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■ THE SHAD FOUNDATION'S ■

SHAD JOURNAL

"For the study, protection, and celebration of shad around the world"

The key to fish locks on the river Rhône
Hilsa: Bangladesh's King of Fishes

VOLUME 3, NUMBER 1, WINTER 1998

COX'S BAZAR IN BANGLADESH where trawlers carry their catch of Hilsa shad to be processed. To learn more about the life history and management concerns of this fish, please turn to page 7.

MIZANUR RAHMAN

President's Note:

As we say good-bye to a world-renowned fishway designer, Milo Bell [see obituary, page 3], we are witness to a new trend in the treatment of U.S. dams deemed harmful to migratory fish—removal. Talk of dam removal or license denial for the benefit of fish was unheard of in Milo's day, when he heard a lot of snide comments about salmon on the Columbia River, USA. At that time he was designing fishways on the Columbia River to prevent the extinction of salmon runs.

Now, the environmental costs of dams are seriously weighed against their benefits, and dams are removed because of the environmental harm that they do. Most recently (23 April) the North Carolina Division of Water Resources signed a contract to remove the Cherry Hospital dam on the Little River, to open spawning habitat to hickory shad, striped bass, and other fish. Other recent developments include the removal of Quaker Neck Dam on the Neuse River, a rejected proposal to build a new dam on the Penobscot River in Maine, and the planned removal of 106-year-old Edwards Dam on the Kennebec River in Maine. The removals and license denials are made for the sake of fish.

If he were alive today, these developments would have pleased Charles H. Stevenson, who, in 1898, deplored the mounting losses of American shad habitat— then 30 percent—to insurmountable dams and other obstructions. [See "The Shad Fisheries of the Atlantic Coast of the United States."]

As developing nations begin to build dams that harm their fishery resources, what lessons can be learned from the successes and failures of others?

-R. Hinrichsen

INSIDE

SHAD FORUM

In the "Shad Forum" department, we publish letters and comments on issues surrounding shad and their fisheries. Your contributions are welcome.

American Shad Not Overlooked For Atlantic Salmon on Connecticut River

To the Editor:

I read with great interest the letter in the Fall 1997 issue from Joe Zaientz [see "New Shad Museum in Connecticut," by Joe Zaientz; SHAD JOURNAL, Winter 1998]. The Connecticut River indeed has a rich tradition of shad fishing and the museum that Joe is establishing is a welcome effort to preserve the history of the fish and the fisheries. However, toward the end of his letter, there were misconceptions that I would like to clear up.

The State of Connecticut's Fisheries Division has an active management program for American shad. Besides working with the federal government and the three other Connecticut River states to restore the shad run to its historical range on the mainstem, our agency is working to restore shad runs to the tributaries of the river in our state, through fishway construction and fish planting.

We have not diverted any funds from our shad program to the salmon restoration program.

Similarly, we are working to restore shad runs to the Naugatuck, Shetucket and Quinebaug rivers. Removing dams, constructing fishways, and planting stocks are the keystones to these restoration initiatives. We continue to monitor the fisheries, produce population estimates, and monitor juvenile abundance in the Connecticut River for which we have a long-standing database.

We have not diverted any funds from our shad program to the salmon restoration program. We are committed to enhancing and properly managing our shad populations *and* restoring salmon to the Connecticut River. It is not an "either/or" proposition. Incidentally, our work with clupeids doesn't end with American shad. We are actively restoring runs of alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) in many streams in our state using similar management tools.

As Joe mentioned in his letter, the size of the annual shad run in the Connecticut River has fluctuated in recent years. The poor years correspond to the poor years experienced by runs in other East Coast rivers and we have no reason to believe that the cause for these poor runs is specific to the Connecticut River. Despite some relatively modest adult runs, the indices of juvenile production have been very high.

The long-term outlook for shad in Connecticut and the Connecticut River is quite good and our agency will continue to work on the shad's behalf. We are pleased that Joe and his friends are working to preserve the history and traditions of the fish and fisheries at his museum.

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Zaientz Responds:

Thank you for enlightening me on your efforts. All these years I and most other shad fishermen felt that shad were put "out to sea" so to speak to be totally replaced by the salmon. I am glad that we were wrong.

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Hanping To Explore Shad Genetics in China

To the Editor:

Thank you for creating the Shad Foundation and Shad Journal, which provide us with a forum for exchange of shad information. I am very interested in your questions about the possible American

YANGTZE RIVER FISHERIES INSTITUTE

REEVES SHAD of China will be analyzed by Wang Hanping to determine whether they are composed of genetically distinct stocks.

THE SHAD JOURNAL ®

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The *Shad Foundation* is a Washington State nonprofit corporation that was established in 1996 to promote a greater understanding of shad for the purpose of restoration where depleted, or their responsible use where sufficiently abundant.

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Submissions. The editors welcome submission of articles on any aspect of shad. The Journal publishes letters, commentaries, histories, scientific articles, interviews, reviews, and philosophical and methodological items related to shad the world over. (See instructions on back cover.)

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shad invasion to Asia [see "Oceanography of the Pacific Shad Invasion," by Curtis C. Ebbesmeyer and Richard A. Hinrichsen; SHAD JOURNAL, February 1997]. I will start a project to discriminate among coastal populations of shad in China using mitochondrial DNA this year. The project might provide some useful information to address your questions.

I suggest that the Shad Foundation develop funds to establish an international project on the identification and phylogenetic relationships among Asia shad and American shad using analysis of mitochondrial DNA polymorphisms. I plan to write a proposal on this. Thank you for your attention.

