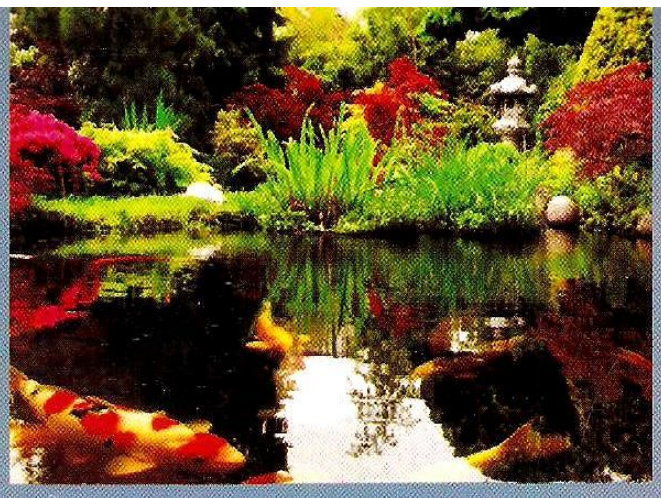

Principles of Aquaculture

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Preface

Aquaculture, i.e., culture of aquatic organisms provides economic and nutritional benefits to mankind since time immemorial. Today, the practice of aquaculture is mainly concentrated in the developing world, which provides substantial income to the nation as well as food to the hungry man.

In India, aquaculture is gaining importance day by day, due to its vast untapped potential, but still, the knowledge of people practising it is very very less. So in order to enhance the knowledge base of aquaculturists as well as students of aquaculture and fisheries of all levels (UG & PG), this book is written in a simple language with suitable diagrams in order to make the readers understand the facts thoroughly, and apply it in a practical way. We hope, his book will meet the requirements of undergraduate as well as postgraduate students of all Indian universities having a subject of aquaculture, aquaculturists and budding aquaculturists of Indian Subcontinent.

In the preparation of this manuscript, a large number of people have helped us in one way or the other, we wish to thank them all, especially Mr. J. S. Maske, Lecturer, Deptt. of Zoology, Govt. Institute of Science, Nagpur, Shri S. S. Gandhewar, Lecturer, J.B. Science College, Wardha and Dr. Shanta Satyanarayan, Ex. Deputy Director, NEERI, Nagpur. We are also thankful to our computer expert Mr. Shrikant Shadangule and Amjadbhai who have taken pains to work the script assembling in a very good and presentable form. In preparing this book, a large number of books are referred which are given as references in the end.

We are grateful to M/s Himalaya Publishing House, for giving constant encouragement in writing and publishing this book in an attractive form.

We will appreciate constructive suggestions from readers for the improvement of this edition.

Authors

CHAPTER 1

The Science of Aquaculture

1.1 Definition

The term *'Aquaculture'* means culture of all aquatic forms like fish, prawns, molluscs and sea weeds in fresh, brackish as well as marine waters.

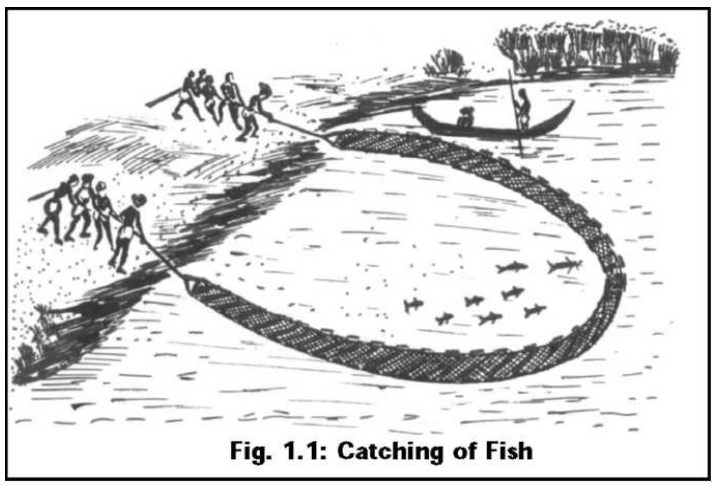

Fig. 1.1: Catching of Fish

The 'Aquaculture' includes:-

- The type of culture systems utilized, e.g., pond culture, cage culture, pen culture, etc.
- The type of organisms cultured, e.g., fish, oyster, shrimp or prawns.

The origin of aquaculture dates back to at least three thousand years ago, but unlike agriculture, which has been the most important way of obtaining food on land, aquaculture has until recently contributed very less to mankind due to age old methods in use coupled with lack of proper knowledge. But now the picture is changing rapidly as aquaculture is gaining more importance in the today's' modern world, due to increase in population and shortage of food.

1.2 Objectives of Aquaculture

The main objectives of aquaculture are:

(1) To boost economy of the nation by way of increasing per capita production.

