinary properties (Alam et al. 2012). Its high commercial demand makes it a good forex earner for many countries (Alam et al. 2012; Rahman et al. 2015). Hilsa shad also has high nutritional value in terms of beneficial amounts of amino acids, minerals and lipids (high content of essential PUFA) that positively influences consumer health. Many mono and poly unsaturated fatty acids, viz., oleic, lenoleic, lenoleneic, arachidonic, eicosapentaenoeic and docosa-hexaenoeic acids contribute in its unique taste (Alam et al. 2012). Hilsa shad is also a preferred prey for several piscivorous species found in GRB such as aquatic birds, Dolphins (*Platanista gangetica gangetica*), Indian mottled eel (*Anguilla bengalensis*), river cat fishes (Hossain et al. 2019) and plays an indirect role in maintaining the ecological balance.

Hilsa: A lifeline for local fisher. (Photo credits CIFRI Barrackpore)

3.0 STATUS OF HILSA IN RIVER GANGA

The ecology of the Hooghly estuary has significantly altered after commissioning of Farakka barrage in 1975, leading to increased freshwater discharge in the Hooghly estuary, reducing salinity, modification in the fishery, fishing pattern and fish production. The true estuarine zone has moved seaward and the marine zone has been restricted to the area near the mouth of the estuary (Mirza 2004). It has changed the plankton dynamics, reduced the number of marine and neritic species in the upper estuary, caused significant increase in Hilsa catch and an overall increase in fish landings from the estuary (Sinha et al. 1996). The marine distribution of the Hilsa coincides with the Indian monsoon season.

Before the Farakka barrage, the Ganga, Yamuna, Hooghly and Brahamputra rivers together contributed 70% of the total Hilsa production of the country

3.1 HISTORICAL MIGRATORY ROUTE OF HILSA

Hilsa is an important fish in lower stretches of river Ganga (Varanasi to Gangasagar). Before the construction of Farakka dam, it used to travel upstream of Varanasi and sometimes upto Allahabad. Several reports have been published by the researchers to describe the range of Hilsa migration in various riverine systems. According to the literature, Hilsa migration covers a distance of about 1,920 km (river kilometre) up to Delhi through the Yamuna tributary of the Ganga River (Hora 1941; Motwani et al. 1957; Quereshi 1968; Swarup 1959). Nowadays, due to Farakka barrage, it is restricted upto Farakka where they have started breeding. Ahsan et al. (2014) reported the spawning ground for Hilsa between Nishchintpur and Diamond Harbour at downstream, Hooghly Ghat and Kalna in freshwater tidal zone and Lalbagh to Farakka in Bhagirathi river. Hooghly river and Matla-Bidya-Raimangal (Ichamti) estuarine complex was also marked as the spawning ground in the marine and estuarine part of the basin. The historical distribution and current reach of Hilsa in GRB is presented in Figure 1 and 2.

Fisherman casting net in lower Ganga basin. (Photo credits CIFRI Barrackpore)

4.0 HILSA FISHERIES IN GRB

Hilsa is the prominent catch component in monsoon (July to October) and winters (November to January). The Hilsa catch varies between 3.9-16.0% of total catch from the estuary. As per the reports published by Central Marine Fisheries Research Institute in 2011 and Department of Animal Husbandry, Dairying and Fisheries in 2014, Hilsa shad is an important contributor to catches in the West Bengal state with 12.5% contribution yet it represents only 2.7% of total national catch (Hossain et al. 2019). More Hilsa catch is reported from the estuarine and marine part of the Bay of Bengal because of development of latest marine fishing techniques. IUCN (2014) reported that 70% of marine catch from the total Hilsa catch is in West Bengal. To increase the seed production through artificial fertilization, the first Hilsa hatchery was

