
ST.ANN'S COLLEGE FOR WOMEN,
Malkapuram.
ST.ANN'S COLLEGE FOR WOMEN
LIGHT TO ENLIGHTEN
AQUACULTURE
CULTIVATION OF AQUATIC ORGANISMS

AQUACULTURE

ST.ANN'S COLLEGE FOR WOMEN, malkapuram.

Accredited by naac with 'A' grade

Submitted by-

B.Sc. 1st semester CBZ and Microbiology

2023-2024

Principal

Dr.Sr. Prema kumari
Designation: Principal
Qualifications: M.Sc. Botany ,PhD

Mentor

S.Lakshmi tulasi madam
Designation: Lecturer
Qualifications :M.Sc. Zoology, PhD (Pursuing)
Skill Qualifications: mushroom cultivation ,Vermi compost, agri-inputs

Mentor

Dr. Adi shesu madam
Designation : Asst. Professor
Qualifications : M.Sc. Botany M.Phill, PhD. Botany
Skill Qualifications: P.G diploma in environmental studies, PGDCA

Acknowledgement

In performing our Assignment, we had to take the help and guideline of the one, who deserves our greatest gratitude. The completion of this assignment gives us much Pleasure. We would like to show our gratitude to S. Lakshmi tulasi madam, for giving us this assignment the purpose of which was to increase our knowledge and to do some practical work.

Aquaculture

Author's:

Sanjana kumari, B.Geethika, Latha sree, Shamran Nisha begun, Sharmila Deepika, Mannemma, G.Anusha, Sowmya swaraj, Nookaratnam, Shymala, Rohini, Kavita

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First edition- 2023

For contact E- mail us on:
geethikabotcha@gmail.com

Contributors

Money contributors:

Final CBZ (2023-2024) Zoology department (seniors), and 1st semester: Prathima Sharon, Rebekah, Sailaja, Amulya, Santhoshi

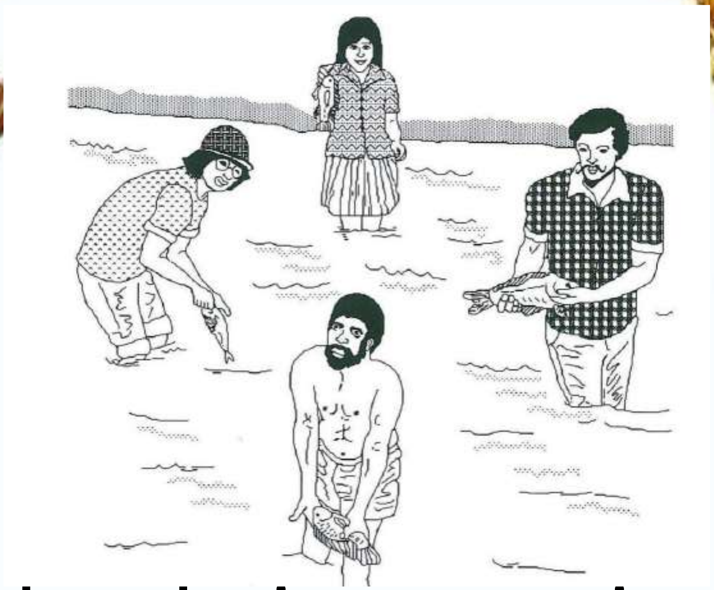
Printing contributors:

Noor printers

Sriharipuram, Visakhapatnam, Andhra Pradesh, 53011.

Content

Introduction



Fish production was previously heavily dependent upon capture fishery and in particular the marine resources. However, the capture fishery cannot be expected to be a perennial protein donar. Moreover, a substantial portion of the marine catch is being utilised for making industrial products which are not directly consumed by man.Therefore, a viable alternative by which fish production could be increased through a popularized biotechnique, called aquaculture.

More than one-fourth of all animal protein consumed by man is aquatic in origin. Regional differences range from Asia where more than one-fourth of dietary animal protein is fish to North and South America where less than 10% of animal protein consumed by man is from aquatic sources.

Aquaculture has been practiced in many Asian countries for centuries, but is a new form of agriculture in many African and Latin American countries. It is defined as the cultivation of animals and plants in aquatic environments. Aquaculturists manipulate certain components of the environment to achieve greater control over production of aquatic organisms than is normally possible in nature.

Increased production of aquatic animals and plants is achieved through aquaculture.

What is aquaculture ?

Aquaculture may be defined as the “farming and husbandary of economically important aquatic animals and plants under controlled conditions”.

Aquaculture is the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments. Aquaculture produces food and other commercial products, but similar techniques can be applied in non-commercial settings to restore habitats, replenish wild stocks, and rebuild populations of threatened and endangered species.

The word aquaculture is the combination of two Latin words in which aqua means, "water," and culture means , "agriculture" or "a cultivating." Originally, this term referred only to fish farming. Today, you can also practice aquaculture by growing seaweed and algae, or raising shellfish like oysters and scallops. Today, aquaculture provides about half of all the fish and shellfish eaten by humans.

It is an important part of the global food and seafood supplies. The Food and Agriculture Organization of the United Nations (FAO) recognizes farm-raised seafood as a key source to grow the global food supply to feed the increasing world population.

History of aquaculture

Farming in ponds through the ages. The earliest evidence of fish farming dates back to before 1000 BCE in China. The Zhou dynasty (1112-221 BCE), then the politician Fan Li, around 500 BCE, were the first to describe carp, a symbol of good luck and fortune, as being farmed for food. During the Tang dynasty, around 618, the Emperor Li, whose name means ‘carp’, forbade farming the fish that bore his name. Farmers then turned their attention to similar fish in the Cyprinidae family and developed the first form of polyculture. Liquid manure from livestock farming was also used to stimulate algae growth in ponds and make it more nutritious. The pond beds were then drained so that they in turn were also used as fertiliser. The first integrated agriculture-aquaculture systems emerged in China, where they are still implemented today.

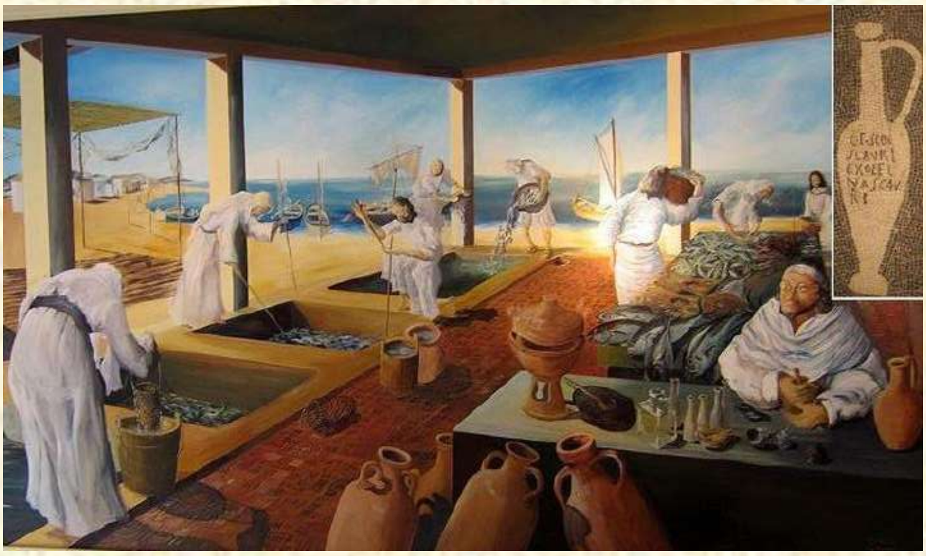
Around 500 BCE, the Romans farmed oysters and fish in Mediterranean lagoons, whereas freshwater aquaculture developed empirically some 1000 years earlier in China. Farming carp in ponds led to the complete domestication of this species in the Middle Ages, which is also when mussel farming began, following a technique that remained largely unchanged until the 20th century. In Europe, aquaculture first began in Ancient Rome. The Romans, who loved sea fish and oysters, created oyster farms and adopted the Assyrian vivarium, a kind of 'swimming pool' where fish and crustaceans caught in lagoons were kept alive until it was time to eat them. These vivaria were built inside wealthier homes, where guests could choose the fish they wished to eat. In the Middle Ages, throughout feudal Europe, the monastic orders and the aristocracy were the main users of freshwater fish vivaria, since they had a monopoly over the land, forests and water courses. Mussel farming was invented in the 13th century and the technique remained largely unchanged until the 1960s. As with hunting, poaching was severely punished and the less well-off would have to wait a few centuries before fresh fish was served on their plates.

Freshwater fish farming was further developed during the Renaissance. Several treatises were published, providing details on pond construction and management techniques, the choice of species to farm, their diseases and their diet. Carp dominated the artificial ponds of Eastern Europe. Emperor Charles IV ordered many such ponds to be built in Bohemia, what is now the westernmost region of the Czech Republic. Artificial breeding was discovered in Germany during the Enlightenment, but it was not until the 19th century, an era of rapid industrialisation, that anyone paid much attention to it. In a hundred years, industry changed the European landscape. Pollution caused fish populations to diminish and dams and irrigation canals obstructed the migratory paths of some species, such as salmon. To combat this dramatic decline, artificial breeding research focused on trout farming, and researchers managed to master all stages of the process, from fertilisation to egg storage and transportation, pond farming and releasing

Fish into the wild. Hatcheries appeared all over the West and, in the 1860s, trout and other salmonids colonised rivers around the world, in the United States, India, New Zealand and even Japan, one of the first producers of edible seaweed.

During the first five decades of the 20th century, colonists introduced and then farmed other species of fish in the Anglo-Belgian colonies in Africa, whether for leisure fishing , to prevent the spread of malaria (using insect-eating species), or as a food source (tilapia for example). In the kibbutzim of Israel, farmers adapted traditional methods imported from Eastern Europe to the arid environment and developed new techniques, enabling them to achieve self-sufficiency in fish products.

In the late 1950s, the invention of artificial granulated food revolutionised fish farming, which until then had relied on products from agriculture and livestock farming (raw meat, for example), to feed the fish.



During the 1970s, marine species aquaculture enjoyed a revival, thanks to new, lighter, more hard-wearing and less expensive building materials (fiber glass, plastic tubes) and the use of floating cages rather than expensive glass and cast iron saltwater ponds. However, these new facilities turned out to be commercially non-viable and the optimisation and stabilisation of marine fish production was a major concern in the following decade. The start of the 21st century saw aquaculture take on great importance worldwide. According to a report on Fishing and aquaculture by the Food and Agriculture Organization of the United Nations (FAO) in 2016, "In terms of global production volume, that of farmed fish and aquatic plants combined surpassed that of capture fisheries in 2013".

IMPORTANCE OF AQUACULTURE.

Importance of Aquaculture has cerahelming importance Mere than 220 species of finfish and shellfish are farmed The practice of aquaculture makes available very important species like salmon ood and many other species without seasonal variations We can break down the importance of aquaculture under the heading below Breaking geographical distribution barrier Introduction of exotic species to different part of the world from their home base is aquaculture based This has made available many important food fish sport pal and aquarium fals in places they naturally were not found Examples rainbow trout corps Nappies hundreds of aquarium fahes etc. FAO 2006 noted are like that in Brazil 64% of aquaculture production as at 2006 was from exotic species In Netherlands African catfish Clarias qariepinus is the second most farmed fish Provision of animal proteins recreation Fish is a valuable source of animal protein. The per capita consumption of fish around the globe is enhanced through aquaculture The dwindling ocean catches have been ameliorated by production through aquaculture Stocking of overfished/endangered species through breeding programs the status of overfished and endangered species can be ameliorated Aquaculture breeding tool is invaluable tool in stock restorationPropagation of desired species Aquaculture offers useful tools for propagation and domestication of desirable Certain fishes have desirable qualities for meeting human demands These fishes Can be propagated through aquaculture and used are effectively Examples of these are

Groups of grass car that can be used for weed control series of mosquitoes eating fish used in big control of malaria vectors and parasite

- **Provision of essential fatty acids**

(EFA) Aquaculture is excellent sources of omega 3 and 6 fatty acids needed by Humans for good health The importance of these fatty acids have been noted In immunity enhancement reproductive performances development of fetus The EFAs are also very important for prevention of cancer and heart disease

- **Provision of jobs and development**

Good source of employment Aquaculture employs millions of people Aquaculture has also opened avenues of many service industries like in areas of aquaculture engineering feed and nutrition medicine and drug civil and etc. construction etc.

FAO 2006 noted that in sub-Saharan Africa alone aquaculture offers employment directly or indirectly to over 6-9 million people

- **Foreign exchange earning**

Good foreign exchange earner Many aquaculture products are exported from one country to the other Asian countries lead in export markets of aquaculture Seafood being the most common food all around the world. Aquaculture help us learn more about fish and seafood, and in the future help us to rebuild some of our wild fish stocks. Product of the same size, color and taste can be supplied to meet the needs of buyers Helps to develop genetically engineered species like transgenic fish.

(1) High Productivity:

In comparison to agriculture or veterinary practices, aquaculture has been found to be more productive.

(2) Integrated Farming:

Aquaculture with agriculture, horticulture or animal husbandary is found to be more profitable,

(3) Recycling:

Aquaculture gives efficient means of recycling domestic and/or agriculture wastes and thus, helps in protecting our environment.

(4) Rural Development:

Aquaculture helps to integrate rural development by generating employment opportunities and would thus help to arrest the exodus of population from rural to urban areas.

(5) Intensive Fish Culture:

In aquaculture practice, owing to the fishes three-dimensional utilization of the water body can be crowded more closely (200/ m3) and grown through water recirculation system. This gives high yield of about 25 t/ha/year.

(6) Earning Foreign Exchange:

Commercially important items, such as ornamental fishes, Artemia cysts, prawns, lobsters, crabs, frog legs, etc., produced through aquaculture are highly valued and can earn good foreign exchange.

(7) Ranching:

Fish seeds and larvae of economically important fishes of capture fisheries are artificially recruited in fish hatcheries through aquaculture, called ranching or aqua range farming. It is commonly known as “culture based capture fishery” and involves restocking of the wild stock for harvesting. This process has replenished the dwindling stock of rivers and seas.

(8) Replenishment of Coral Reefs:

Coral reefs that have been destroyed naturally or anthropogenically are being replenished through construction of artificial coral reef.

(9) Creating Leasure-Time Activities:

Leasure- time activities can be maintained through sport fishing and creating home and public aquaria.

(10) Mariculture and Fisheries Enhancement:

In many reef areas the use of mariculture is fast growing. It provides an alternative source of income and employment in coastal areas.

Replenishment schemes of species that has been greatly diminished has been undertaken in certain areas. This has been useful for returning species such as giant clams and trochus to reefs where they have been largely or completely exterminated by overfishing.

(11) Promoting Agro-Industrial Development:

Aquaculture can promote agro-industrial development through:

(i) Processing and marketing of fishery products, feeds and equipment for aquaculture,

(ii) Seaweed culture for the production of marine celluloids, and

(iii) Pearl oyster culture, etc.

Types of cultures

Aquaculture practices are classified in several ways, depending upon the different aspects and based on the different factors involved in aquaculture.
Situations involved in the culture practice. Some major and important classifications are given below

On the basis of salinity

- Freshwater farming
- Brackish water farming
- Marine water farming

On the basis of intensity

- Extensive fish farming system
- Semi-intensive fish farming system

Intensive fish farming system

On the basis of fish species

- Monoculture
- Polyculture

On the basis of enclosure

- Pond culture
- Cage culture
- Pen culture
- Race-way culture

On the basis of integration

- Agriculture cum fish farming
- Animal husbandry cum fish farming

Some other aquaculture

- Zero water aquaculture
- Air-breathing aquaculture

Freshwater aquaculture

Fresh Water Culture Systems Cultivable organisms are cultured in different types of culture systems. Many culture systems are based on traditional ideas that have been used for years, but some encompass new and some times radical concepts that make them unique. There are three major culture systems - open, semi-closed and closed culture systems. Each has its special characteristics, advantages and disadvantages. The choice of system is largely dependent on the function of the organisms to be grown and the resources and ideas of the farmer.

Introduction of fresh water aquaculture

environment as the fish farm. Natural resources can be used as culture systems and organisms to be cultured are stocked in the water body. Capital expenses are low for the open culture systems. There is less management than in the other systems. The conditions are more natural and uncrowded in the culture environment, less time

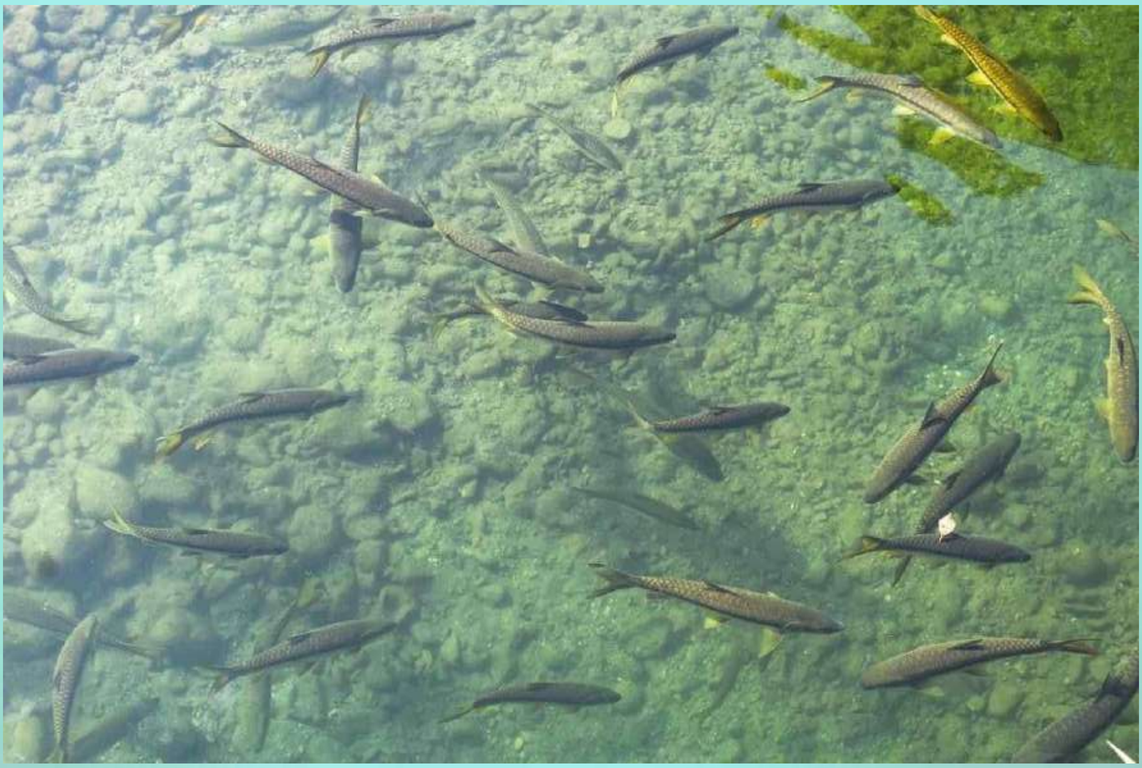
Is required in monitoring the condition of the culture organisms in open systems. The disadvantages like predation and poaching are common. The growth rate and the uniformity of the product are variable compared to other systems. Cages, long lines, floats, rafts, trays and clam beds are examples of open system techniques.

Brackish water farming

Brackish water is defined by its salinity having a salt content between that of freshwater and seawater. Freshwater typically has a salinity of 0.5 parts per thousand while sea waters salinity is approximately 35 parts per thousand Brackish water aquaculture is a form of coastal aquaculture that raises aquatic species in water with a salinity that mixes freshwater and seawater. This type of ecosystem exists where rivers empty into the ocean and in coastal marshlands Much of the brackish water aquaculture focuses on species of brackish water shrimp.

Brackish water aquaculture, system benefits and importance

Brackish water fish farming is an aquaculture system that focuses on the production of standard art and shellfish that are found in canals, lakes, and streams through rational rearing. It has the potential to bridge the gap between demand and supply of fish. Brackish water is a mixture of fresh and saltwater that



Is commonly found in estuaries, and its salinity is usually between 15 and 30 per thousand, depending on rainfall and freshwater flow.

Marine water farming

Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater.

What is Mariculture?

An Oyster Farm in New Zealand

• Sustainable mariculture supports food- provisioning needs through practices that can be maintained over the long term. This includes not compromising the water quality in the farmed area and not relying on wild populations to feed or replenish the cultivated species.

Some types of mariculture may impact the delivery of benefits in other goal through habitat destruction, accidental release of non-native species or other factors. Such factors are included as pressures when scoring those goals.

Provides good quality food More efficient than many other forms of food production farms. Humans consume 1% of terrestrial 1° organic matter production-(which totals 1328 tons, & 0.02% of the 82 billion tons of 10 production of the oceans)•

Fish can replace terrestrial animals at ~ the level of feed inputs.- In other words, 100 kilos of feed can produce 30 kilos of fish or 15 kilos of pork.

Extensive fish farming

Extensive fish farming In the most extensive fish farming, the fish feed entirely from the food web within the pond, which may be enhanced by the addition of fertilizer or manure. Ponds (natural or artificial) and lagoons are fertilized to promote the presence of phytoplankton (microscopic plants), zooplankton (mostly small crustaceans) and aquatic vegetation which form the base of the aquatic food pyramid. This encourages the development of marketable animals at a higher yield than that of the natural ecosystem. Common carp and a number of other fish species are still sometimes farmed extensively in the European Union, though fish farming there is predominantly intensive. Extensive farming of carp and tilapia is common in Asia and Africa. For example, one of the most common methods of farming bighead carp (mainly farmed in China) is to grow them in small lakes and reservoirs without the use of feed or fertilizer. The bighead carp are stocked with other fish species at a stocking

density of 150-750 fish per hectare (i.e. 13-67 square meters per bighead carp) which represents about 40-50% of the total number of fish stocked. Bighead carp are also extensively reared in polyculture ponds and pens, where organic fertilizer is usually applied to increase natural food when bighead and silver carp are cultured as major species.

Semi-intensive fish farming

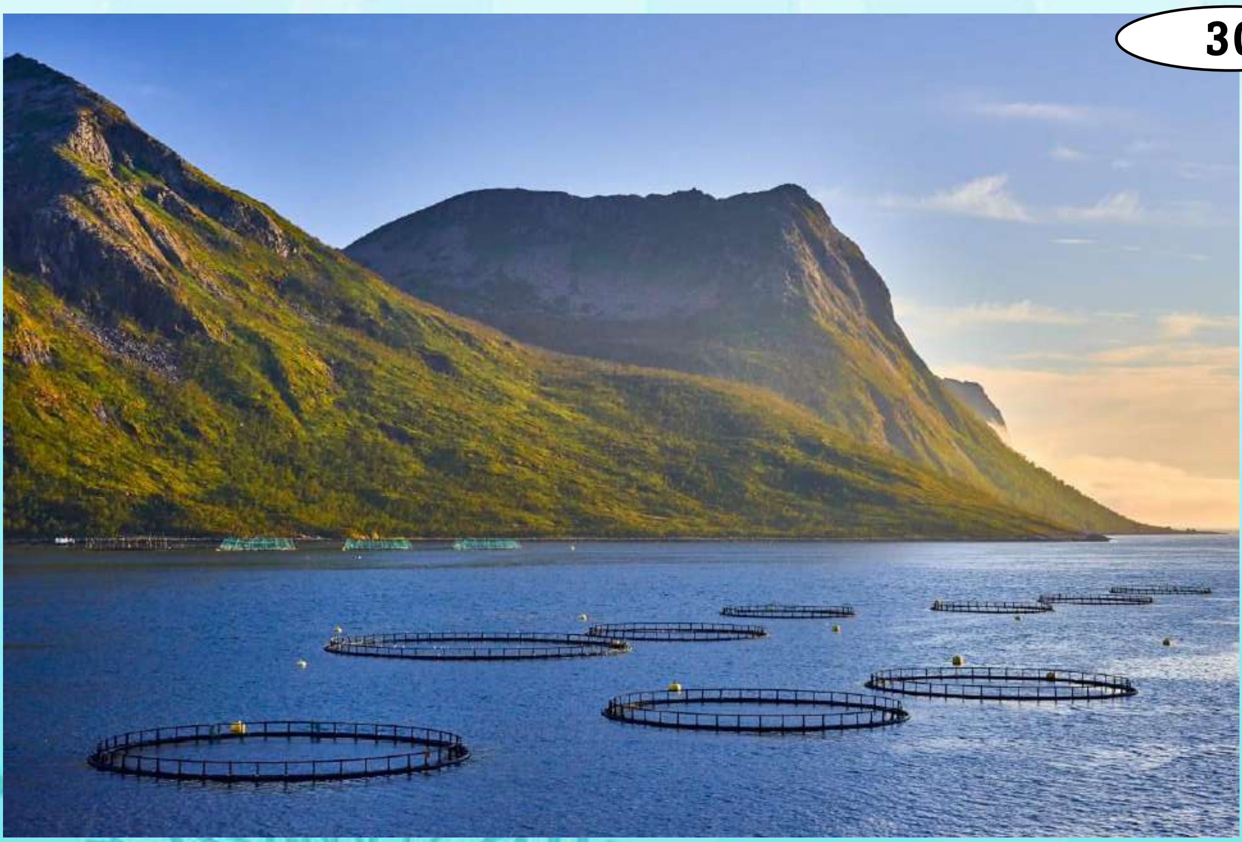
Semi-intensive fish farming In semi-intensive fish farming, the fish still obtain significant nutrition from the food web within their pond, but they are also given supplementary feed. This means the fish can grow faster and/or to a larger size or at a greater stocking density. The feed may be of vegetable origin or may include fish, fish oil and/or fishmeal. Grass carp is the farmed fish species with the highest global production tonnage and is farmed, mainly in China, in both in semi-intensive pond systems and intensively in cages. In semi-intensive farming, the grass carp are stocked in ponds or pens with other carp species (either as a major or secondary species), where aquatic weeds and terrestrial grasses form the main feed. Commercial feeds, such as pellets, and vegetable by-products may be used instead to save labor costs, or at

Specific times of the year when growth of water grasses and algae is reduced. The total stocking density is 750-3,000 fish per hectare (i.e. 3-13 square meters per fish).

Intensive fish farming

Intensive fish farming In intensive farming, the fish are kept at too high a stocking density to obtain significant amounts of feed from their environment. Instead the fish are dependent on the feed provided and water must be replenished at a high rate to maintain oxygen levels and remove waste. The levels of feed inputs and management of the water affect the stocking density of the fish that can be supported.

In the EU, 80% of farmed fish production comprises the following four species that are predominantly intensively farmed: rainbow trout's (reared both in freshwater and at sea) and marine fishes Atlantic salmon, gilthead sea beam and European seabass. In Norway, Atlantic salmon and rainbow trout represent 98% of farmed fish production. Marine fish and rainbow trout are dependent on fish meal and/or fish oil feed. Together they form a relatively small proportion of farmed fish production tonnage, but consume a large part of the global fish oil and fish



meal consumed by aquaculture (see use of fish oil and fishmeal as feed). The intensive farming of these fish, whereby large numbers of them are confined in a small area, causes a range of serious welfare problems.

Mono and Polyculture

Recently researchers conducted by CIFRI (Center Inland fishery research institute) have revolutionized research institute in India for fishery and net production of about 85,000 kilogram per hectare per year has been achieved in fish production in India. Monoculture fish farming refers to the fish farming where only one type of fish species and breed is raised on a farm, Indian Fisheries

- Global position 3rd in Fisheries
- 2nd in Aquaculture
- Per capita fish availability (Kg.)9.0
- Annual Export earnings (Rs. In Crore)7,200
- Employment in sector (million)14.0

Fish culture

There are two systems of fish culture in commercial fish farming Monoculture and Polyculture fish farming

Monoculture

Monoculture fish farming this refer to fish farming where only one types of fish species and breed is raised on a farm. Advantages of monoculture fish farming easy to monitor individual fish breed performance, there is no undue competition for space and feed.

Disadvantages of monoculture fish farming these includes :

regression in water quality, cannibalism among fish themselves. Overstocking of pond with fish which may leads to diseases outbreak

Monoculture of aquatic animal

It is a branch of animal husbandry involving raising or breeding of animals such as Fin-Fish, shell-fish, oyster shell, clams, cockles, shrimps, crayfish, periwinkles, in a controlled water body to marketable size.

Objectives of monoculture in fish culture

To get maximum amount of production, and to prevent species extinction by over-exploitation,
• High nutrient rich fish cultivation,
• Supply high quality animal protein and vitamin rich oil e.g. cod liver fish oil from cod fish which is rich in vitamin A and D.
• Fish oil used in medicines and in soap making industries for research purposes.

Qualities of cultivable fish species in monoculture

- Should have fast growth rate.
- Should have ability to feed on natural and cheap artificial food,
- Should be hardy and resistance to disease,
- Should be able to tolerate adverse and physical-chemical conditions of pond water,
- Should consume small quantity of food for development,
- Should be of high nutritive value.

- Should be gentle and non-poisonous.
- Should be easily harvested,
- Should be a proliferate breeder
- Can reproduce under confined conditions.
- Should support high population density in pond.