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Workshop on Age Estimation of European Shad Held

A workshop on age determination of European shads was hosted by Institut National de la Recherche Agronomique (INRA) at their offices in Rennes, France 1-3 December 1997. It treated shad populations from rivers throughout their European range: River Sebou in Morocco (near the shad's southern limit); the rivers Tagus, Mondego, Lima and Minho in Portugal; the rivers Garonne, Dordogne and Rhône in France; and the river Severn in England (near the shad's northern limit).

We discussed aging of anadromous and landlocked populations of *Alosa alosa* and from two subspecies of *Alosa fallax*; *A. f. fallax* which inhabits rivers draining into the Atlantic Ocean and *A. f. rhodanensis* from the Rhône which drains into the Mediterranean Sea. Also included were scales from *A. alosa* × *A. fallax* hybrids.

The workshop dealt solely with the estimation of age using scales. Topics included the location from which scales should be taken, their preparation, the terms used to describe their characteristics, the time of annulus formation, and the setting of dates for the transfer of fish from one age group to the next. Nomenclature and recording of spawning marks were also discussed.

From the evidence presented at the meeting, identification of the position of the first annulus appeared particularly difficult in the faster-growing southern populations. The problem was particularly evident for the population of *Alosa fallax rhodanensis* from the River Rhône. In those fish which had spawning marks it appeared easier to work from the outside toward the center as opposed to the more usual approach of reading the scale from its origin outwards.

The interpretation of spawning marks was discussed, in particular the number and whether spawning was an annual event. In the latter case doubt arose for certain scales where a spawning mark followed by a winter annulus also showed considerable growth. It was uncertain whether this represented a year, and the fish had missed a spawning, or a few months growth and that the scale material would be eroded and/or resorbed during spawning.

It is proposed to publish the results of the workshop in both French and English, sometime during 1998. This will be a booklet with a large number of illustrations showing not only those scales which are straightforward to read but those where there is considerable doubt, for example those complicated by the presence of supplementary marks, false rings, supernumary annuli and spawning marks which are difficult to separate.

The aim is to provide guidance to those who, in the future, wish to estimate the age of shad from scales. It will deal with the taking, preparation, and interpretation of scales. And it will hopefully ensure that results are presented in a standard manner.

For further information contact Dr. Richard Sabati at Ecole Nationale Superieure Agronomique, Laboratoire d'Halieutique, 65, Rue de Saint Brieuc, 35042 Rennes, France. You may contact the author by phone at (33) 02 99 28 75 38 (Voice) or (33) 02 99 28 75 35 (Fax).

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Historical Fisheries Data on Lower Delaware Sought

The Kensington Historical Project is looking for historical data (especially fishery leases) on the fisheries of the lower Delaware River (Below Trenton, New Jersey) in the 18th and 19th centuries. Our goal is to locate and identify the fisheries, their years of operation and the leaseholders, particularly in the vicinity of Philadelphia County.

Initial data indicates that a small group of related individuals from the Fishtown (East Kensington) Neighborhood of Philadelphia eventually controlled most of the lower Delaware River fisheries. Our goal is to reconstruct a history of the fishing community, the Lower Delaware River fisheries, and their long-overlooked role in the history and economy of the Delaware River Valley. Please contact us if you have helpful information.

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Pioneer Fishway Designer Dies

Milo Bell, 92, a fish ladder engineer, died 21 April 1998 in Seattle, Washington, USA. He was born 4 June 1905 in Marion, Iowa, USA. Milo worked in fisheries for more than 40 years as a researcher, designer, teacher, and consultant. He was Professor Emeritus at the University of Washington School of Fisheries.

He showed an early interest in fish ladder design. At the age of 24, he wrote "Fish ladders and mechanical lifts" as a University of Washington undergraduate majoring in Mechanical Engineering. He was a principal designer of the Bonneville Dam fishways on the Columbia River, which were successful at passing adult American shad and Pacific salmon alike. In 1990, some 4 million shad passed Bonneville Dam on their way upriver to spawn.

He designed more than 60 fish facilities (hatcheries, fishways, and artificial spawning beds) and 50 fish screens, which guided juvenile fish away from turbine intakes. Although most of his work was in the Pacific Northwest—mostly designing fish facilities for the Columbia River and Puget Sound region—his expertise was also sought in the design of fish facilities for Midwest and East Coast rivers. In 1962, he was asked to recommend designs for fishways to pass adult American shad over the Susquehanna River's dams.

Special thanks is due member Mizanur Rahman for providing the photograph for the front cover and for his editing work.

Behavior of Migratory Fish Passing a Lock on the River Rhône, France

Hydroacoustical techniques help us learn more about the migratory behavior of shad and other fish species at the Beaucaire-Vallabrègues lock

by Jean Guillard and Benjamin Colon

For the past 50 years, the Rhône, a river possessing strong hydraulic potential and an impetuous character, has been fitted with dams and locks by the Compagnie Nationale du Rhône for production of electricity and passage of boats. These facilities modified the functioning of the hydrosystem and affected the Rhône's fish populations. Most adversely affected were the migratory species such as the sturgeon (*Acipenser sturio*), lamprey (*Petromyson marimus*), and shad (*Alosa fallax*).

To allow migratory fish to return to their spawning grounds, fish facilities were installed. However, their bad design, which is difficult to alter now, renders them largely ineffective.

Recently the shad and other migratory fish have become a target of a rehabilitation program. These migrants are indicators of the ecological quality and the continuity of rivers and streams.

Since 1993, Migrateur Rhône Méditerranée has organized studies at the Beaucaire-Vallabrègues locks (river kilometer 58)—the first obstacle met by fish migrating up the Rhône.