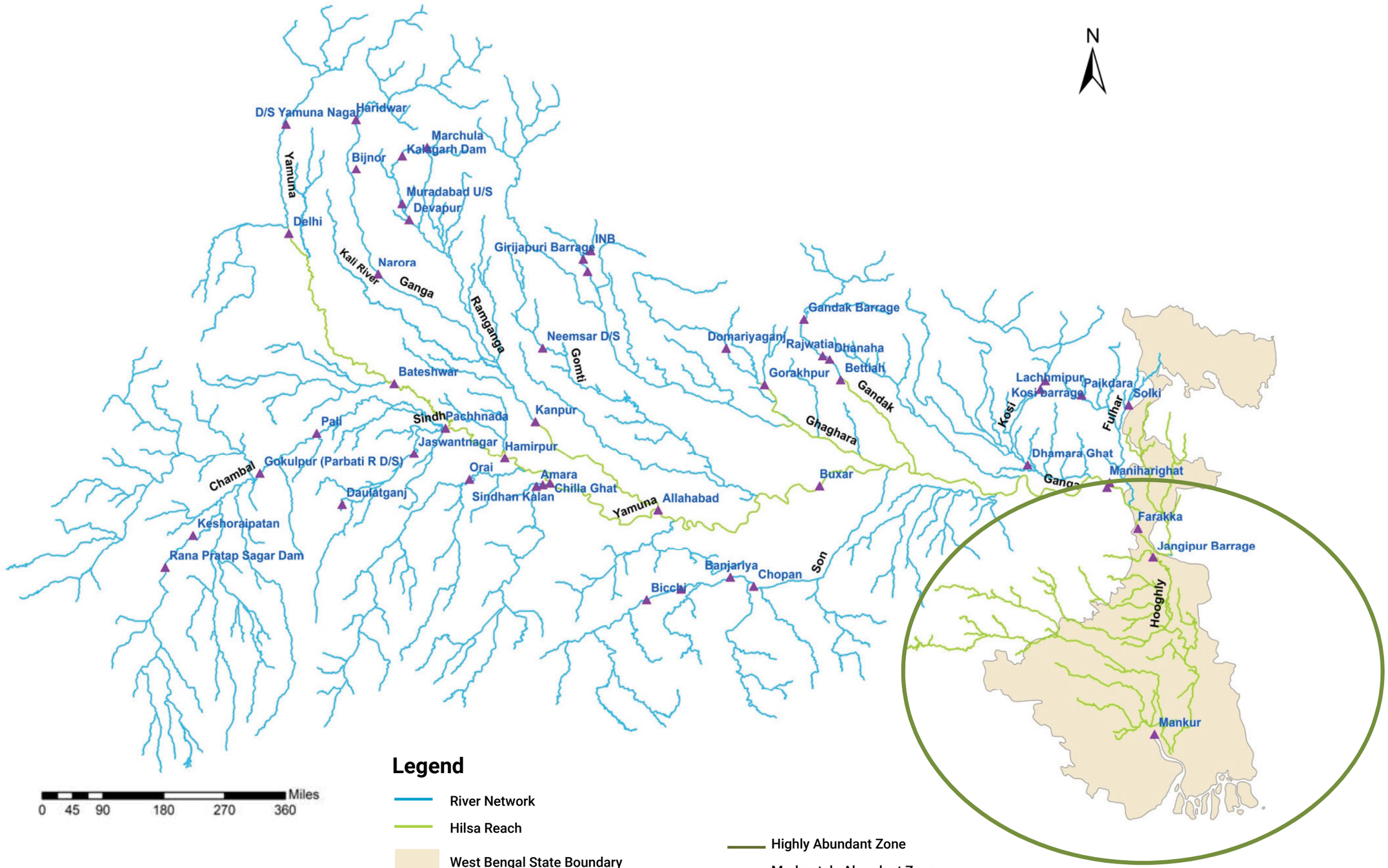
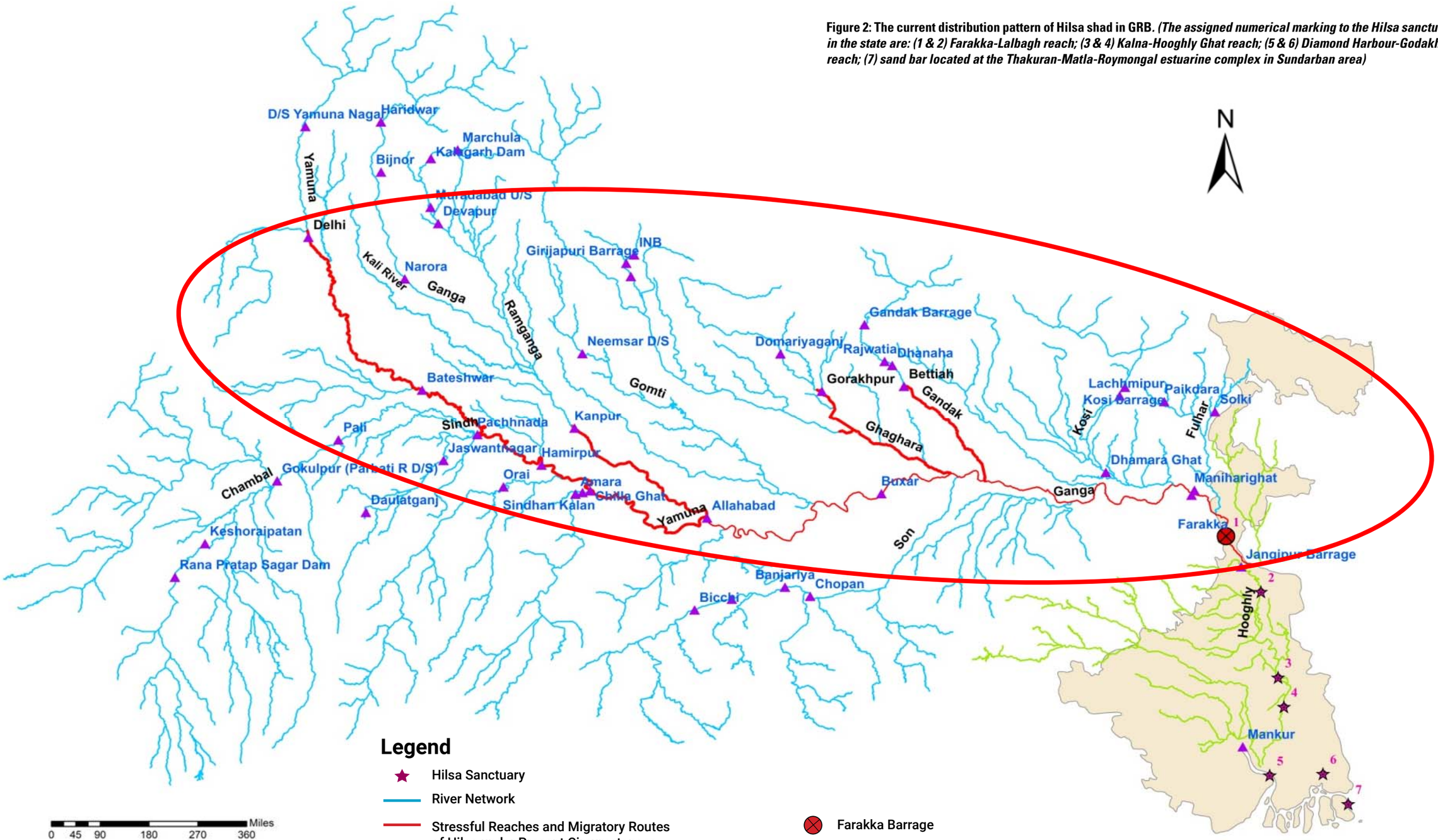