Fish culture is divided into many categories

a) Fresh water fish monoculture.
B) Marine water fish monoculture.
C) Brackish water or salty water fish monoculture (these fishes are acclimatized to fresh water)

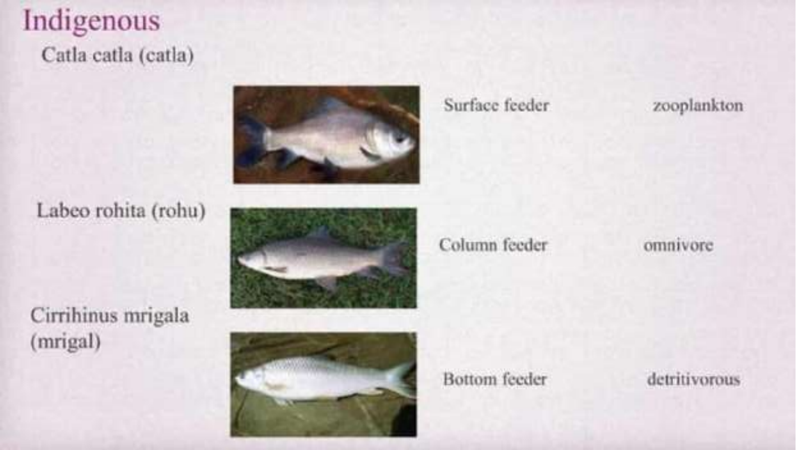
Terms used in monoculture fish farming

Fishery: The study of fish or fishes,
Pond: Artificial body of water where fish where reared,
Fry: Newly hatched fish, Fingerling: Young fish or baby fish.
Hatchery: This is a unit where fish eggs are been hatch artificially into fry, Gears: Equipment's for harvesting fish.

Types of cultivable fish species in Indian system

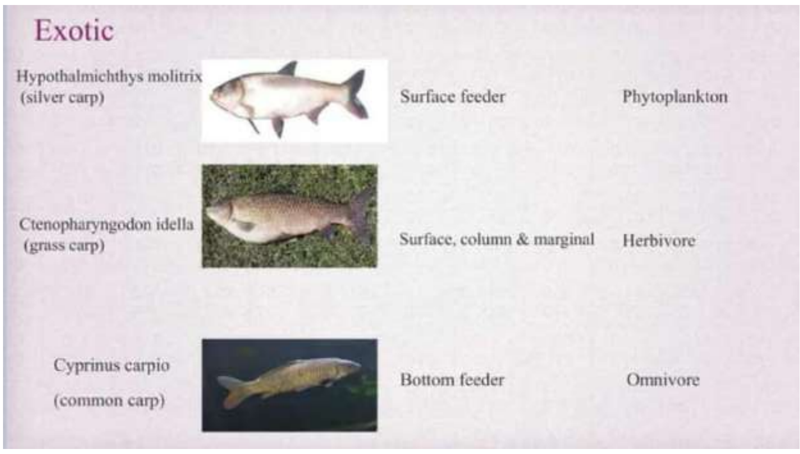
1. Indigenous or Natural fresh water fishes such as Mesocarps like Catla catla. Labeo rohita Cirrhinus mrigala, Labeo calbasu. Cirrhinus cirrhosa and few salt water species

Examples:



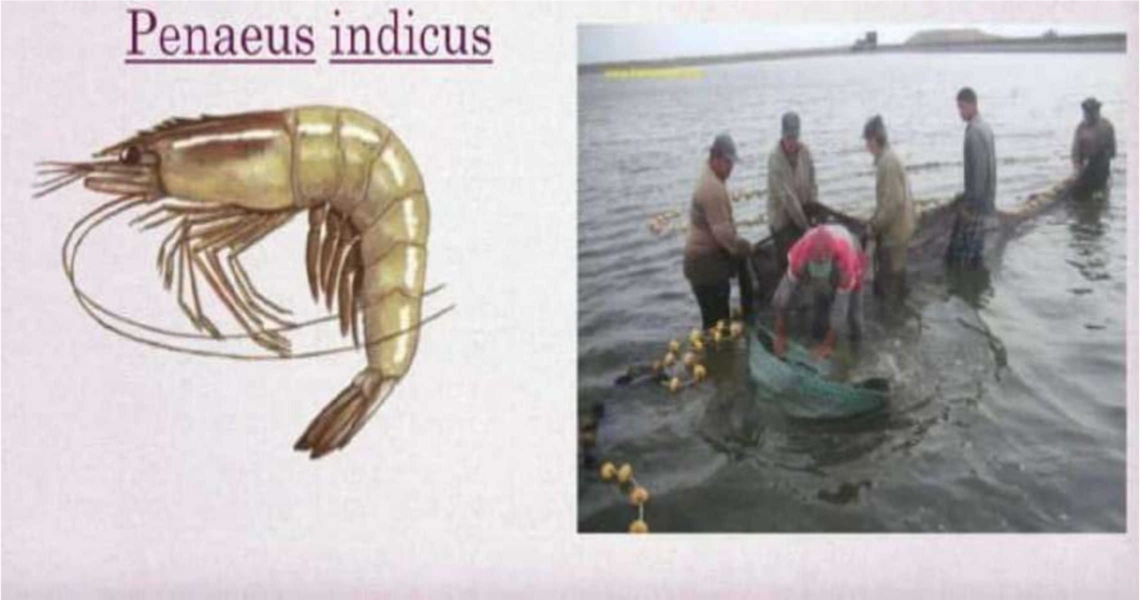
II. Exotic carps: such as. Hypothalmichthys molitrix (silver carp). Ctenopharyngodon idella (grass carp). Cyprinids carpio (common carp)

Examples:



Some examples of Prawn species used in monoculture technique (Penaeus is a genus of prawns, including the giant tiger prawn)

Examples:



Polyculture

In order to obtain high production per half of water body, fast growing compatible species of fish of different feeding habits, or different weight classes of the same species, are stocked together in the same pond so that all its ecological niches are occupied by the fishes. This system of pond management is called mixed farming or composite fish culture or polyculture (Jhingran, 1991). Polyculture, technique of growing at least two compatible aquatic species together in a single pond or lake, has the objective of increasing production using organisms with different feeding habits or spatial distribution (Zimmermann et al., 2009).

Culturing two or more species in one physical space at the same time is known as polyculture. One of the main aims of polyculture is production of multiple products that are economically valuable. It is comprised of combination of animals, plants and animals, aquatic species only, or aquatic and terrestrial species (Stickney, 2013).

In mixed culture the fish usually stocked are a mixture of plankton feeders and macrophyte (waterweed) feeders. In ponds we try to maintain a balance by using both the phytoplankton feeders and the water-weed feeders. Thus, different species fish grazing down both, planktons and macrophytes, are introduced in the pond.

Thus, this can be summarized that –Introduction of fast growing compatible fish species having different food preferences and occupying different ecological niches in ponds/reservoirs to obtain maximum yield by utilizing maximum extent of pond's productivity is termed as composite fish culture or mixed farming or polyculture.

II. Introduction

With the purpose of getting maximum production of fishes from a water body (lake/reservoir/pond) culture of fast growing compatible species of different feeding habits and ecological niches is being practiced in different parts of the globe. This is popularly known as composite fish culture or mixed farming. Term „polyculture" is also loosely applicable for such a culture.

In composite fish culture, all available food supply of the pond (phytoplankton, zooplankton, periphyton, macrophytes, benthos and detritus matter etc.) is most

efficiently utilized by the cultured fishes. Such fishes do not harm each other; rather, they promote growth of other fishes. By proper care and management fish production can be raised by 5-6 times more than usual production
through polyculture. For the ages, mixed fish farming is practiced in China. Chinese system of culture involves Chinese carps viz.,

i. Black carp, Mylopharyngodon piceus that feeds on snails and other molluscs at pond bottom,

ii. Grass carp, Ctenopharyngodon idella that subsists on or macrovagetation,

iii. Silver carp, Hypothalmichthys molitrix, a phytoplankton feeder,

iv. Big head, Aristichthys nobilis that feeds on macroplanktons,

v. Common carp, Cyprinus carpio which is an omnivore,

vi. Bream, Prabramis pekinsis, also an omnivore,

vii. Mud carp, Cirrhinus molitorella, a bottom feeder.

Hora and Pillay, 1962 have recognized following three types of Chinese system of fish culture (Jhingran, 1991):

a) The Kiangsu and Chekiang system -that employs natural climatic conditions of the ponds and available stocking material.

On account of market preference and easy availability of choice food, the black carp is preferred over grass carp in this region.

b) The system of the West River regions-in some parts of South China and the Tonkin Province of Vietnam, stocking strategy is greatly influenced by
the local climatic and ecological conditions. The mud carp, Cirrhinus molitorella, a subtropical species, is preferred over the cold resistant black carp, Mylopharyngodon pieces in these regions.

c) The Hong Kong system- involves utilization of slightly brackish water in ponds and lesser stocking of black and mud carps due to warmer climate. The most striking feature of this system is the use of gray mullets for pond stocking on account of their great local abundance. Indian Polyculture System

In India, initially the multi species culture was started with Indian major carps-rohu (Labeo rohita), catla (Catla catla) and mrigal (Cirrhinus mrigala) alone. Later, the major carps were stocked in combination with calbasu (Labeo calbasu), sometimes with bata (L.bata) and with pearl spot (Etroplussuratensis), gorami (Osphronemus gorami) and acclimatized milk
fish (Chanos chanos). (Sinha, 1985) Alikunhi (1957) have listed an exhaustive list of cultivable fish species in India. As far as

stocking ratio in earliest composite fish culture is concerned, Indian major carps were introduced at different rates

Stocking ratio of different Indian major carps in earliest mixed fish farming

Sl. No.	Catla	Rohu	Mrigal	Reference	Pond area
1.	03	03	04	Alikunhi, 1957	
2.	1975	3750	625	Hora and Pillay, 1962	One hectare
3.	04	03	03	CIFRI, 1960s	@ 3750 per hectare density
4.	03	03	03	CIFRI, 1960s	
5.	01	01	01	CIFRI, 1960s	@ 15,000 per hactare
6.	04	03	03	Chakrabarty et al., 1979c	

Following reasons may be attributed for selection of Indian major carps in mixed fish culture

(1) Catla (Catla catla) being a surface feeds on planktonic organisms particularly zooplanktons.

(2) Rohu (Labeo rohita) is a column feeder, consumes vegetable matter including decaying aquatic plants, algae, etc.

(3) Mrigala (Cirrhinus mrigala) a bottom feeder, prefers decayed plant and animal matter, algae, detritus, organic matter, etc

(4) Calbasu (Labeo calbasu), being a bottom feeder utilizes selectively benthic and epiphytic organisms and organic debris as its feed.

Further, with the advent of exotic Chinese carps, viz, silver carp, grass carp and Bangkok strain of common carp in India, several experiments were conducted at CIFRI, Cuttack to establish their suitability for mixed culture. It was concluded that:

(1) Exotic Chinese carps are fast growing, non-predatory and compatible with Indian major carps.

(2) Exotic Chinese carps always gave better rate of production when they were stocked with Indian major carps rather than when Indian or Chinese carps were stocked alone under identical managerial/material input (Sinha, 1985

Thus, depending on compatibility, feeding habits and preference of ecological niches, a high yielding six species combination , commonly known as composite fish culture was evolved and recommended in India.

Polyculture has further been expanded via addition of new species combinations and pond health boosters, e.g.

i. grey mullets (Mugil cephalus) a benthic-feeder and

ii. Chital (Notopterus chitala) a carnivorous weed controlling fish.

iii. Culture of freshwater shrimp (Macrobrachium rosenbergii) with tilapia (Brick and Stickney, 1979).

iv. Algal blooming is regular problem in ponds and it can be controlled by culturing phytoplanktophagus Silver carp (Islam et al., 2019).

v. Utility of bottom dwelling fishes, e.g., mrigal and common carp in recycling of nutrients to water while digging the base mud while looking for food. Such an activity of bottom tenants additionally circulates air through the water (Rahman, 2006).

Typical six-carp species composite fish culture

Fish	Species	Feeds upon	Trophic Habitat/Feeding habit
Exotic Carps			
Silver carp	*Hypophthalmichthys molitrix*	Phytoplanktons (Plankton feeder)	Surface feeder
Grass carp	*Ctenopharyngodon idella*	Macrovagetation (Hervivorous)	Surface, column and marginal areas
Common carp	*Cyprinus carpio*	Detrivorous/Omnivorous	Bottom feeder
Indian Major Carps			
Catla	*Catla catla*	Zooplanktons (Plankton feeder)	Surface feeder
Rohu	*Labeo rohita*	Omnivorous	Column feeder
Mrigal	*Cirrhinus mrigala*	Detrivorous	Bottom feeder

III. Objectives of polyculture

Polyculture should fulfill the following prime objectives

- **Raising healthy and economically viable fish crop.**
- **Maximum yield or fish production per hectare/ season.**
- **Production of multiple and economically valuable products.**
- **Utilization of full potential of ponds productivity.**
- **Utilization of different types of food available in all available ecological**
- **niches.**
- **Proper financial return to the farmers.**
- **Aggressive marketing strategy.**
- **Appropriate ecological balance of the pond.**
- **Acceptance of low-cost feed by culturable fishes.**
- **Preference of compatible and pond fertilizing fishes, e.g. grass carp.**

IV. Advantages of polyculture

(3) Increases employment opportunities.
(4) Intensive polyculture of fish is fully controlled by the farmer.
(5) More fish can be cultivated and produced within a small water body.
(6) Fish polyculture enhances the pond productivity.
(7) Maintains water quality.
(8) No competition among cultured fishes for food and space in the same water body.
(9) Complete utilization of spatio-trophic habitats.
(10) Fishes can be grown as per market preference.
(11) Various species combined in polyculture framework adequately contribute to improve the health of the pond
(12) Defecated semi-digested food of grass carp serves both as a feed for bottom –dwellers and a pond fertilizer with high cellulose-digesting microbes.
Thus, this species has the ability to promote synergestic composite fish culture (Jhingeran, 1991).

Pond culture

It is the most common method of fish culture Water is maintained in an enclosed area by artificially constructed ponds where the aquatic animals such the finfish and shellfish are reared. The ponds may be filled with canal water rain water bore well water or from other water sources The pond must be constructed after proper site selection. The climate topography water availability and soil quality of the region influence the character of the fish pond

Based on these factors ponds are primarily of two types namely

1.Watershed pond

2. Levee Pond

Watershed Pond Systems

For watershed ponds water required to fill and maintain them pond water is entirely sourced from the watershed runoff though groundwater (bore well) and surface water (stream and

Reservoirs) can be used as additional water sources

The major factors to be considered are soil type characteristics topography and water supplies

• The soil type influences how well the ponds will hold water mud and mud-silt type soils are preferred for pond construction because it prevents leakage The good quality soil containing a lower limit of 20 percent clay is necessary for making ponds

• The topography determines the size and shape of the ponds The watershed ponds should not be more than 10 feet deep The size of the ponds should be less than 20 acres for better management Sites where huge individual ponds could be built can be divided into smaller ponds built in series The availability and quality of water

Determine where and what type of pond should be made Growing and harvesting are more challenging in watershed ponds than levee ponds due to erratic water supplies unseen bottom and side and size excessive depth of the dug out

Advantages of pond culture include Construction of Pond is inexpensive free water is available and

there is less competition for water from other agriculture activities

Levee Pond Systems

Levee ponds are created in flat land areas where there is inadequate water to fill the ponds from the watershed The groundwater is typically used to fill the pends Prior to building of ponds make sure whether the site is suitable for pond construction by looking at the characteristics of soil type quality and ground water availability The type of soil influence the pond productivity

And life expectancy It is necessary to have 20 percent of clay in the soil to prevent the leakage of the pool The pond topography decides the size of the pond generally rectangular pond size is chosen due to its greater simplicity and ease of harvesting and feeding Curved and irregular ponds are not recommended as it is hard to manage water quality The water quality should also be considered before construction of the pond Levee Pond is suitable for growing and harvesting fish than the watershed pond

Cage culture

INTRODUCTION

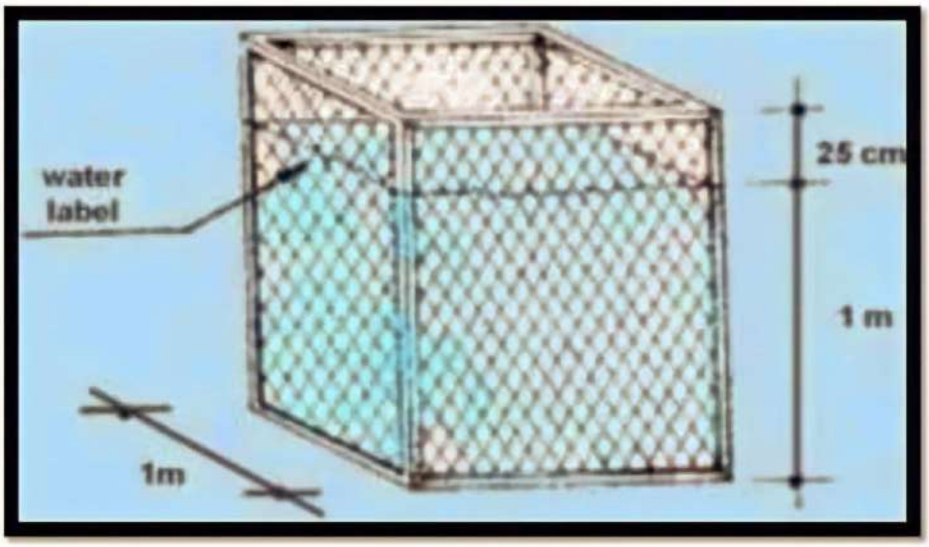
- Culture of fishes in meshed boxes placed in water is called cage culture. It is an intensive method of aquaculture.
- Cage culture is practiced in areas where there is sufficient water movement. It is done in river, estuaries & seas.

cage culture

HISTORY

- Cage culture originated in Kampuchea about 200 years ago.
- Originally cages were used to transport fishes alive from the capture area to the market area.

CONSTRUCTION



COMPONENTS OF A CAGE

FRAME-It can be made up of wood, plastic or steel. Generally plastic is used.

FLOATS-They are made up of empty barrels or polythene balls.• SINKERS-They are made up of stone concrete or metal.

NET- Three types of nets are present inner net, outer net & cover net.

- It is made up nylon, weld mesh or

wooven split bamboo.

STRUCTURE OF CAGE

- The cage may be square, rectangular, circular six sided or eight sided.
- Generally, square and rectangular cages are preferred for culture.
- Normal size of the cage is 20 to 60 meter cube.

TYPES OF CAGES

Based on installation cages are categorized into following types-

- FIXED CAGES- Installed in running water
- FLOATING CAGES- Lakes, rivers & offshore water.
- SUBMERGED&MOVABLE CAGES- Areas affected by cyclone.

Enclosure: an area surrounded by a fence or other structure in order to be kept separate from other areas:

FEEDING

- The water movement bring in nutrients & natural feed.
- In addition artificial feed is also given.
- Example-
  - • Rice bran• Fish meal• Soya bean

Production

Fish production ranges from 3000 to 25,000kg/year in large cages

Pen culture

- ‘Cage culture’ & ‘Pen culture’ both terms are often used interchangeably, particularly in America, where ‘sea pens’ and ‘sea cages’ describe the same method of culture.
- Generally ‘enclosure culture’ is used to describe what more precisely could be defined as cage or pen culture.
- Both cage and pen culture are types of enclosure culture, Le. Holding culturable aquatic organisms in captivity within an enclosed space whilst maintaining a free exchange of water. The two methods (cage and pen culture), however, are distinct from one another.
- A cage is totally enclosed on all sides by mesh or netting, whereas in pen culture the bottom of the enclosure is formed by the lake or sea bottom.

History of Pen Culture

- The origin of pen culture is more obscure, but it also seems to have begun in Asia.
- According to Alfarez (1977) and others, pen culture originated in the inland sea area of Japan in the early 1920s. It was adopted by the People's Republic of China in the early 1950s for rearing carps in freshwater lakes.

Later, introduced to Laguna de Bay and San Pablo Lakes in Philippines by the Bureau of Fisheries and Aquatic Resources (BFAR) and Laguna Lake Development Authority (LLDA) between 1968 and 1970 in order to rear milk fish (Chanos chanos).

- Pens are still constructed at old pattern except that nylon or polyethylene mesh nets have replaced the traditional split bamboo fences.
- The nets are attached to ports set every few meters, and the bottom of the net is pinned to the substrate with long wooden pegs. Buttressing may be used to strengthen the structures in exposed areas.

Where Pens are Built?

• Pens are usually built in shallow (< 10 m) waters, are 3-5 m deep, and 2-7 ha in size. Although, there are much larger enclosures in N. America measuring up to 50 ha and up to 120 ha or more in Japan.

- The areas with too much silt and decomposing organic matter should be avoided.
- The bottom soil should be muddy, clayey, clay-loam or sandy mud with detritus.
- Flow of water should be 0.2-0.5 m/sec. Soft substrates are preferable.

• Pens are formed by damming a bay, an arm of river, lake or reservoir, estuary or sea.

Aquatic Species Suitable for Pens

- The market demand and the availability of seed greatly influence the selection of candidate species for pen culture.
- The main desirable characteristics for enclosure aquaculture are faster growth rate, high survivability, capacity to withstand overcrowding, acceptance of artificial feeds, high FCR, and resistance to diseases.
- Air-breathing catfishes, Tilapia, Murrels and prawns can be cultured in the pens.
- The principal fish species cultured in south east Asian countries like Philippines and China are milk fish (Chanos chanos) and carps viz., grass carp (Ctenopharyngodon idella); Silver carp (Hypothalmichthys molitrix); bighead carp (Aristichthys nobilis).

- Some experimental culture of carps has been carried out in pens in oxbow lakes in Hungary and other countries such as Bangladesh and Egypt have expressed interest in their use.
- The production of tilapias in net pens is also being evaluated in Philippines.
- Generally, the fish species which are herbivores or detritovores, fast growing and tolerant to salinity changes in coastal areas are preferred the most. Chanos chanos (milkfish), Mugil sp, and Etroplus suratensis are highly suitable fish-species for mono or polyculture.
- Some carnivorous fish species, viz., Lates calcarifer, Polynemus tetradactylum, Elops sp., Megalops etc. may also be stocked in separate pens.
- Apart from fishes, certain species of prawns and edible clams may also be culturedin pens.

Stocking Density in Pens

The stocking density of fish or shell fish for pens may range from 10-100 individuals/m.2

Raceway culture

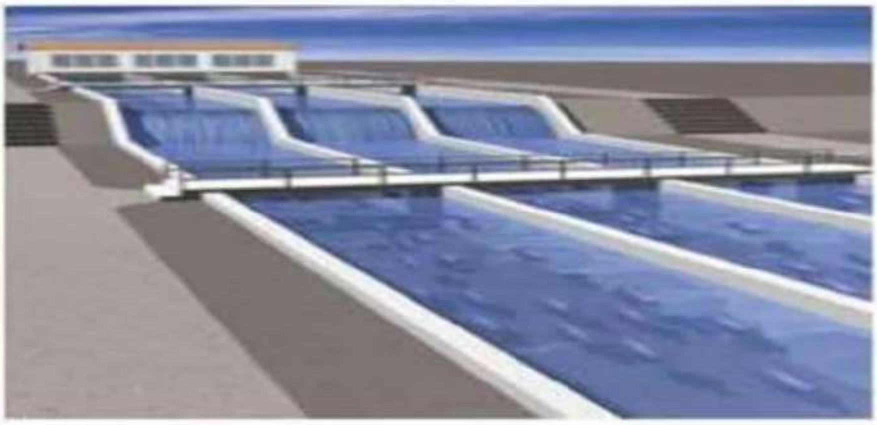
Flowing water is diverted from natural streams or a well. Raceways are typically used for raising rainbow trout. To be considered a low-risk method, waste must be treated and fish escapes prevented.

Advantages of raceways higher stocking densities

- Improved water quality reduced Manpower
- Ease of feeding
- Ease of grading
- Ease of harvest
- Precise disease treatments
- Collection of fish wastes

Types of Raceways

- Concrete
- Stone
- Earth
- Fiberglass
- Polyester resin



Raceway Structures

• Structure should be like that where.......
 Water should be move easily•
 Must be attached with
• Stream
• River
• Canal

Raceway pond

• Different raceway ponds available like for
• Fry culture
• Marketable production of trout
 Brood stocking

Fry culture

 Depth should be 30cm
 Slope should be 1/100
Width of raceway 1.5m
 Length of raceway should be 10-20m
 Inlet and outlet should be cover with gauze

Market production

Depth should be 60cm o Slope should be 1/100

Width should be 3m or less

Length 10-30m

Inlet or outlet according to the fish size to escape from pond

Brood stocking

Depth not less than 90cm. Slope 1/100. Width 2m Length 20-40m

Concrete silo

- Used for trout production
- Diameter 2-10m
- Bottom slope 5-10% for waste removal

Outlet located in center of concrete silo

Requirement of system

- Water supply
- Aerations
- Removal of solid waste matters
- Productivity
- Waste water treatment

Water supply

- Jet nozzle

o Provide force

o Water movement

o Above surface of water

o Or below to water

o Not at bottom because they uplift waste

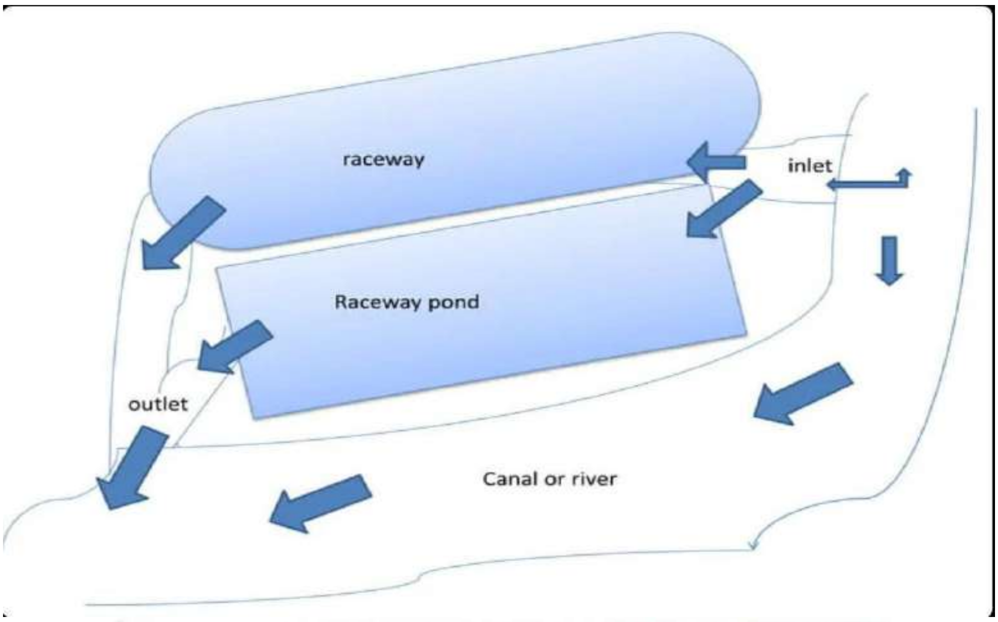
- **Aerations**
- Aeration compulsory for dissolved oxygen
- Different mechanism used like
- o Pumps
- o Agitators
- o Blower

Removal of solid waste

• Waste accumulation spoil water quality waste removed by Sucking machine

Increase water flow o Water velocities over 7-8cm/sec are found to be effective for the waste removal

Lowered water level down to 30 cm in depth makes the removal more effective



Duck cum fishery farming

Problems of present scenario Decline in agricultural growth rate• Decline in factor production. • Static or decline in Food production. Increasing malnutrition. Shrinkage in net cultivable area. Increasing environmental pollution. Depleting ground water level. Increasing cost of production. Low farm income.

Solution: INTEGRATED FARMING SYSTEM

What is Integrated Farming System??

According to pillay (1990): basic principle is utilization of the synergetic effects of inter related farm activities and conservation, including the full utilization of farm waste. It is based on concept that 'there is no waste' and 'waste is only a misplaced resource.' which become valuable material for another product

Types of Integrated Fish Farming systems:

Types of IFFS Agri-Fish System

- Paddy
- Horticulture

mushrooms

Sericulture

Vermi compost

Livestock –

Fish system cattle
Pig
goat or sheep
Duck Poultry
Rabbit.

What is Integrated Duck-cum Fish Farming system?

In this system the rearing of duck is combined with fish culture by constructing duck housing units on the pond embankment or over the pond in such a way that the wastes are directly drained into the pond.

This integrated farming of fish and duck can be divided into 2 groups:

- 1)Fish culture practice

2)Duckery farming practice

Species

Aquaculture producers farm about 622 species and species items, a term that includes groups of organisms not identified to species level such as family or 'not elsewhere included' (nei) groups such as tilapia nei or freshwater fishes nei.
This total includes 387 finfish species or species items (including hybrids), 111 molluscs, 64 crustaceans, seven frogs and reptiles, ten miscellaneous aquatic invertebrates, and 43 aquatic plants.
This contrasts with terrestrial (land-based) agriculture where only about 38 species of livestock and 173 species of crops are farmed.
However, the terrestrial agriculture sector farms many more farmed types, including breeds and varieties. For example, there are over 100 000 varieties of rice curated by the International Rice Research Institute in the Philippines and around 8 800 livestock breeds. The total number of commercially farmed aquaculture species items recorded by FAO has increased by 31.8 percent, from 472 in 2006 to 622 in

2018 (FAO, 2020b) while recent studies have revealed about 250 more species being farmed that are not being reported to FAO during routine data reporting of aquaculture production (FAO, 2019a). Terrestrial agriculture has created hundreds of genetically improved breeds and varieties while there has been relatively little genetic improvement for most farmed aquatic species meaning that the wild type is still the most often farmed type (FAO, 2019a).

