COMPETENCY BASED EDUCATION
KENYA CERTIFICATE OF BASIC EDUCATION
SENIOR SCHOOL CURRICULUM

GRADE 11
MARINE TECHNOLOGY
NOTES



COMPETENCE GROUP

STRAND 1.0: FISH BIOLOGY AND ECOLOGY

SUB-STRAND 1.1: FISH TAXONOMY

1.1.1 Introduction to fish taxonomy

Meaning of fish taxonomy

Fish taxonomy is the branch of biological science concerned with identifying, naming, describing and classifying fish into different groups according to their similarities, differences and evolutionary relationships.

It helps marine technology learners understand the wide diversity of fish found in freshwater and marine environments.

Fish taxonomy involves four major activities:

1. **Identification:** Recognising a fish species using its physical characteristics and other distinguishing features.
2. **Nomenclature:** Giving fish scientifically recognised names according to internationally accepted naming rules.
3. **Classification:** Arranging fish into groups based on shared characteristics.
4. **Description:** Recording the physical features, behaviour and other characteristics of different fish species.

Importance of fish taxonomy

Fish taxonomy is important because it:

1. Helps identify different fish species found in oceans, lakes, rivers and other aquatic environments.
2. Promotes proper management and conservation of fish biodiversity.
3. Helps fisheries officers identify commercially important fish species.
4. Supports fish farming through correct identification of suitable species.
5. Helps prevent confusion caused by different local names for the same fish.
6. Supports scientific research on fish growth, reproduction, feeding and distribution.
7. Helps distinguish edible fish from potentially harmful or poisonous species.
8. Promotes sustainable fishing practices.
9. Supports fish processing, marketing and trade through accurate identification.
10. Helps monitor changes in fish populations and aquatic ecosystems.

Fish diversity in Kenya

Kenya has a wide variety of fish species found in freshwater and marine environments.

These fish support food security, employment, tourism, trade and economic development.

The major aquatic environments where fish are found in Kenya include:

A. Freshwater environments

These include:

- Lake Victoria.
- Lake Turkana.

- Lake Naivasha.
- Lake Baringo.
- Lake Jipe.
- Tana River.
- Athi River.
- Other rivers, dams and freshwater wetlands.

Examples of freshwater fish include:

- Nile tilapia.
- Nile perch.
- African catfish.
- Omena.
- Common carp.
- African lungfish.

B. Marine environments

These include the Indian Ocean and coastal waters around:

- Lamu.
- Kilifi.
- Mombasa.
- Kwale.
- Tana River coastal areas.

Examples of marine fish include:

- Tuna.
- Rabbitfish.
- Kingfish.
- Snapper.
- Grouper.
- Parrotfish.
- Sardines.

1.1.2 Identification of fish species in aquatic environments

Meaning of fish identification

Fish identification is the process of recognising and determining the particular species of a fish by examining its external features, body structure, colour patterns, habitat and other distinguishing characteristics.

Fish species can be identified using:

1. External body shape.

2. Type and arrangement of scales.
3. Number, shape and position of fins.
4. Shape and position of the mouth.
5. Presence or absence of barbels.
6. Shape of the tail fin.
7. Colour patterns and body markings.
8. Shape of the lateral line.
9. Presence or absence of spines.
10. Habitat and geographical distribution.

A. Body shape

Fish have different body shapes depending on their habitat, feeding habits and movement.

The common body shapes include:

1. Streamlined body

- The body is elongated and tapers towards both ends.
- It reduces resistance when swimming through water.
- It enables fish to swim quickly.
- It is common in active swimming fish.

Examples:

- Tuna.
- Mackerel.
- Some species of kingfish.

2. Laterally compressed body

- The body is flattened from side to side.
- It appears deep when viewed from the side.
- It allows fish to manoeuvre easily among aquatic vegetation and obstacles.

Examples:

- Tilapia.
- Rabbitfish.
- Butterflyfish.

3. Dorsoventrally flattened body

- The body is flattened from the upper side to the lower side.
- It enables fish to rest or move along the bottom of aquatic environments.
- It is common among bottom-dwelling fish.

Examples:

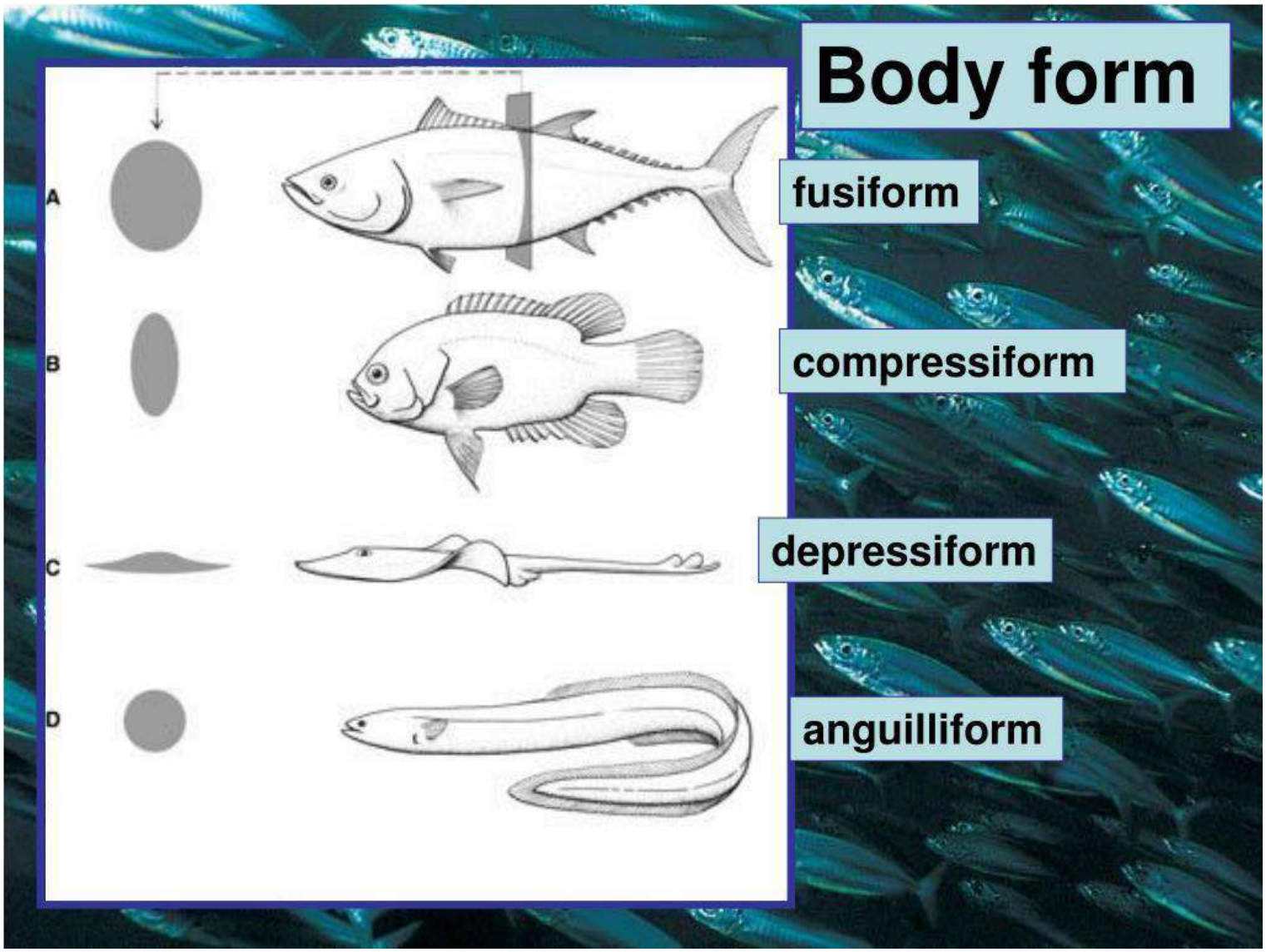
- Rays.
- Some skates.

4. Cylindrical or elongated body

- The body is long and approximately round in cross-section.
- It enables fish to move through narrow spaces and aquatic vegetation.

Examples:

- Eels.
- Some catfish.







B. Identification using scales

Scales are small protective structures covering the skin of many fish.

They protect the body against physical injury, parasites and infection while helping reduce friction during swimming.

Fish scales occur in different forms.

1. Cycloid scales

Characteristics:

- They are thin, smooth and rounded.
- They have smooth outer edges.
- They overlap one another.
- They are flexible and provide protection without restricting movement.

Examples:

- Tilapia.
- Salmon.
- Some freshwater fish.

2. Ctenoid scales

Characteristics:

- They have small comb-like projections along their rear edges.
- They feel rough when touched in one direction.
- They overlap to protect the body.
- They are common in many spiny-finned bony fish.

Examples:

- Many perch-like fish.
- Some marine reef fish.

3. Ganoid scales

Characteristics:

- They are hard, thick and usually diamond-shaped.
- They have a shiny protective outer covering.
- They fit closely together.
- They provide strong physical protection.

Examples:

- Gar fish.
- Bichirs.

4. Placoid scales

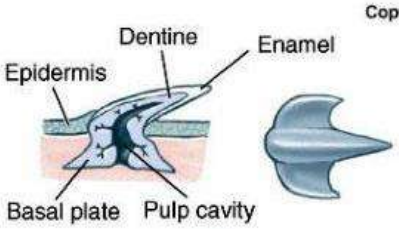
Characteristics:

- They are also called dermal denticles.
- They have a tooth-like structure.
- They have a hard outer covering.
- They are found in cartilaginous fish.
- They help reduce water resistance.

Examples:

- Sharks.
- Rays.

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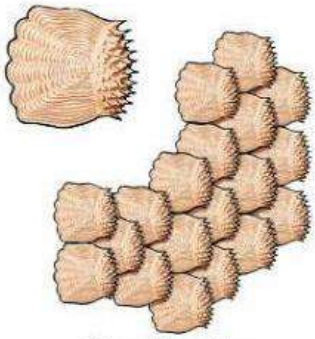
Placoid scales
(cartilaginous fishes)



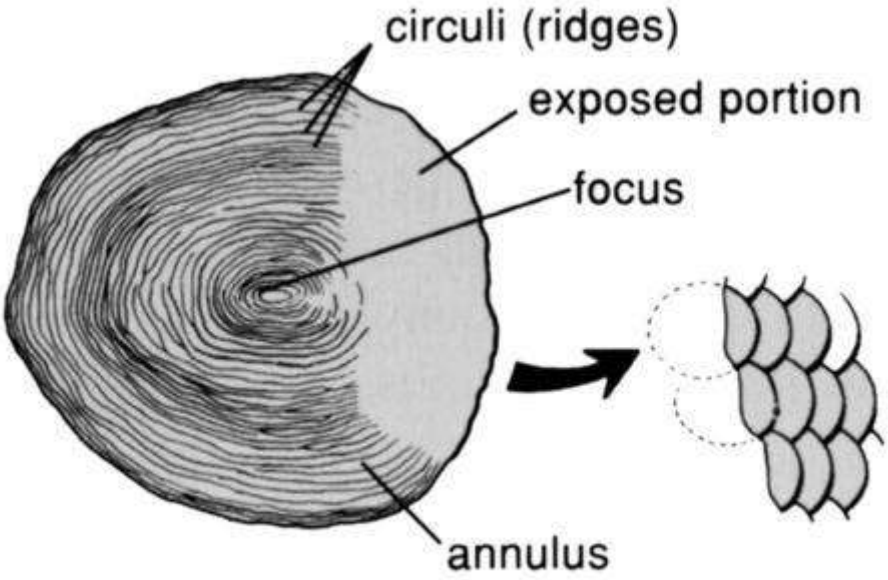
Ganoid scales
(nonteleost bony fishes)



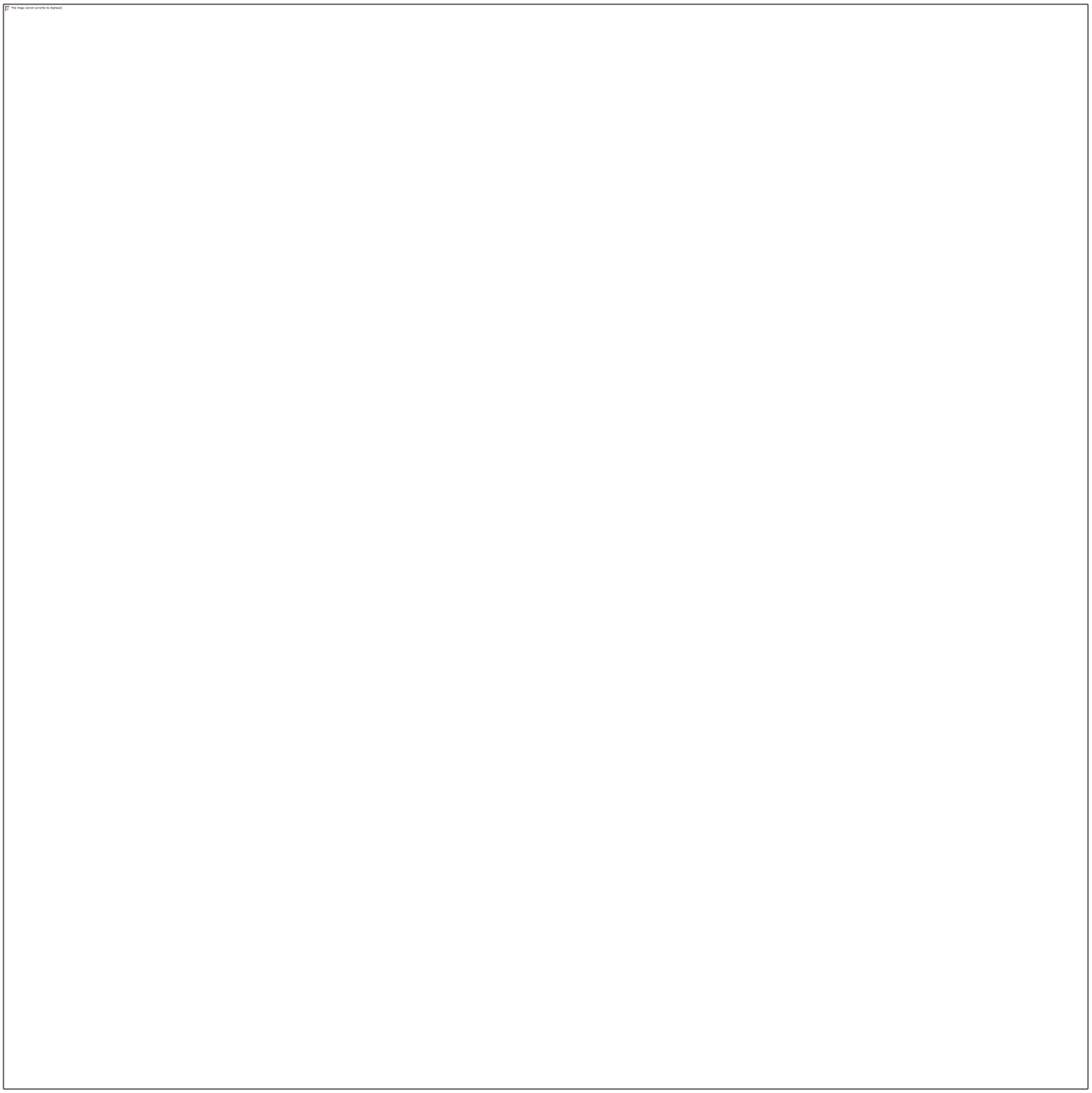
Cycloid scales
(teleost fishes)



Ctenoid scales
(teleost fishes)



F CYCLOID



Important distinction: Not all fish have scales. Some fish have naked skin, while others have bony plates or other protective structures.

Examples:

- African catfish has smooth skin without ordinary overlapping scales.
- Sharks have placoid scales.
- Some seahorses have bony plates rather than typical fish scales.

C. Identification using fins

Fins are external appendages that help fish maintain balance, change direction, control movement and propel themselves through water.

The major types of fish fins include:

1. Dorsal fin

- Located on the upper side of the fish.
- Helps maintain stability while swimming.

- Prevents the fish from rolling sideways.
- Some fish have one dorsal fin, while others have two or more.

2. Caudal fin

- Also called the tail fin.
- Located at the posterior end of the fish.
- Provides propulsion.
- Helps the fish move forward.

3. Anal fin

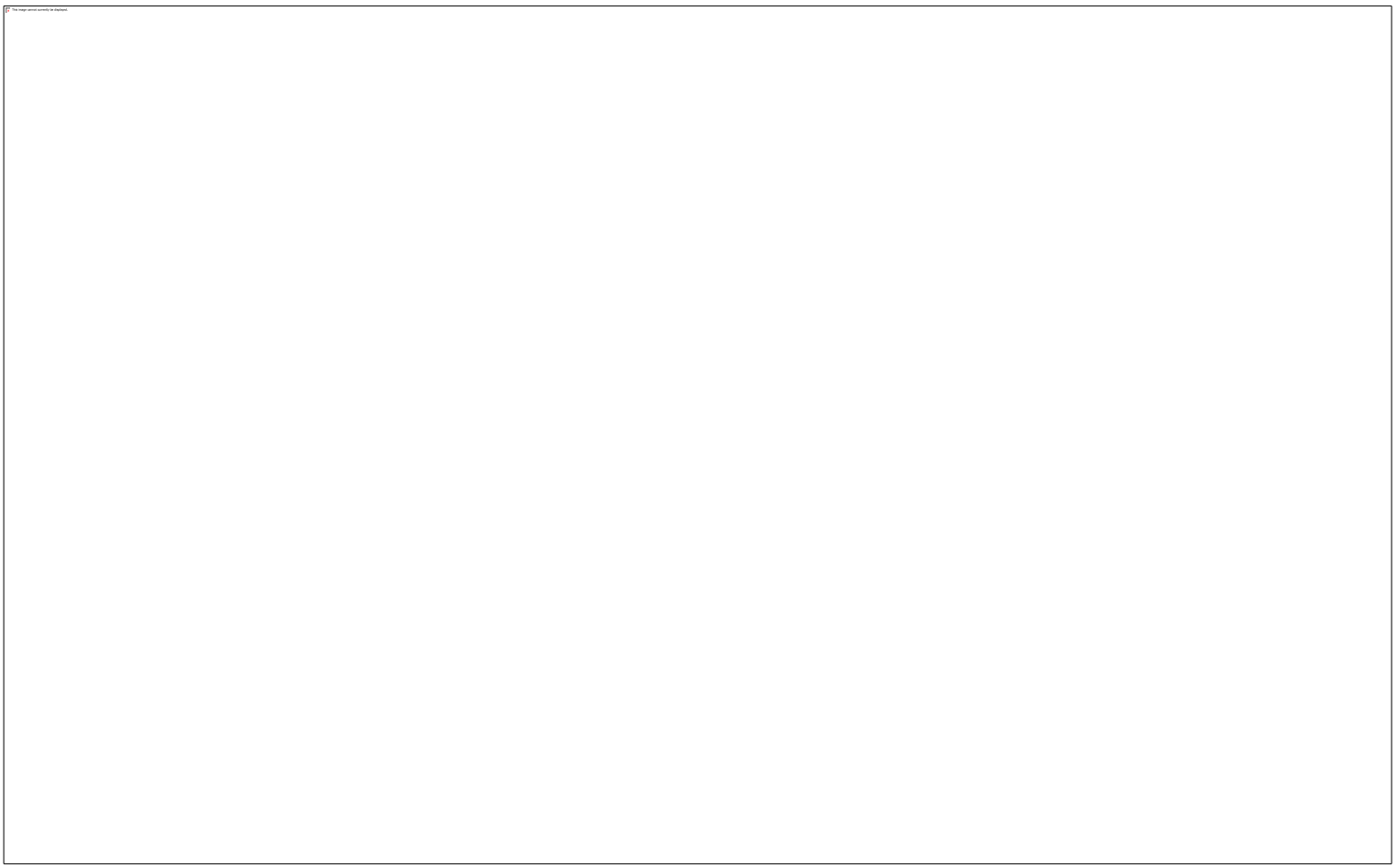
- Located on the lower side of the body behind the anus.
- Helps maintain stability during swimming.

4. Pectoral fins

- Located on either side of the body behind the gill region.
- Help in steering, braking and changing direction.
- Some fish use them to hover or move slowly.

5. Pelvic fins

- Located on the lower part of the body.
- Help maintain balance and control movement.
- Their position varies among fish species.



Differences in fish fins

Fish species differ in the number, position, shape and structure of their fins.

For example:

- Tuna have a powerful crescent-shaped tail fin for fast swimming.
- Tilapia have a long dorsal fin with spiny and soft portions.
- Catfish have prominent pectoral and dorsal fins, and some species have adipose fins.
- Rays have enlarged pectoral fins that form broad wing-like structures.

D. Identification using the mouth

The position and shape of the mouth can provide useful information about the feeding habits of fish.

The major mouth positions include:

1. Terminal mouth

- Located at the front end of the head.
- The upper and lower jaws meet at the front.
- Common among fish that feed on organisms directly in front of them.

Examples:

- Tuna.
- Nile tilapia.

2. Superior mouth

- The mouth opens upwards.
- The lower jaw projects beyond the upper jaw.
- Adapted for feeding near the water surface.

Examples:

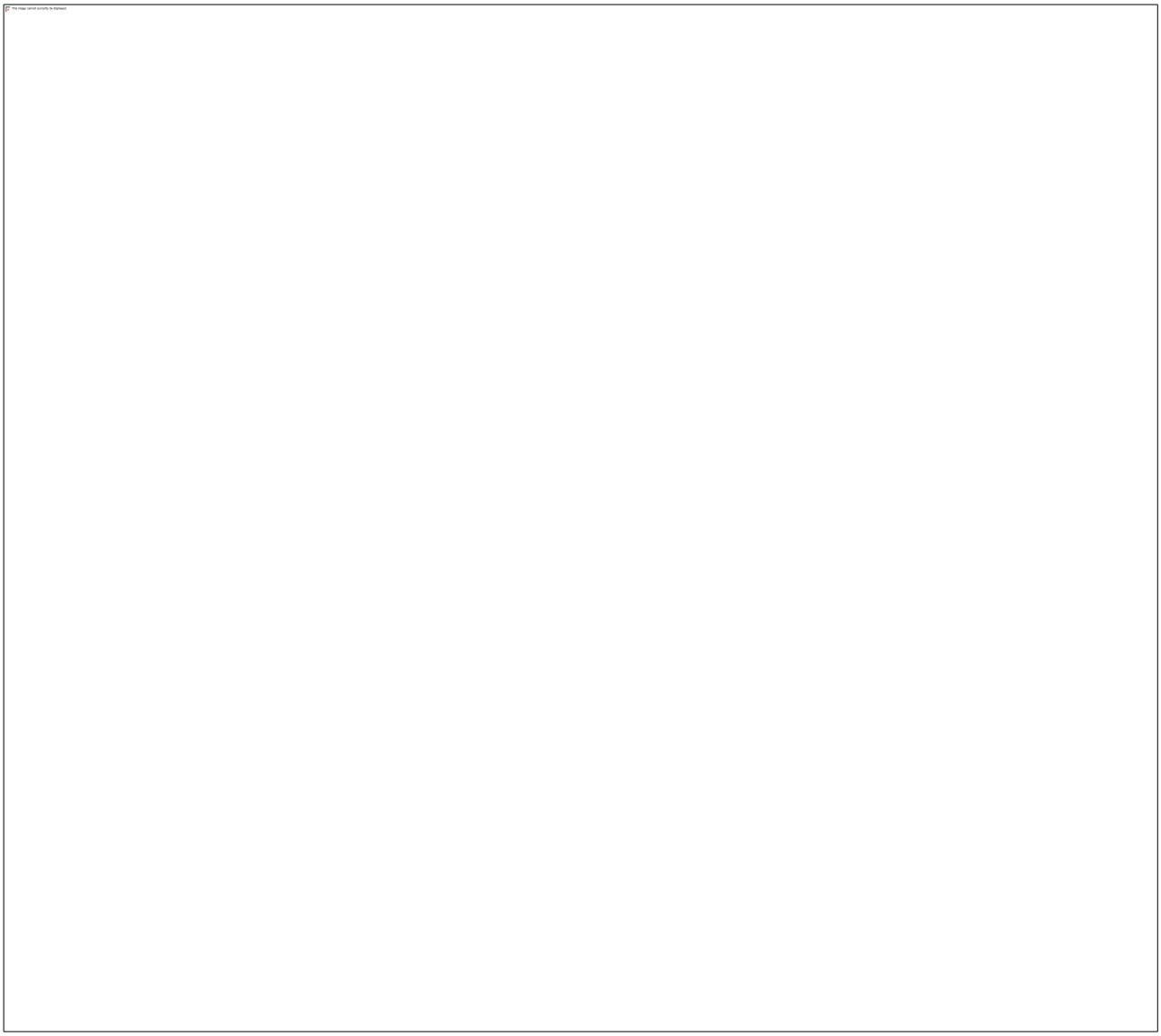
- Some surface-feeding fish.

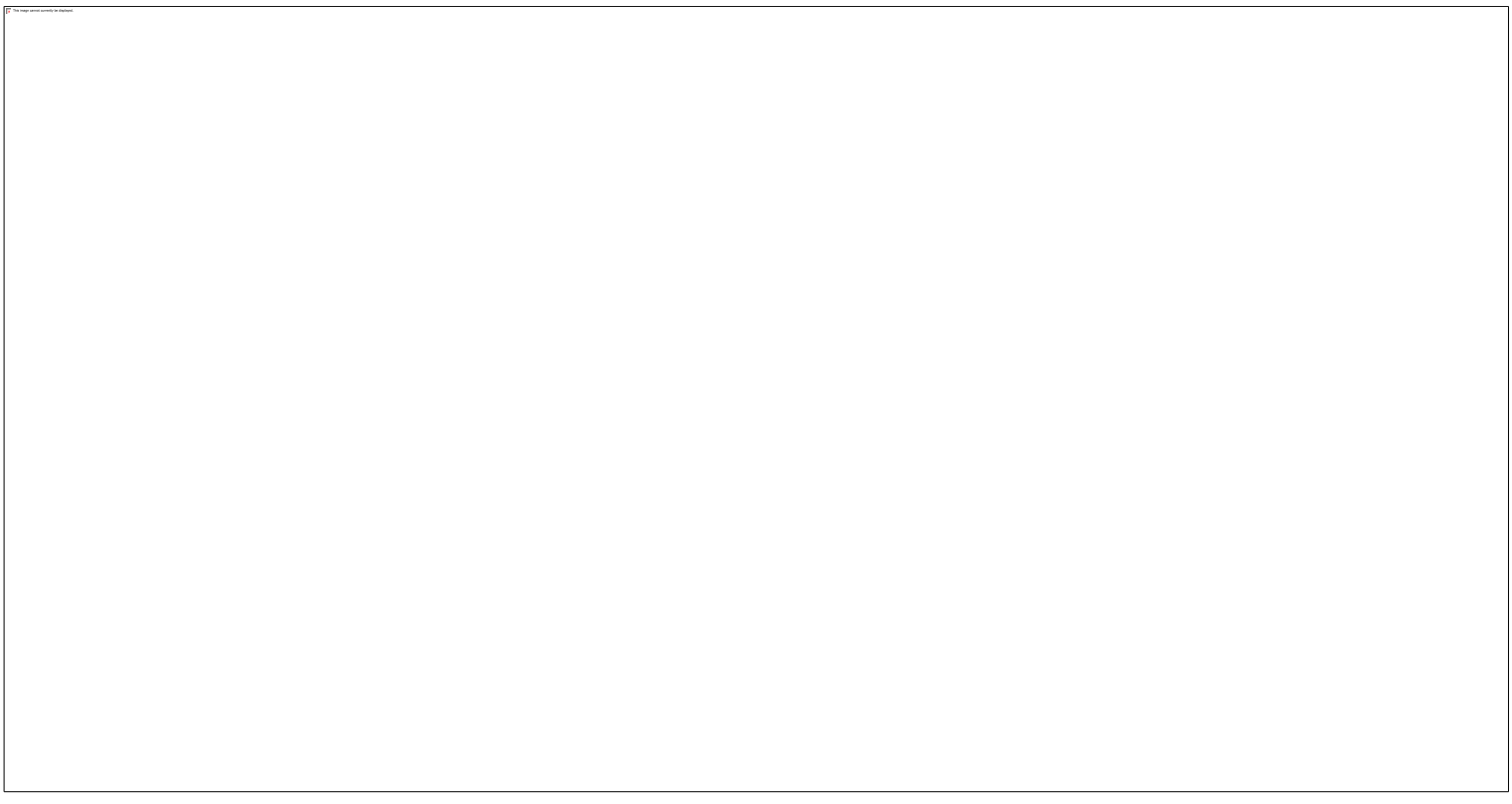
3. Inferior or subterminal mouth

- Located on the lower side of the head.
- Adapted for feeding on organisms found at the bottom.
- Common among bottom-feeding fish.

Examples:

- Some catfish.
- Some bottom-dwelling marine fish.





E. Identification using barbels

Barbels are slender, whisker-like sensory structures found around the mouth of some fish.

Functions of barbels:

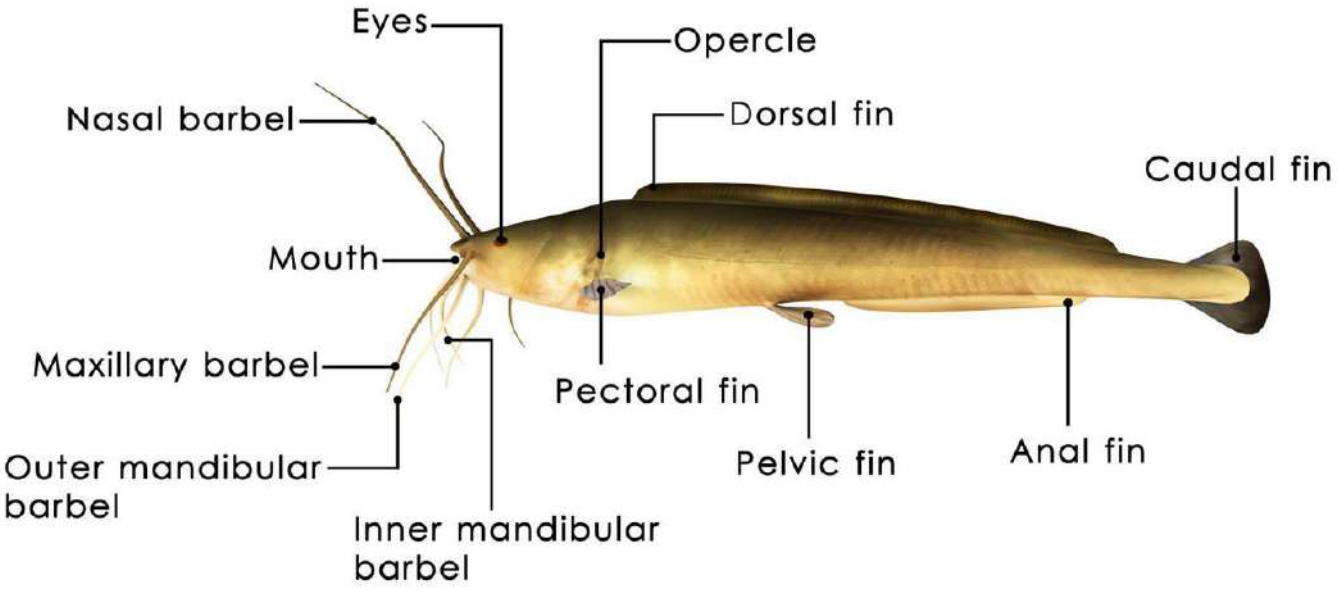
1. Detect food in water.
2. Help fish locate food in muddy or dark environments.
3. Detect chemical substances in water.
4. Assist in sensing objects around the mouth.
5. Help bottom-feeding fish locate prey.

Examples of fish with barbels:

- African catfish.
- Some carp species.
- Some marine goatfish.

Examples of fish without barbels:

- Nile tilapia.
- Nile perch.
- Tuna.



F. Identification using the lateral line

The lateral line is a sensory system found in most fish. It consists of specialised sensory structures arranged along the sides of the body, usually in a visible line or series of pores.

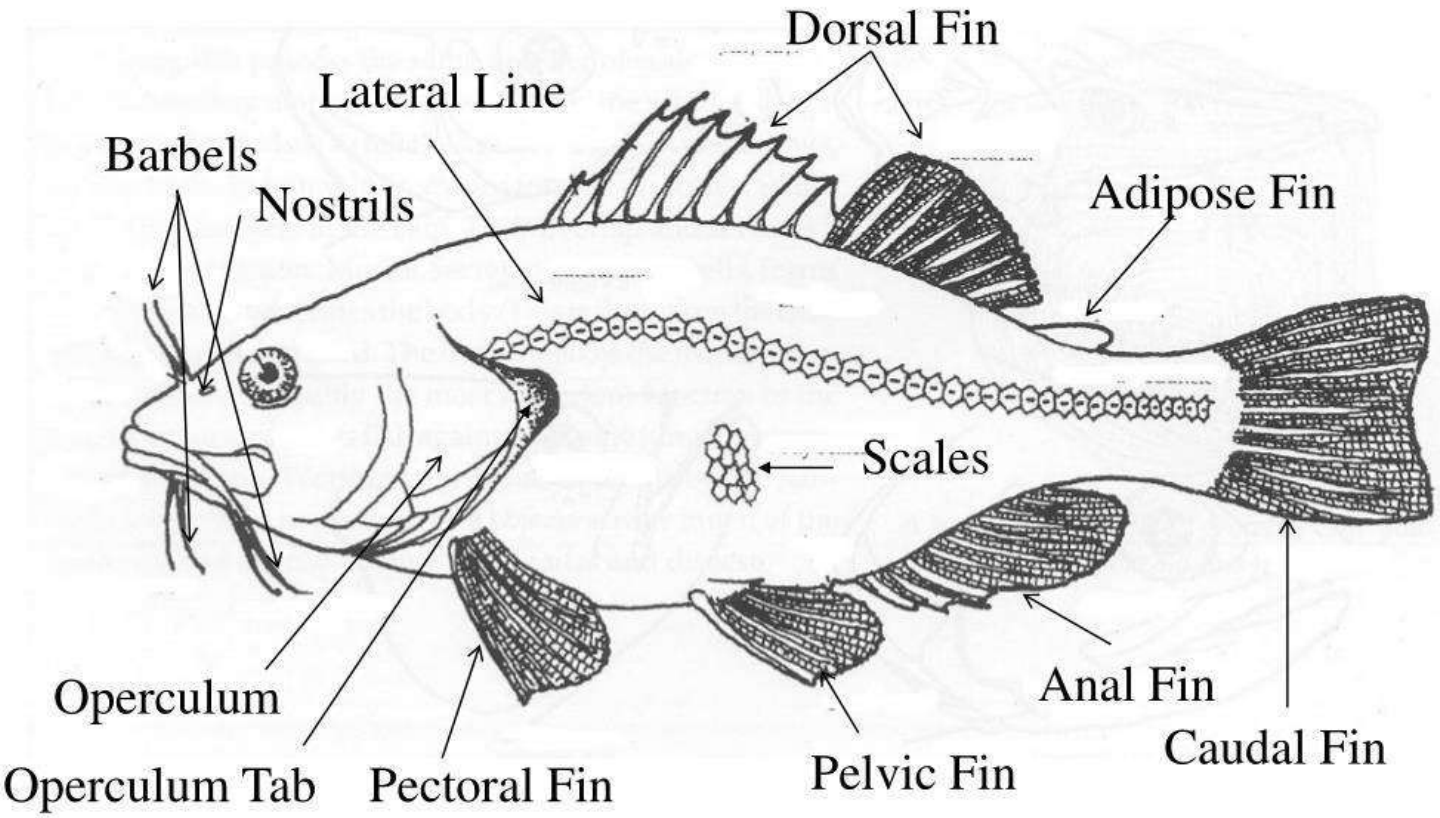
Functions of the lateral line:

1. Detects vibrations in water.
2. Detects movement of nearby organisms.
3. Helps fish avoid obstacles.
4. Helps fish locate prey.
5. Enables fish to detect approaching predators.
6. Helps fish coordinate movement in groups or shoals.

Types of lateral line appearance

- **Continuous lateral line:** Appears as an uninterrupted line along much of the body.
- **Interrupted lateral line:** Appears in separate sections.
- **Incomplete lateral line:** Does not extend along the entire body.

External Anatomy of a Fish



G. Identification using the tail fin

The shape of the caudal fin is another important feature used in fish identification.

1. Homocercal tail

- The upper and lower lobes appear approximately equal.
- Common among many bony fish.

Examples:

- Tilapia.
- Tuna.
- Nile perch.

2. Heterocercal tail

- The upper lobe is larger than the lower lobe.
- The vertebral column extends into the upper lobe.
- Common among many sharks.

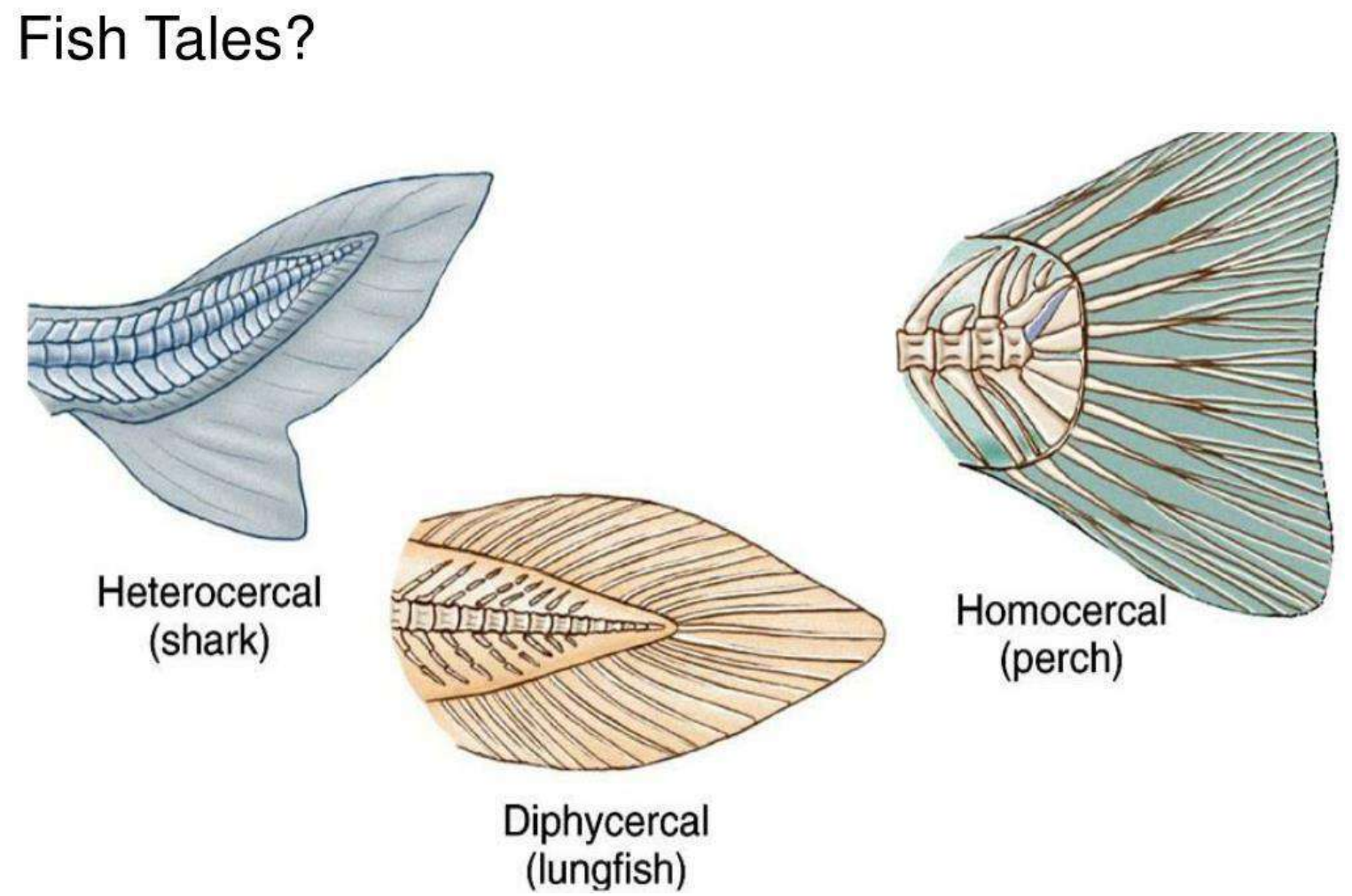
3. Diphycercal tail

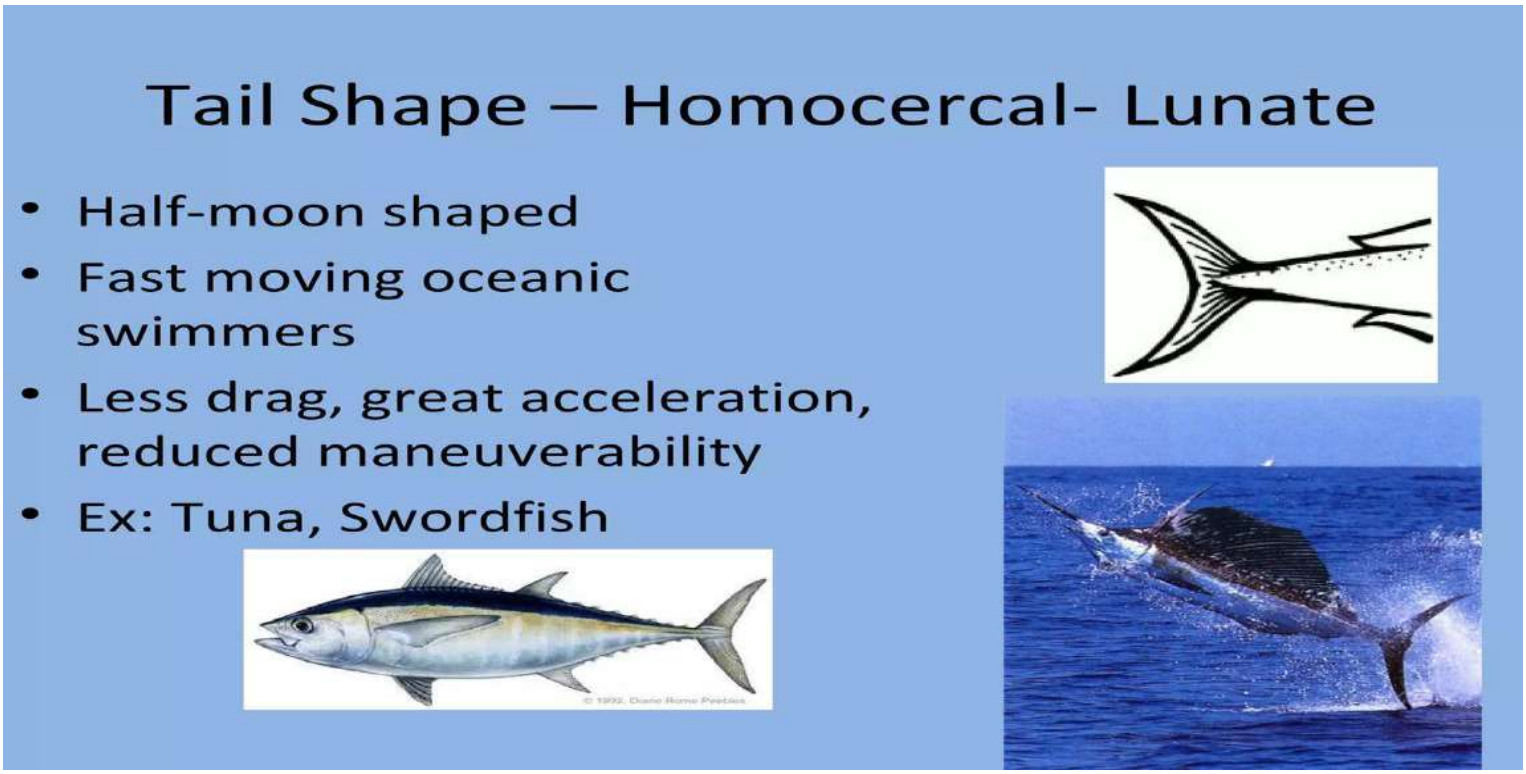
- The vertebral column extends straight towards the end of the tail.

