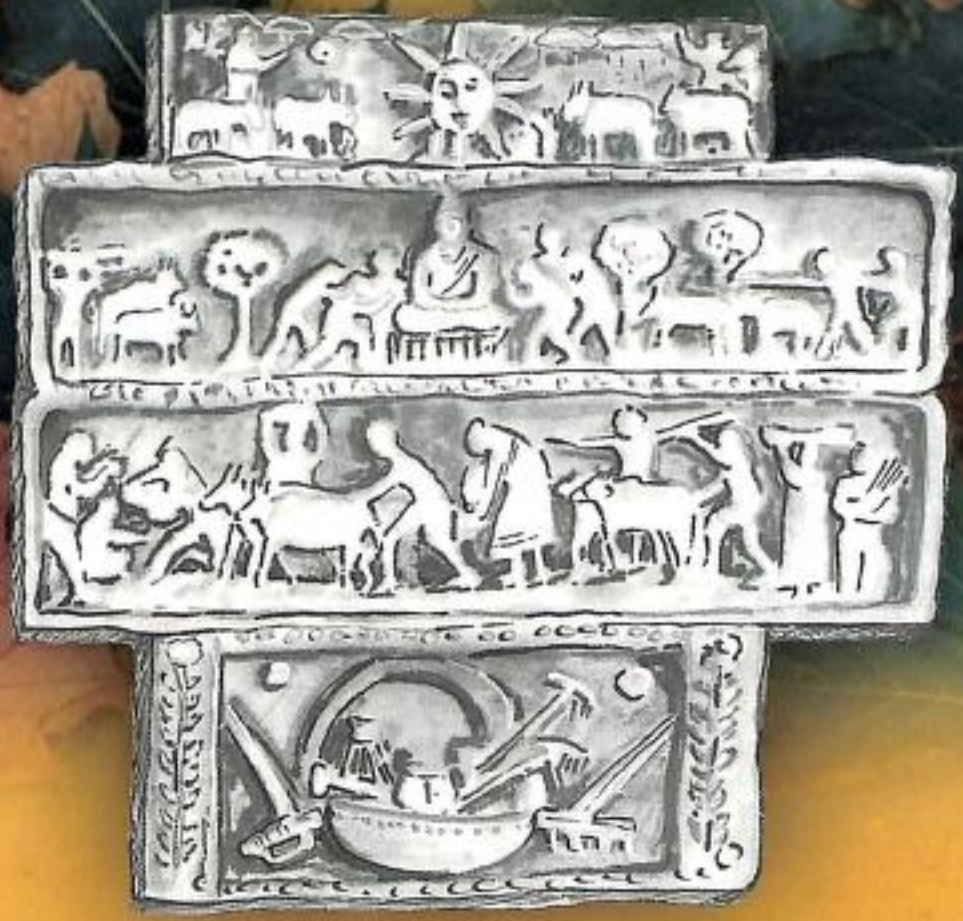
Glimpses of the Agricultural Heritage of India



Editor

Y L Nene

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Fisheries Heritage in India*

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Summary

Fishes are mentioned in the ancient literature of India, the epics Ramayana *and* Mahabharata, *and excavations from Harappa and Mohenjo-daro indicate that fishing with hooks and nets was common as long ago as 3000 BC. During the reign of Emperor Asoka (273–232 BC), fish conservation was ensured through strictly enforced laws. This paper places fishing in historical perspective, tracing its evolution from the capture of individual fish to its present status as a large-scale commercial enterprise.*

Introduction

The aquatic medium, which constitutes more than 70% of the globe, is also of vital importance to its terrestrial inhabitants. With its vibrant variety and complexity, diversity of flora and fauna, and productive potential, this medium is the most wonderful life-supporting system. Yet it also constantly faces threats to its exploitable habitats and resources from physical/climatological as well as anthropogenic causes. Of the wide spectrum of biodiversity that the medium holds, fish, including finfish and shellfish, account for the major taxa of economic importance. Finfish are vertebrates, exclusively adapted for an aquatic life, with their extremities modified into fins; shellfish are invertebrates. Finfishes are a heterogeneous assemblage and exhibit enormous diversity in their morphology, habitat preference, and adaptability, as well as their biology and behavior.

In Hindu mythology, the fish is believed to be the first incarnation of Lord Vishnu—*Matsya,* who is the saviour of the Veda in the Vedic version of the "flood." The epics, *Ramayana* and *Mahabharata,* contain descriptions of fish (Hora, 1952). Satyavati, the mother of Veda-Vyasa, the compiler of the *Mahabharata*, "was condemned to live on earth in the form of a fish" and hence also called *Matsyadari*, "fish-born" (Dowson, 1957). There are several names of food fishes mentioned in the *Ramayana: cakrathunda,* fish with a disc on its head (=*Garra mullya* (Sykes); *nalamina,* fish with a reed-like body (= *Masatacembelus armatus* (Lacepede)); *rohita,* fish with a reddish color (*Labeo fimbriatus* (Valenciennes)); *sakula,* snake-headed fish (*Channa striatus* Bloch); and *pathina*, (*Wallago attu* (Bloch)). In the *Jataka* tales there is a mention of several fishes, such as, catla (*Catla catla* (Hamilton)); rohu (*Labeo rohita* (Hamilton)); whale shark (*Rhineodon typus*); freshwater shark (*Wallago attu* (Bloch)); saw fish (*Pristis cuspidatus*); and *saphari* (*Puntius sophore* Hamilton) (Hora, 1955).

In discussing the *Ramayana,* Hora points out that the heroes of the epic receive advice on cooking fish. Lakshmana is advised to have the scales

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cleared and the fish roasted in an iron pan over the fire (iii. 73. 15). In the *Aranyakanda* (76. 24), Rama and Lakshmana are advised to cook rice and fish with salt and red pepper on reaching an *asrama* on the west bank of Pampa Lake (Hora, 1952). Thus fish have been invested with religious significance, and believers consider fish a valuable and necessary part of their heritage and life.