Notable exceptions are the numerous strains of common carp, tilapia, channel catfish, and the hybrids and polyploids used in aquaculture (FAO, 2019a).

Farmed aquatic plants accounted for 32.4 million tonnes (wet weight) in 2018 or about 28 percent of total aquaculture production (FAO, 2020b).

Marine algae is the main group and they are being farmed in over 50 countries.

Asia also leads the world in aquatic plant production although Chile and United Republic of Tanzania, Zanzibar also feature among the top ten producing countries while Indonesia, the second highest global aquatic plants producer, where production grew rapidly between 2004 and 2014 (FAO, 2017a), has recently experienced declining aquatic plant production

Species used for aquaculture

Trachysalambria curvirostris
Animal

Placopecten magellanicus

Nile tilapia

Araucanian herring

Narrow-barred Spanish mackerel

Cape horse mackerel

Blue whiting
Fish

Gulf menhaden

Yellowstripe scad

Silver cyprinid

Giant salmon fish

Iridescent shark

Cirrhinus mrigala

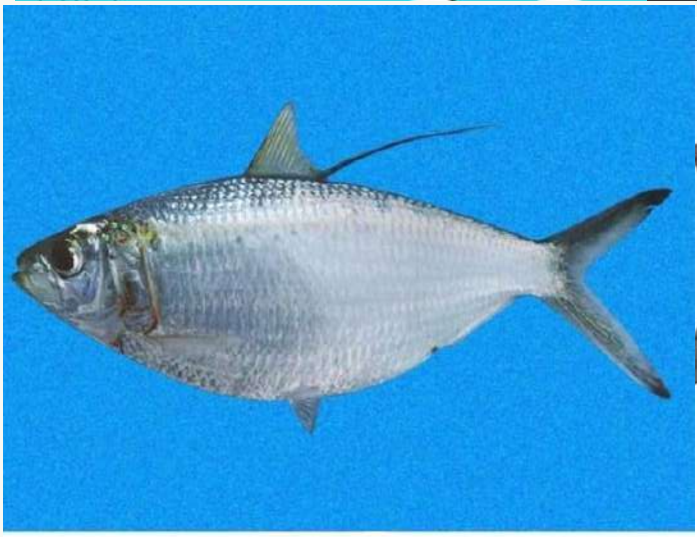
Siniperca chuatsi

Starry tiggerfish

Chilean jack mackerel

Longtail tuna

Tachysurus fulvidraco



Pacific thread herring

Rohu

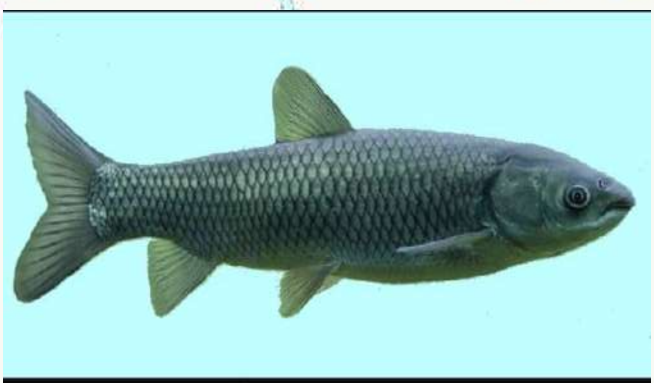
Scissortail sergeant

(Abudefduf sordidus)

Sinonovacula constricta

Indo-Pacific sergeant / Sergeant-major

Rareness : ★★★★★



Black carp

Silver carp

Ablayas binotatus

Grass crap

Atlantic horse mackerel

Rainbow trout

Nile perch

Acetes japonicus

Process

LOCATING YOUR FISH FARM

- Where to put your fish pond
- Water supply
- Soil quality
- Testing soil

CONSTRUCTING FISH PONDS

- How large should your pond be?
- How to build a 20 by 20 metre pond
  Building bigger ponds

INLETS TO LET WATER INTO THE POND

- Simple inlets
- A better inlet

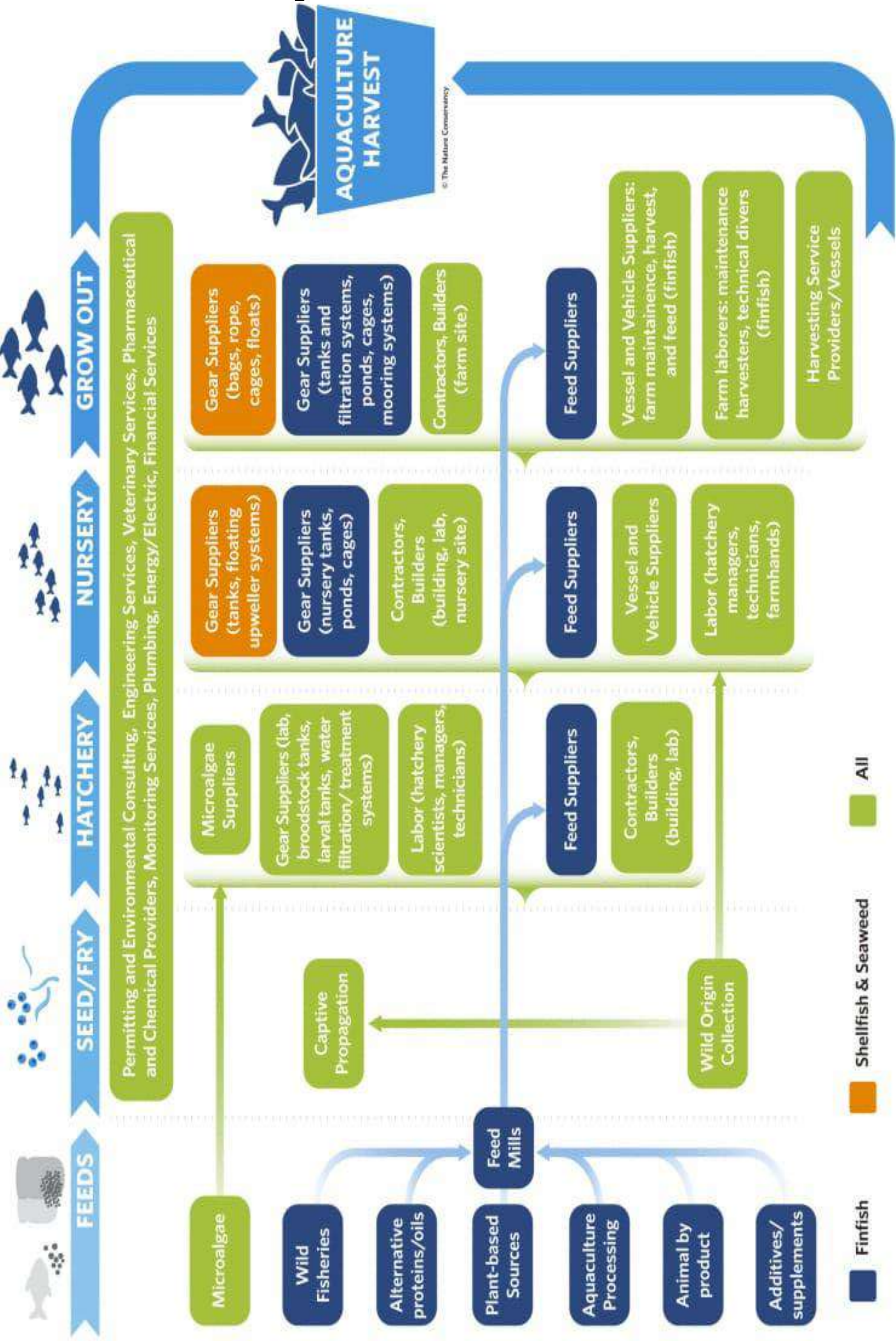
OUTLETS TO LET WATER OUT OF THE POND

- Simple outlets
- A better outlet
- Another kind of outlet: the monk
- Improving your pipe outlet
- Using a siphon to drain your pond

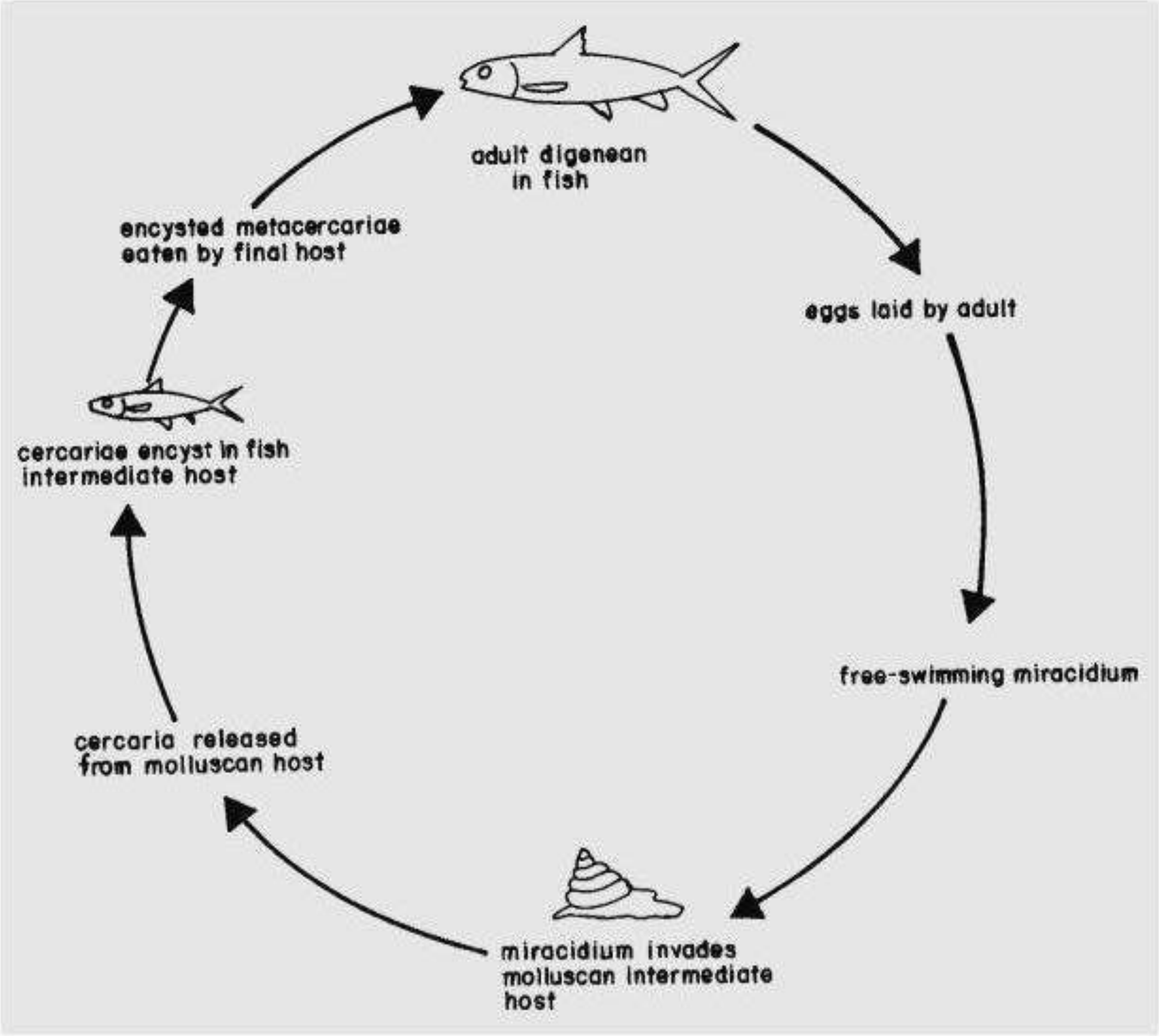
BRINGING WATER TO YOUR PONDS

- Raising the level of your water supply
- Digging a supply ditch
- Digging a return ditch
- Building a sluice to control the water flow

Fish production Cycle

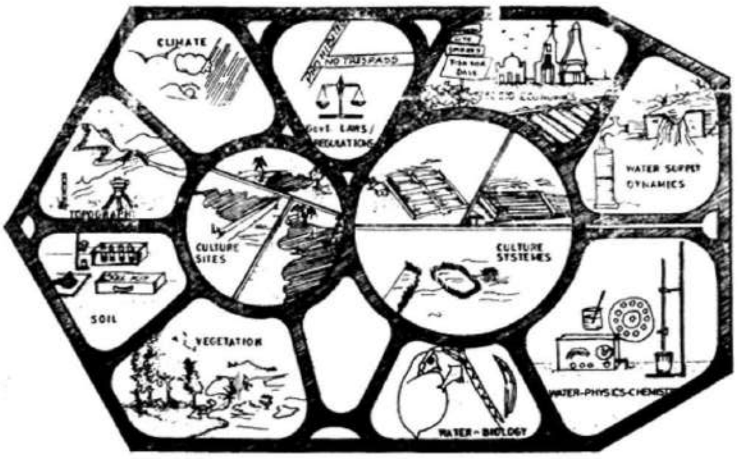


Fish life cycle



Site selection

Several types of water bodies can be used for fish culture - the choice of a specific body would depend on the objective of the investors and also the type of aquaculture. Among the sites suitable for aquaculture could be listed: land-swamps, rivers, stream beds; coastal areas - bays, estuaries backwaters, lagoons, salt marshes and mangrove swamps; lakes, reservoirs and other water bodies, including irrigation tanks and canals. The specific site to be chosen would be based on the requirement of the culture systems. Static water ponds are the most common, hence pond culture the most important system. Most of these are confined to freshwater areas, but Brackishwater ponds are also becoming more common. There is a variety of culture systems which can be developed in open waters - the stocking and management of open waters themselves being major occupation, e.g. extensive stocking of man-made reservoirs and lakes. In the larger freshwater bodies and coastal areas cage and pen culture can be developed. Site selection for these culture systems has to be carefully done, based on the requirements of the species to be cultured and the structures to be erected for the culture. Here and in the culture systems where closed systems are used, the inputs required can be costly and management intensive. Thus there can be gradation of culture, systems based on the input costs and management strategy employed, from extensive, through semi-intensive to intensive.



3. Culture types (Systems)The different culture systems in vogue are listed below:

static water ponds, running water culture, culture in recirculation systems (closed or reconditioned water);culture in rice fields and integrated culture systems, as the duck-cum-fish and pig-cum-fish culture - or any fish-livestock-crop combination; culture in raceways, cages, pens and enclosures; also mollusc/oyster culture - hanging, on-bottom and stick methods. As mentioned already the choice of site for a specific culture system, would depend on the characteristics of the site and the requirement of the culture system - the latter again has two components, the species requirements and the structural requirements of the culture system. will be made out in later discussions, there is a limit for this increase in fish production under the set of conditions. These limits are set by the prevailing environmental conditions. Most of the complex culture systems are often attempts to overcome these limits, or changes made for culturing required species, not necessarily at the ‘peak’ productivity level, due to other reasons referred to the static water bodies have built-in limits due to the finite volume of water and deteriorations of water quality with increase in biomass per unit volume of water. Water quality improvement can be effected by incorporation of costly aeration or by changing the water; the latter leading to running water culture systems or culture in recirculating and closed water systems. Again use of natural running or moving water in water bodies for intensive culture (high biomass per unit volume of water) is done in pen and cage culture. How do the fish and environment interest in each of these culture systems? What are the advantages and disadvantages of each culture system? What should be the consideration of the site and the species (species selection) in each case? We will discuss these in detail

When each culture system is taken up, in the present course. As stated before, the choice of site and species (“Selection of species for aquaculture”) and a specific culture system should not be on technical considerations alone, but should be on total considerations of technical and non-technical aspects, the latter concerning socio-economic, legal and political factors.

TECHNICAL AND NON-TECHNICAL CONSIDERATIONSIN SITE SELECTION

At this point it must be made out that the objectives of producing fish in a culture system should be clearly spelt out (see “Introduction to aquaculture” and separate discussion on “Criteria for selection of species for aquaculture”.) While the acceptance or preference of the local community would be of prime interest in producing fish for local consumption, the acceptability of the target group to whom the fish are supplied, in some cases, even by export, is of major interest. But

On side ration of other socio-economic aspects such as infrastructure facilities for post-harvest treatment of product including marketing, manpower quality and quantity, could be same, if the fish produced is for local (same province/country) consumption or export outside the country. Similarly relative merits or demerits of the specific site, with reference to availability and cost of materials and equipment for farm construction and subsequent needs for renewals in the farm structures and also for the maintenance of the farm, e.g. supplies of feed stuffs and fertilizers, should also be considered.

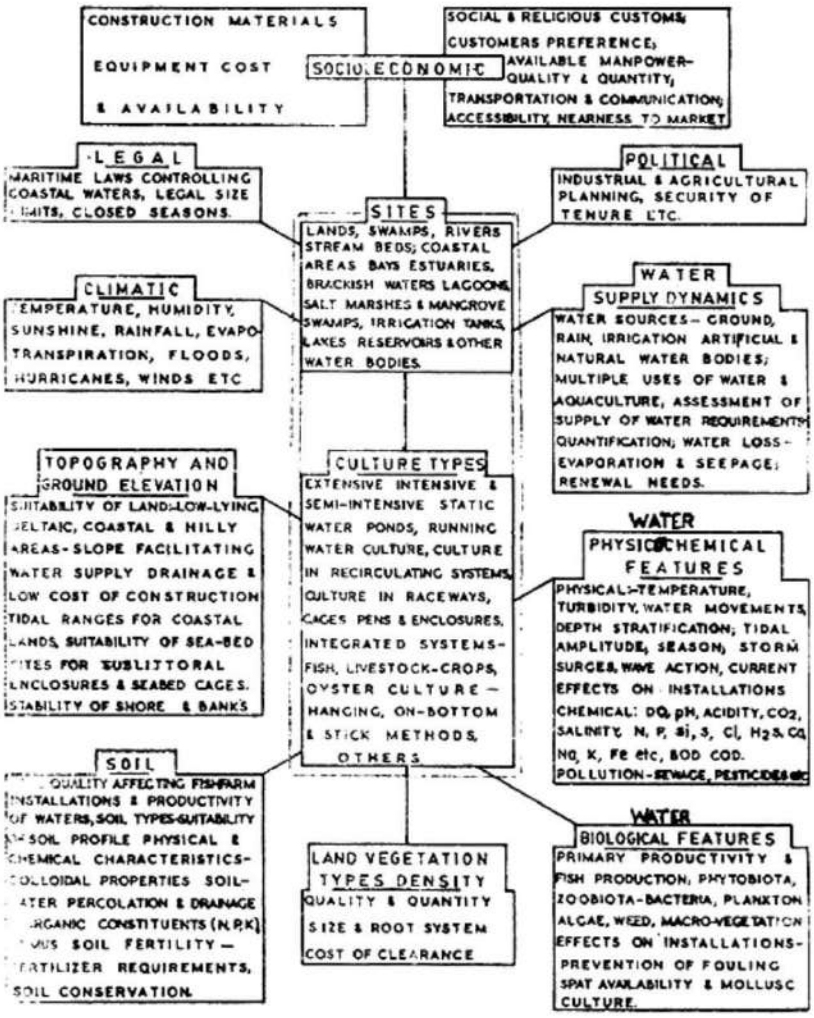
4. Political and legal considerations

The aquaculture project execution should be a part of the overall planning for the specific area under the national plan for development, so that the project can fit into the country's or provincial plan for development of industry and agriculture. This is specially needed when aquaculture is a part of rural development programme, as indeed most such projects are. This should specially help in sharing infrastructural facilities of transportation (road), power supply and communications and also in judicious sharing of imports and recycling outputs. The advantages of their consideration in siting a project are obvious. We shall look into these aspects of macro-economic planning subsequently when “socio-economic aspects” and “aquaculture planning” are discussed in detail. Legal aspects, such as security of tenure, maritime laws controlling coastal waters (in cases where sites are coastal), legal size limits with reference to the ponds/culture area, as well as the species under culture, and closed reasons, should also to be considered. Several countries already have certain regulations concerning these legal aspects, some of which are in force, much before aquaculture was thought of as an industry. In many cases these legal clauses cannot be easily modified, even though some attempt in this direction would be necessary, especially with reference to size-limits of fish and closed seasons. The latter regulations have been included to protect the species' survival under intensive capture systems of wild stock. While this protection may be necessary for such a case, here in aquaculture, capture from the wild fish of certain size, when the season for capture is closed legally, is only for protection of the fish by way of transferring the fish to culture ponds - either as brood fish or as fry or fingerlings in grow-out ponds. In some cases

Maritime areas through which navigational routes and certain other country priorities exist. These aspects should be considered in choosing the site for the aquaculture ventures planned.

5. Climatic and other main environmental factors

The sub-topics, climate, topography and ground elevation, soil, water supply, physical and chemical features of water, productivity, vegetation - aquatic weeds etc, will be discussed separately in detail, under the subject of site selection for aquaculture. It will be realized that much of these discussions involve several basic aspects of ecology and we have attempted to provide information of value in selection of site, at this level. "Topography and ground elevation”, would lead to the construction of pond farms (a subject covered in detail, separately in the present course) and several aspects of environment discussed, have corresponding sections in “Selection of Species for Aquaculture” (also forming separate subject in the present course), for an environmental factor can be discussed only with reference to the effects it can have on the species. As we already pointed out, site environmental requirements for a culture system are the requirements of the species to be cultured.



Suitable Water temperature for aquaculture

Water temperature in aquaculture

Aquatic animals are strongly affected by temperature, and aquaculture production must often be timed to correspond to water temperature, particularly in outdoor operations. An important variable around which operations are often timed water temperature Aquatic animals are strongly affected by temperature, and aquaculture production must often be timed to correspond to water temperature, particularly in outdoor operations. Photo by Darryl Jory. The atoms and molecules of a mass of matter to which energy is added vibrate faster and move slightly farther apart. The heat content of matter is a result of energy of the movements of atoms and molecules. Temperature is simply an indicator of how warm an object is as a result of its internal energy (or heat) content. It is a measurement that man developed and uses to assess how hot things are. A thermometer responds to the average kinetic energy of the molecules within a substance. Sunlight is composed of photons (small particles) of energy. When sunlight passes through water, the energy in the light is transferred to water molecules increasing their heat content and causing the water to warm and its temperature to increase. Of course, energy also can be transferred to water by contact with a hot object, because energy (heat) in the hot object will be transferred to the cooler water by conduction.

Relevance of water temperature

The temperature of water is an important variable in aquaculture, but in most types of aquaculture it cannot be controlled and depends upon the amount of solar radiation, air temperature, or the temperature of water passing through the culture unit. Aquatic animals are strongly affected by temperature; aquaculture operations must be timed to correspond to water temperature, and temperature measurements are critical for efficient operations. Temperature is an important factor effecting the growth and survival of all organisms. However, water temperature is especially important to the growth and survival of shrimp, fish, and other aquaculture animals, because they are poikilothermic (coldblooded). Poikilothermic animals cannot control body temperature, and they equilibrate with the temperature of the surrounding

water. Aquaculture animals usually are classified as Coldwater, warm water, and tropical species. Coldwater species will not tolerate temperatures above 20 to 25 degrees-C. Warm water species will usually not reproduce at temperatures below 20 degrees-C or grow at temperatures below 10 to 15 degrees-C, but they survive much lower winter temperatures. Tropical species will die at temperatures of 10 to 20 degrees-C, and most do not grow at temperatures below 25 degrees-c. Temperature ranges given above are very general, and each species, whether Coldwater, warm water, or tropical has its characteristic temperature requirements. There is a low temperature below which fish die, at slightly higher temperature, fish live, but they do not grow or grow very slowly. At a certain temperature, growth will increase rapidly with increasing temperature until the optimum temperature is reached. As temperature rises beyond the optimum temperature, growth will slow, cease, and fish will die if the increase continues.

Effect on organism growth

Growth involves many metabolic and biochemical processes, and rates of these processes tend to increase in accordance with van't Hoff's law. This law states that chemical reactions will double or triple with each 10 degrees-C increase in temperature. As a result, in the temperature range within which growth increases rapidly with greater temperature, a 10 degrees-C increase in temperature will greatly increase growth rate. In biological applications, the van't Hoff's law effect usually is referred to as the temperature coefficient or Q10 In most aquaculture systems temperature cannot be controlled. There will be daily fluctuations in water temperature, seasonal trends in water temperature, and changes in water temperature related to weather patterns that may occur in any season. Moreover, culture animals may be stressed by factors other than temperature and grow slower than expected for the culture system water temperature.

A nice example of the above relationship is shown in Table 1 using data published years ago by Ji-Qiao Wang and colleagues. Carp were held under controlled temperature considered optimum for growth, but the salinity of the water was varied. Although temperature was near optimum, growth declined as salinity increased. Nevertheless, water temperature is a fundamental factor influencing growth, and aquaculture species should be selected to have temperature requirements allowing near optimum growth for the water temperature range at a particular production facility. Obviously, one cannot expect optimum temperature continuously, but periods with temperature deviating far from optimum will decrease production potential.

Salinity	Food energy recovered as fish growth (%)
0.5	33.4
2.5	31.8
4.5	22.2
6.5	20.1
8.5	10.4
10.5	-1.0

Temperature has another important effect in ponds and in lakes for cage culture. The density of liquid water increases from 0 to 4 degrees-C and then decreases as temperature rises further. This results in ice floating, water bodies not freezing solid, and it causes surface water to heat faster and become less dense (lighter) than deeper water. This temperature-density dependence of water causes less dense surface waters, in which there is light for plants to produce oxygen through photosynthesis, to float on top of deeper, un-illuminated water. This phenomenon, known as thermal stratification, separates the upper layer of water from deeper water, because wind action is not powerful enough to cause them to mix. Dead plankton settles to the bottom, but oxygen from the upper, illuminated layer cannot mix with the deeper layer because of thermal stratification.

This results in dissolved oxygen depletion in the deeper water. Destratification may occur as a result during cool periods or following intense rain and heavy wind that causes surface and bottom layers to mix. This phenomenon is commonly called on overturn, and the mixing of the deeper water with surface water can lead to dissolved oxygen depletion and fish mortality.

Aquaculture ponds usually are intentionally made shallow. They may stratify briefly during the day, but they mix at night when heat from the surface water is lost to the air by convection. Water currents caused by mechanical aerators in ponds also prevent thermal stratification.

Other effects of temperature

Temperature has other effects, because phytoplankton and zooplankton also respond to water temperature. Warmwater also favors greater rates of chemical reactions, and fertilizers and liming material applied to ponds will dissolve faster. Dissolved oxygen concentration in water at equilibrium with air decreases as water temperature rises. This in itself is not troublesome to fish, because they respond to the pressure or percentage saturation of oxygen in water. Two freshwaters, one at 20 degrees-C containing 9.08 mg/L dissolved oxygen and the other at 32 degrees-C containing 7.29 mg/L dissolved oxygen are both saturated with dissolved oxygen. Although the cooler water contains more dissolved oxygen, both water are at 100 percent saturation. Although the fact that warmer water holds less oxygen at saturation than does cooler water does not directly cause a problem, the respiration rate of all aerobic organisms increases with higher temperature. The culture species, phytoplankton, zooplankton and bacteria require more oxygen of respiration at higher temperature but from water that contains less dissolved oxygen. This is why dissolved oxygen depletion becomes a greater threat to the well-being of aquaculture animals as water temperature increases. Temperature has some other impacts on ponds. Because warmer temperatures favor plankton growth, more carbon dioxide and bicarbonate will be removed from the water for use in photosynthesis than at lower temperature. This leads to greater fluctuation between nighttime and daytime pH, but usually this phenomenon does not affect the culture species appreciably. There are several minor effects of temperature in aquaculture ponds that deserve mention. Warmer water has a lower viscosity than cooler water, and lower viscosity favors settling rates of suspended particles and seepage of water through pond soils. Suspended

clay particles settle faster and more water seeps from ponds at higher water temperatures. Evaporation rate also increases with greater water temperature, and gas transfer by mechanical aerators also is favored by increasing water temperature.

Fertilizers

Introduction

The primary productivity of ponds can be augmented by increasing the availability of plant nutrient through Fertilizer application.

Substance that increase nutrient concentration to enhance plant growth are called fertilizers and Manures.

The term manures usually is reserved for animal excreta and Agricultural by-products used as fertilizers.

Relatively purified compounds that contain Nitrogen, Phosphorus, Potassium or other nutrients are called chemical fertilizers.

Fertilizers are mainly inorganic and are manufactured materials.

Manures are organic (made from plant and animal wastes).

A fertilizer or manure contains one or more of the essential elements e.g. N, K, P, Ca, Mg etc.

Primary production of aquaculture ponds by increasing the availability of plant nutrients through fertilizer application.

The manures also enable a soil to hold more water.
Organic manures increase the organic matter in the soil.
The manures where it is organic nutrient are broken down complex - simple forms by mineralization process.
The simple nutrient forms, help the producers getting the nutrients utilized as their foods.
Simultaneously, the zooplanktons also develop.