- The tail is approximately symmetrical around the vertebral axis.

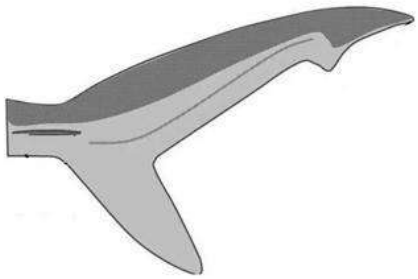
Examples:

- Lungfish.





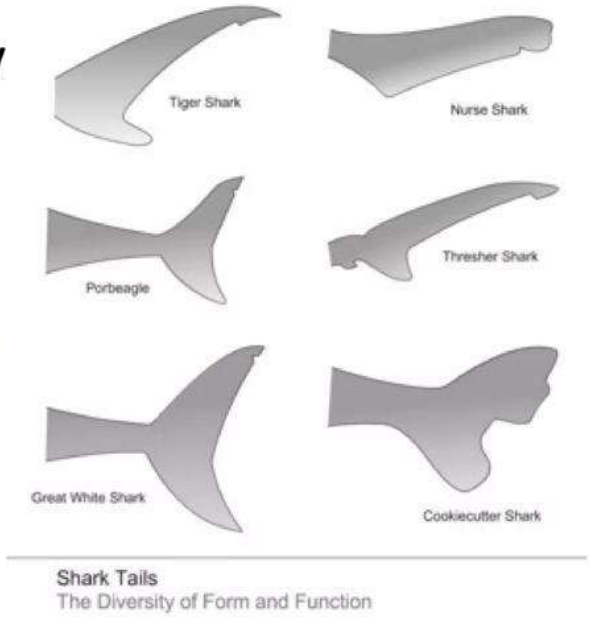
Caudal Fin Shape – Heterocercal



- Medium speed
- Asymmetrical – top longer than bottom
- Provides lift when no air bladder
- Reduced maneuverability
- Example: many sharks

blue shark





1.1.3 Nomenclature and naming of fish

Meaning of fish nomenclature

Fish nomenclature is the scientific system of assigning standard names to fish species so that they can be identified and referred to consistently throughout the world.

Fish may have three main types of names:

1. Local or vernacular names.
2. English or common names.
3. Scientific names.

A. Local or vernacular names

These are names given to fish by people in particular communities, regions or countries.

Characteristics:

- They are influenced by local languages and cultures.
- They may differ from one community to another.
- They are commonly used by fishermen, fish traders and local consumers.
- The same fish may have several local names in different regions.

- Different fish species may sometimes share similar local names.

Examples in Kenya:

- Omena – commonly used for the small silver cyprinid fish harvested from Lake Victoria.
- Mbuta – a commonly used Luo name for Nile perch.
- Sato – a name commonly used for tilapia in some Kenyan communities.

Importance of local names

- They promote communication among local fishing communities.
- They preserve indigenous knowledge about aquatic resources.
- They make it easier for local consumers to identify fish.
- They support local fish marketing and trade.

B. English or common names

These are names used to identify fish in ordinary communication, education, trade and fisheries activities.

Examples:

- Nile tilapia.
- Nile perch.
- African catfish.
- Rabbitfish.
- Tuna.
- Common carp.

Common names are easier to pronounce and remember than scientific names. However, they are not always unique because one common name may refer to several related species.

C. Scientific names

Scientific names are internationally recognised names assigned to organisms using a standard biological naming system known as binomial nomenclature.

Each species has a two-part scientific name consisting of:

1. Genus name.
2. Specific epithet.

The two names together identify a particular species.

Example: Nile tilapia

- Genus: *Oreochromis*
- Specific epithet: *niloticus*
- Scientific name: *Oreochromis niloticus*

Rules of writing scientific names

1. Scientific names are usually written in Latin or Latinised words.
2. The genus name begins with a capital letter.

3. The specific epithet begins with a small letter.
4. Both names are italicised when typed.
5. When handwritten, the two words should be underlined separately.
6. Each species has a unique scientific name.
7. After the first full mention, the genus name may be abbreviated.

Example:

- First mention: *Oreochromis niloticus*.
- Subsequent mention: *O. niloticus*.

Examples of fish scientific names

Common name	Scientific name
Nile tilapia	*Oreochromis niloticus*
Nile perch	*Lates niloticus*
African sharptooth catfish	*Clarias gariepinus*
Omena	*Rastrineobola argentea*
Yellowfin tuna	*Thunnus albacares*
Rabbitfish (example)	*Siganus sutor*
Common carp	*Cyprinus carpio*
Rainbow trout	*Oncorhynchus mykiss*





Importance of scientific naming of fish

Scientific naming is important because it:

1. Provides a universal system of identifying fish species.
2. Eliminates confusion arising from different local names.
3. Helps researchers communicate accurately.
4. Supports fisheries research and documentation.
5. Facilitates international fish trade.
6. Helps fisheries managers prepare conservation policies.
7. Enables accurate recording of fish populations.
8. Supports identification of closely related fish species.
9. Helps in the preparation of scientific reports and publications.
10. Promotes consistency in marine and fisheries education.

D. Biological classification of fish

Biological classification is the arrangement of organisms into groups based on shared characteristics and evolutionary relationships.

The main classification levels are:

1. Kingdom.
2. Phylum.
3. Class.
4. Order.
5. Family.
6. Genus.
7. Species.

The levels move from broad groups to increasingly specific groups.

Example: Classification of Nile tilapia

Classification level	Group
Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Cichliformes
Family	Cichlidae
Genus	*Oreochromis*
Species	*Oreochromis niloticus*

Note: Modern fish classification uses several classes and groups. The examples in this sub-strand mainly focus on commonly encountered bony fish and cartilaginous fish.

Major groups of fish

Fish are commonly grouped into three broad categories for introductory study.

1. Jawless fish (Agnatha)

Characteristics:

- They lack true jaws.
- Their bodies are usually elongated.
- They lack paired fins.
- They have a simple cartilaginous skeleton.
- Many species are adapted to specialised feeding habits.

Examples:

- Lampreys.
- Hagfish.

2. Cartilaginous fish (Chondrichthyes)

Characteristics:

- Their skeletons are made mainly of cartilage.
- They have paired pectoral and pelvic fins.
- Their skin bears placoid scales.
- They lack a typical bony operculum covering the gills.

- Most have several separate gill slits.
- They do not have a swim bladder.

Examples:

- Sharks.
- Rays.
- Skates.

3. Bony fish (Osteichthyes)

Characteristics:

- They have skeletons made mainly of bone.
- Most have gills covered by an operculum.
- Most have a swim bladder, although there are exceptions.
- Most have scales covering their bodies.
- They possess paired and unpaired fins.

Examples:

- Nile tilapia.
- Nile perch.
- African catfish.
- Tuna.
- Omena.
- Rabbitfish.





1.1.4 Comparison of external features of common fish species in Kenya

Fish species have different external characteristics that enable learners, fishermen, fish farmers and fisheries officers to identify them.

The comparison of external features involves examining:

- Body shape.
- Scale type.

- Fins.
- Mouth position.
- Barbels.
- Lateral line.
- Tail shape.
- Body colour and markings.
- Presence or absence of protective body structures.

A. Nile tilapia



Common name: Nile tilapia.

Scientific name: *Oreochromis niloticus.*

Habitat: Freshwater lakes, rivers, dams and fish ponds.

External characteristics:

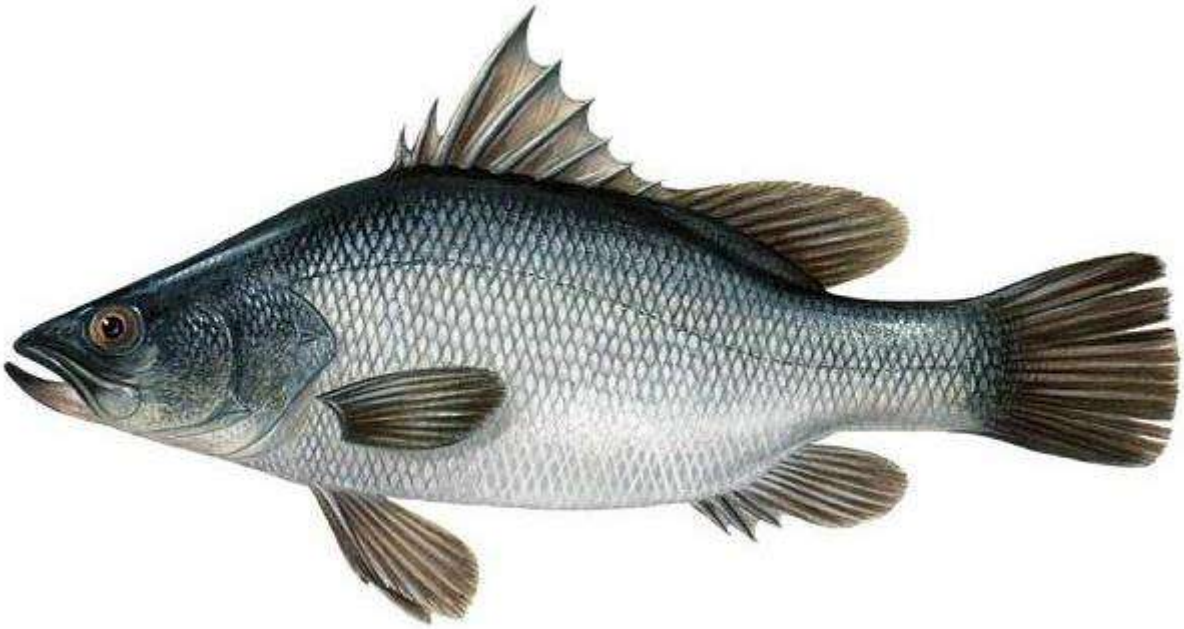
1. Has a laterally compressed body.
2. Body is generally deep and oval-shaped.
3. Has cycloid scales.
4. Has a long dorsal fin with spiny and soft portions.
5. Has a terminal mouth.

6. Has no barbels.
7. Has a continuous lateral line that is divided into two sections.
8. Has a homocercal tail.
9. Its body is commonly greyish or silvery with dark vertical bars.
10. Has paired pectoral and pelvic fins.

Economic importance:

- Provides food rich in protein.
- Supports aquaculture and fish farming.
- Provides income to fish farmers and traders.
- Creates employment in fish processing and marketing.
- Supports food security in Kenya.

B. Nile perch



Common name: Nile perch.

Scientific name: *Lates niloticus.*

Habitat: Freshwater lakes and rivers, particularly Lake Victoria.

External characteristics:

1. Has a large, elongated and moderately compressed body.
2. Has a large mouth with a protruding lower jaw.
3. Has a large head.
4. Has small ctenoid scales.
5. Has two dorsal fins, the first with spines.
6. Has a homocercal tail.
7. Has no barbels.

8. Has a lateral line that is continuous.
9. Has a silvery body with a darker upper surface.
10. Has an anal fin with spiny and soft portions.

Economic importance:

- Supports commercial fishing in Lake Victoria.
- Provides raw materials for fish processing industries.
- Earns foreign exchange through exports.
- Provides employment to fishermen and fish traders.
- Supplies protein to consumers.

C. African sharptooth catfish



Common name: African sharptooth catfish.

Scientific name: *Clarias gariepinus*.

Habitat: Freshwater rivers, lakes, swamps, dams and fish ponds.

External characteristics:

1. Has an elongated cylindrical body.
2. Has smooth, scaleless skin.
3. Has a broad, flattened head.
4. Has a wide terminal mouth.
5. Has several pairs of barbels around the mouth.
6. Has long dorsal and anal fins.
7. Has small pectoral fins with strong spines.
8. Has a small rounded or truncate caudal fin.
9. Has no ordinary visible external scales.
10. Has a specialised accessory breathing organ that enables it to use atmospheric oxygen.

Economic importance:

- Suitable for commercial fish farming.
- Grows well under appropriate aquaculture conditions.
- Has high demand in local markets.
- Provides food and income.
- Can survive in relatively low-oxygen environments better than many other farmed fish.

D. Omena



Common name: Omena or Lake Victoria sardine (silver cyprinid).

Scientific name: *Rastrineobola argentea*.

Habitat: Freshwater, particularly Lake Victoria.

External characteristics:

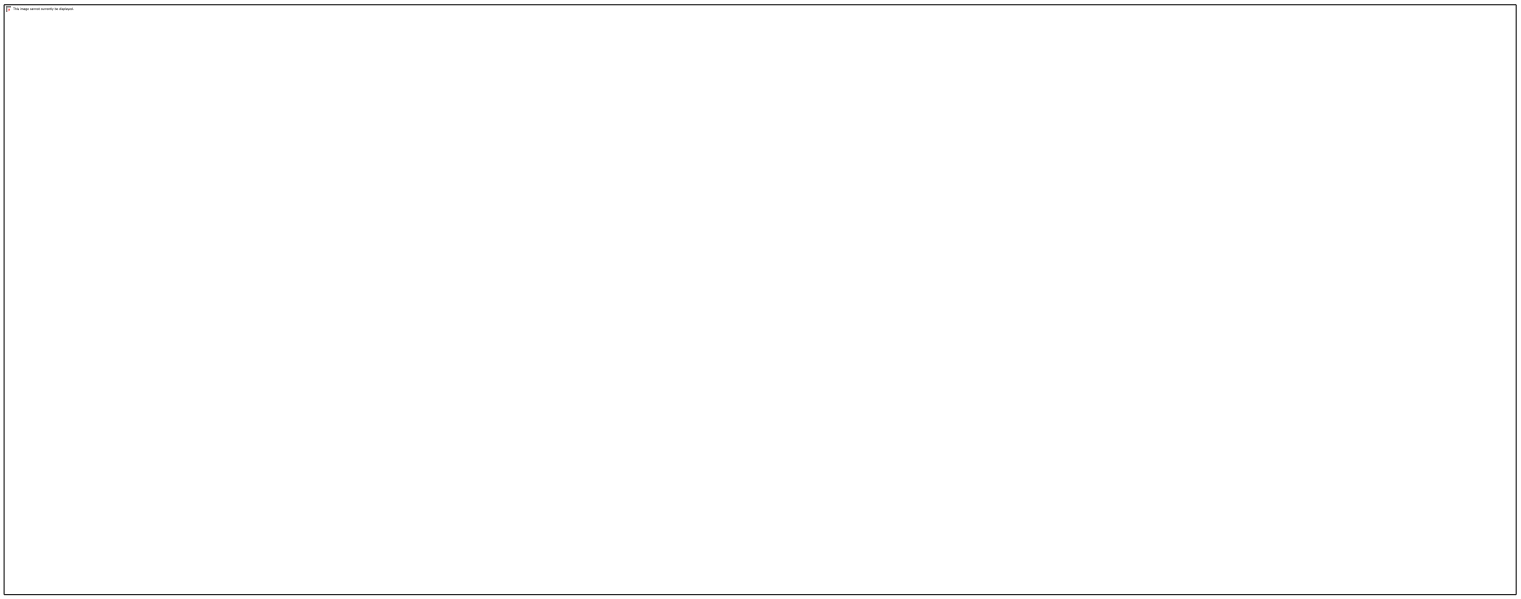
1. Has a small, slender and elongated body.
2. Has a silvery body colour.
3. Has small scales.
4. Has a terminal mouth.
5. Has no barbels.
6. Has a forked tail.
7. Has a relatively large eye in relation to its body size.
8. Has a lateral line characteristic of the species.
9. Has a single dorsal fin.
10. Has a streamlined body suitable for swimming in open water.

Economic importance:

- Provides affordable animal protein.
- Is an important food fish around Lake Victoria.
- Supports small-scale fishing communities.
- Provides raw materials for fish meal production.

- Supports fish drying, transportation and marketing businesses.

E. Tuna



Common name: Yellowfin tuna.

Scientific name: *Thunnus albacares*.

Habitat: Marine waters, including the Indian Ocean along the Kenyan coast.

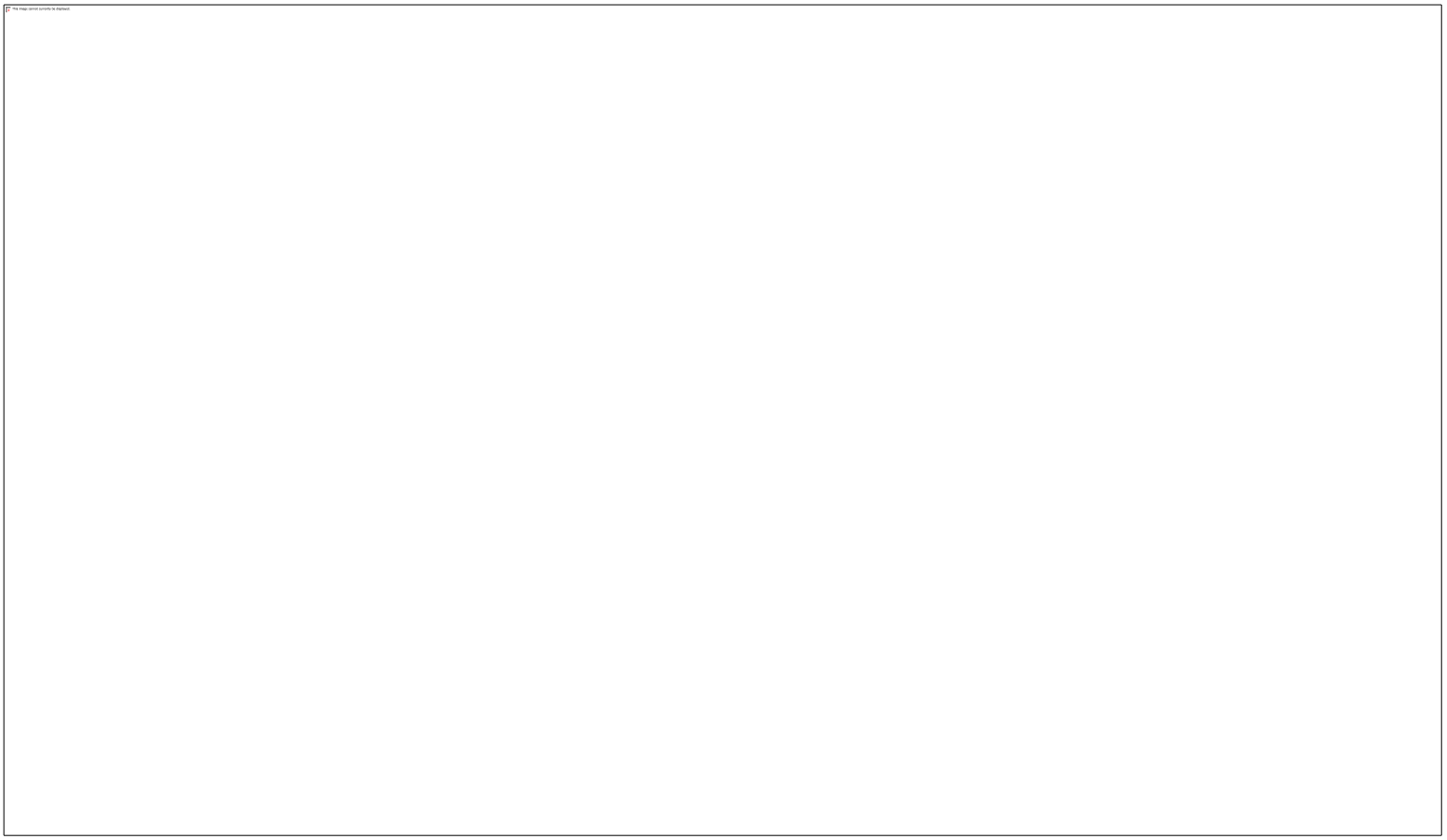
External characteristics:

1. Has a streamlined, spindle-shaped body.
2. Has a pointed head.
3. Has a terminal mouth.
4. Has small scales concentrated mainly around the pectoral region and other limited areas.
5. Has two dorsal fins.
6. Has small finlets behind the second dorsal and anal fins.
7. Has a crescent-shaped tail fin.
8. Has no barbels.
9. Has a continuous lateral line.
10. Has a dark metallic upper surface and a silvery lower surface.
11. Has long yellow dorsal and anal fins in mature yellowfin tuna.

Economic importance:

- Supports marine commercial fisheries.
- Provides high-value seafood.
- Supports employment in fishing and processing.
- Contributes to international fish trade.
- Supports the coastal economy.

F. Rabbitfish



Common name: Rabbitfish.

Scientific name: *Siganus sutor* (a rabbitfish species found in the Western Indian Ocean).

Habitat: Marine coastal waters, coral reefs, lagoons and seagrass beds.

External characteristics:

1. Has an oval and laterally compressed body.
2. Has a small mouth.
3. Has small scales.
4. Has a continuous lateral line.
5. Has a single dorsal fin with spiny and soft portions.
6. Has strong spines on some fins.
7. Has paired pectoral and pelvic fins.
8. Has a homocercal tail.
9. Has no barbels.
10. Has variable body colour, often with spots or mottled patterns.

Economic importance:

- Provides food to coastal communities.
- Supports artisanal fisheries.
- Contributes to local fish markets.
- Helps maintain ecological balance through feeding on algae and other plant material.

1.1.5 Summary comparison of common fish species

Feature	Tilapia	Nile perch	Catfish	Omena	Tuna	Rabbitfish
Habitat	Freshwater	Freshwater	Freshwater	Freshwater	Marine	Marine
Body shape	Compressed	Elongated	Cylindrical	Slender	Streamlined	Compressed
Scales	Cycloid	Ctenoid	Absent	Small	Small/reduced	Small
Barbels	Absent	Absent	Present	Absent	Absent	Absent
Mouth	Terminal	Large terminal	Terminal	Terminal	Terminal	Small terminal
Tail	Homocercal	Homocercal	Rounded/truncate	Forked	Crescent-shaped	Homocercal
Lateral line	Interrupted	Continuous	Not a typical prominent continuous line	Present	Continuous	Continuous

Important learning point: External characteristics may vary with age, sex, breeding condition and species. A learner should use several characteristics together rather than relying on only one feature to identify a fish.

1.1.6 Practical methods of identifying fish species

Fish identification can be conducted through direct observation, examination of preserved specimens, photographs and the use of identification guides.

Materials required

- Fresh fish specimens from a fish landing site or fish farm.
- Fish identification charts.
- Hand lens.
- Measuring ruler.
- Gloves.
- Notebook.
- Camera or mobile phone.
- Identification keys.
- Labels and specimen trays.

Procedure for identifying fish

1. Obtain fish specimens from a recognised fish landing site, fish farm or authorised source.
2. Observe the overall body shape.
3. Examine the body covering and identify whether scales are present.
4. Observe the type of scales where possible.
5. Count and examine the fins.
6. Identify the position and shape of the mouth.
7. Check for the presence or absence of barbels.
8. Examine the lateral line.
9. Observe the shape of the tail fin.

10. Compare the observations with fish identification charts.
11. Determine the likely common and scientific names.
12. Record the findings in a table.

Sample fish identification record

Feature observed	Specimen A	Specimen B
Body shape	Deep and compressed	Elongated
Scales	Present	Absent
Barbels	Absent	Present
Mouth	Terminal	Terminal
Tail	Homocercal	Rounded
Likely identification	Tilapia	African catfish

Safety precautions during fish identification

1. Wear protective gloves when handling fish.
2. Handle fish carefully to avoid injury from sharp spines.
3. Avoid touching poisonous or unfamiliar marine organisms with bare hands.
4. Wash hands and equipment after handling specimens.
5. Use clean tools to avoid contamination.
6. Do not handle decomposing fish.
7. Obtain specimens legally and avoid unnecessary killing of fish.
8. Dispose of specimen waste safely.

1.1.7 Fish diversity and its importance in Kenya

Meaning of fish diversity

Fish diversity refers to the variety of fish species found in a particular aquatic environment or geographical region.

Kenya has fish diversity in freshwater lakes, rivers, dams, wetlands, estuaries, coral reefs and the Indian Ocean.

Importance of fish diversity

1. Food security

- Fish provide proteins, vitamins and minerals.
- They contribute to a balanced diet.
- Omena, tilapia, tuna and Nile perch are important food sources.

2. Employment creation

- Fishing provides jobs for fishermen.
- Fish farming creates employment.
- Fish processing and transportation support livelihoods.
- Fish traders earn income from selling fish.

3. Economic development

- Fish exports generate foreign exchange.
- Fisheries contribute to national economic activities.
- Fish markets stimulate local businesses.

4. Ecological balance

- Fish help regulate aquatic food chains.
- Predatory fish control populations of smaller organisms.
- Herbivorous fish control excessive growth of aquatic vegetation and algae.

5. Tourism development

- Sport fishing attracts tourists.
- Coral reef fish support marine tourism.
- Aquatic biodiversity attracts researchers and nature enthusiasts.

6. Scientific research

- Fish provide opportunities for research on aquatic ecosystems.
- They help scientists understand environmental changes.
- Fish populations can be used to monitor aquatic ecosystem health.

1.1.8 Threats to fish diversity in Kenya

Fish diversity is threatened by several human activities and environmental changes.

Major threats

1. Overfishing

- Occurs when fish are harvested faster than they can reproduce.
- Reduces fish populations.
- May lead to the disappearance of commercially important species.

2. Water pollution

- Industrial waste, sewage and agricultural chemicals contaminate water.
- Some pollutants poison fish.
- Excess nutrients may cause algal blooms and oxygen depletion.

3. Destruction of aquatic habitats

- Destruction of wetlands, mangroves and seagrass beds reduces fish breeding and nursery grounds.
- Removal of aquatic vegetation destroys shelter and feeding areas.

4. Illegal fishing methods

- Use of prohibited fishing gear catches immature fish.
- Destructive fishing methods damage aquatic habitats.
- Unregulated fishing threatens the sustainability of fish populations.

5. Climate change

- Changes in water temperature affect fish distribution.
- Changes in rainfall affect freshwater habitats.
- Ocean warming can affect coral reef ecosystems.

6. Invasive species

- Introduced species may compete with native fish for food and habitat.
- Some invasive species prey on native fish.
- They may disrupt aquatic food chains.

Conservation of fish diversity

Fish diversity can be conserved through:

1. Enforcing fisheries laws and regulations.
2. Preventing illegal fishing.
3. Establishing and managing protected aquatic areas.
4. Promoting responsible fishing practices.
5. Protecting breeding and nursery grounds.
6. Controlling water pollution.
7. Restoring mangroves and wetlands.
8. Promoting sustainable aquaculture.
9. Educating fishing communities about conservation.
10. Monitoring fish populations and biodiversity.

1.1.9 Application of fish taxonomy in marine technology

Knowledge of fish taxonomy is useful in several marine technology and fisheries activities.

1. **Fishing operations:** Helps fishermen identify target species and avoid catching unwanted species.
2. **Fish processing:** Helps processors separate fish species according to market requirements.
3. **Fish marketing:** Enables traders to use correct fish names when selling fish.
4. **Aquaculture:** Helps fish farmers select appropriate species for breeding and production.
5. **Marine research:** Supports studies on fish distribution, population and biodiversity.
6. **Fisheries management:** Enables authorities to monitor commercially important and threatened species.
7. **Fish conservation:** Helps identify rare, endangered and invasive fish species.
8. **Quality control:** Supports accurate labelling of fish products.
9. **Marine navigation and fieldwork:** Helps learners and fisheries personnel record observations accurately during aquatic surveys.
10. **International trade:** Ensures fish products are identified correctly in export documentation.

1.1.10 Key terms and definitions

Term	Meaning
Fish taxonomy	Science of identifying, naming and classifying fish
Identification	Recognising a fish species using its characteristics
Nomenclature	System of naming organisms
Binomial nomenclature	Scientific naming system using two names
Genus	A classification group containing closely related species
Species	A basic classification unit
Barbels	Whisker-like sensory structures around the mouth
Lateral line	Sensory system that detects water movement and vibrations
Dorsal fin	Fin found on the upper side of a fish
Caudal fin	Tail fin
Pectoral fins	Paired fins located behind the gill region
Pelvic fins	Paired fins found on the lower part of the body
Cycloid scales	Smooth, rounded overlapping scales
Ctenoid scales	Scales with comb-like projections
Placoid scales	Tooth-like scales found in sharks and rays
Ganoid scales	Hard, shiny, usually diamond-shaped scales
Fish diversity	Variety of fish species in an aquatic environment
Aquaculture	Farming of aquatic organisms under controlled conditions

1.1.11 Summary of the sub-strand

By studying fish taxonomy, learners should understand that:

- Fish taxonomy involves identification, naming, description and classification.
- Fish are identified using external characteristics such as body shape, scales, fins, mouth, barbels and lateral line.
- Fish have local, common and scientific names.
- Scientific names follow binomial nomenclature.
- Fish occur in freshwater and marine environments.
- Kenya has diverse fish species of economic and ecological importance.
- Fish diversity supports food security, employment, tourism and ecosystem stability.
- Sustainable fisheries practices are necessary for conserving fish biodiversity.

REVISION EXERCISES

STRAND 1.0: MARINE ECOSYSTEMS AND RESOURCES

SUB-STRAND 1.1: FISH TAXONOMY

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions by selecting the correct answer from the alternatives A, B, C or D. Each question carries 1 mark.

1. The branch of biology concerned with identifying, naming and classifying fish is known as:

A. Fish ecology
B. Fish taxonomy
C. Fish physiology
D. Fish nutrition

2. Which of the following is the scientific name of Nile tilapia?

A. Lates niloticus
B. Clarias gariepinus
C. Oreochromis niloticus
D. Rastrineobola argentea

3. The scientific naming system that uses two names to identify an organism is called:

A. Classification
B. Binomial nomenclature
C. Identification
D. Ecological naming

4. Which part of a scientific name begins with a capital letter?

A. Specific epithet
B. Family name
C. Genus name
D. Order name

5. Which of the following fish is commonly known as Omena in Kenya?

A. Lates niloticus
B. Rastrineobola argentea
C. Clarias gariepinus
D. Thunnus albacares

6. Which external structure enables fish to detect vibrations and movements in water?

A. Dorsal fin
B. Lateral line
C. Caudal fin
D. Operculum

7. The whisker-like structures found around the mouth of catfish are known as:

A. Scales
B. Barbels
C. Opercula
D. Finlets

8. Which type of fish scales is characterised by smooth, rounded edges?

A. Placoid scales
B. Ganoid scales
C. Cycloid scales
D. Ctenoid scales

9. Which group of fish possesses placoid scales?

A. Tilapia
B. Tuna
C. Sharks
D. Omena

10. Which fin is mainly responsible for propulsion in most fish?

A. Pelvic fin
B. Caudal fin
C. Anal fin
D. Pectoral fin

11. Which of the following is a marine fish found in the Indian Ocean?

A. Nile perch
B. African catfish
C. Yellowfin tuna
D. Omena

12. What is the scientific name of the African sharptooth catfish?

A. Clarias gariepinus
B. Oreochromis niloticus
C. Cyprinus carpio
D. Lates niloticus

13. Which external characteristic distinguishes African catfish from tilapia?

A. Presence of a mouth
B. Presence of gills
C. Presence of barbels
D. Presence of a tail fin

14. Fish whose bodies are flattened from side to side are described as:

A. Cylindrical
B. Laterally compressed
C. Dorsoventrally flattened
D. Streamlined

15. Which of the following fish has an elongated, streamlined body adapted for fast swimming?

A. Tuna
B. Ray
C. Tilapia
D. African catfish

16. The fin located on the upper surface of a fish's body is called the:

A. Anal fin
B. Pelvic fin
C. Dorsal fin
D. Pectoral fin

17. Which of the following is a characteristic of bony fish?

A. Skeleton made mainly of cartilage
B. Skeleton made mainly of bone
C. Absence of paired fins
D. Presence of only one gill opening

18. Which of the following is an example of a cartilaginous fish?

A. Nile perch
B. Tilapia
C. Shark
D. Tuna

19. Which of the following fish has a crescent-shaped tail?

A. Yellowfin tuna
B. African catfish
C. Omena
D. Tilapia

20. What is the scientific name of Nile perch?

A. Oreochromis niloticus
B. Lates niloticus
C. Thunnus albacares
D. Siganus sutor

21. Which of the following is an example of a local fish name commonly used in Kenya?

A. Clarias gariepinus
B. Omena
C. Thunnus albacares
D. Oreochromis niloticus

22. What is the main function of pectoral fins in fish?

A. Digestion
B. Steering and maintaining balance
C. Reproduction
D. Respiration

23. A fish whose mouth is located on the lower side of its head is described as having a:

A. Superior mouth
B. Terminal mouth
C. Inferior mouth
D. Protruding mouth

24. Which of the following fish has smooth skin without ordinary overlapping scales?

A. African catfish
B. Nile tilapia
C. Tuna
D. Rabbitfish

25. Which of the following classification levels is more specific than family?

A. Kingdom
B. Phylum
C. Order
D. Genus

26. A shark has an upper tail lobe that is generally larger than the lower lobe. This type of tail is called:

A. Homocercal
B. Heterocercal
C. Diphycercal
D. Rounded

27. Which of the following is an economic importance of fish diversity?

A. Increasing water pollution
B. Destroying aquatic habitats
C. Creating employment opportunities
D. Encouraging illegal fishing

28. Which of the following human activities threatens fish diversity?

A. Establishing fish breeding areas
B. Controlling water pollution
C. Overfishing
D. Protecting wetlands

29. Which of the following shows the correct scientific writing of Nile tilapia?

A. oreochromis Niloticus
B. OREOCHROMIS NILOTICUS
C. Oreochromis niloticus
D. oreochromis niloticus

30. A learner observes a fish with an elongated body, smooth scaleless skin and several pairs of barbels around its mouth. Which fish is most likely being observed?

A. Nile tilapia
B. African sharptooth catfish
C. Yellowfin tuna
D. Rabbitfish

SECTION B: 50 MARKS

STRUCTURED QUESTIONS

Answer all questions in this section. Show your understanding using relevant examples from Kenyan aquatic environments.

QUESTION 1: Introduction to fish taxonomy (8 marks)

a) Define the term fish taxonomy. (2 marks)

b) State four reasons why fish taxonomy is important in fisheries and marine technology. (4 marks)

c) Identify two major aquatic environments where fish are found in Kenya. (2 marks)

QUESTION 2: Fish nomenclature (8 marks)

a) Explain the meaning of fish nomenclature. (2 marks)

b) State three rules followed when writing scientific names of fish. (3 marks)

c) Give the scientific names of the following fish:

i) Nile tilapia. (1 mark)

ii) African sharptooth catfish. (1 mark)

iii) Nile perch. (1 mark)

QUESTION 3: External features of fish (8 marks)

a) Identify four external features used in the identification of fish species. (4 marks)

b) Explain two functions of the lateral line in fish. (2 marks)

c) State two functions of barbels in fish. (2 marks)

QUESTION 4: Comparison of fish species (8 marks)

a) Name two freshwater fish species commonly found in Kenya. (2 marks)

b) State three external characteristics of African sharptooth catfish. (3 marks)

c) Give three differences between Nile tilapia and yellowfin tuna based on their external characteristics and habitat. (3 marks)

QUESTION 5: Fish scales and fins (9 marks)

a) Name four types of fish scales. (4 marks)

b) State three functions of fish fins. (3 marks)

c) Differentiate between a homocercal tail and a heterocercal tail. (2 marks)

QUESTION 6: Fish diversity and conservation (9 marks)

a) Explain three economic importance of fish diversity in Kenya. (3 marks)

b) Identify three human activities that threaten fish diversity. (3 marks)

c) Suggest three measures that can be used to conserve fish diversity in Kenya. (3 marks)

TEACHER'S MARKING SCHEME –

Section A: Answer key

Question	Answer	Question	Answer
1	B	16	C
2	C	17	B
3	B	18	C
4	C	19	A
5	B	20	B
6	B	21	B
7	B	22	B
8	C	23	C
9	C	24	A
10	B	25	D
11	C	26	B
12	A	27	C
13	C	28	C
14	B	29	C
15	A	30	B

SECTION B

QUESTION 1 (8 marks)

a) Fish taxonomy is the branch of biological science concerned with the identification, naming, description and classification of fish. (2 marks)

b) Importance of fish taxonomy:

- Helps identify different fish species. (1)

- Supports fish conservation and biodiversity management. (1)
- Promotes proper fish farming and species selection. (1)
- Supports fisheries research and documentation. (1)

c) Aquatic environments:

- Freshwater environments. (1)
- Marine environments. (1)

QUESTION 2 (8 marks)

a) Fish nomenclature is the scientific system of assigning recognised names to fish species to enable accurate and universal identification. (2 marks)

b) Rules of scientific naming:

- The genus name begins with a capital letter. (1)
- The specific epithet begins with a small letter. (1)
- Both names are italicised when typed or underlined separately when handwritten. (1)

c) Scientific names:

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

ii) African sharptooth catfish – *Clarias gariepinus*. (1)

iii) Nile perch – *Lates niloticus*. (1)

QUESTION 3 (8 marks)

a) External features:

- Body shape. (1)
- Type of scales. (1)
- Shape and arrangement of fins. (1)
- Mouth position or shape. (1)

Accept other correct features such as barbels, lateral line, tail shape and body colour.

b) Functions of the lateral line:

- Detects vibrations in water. (1)
- Helps fish detect nearby organisms, obstacles or approaching predators. (1)

c) Functions of barbels:

- Help fish locate food. (1)
- Detect chemical substances and other sensory information in the surrounding water. (1)

QUESTION 4 (8 marks)

a) Freshwater fish:

- Nile tilapia. (1)
- Nile perch. (1)

Accept African catfish and Omena.

b) External characteristics of African sharptooth catfish:

- Has an elongated cylindrical body. (1)
- Has smooth skin without ordinary overlapping scales. (1)
- Has several pairs of barbels around the mouth. (1)

Accept other correct external characteristics.

c) Differences between Nile tilapia and yellowfin tuna:

Nile tilapia	Yellowfin tuna
Mainly freshwater fish. (1)	Marine fish. (1)
Has a deep, laterally compressed body.	Has a streamlined body.
Has a broad dorsal fin.	Has two dorsal fins and finlets.
Has a relatively rounded or truncate tail.	Has a crescent-shaped tail.

Award one mark for each valid difference, up to 3 marks.

QUESTION 5 (9 marks)

a) Types of fish scales:

- Cycloid scales. (1)
- Ctenoid scales. (1)
- Ganoid scales. (1)
- Placoid scales. (1)

b) Functions of fish fins:

- Provide propulsion. (1)
- Maintain balance and stability. (1)
- Help in steering and changing direction. (1)

c) Difference:

- Homocercal tail: The upper and lower lobes appear approximately equal in size. (1)
- Heterocercal tail: The upper lobe is larger than the lower lobe, and the vertebral column extends into the upper lobe. (1)

QUESTION 6 (9 marks)

a) Economic importance of fish diversity:

- Provides food and animal protein. (1)

- Creates employment and income. (1)
- Generates foreign exchange through fish exports. (1)

Accept other relevant economic benefits.

b) Threats to fish diversity:

- Overfishing. (1)
- Water pollution. (1)
- Destruction of aquatic habitats. (1)

Accept illegal fishing, climate change and invasive species.

c) Conservation measures:

- Enforcing fisheries regulations. (1)
- Controlling water pollution. (1)
- Protecting fish breeding and nursery grounds. (1)

Accept restoration of wetlands and mangroves, sustainable fishing and public education.

SUB-STRAND 1.2: FISH PHYSIOLOGY

1.0 INTRODUCTION TO FISH PHYSIOLOGY

1.1 Meaning of fish physiology

Fish physiology is the study of how different organs and systems in the body of fish function to sustain life.

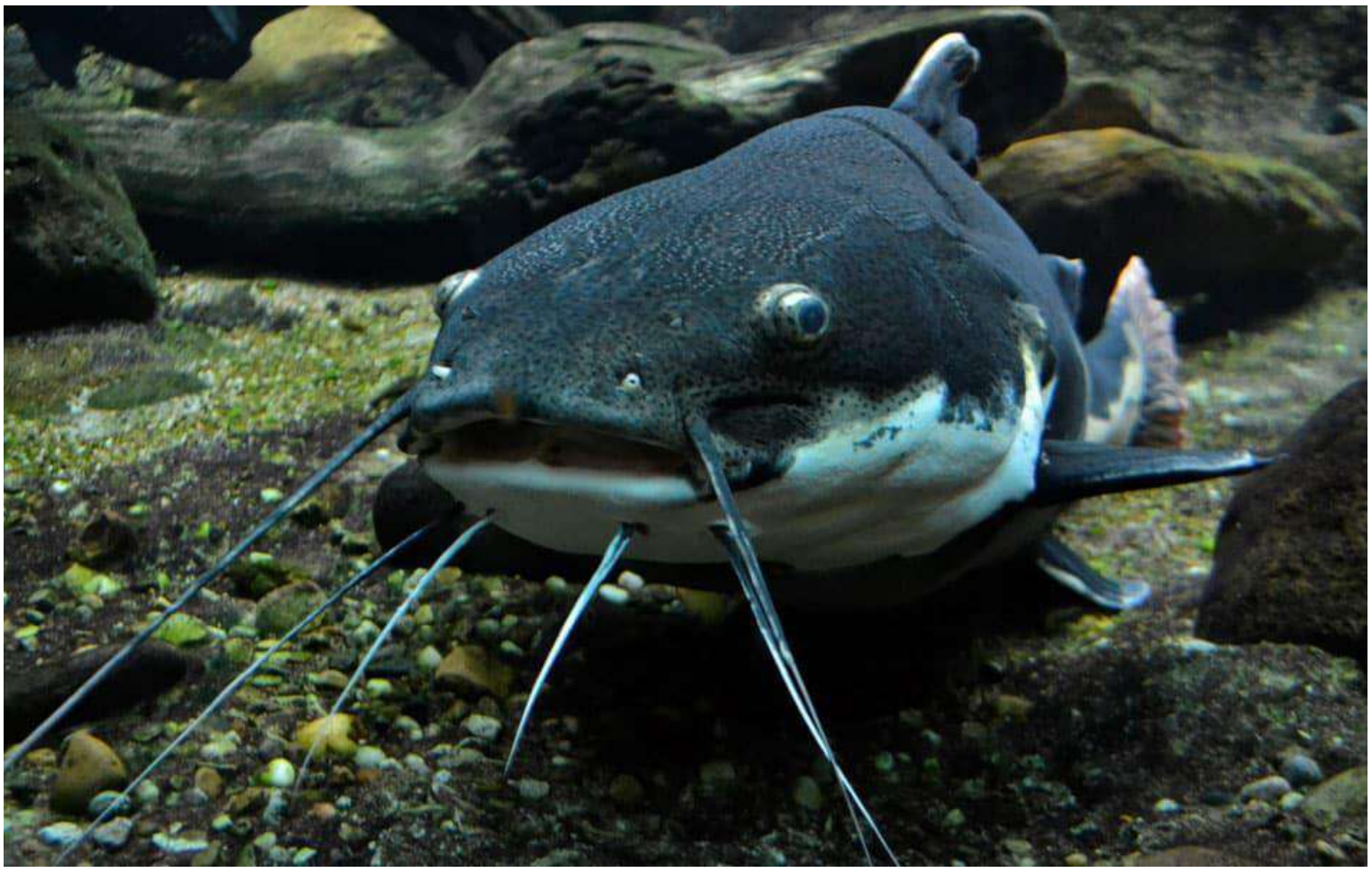
- Fish are aquatic vertebrates adapted to living in freshwater, marine water and brackish water environments.
- Their bodies contain specialised organs that enable them to obtain food, transport nutrients, exchange gases, remove wastes and maintain internal balance.
- Fish physiology explains how the digestive, circulatory and respiratory systems work together to support growth, movement, reproduction and survival.