(2) To generate employment opportunities for the unemployed persons.

(3) To utilize fully the natural water resources available to the maximum.

(4) To uplift the socio-economic status of the people of Indian sub-continent.

(5) To earn foreign exchange revenue by transport of fish to foreign countries.

(6) To culture ornamental fishes for beautifying aquariums.

(7) To culture larvicidal fishes for control of mosquito larvae.

(8) To increase production of food, in the form of fish, and decreasing the pressure on other food items.

1.3 The History of Aquaculture

Earth's surface is covered with water which gives medium to living organisms, which include a varied forms of life from protozoa to chordata. The fishes are one of them, thriving in water bodies of the universe.

(a) The First Fish Ponds

About 4000 years ago, rivers the middle east and the belt of the *Tigris* and *Euphrates* were much better and more fertile. It is the period in which the first fish pond was built by the Sumerians in their temples. The *Assyrians* and other races followed them.

(b) Fish Culture in Egypt

The engraving on a tomb in Egypt showing *Tilapia* being fished out of an artificial tank in about 2500 B.C. provides evidence that the people of Egypt were the first in the world to culture *Tilapia*.

The Egyptians even mummified some of their important species, so that, accuracy of the drawings can be checked. Besides *Tilapia, Nile Perch* and *Mormyrus* were also cultured by them.

(c) The Romans and Fish

The Roman, *Marcus Terentius Varro* (116-27 B.C.) wrote about two kinds of fish ponds kept by the peasants for food and profit and salt water ponds which were owned by wealthy aristocrats who used them to entertain guests. 'Red *Mullets* were favorite fish as the colour changes of the dying fish were admired by guests before the fish was cooked and eaten.

Large *Moray Eels'* were also kept apart from Red mullets. The involvement of Romans with fish was not only for show, but, also for they explored 'Fish Culture' methods and were known to have transported fertilized fish eggs. The Roman's have externally fertilized the fish eggs utilizing the stripping method.

(d) The Chinese Fish Culture

Around 500 B.C. 'Classic of Fish culture' was written by *'FanLei'* in which he cited that his ponds were the source of his wealth. In 1243 A.D. *Chow Mit* of the Sung Dynasty and *Heu* in 1639 A.D. described the collection of carp fry from rivers and methods of rearing them in ponds.

The earliest form of fish culture was that of Common Carp, *Cyprinus carpio* a native of China. From there, this species has been introduced into several countries of Asia, far East and Europe. From the 6th Century A.D. the culture of common carp declined in China. The common name of the carp in Chinese is 'Lee' and this name is associated with the name of the Tang Dynasty Emperor 'Lee'. Since the name of the emperor is considered sacred hence, the culture of the fish for food was not acceptable to the general society. So a search for another species for culture was undertaken which ended with the Chinese Carps, like Grass Carp *(Ctenopharyngodon idella),* Silver Carp *(HypophthalmichthysmolitriX),* Bighead *(Aristichthys nobilis)* and Mud carp *(Cirrhina molitorella).* The rearing of these fish species has given rise to polyculture practice.

(e) Fish Culture in Indo-China

Fish culture was practised in Indo-China for many centuries and the systems called 'Pen' and 'Cage culture' of catfishes originated in Cambodia. Flow through culture was developed and the variations of the same were practiced in Indonesia for carps and in Thailand for *Pangasius sp.*

(f) Aquaculture in India

The evidence about fish culture practised in India years ago, came from the 'Kautilya's 'Arthshastra' in which he mentioned about the secret means of keeping fish in reservoirs. *'King Someshwara'* of Chanakya Dynasty described the methods of fattening the fish in ponds.

There is a long period regarding fish culture in India until, collection and transportation of carp spawn, from rivers and stocking the ponds, was developed traditionally in Bengal, Bihar and Orissa by the end of 19th century. This technique spread in other states also and a notable advance in fish culture in Bengal was the construction of 'Bundhs' for carp breeding. Warm water fish culture got a boost in 1911 when under the guidance of *'H.C. Wilson* the first big fish farm with facilities of carp breeding, came into existence in Tamil Nadu (TN).

The Indian Council of Agriculture Research (ICAR) recommended sponsoring fisheries research schemes by State Governments and Universities on different aspects of fish culture. For extending fish culture activities to all parts of the country Govt. of India established the Central Inland Fisheries Research Institute (CIFRI) at Barrackpore (West Bengal). The pond culture substation of CIFRI was started at Cuttack (Orissa) in 1949 for finding solutions to problems of fish culture in ponds and thereafter a considerable thrust has been laid on research programmes in inland fisheries.

Development after 1970 have led to the use of 'Second generation Techniques' including mammalian hormones, steroids, prostaglandin, and its analogues to make the cultivated species spawn for seed production.