Forms of fertilizers

Solid fertilizers:

The most familiar forms of fertilizers are dry, solid materials.
Solid fertilizers often broadcast over pond surface in areas where the water is not more than 2 m deep.
Boyd (1981) determine that fertilizer containing P dissolve very little while settling through 2 m depth of water, but N & K sources were highly soluble.

Liquid fertilizers

- Phosphoric acid and ammonium polyphosphate, have recently used in aquaculture. Liquid fertilizer are denser than water. If they are poured directly into the water, they will flow to the pond bottom as a density current.

The superiority of liquid fertilizer over solid fertilizer in increasing fish yields in pond (the greater solubility of P in liquid fertilizer).

Role of fertilizers in fish food production According to Swingle, the algae produced by the inorganic fertilization are: euglenophyceae (e.g.. Semidesmous, chlorella, Paendorina). The Microsystems also abundant for a limited period. The application of NPK with cotton seed meal encourage the growth of the filamentous algae.

Some nitrifying algae are able to fix nitrogen from the atmosphere, if P is available (eg. Anabaena, Nostoc.)

Types of Inorganic

Fertilizers Phosphorus fertilizers:• Single Super phosphate (9% P) it is most commonly used phosphorus fertilizer.

• Double superphosphate (17.5% P) and Triple superphosphate (20% P) both of these fertilizers used instead of sulfuric acid.CIFRI-1967 stated that the use of N-18:P-8:K:4 @ 500 kg/ha in carp nursery preparation shows better result.

Nitrogen Fertilizers

Types of the Nitrogenous fertilizers	Name of fertilizers	Chemical composition	Ammonical nitrogen	Nitrate nitrogen
1. Ammonical Nitrogen	Ammonium sulphate	$(NH_4)_2 SO_4$	20 %	
	Ammonium nitrate	$NH_4 NO_3$	20 %	15 %
	Ammonia liquor	NH_3	20%	
	Acid Ammonium Carbonate	$(NH_4)_2 CO_3$	20 %	
	Urea	$NH_4 CO NH_4$	46 %	
2. Nitrate Nitrogen	Sodium nitrate	$NaCO_3$		15 – 20 %
	Potassium nitrate	KNO_3		13 %
	Calcium ammonium nitrate	$CaNH_4 NO_3$		15 – 20 %

Potassium fertilizers

It help in the development of natural vegetation & creates hygienic conditions.

All K fertilizer are water soluble with out having any effect on the water ph.

Action of K fertilizers in the following cases: For ponds poor in K content. For ponds with a low alkalinity. For ponds with hard bottom.

For ponds poor in aquatic plants.

Types of menure

Types of Manures	Common varieties
1. Domestic animal wastes	Cattle-dung
	Poultry-dropping s
	Pig-dung
	Horse-dung
	Camel-dung
	Night soil
2. Vegetable Oil cakes	Mahua oil cake
	Mustard oil cake
	Caster oil cake
	Ground-nut oil cake
3. Common Organic wastes	Sewage
	Green manures
	Fish manure
	Prawn manure

Organic Manures use

Both organic manures and chemical fertilizers are widely used for improving productivity of nurseries.
Cow dung is most widely used organic Manures in many areas and it's typically applied @ 5000-15000 kg/ ha in one installment well in advance of stocking with spawn, preferably at least a fortnight prior. A combination of musturd oilcake, cow dung and poultry Manure in 6:3:1 ratio at 1100 ppm has been successfully used for culturing zooplankton for carp spawn.

Inorganic fertilizers:

These fertilizers containing a fixed percentage of individual nutrient elements or a combination of more than one element are also able to enhance the productivity of nurseries.

Nitrogen: Phosphorus (N:P) @4:1 is considered most effective for increased production in nurseries.

- Weekly application of

Nitrogen: Phosphorus: Potassium mixture (N:P:K) in 8:4:2 ratio is suitable for increased production of fish food organisms

Combined Organic and Inorganic fertilization Combined fertilizers use is another strategy for increased production of either fish food organisms or fry. An aquivalent nutrient badis (N:P:K) Organic manure (Cow dung) is most suitable compare to either inorganic Fertilizer or combined use of organic and Inorganic fertilizers.

1. Cattle Dung

Cattle dung is very cheaply & widely available.

All types of pond like nursery, rearing & stocking ponds can be manured with cow dung.

The cattle dung consists of about 75-85% moisture, 15-25% organic matter and 2-5% mineral matter and C:N – 25:1.

The organic matter of dung is 78-90% of total carbohydrates, 9-18% of crude protein and 2-5% of ether extract.

CIFRI Suggested the optimum dose of cattle dung @ 10,000 to 20,000 kg/ha.

2. Poultry Manures

Poultry manure – faeces of chicken, ducks and goose and are rich in both organic and inorganic matter.

Poultry manures are more effective after decomposition.

Nitrogen is present in the form of uric acid.

The organic fraction of excreta contained 21.5% crude protein, 1.9% ether extract, 13.4% crude fiber and 42.9% nitrogen. (Gaur et al., 1984).

It is found that the alkalinity, hardness & specific conductivity are comparatively higher in poultry manure than cow dung.

3. Pig Manure

Pig manure includes much organic matter and other nutritional elements such as N.P.K.Containing more N content than other livestock faeces (C:N 14:1), Moisture-70-77%.

•Extensively used in other countries (China, Malaysia, Singapore, Germany & European country).In India, its use is still in experimental stage.Wolny-1967 stated the dose of pig dung @ 3000-5000 kg/ha.

4. Night soil

This type of organic manures are used for fishery purpose in China, Hong Kong. Nitrogen is high (C/N-3:1) 70-80% in the form of urea.

Night soil to be used as manure must be fermented before application.

Before application night soil should be treated with quick lime (1-2%) and formalin (0.1-0.2%) are effective in killing the harmful organisms.

- 5. Mahua Oil Cake
- It is mainly used for killing the unwanted trash fishes.
- CIFRI has also recommended its uses @ 200 to 250 ppm mainly for the purpose of eradication of predatory fishes & minnows.
- The chemical content of this cake is N_2-2.51%, P_2 Os -0.80% & K_2O - 1.85%.
- 6. Mustard Oil Cake
- It is also a widely practiced fertilizer for the carp nursery preparation in the eastern state of India.
- Dose 1000 to 1500 kg/hact.
- The NPK content is 4.50%, 1.50% and 0 % respectively.
- Better result are obtained with the use of this manure in the alkaline soil.

7. Caster oil Cake: It contains N2 5.5 %, P_2 Os 2 % & K_2 O nil.
It is Mainly used in Bihar @ 8000 to 1000 kg/hact.

8. Groundnut Oil Cake: It contains N_2 6.5-7.2%, P_2 Os 1.2-1.33% & K_2 O 1-1.33%.

• Experiment with this fertilizer by CIFRI showed a good production of natural fish food in the pond.

9. Sewage Manure Municipal sewage –
Organic manure for pond fertilization.
It contains high % of N, P, K, Ca etc of both animal & vegetative origin.
The sewage should be properly treated into a sewage treatment plant.
Depending upon the concentration of sewage, dilution with water may vary from 2 to 4 times of the water.

10. Green Manure

- Different types of green vegetations are used for preparation of green manure. In the brackish water fish farming the plants like mangrove leaves, bassella leaves etc are used.
- It is high content of P &C.
- Aquatic vegetation like Pistia, Echhornea, Hydrilla, Vallisinaria & different types of grasses are also used.
- Green manures can be prepared into compost in combination with cattle dung, oil cake, lime, & inorganic fertilizers etc.

11. Fish Manure

- It is prepared from the fish and fishery products.
- Fish manure containing high value of organic matters & nutrients.
- Sun dried fish manure - trash fishes & the residue of the fishes are sun dried on the beach, powdered & utilized.

- Peat fish manure dumping of fishes into a peat of about 4-5 feet and covered with leaves.
- After decomposition it can be used.

Manuring Schedule for Different Cultural Activities

Sl. No.	Types of Manure	Dosage per ha.	Remark
1.	Nursery Ponds		
	Cow dung	5-6 tons	15 days before spawn stocking
	Poultry-manure	2-3 tons	
2.	Rearing ponds		
	Cow dung	3-4 tons	7 day before fry stocking in fort-night installment
	Cow dung	0.5 tons	
	Urea	10 kg	
	SSP	15 kg	
3.	Grow-out ponds		
	Cow dung	20 tons	
	Poultry-manure	4-8 tons	
	Urea	150 kg	
	SSP	75 kg	

Application Rules for Manure

The first application may be made two weeks prior to stocking fish to increase natural food abundance.

Do not over fertilize, Manure should be applied to ponds to keep plankton abundance within recommended limits.

Maintain a scheduled routine for adding

manure based on observations of water quality.

Keep Sacchi disk reading within the range of 20-30 cm and the pond before sunrise to detect oxygen problems.

Frequency of Application

The ideal frequency of Fertilizer application probably varies from place to place, but 2-4 week intervals usually are adequate.

The most critical and often most difficult aspect of pond fertilization is initiation of phytoplankton Bloom in the spring Or at the beginning of a crop.

Larger or more frequent applications of fertilizers may be needed to initiate a phytoplankton Bloom than to maintain an existing phytoplankton bloom.

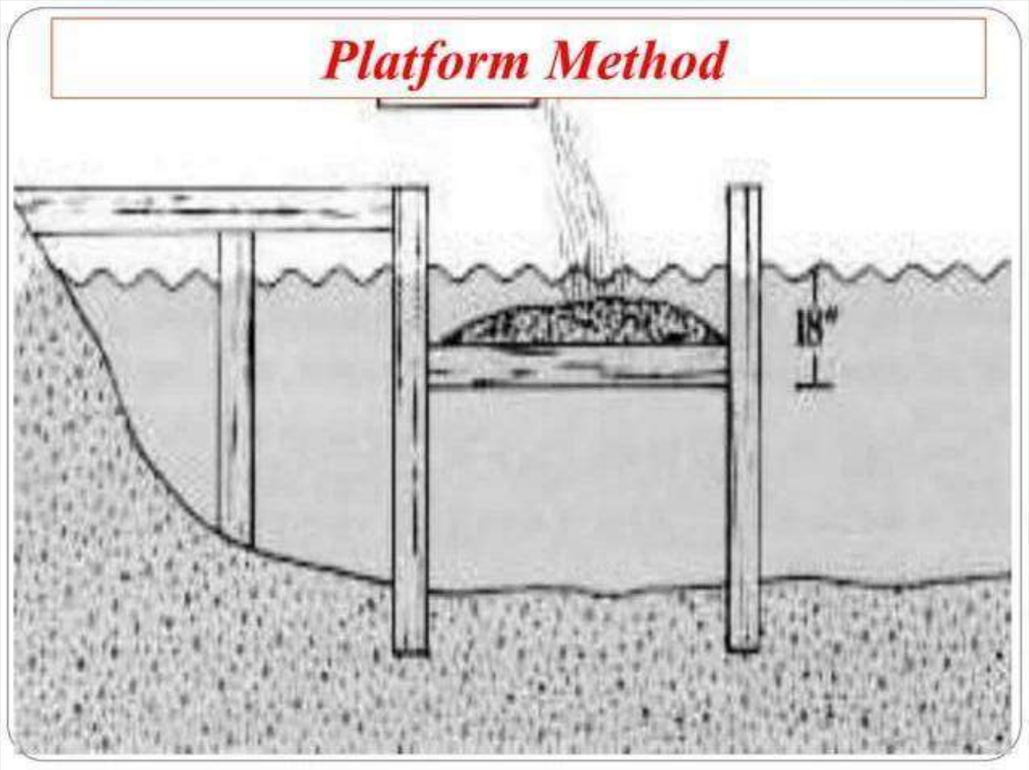
Bio-fertilizers

Bio-fertilizers are natural fertilizers that are microbial inoculates of Bacteria, Algae and Fungi.. Which may help biological nitrogen fixation for the benefit of plants.

- Bio-fertilizer also include organic fertilizers (Manure)
- Use of bio-fertilizer is recommended for improving the soil fertility in organic farming.
- Method of application Broadcast:
- Solid granular fertilizer are broadcast over pond surface.
- In thermally stratified ponds, fertilizer that settles below the thermocline is lost from the epilimnion.
- Fertilizer should not be broadcast over areas where waters are deeper than 1 m.
- Also where the beds of aquatic weeds, because they have the first opportunity to absorb the nutrients.
- Platforms: An alternative to broadcast applications of solid, granular fertilizers is to place them on underwater platform.
- This method prevents phosphorus fertilizer from settling to the pond

bottom.

- Swingle (1965) reported that the platform method of application reduced fertilizer requirement by 20-40%.
- Platforms should be about 30 cm under water.
- Fertilizer is poured onto the platform and water currents distribute nutrients as they dissolve.



Transportation of fish seed

Transport of fish seed from natural environment or hatcheries is considered to be a crucial step in aquaculture. Fry and fingerlings must be transported from hatchery to pond for stocking. Traditional methods of carrying the seeds in earthen pots called "Hundies" but this result in high mortality. In modern transporting system various metallic drums and plastic containers used for seed transportation. Fish need to be anaesthetized to reduce the activity to transport them in good condition. Once fish have been placed in their transport container they are brought to their destination by the quickest possible means that will provide a relatively smooth and direct route Anabas testudeneus Current days seed fishes are transported through train, air Anabas seed sand ship.

Anabas testudineus

The transfer of fish seed from the hatchery or place of collection to the rearing pond is called transport of fish seed. Fish seed Fertilized fish eggs are known as Fish seeds. In simple words, they are the baby fishes used for seeding new Ponds in fisheries. The

Intermediate developmental stages of the fish from the fertilized eggs, hatchlings, early and late fry, fingerlings, yearlings, etc are commonly referred to as fish seeds.

Fish seed can be used in 4 stages:

Hatchling: Larvae stage where it have yolk sac hanging below from where it draws its nutrition for 2-3 days, mouth is not formed.

Spawn: Stage where mouth is formed.

Fry: About 2 cm long, now, it can eat small size zooplanktons.

Fingerling: About 15 cm long. Easier to transport these kinds of fishes to Ponds,

Importance's of fish seed and their sources:-

Fish seed is a key factor to the expansion of fish farming. Save endanger fish from extinction. High production potentiality. High economic growth.

SOURCES

Natural sources
- Riverine resources
- Lakes and reservoirs
- Marine resources

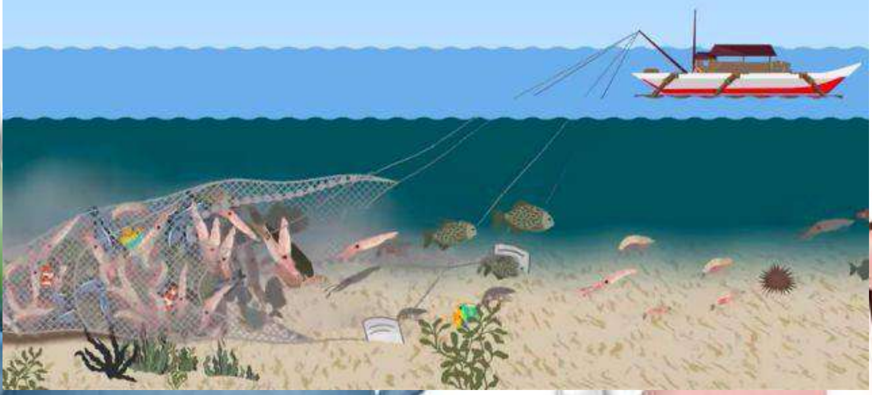
Bundh sourcese

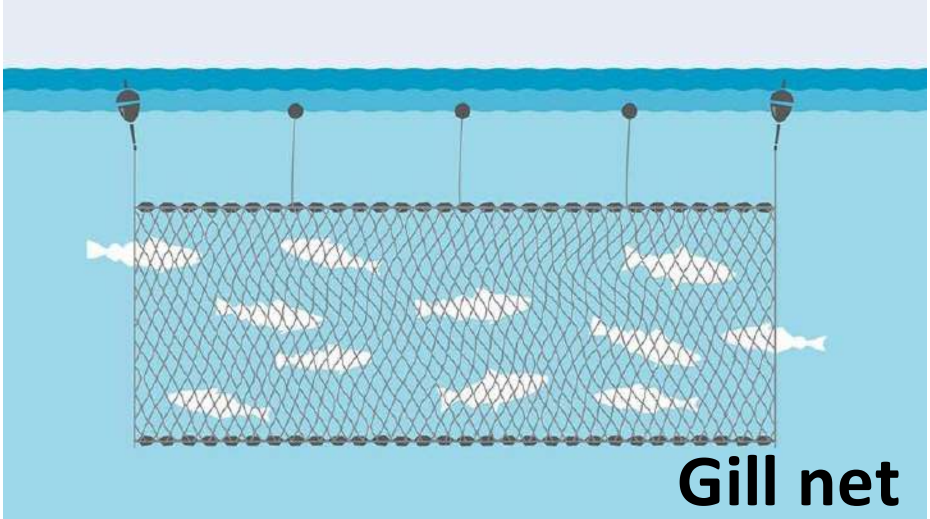
Hatchery sources:
- Hapa Earthen pot hatchery
- Glass jar hatchery
- Chinese hatchery

Harvesting of Fish seed

- Many methods are used for harvesting fish seeds, using different types of traditional and modern equipments. By these methods some times fish get stressed and injured. In case of marine fishes with the assistance of divers and scoop net seeds are collect.
- Generally shooting nets are used to collect the seed in the rivers. The seed moving along with the marginal current collects in the gamcha and stored inhapas or containers after removal.
- Benchi jal, midnapur net are commonly used in bengal for collecting fish seeds from natural water bodies. By the use of trawl net and gill net collect larger fingerlings.

Trawl net





Selected seeds should have the following phenotypic characteristics:

- **Desired shape of body, body should possess the required shape and proportions.**
- **Healthy, with desirable hereditary characteristics**
- **Having no body wounds parasites, or deformations of any type.**
- **There should not be pustules, red/white/black patches in the body of fry/fingerling fish.**

General guidelines for transportation

- Seedlings should be acclimatized first before packing to new water.
- Transport the seeds either during morning or evening or night to have the benefit of cooler journey transit.
- Do not excite fishes by carefully handling them, since excitement or anxiety increases oxygen consumption three to five times in them.
- Oxygen packing is the best method of transportation. Oxygen requirement ranges from 100-1100mg/kg/hours. If the transporting distance is long, glucose powder can be added to the seed packing bags
- Formula for number of seeds
- (N=DO-2×v÷c×h)
- DO-dissolved oxygen in ambient water in mg/l

V-volume of water in liters
C-rate of oxygen consumption by the individual fish (mg/l), h-duration of transportation (hr).

Conditioning of Fish seed before Transportation

The fish are kept starving usually in a cloth hapa" or other containers in a quiet corner of the fish pond or in relatively quiet water in a canal or river for a period of time before transferring them to the transport carrier.

- Advantages of conditioning are:
- The fish become used to confined condition.
- The fish are less excited and thus restrained in expenditure of energy.
- The fish recover from the handling effect of capture – increased blood lactate level and decreased blood pH become normal – excited high metabolic rates become normal.

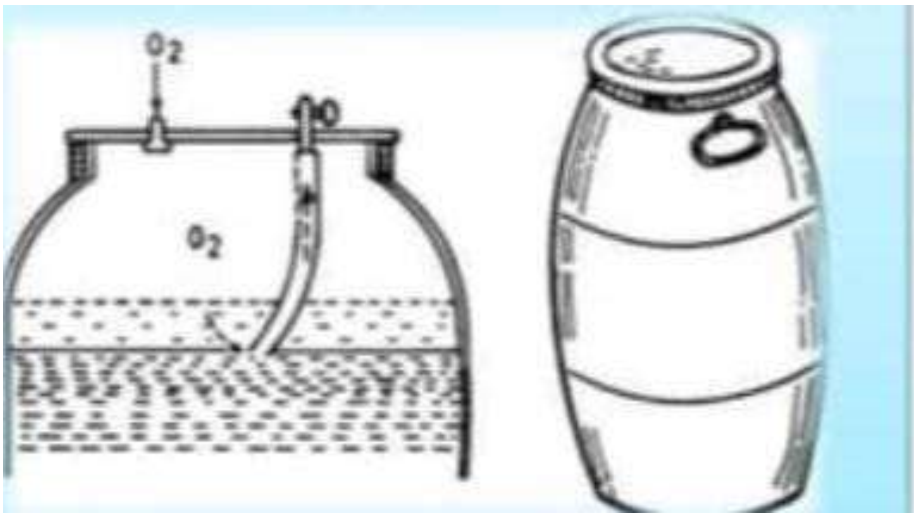
- The fish recover from minor injury mucus loss etc Ion-osmotic balance upset by handling becomes normal.
- Gut evacuation takes place and during the period of transport the medium is not further contaminated by fecal matter.

Methods of Transport

(a) open system comprising open carriers, with or without carriers oxygenation/with oxygen.

This is a traditional method, Plastic or metal drums or traditional earthen pot "hundi" are used for fish transporting. DO content is maintained through splashing of water.

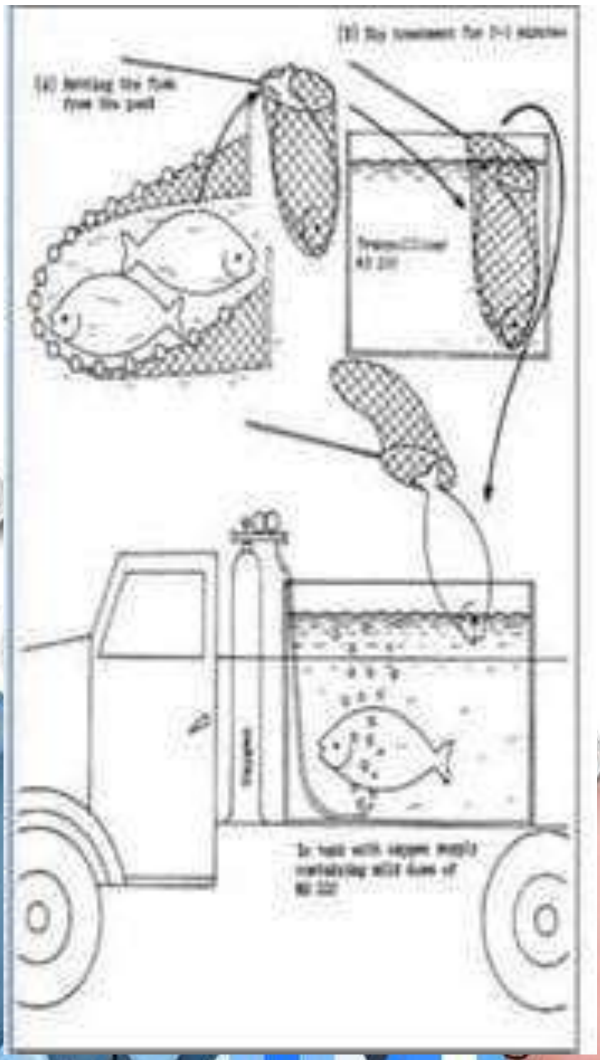
(b) Closed system having artificial sealed air tight water circulation. Modern transporting system. In this system, we have o maintain adequate oxygen supply in the water. Plastic or metal container, Rubber and plastic bags are used in this system for transporting fish. ¼ of the bag usually containing water and fish. Remaining part filled with oxygen.



Transportation of fish seed

- Transport of bigger fingerlings/yearlings and brood fish in small packing containers- not economically feasible. Truck mounted open tanks with facilitates for mechanical aeration and/or circulation were initially used quite successfully (Hora and Pillay.1962: Mammen, 1962).

- Open canvas containers (1m x 1m x 1.25m) are used in Punjab and Madhya Pradesh for transporting carps.
- In those States galvanized iron drums of 180 liter capacity are also used. In India, two successful models of closed system of live-fish carrier were designed.
- One is due to Mammen (1962), which he called 'Splashless tank.



The later model of the splash less tank is of a petrol tanks design of 1,150 liter capacity with an autoclave-type lid. It has a built-in aeration system for supplying compressed air, which works on a belt driven by the engine of the transporting vehicle. An oxygen cylinder is carried only as a stand by for emergency.

The inner surface of the tank is lined with U-foam which prevents physical injury to live fish during transport. A total weight of about 250 kg live fish can be transported at a time in the splash less tank, as also 90,000 carp fingerlings. The load ratio of fish to water in this type of carrier in about 1 kg of fish per 4.5 liter water.

Causes of mortality during transportation

Several factors are may be responsible for mortality of fish in transport:

Depletion of dissolved oxygen in ambient water due to the respiration of fish and also due to oxidation of any organic matter (BOD load), including excreted waste of the fish, by micro-organisms. Accumulation of free carbon dioxide (CO), resulting from respiration, and ammonia (NH) as excretory end product, Sudden fluctuations in temperature. Hyperactivity and stress due to handling and 'confined space' – these result in lactate accumulation and affect again lessening of blood oxygen capacity and also "fatigue collapse".

Use of high level of an aesthetics.

Ion-osmotic imbalance due to stress. Physical injury due to handling before transport and during transport. Diseases.

Drugs and chemicals used during transportation

Drugs and chemicals are either used as tranquilizers and sedatives or as antiseptic. Several drugs have been studied for use as anesthetic for transport of fish. E.g. Tricaine methane sulphonate (MS-222), Sodium amytal, Quinaldine, Novocain etc.

They are mainly used for:

I. Reducing metabolic rates.

II. Reducing excitability of fishes

III.Convenience in handling fish.

Use of antiseptics and antibiotics:

Short-term bath prior to transport reduce the chances of infections.

Chemical	Dosage (mg/l)
Acriflavine	10ppm
Methylene blue	2ppm
$CuSO_4$	5ppm
$KMnO_4$	3ppm
Chloromycetin	8-10ppm
NaCl	3%
Formalin	15ppm

Fish feeds

Aquaculture feeds
Natural feeds
Aquatic live feeds to:

- Non aquatic live feeds
- Artificial feeds/ compound feeds
- Purified or semi- purified feeds
- Practical diets

Aquatic live feeds

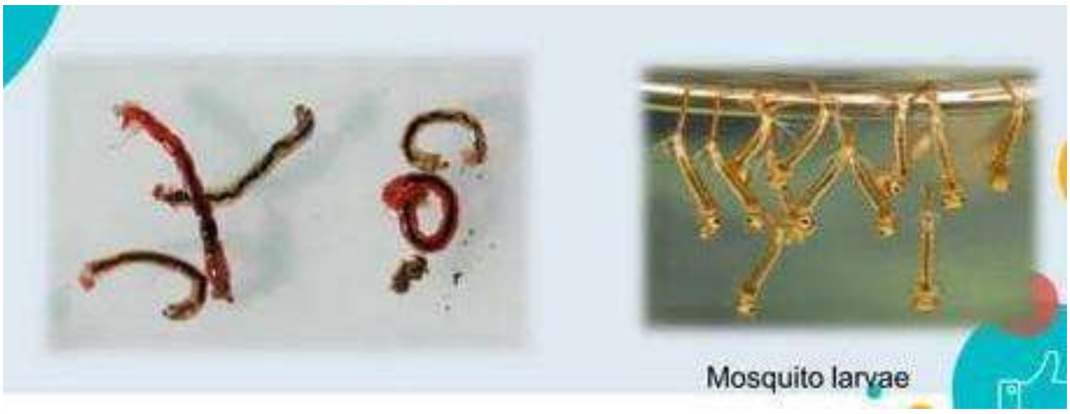
1) Unicellular algae
Single celled plants; act as major producers
2) Lumut
Filamentous -blue green algae mullet
3) Filamentous algae
Colonies of small algal cells attached together
4) Lab-Lab
Bottom mixed algae: Milk fish
5) Bacteria and fungi
Microbial organisms that live on bottom detritus. dead phytoplankton cells, leaves, dead animal tissue

6) Zooplankton
Rotifers, copepods, Cladocerans.

Non - aquatic live feeds

Mud eaters Chironomids, worms etc..

Other insect larvae Du Living in water Mosquito larvae



ARTIFICIAL FEED

Purified or semi-purified feeds Practical diets

Practical diets

- Moisture content or form
- Stage of the life cycle
- Uses in farming practice

Based on moisture content or forms

Non-dry feed

- Wet feed
- Moist feed
- Semi-moist feed

Dry feed

- Meal/Mash
- Pellets
- Crumbles
- Flakes

WET FEED

- Feeds containing moisture levels in the range of 45-70% are prepared from high moisture ingredients such as trash fish, fishery waste, slaughter house waste, etc.
- These feeds are made at the farm shed on a day-to-day basis and fed mainly to carnivorous fish such as sea bass, sea bream, eels, etc.

moisture level in the range of 25-45%made from a mixture of high moisture ingredients as in wet feeds, and dry pulverized ingredients.