Examples of fish found in Kenya include:

1. Nile perch (Mbuta).
2. Nile tilapia (Ngege).
3. African catfish (Mumi).
4. Common carp.
5. Rabbitfish.
6. Marlin.
7. Tuna.







1.2 Importance of studying fish physiology

Understanding fish physiology is important in marine technology, fisheries and aquaculture because it helps learners and fish farmers to:

1. Understand how fish obtain and digest food.
2. Select appropriate feeds for different fish species.

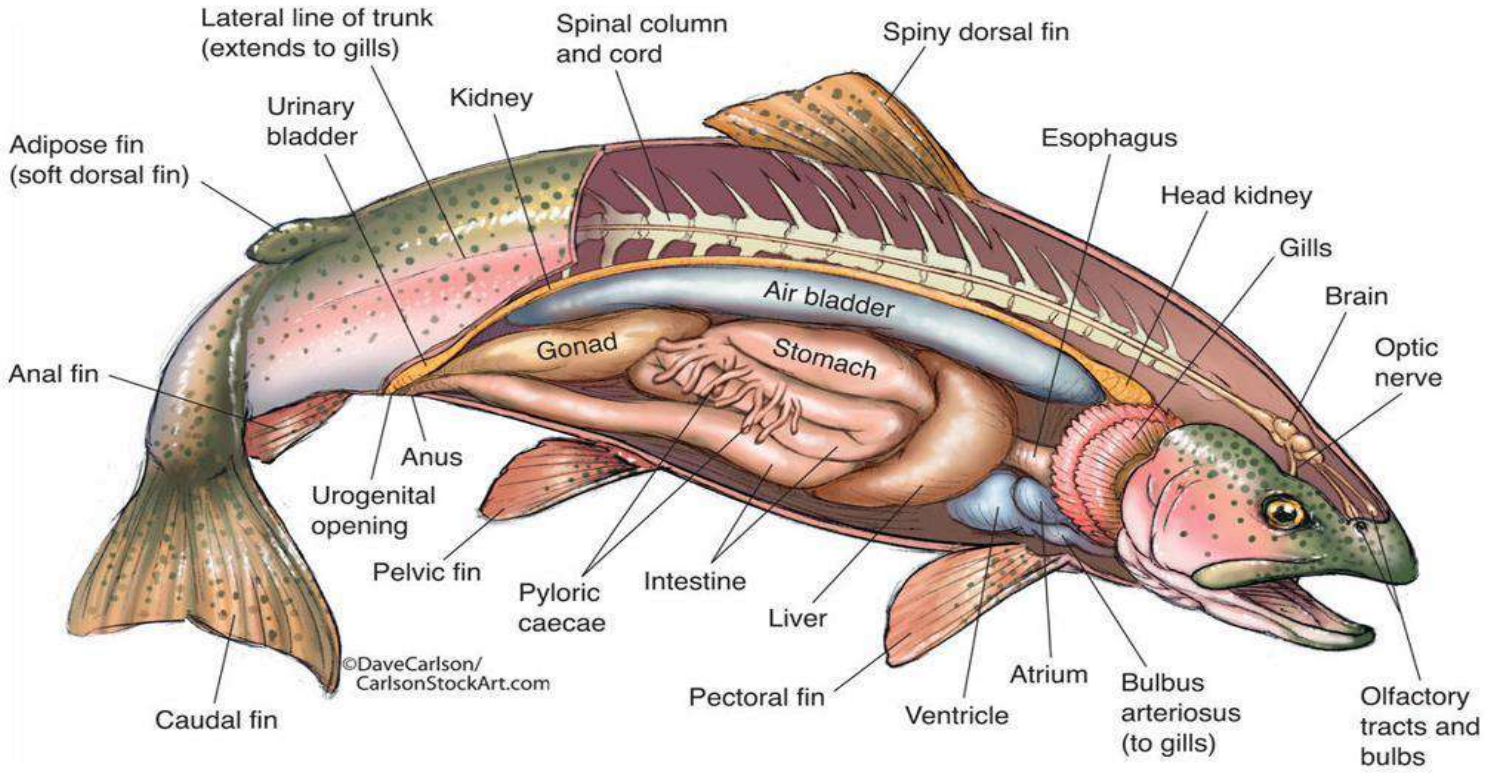
3. Understand how oxygen is absorbed and transported in fish.
4. Maintain suitable water quality in fish ponds and tanks.
5. Identify abnormalities associated with fish organs.
6. Improve fish health and productivity.
7. Understand the effects of pollution on fish.
8. Develop effective fish farming practices.
9. Reduce fish mortality in aquaculture systems.
10. Understand how fish adapt to different aquatic environments.

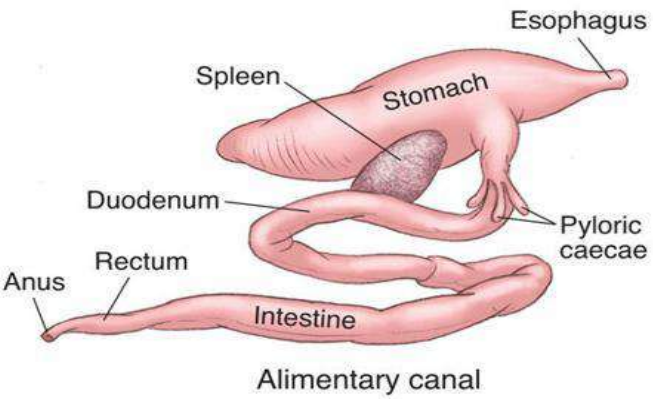
1.3 Major physiological systems in fish

The major physiological systems covered in this sub-strand include:

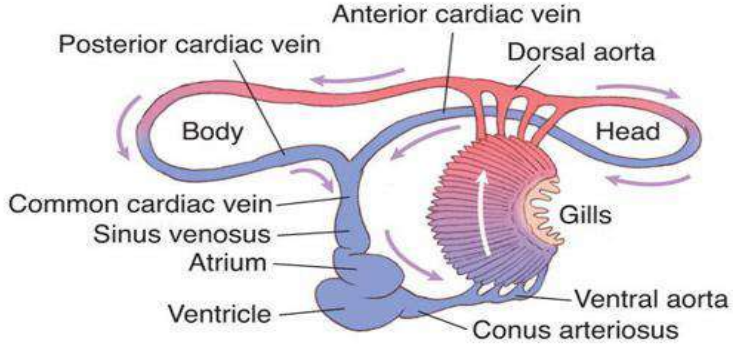
1. **Digestive system** – breaks down food and absorbs nutrients.
2. **Circulatory system** – transports blood, oxygen, nutrients and waste products.
3. **Respiratory system** – takes in dissolved oxygen and removes carbon dioxide.

Other physiological systems include the nervous, excretory, reproductive and muscular systems.





Alimentary canal



Diagrammatic circulatory system

2.0 THE DIGESTIVE SYSTEM IN FISH

2.1 Meaning of the digestive system

The digestive system is a group of organs responsible for taking in food, breaking it down into simpler soluble substances, absorbing nutrients and eliminating undigested materials from the body.

Fish require food to obtain nutrients and energy needed for:

- Growth and development.
- Swimming and movement.
- Repair of damaged tissues.
- Reproduction.
- Maintenance of body functions.
- Production of eggs and sperm.
- Resistance to diseases.

2.2 Feeding habits of fish

Fish have different feeding habits depending on their mouth structures, teeth, digestive organs, habitat and available food.

Fish are generally classified according to their feeding habits as follows:

A. Carnivorous fish

Carnivorous fish are fish that feed mainly on other animals.

Examples:

- Nile perch.
- Tuna.
- Marlin.
- Barracuda.
- Some catfish species.

Characteristics of carnivorous fish:

1. They feed on smaller fish, crustaceans, insects and other aquatic animals.
2. They usually possess strong jaws and sharp teeth for capturing and holding prey.
3. Some have large mouths that enable them to swallow relatively large prey.
4. Their digestive tracts are generally shorter than those of herbivorous fish.
5. They may have expandable stomachs for storing large meals.
6. They possess digestive enzymes that break down proteins and fats.

Example in Kenya: Nile perch in Lake Victoria feeds on smaller fish, including haplochromine cichlids and other suitable prey.



B. Herbivorous fish

Herbivorous fish are fish that feed mainly on plant materials.

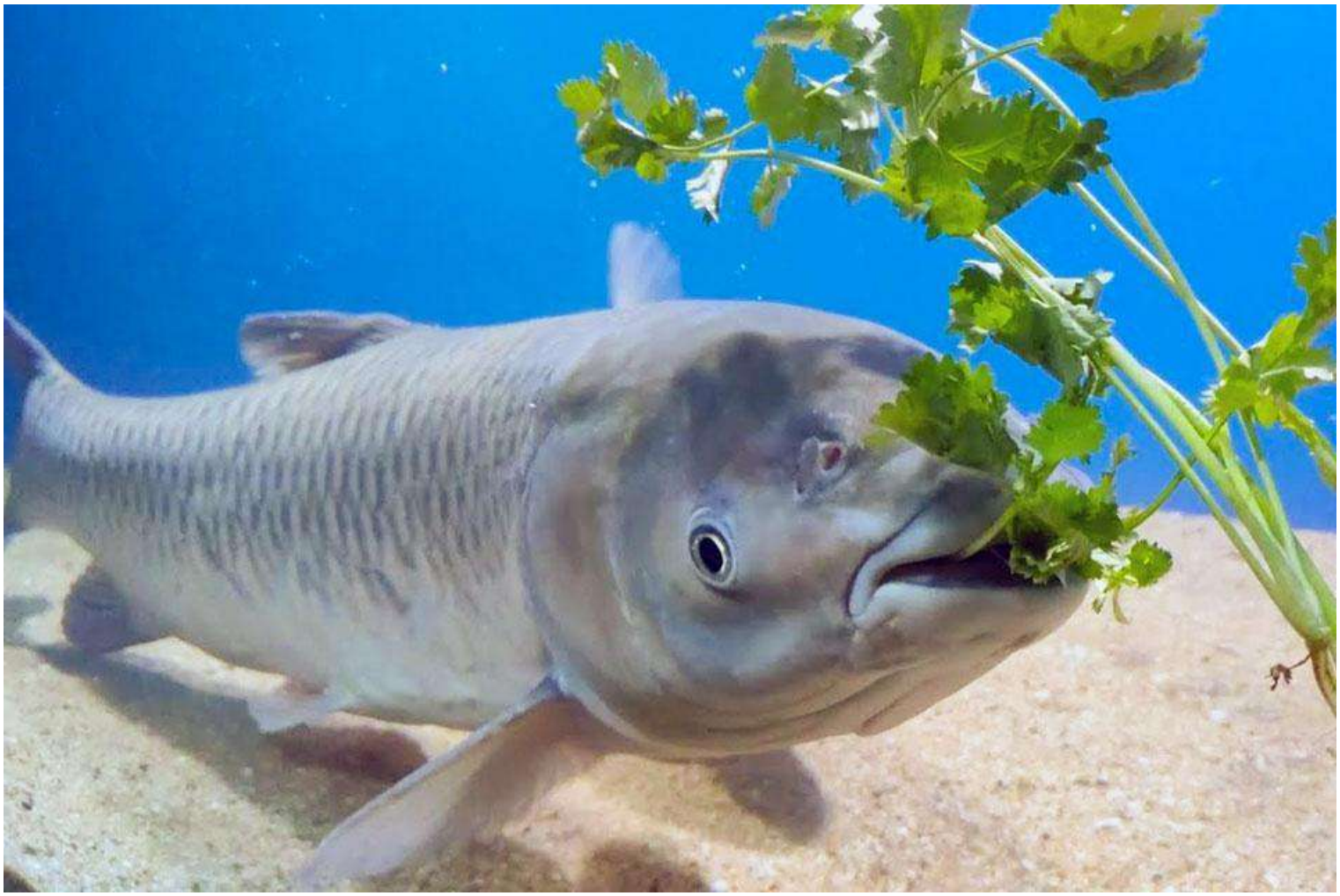
Examples:

- Grass carp.
- Rabbitfish.
- Some tilapia species.

Characteristics of herbivorous fish:

1. They feed on aquatic plants, algae and other plant materials.
2. They may possess specialised teeth for scraping, cutting or crushing vegetation.
3. Their digestive tracts are generally longer to allow sufficient time for processing plant materials.
4. Some have intestinal microorganisms that assist in breaking down plant components.
5. They often feed continuously or frequently because plant materials may contain relatively low concentrations of readily available nutrients.

Example: Grass carp feeds on aquatic vegetation and can be used in the management of excessive aquatic plant growth.



C. Omnivorous fish

Omnivorous fish are fish that feed on both plant and animal materials.

Examples:

- Common carp.
- Nile tilapia.
- Some catfish species.

Characteristics of omnivorous fish:

1. They consume plant materials and animal organisms.
2. Their diets may include algae, seeds, insects, worms, plankton and small aquatic animals.
3. They have feeding structures adapted to handling different types of food.
4. Their digestive systems can process a wide range of food materials.
5. Their feeding habits change depending on food availability and environmental conditions.

Example in Kenya: Nile tilapia can feed on algae, plankton, aquatic plants, insect larvae and other available food materials.



2.3 Comparison of feeding habits

Feeding habit	Main food	Example
Carnivorous	Other animals	Nile perch
Herbivorous	Plant materials	Grass carp
Omnivorous	Plants and animals	Common carp

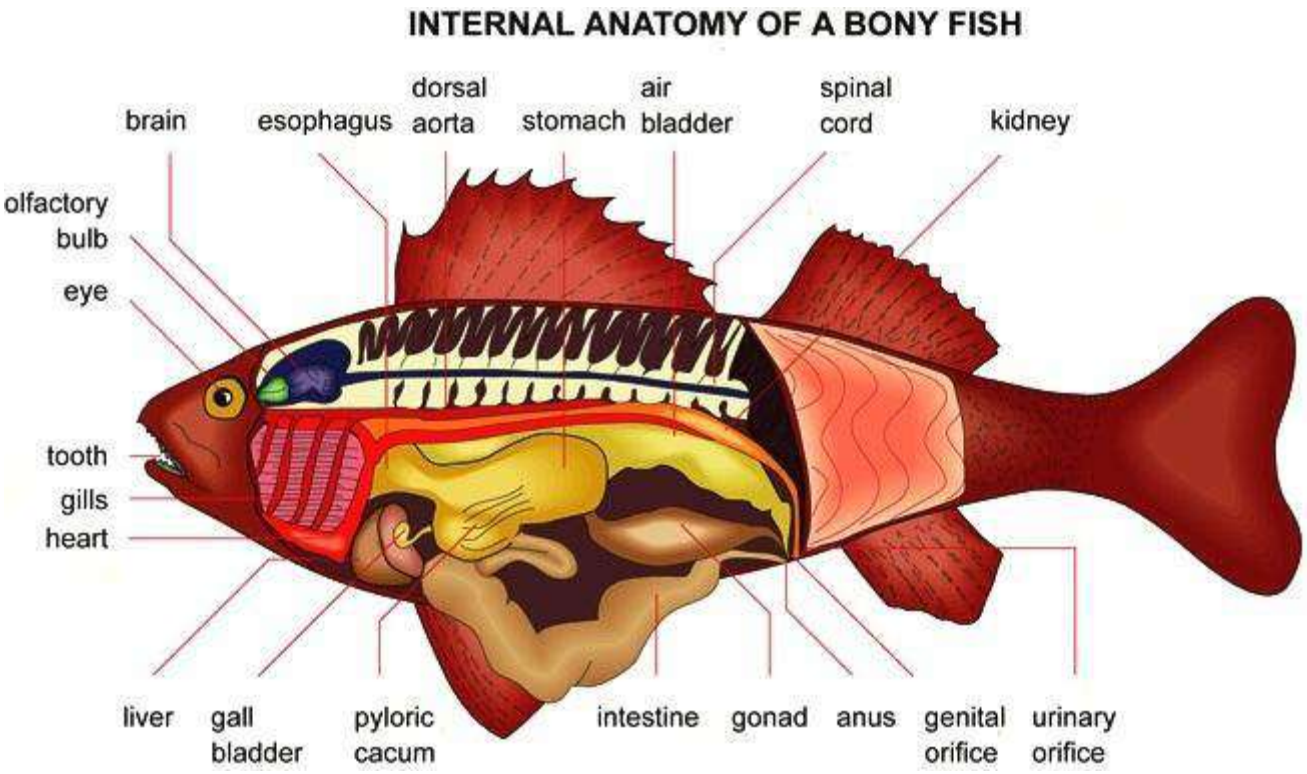
2.4 Adaptation of feeding structures to feeding habits

Different fish possess different feeding structures depending on the type of food they consume.

Structure	Function
Mouth	Takes in food
Teeth	Grasp, tear, scrape or crush food
Jaws	Assist in capturing and processing food
Gill rakers	Filter food particles and prevent large particles from entering the gill filaments
Pharynx	Assists in swallowing food
Tongue	Helps manipulate food in some fish

3.0 PARTS OF THE DIGESTIVE SYSTEM IN BONY FISH

Bony fish, also known as teleost fish, possess a digestive system made up of several organs that work together to process food.



3.1 Main organs of the digestive system

The major organs include:

1. Mouth.
2. Buccal cavity.
3. Pharynx.
4. Oesophagus.
5. Stomach.
6. Pyloric caeca.
7. Intestine.
8. Rectum.
9. Anus.
10. Liver.
11. Gall bladder.
12. Pancreas.

3.2 Functions of the different digestive organs

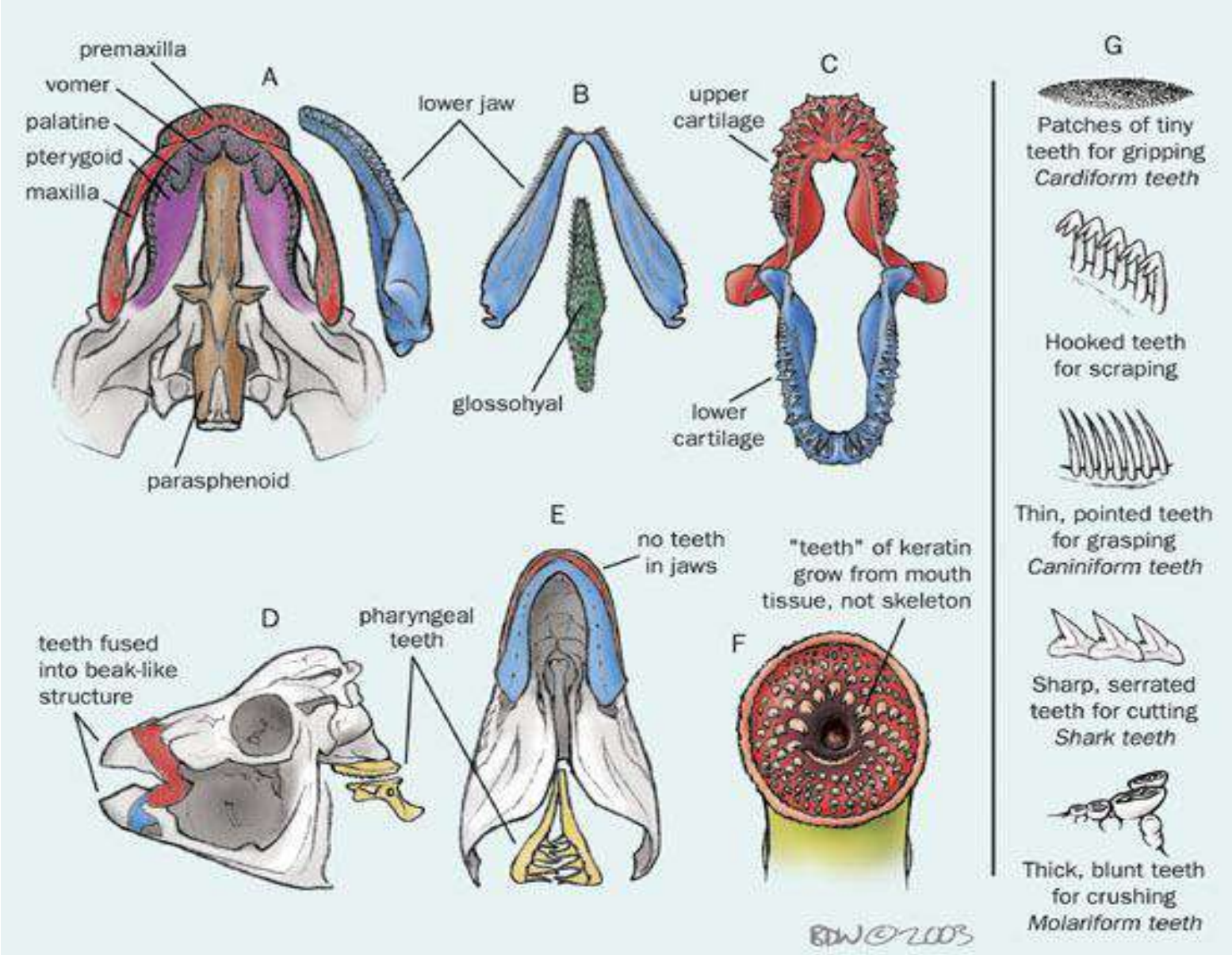
A. Mouth

The mouth is the opening through which food enters the fish's digestive system.

Functions:

1. Takes in food from the aquatic environment.
2. Assists in capturing prey and collecting plant materials.
3. Allows water to enter the buccal cavity during feeding and respiration.
4. Contains teeth in many fish species for gripping, cutting or crushing food.

Adaptation: The position and size of the mouth differ according to feeding habits. For example, a predatory fish may have a large mouth for capturing prey.



B. Buccal cavity

The buccal cavity is the space inside the mouth.

Functions:

1. Receives food entering through the mouth.
2. Holds food temporarily during swallowing.
3. Assists in directing food towards the pharynx.
4. Participates in the movement of water over the gills.

C. Pharynx

The pharynx is the muscular region located behind the buccal cavity.

Functions:

1. Directs food from the mouth towards the oesophagus.
2. Assists in swallowing.
3. Contains structures that may assist in processing food.
4. Separates the food passage from the respiratory pathway.

D. Oesophagus

The oesophagus is a short, muscular tube connecting the pharynx to the stomach.

Functions:

1. Transports swallowed food to the stomach.
2. Uses muscular contractions called *peristalsis* to move food.
3. Allows food to pass into the stomach.
4. Expands in some fish to accommodate relatively large food particles.

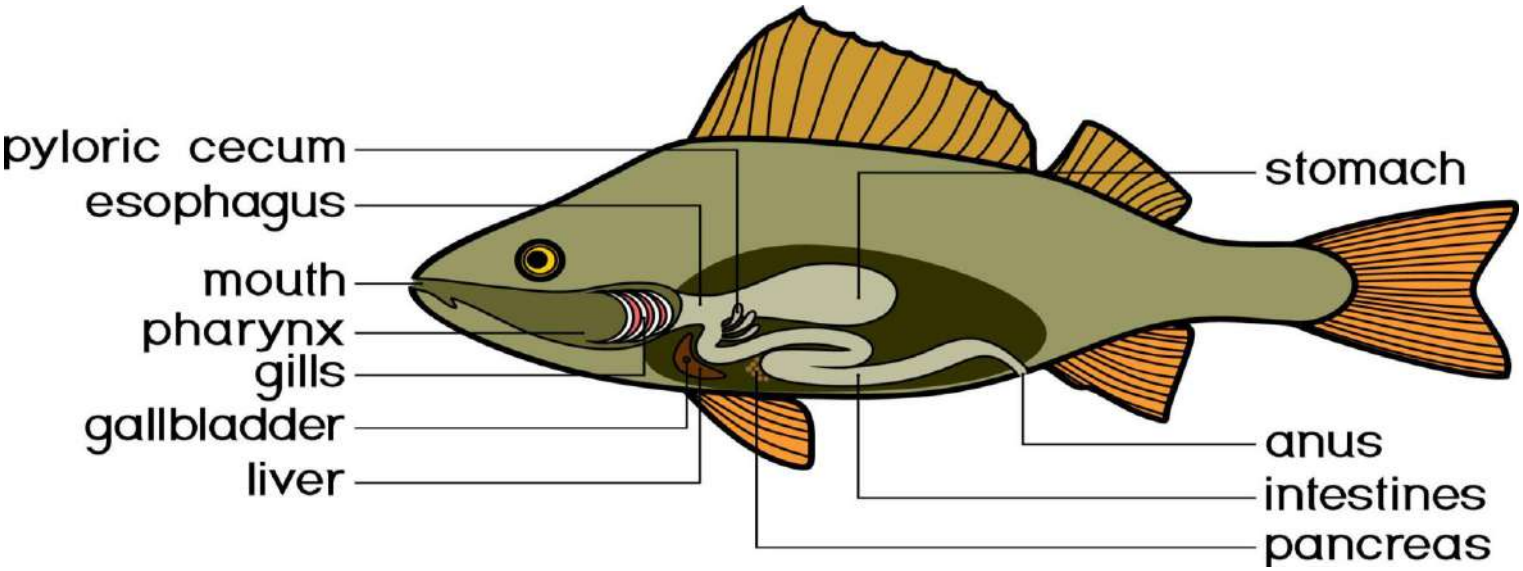
E. Stomach

The stomach is a muscular sac where food is temporarily stored and digestion takes place.

Functions:

1. Stores food after swallowing.
2. Mechanically mixes food through muscular contractions.
3. Produces gastric juice containing hydrochloric acid.
4. Produces enzymes such as pepsin that help digest proteins.
5. Helps destroy some harmful microorganisms ingested with food.
6. Converts food into a semi-liquid mixture called *chyme*.

Important: Not all bony fish possess a well-developed stomach. Some species, such as certain cyprinid fish, lack a true stomach.



F. Pyloric caeca

Pyloric caeca are finger-like projections found near the junction between the stomach and intestine in many bony fish.

Functions:

1. Increase the surface area available for digestion and nutrient absorption.
2. Assist in the secretion of digestive enzymes.
3. Provide additional space for the processing of food.
4. Support efficient nutrient absorption.

Example: Nile perch possesses pyloric caeca.

G. Intestine

The intestine is a long, coiled tube where much of the digestion and absorption of nutrients takes place.

Functions:

1. Completes the digestion of food.
2. Absorbs digested nutrients into the bloodstream.
3. Absorbs water and minerals.
4. Transports undigested food towards the rectum.
5. Supports the action of digestive enzymes.

Adaptations of the intestine:

- It has a large internal surface area for absorption.
- Its lining contains folds that increase the area available for nutrient absorption.
- Its length varies according to the feeding habits of different fish species.
- Herbivorous fish generally have longer intestines than carnivorous fish because plant materials may require more time to process.

H. Rectum

The rectum is the terminal region of the digestive tract before the anus.

Functions:

1. Receives undigested food materials from the intestine.
2. Temporarily holds faecal materials.
3. Assists in removing waste from the digestive system.

I. Anus

The anus is the external opening through which faecal materials are eliminated.

Functions:

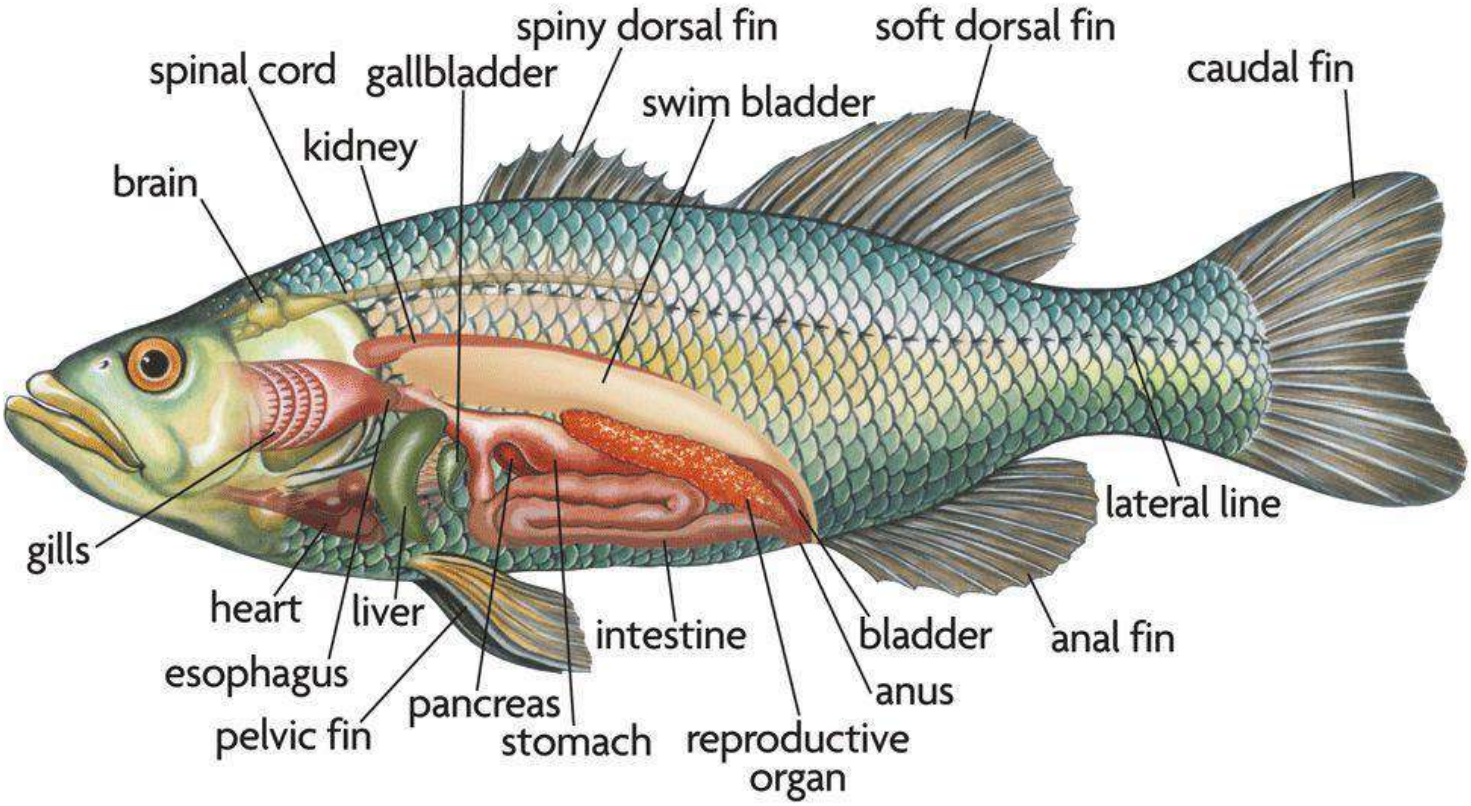
1. Expels undigested food from the body.
2. Completes the digestive process.
3. Prevents the accumulation of faecal waste in the digestive tract.

J. Liver

The liver is a large organ located near the stomach.

Functions:

1. Produces bile that assists in the emulsification of fats.
2. Stores nutrients such as glycogen.
3. Regulates the metabolism of nutrients.
4. Detoxifies harmful substances.
5. Processes absorbed nutrients.
6. Produces important proteins used in body functions.



K. Gall bladder

The gall bladder is a small sac that stores and concentrates bile produced by the liver.

Functions:

1. Stores bile.
2. Concentrates bile by absorbing some water.
3. Releases bile into the digestive tract when needed.
4. Assists in fat digestion through bile action.

Note: Bile is not an enzyme. It breaks large fat droplets into smaller droplets through emulsification, increasing the surface area for lipase action.

L. Pancreas

The pancreas is an organ that produces digestive enzymes and hormones.

Functions:

1. Produces enzymes that digest proteins, carbohydrates and fats.
2. Produces substances that assist in neutralising acidic chyme.
3. Produces insulin, which helps regulate blood glucose.
4. Produces glucagon, which helps increase blood glucose when necessary.

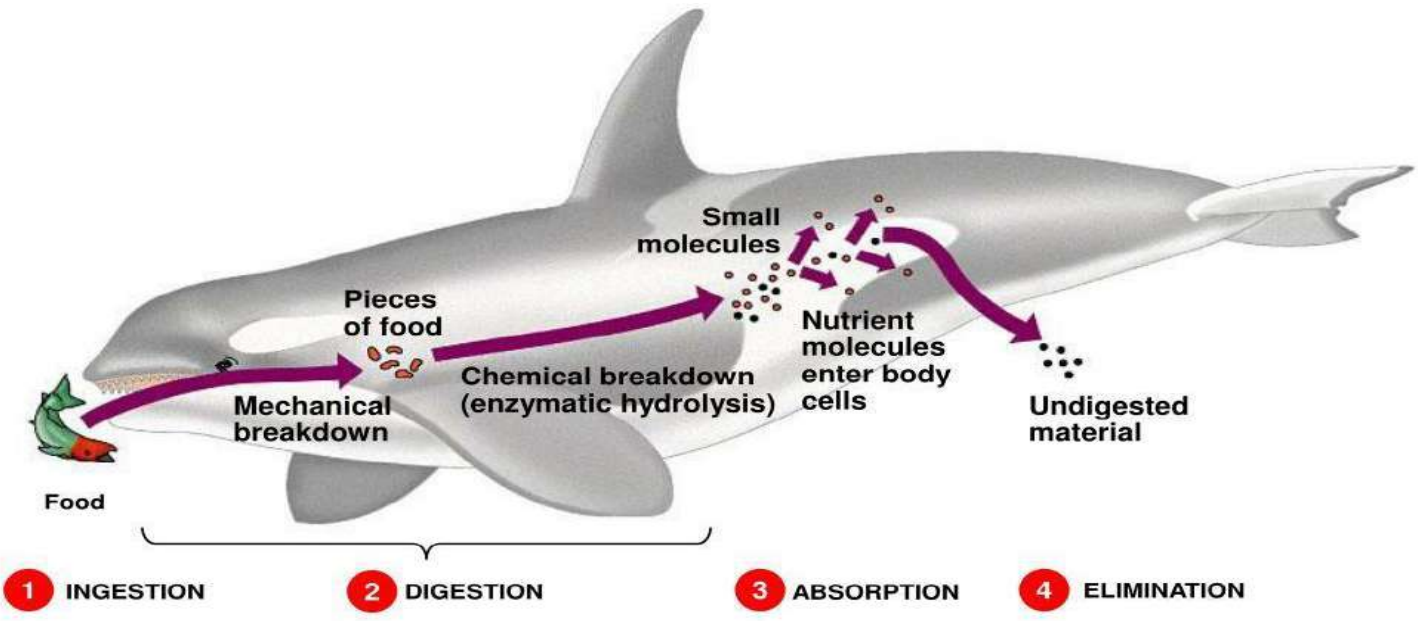
In many fish, pancreatic tissue may occur in scattered areas associated with other organs rather than as one clearly defined organ.

3.3 Summary of digestive organs and their functions

Organ	Main function
Mouth	Ingestion of food
Buccal cavity	Receives and manipulates food
Pharynx	Swallowing
Oesophagus	Transports food
Stomach	Stores and digests food
Pyloric caeca	Increase digestion and absorption capacity
Intestine	Digestion and nutrient absorption
Rectum	Receives and holds faecal material
Anus	Elimination of faeces
Liver	Produces bile and processes nutrients
Gall bladder	Stores bile
Pancreas	Produces digestive enzymes and hormones

3.4 The process of digestion in bony fish

Digestion involves a series of activities that convert complex food substances into simpler substances that can be absorbed and used by the body.



Step 1: Ingestion

- Fish captures and takes food through the mouth.
- Food may consist of plant materials, plankton, insects or smaller fish.

Step 2: Swallowing

- Food passes through the buccal cavity and pharynx.
- Muscular contractions move food into the oesophagus.

Step 3: Movement of food

- The oesophagus transports food into the stomach.
- Peristaltic movements assist in food movement.

Step 4: Digestion in the stomach

- Gastric juice is released.
- Hydrochloric acid creates an acidic environment.
- Pepsin breaks down proteins into smaller peptides.
- Muscular contractions mix food with digestive juices.

Step 5: Digestion in the intestine

- Bile assists in the emulsification of fats.
- Pancreatic and intestinal enzymes break down food substances.
- Proteins are broken into amino acids.
- Carbohydrates are broken into simple sugars.
- Fats are broken into fatty acids and monoglycerides.

Step 6: Absorption

- Digested nutrients pass through the intestinal lining.
- Most water-soluble nutrients enter blood capillaries.
- Many absorbed fats enter the circulatory system through specialised transport pathways.

Step 7: Assimilation

- Absorbed nutrients are transported to body tissues.
- Cells use nutrients for energy, growth and repair.
- Excess nutrients may be stored.

Step 8: Egestion

- Undigested materials move towards the rectum.
- Faeces are eliminated through the anus.

3.5 Digestive enzymes in fish

Digestive enzymes are biological substances that speed up the breakdown of food into simpler substances.

Enzyme	Food acted upon	Products

Amylase	Starch	Simple sugars and smaller carbohydrates
Protease	Proteins	Peptides and amino acids
Lipase	Fats	Fatty acids and monoglycerides
Maltase	Maltose	Glucose
Peptidase	Peptides	Amino acids

Importance of digestive enzymes:

1. Speed up digestion.
2. Help convert complex food into absorbable substances.
3. Support efficient nutrient utilisation.
4. Promote growth and development.
5. Improve the utilisation of feed in aquaculture.

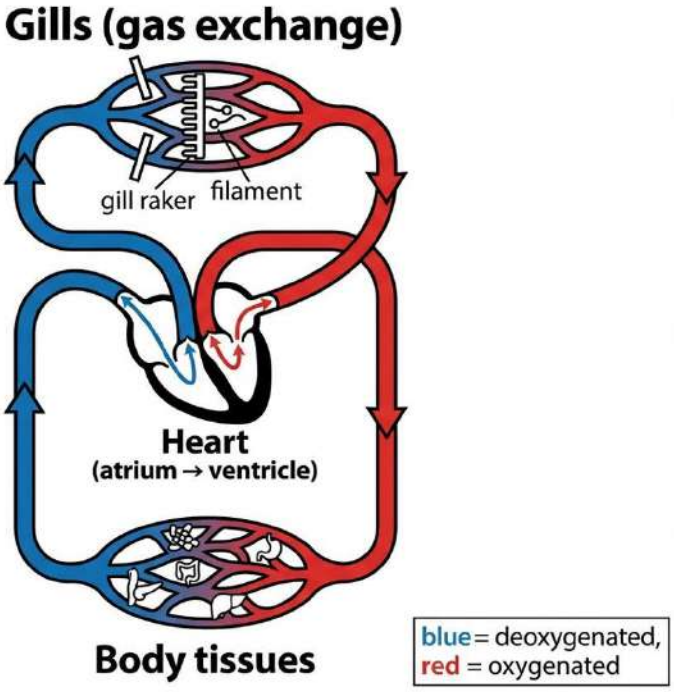
4.0 THE CIRCULATORY SYSTEM IN FISH

4.1 Meaning of the circulatory system

The circulatory system is the body system responsible for transporting blood and dissolved substances to and from different body organs.

In fish, the circulatory system transports:

- Oxygen from the gills to body tissues.
- Carbon dioxide from body tissues to the gills.
- Digested nutrients from the intestine to body tissues.
- Hormones to target organs.
- Metabolic waste products to organs involved in their removal.



4.2 Components of the circulatory system in bony fish

The circulatory system consists of:

1. **Heart** – pumps blood throughout the body.
2. **Blood** – transports gases, nutrients, hormones and waste products.
3. **Blood vessels** – provide pathways through which blood flows.

4.3 The heart of a bony fish

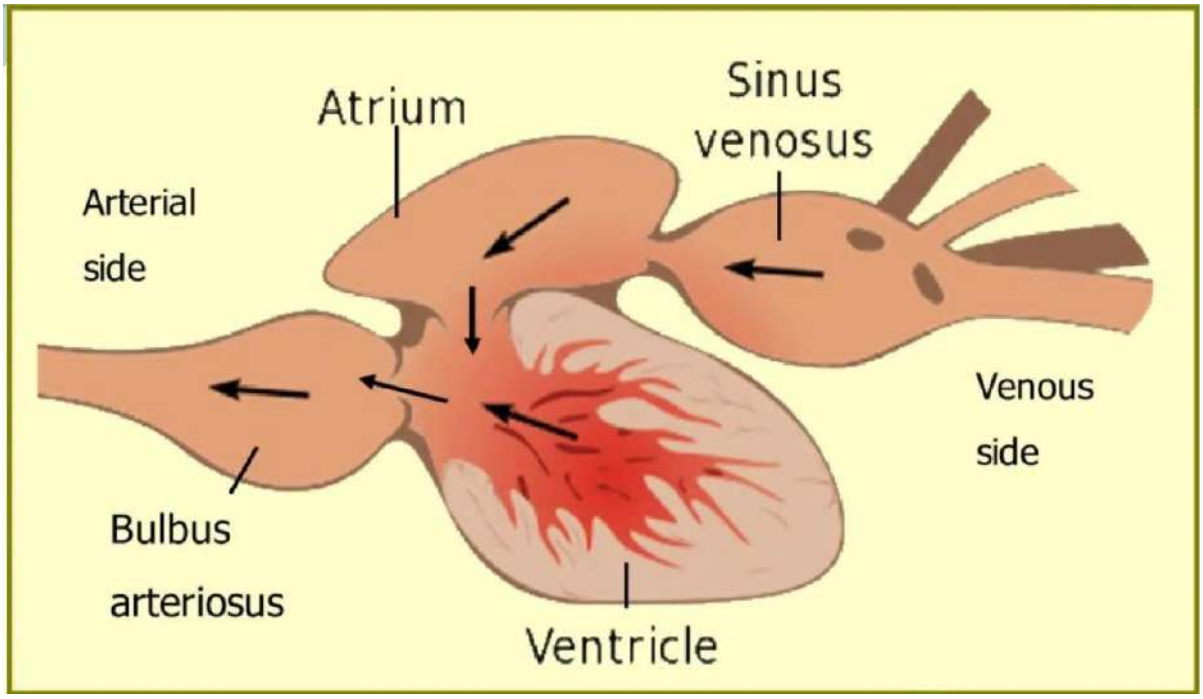
The heart is a muscular organ responsible for pumping blood throughout the body.

Unlike the typical four-chambered heart of mammals, a typical bony fish has a functionally two-chambered heart consisting of:

1. Atrium.
2. Ventricle.

It also has associated structures:

- Sinus venosus.
- Bulbus arteriosus.



A. Sinus venosus

The sinus venosus is a thin-walled chamber that receives deoxygenated blood returning from the body.

Functions:

1. Collects blood from major veins.
2. Directs blood into the atrium.
3. Assists in maintaining the flow of blood through the heart.

B. Atrium

The atrium is a thin-walled muscular chamber located before the ventricle in the direction of blood flow.

Functions:

1. Receives deoxygenated blood from the sinus venosus.

2. Contracts to push blood into the ventricle.
3. Helps maintain continuous blood circulation.

C. Ventricle

The ventricle is a thick-walled muscular chamber of the heart.

Functions:

1. Receives blood from the atrium.
2. Contracts forcefully to pump blood out of the heart.
3. Generates the pressure required to move blood towards the gills.

D. Bulbus arteriosus

The bulbus arteriosus is an elastic structure located after the ventricle in most teleost fish.

Functions:

1. Receives blood from the ventricle.
2. Reduces fluctuations in blood pressure.
3. Helps maintain a relatively smooth flow of blood towards the gills.
4. Protects delicate gill blood vessels from excessive pressure.

4.4 Blood vessels in fish

Blood vessels are tubes through which blood flows.