Figure 1: Reference distribution pattern of Hilsa shad in GRB based on available historical information

Figure 2: The current distribution pattern of Hilsa shad in GRB. ***(The assigned numerical marking to the Hilsa sanctuary in the state are: (1 & 2) Farakka-Lalbagh reach; (3 & 4) Kalna-Hooghly Ghat reach; (5 & 6) Diamond Harbour-Godakhali reach; (7) sand bar located at the Thakuran-Matla-Roymongal estuarine complex in Sundarban area)***



established in CIFRI, Barrackpore, India in 1987. The researchers of CIFRI, Barrackpore and its regional center at Allahabad also captured the data relevant to fish catch at several stations under GRB from past several years and compiled the information in the form of annual reports. The comparative analysis of change in composition of fishes during 1958-1994 at Allahabad and Patna centers has been reported by Payne et al. (2003). Some additional fish landing data compiled from annual reports of CIFRI is also presented in the article (Figure 3 and 4).

In Allahabad, the percent catch of Major Carps (MC) has reduced from 45.0% in 1961-1968 to a mere 13.23% in the period 2001-2010; whereas Catfishes declined from 22.87% (1991-2000) to 9.37% (2001-2010). Hilsa, the migratory clupeid, which used to be a good fishery at Allahabad as 10.3% (1961-1968), has dropped to a meager 0.16% (2001-2010). Similar trends for Major Carps