Moist feeds Wet ingredients:

- Usually prepared by adding moisture and a hydro colloidal binding agent(e.g. Carboxymethyl cellulose, gelatinized starch, gelatin)Or fresh tissue (Liver, blood, ground fish and fish processing waste)
- Some moist diets do not require frozen storage
- As they contain humectants like propylene glycol and sodium chloride(lower water activity, bacteria do not grow)
- Also contain fungi stats like propionic acid and sorbic acid(retard mould growth)

- Diets must be packed in hermetically sealed containers, stored at low temperatures for best storage life
- Moisture enhances loss of vitamin C

Eel feeds are processed and stored dry but are moistened just before feeding

Moist diets

Advantages

- Many fish species find soft diets more palatable than dry diets
- A pelleting machine is not needed, a food grinder will suffice
- Heating and drying are avoided

Disadvantage

- so Susceptible to microbial and oxidation spoilage unless fed immediately or frozen
- Should be heated to destroy possible pathogens and thiaminase

Oregon moist pellet Commercial moist feed developed for salmon smolts(stored frozen)

Ingredient	Oregon mash OM-3 (%)	Oregon pellet OP-4 (%)	Oregon pellet OP-2 (%)
Herring meal	49.9	> 47.5	14.0
Other fish meal	–	–	14.0
Wheat germ meal	10.0	remainder	remainder
Dried whey	8.0	4.0	5.0
Cottonseed meal and poultry by-product meal	–	–	15.0[1]
Corn distillers dried solubles	–	–	4.0
Sodium bentonite	–	3.0	–
Vitamin premix	1.5	1.5	1.5
Mineral premix	0.1	0.1	0.1
Wet fish hydrolysate[2]	20.0	20.0	30.0
Fish oil	10.0	6.5-7.0	6.0-6.7
Choline chloride (70%)	0.5	0.5	0.5
Proximate composition:			
Crude protein		>35	>35
Crude fat		>10	>10
Moisture		<35	<35
Crude fiber		<4	<4

Semi moist feed

Moisture content in the range of 15 to 25% have a minor contribution from high moisture ingredients.

Wet, moist and semi-moist diets are considered to be more palatable to most species because of the soft consistency, and good growth and feed efficiency achieved.

The major disadvantage of these feeds are.

I. The transportation and storage under refrigeration until use to prevent spoilage.

II. Irregular availability of fresh raw fish and other animal wastes in adequate quantities

III. Introduction of pathogens, particularly from fishery wastes, if not adequately pasteurized

IV. Improper transportation and storage damage certain labile vitamins and lipids and favor propagation of fungi and bacteria in such feeds

V. Unconsumed feeds may affect the water quality.

Dry feeds:

Contain moisture in the range 7-13%.122easy to manufacture, transport, store and convenient to dispense into the culture systems.

Advantages:

- Dry feeds include bulk purchase and storage of ingredients option to select a wide variety of ingredients with specific nutritional characteristics.
- Can be produced in different sizes to suit the specific needs of the larvae to specialized diets for brood stock.
- Permit production of specialized feeds such as medicated feeds incorporated with specific medicines or antibiotics required to control any disease out breaks, hormones incorporated feeds to produce monosex individuals or for growth promotion or to induce maturation in fish and prawns'
- Dry feeds may be either prepared using dry ingredients alone or a mixture of wet and dry ingredients adequately processed and dried

MEALS/MASHES

Simple mixtures of dry ground ingredient so made into a dough or paste or balls just before feeding at farm site fed to fish and prawns in trays or baskets or feed bags tied to poles in ponds(as is practiced in carp culture systems in India.)These type of feeds have poor water- stability and cause water quality problems due to the feed breaking-up and dissolving in water.

- **PELLETS**
- **FLOATING PELLETS**
- **For fish species which predominantly feed in the water surface or column, e.g. tilapia, trout, grouper, sea bass carp etc.**
- **Enable observation on feeding activity and, to some extent, the health of the fish.**
- **But, overheating as required in the extrusion manufacturing process of floating pellets may reduce their nutritional value.**

- **SINKING PELLETS**
- **For bottom feeders like prawns (slow feeders)**
- **Ingredients with good binding agents should be used**
- **Extrusion processing is also a valuable tool for making it water-stable**

- **GRANULES**
- **Pellets could be crumbled and graded through screens of different mesh to obtain granules required for feeding the different growth stages of fish and prawns.**

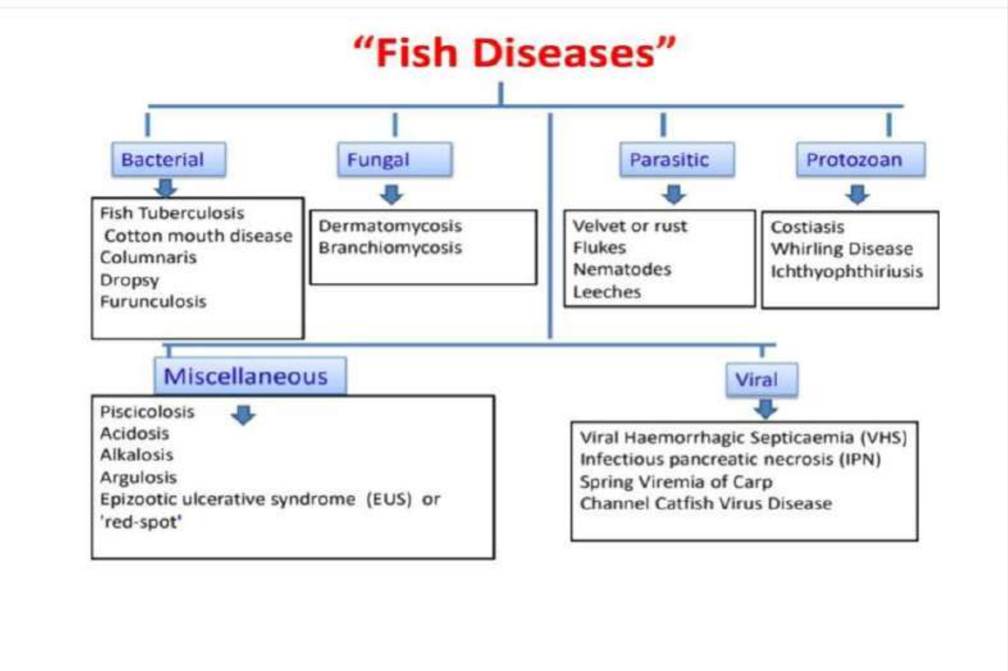
FLAKES

Flakes are not only nutritious and palatable, but float or sink slowly on
Do not disintegrate quickly in water
Processed on rotary drum dryers

- **Ingredients are ground to extremely fine particle size(0,1 mm) (attrition mill)**

- Blended with water to form a slurry. Spread over the surface of a heated rotating cylinder to dry into a thin sheet
- Dried sheet is continuously scraped off the rotating drum and crumbled into flakes
- FLAKES
- The formula must contain ingredients with good hydrocolloidal properties as well as tensile strength Chitin from shrimp shells was important in imparting the desired physical properties on Compounds for external pigment enhancement is also added(astaxanthin in crustacean meal. Canthaxanthin impart pink-red color , xanthophylls from plant pigments impart yellow-orange colour

Fish Diseases



(A) Bacterial Diseases of Fishes

1. Fish Tuberculosis
2. Cotton mouth disease
3. Columnaris
4. Dropsy
5. Furunculosis

1. Fish Tuberculosis

Caused by

- Mycobacterium tuberculosis.
- Mycobacterium piscium

The main symptoms of fish tuberculosis are loss of scales, loss of color, lesions the body, wasting, and skeletal deformities such as curved spines.

Treatments

Fish can be treated with the same drugs as humans get when they become infected by Mycobacterium marinum, e.g.., Kanamycin. Since this is a very resilient microbe, normal treatment involves administering at let two different medications over the course of at least three months.

Prophylaxis

Keeping your fish healthy, happy and well-fed will boost their immune system. New fich should ideally be quarantined before you allow it into you main squari Plants, substrate, equipament eteter should be

Sterilized to kill of potentially harmful bacteria before being introduce

2.Cotton mouth disease

Caused by

•The bacterium Chondrococcus columnaris

Symptoms in fish

It shows up first as a gray or white line around the lips and later as short tufts sprouting from the mouth like fungus.

Treatments

- Hard to treat, but not impossible. Like any disease best caught early.
- There are commercial products available to treat cotton mouth.
- Also change the water daily 20% and use a regular dose of salt in your tank.

Prophylaxis

- It can be controlled by regular water changes and vacuuming of the gravel
- Proper diet and maintaining good water quality in general will keep the fish from being stressed and therefore susceptible to infection.

3.Columnaris

Caused by

Filamentous bacteria e.g. flexibacteria

Symptoms in fish

White spots on mouth, edges of scales, and fin Catt any growth that eats away at the mouth degrade beginning at the edges Fungus often invades the affected sk

Treatment

Change water

Vacuum gravel

Add aquarium salt

Treat with copper sulfate or antibiotic

Discontinue carbon filtration during treatment

Prophylaxis. Maintain high water quality

Provide fish with a nutritionally balanced diet Medicate fish prophylactically before moving them

4.Dropsy

Caused by

Bacteria (Pseudomonas punctata).

Symptoms include

- Accumulation of body fluid/water in the body cavity or in scale pockets, scales become loose, abdomen bulge largely and pressing on it water comes out through the mouth etc

Treatments

- It's possibly the hardest internal bacterial infection to cure.

There are a number of medications available such as penicillin, tetracycline and naladixic acid.

Prophylaxis

- Poor water conditions are often the culprit. Gouramies, Cyprinids (barbs, danios, etc), guppies, betta and goldfish are prone to this disease.
- Goldfish are said to be somewhat more prone to dropsy than other fish. High nitrates are usually the culprit.

Clean Water, is a must! Clean Water, should I say that again? Good water conditions prevent this.

5.Furunculosis

Caused by

Bacteria (Aeromonas salmonicida)

Symptoms

Appearance of bloody boils on the skin and almost all visceral organs.

Treatment

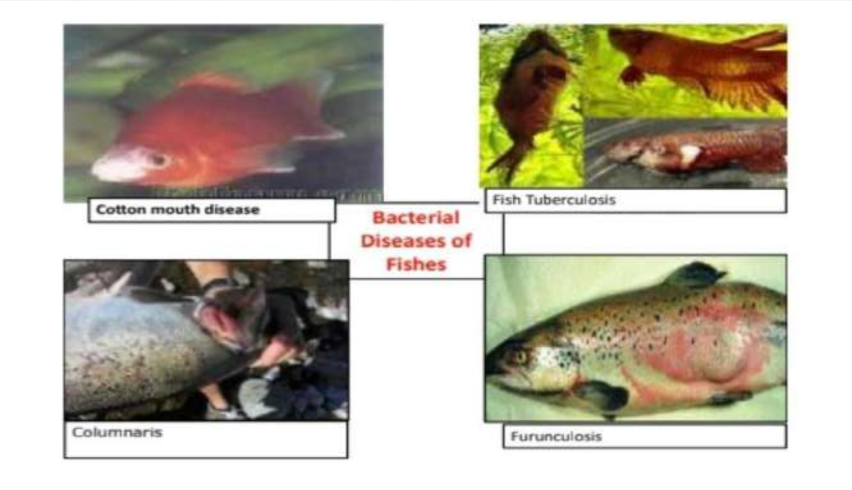
Many types of antibiotics have been used with varying degrees of success. Use of tetracycline, erythromycin and Nitrofurazone have no documented effect on Pseudomonas or Aeromonas.

Prophylaxis

• Optimize your holding system.

. Quarantine and treat all new arrivals

Isolate affected individuals



(B) Viral Diseases of Fishes

1. Viral Haemorrhagic Septicaemia (VHS)
2. Infectious pancreatic necrosis (IPN)
3. Spring Viremia of Carp
4. Channel Catfish Virus Disease

Disease name	Causative agent	Symptoms	Treatment
1. Viral Haemorrhagic Septicaemia (VHS)	VSH Virus having RNA	These include pale gills, dark body colour, ascites (fluid in the body cavity), exophthalmos (bulging eye), and in some cases an intermittent period of erratic spiralling behaviour and rapid respiration.	As with many viral diseases of fish, there is no specific treatment or cure for VHS.
2. Infectious pancreatic necrosis (IPN)	Infectious pancreatic necrosis (IPN) virus	The first sign of a typical IPN epizootic is a sudden increase in mortality. The affected individuals swim in a rotating manner about their long axis.	There is no effective medicine. Use of iodine may be useful
3. Spring Viremia of Carp	spring viremia of carp virus (SVCV) or *Rhabdovirus carpio*	Darkening of the skin, swollen abdomen, exophthalmia(popeye), hemorrhages in the skin, gills, swim bladder, and inflammation of the intestines.	Not specific.
4. Channel Catfish Virus Disease	A herpes virus	Fish may be seen swimming erratically , swollen abdomen; distension of the vent area, and bulging eyes , hemorrhages may be seen at the bases of fins, on the ventral abdomen, and with in muscle tissue.	There are no effective treatment.

(C) Fungal Diseases of Fish

Saprolegniasis	Dermatomycosis	Branchiomycosis
		

1.Saprolegniasis

Pathogen	*Saprolegnia*.
Transmission	*Saprolegnia* grow in trash fish, fish feed, culture gear and benthic organic matters. Masses of free spores are released from the body surface, faeces and rotten carcass of infected fish to look for new hosts in the water. Some ***Saprolegnia*** can survive for several years in benthic sediments in the water. As a result, fish may get infected continuously.
Symptoms	*Saprolegnia* can burrow into the fish body from surface wounds. They can also invade the digestive tract when fish eat food containing them. They bore holes in the intestinal wall and reach internal organs through the circulatory system, reproducing and spreading across the body. Affected fish have greyish white woolly fungi on the body surface. Some ***Saprolegnia*** can cause granuloma - like lesion in internal organs.
Treatment	None. When saprolegniasis is diagnosed, all infected fish must be destroyed and no new fish are to be purchased or introduced until the fish farm is cleared and thoroughly disinfected.

2.Dermatomycosis

Caused by	Various member of class Oomycete
Symptoms:	Appearance of fine hair like tuffs hanging from the infected areas. The fine become eroded and hemorrhagic at the latter stage of disease infected eggs tend to stick together and finally die.
Treatment	Use copper sulphate solution ($CuSO_4*5H_2O$), potassium permanganate ($KMnO_3$) at the dose of 1g per 10L of water for 30 minutes (treatment is repeated every 12 hours for 10 days). Basic Violet K (it is only effective in the early stages of disease).
Prophylaxis	Do not take food from ponds where outbreaks of the disease and fish's death have occurred. The disease is best prevented by providing adequate aquarium maintenance routine and a balanced diet. Environmental management is essential: any uneaten food, dead mollusks and fish should be promptly removed from the tank.

3.Branchiomycosis

Caused by:	*Branchiomyces demigrans* and *B.sanguinis(Phycomycetes Archiomycetes)*
Symptoms	This disease is seen in the blood vessels of the gill tissue, and it obstructs the circulation of blood through the gills, which makes the gills lose their bright red color.
Treatment	Diseased fish can be treated with malachite green at 0.1mg/l for extended periods of time or 0.3mg/l for 12 hours. Ponds with enzootic branchiomycosis should be dried and treated with calcium oxide (quicklime) or 2 to 3 kg copper sulphate per hectare.
Prophylaxis	•Strict sanitation and disinfection are essential for disease control. •Dead fishes should be collected and daily and burned or deeply buried. •Transportation of infected fish areas to non-infected areas must be prevents. •Increase of water supply help in control of that disease

GENERAL CONTROL MEASURES FOR FUNGAL DISEASES

1. Incorporation of medicines like sulfamethanin, terramycin, erythromycin thiocyanate and calomel in the food supplied to the fish

2. Treatment in Phenoxethol solution (10 to 20ce of 1% solution diluted in one litre of water)

3. Infected fishes may also be kept alternatively in bath water, containing 0.5ml of formalin solution in one litre of water plus pipes of malachite green. Gottwald (1961) has suggested a concentration of 10mg of malachite green per litre of water for 15 minutes bath every 2days4.

Fishes kept in 15 to 30gm Nacl solution per litre of water for half an hour may also be freed from the fungus. Treatment may be repeated on the following days and subsequently if required.

5. A5 to 90 minute bath in potassium permanganate ($KMnO_4$) solution is also recommended. The time and dose, however, depends upon the hardiness of fish and should be determined experimentally.

6. A homeopathic drug, the Argentum nitricum (Q) applied topically on the infected yes of Channa striatis has also been found to cure the fungal disease.

7. Branchiomycoses is difficult to cure and the infected fishes so far have been removed and destroyed and the ponds drained and dried till the cracking of soil for fresh stocking

8. The use of quick lime at a rate of 150-200kg/hectare is however, suggested to be added at two weeks

intervals during summer and daily during the outbreak of disease. During treatment the pill of water should be restored below 9.0.

9. Use of copper sulphate is also suggested but proper care should be taken because the chemical also destroys many other aquatic organisms 12kg of $CuSO_4$ per hectare for pond with an average depth I meter has been recommended by Schuperclaus

10. Various dip treatments involving different chemicals are suggested for infected fishes. Thus a 24 hour dip in 0mg per litre of malachite green 10 to 30 minutes dip in mg/litre of copper sulphate solution, a dip in 15-25ppm of formalin, dip in 3-5% of sodium chloride solution or an hour dip in 1-4ppm of benzalkonium chloride are recommended.

11. Ichthyophonosis is extremely difficult to control and only the quarantine regulation is suggested which is helpful in regulating its incidence. In this method (Quarantine) the infected fishes are isolated from the stock and kept for treatment in separate ponds (Quarantine ponds) until they become free of the parasites.

12. A bath of Benzalkonium chloride (1 to 4ppm) may also be used for 1 hour

13. Fungal development on trout egg may be checked by daily formalin bath for 15 minutes.

14. Dense stocking and rich supply of inorganic matter should be avoided.

15. During the hot weather even the artificial feeding should be reduced.

16. Good supply of freshwater should always be maintained

(D) Protozoan Diseases of Fishes

1. Costiasis
2. Whirling Disease
3. Ichthyophthiriusis
4. Diplostomosis
5. Gut blocking

1. Costiasis

Caused by: Costia necatrix

Symptom: It causes the skin of the infected fish to become cloudy and milky.

Treatment

• Due to its inability to live in water above 28°C (82.4°F), treat as if it was Ich by using a commercial Ich treatment or technique.

. Other recommended treatments include MalachiteGreen, Potassium Permanganate, Acriflavine and strong salt baths of 3%

Prophylaxis

Newly bought fish are quarantined for 30 days. Before introducing new fish into the aquarium, give them three short-tem therapeutic baths. It is not advisable to introduce pond plants without first disinfecting them. Nets, scrapers, feed boxes, thermometers, pulverizers and other equipment should not be shared between several Ha.

2. Whirling Disease

Caused by: A microscopic parasite called Myxobolus cerebralis.

Symptoms:

Damaging: cartilage, whirling disease can kill young fish directly, or cause infected fish to swim in an uncontrolled whirling motion.

Treatments

In watersheds where Myxobolus cerebralis is present in wild populations, there is currently no cure or means to eradicate it.

Prophylaxis

The key to preventing the spread of whirling disease is to prohibit the movement of the parasites from infected areas. Never transport live fish from one body of water to another. Do not dispose of fish heads, skeletons or entrails in any body of water.

3.Ichthyophthiriusis

Caused by:

Ichthyophthirius multifilis

Symptoms:

Small white spots resembling sand
Fish scratch against rocks and gravel
In advanced stages fish become lethargic
Redness or bloody streaks stages in advanced

Treatment:

Raise water temperature Medicate for 10-14 days Reduce medication when treating scale less fish Discontinue carbon filtration during treatment

- Perform water changes between treatments

Prophylaxis

- Infection can be effectively controlled only by destruction or elimination of the free dividing tomonts or the tomites they release. In warm water systems (24-28°C), three to four daily transfers of fish to clean tanks will effectively reduce infection, while enabling the fish to develop tolerance to reinfections. vacuum suction.

4.Diplostomosis

Caused by: Termatode, Diplostomulum

Symptoms:

Small black spots on the body.

Treatment

Black spot is generally easy to cure. There are a number of commercially available treatments and preventatives. It is fairly easy to treat with salt baths.

5.Gut blocking

Caused by:

A cestode, Eubothrium.

Symptoms:

Mechanical damage to the gut.

1.Epizootic Ulcerative Syndrome(Red-spot Disease)

Epizootic ulcerative syndrome (EUS) or ‘red-spot’ as it is known colloquially, is an ulcerative syndrome of fish.

It begins as a small area of reddening over a single scale, which subsequently spreads to involve a number of adjacent scales; this is the characteristic ‘red spot.

As the condition progresses, the

Red-spot' expands and deepens, giving a deep ulcer, which sometimes extends into the abdominal cavity. Some fish, especially barramundi (Lates calcarifer) develop unilateral or bilateral cloudiness of the cornea.

Caused by

A pathogenic fungus, Aphanomyces invadans causes EUS.

Infection occurs when motile spores in the water are attracted to the skin of fish. The spores penetrate the skin and germinate, forming fungal filaments hyphae. Or

The hyphae invade widely into the surrounding skin and deeply underlying muscle resulting in extensive ulcer and destruction of tissues.

Species affected

- In the Northern Territory, EUS has been reported in Archer fish (Toxotes chartareus)
- Barramundi (Lates calcarifer)
- Bony bream (Nematolosa erebi)
- Chanda perch (Ambassis agassiz)
- Fork-tailed catfish (Ariussp)
- Long tom (Strongylura kreffti)
- Mangrove jack (Lutjanus argentimaculatus)
- Mouth almighty (Glossamia aprion)
- Mullet (Liza diadema)
- Red scat (Scatophagus argus)
- Saratoga (Scleropages jardini)
- Rainbow fish (Melanotaenia splendida)
- sleepy cod(Oxyeleotris lineolatus)
- Spangled perch (Leiopotherapon unicolor)
- Striped grunter (Amniataba percoides)
- nursery fish (Kurtus gulliveri)

Treatment

There are no specific control measures in fish for EUS in natural environments. In captive fish, early 'red-spot' lesions may respond to topical treatment with an antiseptic Iodophore solution.

Prophylaxis

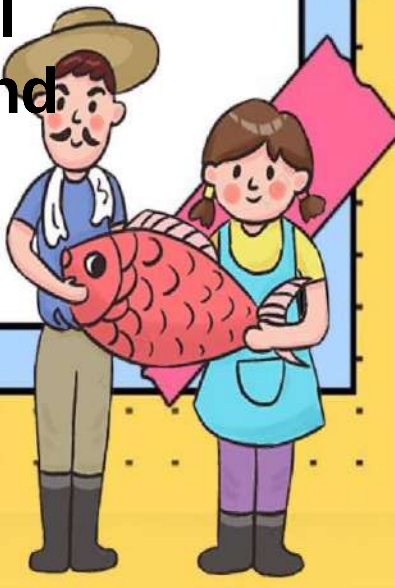
Increasing salinity of holding waters may prevent outbreaks of EUS in aquaculture ponds

Fish from infected waterways, especially those with lesions of EUS, should not be relocated to other waterways.

HARVESTING

Fish harvest technology

Fish harvest technology provides employment and economic benefits to large sections of the society. It encompasses various processes of catching aquatic organisms. Use of fishing methods varies, depending on the types of fisheries, and can range from as simple process as gathering of aquatic organisms by hand picking to highly sophisticated fish harvesting systems, viz. aimed mid-water trawling or purse seining conducted from large fishing vessels. The targets of capture fisheries can range from small invertebrates to large tunas and whales.



The large diversity of targets in capture fisheries and their wide distribution requires a variety of fishing gears and methods for efficient harvest.

These technologies have been developed around the world according to local traditions and technological advances in various disciplines like hydrodynamics, acoustics and electronics. Filtering the water, luring and outwitting the prey and hunting, are the basis for most of the fishing gears and methods used even today. Harvest technologies, as they are practiced today generally fall into 3 main groups:

(i) catching fish singly or in schools by use of nets or spears,

(ii) trapping fish in stationary gears such as fish traps or set nets, and

(iii) Attracting fish to get caught on hooks by use of bait, artificial lures or other means such as light.

Half of the world's sea food is caught or otherwise collected by small-scale fishermen operating millions of fishing crafts. Over the years, traditional fishing gears have been

Upgraded and newer more efficient fishing systems have been introduced. Most important among them are fish harvesting systems like trawls, seines, lines, gill nets and entangling nets and traps.

Most significant among the technological developments which support the evolution of fish harvest technology are

(i) Developments in craft technology and mechanization of propulsion, gear and catch handling,

(ii) Introduction of synthetic gear materials,

(iii) Developments in acoustic fish detection and satellite based remote sensing techniques,

(iv) Advances in electronic navigation and position fixing equipment, and

(v) Awareness of the need for responsible fishing to ensure sustainability of the resources, protection of the biodiversity and environmental safety and energy efficiency.

Advances in satellite-based technologies, viz. Global Positioning System (GPS), have positively influenced safety of fishermen, who undertake one of the dangerous occupations in the world, by providing better communication and navigation and Global Maritime Distress and Safety System (GMDSS) based rescue systems which can be activated during emergencies. The mechanization of gear handling has vastly expanded the scale on which fishing operations can take place.Fish harvesting systemsFish harvesting system includes the components, fishing vessels (craft) and fishing gear. The term fishery vessels is used to denote the mobile floating objects of any kind and size operating in freshwater, brackish water and marine areas, used for catching, transporting, landing, preserving and/or processing of fish, shellfish and other aquatic animals. There are vessels performing other functions related to fisheries such as supplying, protecting, rendering assistance or conducting research or training.

The term fishing vessel is used to distinguish fishery vessels engaged in catching operations. The term non-fishing vessel covers the remaining fishery vessels. The basic criterion used for the classification of fishery vessels is the gear used for catching fish or other aquatic organisms. The characteristics used to distinguish the various types and classes of fishing vessels are the general arrangement and deck layout, position of the bridge or wheelhouse, the fishing equipment used and the method of fish preservation and processing used in the vessel. Traditional methods of fish harvesting are Ring seine, Stake net, Chinese dip net, Cast net, Shore seine, Trammel net, Mini trawls, Gill ntes, Hook and line, traps and pots. Modern methods of fish harvesting include Trawling, Purse seining, Gill net, Hook and line mechanized, Jigging and Trolling lines.

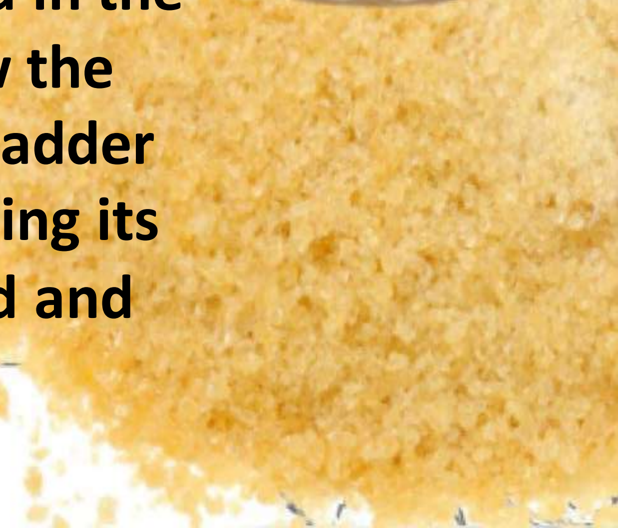
By products

Understanding the preparation and significance of various fishery products

- Isinglass
- Shark leather
- Fish glue
- Pearl essence
- Beach de- mer

Isinglass

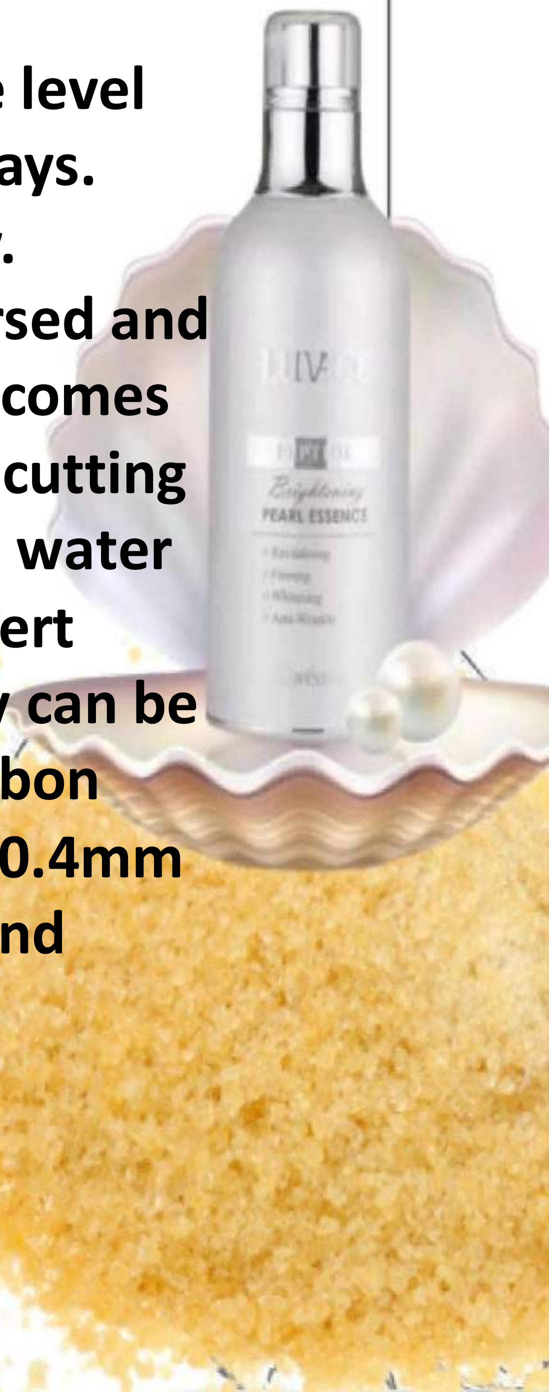
Air bladder, also called sound or swim bladder consists of several membranous layers rich in collagen. Located in the abdominal cavity below the vertebral column, air bladder helps the fish in regulating its specific gravity. Cleaned and



dried air bladder is called as Fish Maw, which is an excellent raw material for production of Gelatin. Hake, Sturgeons and carps are good sources for air bladder.