The importance of fish in the Vedic period was also seen as image/symbol in certain art forms (e.g., Madhubani painting; Vequaud, 1977) and as a symbolic and/or decorative element in royal courts, palaces, etc. As such, the fish was depicted in the emblem of many kingdoms and formed part of the emblem of several states and of political, cultural, and religious organizations.

Fisheries in ancient times

From the earliest times, man appears to have adopted the practice of fishing. About 150,000 years ago, Neanderthal men used to spear fish for a substantial diet (Dembeck, 1966). The spear is believed to be the first tool used by man. As technologies developed, tools took different shapes and sizes. Subsequently, man learnt to use barriers in shallow creeks or at the mouths of tidal inlets to impound fish. In the Palaeolithic era, ancient man used the gorge—a short, straight or curved piece of wood, bone, or other material sharpened at both ends. The gorge was probably baited and attached to the end of a fiber line and can be treated as a primitive form of the hook The Mesolithic people (5000–3000 BC) made useful equipment, particularly for fishing and fowling. In addition to nets and fish traps, they made use of fishhooks of bone, harpoons, complex fish spears, and arrows with various types of bone and flint heads. The first boat appeared in Mesolithic times, together with hook, net, and funnel-shaped trap (Clark, 1952). Towards the end of the Mesolithic period, there is evidence of the beginning of sea fishing from boats.

From the Neolithic period (3000–2000 BC) to the Iron Age, improved fishing gear, such as barbed hooks, metal spears, and net sinkers, increased the efficiency of fishing. Line fishing was also used at this time. Artifacts collected by archaeologists from different sites indicate that hooks, lines, sinkers, floats, nets, and traps were all in use during Neolithic times. Use of hook and line, net, harpoon, and trap is also reported in early Mayan and Chinese fisheries. Spun-silk fish lines were used in China as early as 1500 BC. It appears that use of nets, harpoons, etc., was widespread among ancient people throughout the world.

In India, excavations made by archaeologists and palaeontologists in different parts of the country reveal that angling was a common method of fish-catching in ancient India. Sarkar (1953) gives an account of various types of hooks excavated from the Indus valley. Excavations from Harappa and Mohenjo-daro reveal that fishing was done using nets and fishing hooks. Hooks made of animal bone or iron were excavated from most of the sites. Motifs excavated show different paintings or impressions of fish or fishing activity. In the *Jataka* sculptures (200 BC), the fish is one of the main animals depicted. In excavations at Ganeswar in Sikar district of Rajasthan, 50 fishhooks as old as 2800–2700 BC are reported. Excavations at Navadato in Karnataka report copper fishhooks that date back to 2020–1600 BC (Allchin and Allchin, 1982). From some of the excavations at Etta, Uttar Pradesh, paleontologists recovered pottery shards with impressions of fishing net that date back to 1200–600 BC. From this, it is believed that fishing in India using hooks and nets might have started as early as 3000 BC. Thus there is evidence that fishing has been important throughout human history in providing humans with part of their food supply in a wide variety of situations.

As Hora (1954) has observed, "Prehistoric man in several parts of the world had gathered sufficient knowledge about fish through observation and made use of it in catching fish for food by the use of hook and line." People of the Indus Valley civilization were great seafarers and perhaps established their colonies overseas in the Middle Eastern Gulf countries. Studying fish painted on pottery of the Harappan period, Horá (1954) concluded that these were marine fish. Perhaps

baskets or traps were in use for catching fish, as a fisherman carrying two such baskets is painted on a potsherd. These records indicate that Harappans were familiar with marine fishing. The distribution of shell bangles and other shell artifacts in every Harappan site is also indicative of a well-organized marine fishing activity. There are several fishhooks from Mohenjo-daro, Harappa, Chanhu-daro, Lothal, Padari, and other sites located on the coastal belt of Gujarat. Sarkar (1953) suggested great similarity between fishhooks of the Indus Valley sites and modern ones, indicating the continuity of cultural traits. The Sanskrit word, *badisha,* has been used for fishhook in ancient Indian literature, including the *Mahabharata*. A 12th century AD Indian text, *Manasollasa,* written by the Chalukya king, Someswara, mentions a chapter entitled *Matsyavinod* (pastime of fishing), and how a king can derive pleasure out of angling.

Fishhooks were found among the earliest prehistoric artifacts (Allchin and Allchin, 1982; Sarkar, 1954) and in the artifacts of the Harappan civilization of the Indus Valley (Piggott, 1950; Bagchi, 1955). Two types of fishhooks, barbed and barbless, were found from Mohanjo-daro (Marshall, 1931) and one type of hook from Harappa (Sarkar, 1953). Eariy literary texts provide us a view of a range of fishing activity by the late second or eariy first millennium. Thus the Rig Veda refers to the method of catching fish by net and to the people who catch fish (Das, 1931). If angling and the use of spears and shooting with an arrow, which are found in the *Ramayana* (Hora, 1952), are added, that accounts for most of the methods in use through historic time, certainly in inland fisheries.

The *Arthasastra* contains a great deal of evidence that fisheries were carried on: aquaculture in reservoirs was practiced; fishery produce and fishermen themselves were taxed; and the use of fish as manure in agriculture was recognized (Hora, 1948a). The Asoka epigraphical material (246 BC), from a period shortly after the earliest form of the *Arthasastra,* confirms these indications. Buddhist texts, such as the *Jataka* tales, provide further support to the picture of widespread fisheries. In one place they speak, for instance, of fishing villages of a thousand families in Kosala (Hora and Saraswati, 1955).

Fishing technology

Fishing was probably one of the earliest forms of catching or gathering, as distinct from cultivation, the latter having originated much later. In this respect, fishing is perhaps one of the oldest industries in the world. According to one theory, fishing is older in origin than hunting of terrestrial animals, because only simple tools were needed for fishing, while much better implements were required for hunting. As a staple food item, fish must have found favor with man at a very early stage of his history. To begin with, hand picking was used to collect and capture fish and other aquatic animals along the shores of lakes, rivers, and seas. Gathering by hand is the simplest form of fishing practiced since ancient times by roaming nomads and is practiced even today in many parts of the world, such as in the modern northwestern European countries, where fishing by foot is also practiced.