In our study at these locks, our goals are to monitor and optimize passage of all migratory fish.

Fish Locks

A fish lock is a lock used for fish passage; it works as follows. First, the lock empties, downstream doors open, and a filling flow of 60 cubic meters per second is maintained to create an attraction current. The attraction current allows fish to find the lock's entrance and entices them to enter.

After 20 minutes, the attraction current is shut off, the downstream doors are closed and re-filling of the lock begins. Once it is full, the upstream doors are opened and another upstream attraction current is maintained for 20 minutes at 0 to 5 cubic meters per second. This second attraction current encourages fish to exit the lock.

Hydroacoustic Monitoring

Hydroacoustic techniques use the physical properties of sound in the water to count and track fish. A sound emitted in the water propagates in the form of waves at a speed dependent on the water's temperature, saltiness, and pressure. The sound waves are reflected by all targets met: the river bottom, river surface, and, of course, fish. The reflected sounds (echoes) are then received and analyzed.

When originally developed, the technique was used to detect and study fish at sea or in a lake. Since then, the technique has evolved rapidly for the study of shallow waters, especially for studying fish distributions and behaviors.

In our hydroacoustic study, we used a SIMRAD EY 500 split-beam sounder, frequency 70 kilohertz. It emits sound simultaneously in four separate quadrants and the sound received from each is analyzed separately. Differences of phase between quadrants are proportional to differences of distance covered by the echo, thus allowing us to calculate a target's position.

We are able to differentiate between targets swimming with the current and against, thus allowing us to distinguish between migratory and non-migratory fish. Because we are interested only in tracking upriver migrants, targets not moving against the current are ignored.

Two circular transducers, SIMRAD ES70-11 (11 degrees of total beam angle at -3 decibels), mounted on a frame of steel, are used together with this sounder. These circular transducers, suspended from a winch to allow change in depth, are placed 16 meters upstream of the lock's doors. The data received from the soundings are processed by a computer program, SIMRAD EP 500.

For each fish lock, one obtains target strength, speed and direction, and distance from the transducer. By using software and a modem, the sounder is remotely piloted from the laboratory.

When Fish Migrate

We use the echo-sounder data to study the seasonal evolution of the number of fish crossing the locks. We obtain estimates of the average number of migratory fish by square meter and by lock for each day. We then estimate weekly means, which show clearly the seasonal evolution of migration.

Our 1997 study, which lasted from 15 April to 30 June, shows that fish migration peaked at about 20 May. Because of the high daily variation in the numbers of fish crossing the lock, we sought relationships between environmental parameters and migration. We have studied average daily temperatures, daily average flows, and phases of the moon.

Migration is synchronous with the increase of the average flow and with the increase in average river temperature. However, a decline in average river temperature with a stable flow does not halt

migration.

To study the time of exit, we compared the percentage of fish detected in the lock during a fixed period to the total number of fish that already crossed the lock. We discovered that 90 percent of migratory fish exit the lock after 10 minutes. Therefore there is little gained by maintaining an attraction current for a full 20 minutes.

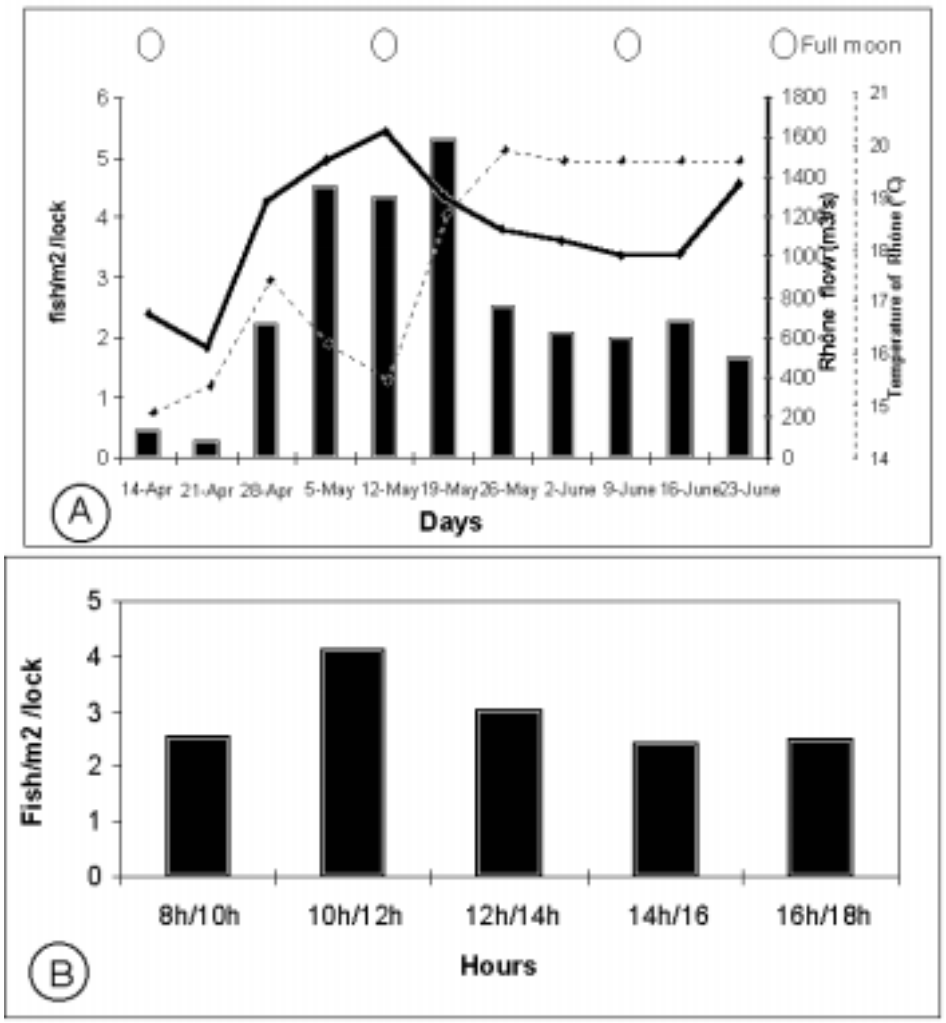
Target strength data, often used to study the size of fish, are not used. It is difficult to analyze because it varies greatly according to the position of the fish. The moderate differences in sizes between shad and other species prevent us from tracking their migration separately. Migration speed and position also do not allow us to make a distinction.

