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**MEKDELA AMBA UNIVERSITY**

**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE**

**DEPARTMENT OF BIOLOGY**

**Fisheries and Aquaculture (Biol3092) Lecture Note**

**Prepared by:**

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**UNIT ONE: Introduction**

**Unit description**

This unit deals with the concept of fisheries and aquaculture. The content will be delivered by brain storming, interactive lecture and group discussion. Students will be assessed by subjective and objective type questions.

**Unit objective**

At the end of this unit students are expected to:

* Describe fisheries and aquaculture,

1. **Introduction**

**Brain storming**

What is the difference between the following terms:fish**,** *Fishery, fisheries, aquaculture, ichthyology and limnology?*

**Interactive lecture:** *what is fish, fishery and fisheries science?*

***Fish*:** they are categorized among aquatic vertebrates; cold-blooded, breathing takes place by its gill, its body is covered by scales and it possesses fins as a locomotors organs. E.g. finfish like tilapia, carp, trout, milkfish, bait minnow, yellow tail, mullet, cat fish and shellfish like shrimps, prawns, oysters, mussels, lobster and any [aquatic animal](https://en.wikipedia.org/wiki/Aquatic_animal) which is harvested

***Fishery*:** is the practice of gathering aquatic organisms (e. g. aquatic plants and animals) for commercial purpose.

**Fisheries science** is the academic discipline of managing and understanding [fisheries](http://en.wikipedia.org/wiki/Fisheries). It is a multidisciplinary science, which draws on the disciplines of [limnology](http://en.wikipedia.org/wiki/Limnology), [oceanography](http://en.wikipedia.org/wiki/Oceanography), [freshwater biology](http://en.wikipedia.org/wiki/Freshwater_biology), [marine biology](http://en.wikipedia.org/wiki/Marine_biology), [conservation](http://en.wikipedia.org/wiki/Conservation_biology), [ecology](http://en.wikipedia.org/wiki/Ecology), [population dynamics](http://en.wikipedia.org/wiki/Population_dynamics_of_fisheries), [economics](http://en.wikipedia.org/wiki/Economics) and [management](http://en.wikipedia.org/wiki/Management) to attempt to provide an integrated picture of fisheries.

*Ichthyology*: the study of biology, ecology and systematic of fishes.

*Limnology*: the study of biological, chemical and physical characteristics of inland water bodies.

*Aquaculture*: the practice of culturing aquatic organisms in confinement for commercial purpose.



Figure 1: external structures of fish

Fish, especially as food, are an important resource worldwide. The world fisheries production annually is about 76 million tones/year.

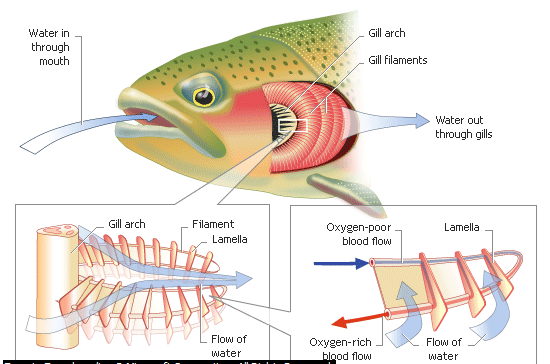


Fig.1.2. Shows the breathing system of fish

**UNIT 2: Aquaculture**

**Unit description**

This unit introduces the student about aquaculture. The content will be delivered by brain storming, interactive lecture and group discussion. Students will be assessed by subjective and objective type questions.

**Unit objectives**

**At the end of this unit, students will be able to:**

* Discuss the system of aquaculture
* Describe establishment of aquaculture
* Explain types of aquaculture (ponds, cages, panes etc.)
* Discuss maintenance of aquaculture,

**2.1 Aquaculture**

**Brain storming**

*Q1. What is aquaculture?*

Aquaculture is the practice of farming aquatic organisms in confinement for commercial or subsistence purpose. It is the controlled cultivation (*the process is held in controlled condition*) and harvest of aquatic organisms. The word “aquaculture” breaks down to “aqua” (water) and “culture” (to grow or farm). Aquaculture is the art, science, and business of producing aquatic plants and animals useful to humans. Mariculture is the raising of such animals ( referred to as crops in the context of agriculture) in the sea. Aquaculture and agriculture are both farming. However, aquaculture is farming in the water and therefore requires a different set of knowledge, skill, and technology. About 20 million tons/year is produced from aquaculture. China is the leading country on the world by aquaculture.

Most commonly grown are finfish and shellfish (edible water invertebrates with shell especially mollusks and crustaceans such as oyster, shrimp or lobster), but other aquatic organisms such as seaweed, microalgae, frogs, turtles, alligators, and endangered species are also cultivated. Not all aquaculture targets food production; live-bait, ornamental, research and education are important markets. There are many similarities between aquaculture and agriculture, but there are some important differences as well. Aquaculture, like agriculture, is necessary to meet the food demands of a growing global population with diminishing natural fisheries stocks. Unlike land under cultivation, the world’s oceans, lakes, rivers and streams are usually public or common resources. Managing these common resources is often problematic.

**2.2. Systems of Aquaculture**

There are three aquaculture systems:

**A. Extensive system**

* Allow natural water to the ponds and management is natural
* Build the pond and stock/supply the species, then all thing is natural without human interference
* But production is low

**B. Semi-intensive system**

* There is some interference of human being
* Build the ponds, and then natural food and some supplementary food
* Production is high comparing with extensive system

**C. Intensive system**

* Build the pond, stock the species and fully interference with human beings like formulated food, aeration, waste treatment etc.
* High production
  1. **Types of aquaculture (ponds, cages and pen)**

*Q1. What are fish pond, cage and pen?*

Fish can be cultured in one of four culture systems—ponds, cages, pens, raceways, recirculation systems. A cage or pen is a system that confines the fish or shellfish in a mesh en closure. By strict definition, a cage and a net pen differ based on their construction. A cage has a completely rigid frame (on all sides) and a net pen has a rigid frame only around the top. However, the terms “cage” and “pen” are often used inter changeably. Within intensive and extensive aquaculture methods, there are numerous specific types of fish farms; each has benefits and applications unique to its design.

1. **Pond systems**

These use irrigation ditches or farm ponds to raise fish. The basic requirement is to have a ditch or pond that retains water, possibly with an above-ground irrigation system. In small systems the fish are often fed commercial fish food, and their waste products can help fertilize the fields. In larger ponds, the pond grows water plants and algae as fish food. Some of the most successful ponds grow introduced strains of plants, as well as introduced strains of fish.

Control of water quality is crucial. Fertilizing, clarifying and pH control of the water can increase yields substantially, as long as eutrophication is prevented and oxygen levels stay high.

Today majority of freshwater aquaculture takes place in ponds

* Ponds could be two types: Manmade (can be constructed from plastic liners) or natural (natural ponds are filled by runoff and rain water, well water or surface water)
* Ponds maximize fish growth and survival and reduce mortality.
* Size of ponds is variable; smaller ponds are easy to construct and manipulation
* Depth ranges from 0.75-1.5 meter (shallow ponds are more productive)
* Can be rectangular (most common) or round in structure
* Have inlets and outlets

1. **Cage system**

Fish cages are placed in lakes, bayous, ponds, rivers seas or oceans to contain and protect fish until they can be harvested. They can be constructed of a wide variety of components. Fish are stocked in cages, artificially fed, and harvested when they reach market size. A few advantages of fish farming with cages are that many types of waters can be used (rivers, lakes, filled quarries, etc.), many types of fish can be raised.

* Involves placing of mesh or wire cage in a flowing, open water system
* Used by fishermen to hold their catch until the fish were ready to sell.
* Constant water flow is critical as it renews the oxygen supply and removes waste products
* Mesh size used is critical to prevent the entry of predators

*Advantages of cage aquacultures*:

* Can be practiced on small scale in almost any body of water
* Unlike ponds, cages can fit to any landscape and leaves opportunity for the water to be used in other ways, such as recreational fishing.