As the human family units expanded into tribal units, planned fishing operations must have been developed. Among the various tools devised by man, the spear appears to be the earliest weapon to be employed and is still used in certain parts of the world. This was followed by some kind of primitive and stationary traps made up of twigs in the form of baskets, suitably baited and designed to entrap roving fish. From such structures, more efficient structures were made of stones or rubble of semicircular shape on the seashore or estuary for trapping fish entering into them during high tide. This, in turn, led to the development of more elaborate structures composed of frameworks of rods with flexible branches or reeds interlaced. In course of time, fixed nets or stake nets could have originated from such structures.

Although evolution of fishing gear had proceeded step by step from capture of individual fish to catching them in bulk, fishing methods also evolved

from the early hunting techniques to the use of ingenious and sometimes large and complicated gear for harvesting them. Recorded history reveals that it was perhaps the Romans who first employed large nets called *sagena*, which are now called "seine" nets. Since shoaling fishes may not be available close to the coast, man must have devised methods for his transport from the coast to the shallow coastal waters, probably with the aid of floating wooden pieces or logs fastened together. In the beginning, perhaps long poles such as of bamboo or other wood might have been used for propelling the log systems, followed by the innovation of wooden oars and subsequent discovery of sails to utilize wind power for propulsion. Development of rudders to change the direction of movement of the log systems as well as the development of dugout canoes and plank-built boats must have followed thereafter. The discovery of steam energy for propulsion and navigation, iron and steel for construction of vessels and use of oil engines and motors are part of the recent history of the development of fishing craft, and may be considered as the ultimate stages in the efforts to fish far and wide.

For most kinds of fishing, the fishing net is essential; however, net making, although some thousands of years old, is a relatively late invention in the history of fishing. The various stages of net making, such as inventing net-making materials, plaiting, weaving, and knitting must have taken hundreds or even thousands of years before net making itself. In the earlier stages, the nets developed were hand-made and would have been small, when man had to spend considerable time and energy for procuring the raw material, spinning, and twisting before making the net. From such small nets, it is only through machinery invented in the past 140 years that large sheets of nets as required in large-scale fisheries of today have been developed. Initially, hemp and cotton were the main raw materials for net making. However, the advent of synthetic fibres such as nylon, ultstron, polythene, netlon, etc., in the 1960s further added to the efficiency and durability of fishing nets and played a decisive role in the efficiency of marine fishing.

It is reported that bottom trawling could have started at the beginning of the 17th century and grown into the status of an industry during the past 150 years. The precursor to the modern bottom trawl was the simple shore-seine net still being used by fisherman to surround fish shoals and drag them ashore. This net is a large bag; with the mouth kept wide open, it is pulled over the seabed towards the shore by two boats, one on each side, and the catch is emptied on the shore. This was followed by using a long wooden beam to hold the mouth open so that the net could be operated by a single boat and be hauled up at sea itself, without the need to reach the coast, similar to the beam trawlers. The next stage is the use of the larger and much more efficient modern otter trawls in steam trawlers (Bensam, 1999).

Fish as food

Starting with the history of fishing activity in Neolithic times, fish as food played an important role in ancient India. Fishhook findings in Bihar and West Bengal suggest that Chacolithic people of this region lived on rice and fish (Acharya, 1994). Fish was one of the important items of bartered foods and was also exported outside the country in ancient times. Hora and Thapar both hold the view that widespread fisheries are an indication that fish was widely used as food. Hora draws evidence from the *Arthasastra* that "fish was relished as an article of diet" (Hora, 1948b) and Thapar talks of fish as "an important item of diet in Mauryan times" (Thapar, 1961). On the evidence of the *Jataka* tales, Hora and Saraswati claim that fish eating was widely prevalent and highly esteemed in the days of *Jataka* tales (Hora and Saraswati, 1955). In discussing the *Ramayana* also, Hora points to the fact that the heroes of the epic receive advice of cooking fish on the shores of Lake Pampa. Lakshmana is advised to have the scales cleared and the fishes roasted in an iron pan over the fire. In the *Aranyakanda* Rama and Lakshmana are advised to cook rice and fish with salt and red pepper on reaching an *asrama* on the west bank of the Pampa Lake (Hora, 1952). In the *Gautama Dharmasutra,* the *Vasistha Dharmasutra* and the *Yajnavalkya Smriti,* fish is among the items, mainly of food, which should not be refused if offered

voluntarily (Hora, 1953) and the *Gautama Dharmasutra,* the *Apastamba Dharmasutra,* the *Manu Smriti* and the *Yajnavalkya Smriti* all make recommendations about fish in the *sraddha* (i.e., ceremonies where food is offered to the manes and is actually consumed by Brahmana priests) (Hora, 1953). But Hora also points out that the texts can contain quite contrary injunctions: the *Yajnavalkya Smriti* orders 3 days' fasting for eating fish in one place but in another lists the fish "fit for eating even by the *Brahmanas,*" namely, the *simhatundaka* (*Bagarius bagarius* (Hamilton)), the *rohita* (*Labeo rohita* (Hamilton)), the *pathina* (*Wallago attu* (Bloch)), and the *rajiva* (*Mugil corsula* (Hamilton)) (Reeves, 2003; Hora, 1953). During the period 600 BC to 200 AD, fish was generally considered a valuable article of food among Hindus, though certain species or kinds of fish, for one reason or another, were forbidden to be eaten. Among those regarded suitable for eating, there was a regular gradation in quality or value. The *Smritis* contain contradictory statements about the use of fish as food, which shows the working of the social, religious, and political influences by which taking of any kind of animal flesh became a taboo afterwards (Hora 1953).

In Bengal, fish was the most important part of the diet for people at all levels of the population (Das, 1931, 1932), that the same was also true of many parts of south India, at least among certain groups (Moses, 1922-23). "Bengalees," Das argued, "utilise this food material to a greater extent than the inhabitants of any other part of India." Reports from just after World War I showed, he suggested, that probably more than 80% of the population were fish-eaters (Das, 1931). As elsewhere in India, he pointed out, fish was certainly food for lower social groups, including tribal people, but in Bengal (and the "*Mahratta* tract") the higher social groups also ate fish, contrary to the strong taboo which was placed on fish-eating by the highest castes, especially Brahmins, in the central Ganga-Yamuna valley.