Conclusions

Our acoustical study during the 1997 migration season allowed us to draw some useful conclusions that will make operations of the Beaucaire-Vallabrègues lock more efficient during the three-month migration period. For example, the duration of the upstream attraction flow will be reduced, simplifying the lock operations.

The experimental apparatus has its advantages but also its limits. It provides a good description of the dynamics of migration. The main limits of the monitoring system are: (1) only a partial view of the lock is obtained, leading to an underestimate of migrants; (2) there is no distinction among migrating species.

These studies will be extended through the next several years. Our monitoring system will allow us to see the changes in fish numbers by year and through the season. It will show us whether fish are returning in greater number to the River Rhône.



(A) EVOLUTION OF THE NUMBER of fish passing through the Beaucaire-Vallabrègues lock; dates on the graphic are the first day of the week. (B) Daily evolution of fish passing through the lock.

The Authors

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Further Reading

DONNÉES RÉCENTES SUR LES CARACTÉRISTIQUES MORPHOLOGIQUES ET BIOLOGIQUES DE LA POPULATION D'ALOSE FEINTE DU RHÔNE (ALOSA FALLAX RHODANENSIS ROULE, 1924). M. LeCorre., J. L. Baglinére, R. Savatier, J. Y. Menella, and D. Pont in *Bull. Fr. Pêche Piscic.*, Vol. 346, pages 527-545; 1996.

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MONITORING FISH MOVEMENT PATTERNS IN A RESERVOIR USING HORIZONTALLY SCANNING SPLIT-BEAM TECHNIQUES. T. W. Steig and S. V. Johnston in *ICES Journal of Marine Science*. Vol. 53, pages 435-441; 1996.

Twaite Shad (*Alosa fallax*)

The twaite shad (*Alosa fallax*) is found along the coasts of Europe from the southern coast of Iceland south to Morocco. Populations are found throughout the Mediterranean, but not in the Black Sea.

It is a marine, pelagic, schooling species of shad which is strongly migratory and anadromous, but it apparently does not migrate far up rivers. Twaite shad enter the tidal parts of rivers in May or early June to spawn. Its eggs sink to the bottom after spawning and scatter over the gravel or sand. The fry, as they develop, move downriver to the sea. The species feeds on small fishes and crustaceans, and when young, feeds on crustaceans, and the fry of herrings, sprats and gobies.

There are landlocked lake-dwelling subspecies of *A. fallax* identified by Regan (1916): *A. fallax benacensis*, which inhabits Lake Garda, Italy; *A. fallax killarnensis*, Killarney Lake, Ireland; and *A. fallax lacustris*, Lakes Como, Maggiore, and Lugano, Italy.

The species is considered palatable, but also bony. It has not always been separated from the catches of *A. alosa* in catch records, but it probably contributes to the major part of the *Alosa* catches reported from France, Portugal and Morocco (267 tons in 1983).

Conservation efforts for this species are now underway in other European countries. Twaite and allis shad are known to British anglers as “May fish”—a reference to the time of year when they swim up rivers to spawn. Their populations have dwindled, and they are now protected under European statute.

The twaite shad is very rare or absent from several British rivers where it once spawned, but Welsh rivers, including the Wye, Usk, Severn, and Tywi, still support spawning stocks. In October 1997 the rivers Usk and Wye were proposed as special areas of conservation along with four other Welsh sites. With a new flood defense scheme on the River Thames, once an extremely polluted waterway, it is hoped that the twaite shad will recolonize their former habitats so that once again local people will talk of “shadding time” in spring.

Shad of the River Rhône

Taxonomic position
The shads of the Rhône always had a confused taxonomic positioning. Indeed, the study of the morphological criteria attaches this taxon to *Alosa fallax*. However their ecological characteristics bring them closer to the taxon *Alosa alosa*. A recent analysis of the morphological and genetic data of nearly 2,000 specimens confirms the existence on the Rhône of the subspecies *Alosa fallax rhodanensis*.

Increasing difficulties of its migrations
Until the nineteenth century, the shad did not meet obstacles on the Rhône. Shad migrated 460 kilometers upriver to the lake of Bourget and also up the tributary river Saône (confluence at river kilometer 330) which gave them access to favorable spawning grounds. The installation of dams on the Rhône started in 1948 with the dam of Génissiat (river kilometer 429) on the High Rhône. The Donzère-Mondragon dam (river kilometer 140), constructed in 1952, was the first dam to block migrations on the Rhône.

Since then, 11 structures were constructed by the National Company of the Rhône. The Beaucaire-Vallabrègues dam, built in 1970, 58 kilometers upstream of the sea, blocked access to tributaries. The migration area of the shads was therefore greatly reduced and shad landings decreased. This shad, however, seems to have stabilized thanks to a spawning ground downstream of the first dam, which shad used as a substitute for their traditional upstream spawning sites.