There are three main types:

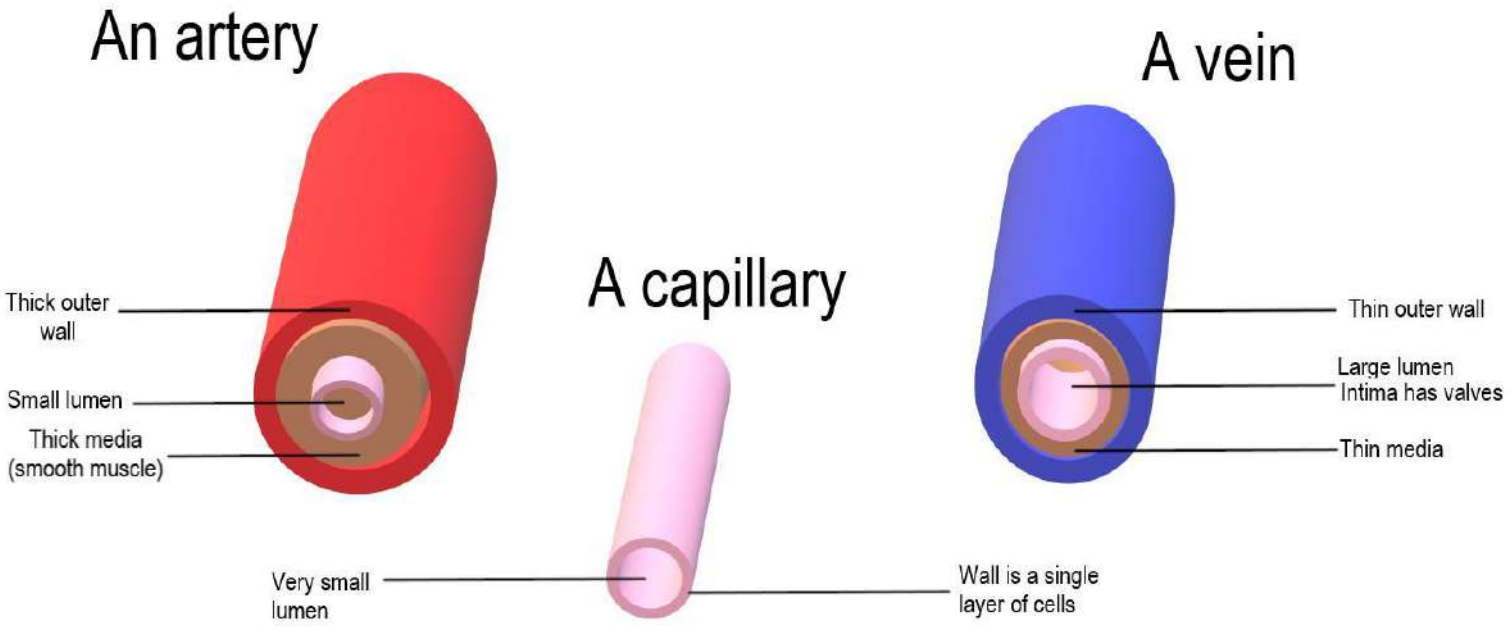
A. Arteries

Arteries are blood vessels that carry blood away from the heart.

Characteristics:

1. They have relatively thick and elastic walls.
2. They withstand relatively high blood pressure.
3. They transport blood away from the heart.
4. They branch into smaller vessels called arterioles.

In fish, the ventral aorta carries deoxygenated blood from the heart towards the gills.



B. Veins

Veins are blood vessels that carry blood towards the heart.

Characteristics:

1. They generally have thinner walls than arteries.
2. They transport blood at relatively low pressure.
3. They return blood from body tissues to the heart.
4. Some possess valves that prevent backward flow.

C. Capillaries

Capillaries are very small blood vessels with extremely thin walls.

Functions:

1. Allow oxygen to diffuse into body tissues.
2. Allow carbon dioxide to enter the blood.
3. Allow nutrients to move between blood and tissues.
4. Facilitate the exchange of waste products.

5.0 TYPES OF BLOOD IN FISH

Blood in fish is commonly described according to its oxygen content.

A. Oxygenated blood

Oxygenated blood is blood containing a relatively high concentration of oxygen.

Characteristics:

- It leaves the gills after gaseous exchange.
- It travels through the dorsal aorta.
- It supplies oxygen to body tissues.

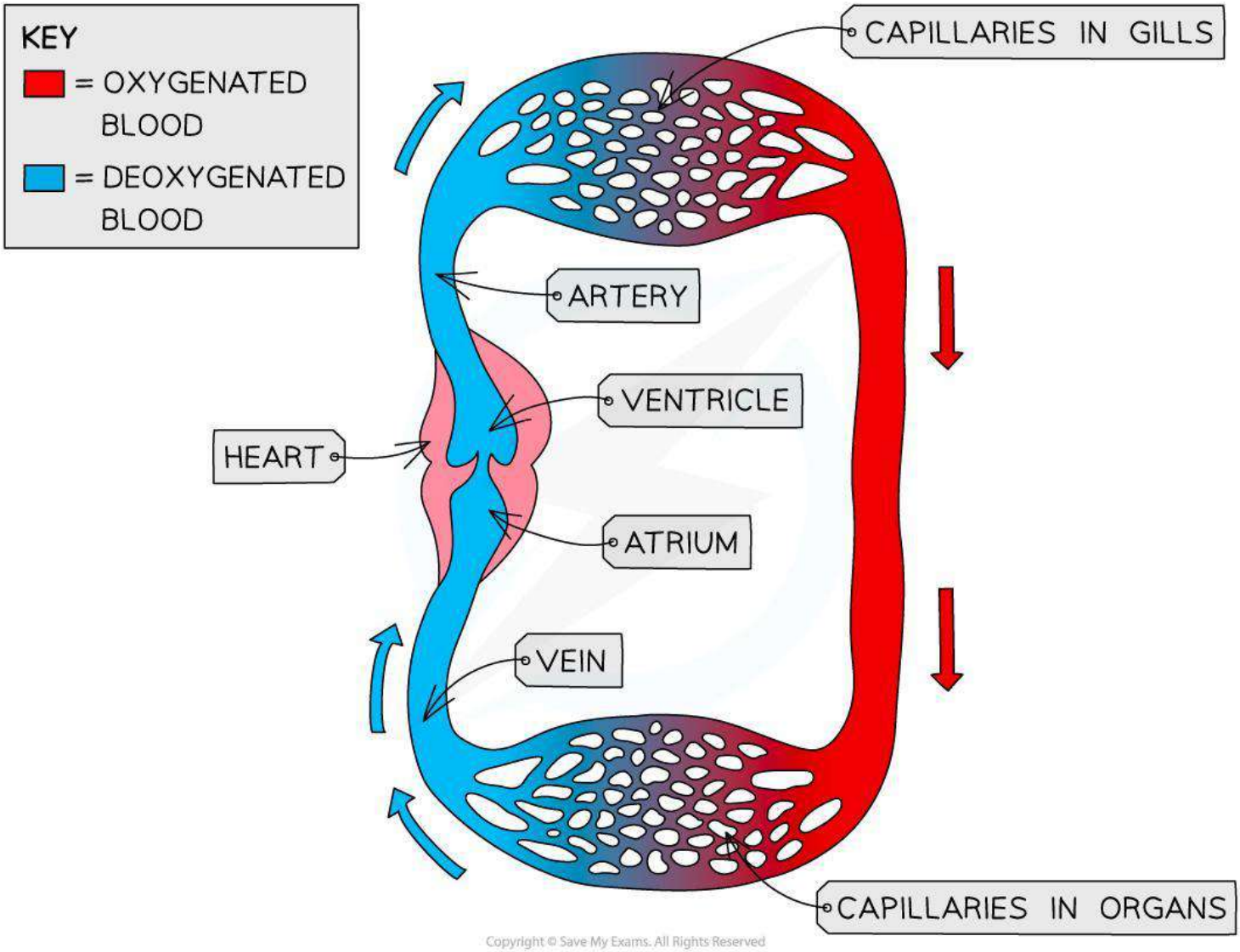
- It returns to the heart after delivering oxygen.

B. Deoxygenated blood

Deoxygenated blood is blood containing relatively little oxygen and a higher concentration of carbon dioxide compared with oxygenated blood.

Characteristics:

- It returns from body tissues through veins.
- It enters the heart through the sinus venosus.
- It is pumped towards the gills.
- It receives oxygen during gaseous exchange.



6.0 THE PROCESS OF BLOOD CIRCULATION IN FISH

6.1 Meaning of single circulation

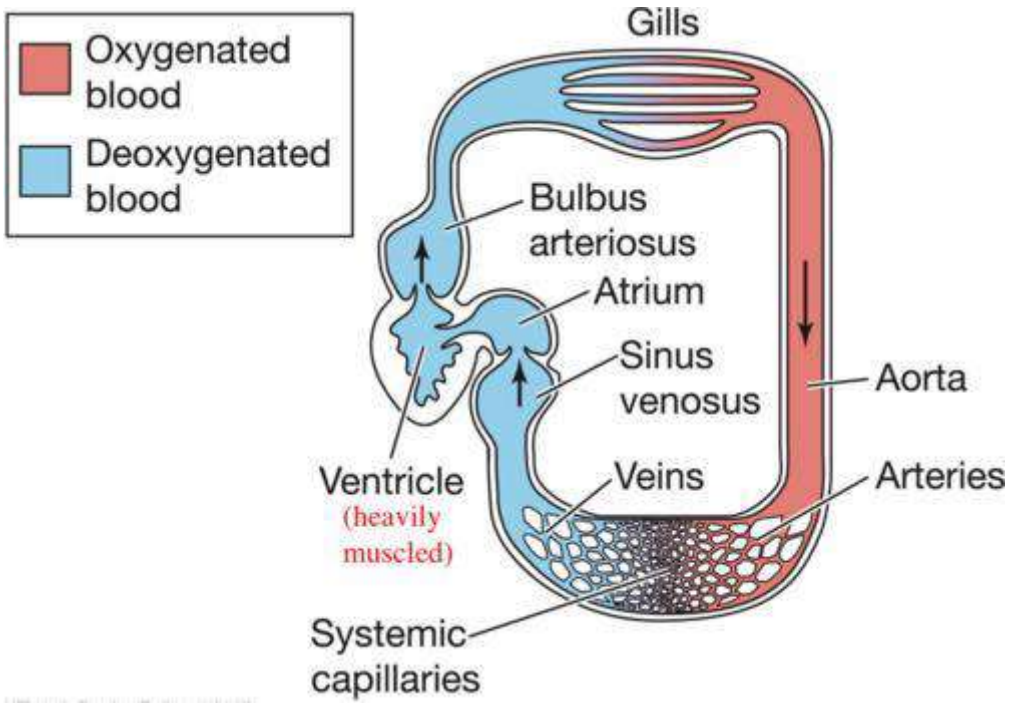
Fish have a single circulatory system, meaning that blood passes through the heart once during one complete circuit of the body.

The circulation takes place in the following sequence:

1. Deoxygenated blood from body tissues enters the veins.
2. Blood flows into the sinus venosus.

3. It enters the atrium.
4. The atrium contracts and pushes blood into the ventricle.
5. The ventricle contracts and pumps blood into the bulbus arteriosus.
6. Blood passes into the ventral aorta.
7. The ventral aorta transports blood to the gills.
8. Blood passes through the gill capillaries, where gaseous exchange takes place.
9. Oxygenated blood leaves the gills.
10. It enters the dorsal aorta through the outgoing gill vessels.
11. The dorsal aorta distributes oxygenated blood to different body tissues.
12. Blood delivers oxygen and nutrients to the tissues.
13. It collects carbon dioxide and other metabolic waste products.
14. Deoxygenated blood returns to the heart through veins.

6.2 Flow of blood in fish



Simplified flow of blood:

Body tissues → Veins → Sinus venosus → Atrium → Ventricle → Bulbus arteriosus → Ventral aorta → Gills → Dorsal aorta → Body tissues.

Explanation of the flow:

- Blood from the body tissues is deoxygenated because it has delivered oxygen to cells.
- Veins return this blood to the heart.
- The heart pumps the blood to the gills.
- At the gills, carbon dioxide is removed and oxygen enters the blood.
- Oxygenated blood is transported to the body tissues.
- The cycle continues continuously.

6.3 Importance of the circulatory system in fish

1. Transports oxygen to body cells.
2. Carries carbon dioxide to the gills for removal.
3. Distributes digested nutrients.
4. Transports hormones.
5. Assists in regulating body temperature in fish that rely mainly on environmental temperature.
6. Transports metabolic waste products.
7. Supports growth and tissue repair.
8. Helps maintain internal balance.

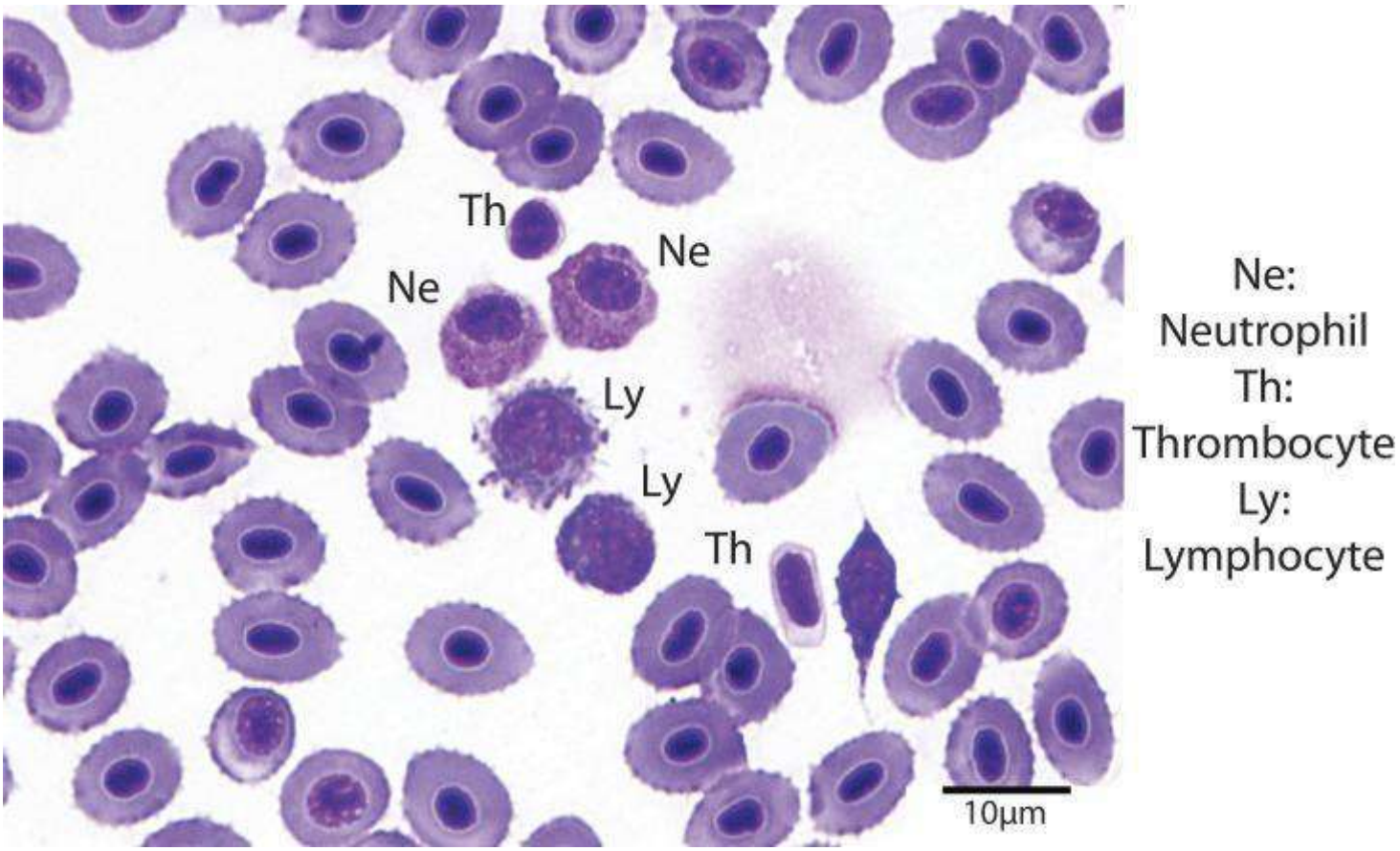
7.0 BLOOD IN FISH

7.1 Meaning of blood

Blood is a specialised fluid connective tissue that circulates throughout the body, transporting gases, nutrients, hormones and waste materials.

7.2 Components of fish blood

Fish blood consists of plasma and blood cells.



A. Plasma

Plasma is the liquid portion of blood.

Functions:

1. Transports nutrients.

2. Carries hormones.
3. Transports waste products.
4. Distributes dissolved substances.
5. Helps maintain the internal chemical balance of the body.

B. Red blood cells

Red blood cells are specialised cells responsible for transporting oxygen.

Characteristics:

- Most fish red blood cells contain a nucleus.
- They contain haemoglobin.
- Haemoglobin combines with oxygen for transport.
- They transport some carbon dioxide indirectly.

C. White blood cells

White blood cells protect fish against infections.

Functions:

1. Destroy disease-causing microorganisms.
2. Participate in immune responses.
3. Remove damaged cells and foreign materials.
4. Protect the fish against infections.

D. Platelets and thrombocytes

Fish possess nucleated blood cells called thrombocytes that play an important role in blood clotting.

Functions:

1. Assist in blood clot formation.
2. Reduce excessive blood loss.
3. Help close damaged blood vessels.
4. Support wound healing.

8.0 THE RESPIRATORY SYSTEM IN FISH

8.1 Meaning of respiration

Respiration refers to the processes through which organisms obtain oxygen and use it to release energy from food.

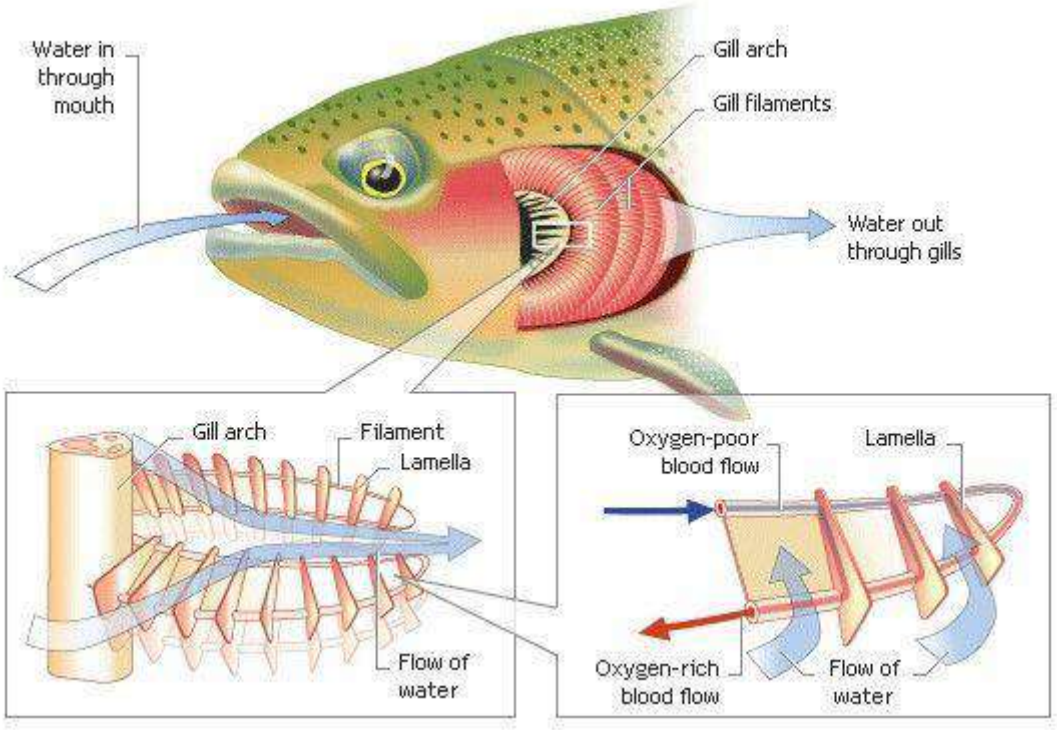
In fish, respiration involves taking oxygen dissolved in water and eliminating carbon dioxide produced during cellular activities.

Fish mainly use gills for gaseous exchange.

8.2 Meaning of the respiratory system

The respiratory system is a group of organs and structures responsible for gaseous exchange between the fish and its aquatic environment.

The main respiratory organs in most bony fish are the gills.



8.3 Importance of respiration in fish

Respiration is important because it:

1. Supplies oxygen for cellular respiration.
2. Supports energy production.
3. Enables normal body functioning.
4. Supports swimming and movement.
5. Promotes growth and development.
6. Helps maintain metabolic activities.
7. Enables fish to survive in aquatic environments.

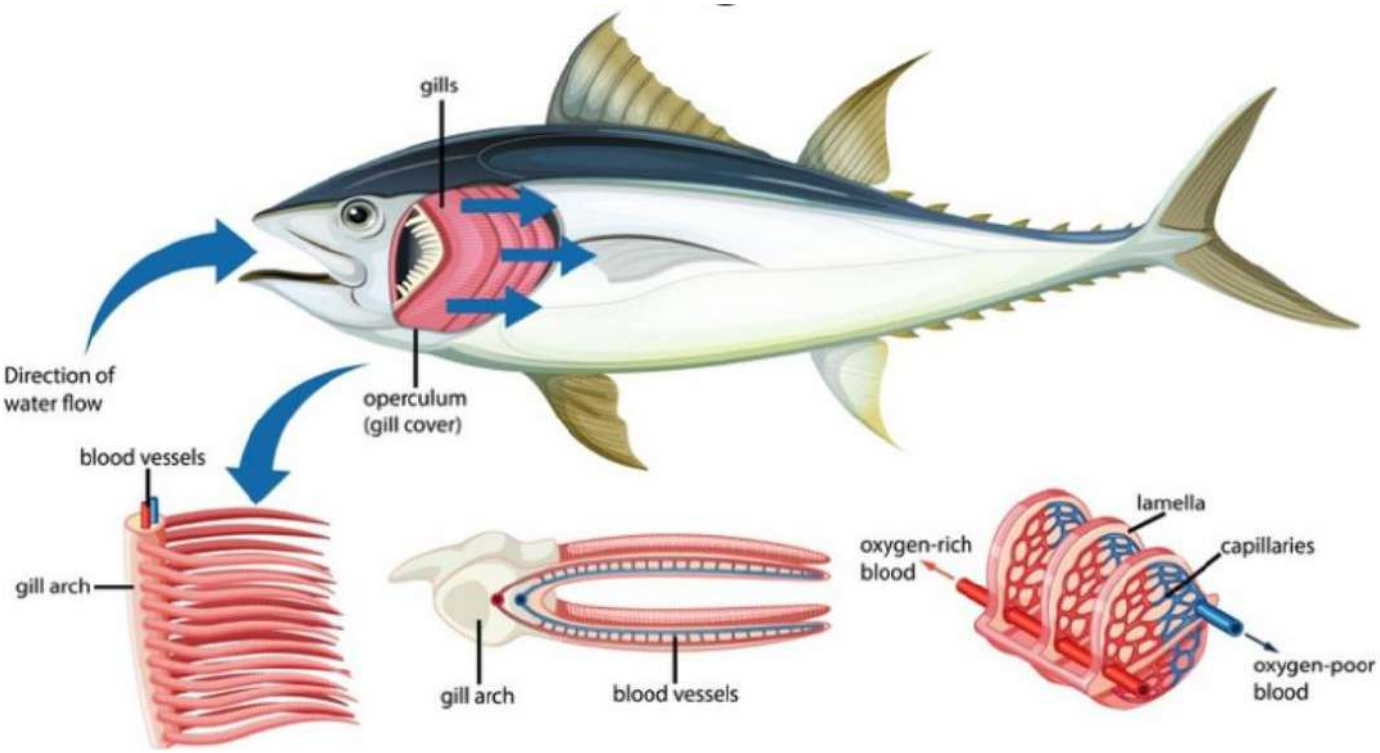
9.0 STRUCTURE OF GILLS IN BONY FISH

9.1 Meaning of gills

Gills are specialised respiratory organs found in most fish that enable them to absorb dissolved oxygen from water and remove carbon dioxide.

Most bony fish possess four pairs of gill arches located on either side of the pharynx.

Each gill is protected by a bony covering called the **operculum**.



9.2 Main parts of the gills

The major structures include:

1. Gill arches.
2. Gill rakers.
3. Gill filaments.
4. Gill lamellae.
5. Gill blood vessels.

9.3 Functions of the parts of the gills

A. Gill arches

Gill arches are curved, supportive structures that hold the gill filaments and gill rakers.

Functions:

1. Support the gill filaments.
2. Provide attachment surfaces for gill rakers.
3. Maintain the structure of the gills.
4. Support blood vessels supplying the gills.

B. Gill rakers

Gill rakers are projections found along the inner side of the gill arches.

Functions:

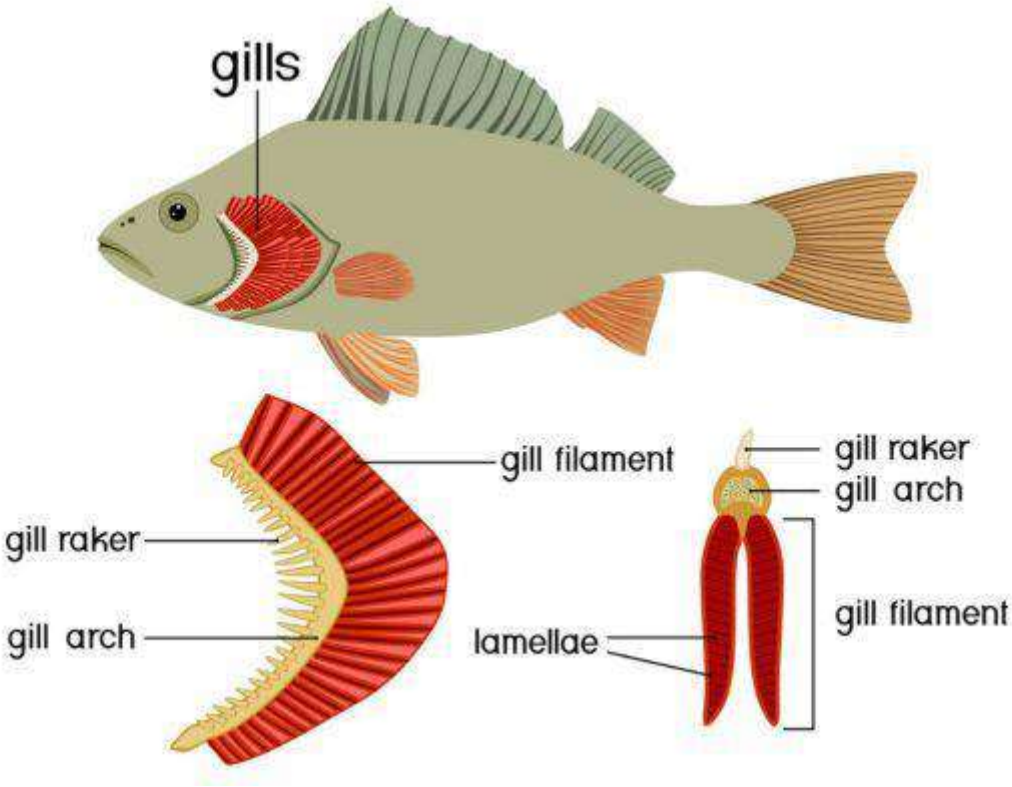
1. Protect the delicate gill filaments from solid particles.
2. Prevent large food particles from entering the gill structures.
3. Assist in filtering food particles in some fish.

4. Assist some filter-feeding fish in collecting plankton.

Adaptation: Gill rakers differ in number, length and spacing depending on the feeding habits of the fish.

For example:

- Filter-feeding fish may possess numerous fine gill rakers.
- Predatory fish may have fewer and shorter gill rakers.



C. Gill filaments

Gill filaments are elongated, soft structures attached to the gill arches.

Functions:

1. Provide a large surface area for gaseous exchange.
2. Support numerous secondary lamellae.
3. Contain blood vessels that transport blood.
4. Allow efficient absorption of dissolved oxygen.

D. Gill lamellae

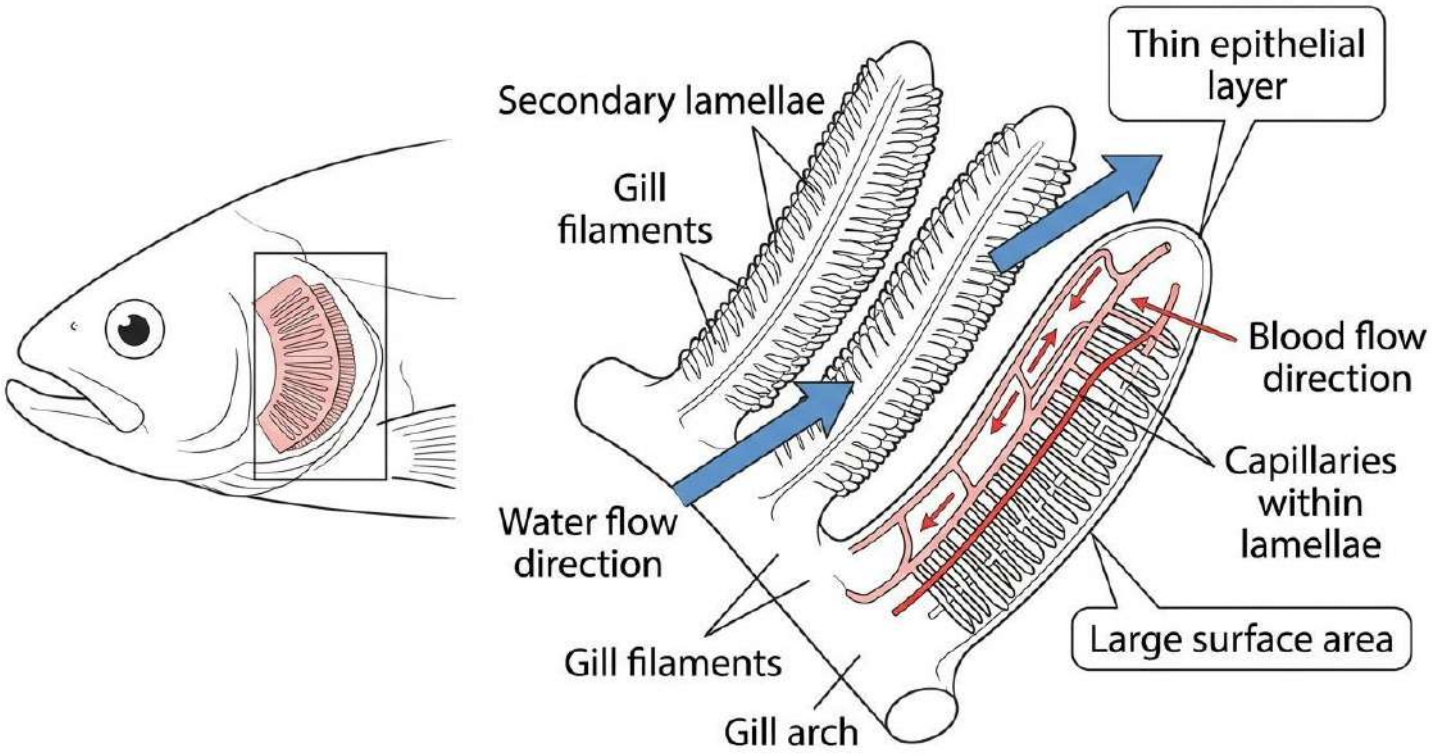
Lamellae are thin, plate-like structures found on the gill filaments.

The secondary lamellae are the main sites of gaseous exchange.

Functions:

1. Increase the surface area available for gaseous exchange.
2. Provide a short diffusion distance between water and blood.
3. Contain dense networks of blood capillaries.
4. Allow oxygen to diffuse into the blood.

5. Allow carbon dioxide to diffuse from blood into water.



E. Gill blood vessels

These are blood vessels supplying and collecting blood from the gills.

Functions:

1. Transport deoxygenated blood to the gills.
2. Allow blood to flow through capillaries in the lamellae.
3. Collect oxygenated blood after gaseous exchange.
4. Transport oxygenated blood towards the body tissues.

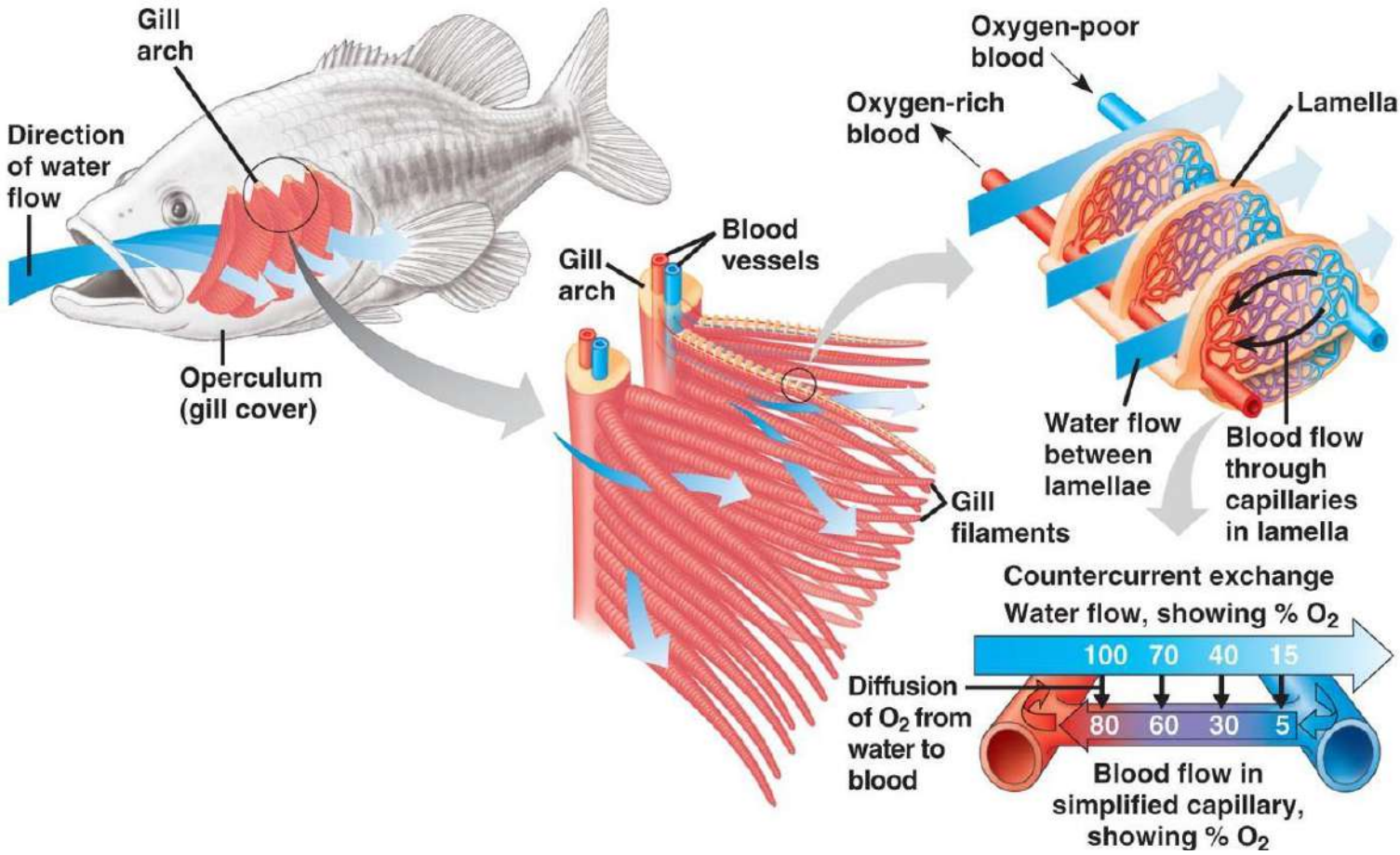
10.0 THE PROCESS OF GASEOUS EXCHANGE IN FISH

10.1 Meaning of gaseous exchange

Gaseous exchange is the process through which oxygen enters the blood from the surrounding water while carbon dioxide moves from the blood into the water.

In bony fish, gaseous exchange takes place mainly across the secondary lamellae of the gills.

10.2 How gaseous exchange occurs



The process takes place as follows:

Step 1: Entry of water

- Water enters the fish through the mouth.
- The mouth opens to allow water to enter the buccal cavity.

Step 2: Movement of water

- Muscular movements of the mouth and buccal cavity help move water towards the gills.
- Water passes over the gill filaments and lamellae.

Step 3: Arrival of deoxygenated blood

- Deoxygenated blood is transported from the heart to the gills through the ventral aorta.
- The blood enters the capillaries in the gill lamellae.

Step 4: Diffusion of oxygen

- Water passing over the lamellae contains dissolved oxygen.
- The oxygen concentration is higher in the water than in the incoming deoxygenated blood.
- Oxygen diffuses across the thin lamellar surface into the blood.

Step 5: Diffusion of carbon dioxide

- Blood contains a higher concentration of carbon dioxide than the surrounding water.
- Carbon dioxide diffuses from the blood into the water.

Step 6: Removal of carbon dioxide

- Water carrying carbon dioxide moves out through the opercular openings.
- Carbon dioxide is released into the aquatic environment.

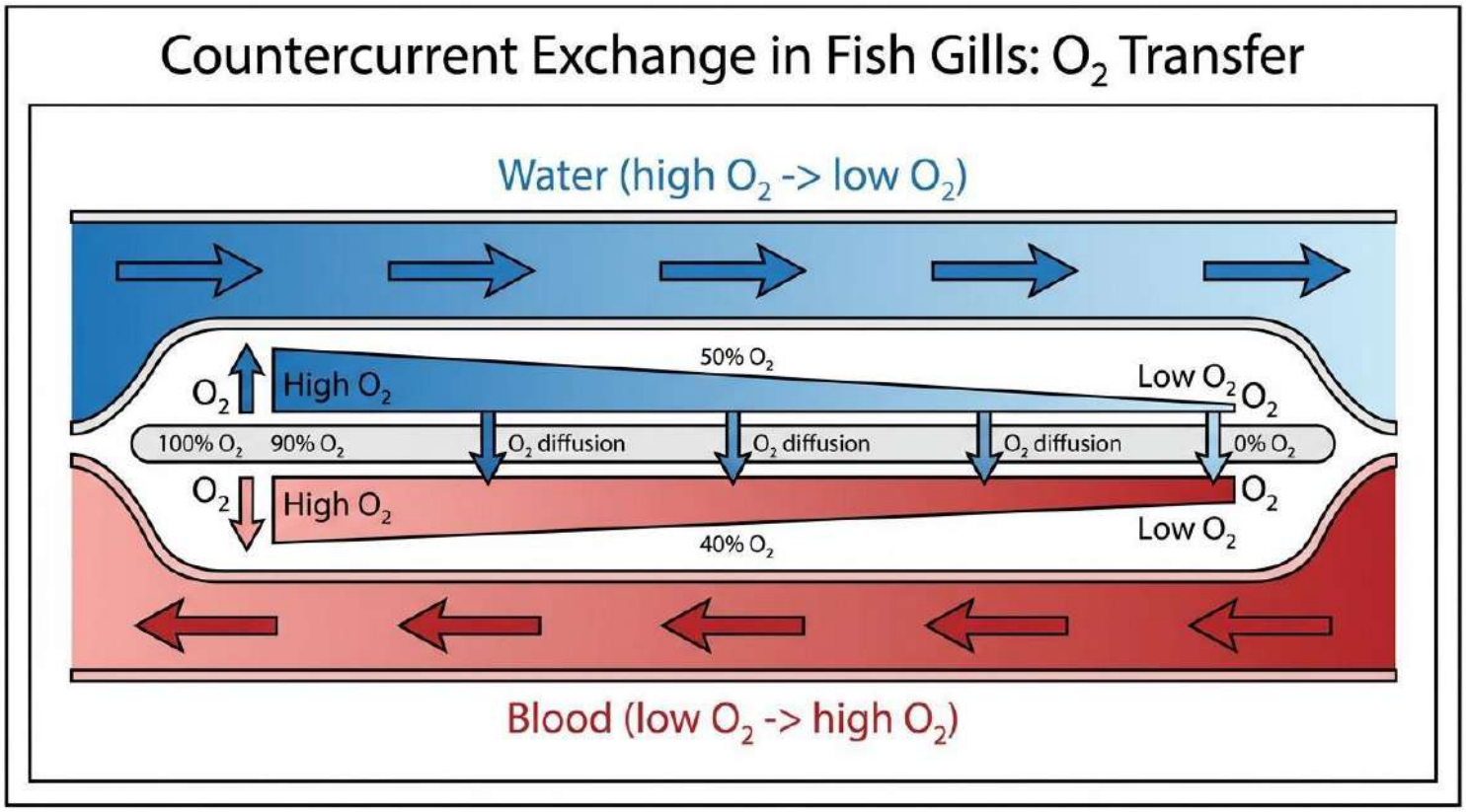
Step 7: Transportation of oxygenated blood

- Oxygenated blood leaves the gills.
- It is transported to the body tissues through the dorsal aorta and associated arteries.

10.3 Counter-current exchange in fish

Counter-current exchange is a process in which water flows over the gill lamellae in the opposite direction to the blood flowing inside their capillaries.

This arrangement makes gaseous exchange more efficient.



How counter-current exchange works:

1. Water flows over the gill lamellae in one direction.
2. Blood flows inside the lamellar capillaries in the opposite direction.
3. At every point along the lamellae, water has a higher oxygen concentration than the blood next to it.
4. Oxygen continues to diffuse from water into blood along the entire length of the lamella.
5. This allows fish to extract a large proportion of the available dissolved oxygen.

Importance of counter-current exchange:

- Increases the efficiency of oxygen absorption.
- Maintains a continuous diffusion gradient.
- Enables fish to obtain sufficient oxygen from water.

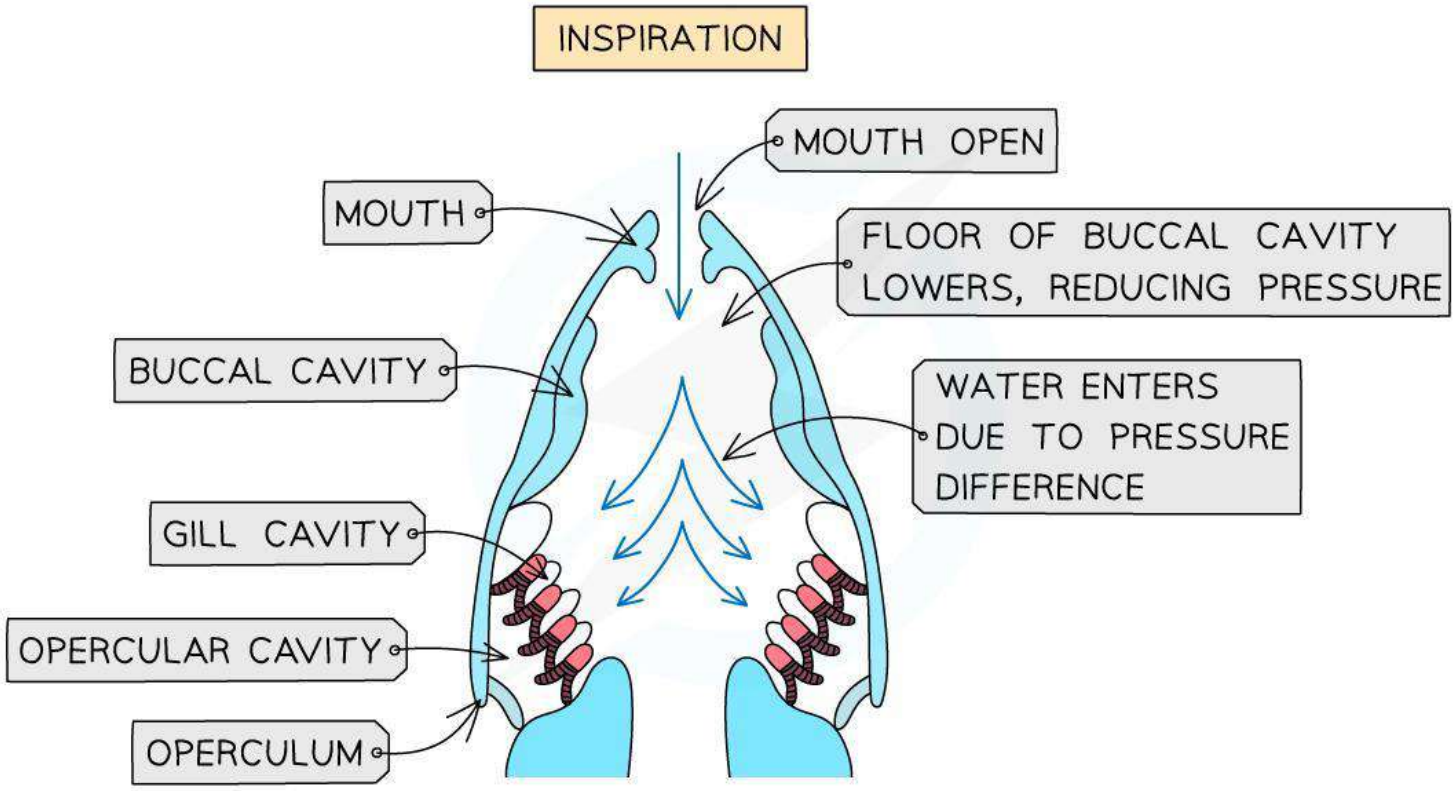
- Supports active swimming and other metabolic activities.