Fish conservation

In ancient India, fish conservation was ensured by very strict laws, as seen in Asoka's Pillar Edict, found in no less than six places throughout the empire, which discusses the fish that are to be fully protected during the breeding season and also seeks to provide other measures to limit the exploitation of fish and their careless slaughter (Hora, 1950; Thapar, 1961). Such concerns reflect, primarily perhaps, Asoka's preoccupation with nonviolence in the propagation of his Buddhist *dhamma,* but they do not suggest any lack of interest in fisheries or their products. Indeed, Romila Thapar (1961) has commented that this edict most probably reflected the difficulty that the emperor experienced in banning the catching of fish because of the importance of fish during the Mauryan times.

The law prescribed that

1. No fish should be caught on the 14th and 15th day of the moon and the 1st day after the full moon during the period of the third *chaturmasya (Sravana,* July-August; *Bhadra,* August-September; *Asvina,* September-October; and *Kartika,* October-November) = 12 days.
2. No fish should be caught on the 14th and 15th day of the moon and the 1st day after the full moon of the month of *Pausha* (December-January) = 3 days.
3. No fish should be caught on the fast days, *Amavasya,* or the day before the new moon and the *Ashtami,* or the 8th day during every fortnightly period of the moon = 12 +24 = 36 days:
4. No tank fish (animals in the preserves of fishermen) should be taken during the above noted days.

Thus fishing was prohibited for a total of 51 days in a year, unless there were other fast days.

Asoka's injunctions regarding the catching of fish are based on true scientific principles. The first injunction is not to catch fish during the 14th, 15th and full moon days falling during the period commencing from the middle of July to the middle of November. The peak breeding period of India's principal food fishes is July, August, and September, but Asoka's prohibition period extends up to the

middle of November. This extended period is also scientifically logical, because after breeding in shallow areas or upriver, the spent fish fall back to their normal habitats in deeper waters, or with *hilsa* fish, to the estuaries and the sea. The young also move down to safer habitats after the rains are over and the flooded areas begin to contract. The young and the weak spent fishes need protection and it is indeed remarkable that even this was thought of in that ancient age. It is perhaps significant to note here that in Bengal, Hindus generally do not eat hilsa from after the Durga Pooja (sometime in October) until Saraswati Pooja (towards the end of January).

There is another great virtue in this law, in that prohibition is restricted only to certain specified days and not to the entire season. The fecundity of carp and hilsa is well known, for a pair of spawners, under favorable conditions, can produce millions of young. Hence nearly 6 days of restriction during each spawning month is ample for conservation of the fisheries, and does not interfere with the trade or the occupation of fishermen to any great extent.

The significance of the second law, whereby catching of fish is prohibited on the 14th and 15th day of the moon and the 1st day after the full moon, besides the fast days of the month of *Pausha* (December-January), may be meant to protect the fish during the height of the cold season, when the fish—particularly in the northern parts of the Gangetic Plain—are benumbed, losing much of their vitality, and can sometimes be caught by hand.

As regards prohibition on all fast days, there are several virtues in this injunction. First, the trade will not be affected to any considerable extent and fishermen themselves will be able to observe fasts. Secondly, besides the principal food fishes, there are other varieties, which do not breed during the rainy season but do so at other times of the year. Thirdly, by spreading prohibition in driblets over the whole of the year, greater respect for law is assured, as no hardship would be felt by the public. It may be worthwhile to record here that the principal food fishes of the Gangetic estuaries, such as mullets, prawns, bhetki, etc., breed in March and April and the salt-water *bheries* (traditional shrimp farms in West Bengal) take in water containing the eggs and young ones of these species during the spring tides of the new moon and full moon periods for stocking purposes.

The fourth law, by which tank fishing is prohibited, is perhaps the most ingenious of all, for it has nothing to do with the spawning of fishes. As the tank fishes are the same as those found in rivers, it would have been difficult to control their sale and at the same time prohibit the catching of fish in the rivers. It was indeed very wise, therefore, to prohibit the catching of all fish for the control of marketing (Hora, 1950).

There is some indication that Asoka's Pillar Edict V records an advancement of knowledge over what Kautilya had recommended in his *Arthasastra* about 25 to 50 years earlier. He had recommended that the King should prohibit the slaughter of animals for half a month during the periods of *chaturmasya* (from July to September), for four nights on the full moon days, and for a night to mark the date of his birth, or celebrate the anniversary of his conquest. It will be obvious from what has been stated regarding the scientific basis of Asoka's laws that they are more perfect, humane, just, and easy to comply with.

Present-day fishery legislation in India

Present-day fishery legislation in India usually adopts the following conservation methods:

1. Restriction of mesh of nets and other approved methods of capture.
2. Prohibition of wholesale destruction by poisoning or dynamiting, etc.
3. Prohibition of capture of brood fish and young ones.
4. Closure of sections of rivers to serve as sanctuaries throughout the year.
5. Closure of fishing season (marine) during breeding period (July-August) = 2 months.

In reserved and protected forests, rules made under the appropriate sections of the Forest Act prohibit poisoning of any river or other water; killing fish by explosives; damming or bailing water; and use of any fixed engine, such as net, cage, trap, or other contrivance to catch fish. . For other areas, the Indian Fisheries Act IV of 1897 forbids and penalizes the use of explosives or poison to kill fish in any waters, including the sea within one marine league of the coast. It further gives power to Government to make rules for regulating the construction and use of fixed engines and weirs, in waters that are not private waters, and the dimensions of nets, together with modes of using them. Fishing in any specified waters may also be prohibited for a period not exceeding 2 years.

The Private Fisheries Protection Act (Bengal Act II of 1899) penalizes catching or destruction of fish without permission of the person who owns the right of fishing, by "fixed engine" or "any matter." This act, it seems, is designed more to prevent theft of fish from private fisheries than for the conservation of fish therein. There is no provision against selling or buying or offering fish for sale, and this practically nullifies all protective measures.