*Disadvantages*:

* Possibility of fish escaping into the environment
* The most incurred to feed the fish, as they have less access to natural food sources
* Vulnerable to damage by pollution, storms, etc.
* The closed, confined environment often leads to rapid spread of disease.

1. **Pen culture**

Pen culture is defined as “a fixed enclosure in which the bottom is the bed of the water body” Pen is to be distinguished from the Cage which in turn is defined as “an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged.” The word ‘pen’ here is also used synonymous with ‘enclosure’ as it is used in enclosure culture. Both cage and pen cultures are types of enclosure culture, and involve holding organisms captive within an enclosed space whilst maintaining a free exchange of water. The two methods, however, are distinct from one another. A cage is totally enclosed on all, or all but the top, sides by mesh or netting, whereas in pen culture the bottom of the enclosure is formed by the lake or sea bottom.

**2.4. Establishment of aquaculture**

**2.4.1. Selecting a Good Pond Site**

In land-based aquaculture, the most commonly used culture units are earthen ponds. When evaluating and selecting sites for earthen fishponds, the main physical factors to consider are the land area, the water supply, and the soil. The following points should be kept in mind for each.

1. **Land area**

* Establish that the land is relatively level. Steeply sloped land is not generally suitable for building ponds. A slope of about 1% is considered ideal.
* Determine that the area is large enough for your present plans and for any future expansion.
* The area should not be prone to flooding. Study weather records for the area, ask local residents about flooding in recent years, and look for actual evidence that flooding has occurred.
* The area should not be subject to pollution in runoff from adjacent land. Find out who owns adjacent and uphill land, how they use the land, and what chemicals (including fertilizers and pesticides) they use.
* If possible, the land must be slightly lower than the water source, so that the ponds can be filled by gravity rather than by pumping. Supplying water by gravity greatly reduces energy inputs and operating costs.
* In most cases the larger the surface area (with gentle slope), the better. This is only true if the land and water are not expensive.
* Consider development plans for neighboring areas and assess any causes for concern.

1. **Water supply**

The most common sources of water used for aquaculture are surface waters (streams, springs, lakes) and groundwater (wells, aquifers). Of these, wells and springs are generally preferred for their consistently high water quality.

* The quantity and quality of water should be adequate to support production through seasonal fluctuations.
* Determine that the quality of the intended water source is good enough for fish to thrive in. A good water source will be relatively free of silt, aquatic insects, other potential predators, and toxic substances, and it will have a high concentration of dissolved oxygen. If fish are already living and reproducing in the water (for example a river or lake), this is usually an indication that the quality is good. Find out if the quality remains constant throughout the year or if there are seasonal changes that result in poor quality at certain times.
* Make the final site selection based on both the quality and quantity of water available.
* The quantity of water required depends on the species to be cultured and on the anticipated management practices, for example whether ponds will be operated as static ponds (no water flowing through) or as flow-through systems.
* Coldwater species like trout require a lot of water because they prefer a continuous supply of clean water with high dissolved oxygen concentrations (above 9 mg/L).
* Warm water species like tilapia can tolerate water with lower dissolved oxygen levels, so tilapia culture is often done in static water, that is, without water flowing through the ponds. However, the best situation is to have a lot of “free” water, meaning water available by gravity flow, even if it is not always being used.

1. **Soil**

* Land should be comprised of good quality soil, with little or no gravel or rocks either on the surface or mixed in. Areas with rocky, gravelly, or sandy soil are not suitable for pond construction.
* The soil should be deep, extending down at least 1 meter below the surface. There should not be layers of rock lying close to the surface.
* Soils in the area where ponds will be built should have clay layers somewhere below the surface to prevent downward seepage.
* Soil that will be used to build the dykes must contain at least 20% clay so the finished pond will hold water throughout the growing period.
* Some soil with higher clay content—preferably between 30 and 40%—should be available nearby. It will be used to pack the core trenches in the dykes.

1. **Other factors to consider**

* Proximity to a market
* Infrastructure
* Availability of needed inputs
* Access to Technical Advice
* Competition

**2.4.2. Pond Design and Layout**

Before beginning the construction of a new fishpond, carefully consider the design. A properly designed and constructed pond will be easily managed and will last longer, saving extra work and bringing greater profit. Some specific design considerations to address include:

1. The source of water used to fill the pond

2. How water will be brought to the pond

3. The type of soil available for building the pond

4. The size, shape, and depth of the pond

5. The slope of the pond bottom

6. The height, width, and slope of the dykes

7. The type of drainage system that will be used

8. The layout (arrangement) of ponds used for different sizes of fish

**2.4.3. Pond size, shape, and depth**

***Size***

* The size of a prospective fish pond should be based on the purpose of the pond.
* If the pond is meant to provide additional food for the family, then it need not be larger than 0.1 ha (1000 m2).
* The size of fish pond should be depend on the interest of pond manager

***Shape***

* Rectangular ponds are usually the easiest to build and manage. However, ponds must sometimes be built with irregular shapes to fit the topography and shape of the available space.

***Depth***

* The best pond depth depends on the fish species, size of fish, and production system to be used.
* The ideal depth for most ponds ranges from 0.75 to 1.2 m.
* For the shallow end, the depth can be from 40 to 70 cm. The absolute minimum is 40 cm; however, 50 to 60 cm is best. Problems that develop in shallow ponds include predation, weeds, and low production.

**2.4.4. Which species are cultivatable?**

*Q1.which species are more preferable for aquaculture?*

On a worldwide basis, aquaculture production has increased rapidly over the last two decades. World production is made up of finfish, seaweed, mollusks and crustaceans. The majority of finfish are farmed in freshwater ponds. Some of the main fishes cultured for human consumption are: carp (several species, mainly *Hypophthalmichthys molitrix* and *Gypfinns carpio*), channel catfish (*Ictalurus punctatus*), Tilapia spp., eels (Anguilla spp.), milkfish (*Chanos chanos*), rainbow trout (*Oncorhynchus mykiss*) and salmon (*Salmo salar*).

Culture systems found in Africa include semi-intensive culture of Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*), practiced by small-scale fish farmers in static ponds. The species used at any given site are mainly endemic to the region and more or less appropriate to the agroclimatic zone. For example, tilapia is a warm water fish and is mainly cultured in a freshwater environment. Catfish are grown in the same agroclimatic region as tilapia, but trout, an introduced coldwater fish, is best grown in high altitude regions where the water is cooler. The major drawback of culturing tilapias in ponds is the risk of uncontrolled reproduction. The challenge with catfish production is high mortality of fry, especially during the first 14 days after the eggs hatch. Desirable characteristics for cultured fish species include:

* Ease of reproduction
* Attainment of market size prior to reaching sexual maturity
* Acceptance of supplemental and/or manufactured feeds
* Feeds low on the food chain, i.e., eats plant material
* Rapid growth
* Efficient feed conversion
* Resistance to diseases
* Tolerance to relatively high stocking density and poor environmental conditions
* Is highly desired in the market place

Few species have all of these characteristics, but both the Nile tilapia and the African catfish have enough of them that their popularity in the market and the ready availability of technical information about their culture make them suitable candidates for warm water fish farming in Africa.