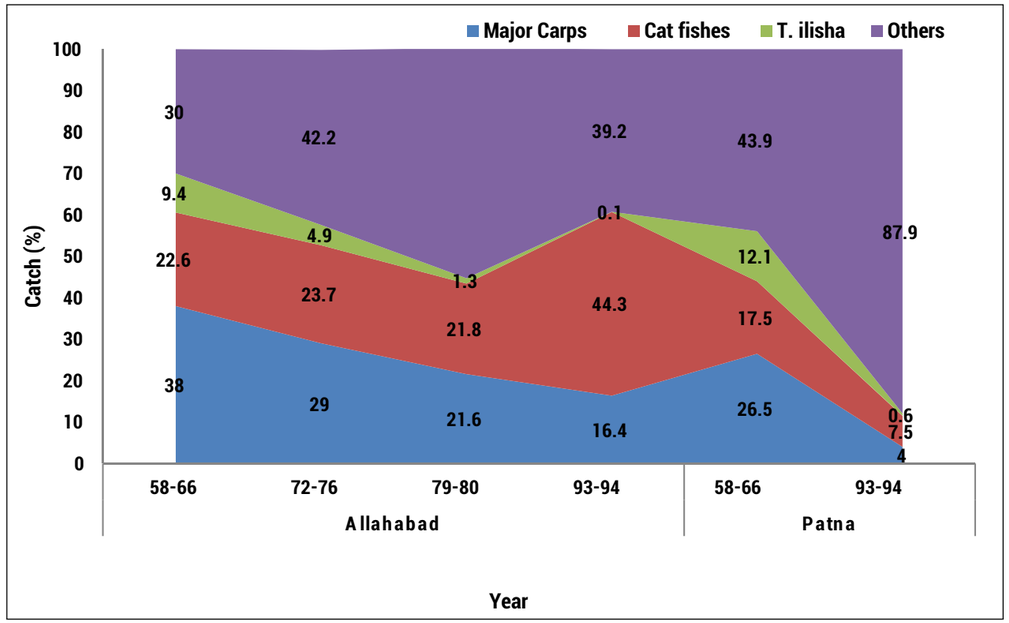


Figure 3: Change in the catch composition downstream from Allahabad during 1958 and 1994 (Payne et al. (2003))

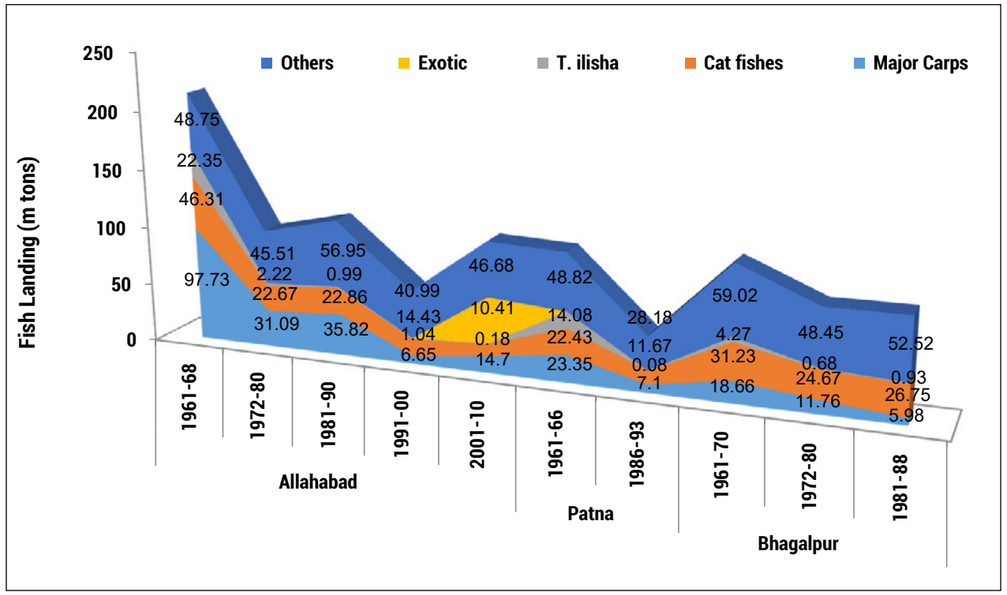


Figure 4: Fish landing (m tonnes) at different centers (compiled from CIFRI Reports: 1961-2010)

and Hilsa are also apparent at Patna and Bhagalpur centers. Ghosh (1976) has mentioned that the production of the Hilsa fishery above the Farakka barrage has dropped from 116.1 kg/km^2 pre-construction to less than 1 kg/km^2 post construction. Before the Farakka barrage, the Ganga, Yamuna, Hooghly and Brahamputra rivers together contributed 70% of the total Hilsa production of the country (De 2014).

Hilsa nearly disappeared and other fishes of less commercial importance increased to 44.9% (1961-1966) to 59.9% (1986-1993) at Patna and 52.14% (1961-1970) to 60.9% (1981-1988) at Bhagalpur. With the construction of Farakka barrage, the fishery scenario at Lalgola center, which is about 45 km below Farakka, also showed a major change in stock structure. Prior to Farakka, the Hilsa used to be the main fishery (92.02%). With the commissioning of the barrage, Hilsa contribution came down to merely 16.8% and the niche has been replaced by other species (Lakra et al. 2011). The details are depicted in Figure 5. According to the report