History of aquaculture

Wild hunting for fish is as old as human civilization; beginning as an avocation for subsistence, this later transformed gradually into a market-oriented industry and thus created many employment opportunities. From Neolithic times, the "fisherman" was generally a farmer, fishing being a seasonal occupation that led to seasonal settlements. Technological advancement made farming possible apart from fishing. The classic treatise on fish culture, believed to have been written around 500 BC by Fan Lei, a Chinese politician-turned-fish culturist, is considered proof that commercial fish culture existed in China even during that time. Kautilya's *Arthasastra,* written between 321 and 300 BC, talks about fish culture in reservoirs (Hora and Pillay, 1962). While the Chinese immigrants were mainly responsible for development of fish farming in Southeast Asia, an indigenous system of Indian carp culture seems to have existed in eastern parts of the Indian subcontinent in the 11th century AD (Pillay, 1990). The earliest brackish-water farming in Southeast Asia appears to have originated in Indonesia, in the islands of Java during 1500 AD. Culture of fish in cage and pen originated in Cambodia. Propagation of trout originated in France, and the monk, Don Pinchot (1400 AD) is credited with discovering a method of artificial impregnation of trout eggs. The British introduced trout into India around 1900 AD, mainly to develop sport fisheries. In India, fish farming started as early as 1900 AD by using the fry collected from rivers, but a breakthrough came only after successful induced breeding in the1950s.

Indigenous technical knowledge

Trickery seems to have been one of the earliest manifestations of the dawn of intelligence in primitive man. From direct, face-to-face attack of prey, which was laborious as well as risky, the caveman began to develop methods of sly approach and sudden grabbing, which in turn become more productive methods of capture by trickery and trapping. The cleverer of our ancestors thus conceived many simple but effective methods. Trapping was probably the earliest device that man ever resorted to for catching fish, long before nets and highly evolved tackle werer thought of. Trapping with different types of devices is still in practice in different parts of the country and it is one of the best methods of fishing, where overexploitation can be avoided and thus fish can be conserved (Job and Pantulu, 1953).

The treasure of indigenous traditional knowledge in the fisheries sector of India assumes significance in view of the threat of possible illegal erosion of the wealth of our ancient knowledge. There are many traps made of bamboo splits being used in India. In Kerala, a method of fish trapping called *Vellavali* (pulling white lines), is used especially for "pearlspots" (*Etroplus suratensis).* The fishermen hold a long rope tied with tender coconut leaf and encircle an area where "pearlspots" are present. By seeing the white color the fish get scared and hide their heads in the silt. Fishermen simply handpick

these. With this type of fishing only the bigger fish are caught and younger ones get a chance to grow big. Another method is the *Bushtrap*. Fishermen aggregate twigs and bushes in a place and allow the fish to make this their hideout and feeding ground. Periodically, this place is encircled with a net and the fish are caught. Several versions of this trap are being used in Kerala today.

In the olden days, craft and gear making and maintenance made use of different local woods, e.g., *punna, paini, cheeni*, mango, etc., with different qualities for craft making. The huge single piece of wood was carved out at the center," under the supervision of expert local craftsmen, to make the *ottathadimaram*. These are lightweight and long-lasting. The outrigger canoe of the Karwar area was a modification with two extensions on one side. For maintenance of different types of craft, different materials, such as locally extracted sardine oil, cashew kemel oil, oil with lime paste, etc., were used, which protected the wood better and were ecofriendly, as well. Gears were made of cotton and jute threads mended by women. *Chemmeen* (prawn) *valai, mathy* (sardine), *valai, ayila* (mackerel) *valai* with a mesh size of 18 mm. For maintenance, these nets were boiled in cowdung slurry and dried in the hot sun. This was done once a month. Another method was to boil along with dried seeds of tamarind, which gave strength as well as a colour to the threads. The life of the gear was up to 10 years. The sap of the *Muncha* plant was applied to the threads; these were then washed in fresh water and the sap applied again, then dried and washed in clean water. In Karnataka, the sap of the *Banpu* plant was used for this. Threads made from *Thalambu* plants were used for making nets, which is a very interesting piece of information, considering its ecofriendly nature.

An indigenous adaptation of flippers for drivers uses aluminum flippers and rubber straps. Kalangatti valai, Thallumadi, etc., were indigenous means used for harvesting in Thoothukudy. Marine *pappad* made of processed stomach and intestine of ray fishes and *Beche-de-mer* made of sea cucumber were considered as special items there and believed to have medicinal properties.

Shoal identification was done by observing the water movement and coloration. *Thondagorakka aruppu* the sound of croaker like fish indicated that the water was clear, with no scope for fish catch. Sardine shoals were characterized by the presence of small bubbles and oily appearance on top of the water. For catching the fish, the strength of men and natural forces like wind were depended upon. Mats made of thin but closely meshed cloth or palmira leaf mats, etc., were tied, and movement made considering the wind force and direction, surely reducing fuel expenses. Spears, chattuli, and hook and line were common implements for harvesting. To predict natural hazards correctly, different methods were adopted, watching the wind direction, color of clouds, temperature of water, etc. These were very correct and were followed by most of the experienced fishers.

Fisheries in modern India

The dawn of the 20th century saw the conduct of a number of detailed studies on the fisheries of British India, notably by Sir F.A. Nicholson, Dr. James Hornell, and Rao Bahadur V. Govindan (Madras Presidency), Sir K.G. Gupta (Bengal Presidency), and Dr. A.T. Sorky and Mr. W.H. Lucas (Bombay Presidency). These reports and studies resulted either in the constitution of separate Departments of Fisheries in several provinces or the provision of some assistance to the fish-curing industry. Despite all this, the Royal Commission on Agriculture (1928) noted the failure of the Government in developing fisheries as a source of food and revenue for the territory and reaching the full potential for growth. In 1941, a report entitled *Preliminary Guide to Indian Fish, Fisheries, Methods of Fishing and Curing* was published by the Directorate of Marketing and Inspection, giving a broad outline of the fishing industry in India. In 1943, Baini Prasad, the then Director of the Zoological Survey of India, submitted a "Memorandum on the Post-war Development of Indian Fisheries" to the Policy Committee on Agriculture, Forestry and Fisheries, giving valuable recommendations for the development of the Indian

fishing industry. His chief suggestion was the establishment of a central institute for promotion of fisheries research in India.