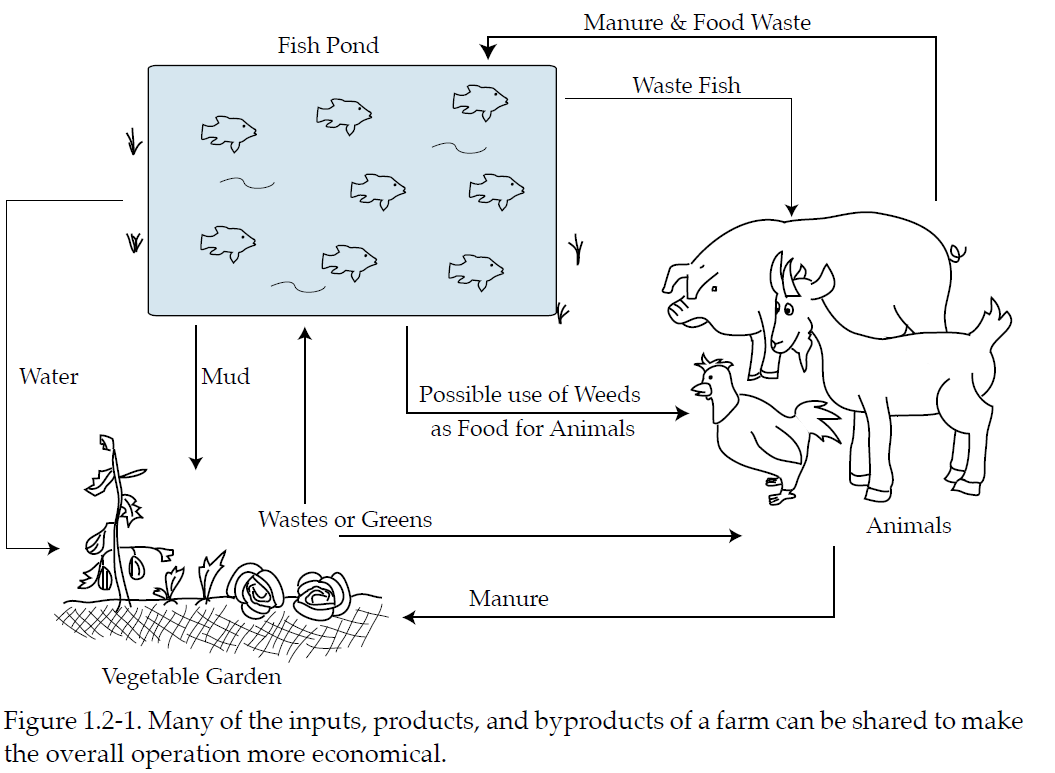
1. **Nile tilapia (*Oreochromis niloticus*)**

Tilapia fish species will be grown in the pond with the stocking of up to 29,000 fish per hectare. The number of fish can be increased up to 50,000 depending on the extent of fertilizing the pond

* Various strains of Nile tilapia differ with respect to their tolerance to cold, but growth is generally limited at temperatures below 16ºC and most strains become severely stressed at 13ºC.
* Death begins to occur at 12ºC, with few fish surviving temperatures below 10ºC for any period of time.
* Nile tilapia do not feed or grow at water temperatures below 15ºC and do not spawn at temperatures below 20ºC.
* The normal water temperature should be 20-30ºC, preferably about 28ºC, which is considered the ideal temperature for good health and growth. At higher temperatures their metabolic rate rises, leading, in extreme cases, to death.
* Gradual conditioning would allow tilapia to live within a range of 8-40ºC.
* Tilapia is able to survive levels of dissolved oxygen (DO) below 2.3 mg/L as long as temperature and pH remain favorable.
* In fertilized ponds, a bloom of algae can reduce oxygen levels to as low as 0.3 mg/L with no fish mortality in tilapia.
* Larger fish are known to be less tolerant than fingerlings; this is due to metabolic demand
* It has been observed that under natural conditions tilapia mature at a larger size and later age than they do when cultured in ponds. This can take two to three years.
* The age and size at which maturity is reached also depends on conditions in the water body.
* Tilapia cultured in ponds sometimes mature at as early as two months, but generally matures in four to six months.

**2.4.5. Integrating Fish Culture**

In addition to producing fish to eat or sell, there are other advantages to growing fish. Adding fish farming to other farm enterprises can make your overall operation more efficient and more profitable. This comes about by sharing space, inputs, byproducts, and labor associated with other crops, and especially by using or re-using materials available on the farm.



**2.4.6.** **The criteria for species selection**

Large numbers of larvae fry or juveniles must be available for grow-out operations. In Australia, aqua culturists are generally not permitted to collect juveniles from the wild (which is an unreliable source); therefore hatcheries are the only source of seed for grow-out operations. Brood fish must be available to establish successful hatchery techniques; the species should be fecund and capable of spawning in captivity. Cultivated species must thrive in captivity and be amenable to crowding. The more fish that can be stocked into a given space, the greater the potential production.

1. **Suitable behavior**

Regular observation and sampling of fish are essential for successful culture; fish that are readily seen and/or easily captured are desirable. *Species that school and swim near the surface or edges are ideal*, as are species that can be readily trained to feed at a particular area. Species that are very flighty or secretive are usually less suitable for aquaculture.

1. **Rapid and uniform growth**

Species must be capable of rapid growth to ensure efficient use of facilities and food. Most species of finfish that are farmed successfully throughout the world grow rapidly under culture conditions and reach minimum market size (500grams) in 18 months or less. Variable growth amongst fish within a rearing unit is undesirable as it necessitates culling or grading, which increases stress and susceptibility to disease, damage to the fish, and requires extra labor and facilities.

**C. Amenable to artificial feeding**

Semi-intensive and intensive fish culture is based on the use of medium to high stocking densities, prepared feeds and with some species, fertilization of pond water. Very high production rates can only be achieved with species that accept prepared feed.

**D. Appropriate dietary requirements**

In general, fish that feed lower in the food chain are most efficient in the use of food under pond culture conditions. Although some carnivorous species accept artificial feeds, they require relatively high levels of protein (including animal proteins) and are unable to use most of the natural food available in ponds.

**E. Efficient food conversion**

The food conversion ratio (FCR) is the ratio of dry weight of food, to the wet weight gain of fish. The lower the ratio, the more efficiently food has been converted to fish flesh. Feed costs often constitute 40-60% of total production costs, so it is essential to use species that convert food efficiently. Modern dry pellet diets enable food conversion ratios of 2:1 (2 kg food fed to 1 kg fish produced) or better.

**F. Non-cannibalistic**

Cannibalism reduces survival rate and production directly by predation or, indirectly through damage and increased stress-related susceptibility to disease. The greater degree of cannibalism, the greater the losses. Most piscivorous and many carnivorous species can be cannibalistic and must be culled/picked to reduce losses.

**G. Disease resistance**

Although all species are susceptible to diseases under culture conditions, some are more so than others. This factor should be considered when selecting a species for aquaculture or choosing the site for grow-out operations.

**H. Tolerance to harsh environment**

Although good water quality is essential for successful culture, species that can tolerate sub-optimal conditions (for example, high or low temperatures, low dissolved oxygen, high pH) for short periods are more suitable than less tolerant species.

**I. High meat recovery**

Species that have high meat to total body weight ratio are desirable because of their more efficient conversion of feed into edible flesh.

**2.3 Maintenance of aquaculture**

*Q1. Why repairing is needed?*

It is all about repairing and maintenance of all installations and equipments of aquaculture.

**IV) Assessment**

1. Give some organisms proper for aquaculture
2. What is the advantage of cage aquacultures?

**UNIT 3: Fish reproduction and growth**

**Unit description**

This unit deals with fish reproduction and growth. The content will be delivered by brain storming, interactive lecture and group assignment. Students will be assessed by group assignment, subjective and objective type questions.

**Unit objective**

**After completing this unit, students are expected to:**

* Differentiate types of fish reproduction and growth pattern in fish

**3.1. Reproduction**

**Brainstorming**

*Q1.How fish reproduces?*

The methods of reproduction in fishes are varied, but most fishes lay a large number of small eggs, fertilized and scattered outside of the body. The eggs of pelagic fishes usually remain suspended in the open water. In herring and mackerel, spawning is a mass enterprise where fishes gathered in huge schools, females expel eggs and the males discharge sperm known as milt (milky white substance) into the water. In some species the eggs float, in the others they sink. Many shore and freshwater fishes lay eggs on the bottom or among plants. Some have adhesive eggs. Many fishes lay their eggs in nests:

* Salmon and bass made their nests at depressions in the beds of streams and lakes
* Stickleback’s nest is made of plant material
* Fighting fish use floating bubbles as nest.

Each female produces thousands, even millions of eggs during spawning (=the act of reproduction). The aim is to increase probability of eggs to grow; vast number of eggs and young are eaten by fish and birds or otherwise destroyed. The eggs and young of nesting fish are commonly guarded by one of the parents; usually the males do that.