Comparisons between the 1995-1997 taxonomic and biological studies and the 1970 sampling campaign carried out by researcher C. Douchement uncovered an adaptation of their biology and their population dynamics. Interestingly, the comparison revealed an increase of length, weight and age, and an increase in fecundity.

Fish and commercial importance
The shrunken migration area led to a decrease in landings. In 1927, 53 tons of shad were caught between Arles and Pont-Saint-Esprit (between river kilometers 47 and 138); in 1950, 10 tons. Currently, 7 tons are caught downstream of the Beaucaire-Vallabrègues dam (river kilometer 58).

The various shad fishing methods used are:

- With “vire Blanchard” or “vire-vire,” a revolving system of basket installed on a fixed boat at the water’s edge, much like a fish wheel. The reduction of the current since the installation of structures in the river rendered this method of fishing impossible.

- With a trawl, a net pulled through the river by a boat.

- With gill-nets. Nowadays, the only active team of commercial fishermen downstream of the Beaucaire-Vallabrègues dam fishes in the Rhône using gill nets. The landings of shad by this method increase by approximately three tons each year.

- With the *plaice*—a small square net raised from time to time by the fisherman generally placed on a boat or sometimes on the bank. About 15 sport fishermen practice this fishing method downstream from the Beaucaire-Vallabrègues dam and capture approximately five tons of shad each season.

- With the line, primarily with a spoon or a fly. This fishing method is used mainly downstream of the first two dams and in the low parts of the tributaries.

Overall, shad fishing is not a very important economic activity, but one observes a renewed interest in recreational fishing—in particular, since adoption of measures that favor passage of migrating fish at the Beaucaire-Vallabrègues locks.

- J. Guillard and R. Hinrichsen

Hilsa shad: Fish for the teeming millions

New management alternatives needed for the hilsa young

by A. K. Yousuf Haroon

Hilsa shad, *Tenualosa ilisha* (Hamilton), is the largest single-species fishery in Bangladesh. It contributes some 200,000 metric tons to the total national fish production (20 percent of the total national fish production) and employs about 2.5 million people. Bangladeshis glorify hilsa as the "king of fishes" and its taste is said to surpass nectar. The fish-loving *Bengalees* of West Bengal, India hold hilsa in similar esteem and according to Hindu mythology, a pair of hilsa is offered to the *Goddess Durga* on *vijaya dashami* day.

Like American shad (*Alosa sapidissima*), hilsa shad (*T. ilisha*) is anadromous. Capable of withstanding a wide range of salinity and traveling great distances upstream—as far as 1,287 kilometers—it feeds and grows mainly in the sea but migrates to fresh water for spawning. Juveniles develop and grow in freshwater, but soon migrate to the ocean, where they spend most of their lives.

Reversal of Fortune

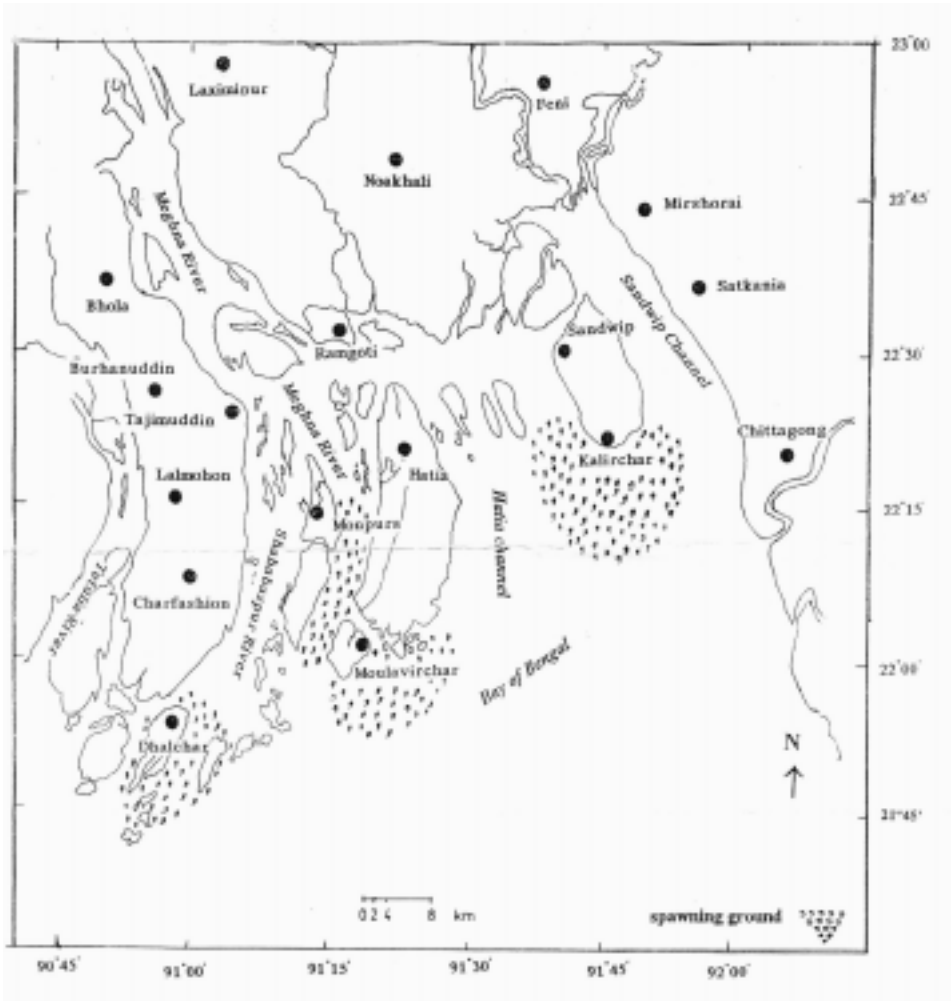
Until 1972, the hilsa shad fishery was restricted to the upstream rivers of Bangladesh, mainly in the rivers Padma and Meghna. After 1972, the fishery severely declined in the upper reaches and is now concentrated in the downstream reaches of rivers, estuaries, coastal areas and the sea. Although the total production of hilsa has remained more or less stable at 190,000-200,000 metric tons, the coastal, estuarine and marine catch has increased significantly, while the riverine catch has greatly decreased.