11.0 MOVEMENT OF WATER THROUGH THE GILLS

Water movement through the respiratory system is essential for gaseous exchange.

11.1 The role of the mouth and operculum

The mouth and operculum work together to create water movement over the gills.



In many bony fish:

1. The mouth opens.
2. The floor of the buccal cavity lowers, increasing its volume.
3. Water enters the mouth.
4. The mouth closes.
5. The buccal cavity contracts, increasing pressure.
6. Water is pushed over the gill filaments.
7. The opercular cavity expands and assists in drawing water over the gills.
8. Water exits through the opercular openings.

11.2 Importance of the operculum

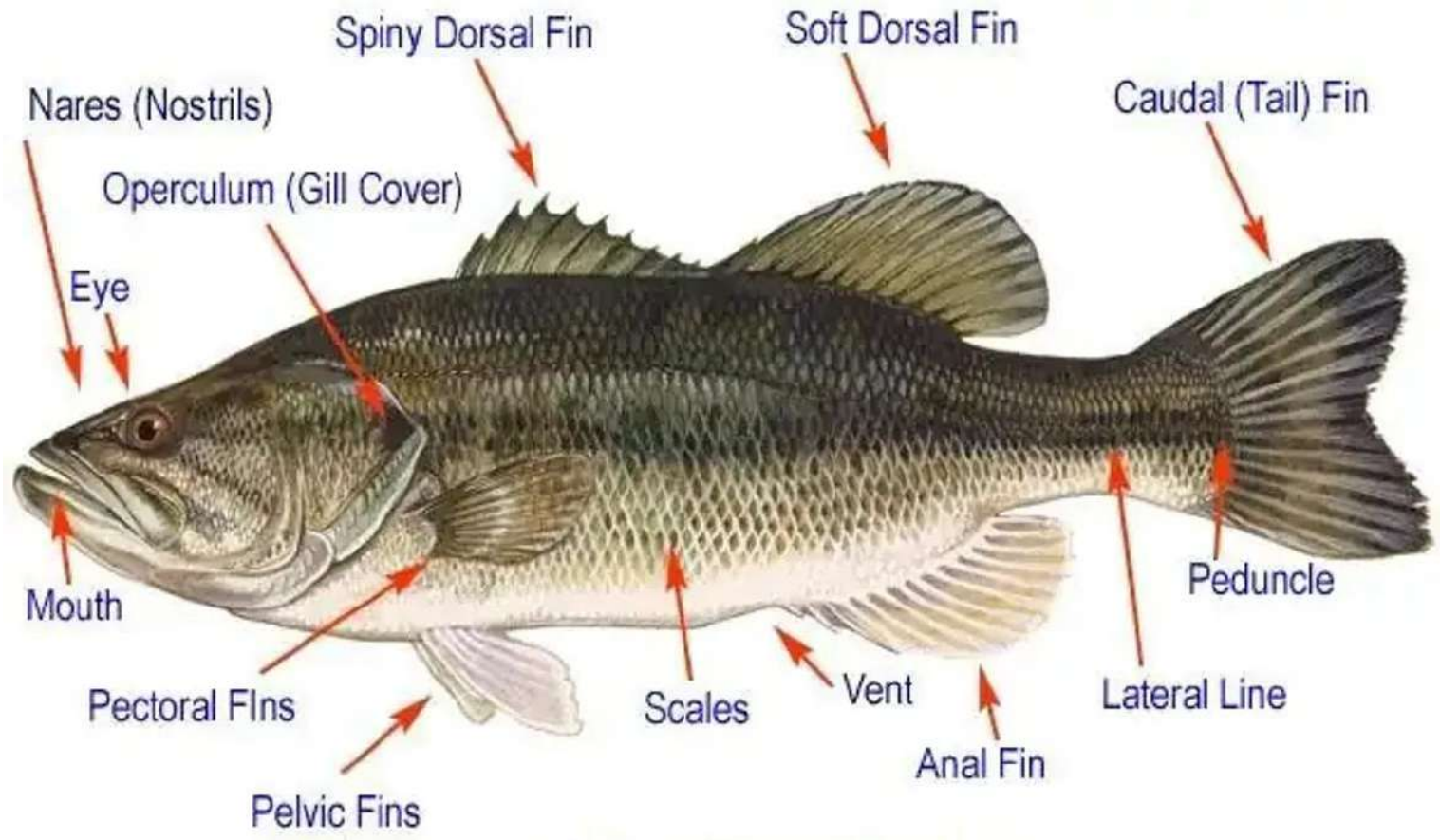
The operculum is a bony flap covering the gills in most bony fish.

Functions:

1. Protects delicate gill structures.
2. Assists in pumping water over the gills.
3. Helps maintain continuous water flow.

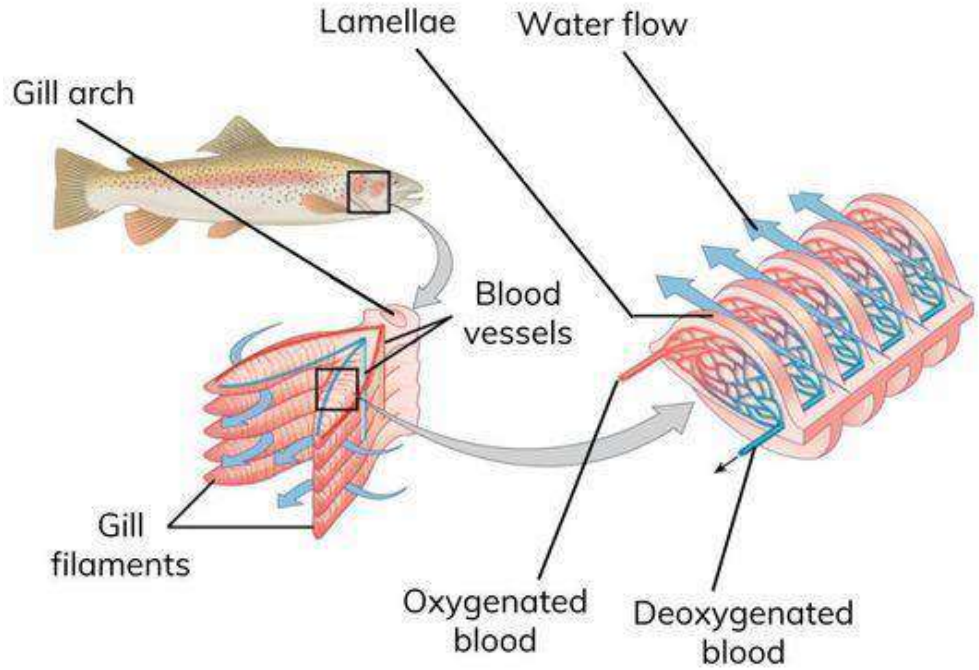
4. Protects the gills from physical injury.
5. Reduces direct exposure of gill structures to harmful particles.

Example: Nile tilapia uses coordinated mouth and opercular movements to move water across its gills.



12.0 ADAPTATIONS OF GILLS TO GASEOUS EXCHANGE

Gills possess several structural features that make gaseous exchange efficient.



Adaptation	Importance

Numerous gill filaments	Increase surface area
Numerous lamellae	Provide a large exchange surface
Thin lamellar walls	Reduce diffusion distance
Dense blood capillaries	Maintain efficient transport of gases
Counter-current flow	Maintains an oxygen diffusion gradient
Continuous water movement	Supplies fresh dissolved oxygen
Moist surfaces	Allow gases to dissolve and diffuse

12.1 Factors affecting gaseous exchange in fish

The efficiency of gaseous exchange is affected by the following factors:

1. Dissolved oxygen concentration

- Water with high dissolved oxygen generally supports efficient respiration.
- Low dissolved oxygen may cause respiratory stress.
- Fish may swim near the water surface or show rapid opercular movements when oxygen levels are low.

2. Water temperature

- Warm water generally holds less dissolved oxygen than cold water.
- Increased temperature can increase the metabolic oxygen demand of many fish.
- Extremely high temperatures may cause respiratory stress.

3. Water pollution

- Chemicals and pollutants may damage gill tissues.
- Suspended particles can interfere with normal gill functioning.
- Toxic substances may reduce the ability of fish to absorb oxygen.

4. Water flow

- Adequate water movement ensures continuous supply of oxygen.
- Stagnant water may have reduced oxygen availability.
- Water circulation helps distribute dissolved oxygen throughout fish ponds and tanks.

5. pH of water

- Extremely acidic or alkaline water may damage gill tissues.
- Unfavourable pH may interfere with normal physiological processes.
- Maintaining suitable pH supports healthy respiration.

6. Crowding

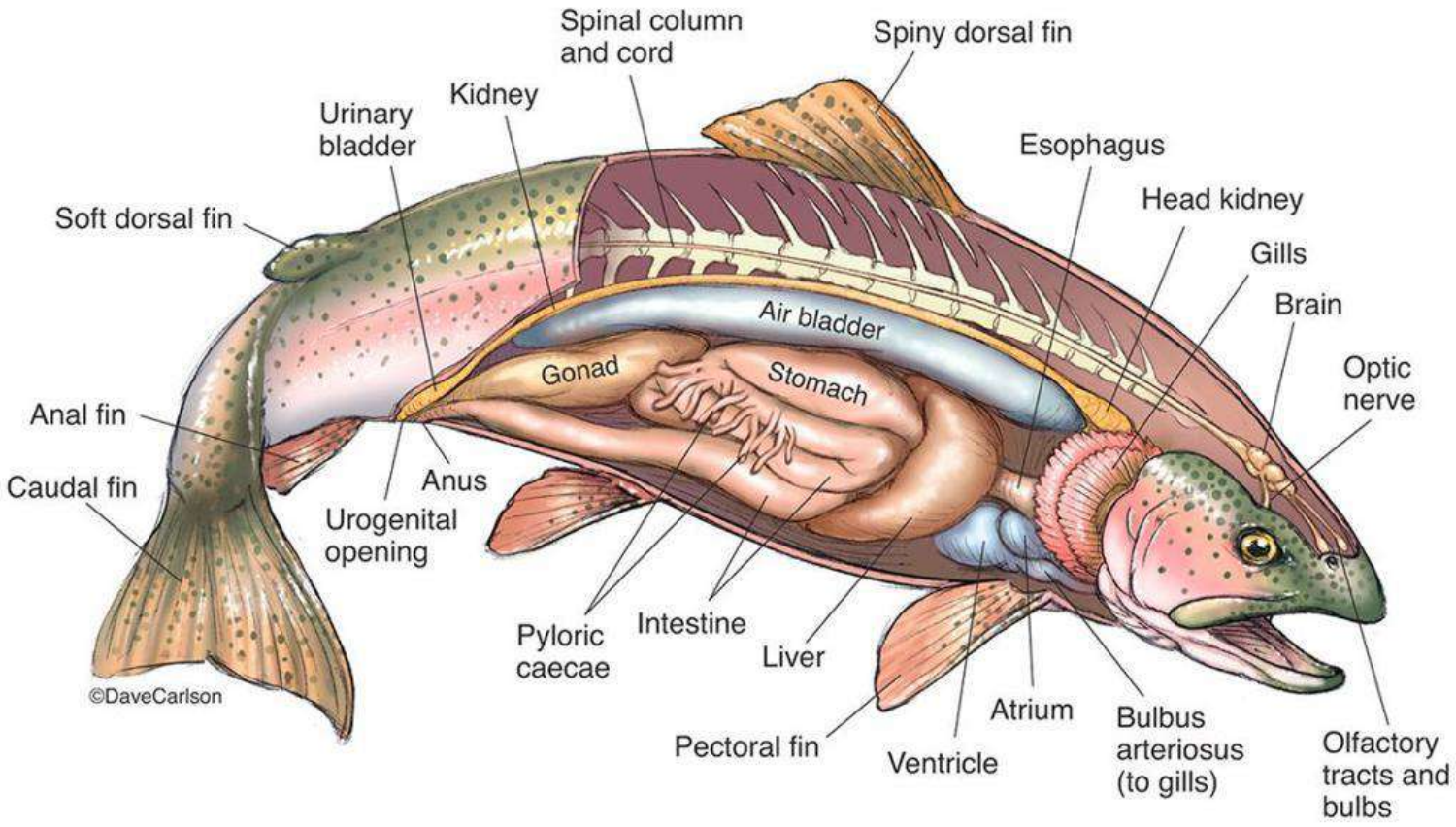
- High stocking densities increase competition for dissolved oxygen.
- Crowding may also increase waste accumulation.
- Excessive stocking may lead to stress and poor fish growth.

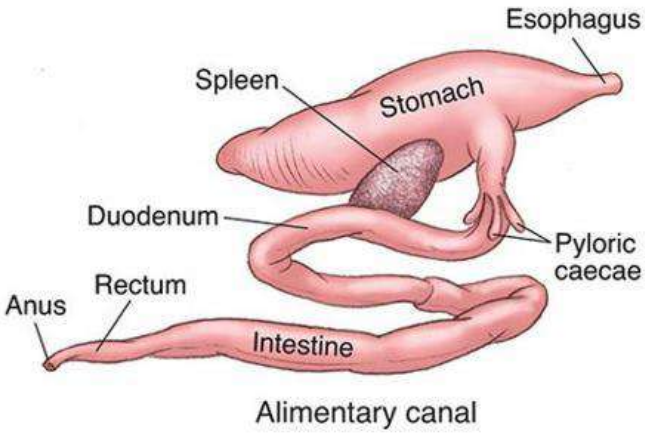
7. Disease and parasites

- Gill infections and parasites may damage respiratory surfaces.
- Damaged gills reduce the efficiency of gaseous exchange.
- Infected fish may show abnormal breathing and reduced feeding activity.

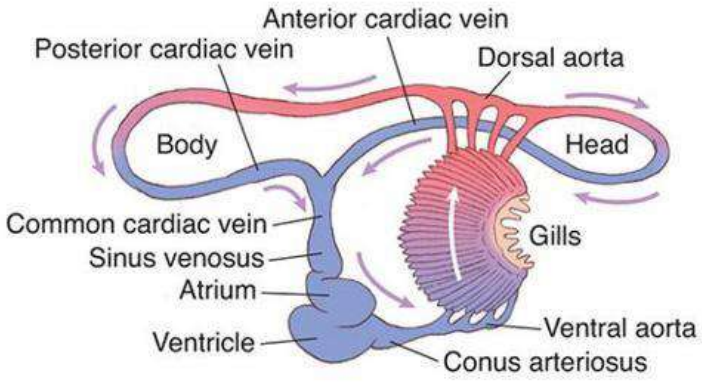
13.0 RELATIONSHIP BETWEEN THE DIGESTIVE, CIRCULATORY AND RESPIRATORY SYSTEMS

The digestive, circulatory and respiratory systems work together to maintain life in fish.





Alimentary canal



Diagrammatic circulatory system

13.1 How the systems interact

A. Digestive system

The digestive system:

- Breaks down food.
- Absorbs nutrients.
- Supplies nutrients required for energy production, growth and tissue repair.

B. Respiratory system

The respiratory system:

- Absorbs oxygen from water.
- Removes carbon dioxide produced by body cells.
- Supplies oxygen needed for cellular respiration.

C. Circulatory system

The circulatory system:

- Transports oxygen from the gills to body cells.
- Transports nutrients from the digestive system to body tissues.
- Carries carbon dioxide to the gills for removal.
- Distributes other substances required by body cells.

13.2 Example of how the three systems work together

When a Nile tilapia feeds on aquatic organisms:

1. Food enters through the mouth.
2. The digestive system breaks down the food.
3. Nutrients are absorbed into the blood.
4. Water passes over the gills.
5. Oxygen enters the blood through the gill lamellae.
6. The heart pumps oxygenated blood to body tissues.
7. Body cells use oxygen and absorbed nutrients to release energy.
8. Carbon dioxide produced during cellular respiration enters the blood.
9. The blood transports carbon dioxide to the gills.
10. Carbon dioxide diffuses into the surrounding water.

This demonstrates the interdependence of the three physiological systems.

14.0 IMPORTANCE OF FISH PHYSIOLOGY IN MARINE TECHNOLOGY

Knowledge of fish physiology has several applications in fisheries, aquaculture and marine resource management.

14.1 In fish feeding and nutrition

Knowledge of the digestive system helps fish farmers to:

1. Identify suitable feeds for different fish species.
2. Formulate balanced diets.
3. Promote efficient digestion and nutrient absorption.
4. Reduce feed wastage.
5. Support healthy fish growth.



14.2 In aquaculture management

Knowledge of fish physiology helps fish farmers to:

1. Determine appropriate stocking densities.
2. Maintain suitable dissolved oxygen levels.
3. Guide proper feeding schedules.
4. Prevent physiological stress.
5. Promote healthy fish production.

14.3 In fish health management

Knowledge of fish physiology:

1. Helps identify abnormal digestive activities.
2. Helps detect respiratory distress.
3. Assists in understanding diseases affecting gills and other organs.
4. Supports early detection of health problems.
5. Improves fish survival rates.



14.4 In water quality management

Knowledge of fish respiration helps fish farmers monitor:

- Dissolved oxygen.
- Water temperature.
- pH.
- Ammonia concentration.
- Water turbidity.
- Water circulation.



14.5 In fisheries conservation

Knowledge of fish physiology:

1. Helps understand fish adaptation to different habitats.
2. Supports the protection of aquatic ecosystems.
3. Helps explain the effects of pollution on fish.
4. Supports sustainable fishing practices.
5. Promotes conservation of native fish species.

PRACTICAL ACTIVITIES IN FISH PHYSIOLOGY

Activity 1: Observation of the digestive system of a bony fish

Learning objective: To identify the main organs of the digestive system in a bony fish.

Materials required:

- Freshly obtained fish specimen, preferably tilapia.
- Dissecting tray.
- Dissecting scissors.
- Forceps.
- Gloves.
- Hand lens.
- Labels.
- Protective clothing.

Procedure:

1. Obtain a fresh fish specimen from a reliable source.
2. Place it on a dissecting tray.
3. Observe its external features.
4. Identify the mouth, operculum and anus.
5. Make a shallow incision along the ventral surface.
6. Carefully open the body cavity.
7. Identify the liver, stomach and intestine.
8. Locate the gall bladder and pyloric caeca, where present.
9. Trace the digestive tract from the oesophagus to the anus.
10. Draw and label the observed structures.

Expected observations:

- The digestive tract consists of connected organs.
- The liver is a large internal organ.
- The stomach is connected to the intestine in species possessing a stomach.

- The intestine is coiled and extends towards the anus.

Safety precautions:

1. Wear protective gloves.
2. Use dissecting instruments carefully.
3. Avoid direct contact with fish blood and internal organs.
4. Wash hands and equipment after the activity.
5. Dispose of specimens appropriately.

Activity 2: Modelling the circulatory system of fish

Learning objective: To construct and label a model showing blood circulation in a bony fish.

Materials:

- Cardboard.
- Coloured strings.
- Modelling clay.
- Glue.
- Markers.
- Labels.
- Drawing paper.

Procedure:

1. Draw an outline of a fish.
2. Represent the heart using modelling clay.
3. Label the sinus venosus, atrium, ventricle and bulbus arteriosus.
4. Use coloured strings to represent blood vessels.
5. Show the ventral aorta leading towards the gills.
6. Show the dorsal aorta leading towards body tissues.
7. Use arrows to indicate blood movement.
8. Label oxygenated and deoxygenated blood.
9. Present the model to classmates.
10. Explain the process of single circulation.

Activity 3: Observation of gill structures

Learning objective: To identify the structures of fish gills and explain their functions.

Materials:

- Fresh fish specimen.
- Dissecting tray.
- Forceps.

- Scissors.
- Hand lens.
- Gloves.

Procedure:

1. Place a fresh fish specimen on a dissecting tray.
2. Lift the operculum carefully.
3. Observe the gill structures.
4. Remove one gill arch carefully.
5. Identify the gill arch.
6. Observe the gill rakers.
7. Identify the gill filaments.
8. Use a hand lens to examine the filaments and lamellae.
9. Draw and label the observed structures.
10. Explain how the structures assist in gaseous exchange.

Expected observations:

- Gill arches support the respiratory structures.
- Gill rakers occur along the inner side of the arches.
- Gill filaments appear as numerous elongated structures.
- Lamellae are found on the filaments.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS **30 MARKS**

Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. Fish physiology is the study of:

A. The classification of aquatic plants.

B. The functioning of organs and systems in fish.

C. The construction of fishing vessels.

D. The marketing of fish products.

2. Which of the following fish is mainly carnivorous?

A. Grass carp.

B. Nile perch.

C. Rabbitfish.

D. Common carp.

3. Which of the following fish is mainly herbivorous?

A. Nile perch.

B. Tuna.

C. Grass carp.

D. Barracuda.

4. A fish that feeds on both plants and animals is described as:

A. Carnivorous.

B. Herbivorous.

C. Omnivorous.

D. Parasitic.

5. The main function of the mouth in fish digestion is to:

A. Absorb nutrients.

B. Take in food.

C. Produce bile.

D. Remove faeces.

6. Which organ connects the pharynx to the stomach?

A. Intestine.

B. Rectum.

C. Oesophagus.

D. Anus.

7. The main function of the stomach in fish is to:

A. Pump blood.
B. Store and digest food.
C. Absorb oxygen.
D. Produce red blood cells.

8. Which organ produces bile in fish?

A. Liver.
B. Pancreas.
C. Stomach.
D. Intestine.

9. The gall bladder is responsible for:

A. Producing oxygen.
B. Storing bile.
C. Pumping blood.
D. Absorbing proteins.

10. Pyloric caeca mainly assist in:

A. Respiration.
B. Digestion and nutrient absorption.
C. Blood circulation.
D. Waste elimination through the kidneys.

11. Which digestive enzyme breaks down proteins?

A. Amylase.
B. Lipase.
C. Protease.
D. Maltase.

12. The final opening through which undigested food leaves the digestive tract is the:

A. Mouth.
B. Gills.
C. Anus.
D. Oesophagus.

13. The circulatory system in fish consists mainly of:

A. Heart, blood and blood vessels.
B. Lungs, trachea and bronchi.
C. Mouth, stomach and intestine.
D. Kidneys, bladder and ureters.

14. A typical bony fish has a functionally:

A. One-chambered heart.

B. Two-chambered heart.

C. Three-chambered heart.

D. Four-chambered heart.

15. The chamber that receives blood from the sinus venosus is the:

A. Ventricle.

B. Atrium.

C. Bulbus arteriosus.

D. Aorta.

16. Which heart chamber pumps blood towards the gills?

A. Atrium.

B. Sinus venosus.

C. Ventricle.

D. Bulbus arteriosus.

17. The bulbus arteriosus helps to:

A. Digest proteins.

B. Regulate blood flow leaving the heart.

C. Absorb nutrients.

D. Remove carbon dioxide from water.

18. The blood vessel that carries blood from the heart towards the gills is the:

A. Dorsal aorta.

B. Ventral aorta.

C. Pulmonary vein.

D. Intestinal vein.

19. Fish have which type of circulatory system?

A. Double circulation. B. Single circulation.

C. Open circulation. D. No circulation.

20. The main function of red blood cells is to:

A. Fight infections.

B. Transport oxygen.

C. Produce bile.

D. Digest fats.

21. The main respiratory organs in most bony fish are:

A. Lungs.

B. Skin.

C. Gills.

D. Tracheae.

22. The bony structure that protects the gills in most bony fish is called the:

A. Operculum.

B. Gill filament.

C. Gill raker.

D. Lamella.

23. Gill rakers are mainly located on the:

A. Gill arches.

B. Heart.

C. Stomach.

D. Intestine.

24. The main function of gill filaments is to:

A. Store food.

B. Increase the surface area for gaseous exchange.

C. Pump blood.

D. Produce digestive enzymes.

25. The main sites of gaseous exchange in bony fish are the:

A. Gill arches.

B. Gill rakers.

C. Secondary lamellae.

D. Operculum.

26. Oxygen enters the blood from water through the process of:

A. Osmosis. B. Diffusion.

C. Active transport. D. Transpiration.

27. Counter-current exchange occurs when:

A. Water and blood flow in the same direction.

B. Water and blood flow in opposite directions.

C. Blood stops flowing through the gills.

D. Water does not pass over the gills.

28. Which gas is removed from the blood during gaseous exchange in the gills?

A. Oxygen.

B. Nitrogen.

C. Carbon dioxide.

D. Hydrogen.

29. Which of the following environmental factors can reduce the availability of dissolved oxygen in water?

A. Excessively high water temperature.

B. Suitable water circulation.

C. Appropriate stocking density.

D. Adequate aeration.

30. The circulatory system transports oxygen from the gills to:

A. The surrounding water.

B. The body tissues.

C. The external environment.

D. The digestive tract only.

SECTION B: STRUCTURED QUESTIONS

50 MARKS

Answer all questions.

QUESTION 1: FISH PHYSIOLOGY (8 MARKS)

a) Define fish physiology. (2 marks)

b) State three reasons why knowledge of fish physiology is important in aquaculture. (3 marks)

c) Differentiate between carnivorous and herbivorous fish, giving one example of each. (3 marks)

QUESTION 2: DIGESTIVE SYSTEM IN FISH (8 MARKS)

a) Name four organs found in the digestive system of a typical bony fish. (4 marks)

b) State two functions of the liver in fish. (2 marks)

c) Explain the role of pyloric caeca in fish digestion. (2 marks)

QUESTION 3: DIGESTION IN FISH (8 MARKS)

a) Explain four stages involved in the digestion of food in bony fish. (4 marks)

b) State two functions of digestive enzymes in fish. (2 marks)

c) Differentiate between the feeding habits of omnivorous and carnivorous fish. (2 marks)

QUESTION 4: CIRCULATORY SYSTEM IN FISH (9 MARKS)

a) Name the four main structures associated with the heart of a typical bony fish. (4 marks)

b) Explain the functions of the following structures:

i. Atrium. (1 mark)

ii. Ventricle. (1 mark)

c) Explain how blood moves from the heart to the gills and then to the body tissues. (3 marks)

QUESTION 5: RESPIRATORY SYSTEM IN FISH (9 MARKS)

a) State four main structures found in the gills of bony fish. (4 marks)

b) Explain the functions of the following:

i. Gill rakers. (1 mark)

ii. Gill filaments. (1 mark)

c) Explain how gaseous exchange takes place in the gills of bony fish. (3 marks)

QUESTION 6: FISH PHYSIOLOGY AND AQUACULTURE (8 MARKS)

a) Explain three adaptations of fish gills that make gaseous exchange efficient. (3 marks)

b) State three environmental factors that may affect respiration in fish. (3 marks)

c) Explain two ways in which knowledge of fish physiology can improve fish production in Kenya. (2 marks)

TEACHER'S MARKING GUIDE

SECTION A: ANSWERS

Question	Answer	Question	Answer
1	B	16	C
2	B	17	B
3	C	18	B
4	C	19	B
5	B	20	B
6	C	21	C
7	B	22	A
8	A	23	A
9	B	24	B
10	B	25	C
11	C	26	B
12	C	27	B
13	A	28	C
14	B	29	A
15	B	30	B

SECTION B: SUGGESTED MARKING SCHEME

QUESTION 1 (8 MARKS)

a) Fish physiology is the study of how organs and systems in fish function to sustain life. (2)

b) Any three:

- Helps in selecting suitable fish feeds.
- Helps maintain proper water quality.
- Helps improve fish growth.

- Helps identify physiological disorders.
- Helps reduce fish mortality.
- Helps improve aquaculture productivity.

(3 × 1 = 3)

c)

- Carnivorous fish feed mainly on other animals (1).
- Herbivorous fish feed mainly on plant materials (1).
- Examples: Nile perch (carnivore) and grass carp (herbivore) (1).

QUESTION 2 (8 MARKS)

a) Any four:

- Mouth.
- Pharynx.
- Oesophagus.
- Stomach.
- Pyloric caeca.
- Intestine.
- Rectum.
- Anus.

(4 × 1 = 4)

b) Any two:

- Produces bile.
- Stores glycogen.
- Processes nutrients.
- Detoxifies harmful substances.

(2 × 1 = 2)

c)

- Increase the surface area available for digestion and absorption (1).
- Assist in digestive enzyme secretion and nutrient processing (1).

QUESTION 3 (8 MARKS)

a) Any four stages, explained:

- Ingestion: Food enters through the mouth.
- Swallowing: Food passes through the pharynx and oesophagus.
- Stomach digestion: Gastric juice and enzymes begin digestion, especially of proteins.
- Intestinal digestion: Digestive enzymes complete the breakdown of food.

- Absorption: Digested nutrients enter the blood.
- Egestion: Undigested materials leave through the anus.

(4 × 1 = 4)

b)

- Break complex food substances into simpler substances.
- Increase the rate of digestion.
- Help produce absorbable nutrients.

(Any 2 × 1 = 2)

c)

- Omnivorous fish feed on both plant and animal materials (1).
- Carnivorous fish feed mainly on other animals (1).

QUESTION 4 (9 MARKS)

a)

- Sinus venosus.
- Atrium.
- Ventricle.
- Bulbus arteriosus.

(4 × 1 = 4)

b)

i. Atrium receives blood from the sinus venosus and pushes it into the ventricle. (1)

ii. Ventricle pumps blood towards the gills. (1)

c)

- Blood enters the heart through the sinus venosus and passes through the atrium and ventricle (1).
- The ventricle pumps blood through the bulbus arteriosus and ventral aorta towards the gills (1).
- Blood gains oxygen in the gills and travels through the dorsal aorta to body tissues (1).

QUESTION 5 (9 MARKS)

a)

- Gill arches.
- Gill rakers.
- Gill filaments.
- Gill lamellae.

(4 × 1 = 4)

b)

i. Gill rakers protect gill filaments and may assist in filtering food particles. (1)

ii. Gill filaments provide a large surface area for gaseous exchange. (1)

c)

- Water passes over the gill lamellae (1).
- Oxygen diffuses from water into the blood while carbon dioxide diffuses from blood into water (1).
- Oxygenated blood leaves the gills and is transported to body tissues (1).

QUESTION 6 (8 MARKS)

a) Any three:

- Numerous filaments increase the surface area.
- Thin lamellae reduce diffusion distance.
- Numerous capillaries facilitate gas transport.
- Counter-current exchange maintains a diffusion gradient.
- Continuous water movement supplies dissolved oxygen.

(3 × 1 = 3)

b) Any three:

- Dissolved oxygen concentration.
- Water temperature.
- Water pollution.
- Water pH.
- Stocking density.
- Water circulation.
- Gill diseases and parasites.

(3 × 1 = 3)

c) Any two explained:

- Helps farmers select suitable feeds, improving growth.
- Helps maintain appropriate dissolved oxygen levels, reducing fish mortality.
- Helps identify respiratory and digestive disorders.
- Helps maintain suitable stocking densities.
- Helps improve fish survival and production.

(2 × 1 = 2)

STRAND 2.0: AQUACULTURE

SUB-STRAND 2.1: FISH CAGE



1.0 INTRODUCTION TO FISH CAGE AQUACULTURE

1.1 Meaning of a fish cage

A **fish cage** is an enclosed structure made using a net or mesh material supported by a frame and placed in a natural or artificial water body to keep and rear fish under controlled conditions.

- The cage allows water to flow freely through its mesh walls and bottom.
- It prevents the cultured fish from escaping.
- It allows farmers to feed, monitor and harvest fish within a confined area.
- It can be installed in lakes, reservoirs, dams and other suitable water bodies.
- It provides an opportunity to produce fish without constructing a conventional fish pond.

Fish cage aquaculture refers to the practice of rearing fish in enclosed net structures placed in existing water bodies.

Examples of fish commonly reared in cages in Kenya include:

- Nile tilapia (*Oreochromis niloticus*).
- African catfish (*Clarias gariepinus*), where suitable cage designs and management systems are used.





1.2 Importance of fish cage aquaculture in Kenya

Fish cage farming is an important aquaculture production system because it makes use of suitable existing water bodies.

Its importance includes:

1. **Increased fish production:** Enables farmers to produce large quantities of fish in suitable water bodies.
2. **Employment creation:** Creates jobs for cage construction workers, fish farmers, transporters, fish traders and processors.
3. **Improved food security:** Provides fish as a source of high-quality animal protein.
4. **Income generation:** Farmers earn income from selling harvested fish.
5. **Efficient use of water bodies:** Makes productive use of suitable lakes, reservoirs and dams.
6. **Reduced land requirements:** Unlike pond aquaculture, cage farming does not require large areas of land for pond construction.
7. **Business opportunities:** Encourages investment in fish feed production, fingerling supply, net manufacturing and fish marketing.
8. **Skills development:** Promotes technical skills in fish husbandry, water-quality monitoring and aquaculture management.
9. **Support for local industries:** Provides raw materials for fish processing, packaging and distribution.
10. **Diversification of livelihoods:** Offers alternative economic activities to communities that depend on fishing and other water-based activities.

1.3 Examples of fish cage farming in Kenya





Fish cage aquaculture is practised in parts of Lake Victoria, particularly around suitable areas in counties such as:

- Kisumu.
- Siaya.
- Homa Bay.
- Migori.

Other suitable inland water bodies may also support cage aquaculture where environmental, technical and regulatory requirements are met.

Important: Cage farming should not be established anywhere in a lake or dam without proper assessment. Poorly located cages can cause environmental pollution, interfere with navigation and negatively affect other aquatic organisms.

2.0 TYPES OF FISH CAGES

Fish cages are classified according to how they are positioned and supported in water.

The main types include:

1. Fixed fish cages.
2. Floating fish cages.
3. Submersible fish cages.
4. Submerged fish cages.

2.1 Fixed fish cages



A **fixed fish cage** is a cage whose supporting frame is firmly attached to poles or posts driven into the bottom of a relatively shallow water body.

Characteristics

- Supported by wooden, metal or concrete poles.
- Remains in a relatively fixed position.
- Usually constructed in shallow, sheltered water.
- The net enclosure is attached to the supporting framework.
- Its position does not change with normal water movement.

Advantages

1. Relatively simple to construct.
2. Can be made using locally available materials.
3. Requires less sophisticated floating equipment.
4. Easy to inspect when installed in accessible shallow water.
5. Suitable for small-scale aquaculture in appropriate locations.

Disadvantages

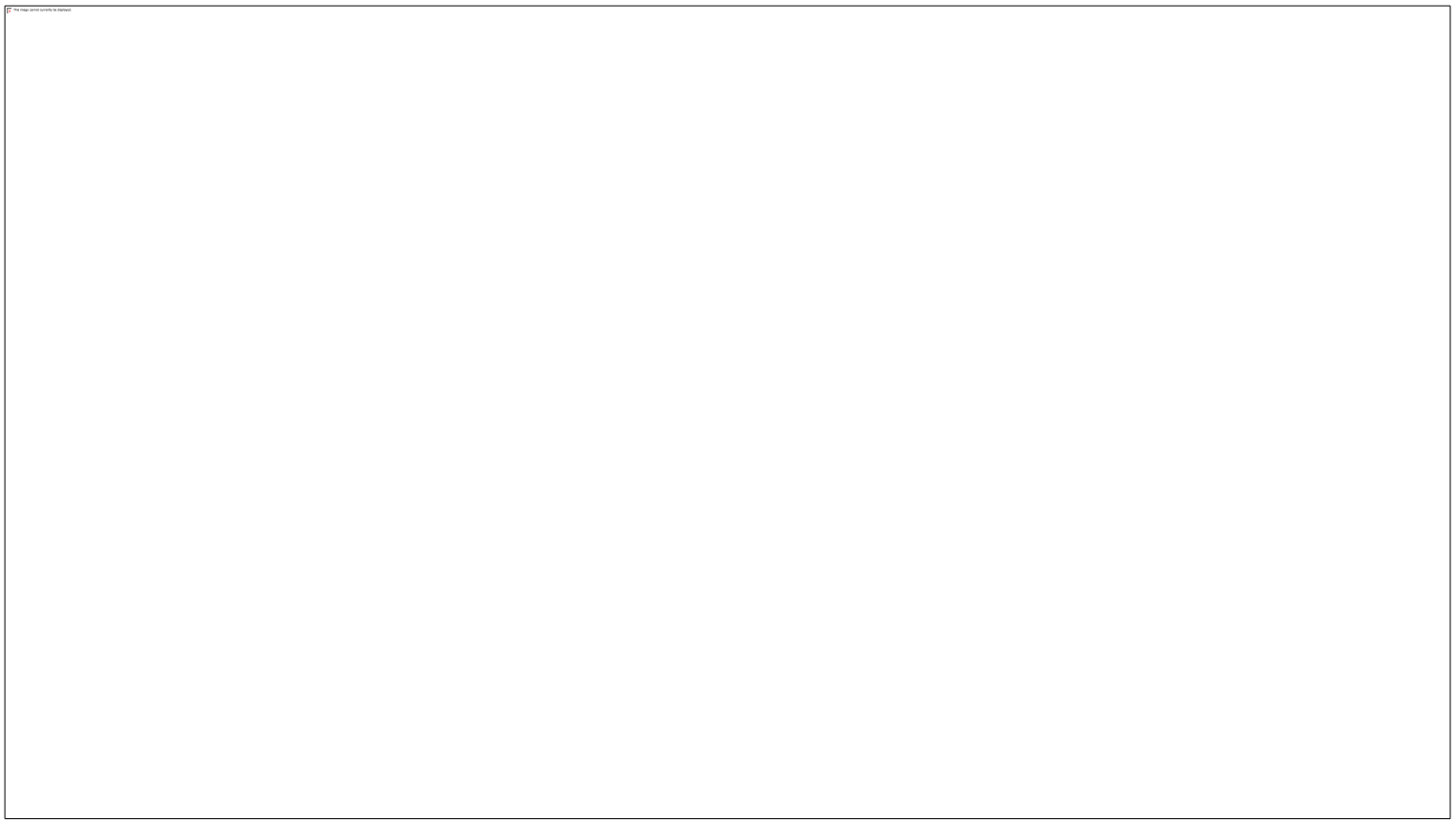
1. Limited to suitable shallow-water locations.
2. May be damaged by strong waves and currents.
3. Changes in water levels can affect the cage.
4. Supporting poles may rot, corrode or become weak.
5. Difficult to relocate once installed.

Examples of materials used

- Treated wooden poles.
- Galvanised metal poles.
- Strong netting material.

- Binding ropes.
- Supporting crossbars.

2.2 Floating fish cages



A **floating fish cage** is a fish-rearing enclosure supported by floating materials that keep the cage at the water surface.

Characteristics

- Has floating rings, frames or pontoons.
- The net hangs below the floating frame.
- Anchors and ropes hold the cage in position.
- The cage moves vertically with changes in water level.
- Can be used in relatively deep water.

Main components

1. Floating frame.
2. Net enclosure.
3. Net weights or sinkers.
4. Mooring ropes.
5. Anchors.
6. Walkway or working platform, where provided.
7. Feeding area.
8. Protective net or bird deterrent, where necessary.

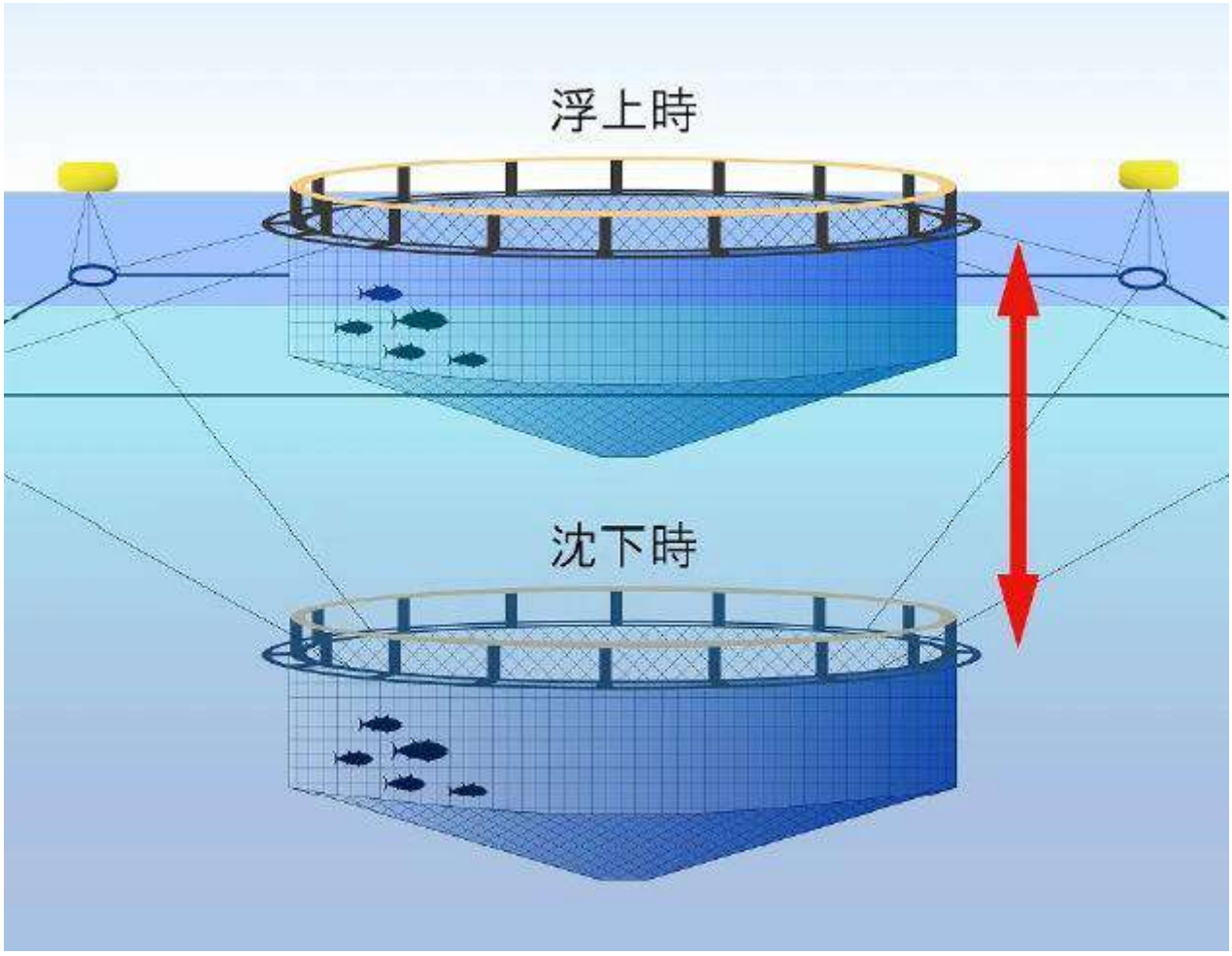
Advantages

- Can be installed in suitable deep water.
- Adjusts to changing water levels.
- Allows easy feeding and monitoring from the surface.
- Can be constructed in different shapes and sizes.
- Can support relatively large-scale fish production.