**3.1.1 Types of Reproduction**

Three types:

1. **Heterosexual reproduction (separate sexes**)

In the most common form, heterosexual reproduction, there are separate male and female parents, but even here there is considerable variation.

In some cases, a female may carry sperm from several males at once.  
 **A. Pairy type:**

Mates are selected------- Suitable site of mating is selected------ Sexual display -----the male and female fish come together ------Release the content of their gonads----- External fertilization takes place.

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Fig. Showing pairy type of heterosexual reproduction

*Q. Why fishes come close together for reproduction?*  Because the coming of both female and male sex fish help them to release both milt and eggs at the same time.

*Q. What happen if female release eggs first and male after some time or vice versa? Eggs released first*: the release of eggs by female first will result into the hardening of the eggs shell by the action of chemical in water = Decreased fertility.

*Milt released first*: the tail of sperm cell stop functioning and sperm dies = Decreased fertility. So, to overcome this problem the sperm and eggs should be released simultaneously.

**B. In Groups**

* When breeding time approaches, thousands of fish in breeding condition congregate in some suitable location.
* The males release milt and females release eggs
* Littoral zone are suitable for reproduction because:
* Food for the coming offspring
* Few predators
* Young gets some problems during its stay in littoral zone:
* Shortage of oxygen for offspring
* Covering of the eggs by sediments during flooding.
* No parental care in case of group reproduction; care is by offspring itself.
* Occur randomly
* Thousands or even millions of fish gather in a single reproduction period.

**2. Hermaphroditic type:**

In hermaphroditic reproduction, a single fish is both male and female, produces both eggs and sperm (either at the same time or at different times), and mates with other similar hermaphroditic fishes. External self-fertilization occurs in one hermaphroditic fish, which sheds egg and sperm simultaneously. In another, internal self-fertilization may occur. In certain fishes there is a time sequence of hermaphroditism, young fishes reversing their sex as they grow older.  
Occur either senchroneously or sequentially

* **Senchroneous** / Self-fertilization/

Occur in unfavorable environmental condition like dark water, water body with few organisms i.e fishes

* **Sequentially**:

Sequential hermaphrodites are born one sex and change sex sometime during the course of life two types:

a. Protandric: males first and females next

b. Protogonic: females first and males next

e.g family Labridae, sheephead are born female and have the potential to transform into males later in life.

**3. Parthenogenic type:**

In parthenogenetic reproduction, unfertilized eggs develop into embryos. This is known to exist in at least one fish species, Poecilia formosa, of the Amazon River; however, even though development proceeds without fertilization in some of these females, mating with a male is still required to stimulate egg development.

**3.1.2 Reproductive method**

## I. Oviparous Reproductive Method

* Female oviparous fish release unfertilized eggs (either laying them on a rock or plant surface, or emitting them into the surface water where they join the zooplankton layer) which are then fertilized by the male by either rubbing his sexual organs on the eggs, releasing his sperm, or emitting his sperm into the water so that fertilization takes place in the zooplankton layer.
* Over 97% of all known fish are [oviparous](http://en.wikipedia.org/wiki/Oviparous),Examples of oviparous fish include [salmon](http://en.wikipedia.org/wiki/Salmon), [goldfish](http://en.wikipedia.org/wiki/Goldfish), [cichlids](http://en.wikipedia.org/wiki/Cichlid), [tuna](http://en.wikipedia.org/wiki/Tuna), and [eels](http://en.wikipedia.org/wiki/Eel)

## II. Ovoviviparous Fish

This means that fertilization and development of the embryonic fish take place inside the female. The fish hatch inside the female's body, being born as live young. Unlike in mammals, the eggs do not receive extra nutrition from the mother's body, developing with energy solely from the egg's yolk. Fish include [guppies](http://en.wikipedia.org/wiki/Guppy), [angel sharks](http://en.wikipedia.org/wiki/Angel_shark), and [coelacanths](http://en.wikipedia.org/wiki/Coelacanth).

**III. Viviparous Fish**

* + Like ovoviviparous reproducers, viviparous fish develop their young within the female's body. However, the eggs hatch inside the mother and remain in the placenta where they receive oxygen and nutrients from the mother's biological system via an umbilical cord. When mature they are also born as live young. Examples of viviparous fish include the [surf-perches](http://en.wikipedia.org/wiki/Embiotocidae), [splitfins](http://en.wikipedia.org/wiki/Goodeidae), and [lemon shark](http://en.wikipedia.org/wiki/Lemon_shark).
  + In live-bearing fishes, fertilization occurs internally, and methods have been evolved for introducing the sperm into the female's body. In sharks the pelvic fins of the male are modified into intermittent organs called myxoptergia, and in the male topminnows the anal fin is modified into a similar-functioning intermittent organ called thegonopodium.

**3.1.3. Reproduction Cycle**

* + The reproductive cycle of fish varies widely. Some fish, such as the clown fish, reproduce many times a year, while others reproduce annually. Some species, notably the Pacific salmon, reproduce only once in their lifetime, dying after releasing their eggs or sperm.

**Larvae:**

The newly hatched young of oviparous fish

* Usually poorly formed, carry a large yolk sac, for nourishment
* Larval period in oviparous fish lasts for some weeks

**Juveniles:**

Larvae rapidly grow and change in appearance Juveniles

* Switch from the yolk sac
* Feeds on plankton

**Adult/mature/:** they are ready to reproduction

**3.2. Determination of Sex and Sexual Maturity**

Secondary sexual characteristics in some fishes

* Ex: African catfish (*Clarias gariepinus*), Nile tilapia (*O. niloticus*)
* We able to differentiate the sex of Nile tilapia by their sex color; males are more attractive than females.
* We use dissecting techniques and observing the gonads
* Gonads located between gas bladder and other accessory organs
* Position of testes and ovaries are the same
* Males and females can be separated by visual inspection of the genital papilla.
* The male genital papilla is **pointed** and contains only the small urogenital pore which is difficult to observe.
* The female papilla is **rounded** and contains a small opening to the urinary duct and a larger oviduct.

**3.3 Growth**

Growth has been one of the most intensively studied aspects of fish biology as it indicates the health of the individual and the population. Growth of an organism can be defined as a change in its size (length and weight) over a period of time. As the age of a fish and its growth are closely related, the assessment of age and growth rate is conducted together. Abundant food supply and existence of other favorable conditions result in fast growth rate, whereas slow growth rate indicates the opposite. The rate of growth varies in fishes from species to species, and for the same fish from different localities, as it is influenced by various factors.

**3.3.1 Factors affecting growth rate**

The growth rate in fishes is highly variable and depends upon a number of environmental factors such as temperature, amount of dissolved oxygen, ammonia, salinity, photoperiod, degree of competition, quality of food taken, age and the state of maturity of the fish. Temperature is one of the most important environmental factors, and along with other factors, influences growth rate. Thus, optimum food consumption for maximum growth is temperature dependent. For example, in the young salmon maximum growth rate is achieved at 15°C.

Dissolved oxygen level depends on temperature, and by itself is also an important factor affecting growth rate of fishes. Possibly, the fish is deprived of ‘extra’ aerobic energy required for growth and reproduction, if dissolved oxygen falls below a certain level. Ammonia if present in high concentration will slow down the growth rate. Growth rate depends on the population density also. Higher densities slow down the growth and lower densities tend to increase it. This is due to competition for available food. Competition may, be *interspecific* as well as *intraspecific*.

Food availability which depends upon temperature affects growth rate on a seasonal basis. Growth may be rapid during warmer months, when plenty of food is available and slow during winter. Similarly photoperiod may also affect seasonal growth. Age and maturity are also important factors. Fish typically grow very fast in length in the first few months or years of life until maturation. Later, large amount of energy is diverted for the growth of gonads, hence body growth slows down. Growth rate of mature fish are therefore, much less than those of immature fish. However, mature fish are typically heavier per unit of length than the immature fish, partly due to the large sized gonads. This is shown by their higher Condition factor (K), Condition factor represents the condition of the fish during a certain period, and is the ratio of the length to the weight of the fish, as calculated by the following formula:

K = W/L3 X 100

Where, W is the weight of the fish in grams, and L is the length in cm.