Low water discharge from the river Ganga at Farakka barrage and associated heavy siltation, indiscriminate exploitation of juveniles (*jatka*), disruption of their migration routes, loss of spawning, feeding and nursery grounds, and increased fishing pressure have all contributed to this decline.

Spawning Season

Monsoon months of August-October bring the peak harvest, but hilsa is sought by fishermen year-round. The most efficient gear used for catching hilsa are drift nets and bag nets. Adults are harvested during their upstream spawning migration and juveniles are harvested during their seaward migration. Hilsa shad spawn throughout the year with a major peak in September-October followed by a minor peak in February-March.

With the advent of the monsoon season (July-August), which brings heavy rains and freshwater discharge, hilsa adults start migrating upstream to spawn. During this time, the fishery is dominated by fish aged 3-5 years and 23-52 centimeters total length. The environmental cues



MAJOR SPAWNING GROUNDS of hilsa (*Tenualosa ilisha*) in Bangladesh.

which trigger migration are not known, although changes in water temperature and salinity seem likely candidates.

The spawning of hilsa is reported to be closely synchronized with the lunar cycle, with the majority of spawning taking place during a three-day period before and after the new and full moons.

The lower reaches and estuarine part of the Meghna and Shahbazpur rivers are the major spawning grounds of hilsa shad. Spawning grounds are also found in the following areas: (1) in and around the south of Moulavirchar of Hatia, the confluence of the Hatia channel and the Meghna River with the Bay of Bengal; (2) east and southeast of Monpura from southwest of Hatia extending up to the northwest of Moulavirchar; (3) the confluence of the lower stretches of the Meghna River with the Bay of Bengal; (4) in and around the south of Charfashion of Bhola; (5) the confluence of the Shahbazpur River with the Bay. Other spawning grounds include the stretch off the south of Sandwip, at the confluence of the Sandwip and Hatia channel with the bay (see map above).

About 11,000 fishing boats with 98,000 fishermen are engaged in harvesting hilsa on the spawning grounds, mainly during September-October during the peak spawning season. The total hilsa harvest from the spawning grounds during the peak spawning season is estimated to be around 39,000 metric tons.

Nursery Grounds

So far only two major nursery grounds have been identified for the Meghna river hilsa populations. One, near Chandpur, between Louhojang-Mawa of Munshiganj and the Hajimara of Laxmipur, is a major riverine nursery ground. Another, along the coastal belt from Kuakata (Patuakhali) to Dubla Island (Khulna), is a major coastal nursery ground. In addition, there are many small nursery grounds in the lower stretches of the Meghna River and its estuary. However, there may be more spawning and nursery grounds in the riverine, estuarine and coastal regions which have not yet been discovered.

Fecundity

Hilsa is a highly fecund fish containing 1-2 million eggs. The mean fecundity for fish caught at Gualondo, Chandpur and Chittagong was 0.6, 0.70, and 0.80 million eggs, respectively. Compare this with a fecundity of 0.1-0.5 million eggs for American shad.

Juvenile Fishery

Of particular concern is the over-exploitation of juvenile hilsa shad (locally termed *jatka*) during their downstream migration (December-April) when they range from four to 15 centimeters in total length. These are caught by the artisan fishermen using very small-meshed knotless, synthetic monofilament nets (locally known as *current jal*) in the foreshore and riverine waters of Bangladesh, including the lower stretches of the rivers Padma and Meghna. The most important gear used to catch *jatka* in the Chandpur area of the Meghna River is the *jagat ber jal* and *gara jal* (small meshed giant seine net fixed with bamboo poles and stretched across the river) and takes about 80 percent of the total *jatka* catch. The most commonly used nets in the coastal areas are *saver jal*, *ber jal* (both seine nets), *chandi jal, behundi jal* (fixed purse/bag net) and *poa jal* (bag net). Currently, the catch of *jatka* is estimated at over 3,700 metric tons a year and is taken from the Meghna nursery grounds.

MIZANUR RAHMAN

ARTISANAL FISHERMEN cast a gillnet in an inland river Jatka fishery. Jatka is the local name for juvenile hilsa shad.

Discrimination of Stocks or Races

Controversy exists over the distinction of stocks/races of hilsa shad in Bangladesh and India. Some believe that only one anadromous stock exists, while others believe that there are many subpopulations that can complete their life cycle within fresh water. Racial or stock analysis is of prime importance since management is best directed towards individual stocks.

Morphometric and meristic analysis carried out at the Riverine Station of the Bangladesh Fisheries Research Institute revealed that there might at least four stocks in Bangladesh. However, preliminary allozyme analysis revealed only two stocks/races: an anadromous stock and a marine stock.

Population genetics studies on hilsa from Bangladesh waters, conducted at the Institute of Fisheries and Marine Biology, University of Bergen, Norway, also revealed the existence of an anadromous and a marine stock. The anadromous populations sampled from the inland habitats (Chandpur and Barguna) could be different sub-populations when compared to the one found in the marine habitat (Cox's Bazar), or could be discrete sub-populations separated from one another by environmental and behavioral barriers that allow little or no gene flow between them.