Thus, in 1947, two major research institutions, one in Mandapam, later shifted to Cochin (the Central Marine Fisheries Research Station, later designated Central Marine Fisheries Research Institute, or CMFRI); the other (later renamed Central Inland Fisheries Research Institute, or CIFRI) in Calcutta, were established. Subsequently, a deep-sea fishing station (later renamed the exploratory fisheries project and now known as the Fishery Survey of India, based at Mumbai) was also established. Later, based on the recommendation of the Fisheries Research Committee (1954) appointed by the Ministry of Food and Agriculture, Government of India, the Central Institute of Fisheries Technology (CIFT), was established at Cochin.

In the modern era, though mechanization has taken place, the basic principles of the tools used to catch the fish in the past are used. The progress made in recent years is seen in the greatly improved purse-seining technique. The rate of development in trawling has been slower than in purse seining, as it started from a more highly developed base. Mid-water trawling has made headway because of improved net and gear design. Also, the knowledge of the fishing grounds that skippers possess is being mapped on the charts. Nowadays large trawlers have been developed, capable of freezing and processing at sea. The tendency is to build faster vessels. Engines have become lighter and more powerful. The lower fuel requirements of the improved boats have made possible increase in fishing without adding to the cost. In India, use of outboard engines for local craft has become widespread. Progress has also been made in improved construction materials for small boats. Plastic reinforced with glass fiber has also been introduced.

Development in electronics and communications has helped make tremendous progress in fishing. Other electronic equipment is also used to locate the fish in the open sea. Fishermen can accurately locate schools of fish, using data from the Geographic Information System (GIS) data and using the Geographic Positioning System (GPS).

Inland fisheries

India is blessed with huge inland water resources: 29,000 km of rivers, 0.3 million ha of estuaries, 0.9 million ha of backwaters and lagoons, 3.15 million ha of reservoirs, 0.2 million ha of floodplain wetlands, and 0.72 million ha of upland lakes. It has been estimated that about 0.8 million tonnes of inland fish is contributed by different types of inland open water systems. Though production break-up of these water bodies is not available, it is believed that capture fisheries production from river and estuaries contribute only a small share of total inland catch, and the bulk of the production comes from reservoirs and floodplain wetlands that are managed on the basis of culture-based fisheries or various other forms of enhancement.

The 14 major rivers, 44 medium rivers and innumerable small rivers of the country, with combined length of 29,000 km, provide for one of the richest fish faunistic resources of the world. While production figures from different riverine systems are not available, estimates made for major rivers showed yield varying from 0.64 to 1.64 t/km, with an average of 1 t/km. Further, as per the available statistics, the average yield in different estuaries ranges from 45 to75 kg/ha.

In recognition of the increasing role of inland fisheries in overall fish production, the Government of India has been implementing two important programs in the inland freshwater: the Fish Farmers' Development Agencies (FFDA) and the National Programme for Fish Seed Development. The FFDAs have covered about 567,000 ha of the total water area under scientific fish culture and trained 651,000, fish farmers. But the average productivity from waters covered under this program remained almost static at about 2.2 t/ha/year during the Ninth Plan period. This scheme was revised during the Ninth Five Year Plan by increasing the unit costs and adding new components such as freshwater prawn seed hatcheries, laboratories, and integrated units including hatcheries for ornamental fishes etc.

In coastal areas, 39 Brackishwater Fish Farmers Development Agencies (BFDAs) have also been established, through which about 6,240 ha was brought under brackish water aquaculture during the Ninth Five Year Plan. Under the national program for fish seed production, more than 50 fish seed hatcheries have been commissioned, leading to a marked increase in the production of fish seed: from 409 million fry in 1973/74 to about 17,000 million fry in 2000/01. Inland fish production increased from a mere 0.22 t in 1950 to 3.4 t in 2002 (Fig.1) (Pillai and Katiah, 2004). This could be achieved through a spate of technologies developed in the inland fish sector in general and in aquaculture, in particular.

Marine fisheries

Before and immediately after independence, marine fishing was done at subsistence level, with the indigenous craft employing gear such as cast nets, small seines, and traps operated close to the shore. In the 1950s, small, mechanized boats with bottom trawl nets were introduced. With the inception of the First Five Year Plan (1951–56), mechanization of fishing craft was encouraged by the Government of India, to help traditional fishermen get better returns by extending their range of operation. The Food and Agriculture Organization (FAO) of the United Nations played a critical role in research and development activities of the fisheries sector in India, developing three prototypes of mechanized surf boats. To increase fish and shrimp production, larger Mexican trawlers were introduced in the mid-1970s. In 1999, medium-sized trawlers, upgraded and fitted with GPS and echo sounders, ventured into deep-sea shrimp fishing along the Kerala coast. Shrimp trawlers based at Quilon, Kochi, and Munambam fisheries harbors carried out intensive fishing operations at the Quilon bank at depths ranging between 175 and 400 m.

In the early 1970s, small mechanized craft of 9.75–10.9 m OAL were very popular and economical for single-day shrimp fishing; however, over the years, the increasing number of vessels operating in inshore waters led to decreasing catches per unit effort and prompted multiday fishing operations for economic reasons. Vessels with upgraded engines could operate profitably in offshore waters during the early 1990s. During the late 1990s, idling shrimp trawlers (9-13m OAL) were modified to enable drift gill netting aiming at high unit value fish, such as tuna and seerfish (Balasubramaniam, 2000). Modifications included removal of the mast, winch, and gallows; reducing the area of the wheelhouse, including its height, conversion of part of the rear portion of the deck as storage for ice blocks and fish catch and storage of gear and craft operational material just in front of the gear hold. During 1983/84, surveys for tuna resources and training programs for tuna long-lining, with the technical guidance of the Japan International Cooperation Agency, were conducted with the aim of developing an export-oriented tuna fishery in the Indian seas.