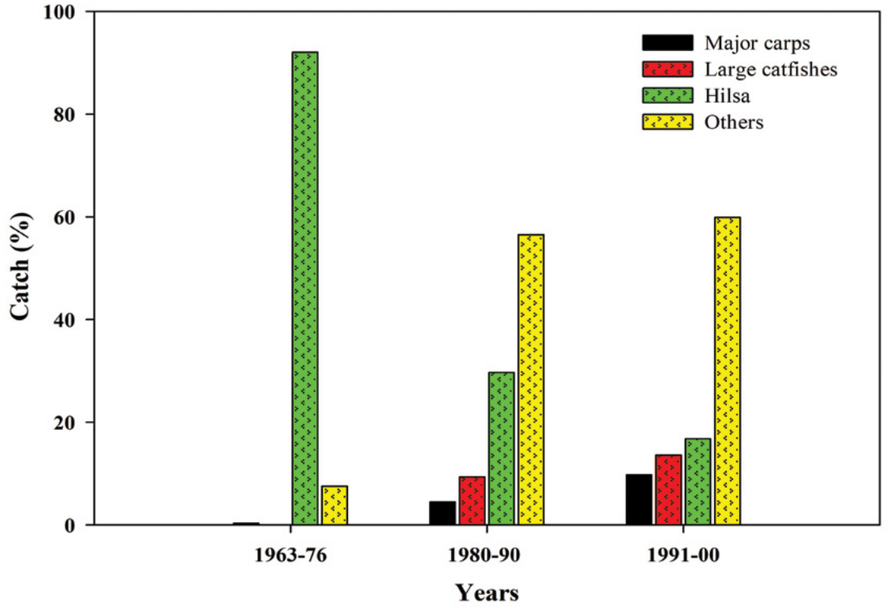


Figure 5: Catch composition (%) at Lalgola, pre and post Farakka period

published by Ahsan et al. (2014), the difference in the catch under fresh water and marine zone in West Bengal was noticed during the years 1998-99 and 2002-03. The catch in riverine zone increased impressively from 6,280 tonnes in 1998-99 to 11,483 tonnes in 2002-03.

4.1 MAJOR THREATS AND PROPOSED MANAGEMENT INITIATIVES

Loss of longitudinal connectivity

In-stream flows/environmental flows should be maintained at downstream of dams and barrages including estuary and associated mangroves ecosystems for migration in peak breeding periods.

Habitat loss and destruction by floodplains elimination due to embankments of the rivers

River embankments destroy the lateral connectivity of rivers to its riparian zone that ultimately leads to the habitat loss for terrestrial and aquatic floral and faunal species. Riparian (riparian buffer zone as well as riparian buffer strip) as well as wetlands should be protected through appropriate legislative framework for managing range of functions and services. An appropriate buffer mapping and designing is a prerequisite for not only the conservation of Hilsa shad in river Ganga but also for the restoration and conservation of other aquatic and semi-aquatic life forms.

Mangroove vegetation in Sunderbans, West Bengal. (Photo Credits CIFRI Barrackpore)

Habitat loss due to unregulated and excessive mining of sand and gravel

The unregulated sand mining substantially altered the channel morphology and channel hydraulics which ultimately leads to the destruction of aquatic and riparian habitat. To minimize the negative effects of mining of sand and gravel requires a site specific scientific assessment on sand and sediment budget analysis. Rigorous monitoring of the engaged agencies and critical periodic evaluation of the impact of the activity on ecosystem sustainability is desired.


The iconic Hilsa: King of all fishes in lower Ganga basin

Loss of benthic and hyporheic biota

A systematic assessment should be planned to assess the impact of anthropogenic pressures over benthic and hyporheic biota. The integrated study should be designed that covers the food web concept, connection and interaction between all the zones (hyporheic zones, riparian zones and parafluvial zones) under Hyporheic Corridor Concept (HCC) and highlights the alternations in the diversity of meiofaunal and algal assemblages due to the change in the hydrological dynamics of Hyporheic Corridor.

Pollution load through domestic and industrial waste waters

Comprehensive policy should be executed to reduce the potential risks associated with the direct domestic and industrial wastewater discharge. The monitoring agencies should develop their capabilities to measure, and monitor the status and the impact of enforced regulations regularly. Long term assessment of the existing pollution status and its impact on the species distribution ranges and meta-community dynamics should be studied to identify ecological drivers.

Introduction of exotic invasive species of plants and animals

Modified ecological habitats (instream, riparian and flood plain) and fragmented river channels often creates favorable environment for invasive non-native species. A regional scale and on-ground management research plan should be initiated to control exotic species and to assess the risk to riverine ecology by these pests. The key management actions should be formulated to recover the native populations by controlling align species. The funds should also be allocated for research activities to address key knowledge gaps on the align species behavior and their impact in GRB environment. A coordinated response from the multiple government agencies (Directorate of Fisheries of State Governments), central organizations/ research institutes (NBFGR, ICAR, NFDB, WII etc.) and state boards is also vital for managing alien fish in GRB.