Disadvantages

- May be expensive to construct.
- Requires proper anchoring.
- Can be damaged by storms and strong waves.
- Nets require frequent inspection.
- Poor management can lead to water pollution.

2.3 Submersible fish cages



A **submersible fish cage** is a cage designed to be lowered below the water surface and raised when necessary.

Characteristics

- Can operate at different water depths.
- Has a specialised supporting structure.
- Uses lifting, lowering or buoyancy-control mechanisms.

- Can be lowered during dangerous surface conditions.
- Can be raised for feeding, inspection and harvesting.

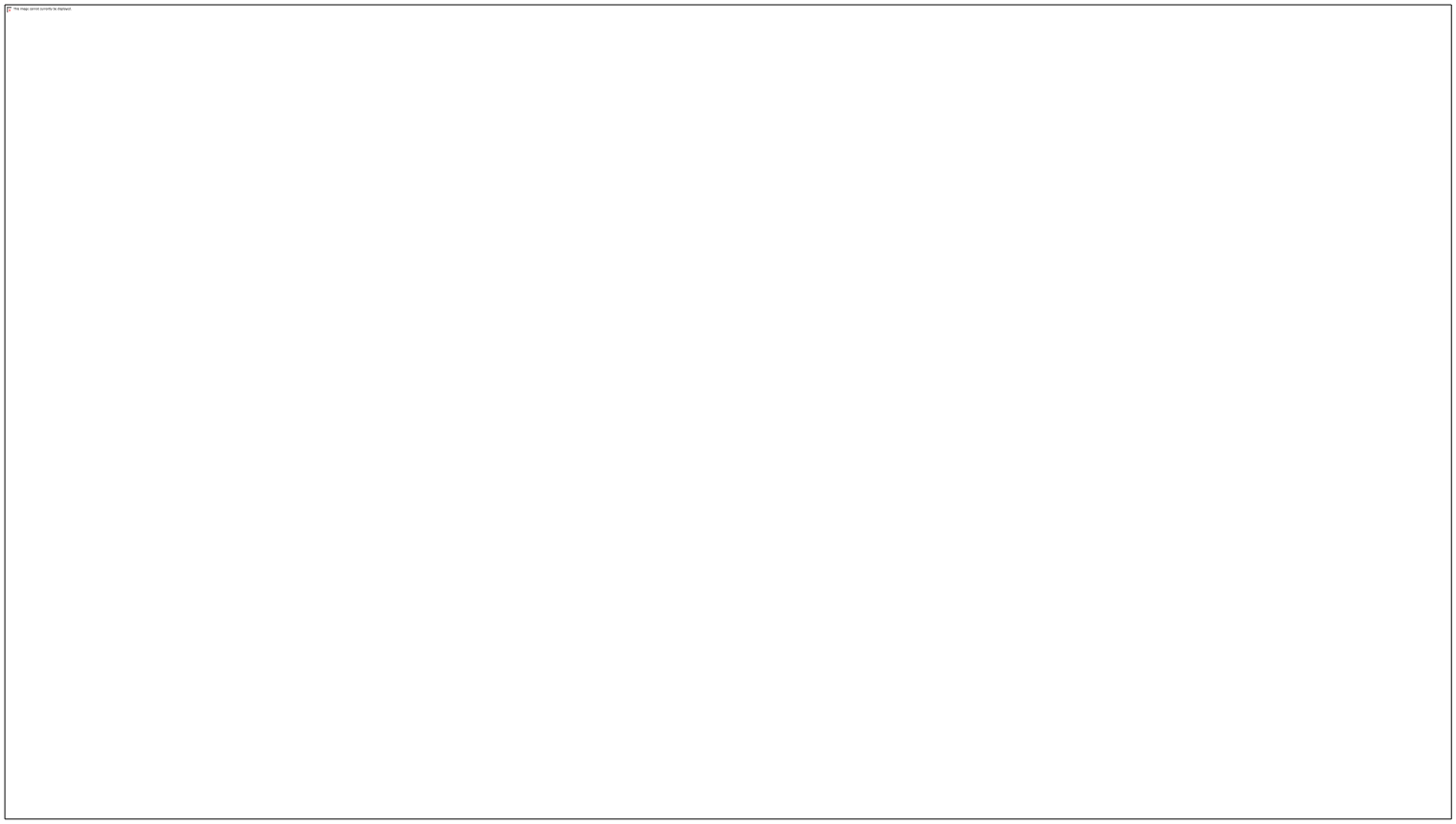
Advantages

1. Can be lowered to avoid some surface disturbances.
2. Offers flexibility in cage positioning.
3. May reduce exposure to strong surface waves.
4. Can access water layers with more suitable conditions.

Disadvantages

1. More expensive than simple floating cages.
2. Requires specialised technical knowledge.
3. Difficult to inspect when underwater.
4. Requires suitable equipment to control depth.
5. Poor positioning can expose fish to unsuitable water conditions.

2.4 Submerged fish cages



A **submerged fish cage** is a cage that remains completely below the water surface during normal operation.

Characteristics

- Located entirely underwater.
- Held in position by anchors and supporting structures.
- May be positioned at a selected water depth.
- Does not normally have its main enclosure floating at the surface.

- Requires specialised arrangements for feeding and monitoring.

Advantages

- Less exposed to some surface disturbances.
- May reduce visual interference with surface activities.
- Can make use of selected underwater locations.

Disadvantages

- Monitoring is more difficult.
- Feeding requires specialised arrangements.
- Maintenance can be challenging.
- Fish may experience oxygen shortages if placed in poorly circulated water.
- Installation and retrieval can be expensive.

2.5 Comparison of the four types of fish cages

Type	Main supporting arrangement	Position in water
Fixed	Poles or posts	Fixed at a particular site
Floating	Floats or pontoons	At the water surface
Submersible	Adjustable buoyancy/lifting system	Can be raised or lowered
Submerged	Anchors and underwater support	Completely underwater

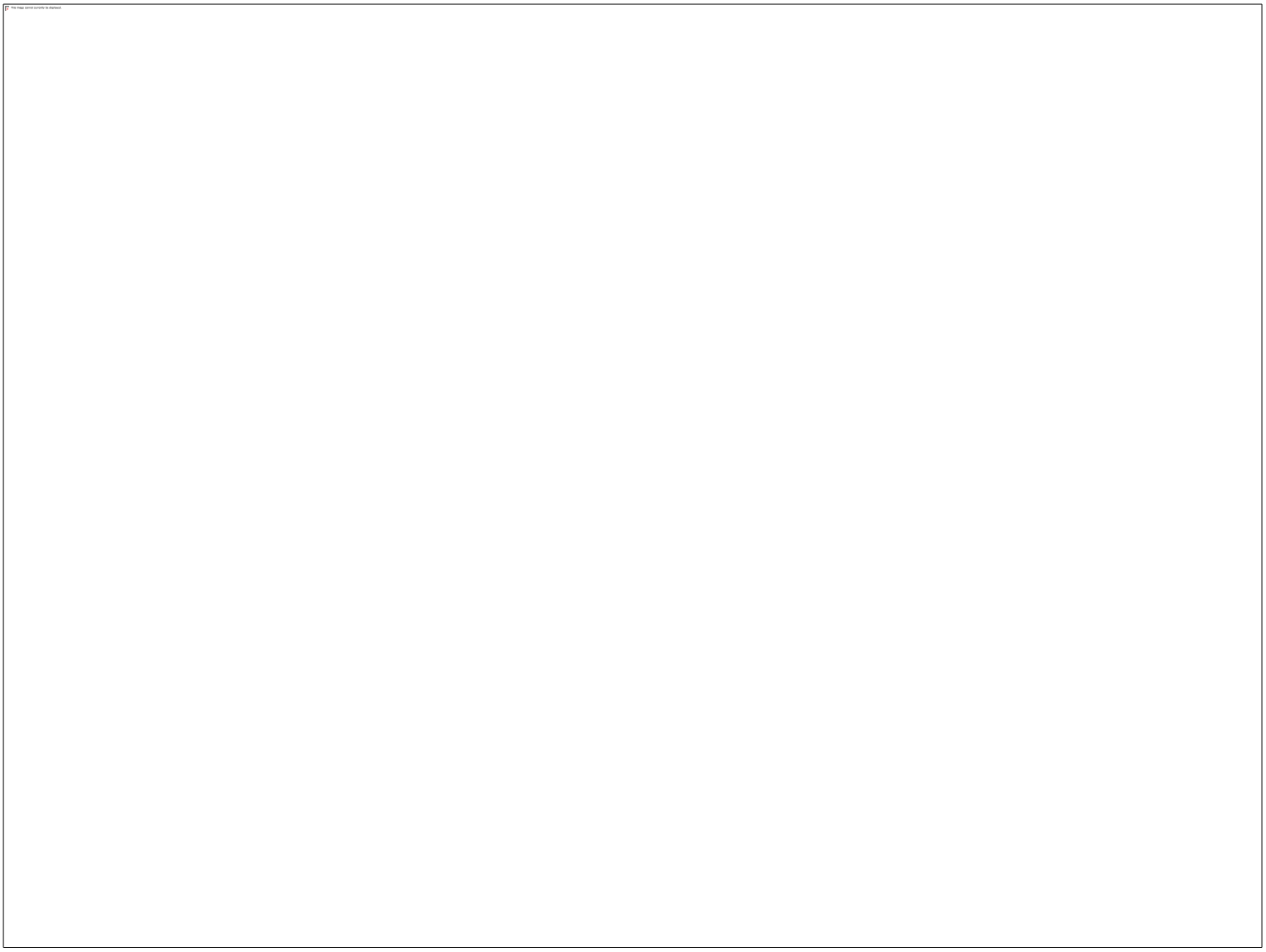
3.0 FACTORS TO CONSIDER WHEN SELECTING A SUITABLE SITE FOR A FISH CAGE

3.1 Meaning of fish cage site selection

Fish cage site selection is the process of identifying and choosing a suitable location in a water body where fish cages can be safely installed and operated successfully.

Proper site selection is important because it influences:

- Fish survival.
- Fish growth.
- Feed utilisation.
- Water quality.
- Production costs.
- Safety of workers.
- Environmental sustainability.
- Profitability of the fish farming enterprise.



3.2 Factors to consider

1. Water depth

Water depth refers to the vertical distance between the water surface and the bottom of the water body.

Considerations:

- The water should be deep enough to accommodate the cage and allow sufficient water circulation below it.
- The cage should not touch the lake or dam bottom.
- Adequate clearance prevents the accumulation of waste around the cage.
- Depth should be sufficient even during periods of low water levels.
- Depth requirements depend on cage dimensions and the species being cultured.

Importance: Adequate depth supports water circulation and helps prevent the cage from becoming obstructed by sediments.

2. Water quality

Water quality refers to the physical, chemical and biological characteristics of water that determine its suitability for aquatic life.

Important water-quality parameters include:

a) Dissolved oxygen

- Refers to oxygen gas dissolved in water.
- Fish use dissolved oxygen during respiration.
- Low dissolved oxygen can cause fish stress, poor growth and death.
- A site should have adequate oxygen throughout the day and night.

b) Water temperature

- Influences fish metabolism, feeding and growth.
- Different fish species have different temperature requirements.
- Extremely high or low temperatures can cause stress and mortality.

c) pH

- Measures how acidic or alkaline water is.
- Extreme pH conditions can harm fish.
- Water should have a pH suitable for the cultured fish species.

d) Water transparency

- Indicates how clear or turbid the water is.
- Excessive turbidity may indicate suspended sediments or pollution.
- Very turbid water can interfere with aquatic ecosystem functioning.

e) Ammonia concentration

- Ammonia is produced from fish waste and decomposing organic matter.
- High concentrations, particularly of unionised ammonia, are toxic to fish.
- The farmer should select a site with good water exchange and monitor ammonia levels.

f) Salinity

- Refers to the concentration of dissolved salts in water.
- The water's salinity must be suitable for the cultured fish species.
- Nile tilapia can tolerate a range of salinities, but freshwater culture is common in Kenya.

3. Water current and circulation

Water current refers to the movement of water from one location to another.

Considerations:

- Moderate currents help supply fresh, oxygenated water.
- Water movement removes some waste materials from around the cage.
- Very strong currents can damage nets and supporting structures.
- Extremely weak currents may encourage the accumulation of waste.
- The site should allow adequate water exchange without exposing the cage to dangerous water movement.

4. Protection from strong waves and storms

- Strong waves can damage cage frames.
- Waves may tear nets and loosen mooring ropes.
- Severe storms may displace or destroy cages.
- Sheltered areas provide better protection.
- The farmer should consider seasonal wind patterns and weather conditions.

5. Accessibility

Accessibility refers to how easily farmers, workers and equipment can reach the fish cage site.

A suitable site should:

- Be accessible by boat or other appropriate means.
- Allow easy transportation of fingerlings.
- Permit delivery of fish feeds.
- Support regular monitoring.
- Allow safe transportation of harvested fish.
- Be accessible during different weather conditions.

6. Navigation routes

- Fish cages should not obstruct boat routes.
- They should not interfere with fishing activities.
- They should not be placed in shipping channels.
- Adequate safety distances and visible markings should be provided.
- Relevant water transport authorities should be consulted where necessary.

7. Security

- The site should be protected against fish theft.
- It should allow regular supervision.
- It should be away from areas with frequent vandalism.
- Appropriate security arrangements should be established.
- Safe access should be available for authorised workers.

8. Pollution sources

A fish cage should be located away from sources of pollution such as:

- Industrial effluent discharge points.
- Untreated sewage outlets.
- Agricultural chemical runoff.
- Oil spills and fuel-handling areas.
- Waste disposal sites.

- Areas receiving excessive domestic waste.

Importance: Pollutants can poison fish, reduce dissolved oxygen and make fish unsafe for human consumption.

9. Bottom topography and substrate

Bottom topography refers to the shape and physical features of the bottom of the water body.

Considerations:

- The bottom should be suitable for securing anchors where required.
- The site should not have excessive sediment accumulation.
- The farmer should understand the nature of the lake or dam bed.
- Anchoring arrangements should be strong enough to withstand water movement.

10. Availability of fingerlings

- The site should be reasonably accessible to reliable fingerling suppliers.
- Transporting fingerlings over long distances increases stress and mortality risks.
- Reliable suppliers help ensure the availability of healthy fish of the correct species and size.

11. Availability of fish feeds

- Commercial fish feeds should be readily available.
- The site should allow convenient transportation and storage of feeds.
- Feed supply should be reliable throughout the production cycle.
- Poor-quality or unavailable feeds can affect fish growth and profitability.

12. Legal and regulatory requirements

In Kenya, fish cage farmers must consider relevant government regulations and approvals.

These may involve:

- Fisheries and aquaculture authorities.
- Environmental assessment and approval requirements.
- Water-body management authorities.
- Navigation and public safety requirements.
- County government requirements where applicable.
- Relevant licences and permissions for using the water body.

The farmer should consult the relevant fisheries and environmental authorities before installing cages.

13. Distance from other fish cages

- Cages should have adequate spacing.
- Proper spacing promotes water circulation.
- It reduces overcrowding of aquaculture facilities.
- It helps minimise the spread of diseases.

- It reduces competition for available environmental resources.

14. Availability of labour

- Skilled and reliable workers should be available.
- Workers are needed for feeding, cleaning, monitoring and harvesting.
- The site should allow safe working conditions.
- Availability of technical support is an added advantage.

15. Market availability

- The site should be reasonably close to fish markets or distribution centres.
- Good transport links reduce post-harvest losses.
- Farmers should assess demand for the fish species being cultured.
- Access to buyers improves business sustainability.

16. Environmental carrying capacity

Environmental carrying capacity is the maximum level of fish production that a water body can support without causing unacceptable environmental degradation.

Considerations:

- The number and size of cages should be controlled.
- Waste production should remain within the water body's ability to absorb and disperse it.
- The farmer should avoid excessive stocking.
- Water quality should be monitored regularly.
- The cumulative effect of other cages in the area should be considered.

3.3 Summary of suitable fish cage site characteristics

A suitable fish cage site should have:

1. Adequate water depth.
2. Good water quality.
3. Moderate water currents.
4. Protection from strong waves.
5. Easy accessibility.
6. No interference with navigation routes.
7. Good security.
8. Minimal pollution.
9. Suitable bottom conditions.
10. Reliable fingerling and feed supplies.
11. Legal approval.
12. Suitable market access.

13. Adequate environmental carrying capacity.

4.0 CONSTRUCTION OF A SIMPLE FISH CAGE

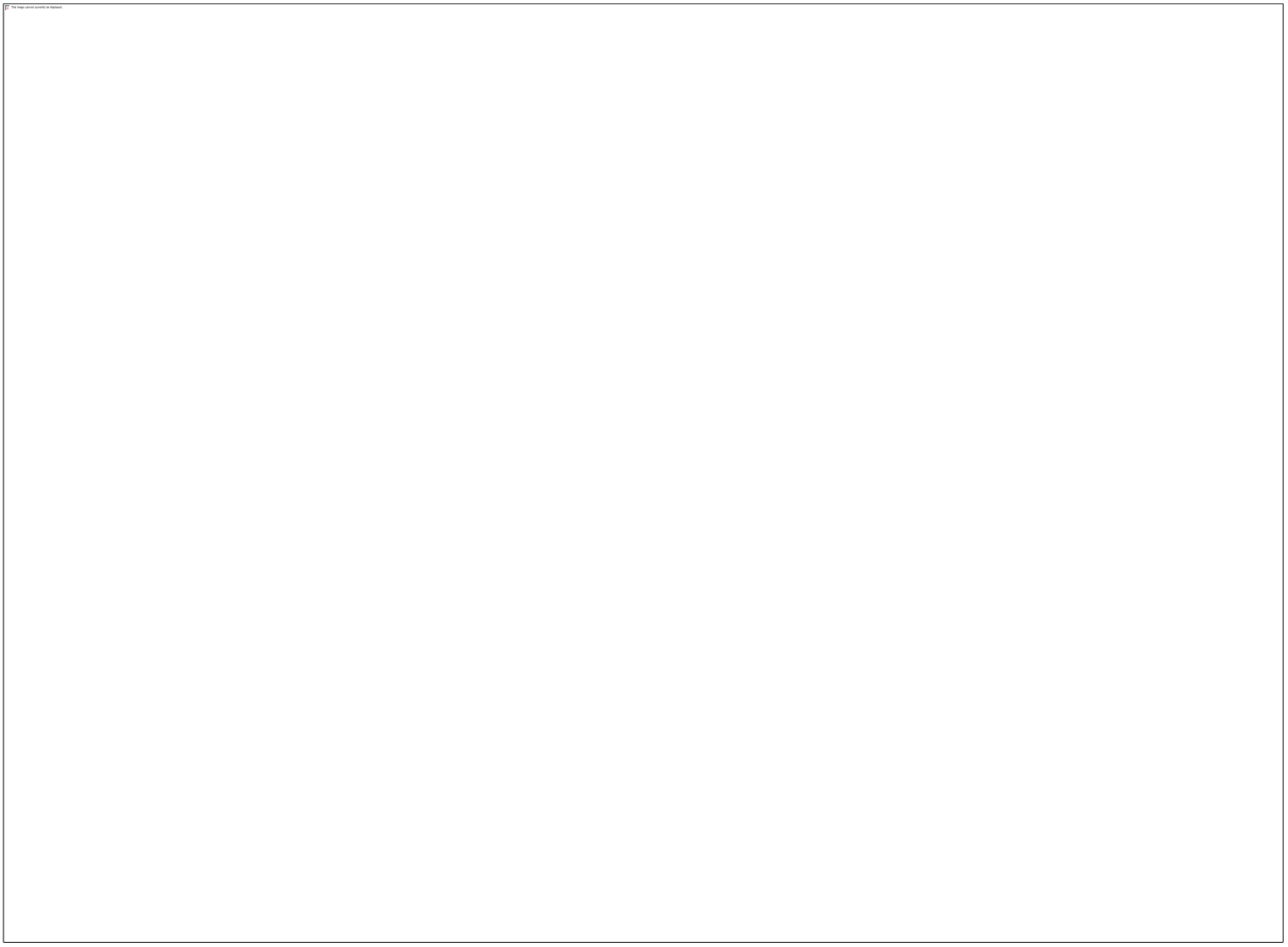
4.1 Meaning of fish cage construction

Fish cage construction is the process of assembling the frame, net enclosure, floating devices, ropes, anchors and other supporting components to form a structure suitable for rearing fish in water.

A fish cage should be:

- Strong enough to withstand water movement.
- Made from durable and non-toxic materials.
- Properly secured to prevent movement or loss.
- Designed to allow free circulation of water.
- Constructed to prevent fish from escaping.
- Easy to inspect, clean and maintain.

4.2 Main components of a floating fish cage



1. Floating frame

- It is the upper supporting structure of the cage.
- It supports the net enclosure.

- It provides a working area for farmers.
- It may be circular, rectangular or square.
- It can be made from high-density polyethylene (HDPE), treated timber or suitable metal materials.

2. Net enclosure

- It is the mesh material that surrounds the fish.
- It prevents fish from escaping.
- It allows water to pass through.
- It should be strong enough to withstand fish movement and water currents.
- The mesh size should be appropriate for the size of fish being cultured.

Qualities of a good cage net

- Strong and durable.
- Resistant to deterioration in water.
- Non-toxic to fish.
- Resistant to tearing.
- Easy to clean.
- Suitable mesh size.
- Resistant to excessive fouling.

3. Floats

- These are materials that provide buoyancy to the cage.
- They keep the cage at the water surface.
- They support the weight of the net and other cage components.
- They may be made from sealed plastic drums, foam-filled floats or specially manufactured flotation units.

4. Mooring ropes

- These are strong ropes used to secure the cage to anchors.
- They prevent the cage from drifting away.
- They help maintain the cage's position.
- They should be resistant to water damage and abrasion.

5. Anchors

- Anchors hold the cage in a fixed position.
- They prevent movement caused by currents and wind.
- They may be made from concrete blocks, metal anchors or other suitable anchoring systems.
- Their size and strength depend on cage size, water depth and environmental conditions.

6. Sinkers and weights

- They are attached to the lower part of the net.
- They help keep the net extended.
- They prevent the bottom of the cage from folding upwards.
- They maintain the intended shape and volume of the net enclosure.

7. Walkway or working platform

- It provides access for feeding and inspection.
- It supports workers during routine management.
- It may be constructed from suitable timber, plastic or metal materials.
- It should be stable and safe.

8. Protective netting

- It may be installed above the cage.
- It helps prevent fish-eating birds from accessing cultured fish.
- It may also reduce fish jumping out of the cage.
- It should not obstruct normal feeding and cage operations.

4.3 Materials required for constructing a simple fish cage

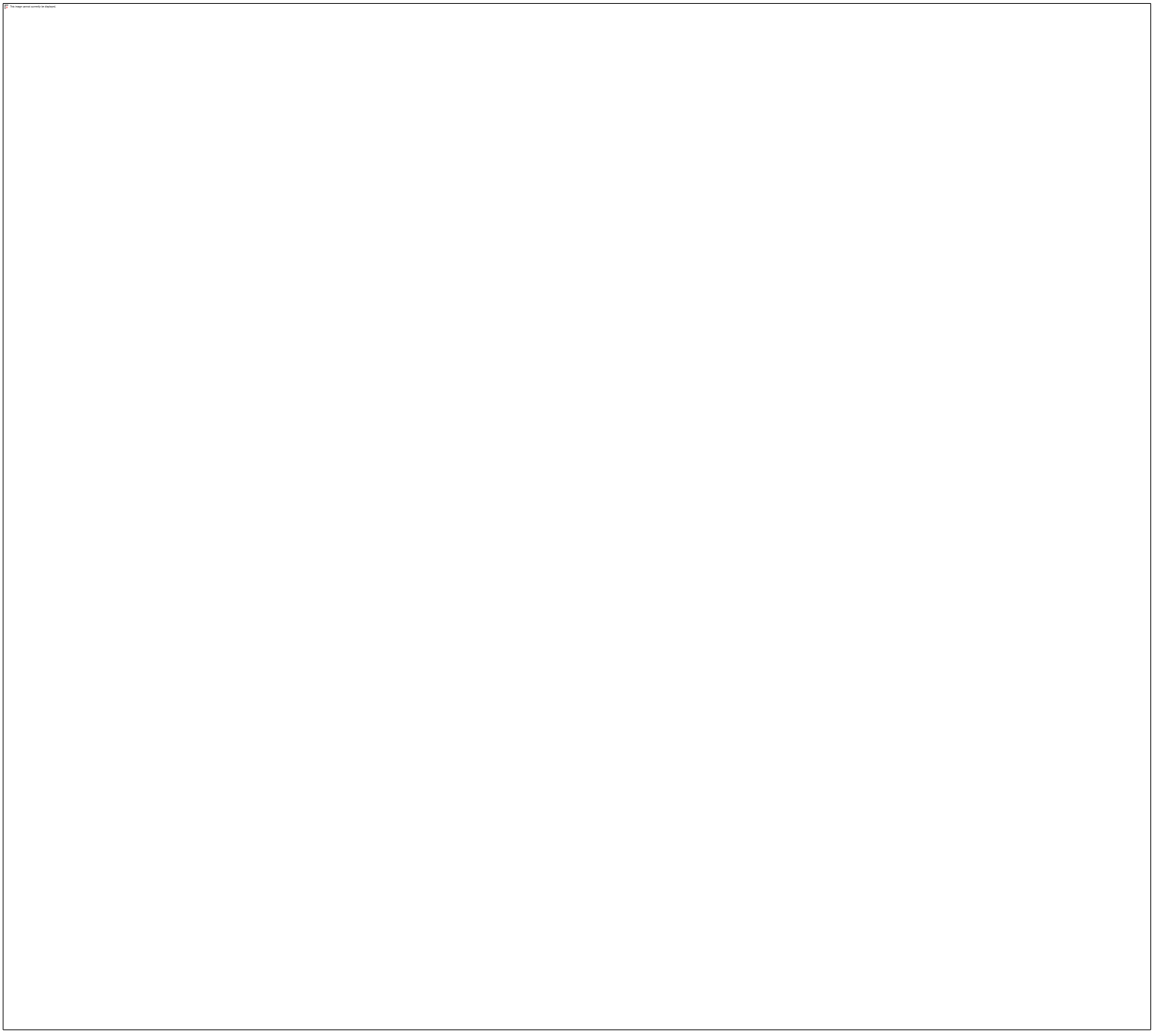
The materials depend on the size, design and location of the cage.

Material	Use
PVC pipes or HDPE pipes	Making the floating frame
Strong netting	Forming the cage enclosure
Nylon ropes	Tying and securing components
Floats	Supporting the cage on water
Concrete blocks	Providing anchorage
Metal or plastic connectors	Joining frame sections
Net weights	Keeping the net extended
Measuring tape	Measuring dimensions
Scissors or netting cutters	Cutting netting

Protective gloves	Protecting hands during construction
Waterproof ties	Securing netting to the frame

Safety precaution: Materials used in construction should not release poisonous substances into the water. Learners should use supervision when handling cutting tools and avoid entering deep or unsafe water.

4.4 Steps involved in constructing a simple floating fish cage





Step 1: Identify the purpose and size of the cage

- Determine the fish species to be cultured.
- Establish the number of fish to be stocked.
- Estimate the desired production.
- Select suitable cage dimensions.
- Consider the available water depth and environmental conditions.

Step 2: Select suitable construction materials

- Obtain strong and durable pipes or frame materials.
- Select suitable fish cage netting.
- Obtain floats, ropes and anchors.
- Ensure that all materials are non-toxic and suitable for aquatic use.
- Check the quality of the materials before construction.

Step 3: Measure and prepare the frame

- Use a measuring tape to establish the required dimensions.
- Cut the frame materials according to the design.
- Arrange the frame components.
- Join them using suitable connectors.
- Ensure the frame is firm and properly aligned.

Step 4: Assemble the floating structure

- Attach floats to the frame.
- Check that the floats provide adequate buoyancy.
- Ensure the frame remains balanced.
- Test the structure in shallow, safe water before installation.

Step 5: Prepare the net enclosure

- Measure and cut the netting according to the cage dimensions.
- Join the net panels securely.
- Form the sides and bottom of the cage.
- Ensure there are no gaps or holes.
- Reinforce weak joints and corners.

Step 6: Attach the net to the frame

- Connect the upper edge of the net to the floating frame.
- Use strong ropes, ties or suitable connectors.
- Ensure the net is firmly attached.
- Avoid leaving openings through which fish may escape.

Step 7: Attach weights and sinkers

- Attach suitable weights to the lower edges of the net.
- Ensure that the net hangs vertically.
- Prevent the net from collapsing or folding.
- Confirm that the enclosure has adequate usable volume.

Step 8: Install the mooring system

- Select suitable anchor positions.
- Secure the mooring ropes to the frame.
- Attach the ropes to suitable anchors.
- Ensure that the cage cannot drift away.
- Allow for changes in water level and movement caused by waves.

Step 9: Install the cage at the selected site

- Transport the assembled cage to the approved site.
- Lower or position it carefully in the water.
- Secure the mooring system.
- Confirm that the cage is stable.
- Check the clearance between the cage bottom and the water-body bed.

Step 10: Inspect and test the cage

- Check the frame for weakness.
- Inspect the net for holes.
- Test the floating ability.
- Check the anchoring system.
- Confirm that water flows freely through the net.
- Make necessary repairs before stocking fish.

Step 11: Prepare the cage for stocking

- Clean the cage.
- Remove unwanted materials.
- Ensure that no harmful chemicals remain.
- Confirm that the water conditions are suitable.
- Obtain healthy fingerlings for stocking.

4.5 Important considerations during fish cage construction

1. **Strength:** The frame must support the cage under normal operating conditions.
2. **Durability:** Materials should withstand prolonged exposure to water and sunlight.
3. **Mesh size:** The net should prevent the stocked fish from escaping.
4. **Water exchange:** The net should allow sufficient water movement.

5. **Buoyancy:** Floats should support the total weight of the structure.
6. **Anchoring:** The mooring system should hold the cage securely.
7. **Accessibility:** The cage should allow easy feeding and inspection.
8. **Safety:** The design should provide safe access for workers.
9. **Environmental protection:** Construction should minimise damage to the water-body ecosystem.
10. **Ease of maintenance:** The design should allow cleaning and replacement of damaged parts.

5.0 STOCKING OF A FISH CAGE

5.1 Meaning of fish cage stocking

Stocking of a fish cage is the process of introducing healthy fingerlings into a prepared fish cage at a recommended number and density.

Stocking is an important stage in cage aquaculture because the number and quality of fish introduced influence growth, survival, feed requirements and final production.







5.2 Important terms used in fish cage stocking

1. Fingerlings

Fingerlings are young fish that have developed beyond the fry stage and are suitable for transfer into a grow-out production system, depending on their size and the cage design.

2. Fry

Fry are young fish at an early stage of development after hatching and absorption of the yolk sac.

3. Stocking density

Stocking density refers to the number or total biomass of fish introduced into a given volume of water.

It can be expressed as:

- Number of fish per cubic metre (fish/m^3).
- Kilograms of fish per cubic metre (kg/m^3).

4. Biomass

Biomass refers to the total weight of all the fish in a cage at a particular time.

Formula:

Biomass=Number of fish×Average fish weight

Example:

A cage contains 500 tilapia, each weighing an average of 100 g.

500×100=50,000g

=50kg

Therefore, the total fish biomass is 50 kg.

5. Acclimatisation

Acclimatisation is the gradual adjustment of fingerlings to the temperature and water conditions of their new environment before release.

6. Nursery net

A nursery net is a smaller mesh enclosure used to hold and rear young fish before they are transferred to a larger grow-out cage.

It helps protect small fish and makes their management easier.

5.3 Factors to consider when stocking a fish cage

1. Fish species

- Select a species suitable for the water conditions.
- Consider the growth rate of the fish.
- Consider the availability of quality fingerlings.
- Consider market demand.
- Consider the feeding requirements of the species.

Example: Nile tilapia is commonly cultured in freshwater cage systems in Kenya.

2. Quality of fingerlings

Healthy fingerlings should:

- Be active and swim normally.
- Have no visible injuries.
- Have no abnormal body shapes.
- Have no visible disease symptoms.
- Be relatively uniform in size.
- Come from a reliable hatchery.

3. Stocking density

- The cage should not be overcrowded.
- Density should be based on the species, fish size, cage design and water quality.
- The farmer should consider the carrying capacity of the water body.
- Excessive stocking can cause poor growth and high mortality.
- The farmer should use professional aquaculture guidance when determining stocking rates.

4. Water quality

Before stocking, assess:

- Dissolved oxygen.
- Water temperature.
- pH.
- Ammonia.
- Water transparency.
- Water circulation.

Poor water quality can cause fingerling stress and death.

5. Size of the cage

- Larger cages can accommodate greater total biomass when other conditions are suitable.
- Cage volume determines the available space for fish.
- Cage size should be appropriate for the intended production level.

6. Availability of feeds

- Sufficient quality feed should be available before stocking.
- Feed should meet the nutritional requirements of the fish.
- The farmer should plan feeding costs.
- Feed storage facilities should be available.

7. Fingerling transportation

- Fingerlings should be transported carefully.
- Use appropriate containers or oxygenated transport bags.
- Avoid overcrowding during transportation.
- Minimise transportation time.
- Avoid sudden temperature changes.

8. Weather conditions

- Stocking should be carried out under suitable weather conditions.
- Avoid unnecessary handling during severe storms.
- High temperatures may increase transportation stress.
- Plan stocking when safe access to the cage is possible.

5.4 Sources of fingerlings

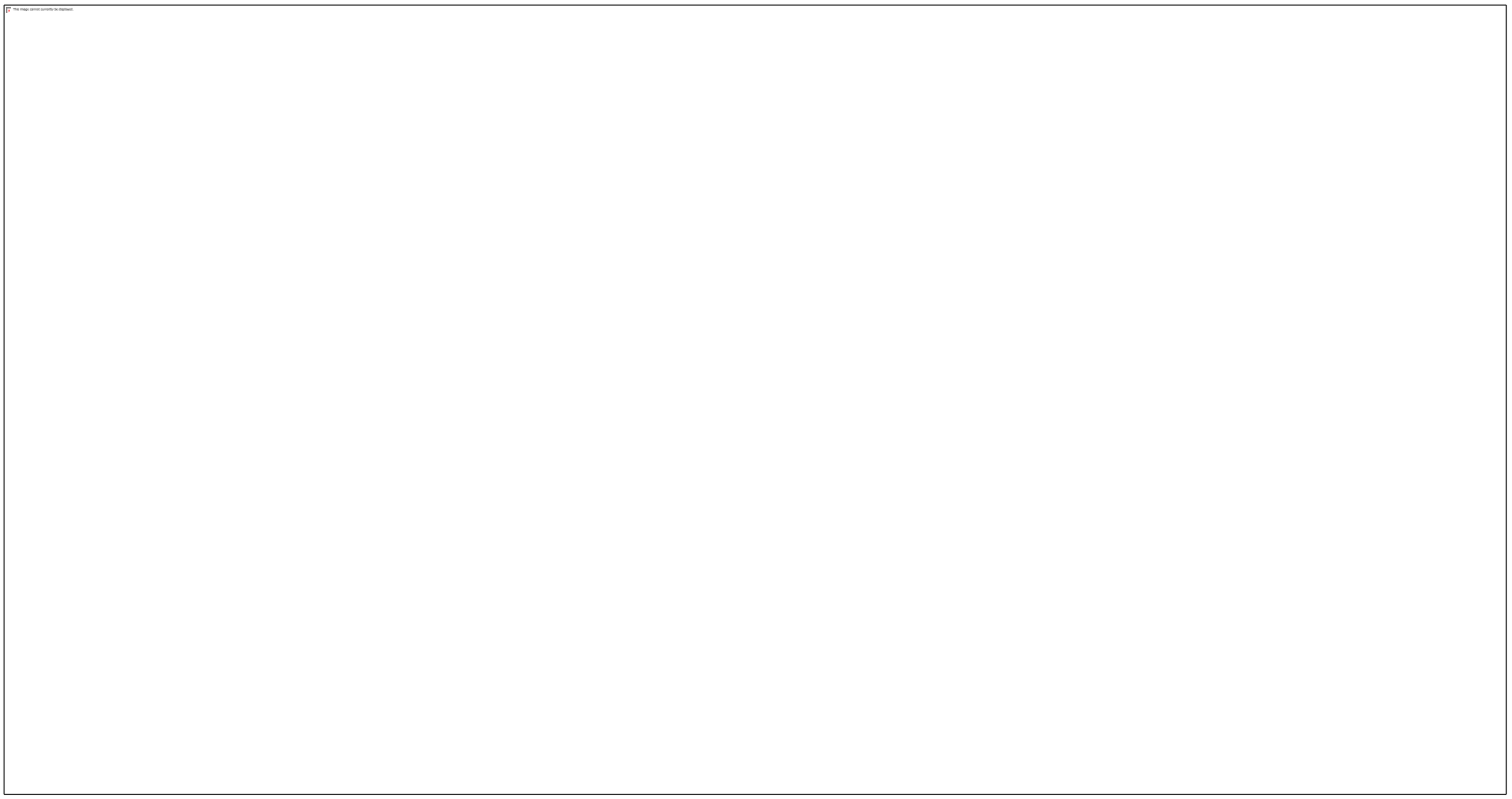
Fingerlings can be obtained from:

1. Registered commercial fish hatcheries.
2. Government-supported aquaculture facilities.
3. Certified private fish farms.

4. Approved aquaculture research and training institutions.

The farmer should obtain fingerlings from reliable suppliers with appropriate health and production records.

5.5 Steps involved in stocking a fish cage



Step 1: Prepare the fish cage

- Inspect the cage for holes and weak joints.
- Clean the net.
- Check the mooring system.
- Confirm that the cage is properly installed.
- Ensure that water quality is suitable.

Step 2: Obtain healthy fingerlings

- Purchase fingerlings from a reliable supplier.
- Confirm the species.
- Check the size and general health of the fish.
- Obtain information about their previous feeding and rearing conditions.
- Record the number of fingerlings purchased.

Step 3: Transport the fingerlings

- Use suitable transport containers.
- Maintain adequate oxygen supply.
- Avoid overcrowding.
- Protect the fish from excessive heat.
- Minimise unnecessary movement and handling.

- Monitor the fish during transportation.

Step 4: Inspect the fingerlings on arrival

- Check their activity.
- Observe for signs of injuries and disease.
- Remove and report dead or unhealthy fish.
- Confirm that the number supplied matches the order.

Step 5: Acclimatise the fingerlings

- Place the sealed transport bags in the cage water for a short period to allow temperature equalisation.
- Gradually introduce small amounts of cage water into the transport container where appropriate.
- Avoid sudden changes in temperature and water chemistry.
- Follow the hatchery or fisheries specialist's acclimatisation instructions.

Step 6: Release the fingerlings

- Gently release the fingerlings into the cage.
- Avoid pouring them forcefully into the water.
- Observe their swimming behaviour.
- Ensure that they are evenly distributed.

Step 7: Use nursery nets where necessary

- Small fingerlings may first be reared in nursery nets.
- The nursery net should have an appropriate mesh size.
- Provide suitable feeds.
- Monitor fish growth and survival.
- Transfer the fish to the grow-out cage when they attain an appropriate size.

Step 8: Record stocking information

The farmer should record:

- Date of stocking.
- Species stocked.
- Number of fingerlings.
- Average fingerling weight.
- Source of fingerlings.
- Supplier's details.
- Cage identification number.
- Any mortalities during stocking.

Step 9: Monitor the fish after stocking

- Observe fish behaviour.
- Monitor feeding response.
- Check for signs of stress.
- Remove dead fish promptly.
- Monitor water quality.
- Keep accurate records.

5.6 Stocking density in fish cages

Stocking density is an important determinant of production success.

It should be established according to:

- Fish species.
- Cage volume.
- Size of fingerlings.
- Water quality.
- Dissolved oxygen availability.
- Water exchange rate.
- Feed quality.
- Management capacity.
- Environmental carrying capacity.

Example of calculating stocking density

A fish cage has the following dimensions:

- Length = 4 m
- Width = 4 m
- Depth = 3 m

First, calculate the cage volume.

$V=L\times W\times D$

$V=4\times4\times3=48m^3$

If 1,440 fingerlings are stocked:

$$Stocking\ density = \frac{1440}{48}$$

$=30$ fish/m^3

Therefore, the stocking density is 30 fish per cubic metre.

Learning point

The figure above is a mathematical illustration, not a universal stocking recommendation. Actual stocking density must be determined using species-specific guidance, water quality and the carrying capacity of the site.

5.7 Importance of proper stocking

1. Promotes uniform fish growth.
2. Reduces overcrowding.
3. Minimises competition for food.
4. Reduces stress among fish.
5. Improves feed utilisation.
6. Helps reduce disease outbreaks.
7. Improves survival rates.
8. Makes monitoring easier.
9. Supports predictable harvesting.
10. Improves profitability.

5.8 Effects of overstocking

Overstocking occurs when more fish are introduced into a cage than its available space and environmental conditions can support.

Effects include:

- Increased competition for feed.
- Reduced dissolved oxygen availability.
- Increased fish stress.
- Slow growth.
- Uneven fish sizes.
- Increased risk of disease transmission.
- Increased accumulation of fish waste.
- Poor feed conversion.
- Increased mortality.
- Reduced quality of harvested fish.

6.0 MANAGEMENT OF A FISH CAGE

6.1 Meaning of fish cage management

Fish cage management refers to the daily and periodic activities undertaken by a fish farmer to ensure healthy fish growth, high survival rates and sustainable production.

Proper management helps to maintain suitable water conditions, prevent diseases, reduce losses and increase farm profitability.



6.2 Major fish cage management practices

6.2.1 Monitoring water quality

Water quality monitoring is the regular assessment of water conditions to determine whether they are suitable for fish survival and growth.

Important parameters include:

A. Dissolved oxygen monitoring

- Measure dissolved oxygen using an appropriate oxygen meter.
- Fish require oxygen for respiration.
- Monitor oxygen especially during early morning hours when levels may be low.
- Take action when oxygen levels approach unsafe limits.
- Avoid excessive stocking and organic waste accumulation.

B. Temperature monitoring

- Use a suitable thermometer or water-quality meter.
- Record water temperature regularly.
- Avoid sudden changes in water temperature during fish handling.

- Observe fish feeding behaviour during temperature changes.