Processing

The air bladder after washing with water and scraping of the outer layer is split open longitudinally and washed well further, sundried to 15 % moisture level by hanging or placing in trays. Dried product is Fish Maw.



Dried air bladder is immersed and soaked in water until it becomes soft. It is then rolled after cutting into small pieces between water cooled iron rollers to convert them into thin strips. They can be further compressed by ribbon rollers into ribbons about 0.4mm thick which are air dried and rolled into coils. This is Isinglass.

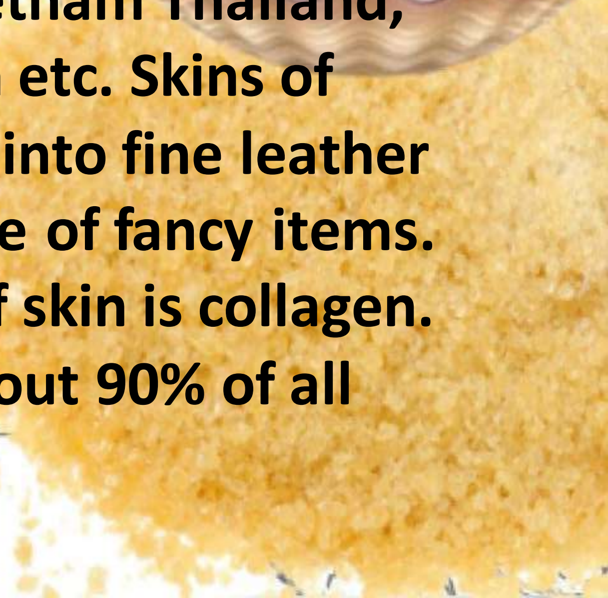
Uses

- Clarifying agent for beer, cider, wine, vinegar etc.

- Can be used as adhesive waste
- Isinglass dissolved in acetic acid forms a strong cement base
- Can be used as a sizing agent in textiles
- It is an ingredient in Indian ink.

Shark leather

Skin from fish and other aquatic animals offer a potential source of leather in the countries where climatic conditions and topography do not allow raising of goats and sheep's. Few such countries are Japan, Vietnam Thailand, Korea, Norway, Sweden etc. Skins of shark can be processed into fine leather suitable for manufacture of fancy items. The main component of skin is collagen. Collagen constitutes about 90% of all



nitrogenous matter of the skin. Leather tanned from Indian shark skin is about one and half times superior to that from cow hides in strength and durability. Shark skin has a protective coating of a calcareous deposit known as “shagreen”. It can be used as a suitable raw material for manufacture of suitcases, shoes, belts, vanity bags etc.

Both demersal as well as pelagic varieties are suitable for the leather production

Process

There are following operations for making of leather from shark skin

Curing of skin: The skin is removed from shark body and cured with salt by spreading it with flesh side or skin may also be preserved by sun drying in tropical countries like India. More care is necessary for removal of skin from body of fish.

Washing and soaking: skins are washed and soaked which plumps up skin and hides restoring them into their original texture and consistency.

Liming: liming is done to remove epidermis layer using calcium hydroxide which attacks epidermal proteins exclusively but dermal layer containing collagen is not affected by liming

Bating: bating is carried out with trypsin which hydrolyses elastin protein of the skin.

Tanning: basically there are two principal types of tanning which includes vegetable tannage and mineral tannage. Vegetable tannage gives heavy leather while mineral tannage gives soft and pliable leather. Mineral tannage is preferred for shark skin where active ingredients are tannin which are glucosides of polyphenol.

Drying: using tunnel drier preferably at slow rate.

Finishing operations: lubrication of fiber with fat – liquor coloring and shading by combination of dyes. Removal of shagreen is necessary as it makes the leather rough.

Fish glue

Fish gelatin and fish glue are more or less same and can be prepared from fish skin and fish head. If required, fish skin can be preserved by salting and drying before processing into glue however, fish head should be processed fresh.

Process

Glue from fish skin : Skin whether fresh or salted is washed and soaked in fresh water for the periods in the range of 1-18 hrs. depending on the condition of the material (fresh or salted). Washed skins are immersed in 0.2% caustic soda solution to open the fiber bundles and remove cementing materials. It is then neutralized with HCl and washed again in cold running water.

Swollen skin is then transferred to steam jacketed double bottomed kettle covered with an equal weight of water and is heated with steam. Small quantities of acetic acid also may be added to the mixture to hasten the hydrolysis of the stock into glue and to act as a catalyst. Cooking is continued for about 8 hrs. and the glue liquid is drawn off from the bottom of the cooker. The second run is made in a similar manner which is then concentrated in open heated pans at atmospheric pressure until the solid content reaches to 50- 55 % and cooled. Sometimes small quantities of volatile essential oils may be added to preserve the glue and to mask the fishy odour.

Glue from fish head: It should be processed fresh with addition of some bleaching agents like sulphurous acid during cooking of the skin some glacial acetic acid is added which softens the

head bones.

Uses

- Can be used in furniture
- Box making
- Sizing agent
- Can be used in special cements
- Photo engraving plate manufacture
- Book binding and small repair work etc

Pearl Essence

Pearl essence is the suspension of crystalline guanine in water or organic solvent.

Guanine is an iridescent material found in the epidermal layers and scales of most pelagic species of fish like oil sardine, mackerel, herring etc. When guanine particles are deposited on the inside surface of solid beads, an optical effect similar to that of real pearl is obtained.

Process

Freshly removed scales are collected and washed to obtain adhering foreign matter. Scale can be preserved in 10- 15% brine which is later drained off and scales are squeezed in muslin cloth bag and compressed. It can be stored at 0° C for several weeks without getting them dry. Pearl essence can be prepared as aqueous and no – aqueous suspension. Aqueous suspension can be prepared by agitating washed scales with water containing little ammonia. The mixture is then passed through a strainer. The pearly substance present as a suspension in the liquor is purified by settling in a cool atmosphere. Guanine settles and supernatant is decanted and replaced with fresh ammoniacal water. The process is repeated several times and 0.3% salicylic acid is used as preservative. Non- aqueous suspension can be made by suspending it in organic solvents like acetone, amyl acetate, chloroform or acetic acid. It is presented in a form of thick paste of crystals suspended in viscous liquor of cellulose of amyl acetate.

Uses

In the manufacture of artificial pearls

- It is used on diverse articles such as shoe, pencil, fishing rod and spectacle frame

Beche- de –mer

This is a product processed out of marine animal called sea cucumber belonging to class Holothuroidea which inhabits in tropical and temperate waters especially in Indo pacific regions. In India, sea cucumbers are found in south-east coast, Gulf of Mannar, Gulf of Kutch and Andaman and Nicobar and Lakshadweep. Holothuriascabra is the most abundantly used in India. Product prepared from sea cucumber is known as beche- de- mer or trepang. The animals are collected from shallow sea bed washed in clean sea water to remove dirt, sand and extraneous matter and then heated gently over a fire without any addition of water in galvanized iron or aluminium tubs. Then they are washed and cleaned and heated more strongly till sufficient water is expelled from their bodies to cover them completely. Boiling is continued for 50 min till a animal shrinks to half of their original size. The material is buried in sand and the sea water is sprinkled over to avoid drying up. After

18 hrs. pit is opened out and skins are peeled off manually and taken in basket. De-skinning is carried out then washed and boiled with sea water. Water is drained and dried in the sun spread on mats. Smoking is carried out if it is desired by buyers.

Fish meal

The term fish meal means a product obtained by drying and grinding or otherwise treating fish or fish waste to which no other matter has been added. The term white fish meal is reserved for product containing not more than 6 per cent oil and not more than 4 per cent salt, obtained from white fish or white fish waste such as filleting offal.

These are semi legal definitions, and for convenience fish meal can be defined as a solid product obtained by removing most of the water and some or all of the oil from fish or fish waste.

What is the importance of fish meal?

Fish meal is traditionally used as live stock feed supplement, since it contains high quality of animal protein with essential amino acids like lysine and methionine and cysteine which the animal can not synthesized. It is also a good source of B group vitamins like cyanocobalamine (B12), choline, niacin, pantathonic acid and riboflavine. Fish meal is rich in minerals like calcium, phosphorous, copper and iron and is also the source of some trace elements referred as unknown growth factors (UGFs). Some unidentified constituents in fish meal contributing to animal growth is a unique feature of which highlights the importance of fish meal in animal nutrition. Fish meal protein is also having high biological value

Fish oil

Introduction

Fish oils may generally be described as flesh oil, liver oil, or oil of the whole fish. It can be the by product in fish meal plant or may be The target product in fish oil production plant. The product, however, is versatile and finds many applications in the food and technical industries and is still of considerable economic importance to producers.

Chemical structure of fish oil

It mainly consists of triglycerides of fatty acids (glycerol combined with three similar or different acid molecules) with variable amounts of phospholipids, glycerol ethers and wax esters. It is characteristic of the oils that they contain a wide range of long-chain fatty acids with the number of carbon atoms ranging mainly from 14 to 22, and high degree of reactivity (unsaturation) ranging up to six double bonds per molecule.

Raw material

According to the Food and Agriculture Organization (FAO) raw material used for the production of fish oil falls into three categories:

 Fish caught specifically for reduction to fishmeal and fish oil such as
menhaden, anchovy, capelin and sardines.
 Incidental or by catch from another fishery (for example the global discards
amounted to 27.0 million metric tons (mmt) with a range of from 17.9 to
39.5 mmt with shrimp by catch accounting for 11.3 mmt)
 Fish by-products from the edible fisheries such as cuttings from filleting operations, fish cannery waste, roe fishery waste and more recently surimi processing waste.

Production of fish oil

There are a number of processes that can be used to convert raw fish and cuttings into fishmeal and oil. These fall into several categories defined as wet rendering, hydrolysis, silage production (autolysis), dry rendering and solvent extraction.

Health beneficial effects

 Fish oil helps with cholesterol by lowering levels of LDL while also increasing levels of HDL
 Heart problems, cholesterol, arthritis, and diabetes are some of the major conditions in which fish oil provides some form of Benefit or improved health.
 Fish oil supplements seem to have an anti-arrhythmic effect on the heart as well as prevent

Cardiac arrest. In doing this, fish oil can help lower the mortality rate of those individuals having heart complications

 Fish oil can benefit the heart because the EPA and DHA that make up the supplement helps to prevent plaque deposits and blood clots inside arteries.

 Fish oil improves the ability of muscle cells to take up glucose in the presence of insulin. This proves to be beneficial to those with type II diabetes

 Fish oil has been shown to have anti-inflammatory effects, especially the Eicosapentaenoic acids (EPA). They can improve overall function in joints as well as limit the amount of other anti-inflammatory drugs that a patient must consume with conditions such as arthritis or other inflammatory disorders such as Inflammatory Bowel Disease.

 Fish oil has been shown to have effects in dealing with certain psychological disorders. It has been found that omega- 3 fatty acids are known to have membrane enhancing capabilities in brain cells. They cause more production of two neurotransmitters, serotonin and dopamine. This allows patients to focus better on tasks that are at hand without as many distractions. The effects of Serotonin have been shown to help individuals better deal with stress and other activities.

 Fish oil has also been shown to have a number of beneficial effect on the brain. It has been shown that 60% of the brain is made up of a structural fat, which has a high number of DHA in it, and the brain requires a regular intake of good fats such as the ones from omega-3 fatty acids. Low intake of omega-3 fatty acids can lead to conditions such as ADHD, dyslexia, depression, aggression, Alzheimer's Disease, or other dementia.

Preservation

What is preservation?

Preservation means keeping the fish, after it has landed, in a condition wholesome and fit for human consumption for a period ranging from days to months depending upon type of preservation.

Traditional methods of preservation

What are the traditional methods followed for preservation of methods?

- Salting
- Drying
- Marinating
- Fermentation
- Combination of the above methods

Though the methods are traditional, these are widely adopted in developing and under developed countries.

What are all the advantages of Traditional methods of preservation?

- Cheapest methods of preservation
- No expensive technology
- Can be employed in both small scale and large scale
- Used for the preservation of low value fishes
- Make the product available in the remote area as well as throughout the year
- Operational skill is not required
- No need of technically qualified people

Which is the traditional method of preservation practiced widely?

Simple sun drying is the widely practiced traditional method of fish preservation.

What is the principle of preservation by sun drying?

Preservation by sun drying was achieved by lowering of water content in the fish, thereby retarding the activity of bacteria and fungi. The heat was able to destroy the bacteria to a certain extent.

Salting

Salting refers to addition of salt or soaking the fish in brine solution. Salting practiced as such or in combination with drying or smoking and is considered a practice as old as drying.

What is basis of preservation by salting?

When salt introduced into the flesh in sufficient quantity, it delays the activity of bacteria or even inactivates them and reduce enzymatic action by reducing the water activity.

What are all the Advantages of salting?

- Low cost of production
- Easiness and compatible with other preservation methods such as drying and smoking
- Does not require any special equipment
- Finished product does not required any special storage facility
- Any type of fish, preferably, low and medium fat fishes

L

- Product has good shelf life
- Nutritionally comparable with other preservation methods

Marinating

Marinating refers to a process of dipping the fish in to marinate before cooking to get a desirable flavour and texture. Marinate is a liquid, mixture of salt and acetic acid.

How preservation is achieved by Marinating?

Salt added in the marinating process retard the bacterial activity. Due to the addition of acid the marinades are at the pH of 4.5, at a pH of 4.5 or below, that is moderately acid, all food poisoning bacteria, and most spoilage bacteria, are prevented from growing.

What are all the Advantages?

- Products having a characteristic flavour
- Flesh of the fish firmer in texture
- Extended but limited shelf life

Sun drying

Sun drying of fish, with or without the addition of salt, is practiced in many tropical countries, and is a low cost form of preservation. Solar energy has been used all around the world to dry food products. Solar drying is use of equipment to collect the sun's radiation in order to harness the radioactive.

Methods of drying

What are all the methods of drying?

Natural Drying

- Drying on the ground
- Rack drying

Solar Drying

- Solar Tent dryer
- Solar Collector Dryer
- Solar cabinet dryer

Artificial /Mechanical dryer

- Hot air dryers
- Cabinet dryer
- Kiln dryer
- Tunnel dryer
- Multi deck tunnel dryer
- Fluidized Bed dryer

Contact dryers

- Vacuum dryers
- Rotary dryers
- Spray dryer Drum Dryer
- Vacuum shelf dryer

Smoking of fish

What is smoking of fish?

Smoking of fish refers to subjecting the fish to the smoke generated using various materials such as wood, coconut husk etc.

Preservation by smoking

How smoking exerts preservative action?

Spoilage of fish can be reduced by reducing some of the important substances like water content, enzyme content and fat content. The smoking process is effective in reducing the water by evaporation.

This occurs due to:

- The movement of the gases in the smoke over the surface of the fish
- Raising the temperature of the fish

The chemical components such as phenols and formaldehyde exist in the form of vapor in the smoke exert antioxidant and antibacterial activity.

In addition the smoking process results in the penetration of the chemicals into the fish and loss of water from the flesh. A layer is formed which reduces the effect of oxygen that enters the fish from the surface air. Therefore the rancidity of the fat is reduced. This layer is called “barrier layer”.

Types of smoking

Based on the temperature at which the process is carried out, smoking can be characterized into two types.

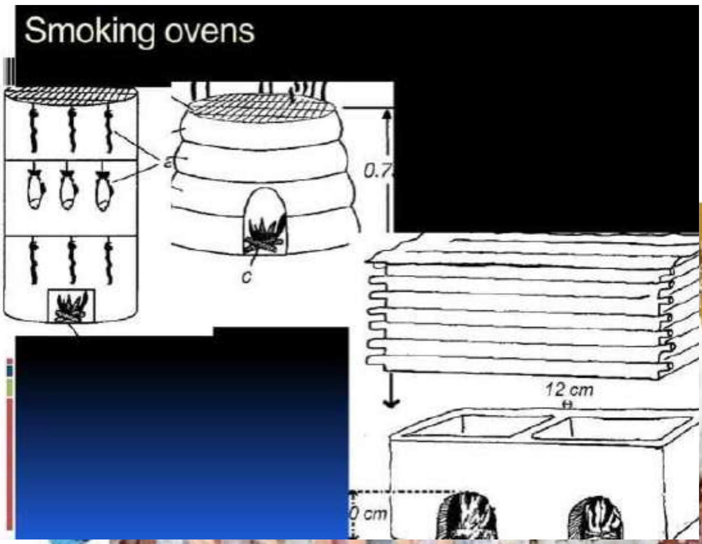
- Cold smoking
- Hot smoking

What is cold smoking?

Carrying out the smoking process at a temperature upto 30°C is called cold smoking, in which cooking of the flesh does not occur. Smoking effect is mainly due to the chemicals killing off the surface bacteria as reduction in water is not significant. Cold smoked products should be cooked before consumption Cold smoking takes 2-4 hrs. when using a mechanical smoking kiln

What is hot smoking?

Carrying out the smoking process in which the fish is exposed to increasing temperatures up to at least 70°C is called hot smoking. It is having following effects



Pickling

Pickling is an easy method of preserving fish. Pickled fish must be stored in the refrigerator at no higher than 40 degrees F (refrigerator temperature) and for best flavour must be used within 4 to 6 weeks. Only a few species of fish are preserved commercially by pickling but almost any type of fish may be pickled at home.

The first step in producing safe, home-pickled fish is to kill the larvae of the broad fish tapeworm, a parasite that can infect humans. It's most common in northern pike, but is found in several Minnesota fish. See the section below for methods to destroy the tapeworm larvae.

Refrigerate the fish during all stages of the pickling process.

Ingredients for Pickled Fish

Fish – Use only fresh, high quality fish.

Water – Avoid hard water, as it causes off color and flavors.

Vinegar – Use distilled, white vinegar with an acetic acid content of at least 5 percent (50 grains means the same thing). This percentage of acetic acid is needed to stop bacterial growth.

Salt – Use high grade, pure canning or pickling salt. It does not contain calcium or magnesium compounds which may cause off color and flavors in pickled fish.

Spices – Fresh, Whole spices

General method for precooked pickled fish

- Soak fish in a weak brine (1 cup salt to 1 gallon of water) for 1 hour.
- Drain the fish.
- Pack in heavy glass, crock, enamel or plastic container in strong brine (2 ½ cups salt to 1 gallon of water) for 12 hours in refrigerator.
- Rinse the fish in cold water. Cut into serving-size pieces.

- Combine the following ingredients in a large pan or kettle. This makes enough for 10 pounds of fish.
  - ¼ ounce bay leaves
  - 2 tablespoons allspice
  - 2 tablespoons mustard seed
  - 1 tablespoon whole cloves
  - 1 tablespoon pepper, ground
  - 1-2 tablespoons hot, ground dried pepper
  - ½ pound onions, sliced
  - 2 quarts distilled vinegar (5% acidity)
  - 5 cups water (avoid hard water of high mineral content)
- Bring to a boil.
- Add fish and simmer for 10 minutes until fish is easily pierced with a fork. Don't overcook.
- Remove fish from liquid and place on a single layer on a flat pan.
- Refrigerate and cool quickly to prevent spoilage.
- Pack cold fish in clean glass jars adding a few whole spices; a bay leaf, freshly sliced onions and a slice of lemon.
- Strain the vinegar solution, bring to a boil and pour into jars until fish is covered.

- Seal the jar immediately with two-part sealing lid, following the manufacturer’s instructions.
- Pickled fish must be stored in the refrigerator as stated in general directions.

Potting

A variation on French rillettes, terrines, pâté and confit, potting is an old English technique for preserving meat or seafood by storing it under a layer of fat. The food was traditionally cooked thoroughly to eliminate excess moisture, then packed into a ceramic pot.

Potted sea food

Modern methods for fish preservation

Modern preservation is done in 6 different ways

- Chilling/icing
- Refrigerator sea water
- Freezing
- Canning
- Irradiation
- Accelerated freeze in drying

Chilling or icing

The use of temperature reduction as a means of preserving fish and fishery products is very important worldwide both for local and export markets. This publication specifically examines the preservative effects and use of ice on board small fishing vessels.

For the purpose of this publication, the definition of chilling is as follows:

Chilling is the process of cooling fish or fish products to a temperature approaching that

Of melting ice.

The purpose of chilling is to prolong the shelf-life of fish, which it does by slowing the action of enzymes and bacteria, and the chemical and physical processes that can affect quality. Fresh fish is an extremely perishable food and deteriorates very rapidly at normal temperatures. Reducing the temperature at which the fish is kept lowers the rate of deterioration. During chilling the temperature is reduced to that of melting ice, 0 °C/32 °F.

Although ice can preserve fish for some time, it is still a relatively short-term means of preservation when compared to freezing, canning, salting or drying, for instance. When used properly it can keep fish fresh so that it is attractive in the market place.

- The use of ice for preserving fish and fishery products has proved to be an effective handling method on board fishing vessels for the following reasons:
- Ice is available in many fishing areas or ports.
- Purchasing patterns can be varied according to need (e.g. block ice of different sizes is frequently manufactured, and crushed, small or fragmentary ice ready for use is sold by weight).
- Ice has a very high cooling capacity.
- Ice is harmless, and in general relatively cheap.
- Ice can maintain a very definite temperature.
- Ice can keep fish moist and as it melts it can wash surface bacteria from the fish.
- Ice can be moved from place to place and its refrigeration effect can be taken to wherever it is needed.
- Ice can be made on shore and used at sea.

Refrigerated Sea Water (RSW) storage

In this system the seawater is cooled by mechanical refrigeration. The advantage of RSW over CSW is that there is a reasonable control of temperature over a range, which is not possible in CSW. At 3.5% salt, the sea water has a freezing point of about -2 0 C and if refrigerated it is possible to reduce the temperature to - 1 o C where maximum storage life for chilled fish can be obtained.

RSW systems, although more complicated than CSW systems, are not necessarily more expensive to operate. The basic components of this system are a heat exchanger to remove heat from seawater, a mechanical refrigerator to discharge heat from the system and a circulatory system to transport the refrigerant between the heat exchanger and the refrigerator.

Freezing

Water accounts for 75-80% of the weight in most of the fish. This water contains several dissolved organic and inorganic substances like sugars, salts and other compounds. Besides more complex organic molecules like proteins are also present in colloidal suspension. Hence the water in fish is actually a suspension of solids which will have to be cooled down to a temperature at which the solute phase and the solvent phase will have the same vapour pressure. So the freezing begins in the fish usually at a temperature of -1 to -2 o C.

Freezing Process:

In the simplest terms refrigeration means removal of heat from the body or atmosphere, which is desired to be cooled and its transfer to another medium. It is usually accomplished by the evaporation of a liquid refrigerant, which extracts heat from the medium to be cooled. The

refrigeration cycle involves steps to remove the heat from the evaporating refrigerant by again converting it into the liquid state in order that it may be used repeatedly in a continuous process

Freezing

- Freezing preserves the storage life of foods by making them more inert and slowing down the detrimental reactions that promote food spoilage and limit quality shelf life. Freezing is one of the most important processing and preservation methods for fish. The main freezing methods used are blast freezing, plate freezing, immersion or spray freezing.
- Advantages of freezing include:
- flesh is changed very little and there is minimal loss of quality
- fish can be stored for many months – for times when catches are scarce
- large quantities of fish can be stored (assuming the cold storage capacity is available)

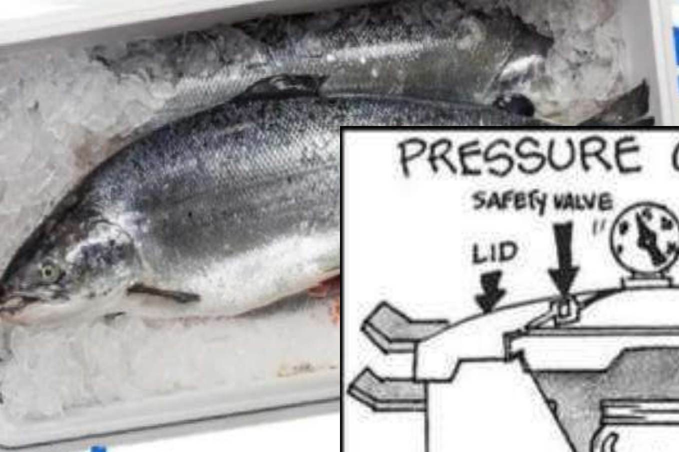
- good quality fish can be transported under refrigerated conditions over long distances (e.g. export to areas where fresh fish are unavailable; fish caught in remote waters can be consumed at home)
- Disadvantages of freezing include:
- Quality changes can occur if fish is not stored properly
- Can be expensive due to the power or fuel needed to operate the freezer
- Customers often have less regard for frozen fish
- Until it has thawed, it may be difficult to identify whether the fish has been abused

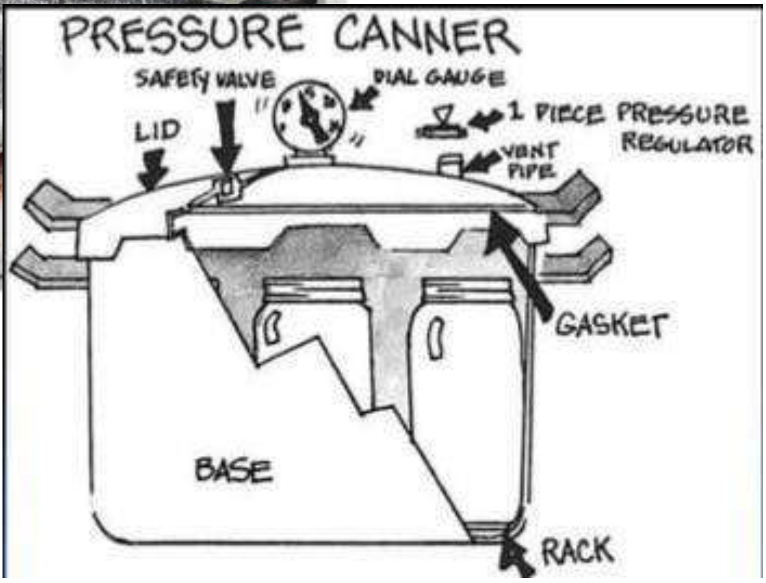
Canning

Basics of Canning Food is placed in a jar and heated to a temperature that destroys targeted microorganisms. Heat also inactivates enzymes that cause spoilage. Air is driven from the jar during heating. As the jar cools a vacuum seal is formed.

Steps to canning fish

- **Start with fresh and healthy fish.**
- **Remove the head, tail and bones of large fish and wash thoroughly with cold water.**
- **Cut Into desired size pieces.**
- **The fish is also salted and smoked to remove blood and water from flesh, this also denatures the protein which makes the fish stay firm and not shrink after canning.**
- **Fill hot, clean, pint or half-pint jar, leaving 1-inch headspace.**



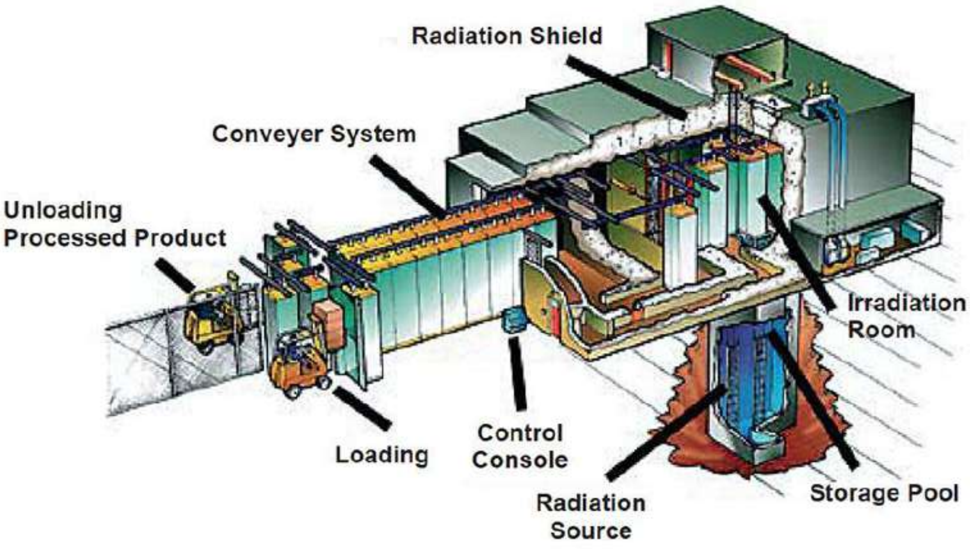


■ Seal jar and place in canner.
■ Process for 100 minutes at 240 degrees at 11 pounds pressure with a dial gauge. Turn off heat at the end of processing. Let pressure drop to 0 psig naturally.
■ Wait 2 minutes after pressure drops. Open the canner. Remove the jars and cool it for 24 hours undisturbed.