Indiscriminate exploitation of adults and juveniles

Similar to the action taken by West Bengal Fisheries Department by introducing new amendments under the West Bengal Inland Fisheries Act,

Hilsa shad is an important contributor to catches in the West Bengal state with 12.5 percent contribution, yet it represents only 2.7 percent of total national catch


Hilsa: Superb taste, mouth-watering flavour and delicate culinary properties

a national level policy should be formalized for sustainable development of Hilsa fishery in the country. Appropriate regulation should be made to ban all negative exploitation activities such as fishing pressure on brood stocks, post breeding harvest of juveniles, over-fishing, mesh-size regulation, etc.

Illegal fishing

To generate accurate data on Hilsa fisheries and to control illegal fishing, "Real Time Monitoring Systems" should be designed for riverine as well as marine systems. A rigorous monitoring with periodic critical evaluation is required to control the activity. Multi-agency committees should be established for surveillance of the implementation of the existing and proposed regulations. Plan should also be prepared for quota based fishing efforts.

4.2 MANAGEMENT AND CONSERVATION MEASURES

A comprehensive action plan for Hilsa management has been formulated by West Bengal Fisheries Department and new amendments have been made in the West Bengal Inland Fisheries Act (West Ben. Act XXV of 1984) on April 2013 to protect Hilsa fishery and its breeding grounds (Hossain et al. 2019). The amendments in the rules can be summarized as, (i) restriction on the size of monofilament gillnets (below 90 mm) and other nets (below 40 mm), (ii) restriction on the fishing of Hilsa below 23 cm length, (iii) identification of 5 breading grounds of the fish marked as Hilsa sanctuary, (iv) prohibition of fishing during June to August and October to December in Hilsa sanctuary, (v) restriction on use of mesh size to protect the Hilsa below 23 cm in the inland open water system (including estuarine area) during February to April, (vi) ban on bottom trawling in shallow marine area/ shallow continental shelf, and (vii) prohibition on Hilsa fishing 5 days prior and post of the full moon during 14th September to 24th October every year." All these changes in the Act are to facilitate Hilsa growth (fingerlings, juveniles and adults) and to protect their breeding grounds which ultimately leads to the sustainable increase in the Hilsa fishery. Apart from the amendments in the Fishery Act, other management practices such as following need to be implemented for Hilsa conservation:

- The fresh water breading grounds under GRB above the Farakka barrage have to be identified and protected.
- Alternate livelihoods should be provided to the fisherman at the time when fishing is banned.
- The fisherman should be trained for other business to diversify their income.
- Illegal fishery should be monitored and regulated.
- More research should be carried out to understand the Hilsa behaviour, spawning, breeding and ecology.
- To implement the proposed regulations, awareness programs should be conducted more frequently.
- Anthropogenic activities near the spawning sites of the fish should be prohibited.
- Factors responsible for higher mortality and high fluctuation in the recruitment rate in the basin should be identified.
- Lack of precise and comparable catch data in riverine and marine sector needs to be captured regularly to fill up the knowledge gap which hinders various scientific activities.
- An accomplished online data base system is the need for the brighter future of Inland fisheries.
- Policy and legislation at the national level needs to be framed in consultation with all stakeholders in monitoring and implementation of various programmes as India contributes 7.2% of the world Hilsa catch (including 14% of the total fish catch of Ganga-Hooghly river system on the east coast and 23% along the Narmada estuarine system on the west-coast, Suresh et al. 2017).
- As recommended in IUCN (2014) report, the bottom-up approaches should be adopted to improve monitoring and implementation frameworks and for finalization of beneficiaries lists under Hilsa management programmes.

A coordinated response from the multiple government agencies (Directorate of Fisheries of State Governments), central organizations/ research institutes (NBFGR, ICAR, NFDB, WII etc.) and state boards is also vital for managing alien fish in GRB

REFERENCES

Ahsan DA, Naser MN, Bhaumik U, Hazra S, Bhattacharya SB (2014) Migration, Spawning Patterns and Conservation of Hilsa Shad (*Tenualosa ilisha*) in Bangladesh and India. Academic Foundation, New Delhi

Alam AKMN, Mohanty BP, Hoq ME, Thilshed S (2012) Nutritional values, consumption and utilization of Hilsa *Tenualosa ilisha* (Hamilton 1822). Proceedings of Regional Workshop on Hilsa: Potential for Aquaculture. Dhaka, Bangladesh

Bhaumik U (2015) Migration of Hilsa Shad in the Indo-Pacific Region – A Review. International Journal of Current Research and Academic Review 3(11):139-155

Bhaumik U (2013) Decadal studies on Hilsa and its fishery in India - A reveiw. J Interacad 17(2):377-405