C. pH monitoring

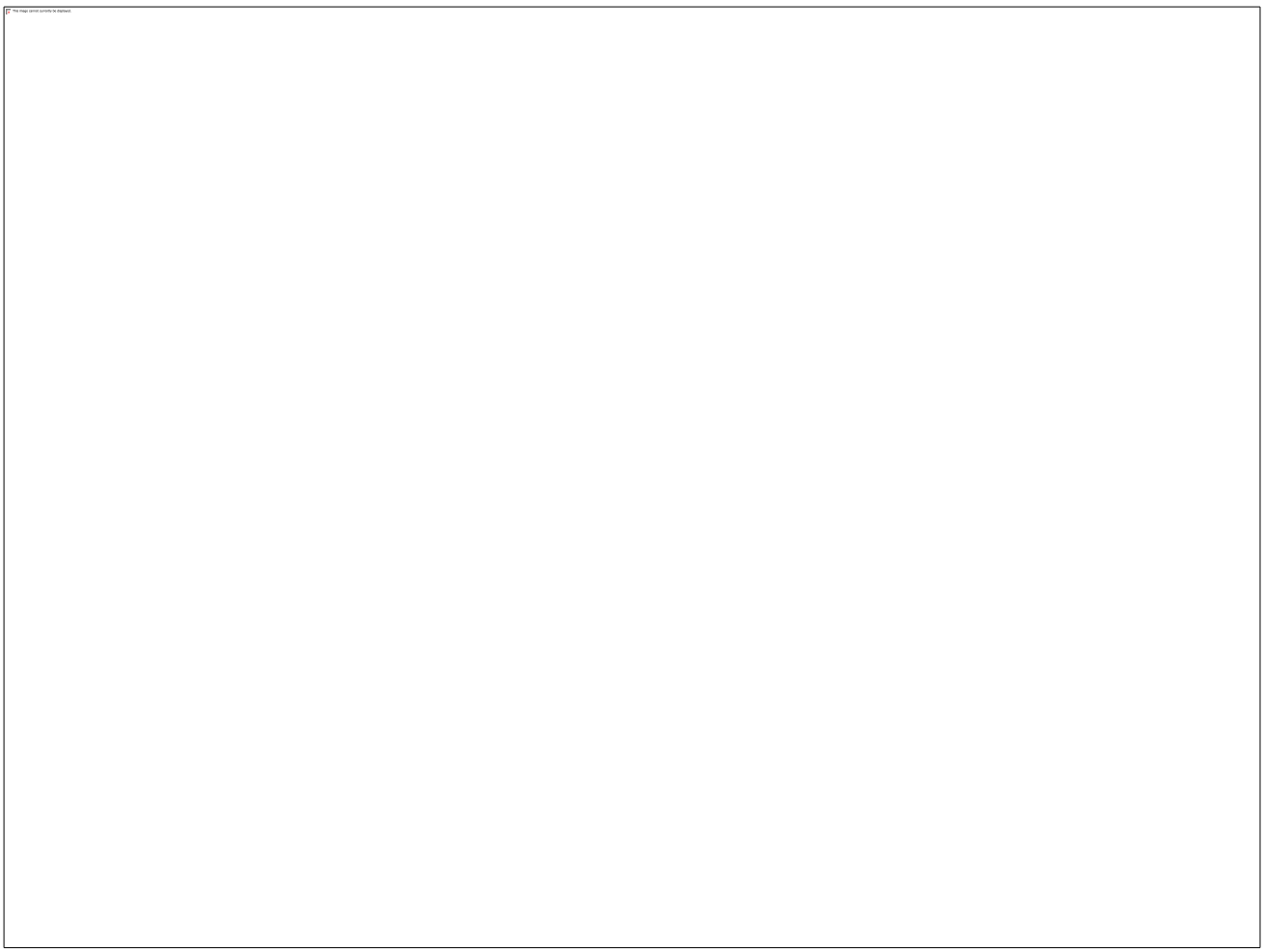
- Use a pH meter or suitable test kit.
- Record pH readings.
- Avoid sudden changes in water chemistry.
- Investigate abnormal readings.

D. Ammonia monitoring

- Use appropriate water-testing kits.
- Ammonia may accumulate from fish excretion and decomposing feed.
- Excessive ammonia can damage fish gills.
- Avoid overfeeding.
- Maintain good water circulation.

E. Water transparency monitoring

- Observe changes in water clarity.
- Excessive turbidity may indicate pollution or suspended materials.
- Investigate sudden changes.
- Record observations.



6.2.2 Feeding management

Feeding management involves providing fish with the correct type and quantity of feed at appropriate times.

Importance of proper feeding

- Promotes rapid growth.
- Improves fish health.
- Supports efficient feed utilisation.
- Reduces wastage.
- Improves production.
- Increases profitability.

Types of fish feeds

1. Floating pellets.
2. Slow-sinking pellets.
3. Sinking pellets.
4. Specialised starter feeds for young fish.

Qualities of good fish feeds

- High nutritional value.
- Appropriate protein content.
- Suitable pellet size.
- Easily digestible.
- Fresh and free from mould.
- Properly stored.
- Appropriate for the fish species and growth stage.

Feeding practices

1. Use feeds recommended for the cultured species.
2. Select the correct pellet size.
3. Feed fish at appropriate intervals.
4. Distribute feed evenly.
5. Observe the feeding response.
6. Avoid excessive feeding.
7. Adjust feeding rates according to fish biomass.
8. Reduce or suspend feeding when water quality is unsafe or fish are severely stressed.
9. Keep feed storage areas clean and dry.
10. Record daily feed quantities.

Factors influencing feeding rates

- Fish size.
- Fish biomass.
- Water temperature.
- Dissolved oxygen.
- Fish species.
- Feed quality.
- Growth stage.
- Health condition.

Feed conversion ratio (FCR)

Feed conversion ratio is the quantity of feed used to produce a unit increase in fish body weight.

$$FCR = \frac{Total\ feed\ consumed\ (kg)}{Weight\ gain\ (kg)}$$

Example:

A farmer feeds fish 120 kg of feed and obtains a fish biomass increase of 100 kg.

$$FCR = \frac{120}{100} = 1.2$$

Therefore, the feed conversion ratio is 1.2.

A lower FCR generally indicates more efficient conversion of feed into fish biomass, provided the production figures are measured accurately.

6.2.3 Monitoring fish growth

- Sample fish at regular intervals.
- Use a suitable fish net or sampling equipment.
- Weigh representative fish.
- Measure fish length where necessary.
- Calculate average body weight.
- Compare growth with expected performance.
- Adjust feeding rates based on updated biomass.
- Record growth data.

Average fish weight formula

Average weight=Total sample weightNumber of fish sampledAverage weight=Number of fish sampledTotal sample weight

Example:

Ten fish have a combined weight of 2 kg.

$$\frac{2}{10} = 0.2kg$$

Average fish weight = 200 g.

6.2.4 Fish disease monitoring and control

Fish disease is a condition that interferes with the normal functioning of fish and may affect growth, survival and production.

Common signs of disease or ill health

- Loss of appetite.
- Abnormal swimming.
- Slow movement.
- Unusual body colour.
- Visible wounds.
- Damaged fins.
- Excessive mucus production.
- Gasping at the water surface.
- Unexplained deaths.

Factors that contribute to fish diseases

1. Poor water quality.
2. Overstocking.
3. Poor nutrition.
4. Injuries during handling.
5. Introduction of infected fingerlings.
6. Poor cage hygiene.
7. Sudden environmental changes.
8. Stress during transportation.

Disease prevention and control measures

- Obtain fingerlings from reliable hatcheries.
- Maintain suitable stocking density.
- Monitor water quality.
- Feed fish with balanced feeds.
- Remove dead fish promptly.
- Avoid unnecessary handling.
- Inspect fish regularly.
- Clean and maintain cage nets.
- Seek assistance from qualified fisheries or aquatic animal health personnel.
- Use medicines only under appropriate professional guidance.

6.2.5 Predator control

Predators are animals that feed on cultured fish.

Examples include:

- Fish-eating birds.
- Otters.
- Predatory fish entering damaged cages.
- Other aquatic animals capable of attacking cultured fish.

Methods of controlling predators

1. Install suitable protective netting.
2. Repair holes in cage nets.
3. Inspect cages regularly.
4. Use appropriate visual deterrents.
5. Maintain secure cage covers.
6. Monitor predator activity.
7. Use humane and legally permitted control methods.

Importance of predator control

- Reduces fish losses.
- Protects fingerlings.
- Improves fish survival.
- Increases production.
- Reduces economic losses.

6.2.6 Record keeping

Record keeping involves documenting all activities and observations related to the operation of a fish cage.

Important records maintained by a fish cage farmer

Record	Information recorded
Stocking records	Number, species, size and source of fingerlings
Feeding records	Feed type, quantity and feeding times
Water quality records	Temperature, dissolved oxygen, pH and ammonia
Growth records	Average fish weight and length
Mortality records	Number of fish that die
Treatment records	Health problems and corrective measures
Maintenance records	Cleaning, net repairs and equipment replacement
Financial records	Expenses, income and profits
Harvest records	Number and weight of fish harvested
Sales records	Quantity sold, buyers and prices

Importance of record keeping

1. Helps monitor fish growth.
2. Helps determine feed requirements.
3. Makes it easier to identify production problems.
4. Helps calculate production costs.
5. Supports business planning.
6. Helps evaluate profitability.
7. Provides information for future production cycles.
8. Helps maintain traceability and accountability.

6.2.7 Biomass estimation

Biomass estimation is the process of determining the total weight of fish in a cage.

It helps the farmer determine:

- Feed requirements.
- Fish growth.
- Production levels.
- Stocking performance.
- Expected harvest quantities.

Example

A cage contains 1,000 fish with an average weight of 250 g.

Biomass=1000×250g

=250,000g=250kg

The total estimated biomass is 250 kg.

6.2.8 Sorting and grading of fish

Sorting is the separation of fish according to size, weight or other characteristics.

Grading involves grouping fish into categories based on selected quality or size standards.

Importance

- Reduces size variation.
- Supports appropriate feeding.
- Helps identify unusually small or unhealthy fish.
- Facilitates marketing.
- Improves harvest planning.

Sorting should be done carefully to minimise injury and stress.

6.2.9 Maintaining suitable stocking levels

- Monitor the number of surviving fish.
- Estimate biomass regularly.
- Avoid introducing excessive numbers.
- Consider the cage's carrying capacity.
- Plan harvesting according to fish growth.
- Consult fisheries specialists when adjusting stocking levels.

6.2.10 Security management

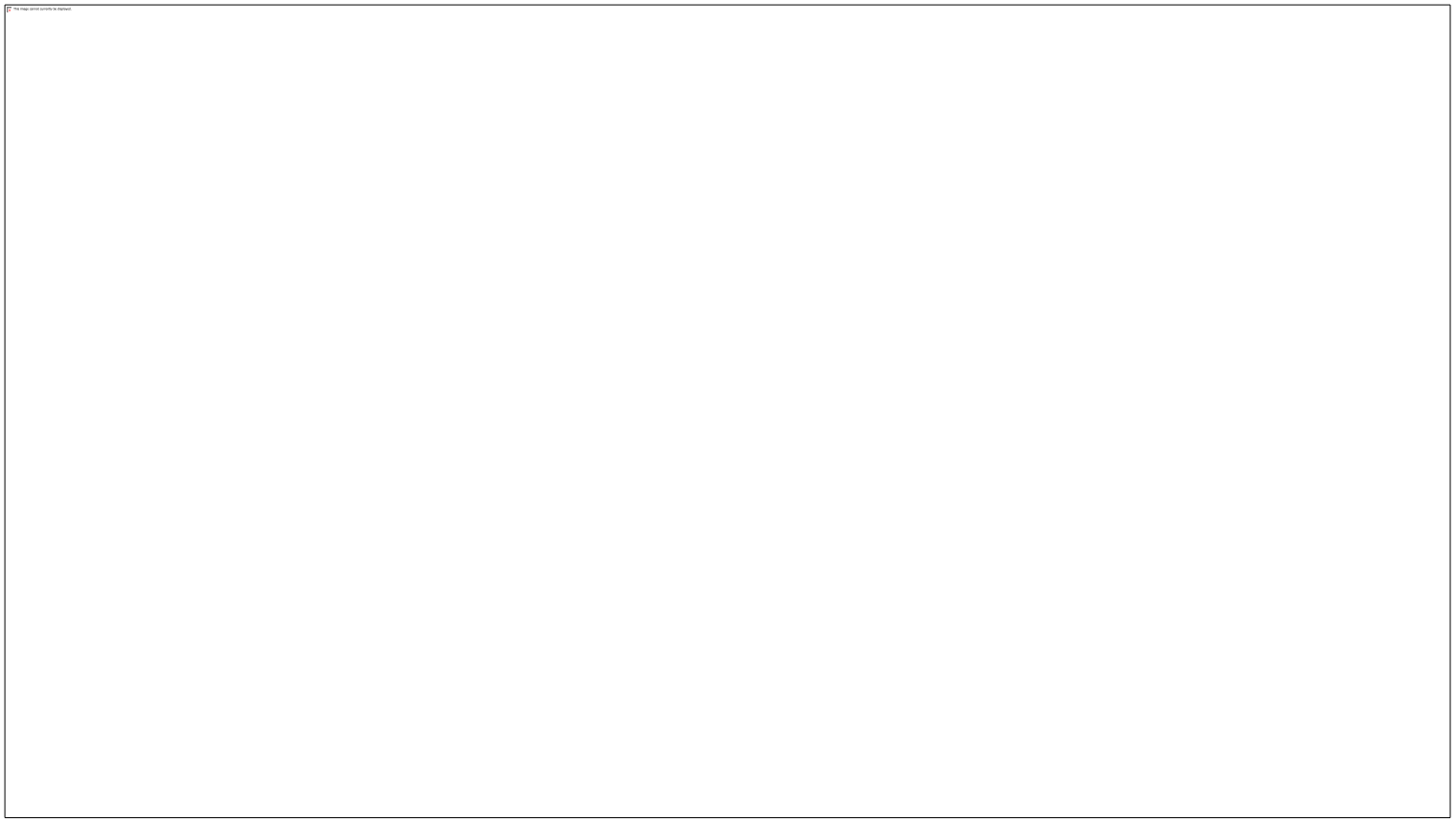
- Inspect the cage site regularly.
- Restrict access to authorised persons.
- Maintain secure mooring systems.
- Keep accurate stocking and harvest records.
- Provide appropriate night-time security where possible.
- Report theft or vandalism to relevant authorities.

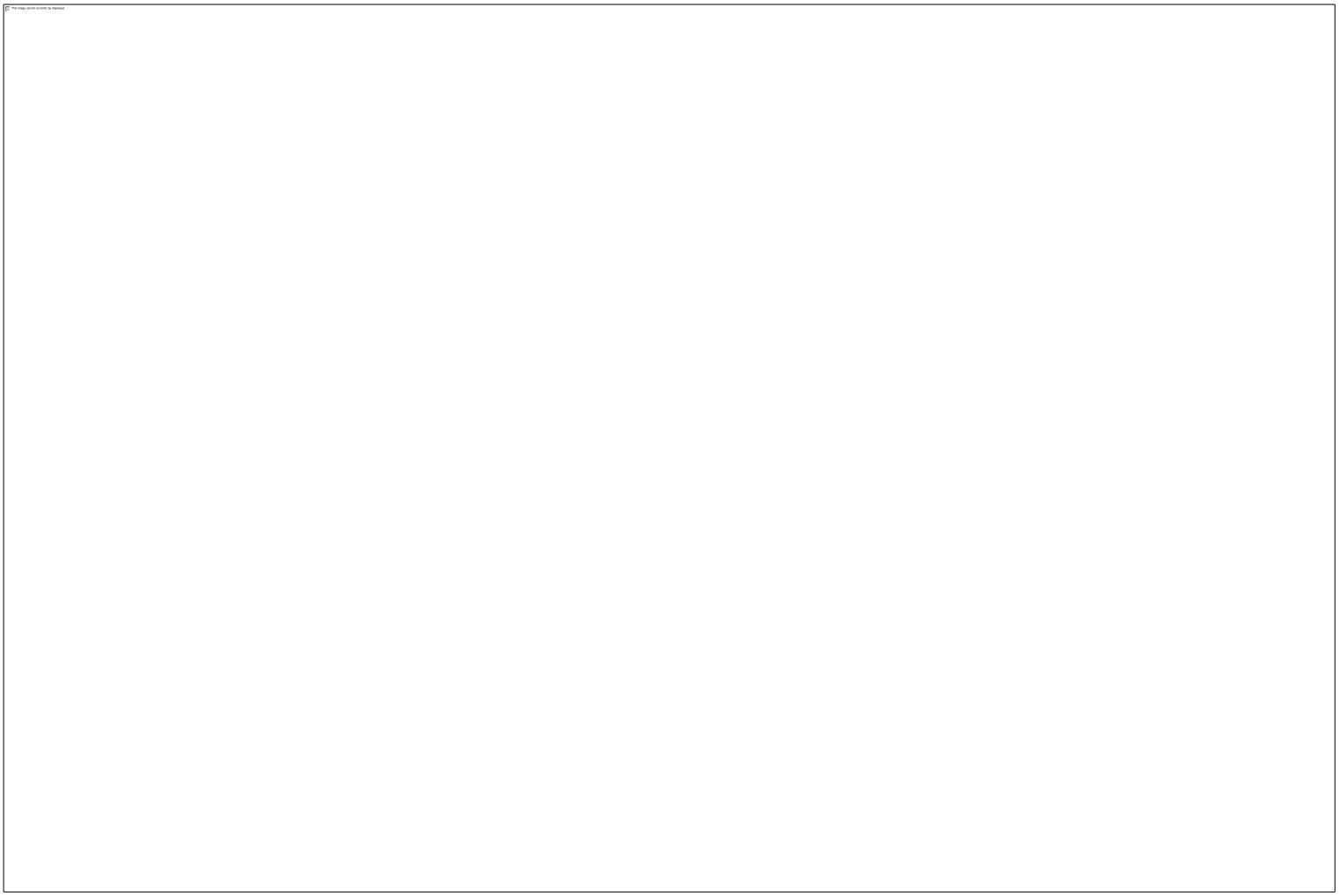
7.0 MAINTENANCE OF A FISH CAGE

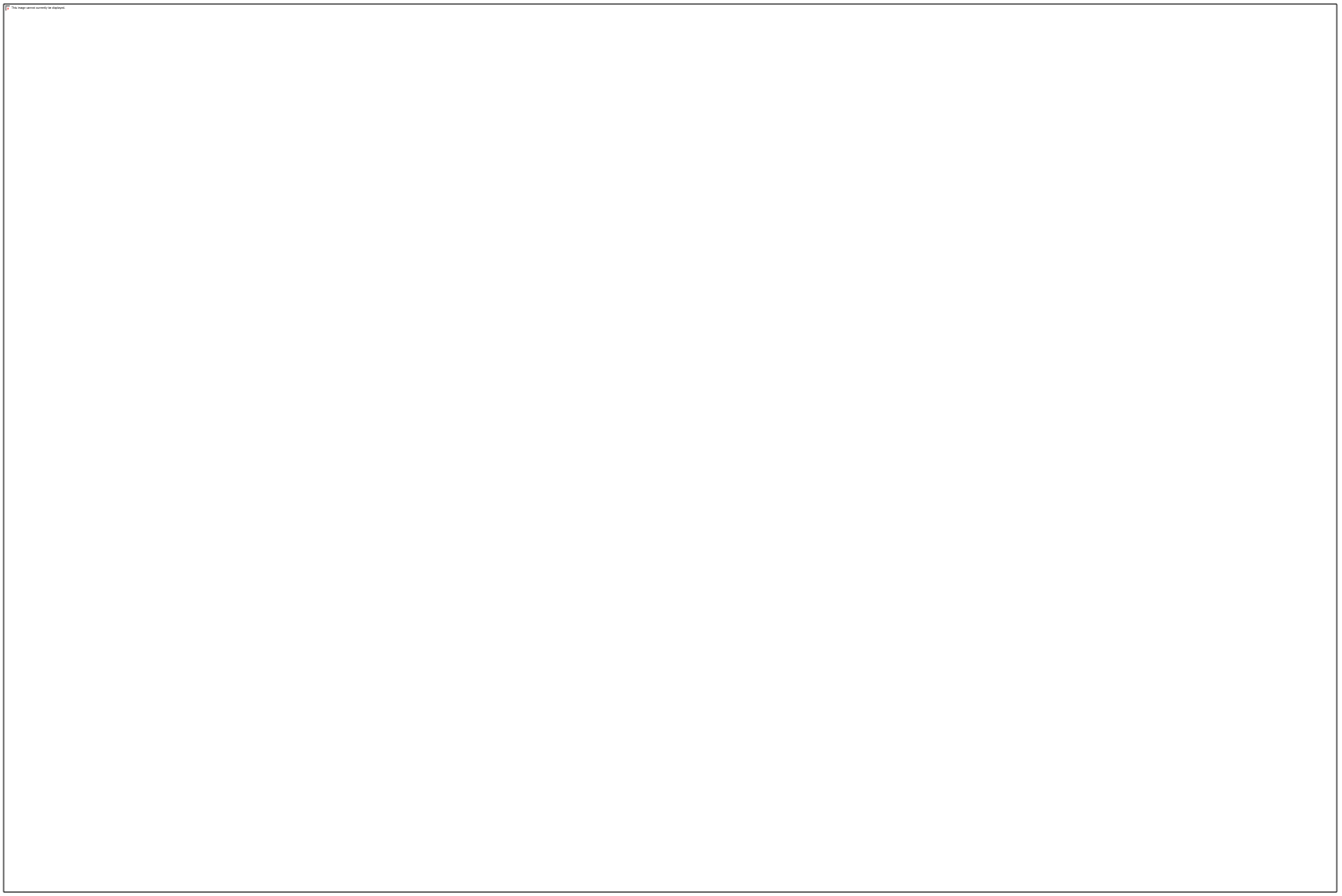
7.1 Meaning of fish cage maintenance

Fish cage maintenance refers to the activities undertaken to keep the cage, nets, floats, ropes, anchors and other equipment in good working condition.

Maintenance prevents equipment failure, fish escape, accidents and unnecessary production losses.







7.2 Major fish cage maintenance practices

1. Regular inspection of nets

- Check the nets for holes and tears.
- Look for weak joints and loose attachments.
- Inspect areas that experience frequent contact with the frame.
- Repair minor damage immediately.
- Replace badly damaged net sections.

Importance: Prevents fish from escaping and predators from entering the cage.

2. Cleaning of nets

- Remove accumulated algae.
- Remove attached aquatic organisms.
- Remove trapped debris.
- Clean nets using appropriate methods.
- Avoid damaging the mesh.
- Ensure that cleaning activities do not introduce harmful substances into the water.

Importance of cleaning

- Improves water circulation.
- Reduces obstruction of net openings.
- Helps maintain dissolved oxygen availability.
- Reduces excessive fouling.
- Makes inspection easier.

3. Changing damaged nets

- Remove badly damaged nets.
- Obtain replacement nets of suitable material and mesh size.
- Transfer fish safely where necessary.
- Attach the replacement net firmly.
- Inspect all connections before restocking or returning fish.

4. Repairing holes and tears

- Identify the damaged area.
- Remove the net from the water where practical and safe.
- Clean the damaged section.
- Use suitable netting material.
- Stitch or secure the patch properly.
- Check that the repair is strong.

- Reinspect the repaired section regularly.

5. Inspecting the floating frame

- Check for cracks.
- Inspect joints and connectors.
- Examine plastic pipes for damage.
- Check for corrosion in metal components.
- Replace weak or broken parts.
- Ensure the frame remains properly aligned.

6. Checking floats

- Inspect floats for leakage.
- Check whether they have lost buoyancy.
- Replace damaged floats.
- Ensure that the cage remains balanced.
- Clean floats where necessary.

7. Inspecting mooring ropes

- Check for fraying.
- Inspect knots and connectors.
- Look for signs of wear and deterioration.
- Replace weak ropes.
- Ensure that ropes are correctly positioned.

8. Inspecting anchors

- Check that anchors remain secure.
- Inspect mooring attachment points.
- Check for signs of movement.
- Reposition or strengthen anchors when necessary.
- Ensure that anchoring arrangements can withstand expected environmental forces.

9. Removing debris

- Remove floating materials trapped around the cage.
- Remove branches and other debris.
- Prevent objects from damaging the net.
- Dispose of waste responsibly.
- Avoid releasing rubbish into the water body.

10. Maintaining walkways and platforms

- Inspect platforms for cracks and loose joints.

- Replace weak boards.
- Ensure that working surfaces are not slippery.
- Maintain handrails where necessary.
- Provide safe access for workers.

11. Controlling biofouling

Biofouling refers to the accumulation of algae, microorganisms and other aquatic organisms on submerged cage surfaces.

Effects of biofouling

- Blocks net openings.
- Reduces water exchange.
- Increases the weight of nets.
- Places extra stress on the cage frame.
- Makes cleaning more difficult.

Control measures

- Regular net inspection.
- Appropriate net cleaning.
- Net rotation and replacement where necessary.
- Use of suitable approved net materials.
- Responsible management of removed organisms.

12. Maintaining feeding equipment

- Clean feeding equipment.
- Inspect automatic feeders.
- Repair damaged feeding pipes.
- Check batteries or power systems where applicable.
- Store feeding equipment safely.

7.3 Difference between fish cage management and maintenance

Fish cage management	Fish cage maintenance
Focuses on fish production and health	Focuses on cage and equipment condition
Includes feeding fish	Includes repairing feeding equipment
Includes monitoring water quality	Includes cleaning and repairing nets
Includes disease prevention	Includes replacing damaged components
Includes fish growth monitoring	Includes checking floats and anchors
Includes record keeping	Includes maintenance records

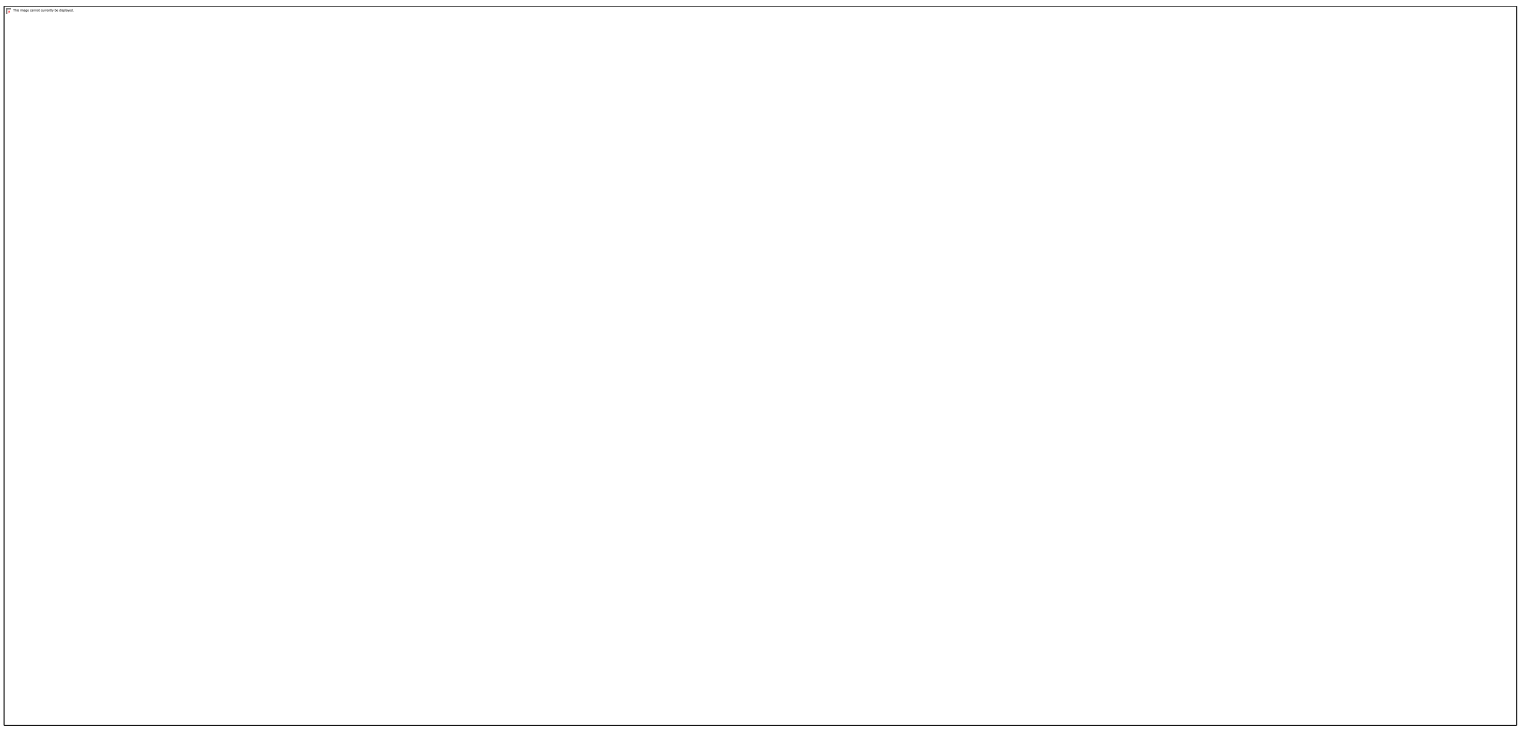
Both activities are necessary for successful cage aquaculture.

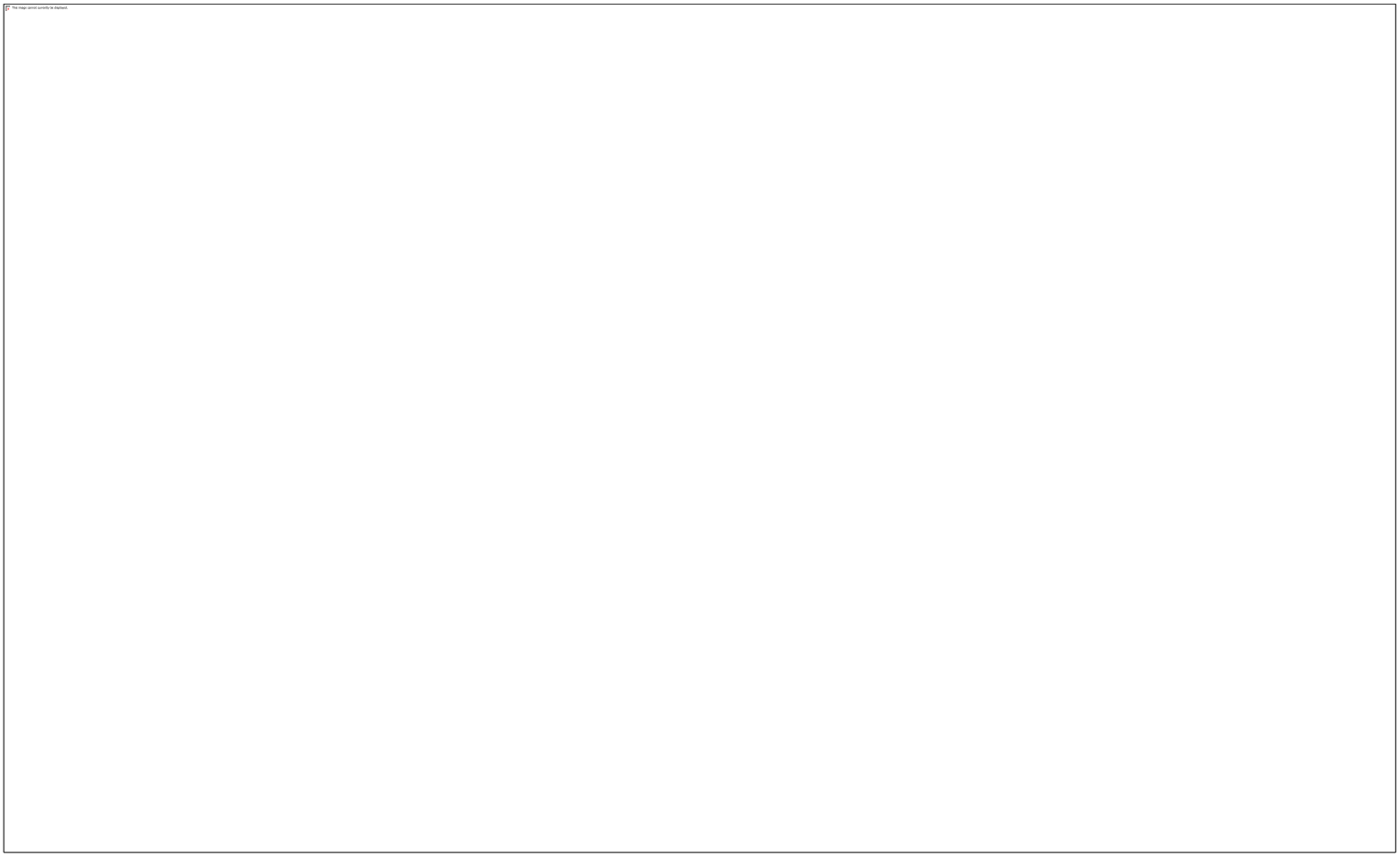
8.0 HARVESTING OF FISH FROM A CAGE

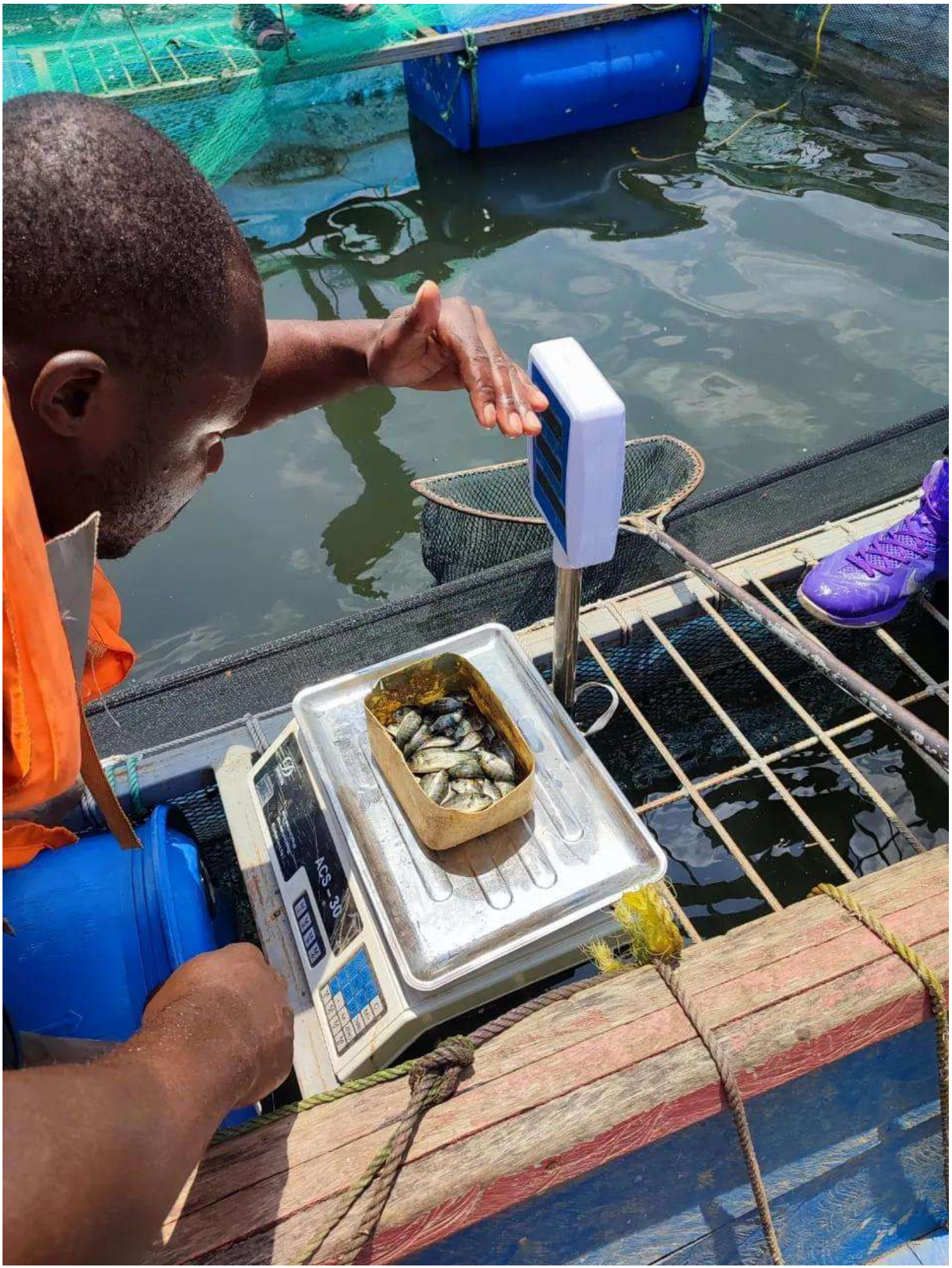
Although stocking, management and maintenance are the major activities in cage aquaculture, harvesting is the final production stage.

8.1 Meaning of fish harvesting

Fish harvesting is the process of removing mature or marketable fish from a cage for sale, processing or consumption.






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8.2 Indicators that fish are ready for harvesting

- Fish have attained the required market size.
- Fish have reached the desired average weight.
- There is market demand.
- The farmer has achieved the intended production period.
- Fish are healthy and suitable for consumption.

8.3 Methods of harvesting fish from cages

1. Partial harvesting

- Only a selected number of fish are removed.
- Smaller fish remain in the cage.
- It allows the farmer to supply fish gradually.
- It reduces the need to harvest the entire stock at once.

2. Complete harvesting

- All marketable fish are removed.
- The cage is emptied.
- The farmer can clean and inspect the cage before another production cycle.
- It is suitable where the production cycle is completed.

8.4 Steps involved in harvesting

1. Plan the harvesting date.
2. Identify the fish to be harvested.
3. Prepare harvesting equipment.
4. Prepare suitable containers.
5. Reduce feeding before harvest according to appropriate fish-handling guidance.
6. Gather fish carefully using suitable nets.
7. Avoid unnecessary injury.
8. Remove fish from the water.
9. Handle fish hygienically.
10. Weigh and grade the harvested fish.
11. Preserve fish using appropriate cooling methods.
12. Transport fish to the market under hygienic conditions.
13. Record the harvest quantity and sales.

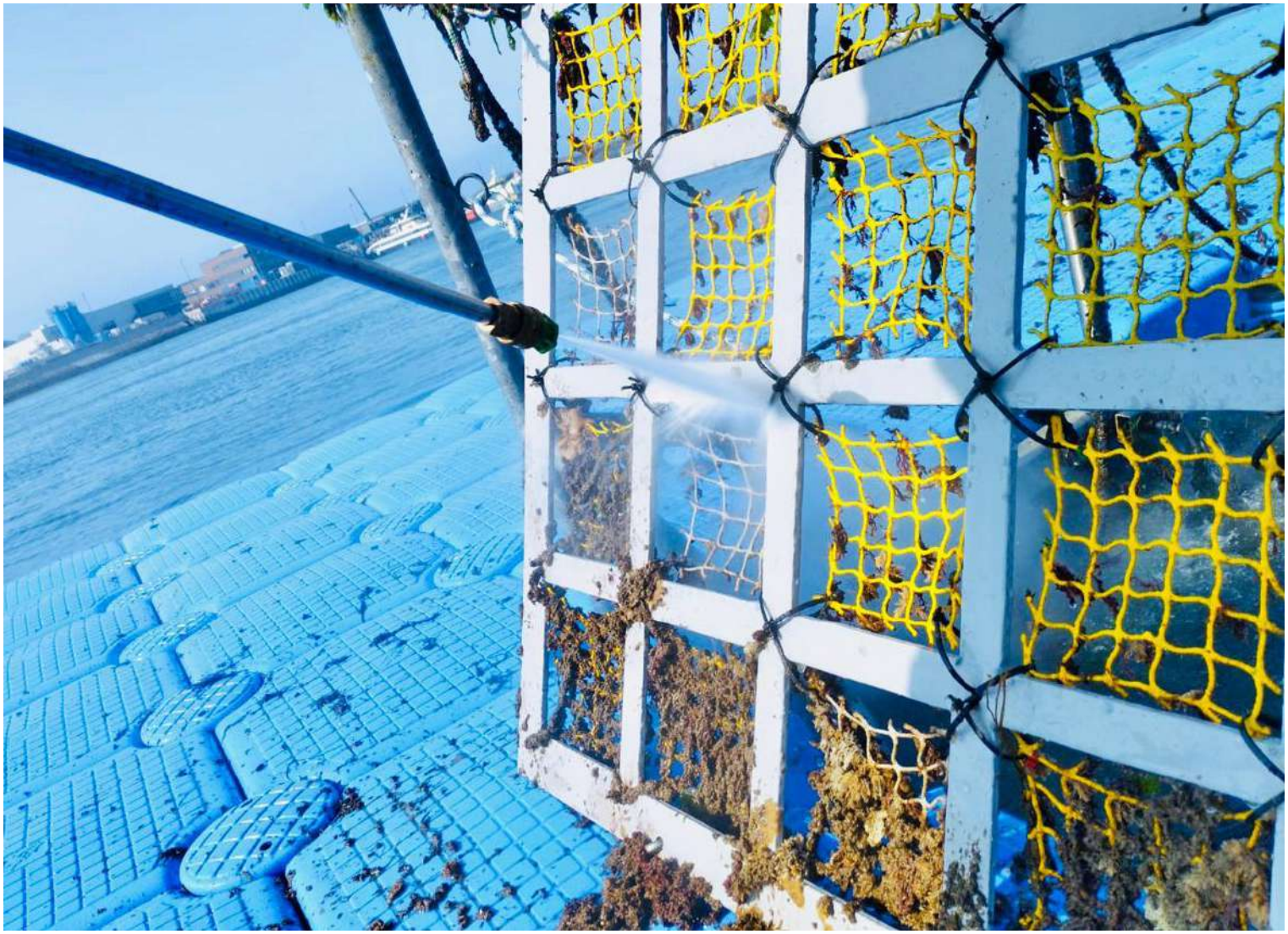
8.5 Importance of proper harvesting

- Reduces physical damage to fish.
- Maintains fish quality.

- Minimises post-harvest losses.
- Improves market value.
- Promotes food safety.
- Supports customer satisfaction.
- Improves profitability.

9.0 CHALLENGES FACING FISH CAGE AQUACULTURE IN KENYA





1. High cost of construction

- Quality nets and floating frames can be expensive.
- Anchoring materials increase installation costs.
- Specialised equipment may be difficult to obtain.

Possible solution: Use durable, locally available approved materials and plan construction costs carefully.

2. High cost of fish feeds

- Commercial feeds may be expensive.
- Feed costs can account for a large proportion of production expenditure.
- Poor feed quality can reduce growth.

Possible solution: Purchase quality feeds from reliable suppliers, reduce wastage and monitor feed conversion.

3. Fish diseases

- Diseases can spread quickly in crowded cages.
- Poor water quality increases stress.
- Infected fingerlings can introduce pathogens.

Possible solution: Maintain good biosecurity, monitor fish health and seek professional assistance.

4. Water pollution

- Agricultural runoff may introduce chemicals.
- Domestic waste can contaminate water.
- Industrial discharge can affect fish survival.

Possible solution: Select clean sites, monitor water quality and support pollution prevention.

5. Predation

- Fish-eating birds and other predators may attack fish.
- Damaged nets allow predators to enter.

Possible solution: Install suitable protective structures and inspect nets regularly.

6. Fish theft

- Fish may be stolen from cages.
- Remote sites may be difficult to supervise.

Possible solution: Improve security, organise community surveillance and maintain proper records.

7. Strong waves and storms

- Severe weather can damage cages.
- Mooring systems may become loose.
- Fish may escape through damaged nets.

Possible solution: Select sheltered sites and install strong anchoring systems.

8. Limited technical skills

- Some farmers lack adequate knowledge of stocking and water-quality management.
- Poor management may cause production losses.

Possible solution: Provide training and seek technical support from fisheries officers and aquaculture specialists.

9. Unreliable fingerling supply

- Healthy fingerlings may not always be available.
- Poor-quality fingerlings may have slow growth and high mortality.

Possible solution: Establish reliable hatchery supply arrangements.

10. Environmental concerns

- Excessive cage numbers can increase organic waste.
- Poorly managed cages may affect aquatic ecosystems.
- Escaped fish may interact with wild populations.

Possible solution: Observe environmental regulations and operate within the water body's carrying capacity.

10.0 ENVIRONMENTAL CONSERVATION AND RESPONSIBLE FISH CAGE FARMING

Fish cage farming should be undertaken in a manner that protects aquatic ecosystems and supports sustainable fish production.