The condition factor is generally used by the biologists as an indication of the health of a fish population. A high value of K shows that plenty of food is available to support both somatic and gonadal development of the fish. Fish have a wider range of size than any other group of vertebrates. The smallest fish known, the pygmy goby of the Philippines averages less than one-half of an inch (13 mm) at maturity. The largest is the whale shark, which is estimated to reach a length of 60 feet (18 m) or more. (The largest of all sea-dwelling animals, the blue whale, is not a fish but a mammal.)

**3.3.2 Regulation of growth**

Growth of fish is known to be regulated by certain hormones, especially the growth hormone synthesized in the pituitary gland. Hypophysectomy results in the cessation of growth in various species, while injections of mammalian growth hormone bring about increase in growth rate. This may be due to enhancement in the food conversion rate, possibly by stimulating stored fat mobilization, protein synthesis and insulin secretion. Increase in growth is also achieved by the thyroid hormone, triiodothyronine (T3). Addition of T3 increases growth rate and food consumption in certain species like salmon, and trout. Androgens (testosterone and 11- Ketotestosterone) are also reported to bring about improvement in food conversion efficiency of common carp, when added to their diet.

**IV) Assessment**

1. What affects fish growth rate?

**UNIT 4**

**Diversity of fishes (number of species and abundance of cartilaginous and bony fishes)**

This unit deals with diversity of fishes. The content will be delivered by brain storming, interactive lecture and group discussion. Students will be assessed by subjective and objective type questions.

**Objectives**

**At the end of this unit, students will be able to:**

* Describe marine fish diversity
* Explain freshwater fish diversity

**Self directed reading assignment**

**Read from the book or internet about the diversity of marine and freshwater fishes**

**Diversity of Fishes**

Fish are very diverse and are categorized in many ways. Although most fish species have probably been discovered and described, about 250 new ones are still discovered every year. Recently, 35,000 species of fish had been described. That is more than the combined total of all other vertebrates: mammals, amphibians, reptiles and birds.

**Classification of fishes**: Fish, the member of the Animalia Kingdom is classified into Phylum Chordata and Vertebrata Subphylum. All the species of the fish found in the world are classified into the following three groups (classes). They are:

* Agnatha - jawless fish
* Chrondrichthyes - cartilaginous fish
* Osteichthyes - bony fish
* Ray finned group
* Lobe finned group

**1. Agnatha** (= jawless fish)

* Subclass Cyclostomata (hagfish and lampreys)

Subclass Ostracodermi (armoured jawless fish) – *extinct group*\*

Placodermi (= armoured fish) – *extinct group\**

Endoskeleton and exoskeleton was made up of bony-armor Jaws were- primitive

Eg. Climatius, Palaeospondylus.

Acanthodii (‘spiny sharks’, sometimes classified under bony fishes) – *extinct\**

2. **Chondrichthys** (= cartilaginous fish)

* Subclass Elasmobranchii (sharks and rayes)
* Subclass Holocephali (chimaeras and *extinct relatives*\*)

3. **Osteichthys** (= bony fishes)

* Subclass Actinopterygii (= ray finned fishes)
* Subclass Sarcopterygii (= fleshy finned fishes, ancestor of tetrapods)

*Fish are very diverse, and their diversity can be expressed*:

1. **by species**

Fish systematics is the formal description and organization of fish taxa into systems. It is complex and still evolving. Unlike groupings such as birds or mammals, fish are not a single clade but a paraphyletic collection of taxa, including jawless, cartilaginous and skeletal types.

1. **Jawless fish**

Jawless fish are the most primitive fish. There is current debate over whether these are really fish at all. They have no jaw, no scales, no paired fins, and no bony skeleton. Their skin is smooth and soft to the touch, and they are very flexible. Instead of a jaw, they possess an oral sucker. They use this to fasten on to other fish, and then use their rasp-like teeth to grind through their host's skin into the viscera. Jawless fish inhabit both fresh and salt water environments. Some are **anadromous**, *moving between both fresh and salt water habitats*. Extant jawless fish are either **lamprey** or **hagfish**. Juvenile lamprey feed by sucking up mud containing micro-organisms and organic debris. The lamprey has well-developed eyes, while the hagfish has only primitive eyespots.

1. **Cartilaginous fish**

Cartilaginous fish have a cartilaginous skeleton. However, their ancestors were bony animals,and were the first fish to develop paired fins. Cartilaginous fish don't have swim bladders. Their skin is covered in placoid scales that are as rough as sandpaper. Because cartilaginous fish do not have bone marrow, the spleen and special tissue around the gonads produces red blood cells. Their tails can be asymmetric, with the upper lobe longer than the lower lobe. There are over 980 species of cartilaginous fish. They include **sharks, rays** and **chimaera.**

1. **Bony fish**

Bony fish include the **lobe** finned fish and the **ray** finned fish. The lobe finned fish is the class of fleshy finned fishes, consisting of lungfish, and coelacanths. They are bony fish with fleshy, lobed paired fins, which are joined to the body by a single bone. These fins evolved into the legs of the first tetrapod land vertebrates, amphibians. Ray finned fishes are so-called because they possess fin rays, their fins being webs of skin supported by bony or horny spines ("rays").

There are three types of ray finned fishes: the *chondrosteans, holosteans*, and *teleosts.* The chondrosteans and holosteans are primitive fishes sharing a mixture of characteristics of teleosts and sharks. In comparison with the other chondrosteans, the holosteans are closer to the teleosts and further from sharks.

**Teleosts**

Teleosts are the most advanced or "modern" fishes. They are overwhelmingly the dominant class of fishes (or for that matter, vertebrates) with nearly 30,000 species, covering about 96 percent of all extant fish species. They are ubiquitous throughout fresh water and marine environments from the deep sea to the highest mountain streams. Included are nearly all the important commercial and recreational fishes. Teleosts have a movable maxilla and premaxilla and corresponding modifications in the jaw musculature. These modifications make it possible for teleosts to protrude their jaws outwards from the mouth. The caudal fin is homocercal, meaning the upper and lower lobes are about equal in size. The spine ends at the caudal peduncle, distinguishing this group from those in which the spine extends into the upper lobe of the caudal fin.

**2. By size**

The smallest fish species is *Paedocypris progenetica*, a type of minnow which lives in the dark–colored peat swamps of the Indonesian island of Sumatra. The females of this species have a standard length of 7.9 mm at maturity. Until recently, this was the smallest of all known vertebrates.

* However, recently a minute Papua New Guinea frog, *Paedophryne amauensis*, with a standard length of 7.7 mm was discovered.
* The largest fish is the whale shark. It is a slow moving filter feeding shark with a maximum published length of 20 m and a maximum weight of 34 tones. Whale sharks can live up to 70 years.
* The heaviest bony fish is the ocean sunfish. It can weigh up to 2,300 kg. It is found in all warm and temperate oceans.
* The longest bony fish is the king of herrings. Its total length can reach 11 m, and it can weigh up to 272 kg. It is a rarely seen oarfish found in all the world's oceans, at depths of between 20 m and 1,000 m.

**3. By life span**

Some of the shortest-lived species are gobies, which are small coral reef–dwelling fish. Some of the longest-lived are rockfish.

* The shortest lived is the seven-figure pygmy goby, which lives for at most 59 days. This is the shortest lifespan for any vertebrate. Short lived fish have particular value in genetic studies on aging. In particular, the ram cichlid is used in laboratory studies because of its ease of breeding and predictable aging pattern.
* The longest–lived fish is the 205 years reported for the rougheye rockfish, *Sebastes aleutianus*, found offshore in the North Pacific at 25–900 metres.
* There are stories about Japanese Koi goldfish passed from generation to generation for 300 years.