Bhaumik U, Sharma AP (2012) Present status of Hilsa in Hooghly-Bhagirathi river. CIFRI Bulletin No.179. ICAR-Central Inland Fisheries Research Institute, Barrackpore, pp 42

Bhaumik U, Sharma AP (2011) The fishery of Indian Shad (*Tenualosa ilisha*) in the Bhagirathi-Hooghly river system. Fishing Chimes 31(8):21-27

Blaber SJM, Mazid MA (2001) *Hilsa* fishery research in Bangladesh, ACIAR Project 9430, Final Report, pp 1-143

CMFRI (2011) Annual Report 2010-2011. Central Marine Fisheries Research Institute, Indian Council of Agricultural Research. Kerala, India

Blaber SJM (2000) Tropical estuarine fishes : Ecology, Exploitation and Conservation. Blackwell publications Ltd, pp 1-372

DAHDF (2014) Department of Animal Husbandry, Dairying and Fisheries, Government of India. Ministry of Agriculture. Krishi Bhavan, New Delhi

Das BK, Sahoo AK, Roshith CM, Chowdhury AR, Saha D, De DK (2017) Exploratory survey on Hilsa (*Tenualosa ilisha*) catch and life stages availability along up / down stream of Farakka Barrage, Project report NMCG-CIFRI, Barrackpore, pp 40

Das I, Hazra S, Das S, Giri S, Maity S, Ghosh S (2018) Present status of the sustainable fishing limits for *Hilsa* Shad in the northern Bay of Bengal, India. The Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences, pp 1-8

Day F (1873) Report on the freshwater fish and fisheries of India and Burma. Office of Superintendent of Government Printing, Calcutta, India

De DK (2014) The shad Hilsa, *Tenualosa ilisha* (Ham.) its biology and fishery. Nagendra Publishing House, New Delhi, India

De DK (2001) An overview of the biology and fishery of Hilsa, *Tenualosa ilisha* (Ham.) of Hooghly Estuary and River Ganga, In: Blaber S, Brewer D, Milton D, Baiano C (Eds.), International Terubok Conference. Sarawark Development Institute (SDI), Kuching, Sarawark, Malaysia, pp 25-51

De DK, Sinha M (1997) Studies on the migration of hilsa, *Tenualosa ilisha* by tagging experiments. In: National Seminar on Changing Perspectives on Inland Fisheries. Inland Fisheries Society of India and Central Inland Capture Fisheries Research Institute, Barrackpore, pp 16-17

De DK, Sinha M, Ghosh A (1994) Impact on Farakka barrage on the spawning of Hilsa, *Tenualosa ilisha* (Ham.) in the Hooghly estuary. Journal of the Inland Fisheries Society of India 26:121-124

De DK, Saigal BN (1989) Spawning of hilsa, *Tenualosa ilisha* (Ham.) in the Hooghly estuary. Journal of the Inland Fisheries Society of India 21:46-48

De DK (1986) Status on the food and feeding habit of hilsa, *Hilsa ilisha* (Hamilton) of the Hooghly estuarine system and some aspects of its biology. Ph.D. Thesis, Calcutta University, India

Dutta S, Maity S, Chanda A, Hazra S (2012) Population structure, mortality rate and exploitation rate of *Hilsa* shad (*Tenualosa ilisha*) in West Bengal coast of Northern Bay of Bengal, India. World Journal of Fish and Marine Sciences 4 (1):54-59

Dutta S, Maity S, Bhattacharyya SB, Sundaray JK, Hazra S (2013) Diet composition and intensity of feeding of *Tenualosa ilisha* (Hamilton, 1822) occurring in the Northern Bay of Bengal, India. Proceedings of the Zoological Society 67 (1):33-37

Gopalakrishnan V (1971) The biology of the Hooghly-Matlah estuarine system (West Bengal, India) with special reference to its fisheries. Journal of the Marine Biological Association of India 13:182-194

Ghosh AN (1976) Observation on the Hilsa fishery of the river Jamuna during the years 1955-62 at Allahabad. Journal of the Zoological Society of India 17(172):135-149

Hora SL (1941) Life history and wandering of Hilsa in Bengal waters. The Journal of the Asiatic Society of Bengal 6:93-112

Hossain MAR, Das I, Genevier L, Hazra S, Rahman M, Barange M, Fernandes JA (2019) Biology and fisheries of Hilsa shad in Bay of Bengal. Science of the Total Environment 651:1720-1734

IUCN (2014) Migration, spawning patterns and conservation of Hilsa Shad (*Tenualosa ilisha*) in Bangladesh and India. Academic Foundation, New Delhi, India

Jafri SIH (1988) Biology and fishery of river shad - A review. Pakistan Journal of Agricultural Research 9(2):252-263