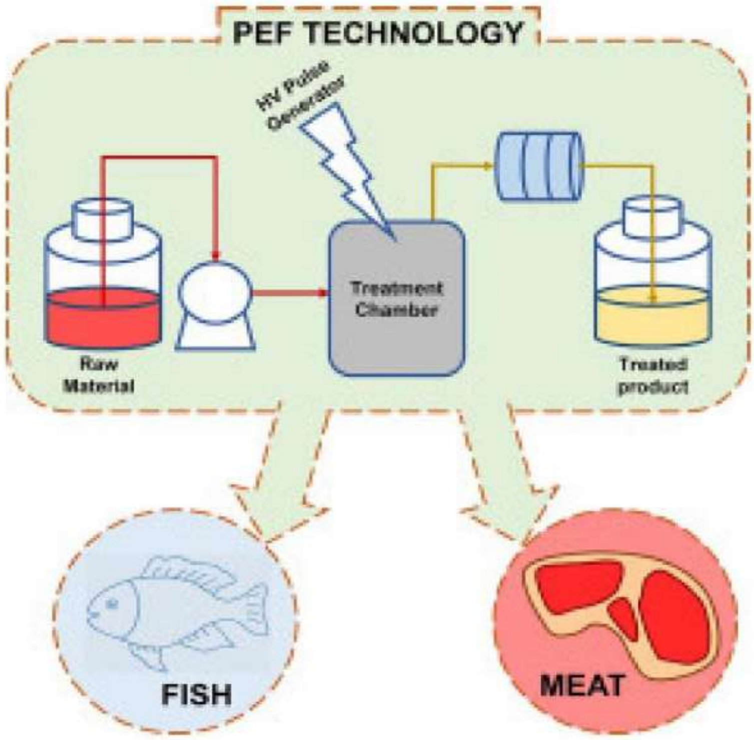
Irradiation

Irradiation is a ‘cool’ technique (calle cool pasteurization) that does not raise the temperature. Fish that have been irradiated maintain their flavors and aromas. It also avoids the need for chemical treatments such as fumigation or insecticides to manage bacteria and other pests. Irradiation can provide

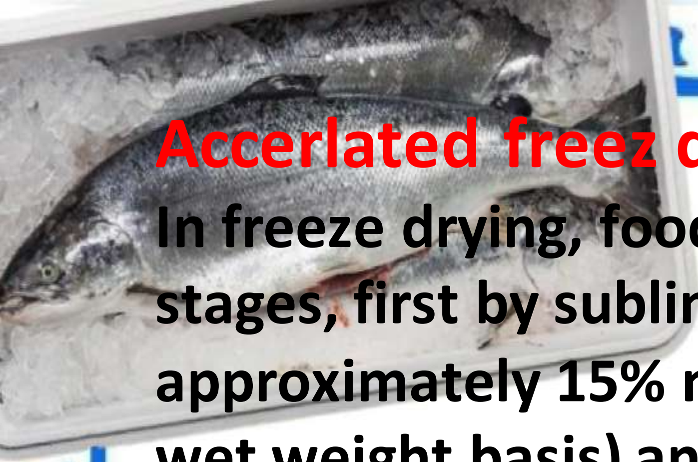
consumers with good quality fish and fish products. Gamma irradiation is a well-known and commonly used fish preservation method that does not cause any increase in temperature, decreases the microbial population, and extends fish shelf life . This process exposes fish to a carefully controlled amount of energy in the form of high-speed particles or rays that reduce the risk of food poisoning, control fish spoilage, and extend the shelf life of fish without any health risk and with minimal effect on nutritional or sensory qualities. This technique has no effect on food taste, color, and odor, and no radioactive residues are left. Therefore, we found it timely and important to use an alternative method



Rather than the traditional methods of preserving fish. Owing to the above-mentioned crises correlated with poor fish hygiene, we apply a new and safe method of fish preservation (irradiation at different doses) that can reduce microbial loads and



Eliminate resistant pathogens contaminating the fish meat while keeping their sensory and nutritional properties intact



Accerlated freez drying

In freeze drying, foods are dried in two stages, first by sublimation to approximately 15% moisture content (on wet weight basis) and then by evaporative drying of unfrozen water to 2% of moisture content. The rate of drying depends mostly on the resistance of the food to heat transfer and on the resistance to vapour flow.

Principle of the equipment.

Equipment Freeze drier consists of a vacuum chamber containing trays to hold food during drying, source of heat to supply latent heat of sublimation, refrigeration coils to condense vapour with automatic devices to keep maximum area of the coil free of ice for vapour condensations and vacuum pump to remove non expansible vapour.

Types of equipment's

- Accelerated freeze driers
- Radiation freeze driers
- Microwave and dielectric freeze driers

Freeze drying process

- Freezing
- Primary drying to remove water ice.

Secondary drying to remove bound water molecules from the primarily dried materials.

Primary drying

During drying, an interface is set up which comes from the exposed surface to vacuum system to the surface where heat source is in contact or moves deeper in radiant heat.

Secondary Drying

The locked in or bound water is removed form the products by supplying additional heat energy to the system.

Effect of freeze drying on food

Freeze dried foods have high retention of sensory and nutritional qualities and shelf life of more than 12 months when correctly packed. Allows rapid and full rehydration but the product is fragile and require protection from mechanical pressure. The open porous structure of

The food may allow oxygen to enter and cause oxidative changes. Therefore vacuum or inert gas packaging is required.

Migration

INTRODUCTION

Few species travel long distance moving from place to place in search or food or for breeding. This movement of a large number of fishes for the purpose of feeding or spawning is known as Migration. According to baker (1998) it is the act of moving from one spatial unit to another'.

According to nikolsky (1963) - migration is an adaptation toward increasing the abundance of aspecies.Migration behaviour is of course one of the phenomena in the life histories of the fish directed toward reproductive success.

MIGRATORY SPECIES

Several species are migrated of mature adults for spawning and feeding. These are example of migratory fishes

1. The cod (Gadus morhua)
2. Herring (Clupea harengus)
3. Salmon (salmo sp.)
4. Eel (Anguilla anguilla,
   a. Rostrata and b. japanica
5. Hilsa (Hilsa ilisa)
6. Three-spined stickle back (Gasterosteus aculeatus)
7. The lampreys (Petromyzon marinus)
8. The tunnas (Thunnus thynnus)

TYPES OF MIGRATION-

Migration may be the following types:

a. ALIMENTORY MIGRATION – This is in search of food and water.

B. GAMETIC MIGRATION For reproduction

C. CLIMATIC MIGRATION – to secure more suitable climatic conditions.

D. OSMOREGULATORY MIGRATION.

METHOD OF MIGRATION-

A Fish can make migratory movements by several methods:

1. BY DRIFTING:

Fishes are carried passively be water currents. This is called DRIFT, and may result in ‘directional movements. If the over all water movement is in one direction.

2. RANDOM LOCOMOTORY MOVEMENT-

Locomotary movements that are random in direction lead to a uniform distribution or to an aggregation.

If the fishes are released from a point in a uniform environment and spread out in all directions the process is called – **DISPERSAL** and leads to uniform distribution of the species.

3. ORIENTATION SWIMMING MOVEMENT-

➤ Fishes swim in a particular direction:

a. Either towards or away from the source of stimulation

b. At some angle to an imaginary line running between them and the source of stimulation.

PERIODICITY OF MIGRATION-

most of migration occurs at regular intervals and may be daily, monthly, seasonally, yearly biannually or longer.

➤ Thus, pacific salmon may remain at sea for several years before returning to the spawning grounds.

➤ Larvae of Petromyzon marinus may spend several year in the mud before metamorphosis and migrating to sea.

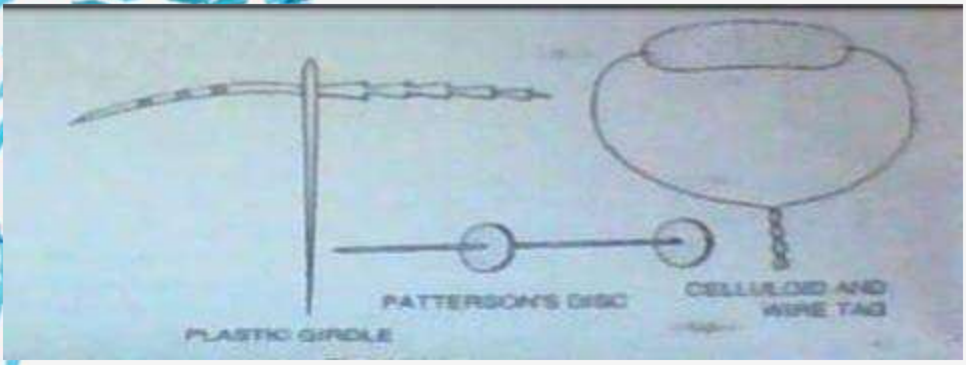
> Eel spend several years (up to 20) feeding in fresh water , before undertaking spawning migration to sea.

> The periodicity thus varies between different species, and even within a species and appears to be due to many biotic and abiotic initiating factor.

MARKING AND TAGGING -:

Information about the pattern of fish migration, its direction and speed of movement, can be studied by marking and tagging of fish followed by raptured.

The mark or tag must be easily identible and must stay with the till end of the study.



Many types of tags have been developed for attachment to the fish for recognise.

PATTERNS OF MIGRATION-:

The form or pattern of migration differs between species, as well as within a species, Myer's (1949) has used the following terms to describe fish migration:

1. DIADROMOUS FISHES

A. Anadromous (salmon and hilsa)

B. Catadromous (anguilla)

C. Amphidromous

2. POTAMODROMOUS FISHES

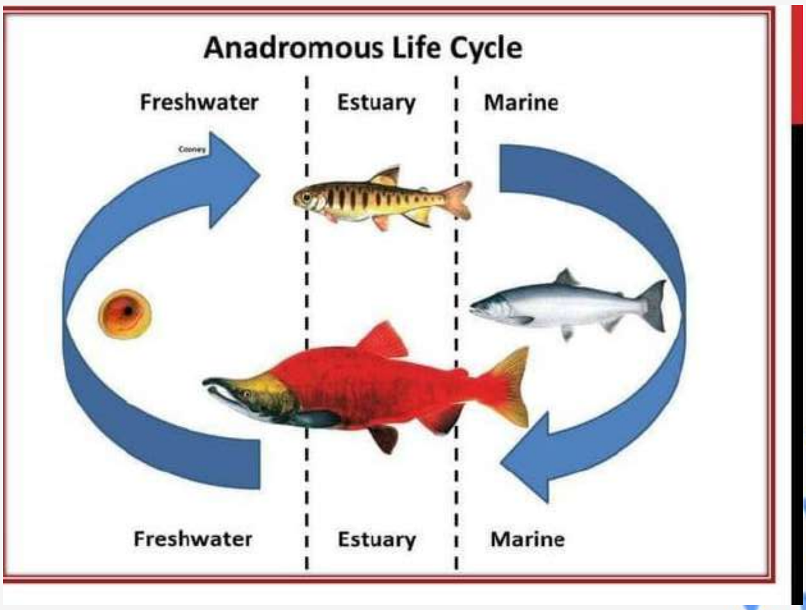
3. OCEANODROMOUS FISHES

1- DIADROMOUS FISHES-: these are truly migratory fishes which migrate between the sea e types:

A. ANADROMOUS FISHES -:

❖ Anadromous fishes which spend a major part of there lifes in the sea but migrate to fresh water during breeding period for spawning. Thus, many marine fishes like the Salmon shad Lamprey and Hilsa, travel long distances in the sea and run up the river to spawn in fresh water.

❖ Salmon and Hilsa have been found to travel several thousand km in the sea, then several hundred km inland to reach the spawning ground, after egg laying, the spend fishes return to feeding places in the sea.



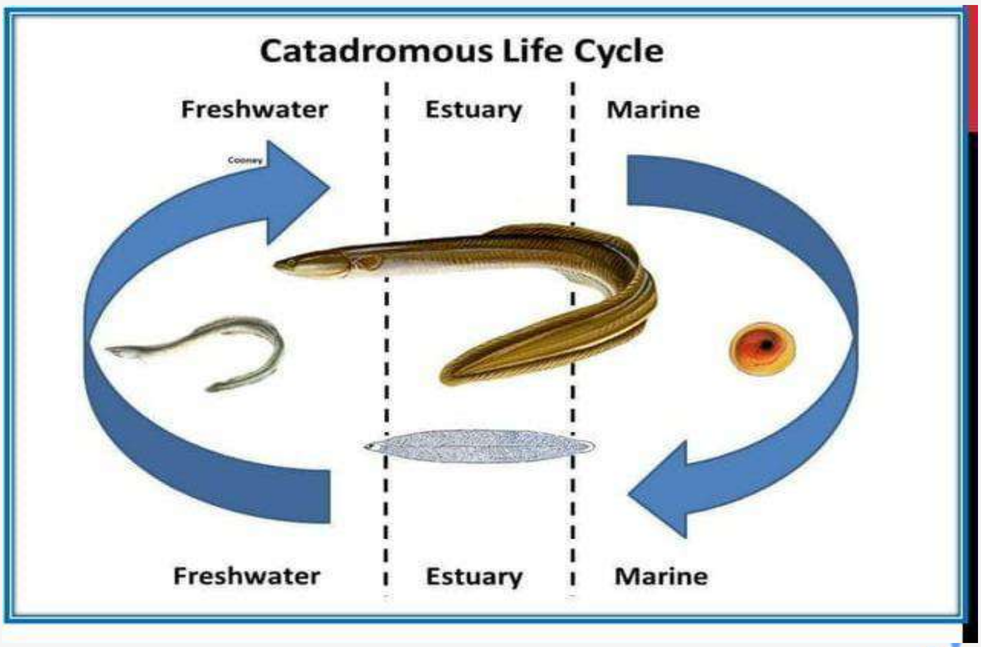
B. CATADROMOUS:

This group including diadromous fishes which spend a major of their lives in fresh water but migrate to the sea for breeding purpose.

➤ Thus the fresh, water eel Anguilla travels several thousand km starting from the rivers and reaching the spawning grounds in the sea.

After egg laying, the river die and the young larvae drift and swim back towards the fresh water, taking three years in reaching the rivers.

➤Here,they become adult, and on reaching maturity start their seaward migration again.

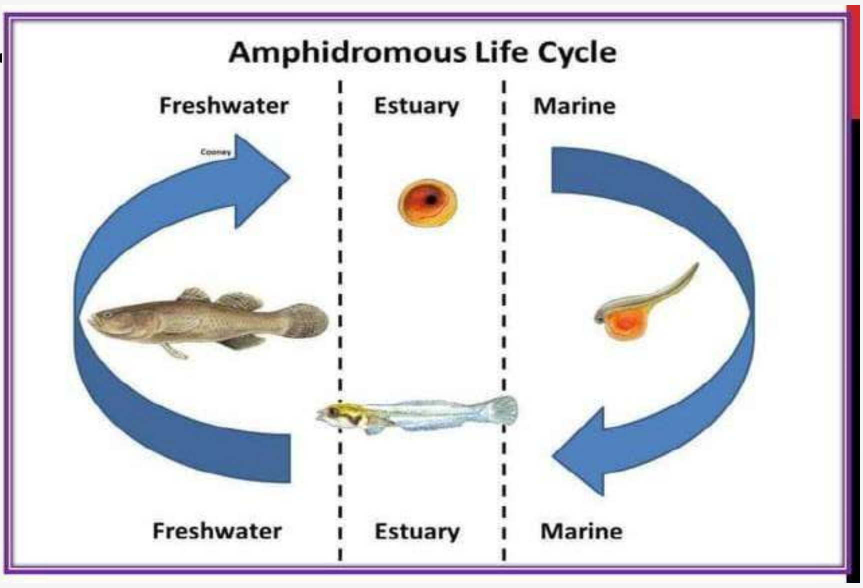


C. AMPHIDROMOUS:

These are diadromous fishes in which migration from fresh water to the sea or vice versa is not for the purpose of breeding.

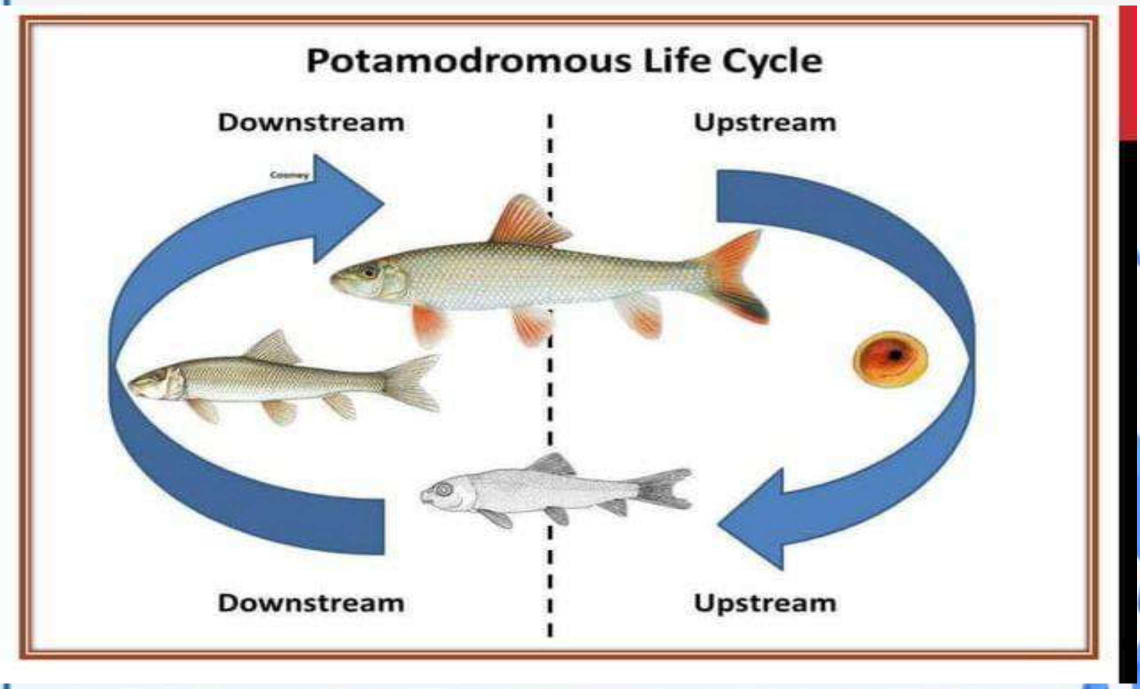
But occurs regularly at some other definite stage of the life cycle.

Myer suggests that the migration of some gobies might fall into this category.



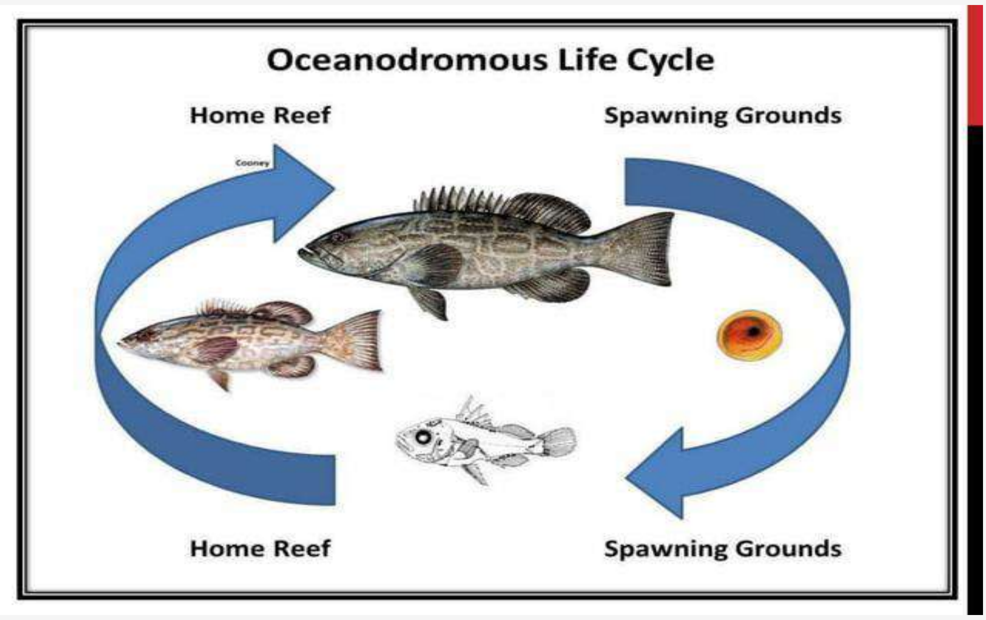
2. POTAMODROMOUS FISHES-:

Truly migratory fishes whose migration remain confined to fresh water, e.g. the carps and the trout travels long distance in large rivers in search of spawning grounds.
***After egg laying at suitable places they return to the feeding area.**



3. OCEANODROMOUS FISHES

❖Truly migratory fishes which live and migrate in the sea.Many marine fishes like the cod, theherrings (Clupea), mackerels (Scomber) and the tunnas (Thunnas) travel long distance in the sea to deposit their eggs, and later return to the feeding grounds.



FACTOR INFLUENCING AND CONTROLLING MIGRATION-:

Migration are influenced by several factors which may be physical, chemical and biological.

Physical factors-

1. Bottom materials
2. Depth of water
3. temperature
4. light intensity

5. Photoperiod
6. Current turbidity

Chemical factor-

1. Salinity
2. pH
3. Smell and taste of water.

Biological factor

1. Migration are the sexual maturity
2. Blood pressure
3. Food
4. Memory
5. Physiological clock
6. The endocrine glands
7. Presence or absence of the predators and competitors may also be considered as the biological factors governing migration of fishes.

MECHANISM OF ORIENTATION -:

The mechanism of orientation during fish migration has been reviewed by Hasler (1971) and Able (1980).

* Orientation means arranging of an animal in a given direction.

❖ Homing- a fish may recognised its home site by a direct sensory stimulus vision or olfaction. This is called ‘homing’ or ‘piloting.

‘navigation’ refers to the mechism by which an animal can find direction towards a desired area.

➤ Homing ability of a fish required a knowledge of some kind of’ map’, whose information might be stored in the central nervous system

> fish can use the sun for orientation during migration the fishes are observe the changing angle of the sun, relative to the horizontal and vertical planes.

> During night, fish might use the position of moon for orientation

➤ some species might make use of the magnetic and electrical field for orientation, and have the ability to produce and receive electric signals and exhibit the power of electrolocation.

Causes OF MIGRATION-:

Several authors have given various reasons as to why fish migrate,according to Northcote (1978) this is:

1) To optimize feeding
2) To avoid unfavourable condition,
3) To enhance reproductive success, and
4) Possibly to promote colonization.

The strategy of fish is to exploit rich food source, to enhance food intake which is necessary for increased growth rate, fecundity and survival.

ADVANTAGES OF MIGRATION-:

Migration is an adaptation towards abundance.

➤ it would be an advantage to have separate spawning, nursery and feeding grounds.

➤ A species whose adults return to spawn in an area where the environmental condition were similar to those under which they themselves survived when young.

> Thus a better egg and larvae survival would lead to a greater number of spawners on a particular ground.

Aquarium

List of 34 Commonly used Fishes for Aquarium

Article shared by:

List of thirty-four commonly used fishes for aquarium:-

1. Knife Fishes 2. Eel 3. Barbs 4. Hatchet Fishes 5. Razorbelly and Streak 6. Carplets 7. Trouts 8. Danios 9. Rasbora 10. Alga-Eater 11. Torrent Fish 12. Loaches 13. Characins 14. Goldfishes 15. Catfishes 16. Toadfishes 17. Halfbeaks 18. Killifishes or Egg-Laying Tooth Carps 19. Live-Bearing Tooth-Carps 20. Sea Horses and Pipe Fishes and Others.

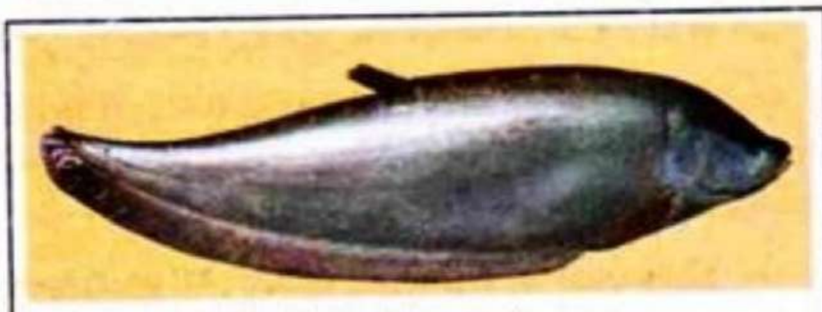


Fig. 6.58. Black Knife Fish

Fig. 6.59. Spotted Moray Eel

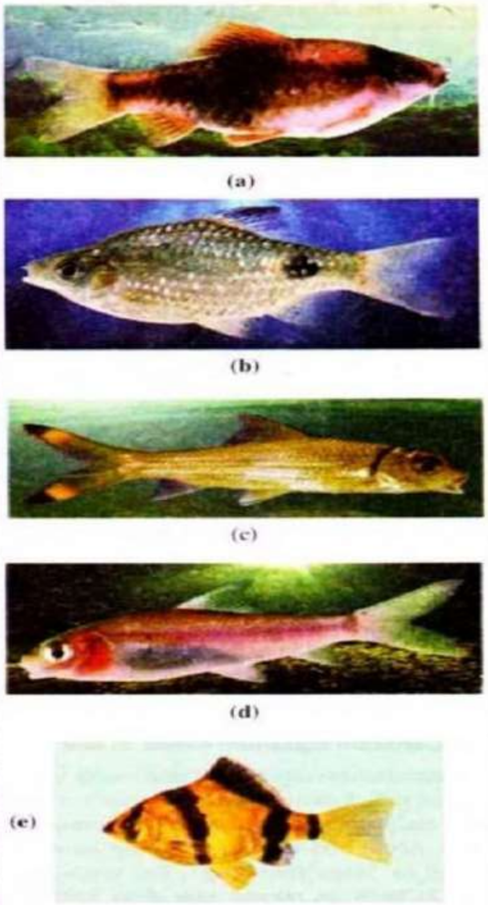


Fig. 6.60. (a) Melon Barb, (b) Indian Rosy Barb, (c) Red Tailed Silver Shark, (d) Red Gilled Violet Shark, (e) Tiger Barb

Fig. 6.61. Burjor's Brilliance

Fig. 6.62. Silver Streak

Fig. 6.63. Brass Carplet

Fig. 6.64. Blue Dotted Hill Trout

Fig. 6.65a. Turquoise Danio

Fig. 6.65b. Moustached Danio (exotic species)

Fig. 6.66. Black Line Rasbora

Fig. 6.67. Rinocerous Alga-eater

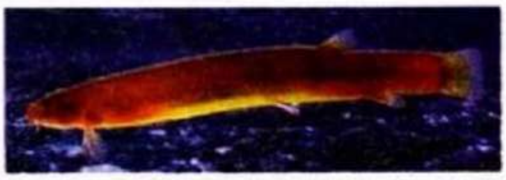


Fig. 6.69a. Indian Coolie Loach

Fig. 6.69b. Striped Loach

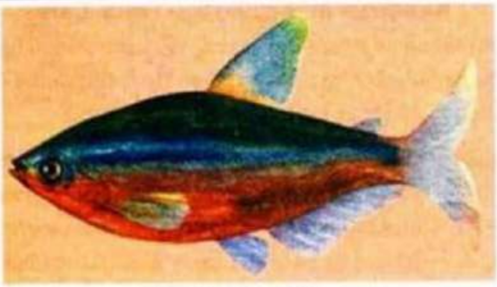


Fig. 6.70. Neon Tetra

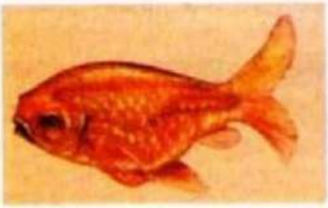


Fig. 6.71(a). Typical Goldfish

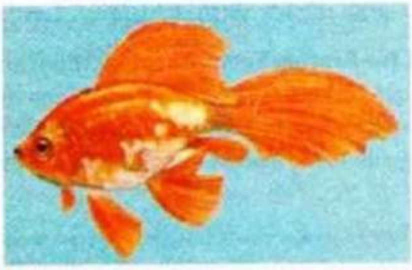


Fig. 6.71(b). Comet Goldfish

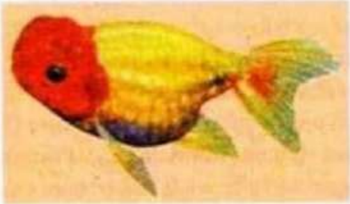


Fig. 6.71(c). Lionhead Goldfish

Fig. 6.72(a). Velvet Catfish

Fig. 6.72(b). Striped Glass Catfish

Fig. 6.72(c). Thread Tail Catfish

Fig. 6.78. Jewelled Alligator Fish

Fig. 6.72d. Long Fighting Catfish

Fig. 6.72e. Spotted Shark Catfish

Fig. 6.73. Gangetic Toadfish

Fig. 6.74(a). *Aplocheilus parvus*

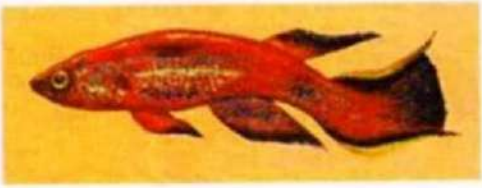


Fig. 6.74(b). *Aphyosemion australe*

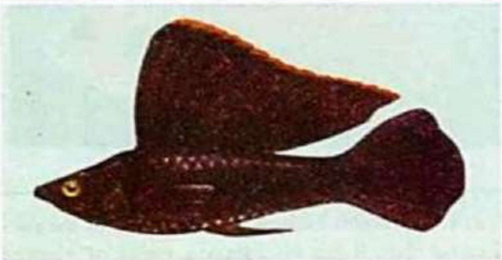


Fig. 6.76. Black Sail-fin Molly

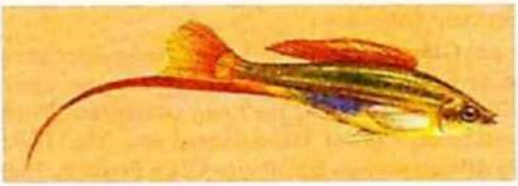


Fig. 6.77. Sword Tail

Fig. 6.79. High Fin Glassfish

Fig. 6.80. Red Scat

Fig. 6.81. Malabar Sunfish

Fig. 6.82. Dwarf Chameleon

Fig. 6.83(a). Pearl Spot

Fig. 6.87. Spring Green Eel

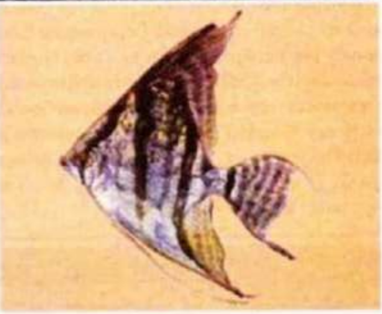


Fig. 6.83(b). Angel Fish

Fig. 6.83(c). Discus Fish

Fig. 6.84. Blue Spot Dragon

Fig. 6.85. Dwarf Gourami

Fig. 6.86. Bengal Snakehead

Fig. 6.88. Red Green Dwarf Puffer

Diseases of Aquarium Fishes (With Treatment)

1. Degenerative Diseases:

Increasing age leads to heart failure, kidney failure, skeletal deformities, development of growth and pigmented tumors, imbalance, etc. Senile changes takes place and the fishes become incapable of breeding. Air-bladder disease is also common.