**4. By habitat**

There is 10,000 times more saltwater in the oceans than there is fresh water in the lakes and rivers. However, only 58 percent of extant fish species are saltwater. A disproportionate 41 percent are freshwater fish (the remaining one percent is *anadromous*). This diversity in freshwater species is, perhaps, not surprising, since the thousands of separate lake habitats promote speciation. Fish can also be demersal or pelagic. Demersal fish live on or near the bottom of oceans and lakes, while pelagic fish inhabit the water column away from the bottom. Habitats can also be vertically stratified. Epipelagic fish occupy sunlit waters down to 200 metres, Mesopelagic fish occupying deeper twilight waters down to 1,000 meters, and Bathy pelagic fish inhabiting the cold and pitch black depths below. Most oceanic species (78 percent, or 44 percent of all fish species), live near the shoreline. These coastal fish live on or above the relatively shallow continental shelf. Only 13 percent of all fish species live in the open ocean, off the shelf. Of these, 1 percent is epipelagic, 5 percent are pelagic, and 7 percent are deep water.

**5. By breeding behavior**

Grouper are protogynous hermaphrodites, who school in harems of three to fifteen females. When no male is available, the most aggressive and largest females shift sex to male, probably as a result of behavioral triggers. In very deep waters, it is not easy for a fish to find a mate. There is no light, so some species depend on bioluminescence. Others are hermaphrodites, which doubles their chances of producing both eggs and sperm when an encounter does occur. The female anglerfish releases pheromones to attract tiny males. The breeding behavior (cycle) of fish is monthly, annually and once throughout their life.

**6. By brooding behavior**

Fish adopt a variety of strategies for nurturing their brood and safe from predator.

* Cat sharks and others are, oviparous, laying their eggs to hatch in the water.
* Some animals, predominantly fish such as cardinal fish practice mouth brooding, caring for their offspring by holding them in the mouth of a parent for extended periods of time. Mouth brooding has evolved independently in several different families of fish.
* Others, such as seahorse males, practice pouch-brooding, analogous to Australia's kangaroos, nourishing their offspring in a pouch in which the female lays them.

**7. By feeding behavior**

There are three basic methods by which food is gathered into the mouths of fish: by suction feeding, by ram feeding, and by manipulation or biting. Nearly all fish species use one of these styles, and most use two. Early fish lineages had inflexible jaws limited to little more than opening and closing. Modern teleosts have evolved protusible jaws that can reach out to engulf prey. An extreme example is the protusible jaw of the slingjaw wrasse. Its mouth extends into a tube half as long as its body, and with a strong suction it catches prey. The equipment tucks away under its body when it is not in use. In practice, feeding modes lie on a spectrum, with suction and ram feeding at the extremes. Many fish capture their prey using both suction pressures combined with a forward motion of the body or jaw.

**Unit Five: Commercially important fishes**

**Unit description**

This unit introduces the student with commercially important fish. The contents will be delivered by brain storming, interactive lecture, and group discussion. Students are assessed by individual assignment, objective and subjective type questions.

**Unit objectives**

After completing this unit, students are expected to:

* Explain commercially important fishes of the temperate region
* Discuss Commercially important species of the tropics

**Be in group/Individually.**

***Refer different books and identify and discuss*** *commercially important fishes* ***and prioritize them according to the consumers’ preference.***

**UNIT 6: Fisheries Management**

**Unit description**

The sixth unit introduces the student with fishery management. The contents will be delivered by brain storming, interactive lecture, and group discussion. Students are assessed by objective and subjective type questions.

**Objective**

* Describe stock assessment
* Explain recruitment of young
* Summarize ecological requirements of commercially important fish
* Discuss sustainable exploitation

**6.1. Fisheries Management**

*What is fisheries management?*

The integrated process of information gathering, analysis, planning, consultation, decision- making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives.

Fisheries management is a fisheries science that finds ways to protect fishery resources or fish stock to sustainable exploitation. It is appropriate management of rules based on defined objectives. Appropriate management means to implement the rules by monitoring control and surveillance.

**6.1.1.** **Objectives of fisheries management**: to

* Maximize sustainable biomass
* Maximize sustainable economic yield
* Secure and increase employment
* Secure protein production and food supply
* Increase income from fish export
* Increase biological and economic yield

**6.1.2 Criteria’s for fisheries Management**

The following criteria will apply to management systems for any fisheries, but it must be recognized that special consideration needs to be given to small-scale fisheries with respect to the availability of data and that management systems can differ substantially for different types and scales of fisheries.

* + adequate data and/or information are collected, maintained and assessed
  + the best scientific evidence available is taken into account as well as consideration of relevant (and validated) traditional fisher or community knowledge
  + Management targets are consistent with achieving maximum sustainable yield (MSY) (or a suitable proxy) on average, or a lesser fishing mortality if that is optimal
  + appropriate measures for conservation and sustainable use implemented
  + an effective legal and administrative framework and compliance is ensured
  + the precautionary approach is being implemented

**6.1.3. Types of fisheries management**

**A. Co-management**:- may be described as a partnership arrangement using the capacities and interests of the local fishers and their community, complemented by the ability of government to provide enabling legislation and other assistance. There is no single blueprint solution for success with co-management

* A partnership arrangement between,
  + Government agencies
  + Local fisher community
  + NGOs
  + Other stakeholders
  + Share the responsibility and authority for the management of a fishery.
  + Integrate local (informal, traditional) and government management systems.
  + Power-sharing between government and fishermen (Pomeroy 1998).

**B.Community based management**

* All activities are given to communities and fishermen
* It is not recommendable/effective

**C.Goverment based management**

* All activities are given to government and experts
* It is not recommendable/effective/

**Stakeholders who could help with management or *influence* success**:

* + Fisheries management agency
  + Fishery researchers and scientists
  + Local government administrations (planning etc)
  + Traditional village leadership organizations
  + Non-governmental development organizations (NGOs)
  + Agricultural extension service
  + Enforcement agencies (e.g. local police)
  + Farmers and their employees who farm in the surrounding floodplain or use water for irrigation
  + Towns or industries upstream who affect water quality and quantity
* **What is a sustainable fishery?**
* Monitor the condition and health of the fishery
* Protect it from destructive fisheries
* Prevent overfishing from unsustainable practices
* Fishers transformed from: Resource exploiters/users to Resource stewards/caretakers/managers

**6.2 Stock Assessment**

**Brainstorming**

*Q1. What is fish stock?*

A "stock" is a population of a species living in a defined geographical area with similar biological parameters (e.g. growth, size at maturity, fecundity etc.) and a shared mortality rate.

### 6.2.1. The aim of stock assessment

Stock assessment involves using mathematical and statistical models to examine the retrospective development of the stock and to make quantitative predictions to address the following fisheries management questions:

1) What is the current state of the stock?  
2) What has happened to the stock in the past?  
3) What will happen to the stock in the future under alternative management choices?

**Interactive lecture**

*Q1. Why stock assessment is needed in fishery activities?*

**6.2.2. Fish stock**

* Refers to a harvested or managed unit of fish
* Typically stocks are divided based on geographical location not based on individual location
* Stocks are not always composed of a single species but can be composed of multiple species due to their being harvested together or as a form of convenience for managers as herrings, sardines fishes
* It is a subpopulation of a particular species of fish
* In fish stocks intrinsic parameters like growth, recruitment, mortality, and fishing mortality are the only significant factors in determining the population dynamics.
* But extrinsic factors like immigration, emigration are considered to be insignificant.

**6.2.3. Fish Stock assessment:**

Provides information to managers that are used in the regulation of fish stock. During stock assessment both biological and fisheries data are collected.

* **Biological data includes:**
  + *Age structures of fish stock*
  + *Age at first spawning*
  + *Fecundity (=ability to reproduce)*
  + *Ratio of males to females in the stocks*
  + *Natural mortality*
  + *Fishing mortality*
  + *Growth rate of fish*
  + *Spawning behavior*
  + *Critical habitats*
  + *Migratory habits*
  + *Food preferences*
  + *Estimation of total biomass*
* **Fisheries data is all human activities in fish stock and includes**
* *The kind of fisherman*
* *Type of gears or net used by the fisherman*
* *Value of fish to the different fisherman*
* *Time and geographical location of the best catches*
* *Fishing effort by fisherman*
* *Age structures of fish harvested*
* *The ratio of males to females that are captured*
* *How fishes are marketed*

From the combined biological and fisheries data, the current status and condition of the stock is defined and predict how in the future, stock will respond to varying level of fishing pressure

Stock assessment is very important to reduce the level of overfishing that occur and restore stocks that have been overfished. Overfishing is an activity of fisherman that reduce fish stock below an acceptable level

**6. 3.Recruitment of young fish**

**Interactive lecture**

*Q1. Why size of fish population fluctuates?*

* Recruitment is the number of new young fish enter a population in a given year
* The size of fish population can fluctuate by different factors
* Fluctuations in reproductive and recruitment success are prime factors behind fluctuation
* Recruitment success often has a poor relationship to adult stock levels and fishing stock

**6.4. Ecological requirements of commercially important fish- note will be given**

**Group discussion**

Discuss on ecological requirements of commercially important fish being 5 in a group for 10 munities.