Lakra WS, Sarkar UK, Dubey VK, Sani R, Pandey A (2011) River inter linking in India: status, issues, prospects and implications on aquatic ecosystems and freshwater fish diversity. Reviews in Fish Biology and Fisheries 21:463-479

Mathur RP, Sharma AP, Joshi KD, Kapoor V (2019) Status of fish and fisheries. Compendium of biodiversity in Ganga river system. Lambert Academic Publishing, Mauritius, pp 113-178

Mirza MMQ (2004) The Ganges water diversion: Environmental effects and implications. Water Science and Technology Library. Springer-Science+Business Media, B.V. p 9

Motwani MP, Jhingran VG, Karamchandani SJ (1957) On the breeding of the Indian shad, *Hilsa ilisha* (Hamilton) in fresh waters. Science and Culture 23:47-48

Mojumdar CH (1939). Foreshore fishing in the eastern parts of the Bay of Bengal. Science and Culture 5(4):219

Naidu MR (1939) Report on survey of the fisheries of Bengal, Calcutta, India

Pantalu VR, Alagaraja K, Bhimchar BS (1966) Fisheries of Damodar valley in relation to construction of dams. Proceedings National Institute of Sciences, India 32B(5&6):191-207

Payne AI, Sinha R, Singh HR, Huq S (2003) A review of the Ganges Basin: its fish and fisheries. In: Welcomme RL, Petr T (Eds.) Proceedings of the Second International Symposium of Management of Large Rivers for Fisheries, Vol 1. RAP Publication, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, pp 229–252

Pillay SR, Rao KV (1963) Observation on the biology and fishery of the Hilsa, *Hilsa ilisha* (Hamilton) of river Godavari. Proceedings Indo-Pacific Fish Council, pp 37-61

Pillay TVR (1958) Biology of *Hilsa ilisha* (Hamilton) of the river Hooghly. Indian Journal of Fisheries 5:201-257

Pillay TVR, Pillay SR, Ghosh KK (1963) A comparative study of the populations of Hilsa, *Hilsa ilisha* (Hamilton) in the Indian water. Proceedings Indo-Pacific Fish Conference 10:63-104

Pillay TVR, Rosa H (1963) Synopsis of biological data on *Hilsa ilisha* (Hamilton). FAO Fisheries Biology Symposium 25:24-64

Quereshi MR (1968) *Hilsa* fishery in East Pakistan. Pakistan Journal of Scientific and Industrial Research 11:95-103

Rahman ASMS, Begum MH, Reza HA, Ahsan MN, Ahmed MS (2018) Molecular characterization of hilsa shads in Bangladesh using cytochrome C oxidase subunit I (COI) gene. International Journal of Fauna and Biological Studies 5(3):01-05

Rahman MA, Flura, Ahmed T, Pramanik MMH, Alam MA (2015). Impact of fifteen days fishing ban in the major spawning grounds of Hilsa (*Tenualosa ilisha* Hamilton 1822) on its spawning success. Research in Agriculture, Livestock and Fisheries 2(3):491-497

Raja BTA (1985) A review of the biology and fisheries of *Hilsa ilisha* in the upper Bay of Bengal. Bay of Bengal Programme. Marine Fisheries Resources Management. Food and Agriculture Organization of the United Nations. BOB P/WP/37. p1

Roy A, Manna RK, Sharma AP (2016). Socio-economic and livelihood analyses of hilsa (*Tenulosa ilisha*) fishers of lower stretch of Ganga River, India. Indian Journal of Fisheries 63(1):83-88

Rueben S, Dan SS, Somaraju MV, Phillipose V, Sathianandan TV (1992) The resources of Hilsa shad, *Hilsa ilisha* (Hamilton) along the northeast cost of India. Indian Journal of Fisheries 39(3-4):169-181

Sinha M, Mukhopadhyay MK, Mitra PM, Bagchi MM, Karamkar HC (1996). Impact of Farakka barrage on the hydrology and fishery of Hooghly estuary. Estuaries 19(3):710-722

Southwell T, Prashad B (1918) On Hilsa investigations in Bengal, Bihar and Orissa. Bull Dep Fish Bengal, Bihar and Orissa, Bull No. 11, pp 1-12

Suresh VR, Sajina AM, Dasgupta S, De D, Chattopadhyay DN, Behera BK, Ranjan R, Mohindra V, Bhattacharya S (2017) Current status of knowledge on Hilsa. ICAR-Central Inland Fisheries Research Institute, Barrackpore, India

Swarup K (1959) Seasonal variations in the ovary of *Hilsa ilisha* (Ham.) found at Allahabad. Proceedings of National Academy of Science India, Section B 29:127-133

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