It is clear that the anadromous stock varies genetically from the marine one, ultimately providing evidence of separate gene pools in Bangladesh waters. Thus there are no random spawning populations of hilsa shad in Bangladesh waters. The same study also demonstrated that the *jatka* are the juveniles of the anadromous stock of hilsa shad.

In addition, stock discrimination studies on hilsa were jointly carried out by Bangladesh, Indonesia, and Australia. The studies revealed that: (1) hilsa samples from Bangladesh rivers were not genetically distinct; (2) Kuwait and Indonesian samples were genetically distinct from each other; and (3) Kuwait and Indonesian samples were genetically distinct from Bangladesh samples.

Meghna River Population

Population characteristics, growth and mortality have been studied in the Meghna River basin by the Riverine Station, Chandpur of the Bangladesh Fisheries Research Institute since 1987. Hilsa growth rates suggest that it takes nine years for them to attain a maximum length of about 57 centimeters. We found that larvae were 1.03 millimeters long at birth, and the smallest size at first capture was 3.65 centimeters. From these quantities, we estimated the minimum age at which fish enter the fishery to be six months.

The hilsa population in the Meghna River basin is affected more by fishing mortality than natural mortality, indicating a trend towards over-exploitation. The natural mortality rate was estimated at 0.89 per year, compared to a fishing mortality rate estimate of 1.14 per year. This means that only 13 percent of the recruited hilsa survive in the Meghna River basin. (In the absence of fishing, we estimate that this could be increased to 41 percent.) Further deterioration of the hilsa population due to over-fishing of adults and increased harvest of juveniles will further diminish the hilsa shad fishery unless measures are taken immediately.

Hooghly-Matlah Population

Fishing mortality in the Hooghly-Matlah estuary (0.58 per year) was about equal to natural mortality per year, giving a total mortality rate of about 1.15 per year. This means that each year, only 32 percent of the fish survive. In the Hoogly-Matlah estuary hilsa stock may not be truly anadromous. Prior to its upstream spawning migration it normally resides in the inshore lower estuarine areas—not the ocean.

Farakka Barrage

A lucrative fishery for *T. ilisha* existed in the middle stretches of the River Ganga before the mid-1970s (pre-Farakka period), but it collapsed soon after the construction of the Farakka Barrage, indicating that the fish caught in the rivers belonged to the migratory stock of the Padma and Hoogly rivers.

Tagging experiments conducted by the Central Inland Capture Fisheries Research Institute (CICFRI), Barrackpore, India, revealed that the hilsa shad migrate across the Farakka Barrage. Moreover, some fish, tagged above the barrage and recaptured below the barrage, had completely shed their gonadal products, indicating that they spawned above the barrage.

Of particular concern is the over-exploitation of juvenile hilsa shad ("jatka").

The distribution of hilsa eggs in the estuary is greater than it was before barrage. This increase is largely due to the increased flow of fresh water into the estuary following construction. Water from the River Ganga (India) is prevented from flowing into the Padma River (Bangladesh) at the Farakka Barrage and diverted to the Hooghly River system. 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 is now almost fresh water and therefore better for spawning.

The fresh water stretch of the estuary also acts as a nursery ground for the young hilsa. Before Farakka Barrage, hilsa were ascended only Hooghly estuaries. Now adult hilsa ascend the Thakuran and Matlah estuaries as well. Hilsa fry between four and nine centimeters long are also recorded in most of the West Bengal estuaries.

AVERAGE HILSA LANDINGS (in metric tons) from the Hoogly-Matlah estuary during the pre- and post-Farakka periods.

Period	*Landings (in metric tons)*
Pre-Farakka (1966-1975)	1,457.1
Post-Farakka (1975-1978)	2,126.2
Recent (1984-1994)	2,135.4

Landing statistics for hilsa shad show a large increase after the construction of Farakka Barrage. Unfortunately, Farakka Barrage has caused the decline of the hilsa stock in the Padma River (Bangladesh) which was once more famous than that in the River Ganga.

Habitat Degradation

Dams and barrages constructed across the rivers to supply irrigation water, flood protection and hydropower not only prevent migration, change migration routes, and alter spawning and nursery grounds, but also concentrate the shad population in certain areas, thereby subjecting them to over-fishing. The development of Meghna Estuary by the Government of Bangladesh with Dutch assistance for land reclamation and other flood protection in the south will eventually affect the major spawning grounds of hilsa shad around Bhola, Monpura, Moulavir char and Sandwip unless due regard is given to protect hilsa habitat.

Management

The main way in which the hilsa shad fishery in Bangladesh can be improved is through (1) regulating exploitation of both the monsoon spawning run (the anadromous stock) and the *jatka* fishery, (2) ensuring sufficient water discharge from the Ganga and the Brahmaputra-Jamuna system, and (3) improving habitat.

A conflict exists between one group of people who want to totally ban *jatka* fishing, and others who want to exploit the juveniles at a rate closer to the natural level of mortality.

Because the fish are so fecund, allowing them to spawn would help replenish

ANISUR RAHMAN

A BASKET OF HILSA CATCH at one of Bangladesh's landing centers.

ANISUR RAHMAN

A TYPICAL SCENE OF HILSA SHAD TRADING by artisanal fishermen in landing centers of Bangladesh.

stocks and eventually improve the yield per recruit. If 10-20 percent of these *jatka* were protected, an additional 100,000 metric tons of adult hilsa shad could be harvested each year.