The history of the Beach landing Craft Development (BCD) project covers two phases. During the first phase (1979–1984), several prototypes of craft were developed and trials were carried out, resulting in two models being deemed suitable for commercial introduction by 1984. In the second phase (1985–92), these models were introduced commercially, and the technology considerably refined, mainly in respect of the engine and propulsion system and hull details, offshore fishing trials, and evaluation of performance of the craft. Beach Landing Craft (BLC) were specifically designed for the coast of Andhra Pradesh and Orissa by the Bay of Bengal Programme (BOBP) and this is a classic example of developing a successful fishing vessel technology. It has replaced the existing traditional *Nava* boat of the region, as the fishermen view it as a safe and comfortable craft, with its higher mobility, fuel economy, and ability to carry more gear. On technical grounds, the BLC has proven itself as a surf-crossing and beach-landing craft mainly due to the superior features of its hull, such as a flat and rounded bottom without keel enabling it to sit upright on the beach, and its high maneuverability achieved by a large rudder directly behind the propeller, complemented by the pivoting engine installation, combined with in-built buoyancy and a water-tight deck.

Motorization of country craft began only in the early 1980s, even though experimental projects on motorization were tried much earlier (Jacob et al., 1987). In Kerala, the ring seine or the mini-purse seine was introduced in the mid-1980s as new pelagic gear for traditional craft. Adoption and popularization of this gear in the second half of the 1980s was the most significant development in the post-motorization phase of fisheries in India.

Fisheries became a focal theme of the Government of India's Five Year Plans; between 1951 and 1996, this resulted in the introduction and popularization of mechanized fishing vessels, modern and synthetic gear materials, purse-seining, motorization of artisanal craft, and rapid popularization of ring-seine gear operations (Devaraj et al., 1997). Annual marine fish production increased from 0.6 million tons in 1950 to 2.7 million tons in 2003 (Pillay and Katiha, 2004).

The programs for development of marine fisheries as envisaged in different Five Year Plans include (i) conducting intensive surveys, particularly of the Exclusive Economic Zone (EEZ), on marine fishery resource assessment; (ii) ensuring optimum exploitation of marine resources through a judicious mix of traditional country boats, mechanized boats, and deep-sea fishing vessels; (iii) providing adequate landing and berthing facilities to fishing vessels by completing the ongoing construction of major and minor fishing harbors; (iv) intensifying efforts on processing, storage, and transportation; (v) improving marketing, particularly in the cooperative sector; and (vi) tapping the vast potential for export of marine products. During the Seventh Plan some selected villages were grouped for setting up "Fisheries Industrial Estates." The major developments include construction of 30 minor fishing harbors and 130 fish landing centers in addition to the five major fishing harbors, Cochin, Chennai, Visakhapatnam, Roychowk, and Paradip. They provide landing and berthing facilities to fishing craft. There were 181,284 nonmotorized traditional craft, 44,578 motorized traditional craft,

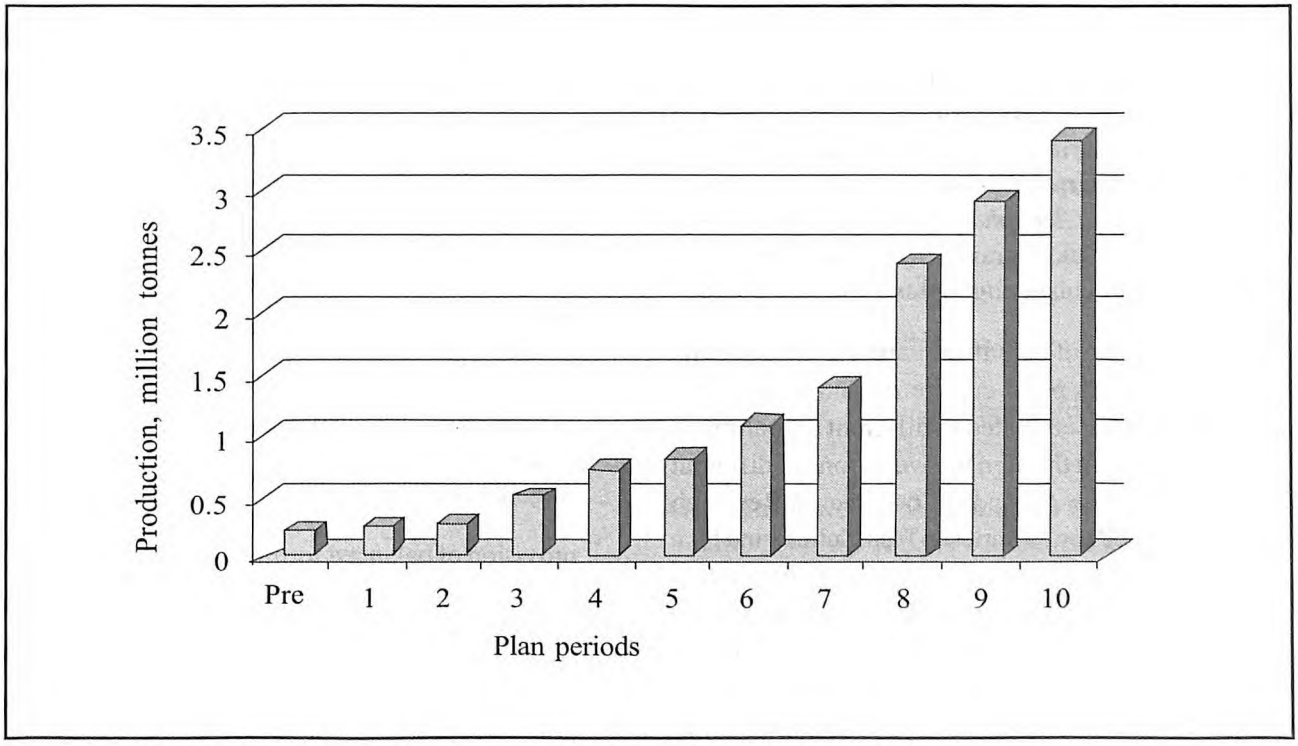

Figure 1. Inland fish production in India over Five Year Plans.

and 53,684 mechanized boats available in India in 2000/01. The Government also provides subsidy to poor fishermen for motorizing their traditional craft, which increases the fishing area and the frequency of operation, with a consequent increase in catch and earnings of fishermen. Improved beach landing craft are also being supplied to groups of fishermen. A scheme of reimbursing Central excise duty on HSD oil used in fishing vessels below 20 m length is also in operation to help the small fishermen reduce their operational costs. About 18,000 such vessels are being benefited per annum under the program for the last few years.