The Central Institute of Fisheries Education (CIFE) Versova, Mumbai, Aquaculture Research and Training Centre, Kakinada, Central Marine Fisheries Research Institute (CMFRI), Cochin; Central Institute of Freshwater Aquaculture (CIFA), Kausalyaganga, Orissa, Central Institute of Brackishwater Aquaculture, Chennai, have been established for the development of aquaculture in India.

(g) Trout Propagation: History

The trout originated in France and the monk *Don Pinchot* of 14th century discovered the artificial propagation of trout eggs. Being a sport fish the, trout culture spread to almost all continents thereafter. Commercial trout culture developed in countries like France, Denmark, Japan and recently in Norway and Italy. With the development of 'Cage Farming' of Trout in Norwegian 'fiords' salmonoid culture achieved a remarkable place in production and public attention.

The fish culture in North America was centered earlier towards propagation of salmon and trout. In 18th century trout hatcheries were established. Gradually the trout propagation spread to the temperate and semi temperate areas of central and south America. The British introduced trout in Asia and Africa, mainly to develop sport fisheries. The first attempt to transplant trout in India was made at Nilgiris in Western Ghats of Tamil Nadu.

(h) Exotic Fish Culture in India and Other Countries

Besides trouts there are other species which from their place of origin have been introduced in other countries for culture purpose, e.g., *Cyprinus carpio* is the most extensively cultivated species worldwide. In India, the common carp *(Cyprinuscarpio)* is cultured in combination with Indian major carps.

The Silver Carp *(Hypophthalmichthysmolirix),* has been introduced in many countries and cultured in China, Taiwan, Thailand, Malaysia, Japan, Sri Lanka, India, Pakistan, Nepal, Philippines, Russia, Myanmar, Hong Kong, Singapore and Israel. In India for the first time fingerlings of silver carp were brought from Japan in 1959. Likewise, the *Grass Carp* (from China) and *Tilapia mossambica* (from Africa) have been transplanted throughout the world for cultural practices. There was resistance to its introduction in many countries as it was considered a pest by some countries.

The larvivorous fishes were also introduced in different parts of the world.

The catfish family Clariidae enjoys the widest range of geographical distribution and species *Clarias gariepinnus* (Nile Catfish) from Africa was introduced in South Vietnam in 1974. From Vietnam it reached Campuchia, Laos and Thailand and it and gets entry in India, in 1993.

(i) Coastal Aquaculture

The oldest form of 'Coastal Aquaculture' is the 'Oyster Farming' practiced by the early Romans, Greeks and Japanese. In Japan around 2000 years ago coastal aquaculture was practiced.

Aristotle mentioned the cultivation of Oysters in Greece. The culture of mussles and clams developed at a quite later stage. The terms 'Mariculture' and 'Sea Farming' are frequently used for raising organisms in the marine environment until recently, and from the worldwide interest, that the sea farming has received in recent years, it appears that sea will be cultivated on a large-scale. The animals now cultured include shrimps, lobsters, oysters and clams.

(J) Sea Weed Culture

Sea weed culture is relatively of recent origin. The earliest reference about 'sea weed' culture appears to have published in Japan in 1952. It was after II World War the culture of edible sea weeds expanded and intensified considerably and practised in Korea, Taiwan and China.

In Philippines and Hawaii several sp. of algae are regularly eaten. Several sp. of sea weeds contain 'Gelatin', used for the preparation of Jelly and Jams.

Dried sea weeds are regularly used in domestic cookery for making soups, pudding, etc.

The active ingredient in the sea weeds is 'Agar' (Sodium Alginate) which is used as a gelling substance.

A few years ago, India used to export sea weeds and the products such as Agar and Alginates used to be imported. Now India is self-sufficient in its production.

1.4 Aquaculture in India

India is the second largest producer with about 9% share of the world's total aquaculture. The top producer is China (57%).

- **Freshwater Aquaculture in India**

Inland aquaculture emerged today, as a major fish producing system in India (Fig 1.1) with production around 1.7 million ton/yr. Carp accounts for over 80% of cultured fish. Major Carps cultured are Rohu *(Labeo rohita),* Catla *(Catla catla),* Mrigal *(Cirrhinusmrigala),* Grass carp *(Cenopharyngodon idellus),* Common Carp *(Cyprinus carpio),* Silver Carp *(Hypophthalmichthys molitrix),* Magur *(Clarias batrachus),* Singhi *(Heteropneustes fossilis),* Rainbow trout *(Salmo gairdneri)* and giant prawn *(Macrobrachium rosenbergii).*

West Bengal is the largest producer of fish in India. The state is also the largest supplier of fish seed and supplies nearly 80% of the carp seed demand of the country.

The Central Institute of Freshwater Aquaculture (CIFA) Kausalyaganga (Orissa) established in 1986 is the top level institute in the country with the motto of conducting research on different aspects of freshwater aquaculture and undertaking transfer of technology to the field. The institute serves as the lead Centre on Carp Farming.