This could be done by declaring: (1) that the major spawning grounds of the largest stock in the peak spawning period during the new and full moons of September-October are closed for 30 days, (2) that the major nursery grounds of *jatka* in the peak period of abundance (February-March) are closed for 30 days for fishing using small meshed monofilament nets (less than nine centimeters) and (3) that an alternative source of fishery-based employment is provided for the hilsa shad fishermen.

Other minor spawning and nursery grounds may be kept open for fishing during the period of the ban. The government is well aware of the situation and has already modified the Fish Act of 1951 by banning *jatka* exploitation, imposing a net mesh regulation and banning exploitation of gravid hilsa for seven days in one full moon during September, in and around the Bhola, Charfashion, and Monpura areas (the major spawning grounds).

The making of a law is one thing but its execution is quite different, especially in a country with a high population density, illiteracy, unemployment, hunger and other intricate social, economic, and political problems.

To make a ban successful, fishermen must be taught to recognize: (1) the differences between the *jatka* and the juveniles of common river shad (*Gadusia chapra)*, and (2) the benefits of the jatka ban. They must also be assured of an alternative job so that they do not go unfed!

This seems difficult, especially because various species are harvested with many different types of gear. Maintaining a closure in areas adjacent to open fisheries or banning hilsa fishing while leaving fishing open for other species is fraught with difficulties.

Conclusions

To sustain the harvest of this species we are left with little choice but to regulate the exploitation of both adults and juveniles. We must also regulate flow. This is a particularly important and sensitive issue for the Ganga-Padma and the Brahmmaputra-Jamuna river systems which flow through more than one country.

Acknowledgment and disclaimer. The author acknowledges the use of information from the references as mentioned under Further Reading. Views expressed in this article are exclusively the author's personal opinion; they do not reflect those of the Bangladesh Fisheries Research Institute.

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Shad Bites

Native American Fishing Camps Unearthed

Archaelogists believe they have discovered three prehistoric fishing camps, built 2,000 years ago on Wakefield Plan tation land in northern Wake County in North Carolina, USA. The discoveries, made while surveying wetlands are located at sites where schools and a championship golf course will be built.

Dr. Joel Gunn, a senior archeologist with TRC Garrow Associates, Inc. of Chapel Hill believes that the sites are indeed fishing stations, and that some date back as far as 500 B.C. Some of the artifacts discovered are much older, 10,000 or 11,000 years old. According to Gun, native Americans probably traveled to the fishing stations a few weeks out of the year to get their fill of shad and bass as they moved up the Neuse River in late February and early March. "This would have been a very happy, pleasant time of year," Gunn said, comparing it to a state fair. These findings are similar to fishing sites unearthed in Virginia and South Carolina.

One of the sites, at Wakefield Plantation, turned up a a kettle stand, a rock hearth and stone flakes that once comprised a well-equipped fish kitchen.

At Wakefield, archaeologists say, Native Americans developed the fish kitchen, a fish processing site and a base camp—all signs that this area was important. Carbon-dating soil samples will take about a month and testing for amino acids—to look for fish oils—is being done by a scientist in Hungary and may take longer.

U.S. Orders Dam Removal in Maine; Could Impact Other Dams.

To restore fish runs and return a river to its natural state, the U.S. government for the first time has ordered destruction of a hydroelectric dam against the wishes of its owner. The U.S. Energy Regulatory Commission last November ruled that environmental concerns along the Kennebec River in Maine outweigh the industrial benefits of the electricity-generating, 160-year-old Edwards Dam in Augusta, the state capital. Among reasons cited were the spawning needs of American shad, Atlantic salmon, and endangered shortnose sturgeon.

The decision marks a reversal in federal policy. Now, when the debate is raging over the environmental impact of damming rivers to generate electricity, the decision could have a major impact on similar bids to remove environmentally destructive dams.

In the Northwest's Columbia River Basin, fish recovery agencies and the U.S. Army Corps of Engineers are examining proposals to remove or alter dams on the lower Snake River in an effort to help dwindling salmon stocks. And one of two dams on the Elwha River on Washington state's Olympic Peninsula, built without fish ladders, is slated to be demolished.

While more than 20 nonhydroelectric dams, mostly in Wisconsin and Michigan, have been destroyed in recent years or are scheduled for destruction, each was destroyed by agreement with its owner. But none has been as large as the Edwards Dam, which is 40 feet high and spans 1,000 feet across one of Maine's longest rivers, the Kennebec.

The Kennebec originates in Maine's dark central forests and empties into the Atlantic Ocean. The dam blocks spawning fish, including American shad, making 15 miles of river inaccessible. The Edwards Dam was built in 1837, under a charter granted by the state legislature, to turn machinery in a cotton mill. A century later, electric generators were installed. In the 1980s, the mill was shut down and the factory burned.

In 1723, a French priest described fish migrating upriver in such numbers that a person could fill 50,000 barrels in a day, if he could endure the labor. Records from the late 1700s and early 1800s described a single fisherman catching 500 salmon in a season, four men landing 6,400 American shad (*Alosa sapidissima*) on a single day, and 1,000 pounds of striped bass being caught in one weir during a single tide. Salmon were plentiful and people tired of eating them. Hundreds of thousands of pounds of alewives (*Alosa pseudoharengus*) were shipped from the state as far away as the West Indies.

Following construction of the Edwards Dam in 1837, fish populations plummeted. By the late 1850s, individual fishermen were catching a single salmon in a season; alewives disappeared almost entirely; and American shad, striped bass and sturgeon were decimated.

Submissions

Contributions should be double-spaced. Submissions via e-mail or on disk are encouraged. Direct your contributions to Editor-In-Chief, The Shad Journal, P.O. Box 21748, Seattle, WA 98111-3748 or to the e-mail address: hinrich@accessone.com.

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