Aquaculture

Fish culture has a long history in India. Farmers have cultured the three major Indian carp—catla (*Catla catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*) in fish ponds for ages (Chaudhuri, et al., 1974). However, the production from these systems remained significantly low at 600 kg/ha/year (Banerjee, 1967; Jhingran, 1969) until the advent of composite carp culture technology during the 1970s.

Carp culture. The introduction of exotic species, such as the Bangkok strain of common carp (*Cyprinus carpio*) in 1957 (Ayappan and Jena, 1998), and the silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) in 1959 (Alikunhi and Sukumaran, 1964) also contributed significantly to enhancing yields from fish ponds.

The technology of scientific carp culture in India developed at the pond culture division of CIFRI, Cuttack, was disseminated to different agroclimatic zones and refined through the work done at different centers under the All India Coordinated Research Project (AICRP) on Composite Fish Culture and Fish Seed Production, initiated in 1971 by the Indian Council of Agricultural Research, New Delhi. Studies from all the six centers of AICRP revealed initial production of 2436–6522 kg/ha/year through fertilization and supplementary feeding in various agroclimatic zones. Research (Lakshmanan et al., 1971; Sinha et al., 1973; Chaudhuri et al., 1974, 1975; Ayyappan and Jena, 2001; Jena et al., 2002a, 2002b) has helped develop, refine, and standardize a host of technologies with various production levels, depending on the input use.

Carp culture has thus entered a new era: geographical coverage has expanded, use of culture species and methods diversified, and farming systems considerably intensified, revolutionizing freshwater aquaculture in India and turning it from a backyard activity into a fast-growing, well-organized industry. The average national production from stillwater ponds has gone up from 600 kg/ha/year to over 2 t/ha/year, with several farmers demonstrating even higher production levels of 8–12 t/ha/year.

Other fish culture. Development of air-breathing fish culture (Dehadrai et al., 1985; Thakur and Das, 1986; Seth, 1997; Seth and Katiha, 2002), freshwater prawn culture technology, and mono- and polyculture with carp (Rama Rao et al., 1992; Raje and Joshi et al., 1992; Tripathi, 1992) are other milestones in freshwater aquaculture in the country. India has attained intensive carp culture technology (15 t/ha/yr) employing a standardized package of practices, which includes

- predatory and weed fish control by use of certain chemicals or plant derivatives;
- pond fertilization with application of *Azolla* at 40 t/ha/yr at weekly split doses as biofertilizer, substituting traditional organic and inorganic fertilization;
- stocking of Indian major carps and exotic carps of 25–50 g size at densities of 15,000–25,000 fingerlings ha^{-1};
- provision of balanced formulated supplementary feed, comprising rice-bran, ground nut oil-cake, soybean flour, fish meal and vitamin mineral premix;
- provision of 4–6 paddle-wheel aspirator/aerators per hectare of water to keep dissolved oxygen

within desirable limits, especially during the night, maintenance of water column of 1.5–2 m;

- water replenishment, depending on the water quality; and
- fish health management through prophylactic and curative measures.

An improved strain (*Jayanti*) of rohu developed through selective breeding has successfully demonstrated growth increments of about 15% over the parental stock (Reddy et al., 1998).

Shrimp farming. Shrimp being a highly valued export commodity, shrimp farming is considered a lucrative industry. Depending on the area of the pond and on inputs, such as seed and feed, and management measures, such as predator control and water exchange through tidal effects or pumping, farming systems have been classified into extensive, modified extensive, semi-intensive and intensive. In the coastal lowlands (*Pokkali* fields in Kerala, *Khar* lands in Goa, *Khazans* in Karnataka, and *Bheries* in West Bengal) of India, there is a traditional practice of shrimp farming in rice fields as a rotational crop after the rice harvest, which yields up to 0.5 t/ha/year.

During the 1990s, shrimp farming grew rapidly, and at present about 156,500 ha is under shrimp culture in the country, with an average production of 0.7 t/ha/year. Currently, 80% of the shrimp production comes from small and marginal holdings, with farms of less than 2 ha constituting 49.24% of the total area under culture. Hatchery technology is a milestone in shrimp farming. At present, there are more than 200 operational shrimp hatcheries in the country, with a total annual production capacity of 10.8 billion seed (PL 20). Coupled with this, feed mills with a total installed capacity of 150,000 t cater to the shrimp industry.

Conclusion

The species of fish referred to in the ancient literature of India are of high quality and are high-value fish even today. It would thus appear that man remains conservative in his taste for specific articles of diet over thousands of years. This shows the importance of documenting traditional knowledge of conservation and management, based on primary and secondary information; this may be of use for developing innovative new technologies. Traditional information should be collected from old fishers and the different traditional methods and practices in fisheries filmed for future reference, especially in view of the WTO regime. A national heritage museum on fisheries should be established to show both the documented traditional information and the modern technologies being practiced today. This would help others to get information on ancient and modern fisheries from a single source. The scientific basis of the traditional knowledge collected from fishers should be examined. Importance was given to fish conservation even in ancient times, as evident from Asoka's Pillar Edict, and such measures should be strictly implemented today.

India has developed most modern tackling methods using improvised craft and gear with the help of different Government schemes. From merely hunting of wild fish in ancient days, aquaculture has taken a long leap through innovations in the technology of catching and processing, bringing from a few thousand tons to millions of tons today and earning millions of dollars from the export market. Therefore it is vital that research and development institutions emphasize scientific research on traditional technologies.

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