- **Brackishwater Aquaculture in India**

The area of brackishwater available in India for aquaculture is 1.19 million ha. Traditional shrimp farming practices are popular in Kerala, West Bengal and Goa. The yields vary from 300 to 1000 kg/ha year. Because of its high commercial value, Giant tiger prawn *(Penaeus monodon)* is the dominant species in commercial production, although, Indian white prawn *(Penaeus indicus)* is also farmed in several places. Shrimp production by farming reached a record value in 1994-95. subsequently production suffered a set back due to a ban imposed by the Supreme Court of India in response to petition filed by environmentalists pleading that shrimp farming had created severe environmental damages. Subsequently many shrimp farms in coastal areas were closed. Intensive shrimp farming is banned and only modified improved farming is permitted with a productivity of around 2 to 2.5 ton/ha/yr.

West Bengal is the highest producer of shrimps in India. Its estuarine area in the Sunderbans is ideally suited for the extensive culture of prawns and shrimps.

The Central Institute of Brackishwater Aquaculture (Chennai) is today, conducting research on different aspects of brackishwater aquaculture as a national level institute transferring the techno logy to the field.

- **Mariculture (Sea Farming) in India**

Indian 'Sea farming' progress has been very slow. Of the 1.2 million ha. of potential land identified for shrimp farming only about 100,000 ha. is utilized. The slow progress in this area is due to the collapse of the Shrimp farming industry because of environmental concerns and disease problems. Although the present attention is towards diversification of fish species other than shrimp the commercial ventures are constrained due to unreliable seed supply and lack of technology for commercial marine finfish hatchery seed production.

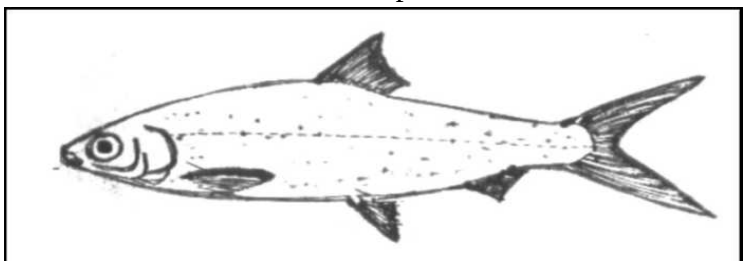

***Fig.1.2: Chanos chanos* (Milk Fish)**

The culture of Sea bass *(Lates sp.,)* milkfish *(Chanos sp.)* grey mullets *(Mugil sp.),* pearl spot *(Etroplus sp.)* etc. has been practiced in India since 1960's. Most of the culture systems are operated on small-scale level.

Potential mariculture sites especially for open sea-cage fish farming have been identified at Andaman Sea, northeastern arm of the Indian Ocean, bounded on the west by the Andaman and Nicobar Islands with the coral lagoons and protected deep-water bays. It provides environmental conditions for finfish farming using 'sea-cages'.

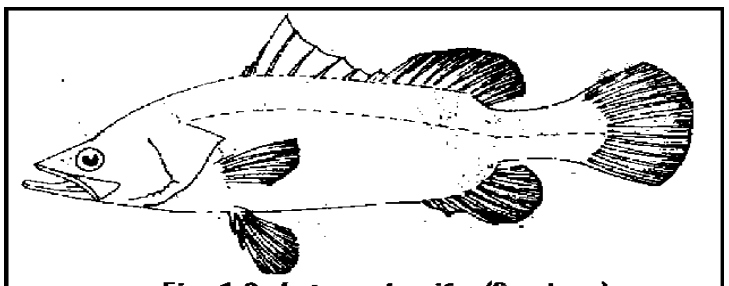

Fig. 1.3: *Lates calcarifer* (Sea bass)

Lates calcarifer (Sea Bass) (Fig 1.3) is a potential species for farming in India because of its fast growth rate, wider tolerance to environmental conditions and demand in export markets. It is distributed along the East and South west coast of India and is farmed traditionally in North east India using seed collected from wild.

Epinephelusspp. (The Grouper) has abundant nursery grounds in Gulf of Mannar, Coral Lagoons of Lakshadweep and Andaman and Nicobar Islands. In India farming of groupers as an alternative species will be a productive venture.

The culture of *Mullets'* is also restricted due to non-availability of hatchery seed. The *'Pearl spot' (Etroplus* sp.) is monocultured using wild seeds in traditional ponds of Kerala. Experimental cultures of this species show its potential for polyculture.

Sustainable marine fish farming will be achieved in India through integrated farming through cage culture, polyculture and by establishing hatchery technology on a wide scale. Industrial aquaculture will flourish only if commercial marine fish hatcheries will be established and environmental protection norms are to be strictly followed.