**Tilapia, Labeo barbus, small barbus (T. pelagus, B.humilis, B.pelorogamma and gara )**

**Catfish**

*Clarias gariepinus* can endure extremely harsh conditions (Skelton 2001). It is able to tolerate very low oxygen concentrations and even survive for considerable periods out of water, via the use of a specialised suprabranchial organ (Safriel & Bruton 1984, Hecht *et al.* 1988). This organ is a large paired chamber with branches above the gill arches specifically adapted for air breathing (Maina & Maloiy 1986) and allows it to move over land even when not forced to do so by drought (Welman 1948, Johnels 1957). Water temperatures between 8 and 35°C, salinities of 0 to 10‰ and a wide pH range are all tolerated (Safriel & Bruton 1984). *C. gariepinus* exhibits high growth rates between 25 and 33 °C, with optimum growth recorded at 30°C (Britz & Hecht 1987). The ability of the fish to be able to tolerate these extreme conditions allows it to survive even in moist sand or in borrows with an air-water interface (Bruton 1979c, Van der Waal 1998).

**6.5. Sustainable Exploitation**

*Q1. What will be the consequence if fish catch is not sustainable?*

* It is sustainable fishing
* It is fishing at a level and in a manner that it is reasonably believed can be sustained indefinitely, assuming proper response to changes in the ecosystem
* Maximize sustainable yield (MSY) is the largest average catch or yield that can continuously be taken from a stock under the existing environmental condition

• **During Sustainable exploitation**

* Habitat needed by fishes is not damaged or reduced in extent
* Particular cares need to be taken over spawning and nursery grounds
* Exploitation allows the survival of sufficient adults to produce strong recruitment
* The effect of climate need to be monitored and catch adjusted accordingly
* Exploitation is at a level that does not change the age structure and life history of fish

**IV) Assessment**

1. Which data are needed for stock assessment?

2. What is recruitment means?

3. What will be the consequence if fish catch is not sustainable?

**UNIT 7: Types of marketing (2 hrs)**

**Objectives**

* Describe preservation technique
* Describe fresh food of fish
* Describe canned fish food
* Describe smoked fish food

**Preservation techniques**

*Q1. What are traditional and modern fish preservation techniques?*

**7.1. Preservation:** is the processing of foods so that they can be stored longer. Because most of food products are readily available only during certain seasons of the year and because fresh food spoils quickly, methods have been developed to preserve foods. Preserved foods can be eaten long after the fresh products would normally have spoiled. With the growth of towns, the need to preserve foods longer increased as some people could no longer grow their own vegetables nor keep animals. Preservation must be seen as a way of storing excess foods that are abundantly available at certain times of the year, so that they can be consumed in times when food is scarce. Consumption of fresh foods is always preferable, however, as preservation usually decreases the nutritional value. In other words, preserved foods are not as healthy as fresh foods.

Ancient methods of preserving fish included *drying*, *salting* and smoking. All of these techniques are still used today but the more modern techniques of *freezing* and *canning* have taken on a large importance.

**7.1.1. Drying**

Drying is a method of food preservation that works by removing water from the food, which inhibits the growth of microorganisms. Open air drying using sun and wind has been practiced since ancient times to preserve food. A solar or electric food dehydrator can greatly speed the drying process and ensure more-consistent results.

Water is usually removed by evaporation (air drying, sun drying, smoking or wind drying):

* *Reduce moisture content*
* *Reduce water activity that reduce microbial and enzyme activities*
* *Reduce deterioration*

Bacteria, yeasts and molds need the water in the food to grow, and drying effectively prevents them from surviving in the food.

**7.1.2. Smoking**

The heat of the fire dries the fish or meat during the smoking process and if the temperature gets high enough, the flesh is cooked. This means that bacterial spoilage and spoilage due to enzyme activity is prevented. Drying and cooking of the flesh when being smoked play an important role in the preservation. If a product is well dried during smoking then it can be stored for a long time.

**7.1.3. Salting**

By salting food, storage life is prolonged. Salt absorbs much of the water in the food and makes it difficult for micro-organisms to survive. For salting, it is important that the fish or meat has been prepared in such a way that the salt added can quickly draw into the flesh and the moisture can leave the fish or meat. Large pieces of flesh must be cut into thin slices to allow this.

**7.1.4. Canning**

The canning process involves placing foods in cans or jars and heating them to a temperature that destroys micro-organisms that could be a health hazard or cause the food to spoil. Canning also inactivates enzymes that could cause the food to spoil. As the cans or jars are sealed, re-contamination from outside is prevented. In general, canned products can be stored for a long time without refrigeration. Chemical quality loss (in taste, color and amount of certain essential nutrients) will slowly continue though.

The ***high price*** of the preserved foods due to glass or tinned steel packaging materials used, the processing equipment, the process requires a lot of fuel, the extended heating at high temperatures causes both a decrease in taste and vitamin losses, etc.

**7.1.5. Freezing (lowering temperature)**

Bacteria and enzymes are adapted to the temperature at which the fish lives. But, it is possible to make bacteria and enzymes inactive at lower temperature. While doing this spoilage rate can be reduced. Therefore, fish can be chilled or frozen to preserve it.

**7.2. Fish transportation**

*Q1. How fish is transported from the place of harvest to the place where needed?*

Development in fish transportation has increased significantly the share of fish production that enters international trade. Fish is traded *live*, *fresh*, *frozen*, or canned. It is transported by *sea*, *air* or *land*. Live, fresh and frozen fish require special care in comparison with cured or canned fish.

### 7.2.1. Live fish

Transportation of live fish requires oxygen for respiration and removal of the toxic gases and by-products that accumulate, such as CO2 and ammonia. Certain fish, like catfish, can obtain oxygen through the damp surface of their gills or through the body skin. Other fish, like the climbing perch, have accessory air-breathing organs. But most fin fish are transported live in water supersaturated with oxygen and kept at a temperature low enough to reduce their metabolism.

### 7.2.2. Transporting by air

Air cargo is responsible for transporting over 5% of the world annual catch and the increasing demand for fresh fish fuels a growing demand for air shipment of fish. *However, successful air transport of fish and seafood requires special care in preparation and handling of the shipments, and excellent communication among the shipper, carrier and consignee*. Also, it should be stressed that hubs often necessitate cargo transfers under tight schedules and the reliance on combination passenger-cargo, entry and exit in all markets can influence the timing of the delivery and the quality of the delivered products. Although ice is permitted to keep the fish cool, given it is sealed in plastic pouches, dry ice or gel packs are preferred by most airliners.

### 7.2.3. Transporting by land or sea

The most challenging aspect of fish transportation by sea or by road is the maintenance of the cold chain, for fresh, chilled and frozen products and the optimization of the packing. Maintaining the cold chain requires the use of insulated containers or transport vehicles and adequate quantities of coolants or mechanical refrigeration. Continuous temperature monitors are used to provide evidence that the cold chain has not been broken during transportation.

Transport of fish by sea allows for the use of special containers that carry fish under vacuum, modified or controlled atmosphere, combined with refrigeration.

**7.3. Fish marketing**

*Fish marketing?*

*Shelf life* is the length of time that foods, beverages, pharmaceutical drugs, chemicals, and many other perishable items are given before they are considered *unsuitable for sale, use, or consumption.* In some regions, a best before, use by or freshness date is required on packaged perishable foods. Shelf life is the recommendation of time that products can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under expected (or specified) conditions of distribution, storage and display.