2. Traumatic Diseases:

Injuries due to fighting or popping out of the aquarium may lead to traumatic diseases.

3. Congenital Diseases:

Certain inborn deformities (absence of gill covers, twisted backbone, etc.) leads to congenital diseases.

4. Sudden Shocks:

Aquarium fishes turns upside down, when transferred from acid to hard alkaline water. Similar shock symptoms are also observed in fishes when placed in water of different temperature.

etc

5. Infectious Diseases:

Infectious diseases caused mainly by protozoans are common in aquarium. Such diseases are transmitted through infected fishes either directly or at the of transfer by a net.

Some common diseases witnessed are:

(i) White spot diseases:

Caused by the protozoan Ichthyophthirius sp., the white spot disease is very common infection in aquarium. It causes itching and the infected fish is seen to be rubbing its body against object in the aquarium to reduce irritation. They are often caused by a drop in water temperature.

A dip of the infected fish for ten days in 5% aquous solution of Methylene Blue is effective but should be applied in a tank where plants are absent, as methylene blue is harmful to plants.

(ii) Velvet disease:

Caused by the protozoan, Oodinium sp., velvet disease mostly affects labyrinth fishes and members of carp family such as Barbs, Minnows, Danios and live-bearing looth-carps. Fishes affected by this parasite have golden dust-like spots on their skin as if sprayed with golden powder.

Infected fry and young fishes usually succumb to the disease before it is determined. The free-swimming parasite is very difficult to eradicate as this protozoan also contains chlorophyll and can exist without fish for a long time in the presence of light.

Total treatment of the tank has to be done with Methylene Blue for ten days. The drug Acriflavin can also be used but it would cause temporary sterility in fishes. The plants in the infected tanks must be removed and washed in a solution of potassium permanganate. The gravel should be washed and Preferably in boiling water.

(iii) Chilodon disease:

Caused by Chilodon cyprine, the protozoan parasite attaches itself to the skin ad gills of the fish resulting in asphyxiation. The affected fish is often seen to spiral up to the surface of the water to gasp a bubble of air.

Treatment with Methylene Blue or Acriflavin may obtain favourable result.

(iv) Costiasis:

Costiasis results due to the infection of the protozoan, costia sp., which grows on the mucus of the fishes, skin. The affected fishes lose their appetite, becomes lethargic and breaths heavily. A dip in 2.5% salt solution for fifteen minutes is recommended for cure.

(v) Fin rot:

The bacteria causing this disease enter through the damaged fin or inflammation and causes destruction of the fin tissue, resulting in death of the affected fish. Treatment with a weak solution of Acriflavin or Penicillin will be effective.

(vi) Columnaris disease:

Caused by Chondoccus columnaris, this bacteria enters the fishes' body through injured areas, particularly near the mouth region. The cure recommended is 250 mg Chloramphenicol capsule per gallon of water.

(vii) Pop-eye exophthalmos:

Aquarium with Siamese Fighting Fishes generally succumbs to this bacterial disease, when the eyes become swollen and cloudy

. The affected fish loses its eye sight if not treated in time. The affected fighter fish is put in a net and one drop of silver eye drop is applied four times a day.

(viii) Cotton-wool disease:

Caused by the fungus Saprolegnia sp., the parasite attacks and grows at the region where damage of the skin has occurred It produces a cotton wool-like growth and the mycelia eventually invades the body tissue. The affected fishes should be removed and the wound treated daily with 50% Methylene Blue till its total irradication.

(ix) Infection by flukes:

Infection by flukes are caused by the trematodes, such as Zygodactylism and Dactylogyrus that grow on the body and gills, respectively. The infected fishes become pale with torn and slimy fins. The fishes should be kept in a blue solution of Methylene Blue for three days.

6. Enemies:

Fishes are also prone to attack by other animals and insects that accidentally enter into the aquarium through addition of pond water (through live food). The enemies are Hydra, Piscicola, Great Diving Beetle, Dragonfly larva,

Gene editing

Genetic Improvement for Sustainable Aquaculture Production Domestication and genetic improvement of terrestrial livestock has occurred for several millennia, with organized breeding programs for most species in place for >50 years. The results have been striking; for example, selective breeding has led to a threefold increase in efficiency of milk production in cows, with similar gains for other target traits [8.]. By contrast, relatively little aquaculture production is underpinned by modern selective breeding programs [9., 10.]. Most farmed aquatic species are either still sourced from the wild or in the early stages of domestication, suggesting that there is substantial standing genetic variation for traits of economic importance. The reproductive biology of aquatic species can be amenable to the application of genetics and breeding technologies, enabling high selection intensity and, therefore, genetic gain. In part, this is due to the near

universal high fecundity of aquatic species, and the resulting large nuclear families, which can facilitate extensive collection of phenotypic records in close relatives (including full siblings) of selection candidates in breeding programs. The reproductive output from genetically improved brood stock (see Glossary) together with ease of transport of eggs and juveniles, also means widespread dissemination of improved stocks can have a rapid impact on production. Furthermore, with the development of high-density SNP arrays and routine genotyping by sequencing, genomic selection has become the state-of-the-art in several globally important aquaculture sectors, offering higher selection accuracies than selection based on phenotypic and pedigree records alone. However, genetic progress in selective breeding is limited by the heritability of the target traits, the generation interval of the species, and the need to target multiple traits in the breeding goal. In addition, advanced breeding programs are typically closed systems, and are limited to the standing genetic variation in the brood stock (typically sourced from a limited sample of wild populations), and new variation that arises from de novo mutations.

Genome-editing technologies, such as CRISPR/Cas9, offer new solutions and opportunities in each of these areas. Current Status of Genome Editing in Aquaculture Species Genome editing using CRISPR/Cas9 was recently successfully applied in vivo and/or in cell lines of several major aquaculture species of Salmonidae (Atlantic salmon, Salmo salar and rainbow trout, Oncorhynchus mykiss), Cyprinidae (Rohu, grass, and common carp, Labeo rohita, Ctenopharyngodon idella, and Cyprinus carpio, respectively), Siluridae (channel and southern catfish, Ictalurus punctatus), as well as Pacific oyster (Crassostrea gigas), Nile tilapia (Oreochromis niloticus), and gilthead sea bream (Sparus aurata) where successful CRISPR/Cas9 editing has not yet been reported is shrimp (Penaeus sp.), which may be partly due to practical limitations, as discussed briefly below. Most studies have a proof-of-principle focus, have typically followed CRISPR/Cas9 protocols developed in model organisms, such as zebrafish (Danio rerio), and have often targeted genes with a clearly observable phenotype to test editing success (e.g., pigmentation). The standard methodology to induce in vivo mutations in aquaculture species is injection of the CRISPR/Cas9 complex into newly fertilized eggs as close as possible to the one-cell stage of development. Typically, mRNA encoding the Cas9 protein is injected together with the guide (g)RNA, leading to the high efficiency of editing demonstrated in various species to date (Table 1); using the Cas9 protein in place of mRNA is also effective [25.]. While most studies have used nonhomologous end joining (NHEJ) to induce mutations, homology-directed repair (HDR) has been successfully used to insert a template DNA in Rohu carp [30.]. Furthermore, successful germline transmission of edits has been reported in several of the studies to date (Table 1). Mosaicism is common in edited animals, implying that the Cas9-induced cutting and editing continues past the one-cell stage; this is an issue to tackle with future research.

Target production traits for genome-editing studies in aquaculture species to date have included sterility, growth, and disease resistance.

Creating sterile animals for aquaculture is desirable to prevent introgression with wild stock and to avoid the negative production consequences of early maturation; in this context, CRISPR/Cas9 has been used to induce sterility in Atlantic salmon and Catfish. For growth-associated traits, several groups have edited the myostatin gene (famous for its role in 'double-muscled' cattle, such as the Belgian Blue), resulting in larger fish. To date, this has been performed in channel catfish and common carp .Immunity and disease resistance have already been investigated using genome editing in Rohu carp and Grass carp, respectively, and it is expected that this area of research will flourish as a route to improving and understanding disease resistance as a key target trait for aquaculture. Genome editing can also be applied to develop models for studying fundamental immunology, such as the targeted disruption of the TLR22 gene in carp. Such models can improve our fundamental understanding of host response to infection in fish and may lead to more effective treatment protocols. Along similar lines, it is plausible to use genome-editing technology to generate

improved cell lines for fish species, for example by enabling more efficient production of viruses for future vaccine development by knocking out key components of the interferon pathway Some practical reasons why genome editing has such potential for research and applications in aquaculture species are the ease of access to many thousands of externally fertilized embryos, and the large size of those embryos facilitating microinjection by hand. The ability to use large nuclear families enables a degree of control of background genetic effects, with ample sample sizes achievable for downstream comparisons of successfully edited individuals with their unedited full-sibling counterparts. The ability to perform extensive 'phenotyping' is often also feasible, for example using well-developed disease challenge models to assess resistance to many viral and bacterial pathogens during early-life stages. Finally, should favorable alleles for a target trait (e.g., disease resistance) be created or discovered, then there is potential for widespread dissemination of the improved germplasm for rapid impact via the aforementioned selective breeding programs. In parallel, high-quality, well-annotated reference genomes are available for most of the key species. A high-quality species-specific reference genome is essential for the effective design of target g-RNAs with high specificity and minimum change of off-target editing, in particular given the relatively recent whole-genome duplication events that are features of several finfish lineages, including salmonids.

Applications of Genome Editing for Aquaculture Research and Production

Infectious diseases are one of the primary threats to sustainable aquaculture, with an estimated 40% of the total potential production lost per annum [39.]. Due to the formative stage of domestication of many aquaculture species, new selection and disease pressures in the farm environment may increase the possibility that standing genetic variation in farmed populations includes loci of major effect, which may represent potential 'low-hanging fruit' for genome editing to increase the frequency of the favorable allele.

A well-known example of a major quantitative trait locus (QTL) affecting disease resistance is the case of infectious pancreatic necrosis virus (IPNV) in Atlantic salmon, in which a major QTL explains the majority of the genetic variation. Marker-assisted selection, which is based on the targeted use of molecular genetic markers linked to QTL, has been successfully applied to markedly reduce the impact of this disease. However, despite several QTL studies in Aquaculture species and ample evidence for the heritability of disease resistance traits, only a handful of large-effect QTL have been detected, and most disease resistance and other production-relevant traits are underpinned by a polygenic genetic architecture. As such, genetic improvement of disease resistance relies on family-based selective breeding programs, augmented by the use of genomic selection, for which disease resistance has been a major focus. The substantial opportunity for genetic improvement of disease resistance and other performance traits in aquaculture species, combined with initial success of in vivo genome-editing trials, opens exciting new avenues to improve aquaculture production and sustainability. There are three main categories by which genome-editing technology could be applied to make step changes in genetic improvement, and each requires different approaches to the underpinning research leading to discovery of functional alleles: (i) detecting, promoting, removing, or fixing targeted functional alleles at single or multiple QTL(s) segregating within current brood stock populations of a selective breeding program; (ii) targeted introgression-by-editing of favorable variants from different populations, strains, or species to introduce or improve novel traits in a population; and (iii) creating and utilizing de novo favorable alleles that are not known to exist elsewhere. Here, each of these avenues are discussed in turn, and a unique opportunity to harness a combination of in vivo and in vitro approaches to understand and improve disease resistance in aquaculture species is presented.

Economic importance of aquaculture

Economic importance of fishes:

1. Fishes are caught, processed, raised, and marketed under fisheries. It provides good job opportunities and self-employment.
2. Culturing fishes on a large scale in ponds, lakes, and reservoirs boost the productivity and economy of the nation.
3. Fishes are a source of nutritious food as they are rich in proteins, vitamins (A, D, and K), carbohydrates, fats, and minerals.
4. They also yield a number of by- products that hold commercial value.
5. The by-products obtained from fishes include fish oil, fish meal, fertilizers, fish guano, fish glue, and isinglass, which are widely used in paints, soaps, oils, and medicines.
6. Prawns and lobsters have a market value all over the world.

Fisheries sector in India play a significant role in the Indian economy and provide livelihood to millions of fisher folk. **India is the 3rd largest fish producing and 2nd largest aquaculture producing nation in the world.** The Blue Revolution in India demonstrated importance of Fisheries and Aquaculture sector. To improve the quality of life and economic well-being of people in rural areas and to create more livelihood opportunities, a holistic approach has been adopted by the Government of India to meet Sustainable Development Goals (SDGs). "SagarParikrama" is an evolutionary journey envisaged in the sea across the coastal belt demonstrating solidarity with all fisher folk, fish farmers and concerned stakeholders as a spirit of 75th Azadi Ka Amrit Mahotsav saluting our great freedom fighters, sailors and fishers. It is an initiative by Government of India, aiming to resolve the issues of the fishers and other stakeholders and facilitate their economic up liftment through various fisheries schemes and programs being implemented by the Government of India such as PMMSY& KCC.

The journey of “Sagar Parikrama” has started with the theme of “KRANTI se SHANTI” on 5th March 2022 from Mandvi, Gujarat covering 3 locations Mandavi, Okha-Dwarka and Porbandar. Followed by Phase-II program covered 7 locations from Mangrol, Veraval, Diu, Jafrabad, Surat, Daman &Valsad. Later, Phase-III ‘SagarParikrama’ covered the 5 locations in coastal areas of northern Maharashtra namely Satpati (District Palghar), Vasai, Versova, New Ferry Wharf (BhauchaDhakka) & Sasson Dock, and other areas of Mumbai. Phase IV ‘SagarParikrama’ in Karnataka covered main locations viz. Udupi and Dakshina Kannada & Uttar Kannada. 50,000 people physically attended the event and the program was live-streamed on various social media platforms and around 30,000 people watched the event. Successfully completed Sagar Parikrama in four phases covering 19 locations in Gujarat, Damen & Diu, Maharashtra and Karnataka. SagarParikrama song has been launched in Gujarati, Marathi& Kannada. Sagar Parikrama Phase-V, journey shall continue covering 6 locations Raigad, Ratnagiri, and Sindhudurg Districts in Maharashtra and Vasco, Maorugoa, and Canacona in Goa.

Maharashtra has 720 km. of coastline with a continental shelf area of 111512 sq. km and 5 coastal districts Thane, Raigad, Greater Mumbai, Ratnagiri, and Sindhudurg. Maharashtra state ranks 7th with around 5 %share in the country's fish production and is yet to explore its untapped potential completely. Marine fisheries had always a major share (currently 82 %) compared to inland fisheries (currently 18 %) for Maharashtra. Goa is bestowed with a coastline of 104 km with numerous bays and headlands. The continental shelf area of Goa extends to 10,000 km2 of about 100 fathoms depths. The current annual average marine and inland fish production is estimated at 86,027 and 3669 tons, respectively. Fish is considered a staple diet for more than 90% of the population of Goa and holds greater importance to the state of Goa being an integral part of goan life and culture. The annual average per capita consumption of fish in Goa is 15-17 kg. The marine fishery sector provides livelihood to a large number of people in Goa.

Union Minister for Fisheries, Animal Husbandry and Dairying, Shri.Parshottam Rupala, Minister of State for Fisheries, Dairying and Animal Husbandry and Dairying, Dr. Sanjeev Kumar Balyan, Minister of State for Fisheries, Dairying and Animal Husbandry and Dairying & Information and Broadcasting Dr. L. Murugan, Shri. Sudhir Mungantiwar, Minister, Department of Forest, Cultural Affairs, Fisheries, Dr.Abhilaksh Likhi, OSD, Department of Fisheries, Ministry of Fisheries Animal Husbandry and Dairying, Government of India, Dr. Atul Patne, I/C Secretary Fisheries & Commissioner of Fisheries, Maharashtra state, Dr. J. Balaji, Joint Secretary, Fisheries, Govt of India, Speaker & Members of Legislative Assembly, Members of Legislative Council and Member of Parliament and senior officials of Department of Fisheries, Govt of India, National Fisheries Development Board, Director of Fisheries, Government of Maharashtra and Government of Goa, Senior officials from Indian Coast Guard, Fishery Survey of India, Maharashtra Maritime Board and fishermen representatives shall take part in the event. The journey shall be accompanied by State Fisheries officials, Fishermen representatives, Fish-Farmers, entrepreneurs, stakeholders, professionals, officials and Scientists from across the nation. During the event, certificates/sanctions related to Pradhan Mantri Matsya Sampada scheme, KCC& State Scheme shall be awarded to the progressive fishermen, especially coastal fishermen, fishers and fish farmers, young fishery entrepreneurs etc. Literature on PMMSY scheme, State schemes, e-shram, FIDF, KCC, etc. shall be popularised through print media, electronic media, videos, and digital campaigns through jingles among fishers for wide publicity of schemes. A song on Sagar Parikrama in Marathi & shall also be launched.

This would enable the Government in devising better policies for improving the quality of life and economic well-being of people of the coastal community, especially the marine fishermen in the country. The journey of Sagar Parikrama shall focus on the sustainable balance between the utilization of marine fisheries resources for the food security of the nation and livelihoods of coastal fisher communities and the protection of marine

Economic Importance of Aquaculture

ecosystems, to bridge the gaps of fisher communities and their expectations, development of fishing villages, upgradation and creation of infrastructure such as fishing harbours & fish landing centres to ensure sustainable and responsible development through an ecosystem approach.

Government schemes for aquaculture

INTRODUCTION

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) was launched in September 2020 with an aim to double the income of fish farmers and fishers in the country. It focuses on sustainable development of India's fisheries sector and is a part of the Atmanirbhar Bharat scheme.

The scheme adopted a “cluster or area-based approach” to create fisheries clusters. The scheme focuses on activities with potential to generate employment such as seaweed and ornamental fish cultivation. It also emphasises on the breeding technique for quality brood, seed & feed and species diversification.

With implementation of the scheme, the government aims to help reduce post-harvest loss from 20–25% to 10%, double the incomes of fishers and fish farmers and generate an additional 55 lakhs direct and indirect employment opportunities.

In line with this, key targets of the Pradhan Mantri Matsya Sampada Yojana are as follows:

Increasing fish production from 13.75 million metric tons in 2018-19 to 22 million metric tons by 2024-25.

Improving aquaculture productivity from 3 tons per hectare to 5 tons per hectare.

Enhancing domestic fish consumption from 5 kg to 12 kg per capita.

Increasing contribution of the fisheries sector to the Agriculture GVA from 7.28% in 2018-19 to about 9% by 2024-25.

Doubling export revenue from Rs. 46,589 crore (US$ 6.37 billion) in 2018-19 to Rs. 100,000 crore (US$ 13.68 billion) by 2024-25.

Reducing post-harvest losses to about 10%.

Creating 55 lakh direct and indirect employment opportunities across the value chain.

NEED FOR PM MATSYA SAMPADA YOJANA

Fisheries and aquaculture play an important role in food, nutrition, employment and income in India. The sector employs ~16 million fish farmers and fishers at the primary level and almost twice the number along the value chain. The fisheries sector accounted for 1.24% of the national GVA (gross value added) and 7.28% of agriculture GVA in 2018-19. As per the department of fisheries, marine fishing resources are estimated at 4.41 million tons and its activities extend along 8,118 kms of the country's coastline. To improve fish production, it was important to conduct integrated fish farming and diversify fish production in areas such as old water, river and brackish water fishery.

To facilitate an enabling environment for comprehensive development of the full potential of the country's fisheries, the government introduced the 'Blue Revolution' for a period of five years (2015-16 to 2019-20). The 'Blue Revolution' helped enhance local fish production from 10.26 MMT (million metric tonnes) in FY15 to 13.75 MMT in FY19. Fish productivity increased from 2.3 tonnes per hectare in FY15 to 3.3 tonnes per hectare in FY19.

Further, the fisheries sector has been a major contributor to foreign exchange earnings, with India being one of the world's leading seafood exporters. In FY19, marine products export earnings stood at Rs. 465.89 billion (US$ 6.73 billion), driven by rapid development of the brackish water aquaculture.

In FY20, aquaculture products accounted for 70–75% of the country's total fishery exports.

Further development of the country's fishery sector presents a great opportunity for fish farmers to generate more income, increase fish production and enhance exports and thereby, drive the country's economic growth. In line with this, recognizing the huge potential in this sector, the Indian government launched PMMSY in September 2020 and allocated funds worth Rs. 20,050 crore (US$ 2.74 billion) for a period of five years (from FY21 to FY25) for overall development of the country's fisheries.

KEY INITIATIVES AND PROGRESS

The PM Matsya Sampada Yojana includes key activities such as fishing vessel insurance, support for

new/upgrade of fishing vessels, aquaculture in saline/alkaline areas, Sagar Mitras, nucleus breeding centres, fisheries and aquaculture start-ups, incubators, and integrated aqua parks.

IMPLEMENTATION STRATEGY

The PMMSY has the Central Sector and Centrally-sponsored Scheme Components and hence, is being implemented as an umbrella scheme. The scheme is expected to intervene at almost all key components of the fisheries value chain to focus on all-round development of the fisheries sector. To effectively implement the scheme and get optimal outcome, the implementation is done in collaboration with the states/union territories.

While financing of the scheme differs by component and areas, the central government bears the whole cost in some key areas of national importance.
While improving fish production is the key objective of PMMSY, it is imperative to achieve quality, sustainability, standards and traceability in the fisheries Sector. The scheme encourages private participation and development of entrepreneurial culture in the fisheries sector to achieve its end-objectives. The scheme will also look for suitable linkages and convergence with various centre and state government schemes. A few of the identified schemes for linkages are "Sagarmala Project" of the Ministry of Shipping, PMKSY of the Ministry of

Food Processing Industries, MGNREGS and the National Rural Livelihoods Mission of the Department of Rural Development, Rashtriya Krishi Vikas Yojana (RKVY) and other schemes under the Ministry of Agriculture and Farmers Welfare.

FUNDING PLAN

PMMSY will be implemented with the following funding plan:

Central Sector Scheme – The entire scheme cost will be borne by the central govt. Also, in cases of direct beneficiary-oriented activities undertaken by central. Government entities such as the NFDB, central assistance will be up to 40% of the project cost for the general category and 60% for the SC/ST/women category.

Centrally Sponsored Scheme (CSS) – In case of CSS components and

Subcomponents implemented by the states/Uts, the entire project cost will be shared between the centre and state.

	Total	Centre Share	State Share	Beneficiary Share
(A) Central Sector Scheme	Rs. 1,720 crore (US$ 235.24 million)	Rs. 1,720 crore (US$ 235.24 million)	-	-
(B) Centrally Sponsored Scheme (CSS)	Rs. 18,330 crore (US$ 2.51 billion)	Rs. 7,687 crore (US$ 1.05 billion)	Rs. 4,880 crore (US$ 667.42 million)	Rs. 5,763 crore (US$ 788.18 million)
1. Beneficiary-oriented activities	Rs. 11,990 crore (US$ 1.64 billion)	Rs. 3,878 crore (US$ 530.38 million)	Rs. 2,349 crore (US$ 321.26 million)	
2. Non-beneficiary-oriented activities	Rs. 6,340 crore (US$ 867.10 billion)	Rs. 3,809 crore (US$ 520.94 million)	Rs. 2,531 crore (US$ 346.16 million)	
Total (A)+(B)	Rs. 20,050 crore (US$ 2.74 billion)	Rs. 9,407 crore (US$ 1.29 billion)	Rs. 4,880 crore (US$ 667.42 million)	Rs. 5,763 crore (US$ 788.18 million)

KEY DEVELOPMENT

In FY20, institutes such as the Central Institute of Fisheries Nautical & Engineering Training (CIFNET) expanded its mission to train fishermen from the coastal states and union territories through a capacity building training programme under the PMMSY.

In March 2021, Guru Angad Dev Veterinary and Animal Sciences University became the first Indian university to receive fishery project funds under the PMMSY worth Rs. 139.05 lakh (US$ 190.40 thousand) to promote low-density intensive aquaculture technologies in the region through integrated modules for research, demonstration and skills development, such as the circulating aquaculture system (RAS) and Biofloc aquaculture.

As part of other developments in the Indian fisheries sector, in April 2021, Manipur's State Fisheries Minister, Mr. S. Rajen Singh, announced that fish farms maintained by the state government will be leased to interested fish farmers in a public-private partnership (PPP) model to provide employment and income opportunity in the state.

PM MATSYA SAMPADA YOJANA – THE PROGRESS SO FAR

As of January 2021, proposals with an outlay of Rs. 6,567.20 crore (US$ 898.17 million) were received from various states/Uts. Project proposals with a total outlay of Rs. 2,309.08 crore (US$ 315.80 million) have already been approved.

The PMMSY scheme is anticipated to have impacted ~800,000 employment and beneficiaries across the country. The government proposed mega

Investments to strengthen fishing ports and landing centres for healthy fish management and reduction of post-harvest erosion, high cost, etc. The government allocated funds worth ~Rs. 7,700 crore (US$ 1.05 billion) on fisheries infrastructure such as deep-sea vessels and for building an integrated laboratory network for diagnostic and quality testing.

THE ROAD AHEAD

Looking forward, the government has set the target to double its fishery export earnings to Rs. 100,000 crore (US$ 13.68 billion) by FY25, from Rs. 46,589 crore (US$ 6.37 billion) in FY19.

The government is taking significant measures to make the PMMSY scheme a success. In the Union Budget 2021-22, the government allocated funds worth Rs. 1,220.84 crore (US$ 166.97 million) to the

Department of Fisheries, an increase of 34% YoY. Of the total allocation, funds worth Rs. 1,000 crore (US$ 136.77 million) was awarded to the PMMSY scheme for FY22, an increase of 43% YoY. This will further contribute to the advancement of fishermen's livelihood in the country.

Under the PMMSY, the government has helped develop a Fish Brood Bank and an Aquatic Disease Referral Laboratory in select states (e.g., Bihar) to boost fish production and quality by ensuring proper availability of high-quality, low-cost fish seed for fish farmers as well as addressing the need for disease detection and water & soil testing..

The government is also focusing on adopting technologies such as the Iot to integrate with the **PMMSY** to better facilitate development of the fisheries sector as well as its auxiliary

Industries and help bring fishermen into the mainstream industry—making them economically stable and secure.

Conclusion

The aquaculture industry must work towards ways and means of efficiently managing and utilizing local feedstuff resources, such as by improving processing methods, increasing digestibility and nutritional value, extending shelf life and freshness, and by developing formulations specific for each species, culture system, and culture environment. Efficiency in feed utilization can also be better attained by ensuring hydro stability and by employing appropriate feeding methods and strategies. The streamlining of marketing channels and the development of non-conventional feedstuffs that are economically and commercially viable to mass produce, will be particularly valuable for the feed industry.

We are grateful to our honorable Dr.Sr. Prema Kumari (Principal of our college) for supporting and encouraging and allowing us to write a book.

We would also like to thank to our most respected Lakshmi tulasi madam for acknowledging us to write a book. Your encouragement and support and guidance help us in all aspects of this book. Thank you madam for giving encouraging us to write a book. Further, we would like to work in various activities with you just like now

We would also like to thank to our most respected Adi shesu madam for your encouraging supportive words and your guidance helped us in all ways. We want you to support and help us in future activities also as you supported us now.

Reference

- We referred the above information through some websites of Google
- We also referred some of the PPT's
- Some of the information is referred from Library
- Slide share website (http://www.slideshare.net)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ST.ANN'S COLLEGE FOR WOMEN, Malkapuram, Visakhapatnam- 53011.