The foods are usually classified as *less perishable, moderately perishable* and *highly perishable* in order to understand their perishable nature. Sea foods are highly perishable food items. Sea foods are less stable because of their high moisture content and availability of nutrients for the growth of microorganisms. Ambient temperature plays a crucial role to alter the stability of a product. Highly perishable foods like seafood's have low tolerance to ambient temperature.

**IV) Assessment**

1. Why canning is needed?

2. What is food preservation?

**UNIT 8: Benefits from fisheries activities**

**I) Objective**

* Summarize monetary benefit of fisheries activities
* Explain nutritional benefit of fisheries activities
* Discuss fish food security

*Q1. What are advantages of fish farming?*

***Q2. To what extent fish farming is being done in Ethiopia?***

***Q3. Are there really fishery experts in Ethiopia?***

***Q4. Dou you have any information that how much the renaissance dam will create job opportunity and bring economic income for the country?***

**8.1 Income (Monetary)**

* Reduce unemployment (fishing employments)
* Increase fisherman
* Contribute to GDP

E.g. USA: The current value of US aquaculture production is near $900 million annually, the US Department of Commerce hopes to increase this to $5 billion by 2025.

**Fishery farming:**

* **Increases individual income**
* **Decreased foreign dependence-** decreases dependence on foreign imports
* **Increase job opportunities**

*Q. What about of Ethiopia?*

**8.2. Food Security**

Agriculture is not enough to supply food to the people due to different factors like drought, low nutritional values of crops, climate change, rising of global food and fuel prices and increased urbanization. Fish are important to food security because they are high in protein and rich in essential fatty acids, vitamins, and minerals. According to WHO up to 50% of the protein intake need to come from fish. On average each person should eat 35 kgs of fish per year.

**8.3 Nutritional values**

Fish are a great way of producing high quality protein extremely efficiently; they do not use much energy living, as their weight is carried by the water, and tend to hang about just getting bigger without too much fuss.

Fish is a low-fat high quality protein. Fish is filled with omega-3 fatty acids and vitamins such as D and B (riboflavin). Fish is rich in calcium and phosphorus and a great source of minerals, such as iron, zinc, iodine, magnesium, and potassium. The American Heart Association recommends eating fish at least two times per week as part of a healthy diet. Fish is packed with protein, vitamins, and nutrients that can lower blood pressure and reduce the risk of a heart attack or stroke.

Eating fish is an important source of omega-3 fatty acids. These essential nutrients keep our heart and brain healthy. Two omega-3 fatty acids found in fish are EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Our bodies don't produce omega-3 fatty acids so we must get them through the food we eat. Omega-3 fatty acids are found in every kind of fish, but are especially high in fatty fish. Some good choices are salmon, trout, sardines, herring, canned mackerel, canned light tuna, and oysters.

Fishes are important for

* Healthy growth
* Good heart health
* Mental development
* Digestive system
* Physical development

**Fish contains:**

* Vitamins
* Vitamin B
* helps the body metabolize fatty acids, amino acids, carbohydrates
* vitamin D – help prevent osteoporosis by absorbing calcium to the body
* vitamin A – fish like salmon have vitamin A
* vitamin B12
* fishes like tuna, salmon, herrings, rainbow
* Minerals like potassium iron, calcium, phosphorus, zinc which are important to the health of muscles nerves bones etc.
* Proteins
* Proteins are important for normal human growth
* Good for people with diabetes
* Regulate blood sugar
* Important for weight loss
* Fishes like Tilapia contains high protein
* Fat
* Fish contain fewer fats than most meat but fat such as omega-3-fatty acids are important fats for heart health and mental development.
* According to American heart foundation it suggested the people should eat fish at least two times per a week.
* Fishes like sardines, mackerel, anchovies, trout, and herrings have high fat content than other fishes.

**Regular consumption of fish can reduce the risk of various diseases and disorders:**

* Asthma

Children who eat fish may be less likely to develop asthma.

* Brain and eyes

Fish rich in omega-3 fatty acids can contribute to the health of brain tissue and the retina

* Cancer

The omega 3 fatty acids in fish may reduce the risk of many types of cancers by 30 to 50 per cent, especially of the oral cavity, esophagus, colon, breast, ovary and prostate.

* Cardiovascular disease

Eating fish every week reduces the risk of heart disease and stroke by reducing blood clots and inflammation, improving blood vessel elasticity, lowering blood pressure, lowering blood fats and boosting 'good' cholesterol.

* Depression

People who regularly eat fish have a lower incidence of depression (depression is linked to low levels of omega 3 fatty acids in the brain).

* Diabetes

Fish may help people with diabetes manage their blood sugar levels.

* Eyesight

Breastfed babies of mothers who eat fish have better eyesight, perhaps due to the omega 3 fatty acids transmitted in breast milk.

* Inflammatory conditions

Regular fish consumption may relieve the symptoms of rheumatoid arthritis, psoriasis and autoimmune disease.

* Prematurity

Eating fish during pregnancy may help reduce the risk of delivering a premature baby.

**IV) Assessments**

1. Why fish food is important for food security?

2. How fisheries decrease unemployment?

**UNIT 9: Status and potentials of Ethiopia's fishery resources**

**I) Objective**

* Discuss status and potentials of Ethiopia's fishery resources, AL2

**9. 1 Status of Ethiopian Fisheries**

**Brainstorming**

*Q1. To what extent is the potential of Ethiopia’s water bodies to give fishes for market?*

**Interactive lecture**

*Q1. How about the potential of Ethiopian Lake to give fish product?*

**The Seven Ethiopian drainage basins; their tributaries and fish**

River basin is the portion of land drained by a river and its tributaries. It encompasses all area of the land surface dissected and drained by many streams and creeks that flow downhill into one another, and eventually into one river. The final destination is an estuary, a sea or an ocean.

* Ethiopia hydrological system derived from seven major basins. These are:

**1. Abay basins**

* Rivers are Blue Nile, Nile Dedessa, Mugar, Beshila, Belesse, Dabuse, Guder
* Lakes like Tana, Zegena, Wonchi, Dandi
* About 28 fish species

**2. Baro basin**

* Rivers are, Baro, Akobo, Gillo, Sore Geba, (White Nile?)
* About 90 fish species

**3. Omo-Gibe basin**

* Rivers like Gibe, Omo, Gojeb, Gilgel Gibe

**4. Genale-wabishebele basins**

* Rivers like Genale and Wabishebele

**5. Awash basins**

* Lakes of Abye, Hike, Aredebo and rivers of Akaki, Borkena

**6. Tekeze basins**

* Rivers of Tekeze, Angereb, Zarima, Shinfa, Gedema, Ghendwwoha, Haymen

**7. Rift valley Basins**

a. Saline northern lakes – includes Lake Abbe, Afdera, Gamari, Afambo

b. Centeral Rift valley lakes- includes Lake Ziway, Abjita, Langano, Hawassa

c. Southern rift valley lakes- includes Lake Chamo and Abaya

Ethiopia has water resources:

* About 7,400 km2 of standing water
* 7,000km length of rivers more than 150 indigenous fishes
* 10 exotic fish
* Solid fish potential over 51,000 tons
* But fish production is much lower than the potential
* And most of the fishing area found in the natural lakes and the most fished lakes includes: Ziway, Langano, Hawassa, Abaya and Chamo, Fincha and Koka reservores
* The most riverine fishing activities are performed in Baro River in the western part of Ethiopia and Omo River in the southern area near the border with Kenya. More than 100 local commercial fishes have been identified, however the most captured fishes are:
* Tilapia, Lates, Barbus, Bagrus, Clarias, Labeo, Nile perch about *80%* of the total catch is ***tilapia***
* Nile perch also caught in large quantities on Lake Chamo and Abaya. Catfish and barbus are also the third catch in Ethiopia. Ethiopia can have fish potential yield 30,000 tone to 40,000 tons per year in lakes and reservoirs and about 5000 tons per year in rivers. But present actual fish production in both lakes and rivers is about 5,500 tons per year?