10.1 Environmental conservation practices

1. Avoid installing cages in protected or restricted areas without approval.
2. Avoid blocking natural water movement.
3. Do not dispose of waste materials into lakes and dams.
4. Avoid excessive feeding.
5. Monitor water quality.
6. Control the number of cages according to environmental carrying capacity.
7. Remove dead fish promptly.
8. Dispose of dead fish responsibly.
9. Prevent the escape of cultured fish.
10. Use durable and environmentally suitable materials.
11. Avoid harmful chemicals when cleaning nets.
12. Comply with fisheries and environmental requirements.

10.2 Importance of sustainable cage aquaculture

- Protects aquatic biodiversity.
- Maintains water quality.
- Supports long-term fish production.
- Reduces conflicts with other water users.
- Protects the livelihoods of surrounding communities.
- Promotes responsible use of natural resources.

11.0 SAFETY PRECAUTIONS DURING FISH CAGE OPERATIONS

Fish cage farming involves working near or on water. Therefore, safety must be given priority.

Safety measures

1. Workers should wear suitable life jackets when working on boats or exposed cage platforms.
2. Use non-slip footwear.
3. Avoid working alone in deep water.
4. Inspect walkways before use.
5. Store tools safely.
6. Use protective gloves when handling nets.
7. Avoid direct contact with unknown chemicals.
8. Keep first-aid equipment available.
9. Provide safe boat access.
10. Avoid working during dangerous storms.
11. Train workers in water safety and emergency procedures.

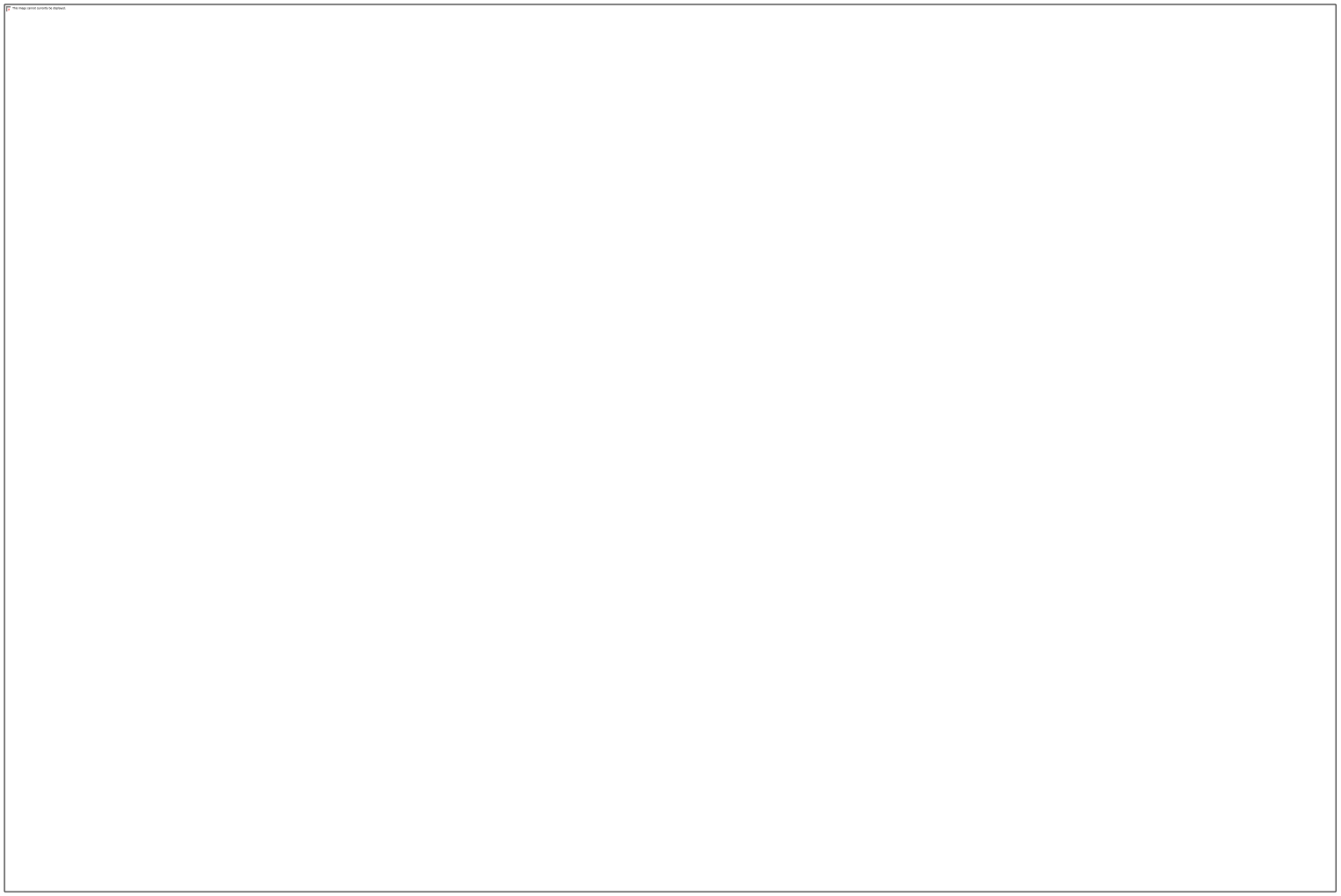
12. Maintain communication equipment.

13. Avoid overloading floating platforms.

14. Ensure that all electrical equipment used near water is suitable and safely installed.

12.0 PRACTICAL PROJECT: CONSTRUCTING A MODEL OF A SIMPLE FISH CAGE





Project title

Making a Model of a Simple Floating Fish Cage

12.1 Purpose of the project

To enable learners to apply practical skills in designing and constructing a simple fish cage model and understanding the components of a floating fish cage.

12.2 Learning outcomes

By the end of the project, the learner should be able to:

1. Identify materials used in constructing a fish cage.
2. Draw a simple fish cage design.
3. Measure and cut construction materials.
4. Assemble a model fish cage.
5. Identify the main components of the cage.
6. Explain the functions of different components.
7. Demonstrate the floating ability of the model.
8. Observe safety precautions during construction.
9. Work collaboratively with other learners.
10. Appreciate fish cages as aquaculture production systems.

12.3 Materials required

- Small plastic pipes or drinking straws.
- Small piece of mosquito netting or suitable mesh.
- Strong thread or nylon strings.
- Small plastic bottles or floats.
- Adhesive suitable for the model.
- Small stones or weights.
- Scissors.
- Ruler.
- Marker pen.
- Shallow basin containing water.

12.4 Procedure

1. Draw a simple design of the proposed fish cage.
2. Measure and cut the frame materials.
3. Join the frame materials to form a square or rectangular structure.
4. Attach small floats around the frame.
5. Measure the netting material.
6. Cut the netting to form the sides and bottom.
7. Attach the net to the frame.
8. Tie a small weight to the bottom of the net.
9. Use strings to represent the mooring ropes.
10. Place the model in a basin of water.
11. Observe whether the model floats.
12. Check whether the net remains extended below the frame.
13. Make adjustments where necessary.
14. Label the main parts of the model.

12.5 Expected observations

- The floats keep the frame at the water surface.
- The net forms an enclosure below the frame.
- The weight helps keep the net extended.
- The ropes represent the anchoring system.
- Water can pass through the netting.
- The model demonstrates how fish are confined within a cage.

12.6 Project presentation

Each group should present:

- The completed fish cage model.
- A labelled drawing.
- A list of materials used.
- The construction procedure.
- The functions of the main components.
- Challenges encountered.
- Suggestions for improving the model.

12.7 Assessment criteria

Assessment area	Marks
Design and planning	5
Selection of materials	5
Construction skills	10
Correct identification of components	5
Functionality and demonstration	5
Safety and teamwork	5
Presentation and explanation	5
Total	40

13.0 IMPORTANT TERMS AND DEFINITIONS

Term	Meaning
Aquaculture	Farming of aquatic organisms under controlled or managed conditions
Fish cage	A net-enclosed structure used for rearing fish in a water body
Fingerlings	Young fish suitable for stocking into a rearing system
Fry	Young fish at an early developmental stage
Stocking	Introducing fish into a rearing facility
Stocking density	Number or biomass of fish per unit volume of water
Biomass	Total weight of fish in a given population
Acclimatisation	Gradual adjustment of fish to new environmental conditions
Nursery net	A small mesh enclosure for rearing young fish
Mooring	Securing a floating structure in a particular position
Anchor	A device used to hold a cage in position
Float	A buoyant component that supports a cage at the water surface
Sinkers	Weights used to keep a cage net extended
Biofouling	Accumulation of aquatic organisms on submerged surfaces
Dissolved oxygen	Oxygen gas available in water for aquatic organisms
Water exchange	Movement of water into and out of a cage
Feed conversion ratio	Quantity of feed used per unit of fish weight gain
Predators	Animals that feed on other animals
Harvesting	Removal of mature fish from a production system
Carrying capacity	Maximum production an environment can support without unacceptable degradation
Net mesh	Openings in the net material
Submersible cage	A cage designed to be lowered below the water surface
Submerged cage	A cage that remains completely below the water surface

REVISION QUESTIONS

GRADE 11 – MARINE TECHNOLOGY

STRAND 2.0: FISH CAGE AQUACULTURE

SUB-STRAND 2.1: FISH CAGE AQUACULTURE

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is a fish cage in aquaculture?

A. A structure used for storing fishing equipment.
B. An enclosed net structure used for rearing fish in water.
C. A structure used for drying harvested fish.
D. A container used for transporting fish.

2. Which of the following fish species is commonly cultured in cages in Kenya?

A. Nile tilapia.
B. Nile perch.
C. Lungfish.
D. Marlin.

3. Which type of fish cage is supported by poles driven into the bottom of a water body?

A. Floating cage.
B. Submerged cage.
C. Fixed cage.
D. Submersible cage.

4. Which component provides buoyancy to a floating fish cage?

A. Anchors.
B. Floats.
C. Sinkers.
D. Net weights.

5. What is the primary function of the netting used in fish cages?

A. To increase water temperature.
B. To prevent water circulation.
C. To provide food for the fish.
D. To confine fish while allowing water to flow through.

6. Which of the following is an important consideration when selecting a site for fish cage installation?

A. Availability of good-quality water.
B. Presence of industrial waste.
C. High levels of water pollution.
D. Proximity to sewage outlets.

7. Why should fish cages be located away from water navigation routes?

A. To increase fish feeding rates.
B. To improve fish colour.
C. To prevent interference with water transport.
D. To increase water temperature.

8. Which water-quality parameter indicates the amount of oxygen available to fish?

A. Salinity.
B. Dissolved oxygen.
C. Transparency.
D. Turbidity.

9. What is the main function of anchors in floating fish cage systems?

A. To increase fish growth.
B. To supply oxygen to fish.
C. To prevent fish diseases.
D. To hold the cage securely in position.

10. Which of the following materials is commonly used in manufacturing fish cage netting?

A. Nylon netting.
B. Paper.
C. Cotton wool.
D. Cardboard.

11. Which type of fish cage can be lowered below the water surface when necessary?

A. Fixed cage.
B. Floating cage.
C. Submersible cage.
D. Traditional pond.

12. What is stocking in fish cage aquaculture?

A. Removing fish from the cage.
B. Introducing fingerlings into a prepared cage.
C. Cleaning the cage netting.
D. Repairing the floating frame.

13. What are fingerlings in fish farming?

A. Mature fish ready for harvesting.
B. Fish eggs awaiting hatching.
C. Processed fish feeds.
D. Young fish suitable for stocking.

14. What is the main purpose of acclimatisation when introducing fingerlings into a fish cage?

A. To allow fish to adjust gradually to new water conditions.
B. To increase the number of fish in the cage.
C. To reduce the size of the cage.
D. To prevent water circulation.

15. Which of the following characteristics indicates healthy fingerlings suitable for stocking?

A. Abnormal swimming behaviour.
B. Visible body injuries.
C. Active swimming behaviour.
D. Unusual body deformities.

16. What is meant by stocking density in fish cage aquaculture?

A. The amount of feed supplied to fish daily.
B. The number or biomass of fish per unit volume of water.

C. The number of cages installed on a fish farm.
D. The amount of water available in a lake.

17. Which of the following is a likely consequence of overstocking fish cages?

A. Improved water circulation in all circumstances.
B. Elimination of fish diseases.
C. Reduced competition for feed.
D. Increased fish stress and mortality.

18. What is the main purpose of using a nursery net in fish cage aquaculture?

A. To rear young fish before transferring them to grow-out cages.
B. To harvest mature fish.
C. To store fish feeds.
D. To prevent water movement.

19. Which of the following practices promotes effective feeding management in fish cages?

A. Feeding fish without considering their sizes.
B. Supplying excessive quantities of feed.
C. Providing appropriate quantities of quality feed.
D. Using mouldy and contaminated feeds.

20. What does the abbreviation FCR represent in aquaculture?

A. Fish Cage Requirement.
B. Feed Conversion Ratio.
C. Fish Culture Record.
D. Feeding Control Rate.

21. Which instrument is used to measure dissolved oxygen levels in water?

A. Thermometer.
B. Measuring tape.
C. Weighing scale.
D. Dissolved oxygen meter.

22. What is biofouling in fish cage aquaculture?

A. Accumulation of aquatic organisms on submerged cage surfaces.
B. Removal of fish from cages.
C. Transportation of fingerlings to a fish farm.
D. Feeding fish using commercial pellets.

23. Which of the following may indicate the presence of disease among cultured fish?

A. Normal swimming behaviour.
B. Healthy feeding behaviour.
C. Loss of appetite.
D. Normal body appearance.

24. Why is it important to remove dead fish from cages promptly?

A. To increase the size of the cage.
B. To reduce pollution and possible disease transmission.
C. To increase water turbidity.
D. To increase stocking density.

25. Which of the following is an appropriate method of controlling predators in fish cage aquaculture?

A. Leaving damaged cage nets unrepaired.
B. Increasing water pollution.
C. Removing all cage floats.
D. Installing suitable protective netting.

26. What is the main purpose of regularly cleaning fish cage nets?

A. To improve water circulation through the cages.
B. To reduce the volume of the cages.
C. To increase fish mortality.
D. To prevent fish from feeding.

27. Which farm record shows the quantity of feed supplied to fish over a given period?

A. Harvest record.
B. Mortality record.
C. Feeding record.
D. Security record.

28. What is meant by partial harvesting in fish cage aquaculture?

A. Removing all fish from the cage at once.
B. Removing some fish while leaving the remaining fish in the cage.
C. Removing the entire cage from the water.
D. Removing all the netting from the cage.

29. Which of the following is an environmental concern associated with poorly managed fish cages?

A. Improved biodiversity in all cases.
B. Elimination of water pollution.
C. Increased natural water purification.
D. Accumulation of organic waste beneath the cages.

30. Which of the following is an essential safety precaution during fish cage operations?

A. Wearing life jackets when working on boats.
B. Working alone in deep water.
C. Carrying out operations during severe storms.
D. Using damaged walkways.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions. Show your working where calculations are required.

QUESTION 1: INTRODUCTION AND TYPES OF FISH CAGES (8 MARKS)

a) Define the term fish cage as used in aquaculture. (2 marks)

b) State four types of fish cages used in aquaculture. (4 marks)

c) State two advantages of using floating fish cages in fish production. (2 marks)

QUESTION 2: SITE SELECTION (8 MARKS)

a) Explain four factors that should be considered when selecting a suitable site for establishing a fish cage. (8 marks)

QUESTION 3: CONSTRUCTION OF A FISH CAGE (8 MARKS)

a) State four materials used in constructing a simple floating fish cage. (4 marks)

b) Explain four steps followed when constructing a simple floating fish cage. (4 marks)

QUESTION 4: STOCKING OF A FISH CAGE (8 MARKS)

a) Define the following terms:

i) Fingerlings. (1 mark)

ii) Stocking density. (1 mark)

b) Explain three considerations when selecting fingerlings for stocking a fish cage. (3 marks)

c) State three practices undertaken when stocking fingerlings into a fish cage. (3 marks)

QUESTION 5: MANAGEMENT AND MAINTENANCE (9 MARKS)

a) Explain three fish cage management practices undertaken to promote healthy fish growth. (3 marks)

b) Explain three maintenance practices undertaken to keep a fish cage in good working condition. (3 marks)

c) State three signs that may indicate the presence of disease in cultured fish. (3 marks)

QUESTION 6: RECORD KEEPING, ENVIRONMENT AND SAFETY (9 MARKS)

a) State three types of records maintained by a fish cage farmer. (3 marks)

b) Explain three environmental conservation practices that should be observed during fish cage farming. (3 marks)

c) State three safety precautions observed during fish cage operations. (3 marks)

TOTAL: 50 MARKS

MARKING SCHEME –

SECTION A: ANSWER KEY

Question	Answer	Question	Answer
1	B	16	B
2	A	17	D
3	C	18	A
4	B	19	C
5	D	20	B
6	A	21	D
7	C	22	A
8	B	23	C
9	D	24	B
10	A	25	D
11	C	26	A
12	B	27	C
13	D	28	B
14	A	29	D
15	C	30	A

SECTION B

QUESTION 1 (8 MARKS)

a) Definition of fish cage. (2 marks)

- An enclosed structure made of netting or mesh supported by a frame and placed in a water body for rearing fish. (2 marks)

b) Types of fish cages. (4 marks)

Award 1 mark each for any four:

1. Fixed fish cage.
2. Floating fish cage.
3. Submersible fish cage.
4. Submerged fish cage.

c) Advantages of floating fish cages. (2 marks)

Award 1 mark each for any two:

- Can be installed in suitable deep water.
- Adjusts to changes in water levels.
- Allows easy feeding and monitoring.
- Can support relatively large-scale production.
- Can be constructed in different sizes and shapes.

QUESTION 2 (8 MARKS)

a) Factors considered when selecting a suitable fish cage site.

Award 2 marks for each well-explained factor, any four.

1. **Water depth:** The water should be sufficiently deep to accommodate the cage without allowing it to touch the bottom.

2. **Water quality:** The water should have suitable dissolved oxygen, temperature and pH for fish survival.
3. **Water current:** Moderate currents promote water exchange and remove some waste materials.
4. **Accessibility:** The site should be easily accessible for transportation of feeds, fingerlings and harvested fish.
5. **Navigation routes:** The cage should not obstruct boats and other water transport activities.
6. **Pollution:** The site should be away from sewage, industrial effluent and other pollution sources.
7. **Security:** The site should be protected against theft and vandalism.
8. **Protection from waves:** The site should be sheltered from destructive waves and strong winds.
9. **Market availability:** The site should allow convenient access to fish markets.
10. **Environmental carrying capacity:** The water body should be able to support the proposed fish production without environmental degradation.
11. **Legal requirements:** The farmer should obtain the necessary approvals and comply with relevant regulations.

QUESTION 3 (8 MARKS)

a) Materials used in constructing a floating fish cage. (4 marks)

Award 1 mark each for any four:

- PVC or HDPE pipes.
- Strong netting material.
- Nylon ropes.
- Floats.
- Concrete anchors.
- Net weights or sinkers.
- Connectors.
- Waterproof ties.

b) Steps involved in constructing a simple floating fish cage. (4 marks)

Award 1 mark each for any four well-explained steps:

1. Measure and prepare the frame materials.
2. Assemble the frame using suitable connectors.
3. Attach floats to the frame.
4. Measure and cut the netting material.
5. Join the netting to form the sides and bottom.
6. Attach the net securely to the floating frame.
7. Attach sinkers to the lower part of the net.
8. Install the mooring ropes and anchors.

9. Test the cage for buoyancy and stability.
10. Inspect the cage for holes and weak joints.

QUESTION 4 (8 MARKS)

a) Definitions.

i) Fingerlings. (1 mark)

- Young fish that have developed beyond the fry stage and are suitable for stocking into a rearing system.

ii) Stocking density. (1 mark)

- The number or biomass of fish stocked per unit volume of water.

b) Considerations when selecting fingerlings. (3 marks)

Award 1 mark each for any three:

- Fingerlings should be healthy and active.
- They should be free from visible diseases.
- They should be relatively uniform in size.
- They should come from a reliable hatchery.
- They should be of the correct species.
- They should be suitable for the intended cage system.

c) Practices undertaken when stocking fish cages. (3 marks)

Award 1 mark each for any three:

- Preparing and inspecting the cage.
- Obtaining healthy fingerlings.
- Transporting fingerlings carefully.
- Acclimatising fingerlings.
- Releasing fingerlings gently.
- Recording stocking information.
- Monitoring fish behaviour after stocking.

QUESTION 5 (9 MARKS)

a) Fish cage management practices. (3 marks)

Award 1 mark each for any three well-explained points:

- **Feeding:** Providing appropriate quantities of balanced feed to promote fish growth.
- **Water-quality monitoring:** Measuring dissolved oxygen, temperature and pH to ensure suitable conditions.
- **Disease monitoring:** Observing fish for signs of disease and taking appropriate control measures.
- **Predator control:** Installing protective netting to prevent predators from attacking fish.
- **Growth monitoring:** Weighing sampled fish to determine growth and adjust feeding rates.

- **Record keeping:** Recording feeding, mortality, stocking and growth information.

b) Maintenance practices. (3 marks)

Award 1 mark each for any three:

- Cleaning nets to remove algae and other attached organisms.
- Repairing torn or damaged nets.
- Replacing badly damaged nets.
- Inspecting floats for leakage.
- Checking mooring ropes for wear.
- Inspecting anchors.
- Repairing damaged frames.
- Removing trapped debris.
- Maintaining walkways and platforms.

c) Signs of fish disease. (3 marks)

Award 1 mark each for any three:

- Loss of appetite.
- Abnormal swimming.
- Visible body wounds.
- Damaged fins.
- Unusual body colour.
- Excessive mucus production.
- Gasping at the water surface.
- Unexplained fish deaths.

QUESTION 6 (9 MARKS)

a) Records maintained by a fish cage farmer. (3 marks)

Award 1 mark each for any three:

- Stocking records.
- Feeding records.
- Water-quality records.
- Growth records.
- Mortality records.
- Treatment records.
- Maintenance records.
- Financial records.
- Harvest records.

- Sales records.

b) Environmental conservation practices. (3 marks)

Award 1 mark each for any three well-explained points:

- Avoid disposing of waste materials into the water body.
- Avoid excessive feeding to minimise organic waste accumulation.
- Monitor water quality regularly.
- Avoid excessive cage stocking.
- Remove dead fish promptly and dispose of them responsibly.
- Prevent cultured fish from escaping.
- Avoid harmful chemicals when cleaning nets.
- Comply with environmental regulations.
- Avoid installing cages in restricted or protected areas without approval.

c) Safety precautions. (3 marks)

Award 1 mark each for any three:

- Wear life jackets when working on boats.
- Use non-slip footwear.
- Avoid working alone in deep water.
- Avoid working during severe storms.
- Inspect walkways before use.
- Keep first-aid equipment available.
- Store tools safely.
- Use protective gloves when handling nets.
- Maintain communication equipment.

16.0 KEY TAKEAWAYS

By the end of this sub-strand, learners should understand that:

1. A fish cage is an enclosed structure used for rearing fish in a water body.
2. The four main types are fixed, floating, submersible and submerged cages.
3. Site selection determines the success and sustainability of cage aquaculture.
4. A fish cage consists of a frame, net enclosure, floats, ropes, anchors and sinkers.
5. Cage construction requires appropriate materials and proper assembly.
6. Stocking involves introducing healthy fingerlings at an appropriate density.
7. Acclimatisation reduces stress during fish transfer.
8. Management includes feeding, water-quality monitoring, disease control, predator control and record keeping.

9. Maintenance includes net cleaning, net repairs, replacement and inspection of cage components.
10. Responsible cage farming protects aquatic ecosystems and promotes sustainable fish production.

CBE COMPETENCIES DEVELOPED

- Communication and collaboration.
- Critical thinking and problem-solving.
- Creativity and imagination.
- Digital literacy.
- Learning to learn.
- Self-efficacy.
- Citizenship.
- Environmental awareness.
- Practical and entrepreneurial skills.

STRAND 2.0: AQUACULTURE

SUB-STRAND 2.2: FISH HARVESTING AND POST-HARVEST HANDLING

1.0 INTRODUCTION

Fish harvesting and post-harvest handling are important activities in aquaculture. They determine the quality, safety, market value and shelf life of fish produced in fish ponds and fish cages.

Fish are highly perishable foods because they contain a lot of moisture, proteins and nutrients that support the growth of microorganisms. Poor handling after harvesting can cause fish to spoil within a short time.

Therefore, fish farmers, fish handlers, processors and traders must observe proper food safety standards during harvesting, transportation, processing, preservation and storage.

In Kenya, fish harvesting and post-harvest handling are important activities in areas such as:

- Lake Victoria region.
- Lake Turkana region.
- Lake Naivasha region.
- Coastal fishing communities.
- Fish farming areas in Kisii, Nyeri, Meru, Nakuru, Kirinyaga and other counties.

Common farmed fish include:

- Nile tilapia.
- African catfish.
- Rainbow trout.
- Common carp.

2.0 MEANING OF KEY TERMS

1. Fish harvesting

Fish harvesting is the process of collecting or removing mature or marketable fish from a fish production system, such as a fish pond or fish cage, for consumption, processing or sale.

2. Post-harvest handling

Post-harvest handling refers to all activities carried out on fish immediately after harvesting to maintain quality, prevent contamination, reduce spoilage and prepare fish for storage, transportation, processing or sale.

3. Fish preservation

Fish preservation refers to the methods used to prevent or slow down fish spoilage so that fish remains safe and suitable for consumption for a longer period.

4. Fish spoilage

Fish spoilage is the deterioration of fish quality due to the activities of microorganisms, enzymes and chemical reactions, making the fish unacceptable or unsafe for consumption.

5. Food safety

Food safety refers to the practices and conditions necessary to ensure that food does not cause harm to consumers when prepared and consumed as intended.

6. Chilling

Chilling is the process of reducing the temperature of fish using ice or refrigeration to slow down bacterial growth and enzymatic activities.

7. Icing

Icing is the process of placing fish in contact with clean ice to lower and maintain its temperature.

8. Fish processing

Fish processing involves activities that transform harvested fish into products that are ready for consumption, preservation, storage or sale.

9. Fish freshness

Fish freshness refers to the condition of fish in terms of its original quality, appearance, smell, texture and suitability for consumption.

10. Cross-contamination

Cross-contamination is the transfer of harmful microorganisms, chemicals or foreign materials from one surface, food item or object to another.

3.0 FOOD SAFETY STANDARDS WHEN HANDLING FISH

3.1 Meaning of Food Safety Standards

Food safety standards are established rules, procedures and practices that ensure fish is harvested, handled, processed, stored and transported under hygienic conditions to protect consumers from foodborne illnesses.

Fish can become contaminated at any stage of handling. Therefore, food safety must be observed from the time fish is harvested until it reaches the consumer.

3.2 Importance of Observing Food Safety Standards

Food safety standards are important because they:

1. **Prevent foodborne diseases:** Proper handling reduces contamination by disease-causing microorganisms such as bacteria.

2. **Maintain fish quality:** Hygienic handling preserves the natural colour, smell, taste and texture of fish.

3. **Reduce fish spoilage:** Proper cooling and storage slow down the growth of microorganisms responsible for spoilage.

4. **Increase shelf life:** Fish that is properly handled and preserved remains suitable for consumption for a longer period.

5. **Protect consumers:** Safe handling prevents people from consuming contaminated or unsafe fish.

6. **Increase market value:** Fresh, clean and properly preserved fish attracts better prices.

7. **Reduce economic losses:** Proper handling prevents unnecessary rejection and wastage of fish.

8. **Promote consumer confidence:** Consumers are more willing to purchase fish from suppliers who maintain good hygiene.

9. **Promote public health:** Safe fish reduces the risk of food poisoning and other food-related illnesses.

10. **Facilitate trade:** Fish that meets required hygiene and quality standards is more acceptable in formal markets.

3.3 Basic Food Safety Standards During Fish Handling

A. Personal Hygiene

Personal hygiene refers to maintaining cleanliness of the body, clothing and hands when handling fish.

Fish handlers should:

1. Wash hands thoroughly with clean running water and soap before handling fish.
2. Wash hands after visiting the toilet.
3. Keep fingernails short and clean.
4. Wear clean protective clothing, such as aprons and overalls.
5. Wear clean gloves when appropriate.
6. Cover cuts and wounds using waterproof dressings.
7. Avoid handling fish when suffering from infectious illnesses.
8. Avoid coughing, sneezing or spitting near fish.
9. Avoid wearing jewellery that can trap dirt and microorganisms.
10. Maintain clean footwear when working in fish processing areas.

Explanation: Dirty hands and clothing can transfer harmful microorganisms to fish, making it unsafe for human consumption.

B. Cleanliness of Equipment and Utensils

Equipment used during harvesting and post-harvest handling must be clean and suitable for food handling.

Examples include:

- Knives.
- Chopping boards.
- Fish baskets.
- Weighing scales.
- Harvesting nets.
- Containers.
- Ice boxes.
- Sorting tables.

Good practices include:

1. Wash equipment before and after use.
2. Use food-grade materials that are easy to clean.
3. Disinfect equipment where necessary using approved methods.
4. Avoid rusty or damaged equipment.
5. Use separate equipment for dirty and clean operations where possible.
6. Store equipment in clean and dry places.
7. Avoid placing fish directly on the ground.
8. Repair damaged containers that may harbour dirt and microorganisms.

C. Use of Safe Water

Water used during fish handling must be clean and suitable for the intended food-handling purpose.

Good practices include:

1. Use potable water when washing fish and food-contact surfaces.
2. Avoid using contaminated river, pond or drainage water.
3. Protect water sources from sewage and chemical pollution.
4. Store water in clean, covered containers.
5. Use clean water when making ice for fish preservation.
6. Avoid reusing dirty water during fish washing.
7. Ensure water storage tanks are regularly cleaned.

Importance of safe water:

- Prevents microbial contamination.
- Removes dirt and unwanted materials.
- Maintains fish hygiene.
- Protects consumers from waterborne diseases.

D. Prevention of Cross-Contamination

Cross-contamination can occur when fish comes into contact with contaminated materials, surfaces or other foods.

It can be prevented by:

1. Separating raw fish from ready-to-eat foods.
2. Using clean chopping boards and knives.
3. Keeping chemicals away from fish.
4. Avoiding contact between fish and dirty surfaces.
5. Using separate containers for waste and harvested fish.
6. Washing hands after handling waste.
7. Keeping pests away from fish processing areas.
8. Separating clean fish from fish that is spoiled or suspected to be contaminated.

E. Temperature Control

Temperature control is the maintenance of appropriate temperatures during fish handling, storage and transportation.

Good practices include:

1. Cool fish immediately after harvesting.
2. Use clean crushed ice to chill fish.
3. Maintain fish at an appropriate chilled temperature, generally around 0°C.
4. Avoid exposing fish to direct sunlight.
5. Use insulated containers during transportation.

6. Avoid unnecessary delays between harvesting and cooling.
7. Monitor storage temperatures using thermometers.
8. Maintain the cold chain until fish reaches the buyer or processor.

The cold chain is the continuous maintenance of appropriate low temperatures from harvesting to consumption or processing.

F. Proper Waste Disposal

Waste materials generated during fish handling should be disposed of safely.

Examples include:

- Fish scales.
- Fish intestines.
- Spoilt fish.
- Dirty water.
- Used packaging materials.

Good waste management practices include:

1. Collect fish waste in covered containers.
2. Remove waste from processing areas regularly.
3. Dispose of waste in approved locations.
4. Avoid dumping fish waste into water bodies.
5. Clean waste storage containers regularly.
6. Prevent waste from attracting flies, rats and other pests.

G. Protection Against Pests

Fish should be protected from insects, rodents, birds and other animals.

This can be achieved by:

1. Keeping processing rooms clean.
2. Covering fish during handling and storage.
3. Installing appropriate screens on windows.
4. Storing fish in closed containers.
5. Removing food waste regularly.
6. Using approved pest-control measures.
7. Avoiding stagnant water around processing areas.

3.4 Common Sources of Fish Contamination

Source	Possible contamination

Dirty hands	Harmful microorganisms
Contaminated water	Bacteria and parasites
Dirty knives	Microorganisms and dirt
Flies	Disease-causing microorganisms
Chemicals	Chemical residues
Dirty containers	Bacteria and foreign materials
Soil and mud	Dirt and microorganisms
Spoilt fish	Microbial contamination
Poor storage	Rapid microbial growth

4.0 FISH HARVESTING

4.1 Meaning of Fish Harvesting

Fish harvesting is the removal of marketable fish from a fish production system for consumption, processing, sale or further distribution.

Harvesting is an important stage in aquaculture because it determines the quantity and quality of fish obtained from a production unit.

4.2 Reasons for Harvesting Fish

Fish are harvested for the following reasons:

1. **When they attain marketable size:** Fish are removed when they reach the required weight and size preferred by consumers.

2. **To generate income:** Farmers harvest fish to sell to consumers, traders, hotels and fish processors.

3. **To reduce overcrowding:** Removing some fish reduces competition for food and space.

4. **To improve growth:** Selective harvesting allows the remaining fish to grow with reduced competition.

5. **To supply household food:** Fish provides proteins and other essential nutrients.

6. **To prevent losses:** Harvesting may be necessary when fish are threatened by disease, poor water quality or other environmental conditions.

7. **To prepare ponds for restocking:** Complete harvesting allows farmers to prepare ponds for another production cycle.

8. **To meet market demand:** Farmers may harvest fish when there is demand for particular sizes or quantities.

4.3 Factors to Consider Before Harvesting Fish

Before harvesting fish, the farmer should consider:

1. **Market demand:** Determine the quantity and size of fish required by buyers.
2. **Fish size:** Assess whether fish have reached the desired marketable size.
3. **Fish health:** Harvest healthy fish and assess any signs of disease.
4. **Weather conditions:** Choose suitable weather to reduce handling difficulties and delays.
5. **Availability of equipment:** Ensure harvesting nets, baskets, weighing scales and containers are available.
6. **Availability of ice:** Prepare sufficient clean ice before harvesting.
7. **Labour availability:** Ensure enough trained workers are available.
8. **Market arrangements:** Organise transportation and buyers in advance.
9. **Water quality:** Assess pond or cage conditions before harvesting.
10. **Food safety requirements:** Ensure that hygiene and sanitation measures are in place.
11. **Harvesting time:** Early morning or cooler periods may be suitable because they reduce exposure to high temperatures.
12. **Harvesting method:** Select a method that minimises injury and stress to fish.

5.0 METHODS OF HARVESTING FISH FROM A FISH POND

A fish pond is an artificial or constructed water body used for raising fish under controlled conditions.

Fish ponds are commonly used in Kenya for farming Nile tilapia and African catfish.

5.1 Partial Harvesting

Partial harvesting is the removal of some marketable fish from a pond while leaving the remaining fish to continue growing.

It is also referred to as selective harvesting.

Procedures involved:

1. Identify fish that have attained marketable size.
2. Prepare suitable harvesting nets.
3. Inspect the net for damage.
4. Reduce feeding shortly before harvesting according to the farm's harvesting plan.
5. Carefully introduce the net into the pond.
6. Move the net to collect the target fish.
7. Lift the net slowly to avoid injuring fish.
8. Select fish of the required size.
9. Transfer harvested fish into clean containers containing suitable water.
10. Move the harvested fish to the handling area for further processing and chilling.
11. Return undersized fish carefully into the pond.
12. Record the number and weight of fish harvested.

Advantages of partial harvesting

- Allows continuous fish production.
- Provides regular income.
- Reduces overcrowding.
- Allows smaller fish to continue growing.
- Meets different market demands.
- Reduces the need to drain the entire pond.

Disadvantages of partial harvesting

- May cause stress to fish.
- Requires repeated labour.
- May disturb fish remaining in the pond.
- Some fish may escape during harvesting.
- Requires careful selection of marketable fish.

5.2 Complete Harvesting

Complete harvesting is the removal of all or nearly all fish from a pond at the end of a production cycle.

It may involve draining the pond or using suitable harvesting nets.

Procedures involved:

1. Identify the appropriate harvesting date.
2. Inform buyers and arrange transportation.
3. Prepare harvesting equipment.
4. Prepare clean containers and ice.
5. Reduce or stop feeding according to the farm's harvesting plan.
6. Gradually lower the pond water level using a suitable outlet.
7. Use a harvesting net to collect fish as the water level reduces.
8. Collect fish carefully to avoid injuries.
9. Transfer fish into clean containers.
10. Separate fish according to size and species.
11. Weigh and record the harvested fish.
12. Immediately undertake appropriate post-harvest handling.
13. Drain the pond completely where appropriate.
14. Clean and prepare the pond for the next production cycle.

Advantages of complete harvesting

- Allows collection of most fish in the pond.
- Makes pond cleaning easier.

- Allows pond repairs and maintenance.
- Helps farmers assess total production.
- Makes it easier to prepare for a new production cycle.

Disadvantages of complete harvesting

- Requires more labour and equipment.
- May interrupt fish production.
- Requires proper planning and marketing.
- Fish may be injured during mass collection.
- Poor timing may lead to losses if the market is unavailable.

5.3 Common Equipment Used in Pond Harvesting

1. Seine net

A seine net is a long fishing net used to surround and collect fish from a pond.

Uses:

- Capturing fish during partial harvesting.
- Collecting fish during complete harvesting.
- Separating fish according to size.

2. Scoop net

A scoop net is a small net attached to a handle and used to remove fish from water or harvesting nets.

3. Fish baskets

These are containers used for temporarily holding and transferring harvested fish.

4. Weighing scales

Used to measure the weight of harvested fish.

5. Plastic fish crates

Used to transport and temporarily hold harvested fish under hygienic conditions.

6. Water drainage equipment

Used to lower or remove pond water during complete harvesting.

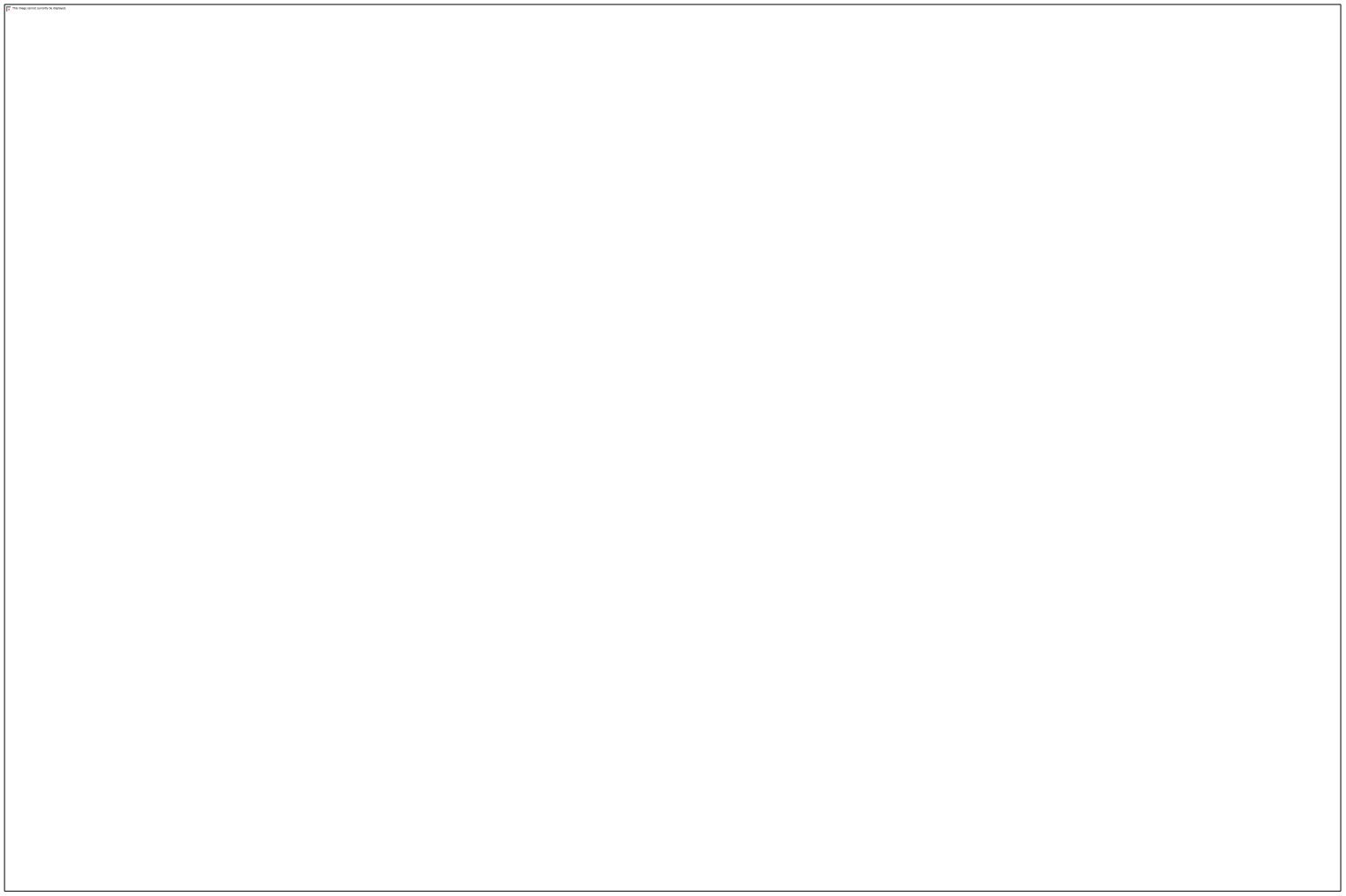


Figure 1: Harvesting fish from an earthen fish pond using a seine net.

6.0 FISH HARVESTING FROM A FISH CAGE

6.1 Meaning of a Fish Cage

A fish cage is an enclosed net structure placed in a natural or artificial water body and used for raising fish under controlled management.

Fish cages are commonly used in Lake Victoria in Kenya.

They allow water to flow freely through the net while preventing farmed fish from escaping.

6.2 Cage Harvesting

Cage harvesting is the process of collecting mature or marketable fish from a fish cage using appropriate nets and handling equipment.

6.3 Procedures for Harvesting Fish from a Cage

1. **Plan the harvesting exercise:** Determine the quantity and size of fish required.
2. **Prepare equipment:** Assemble harvesting nets, scoop nets, weighing scales, containers and ice boxes.
3. **Prepare the working area:** Ensure the harvesting platform is stable and clean.
4. **Inspect the cage:** Check the cage structure and netting for damage.
5. **Reduce feeding where appropriate:** Follow the farm's recommended pre-harvest feeding management.
6. **Gather fish:** Use suitable methods to concentrate fish in a section of the cage.
7. **Lift or draw the net carefully:** Slowly raise the harvesting net to concentrate fish for collection.

8. **Collect fish:** Use scoop nets to remove fish carefully.

9. **Avoid overcrowding:** Do not keep too many fish in a small container.

10. **Sort fish:** Separate fish according to species and marketable size.

11. **Weigh fish:** Determine the total weight harvested.

12. **Transfer fish:** Place harvested fish into clean containers with suitable water or directly into appropriate chilling systems.

13. **Chill fish:** Immediately place fish in clean ice to maintain freshness.

14. **Clean equipment:** Wash and sanitise harvesting equipment after use.

15. **Record harvesting information:** Document quantities, weights, dates and other relevant details.



Figure 2: Harvesting tilapia from a floating fish cage.

6.4 Equipment Used in Cage Harvesting

1. **Harvesting nets:** Used to concentrate fish and facilitate their removal from the cage.

2. **Scoop nets:** Used to collect individual fish.

3. **Floating platforms:** Provide working surfaces for fish farmers during harvesting.

4. **Fish crates:** Used for temporary holding and transportation.

5. **Weighing scales:** Used to measure harvested fish.

6. **Protective clothing:** Protects workers during harvesting.

7. **Ice boxes:** Used to maintain fish at low temperatures.

8. **Ropes and lifting equipment:** Used to manipulate cage nets and harvesting structures.

6.5 Advantages of Cage Harvesting

1. Allows harvesting without draining the entire water body.

2. Makes it easier to harvest fish from a concentrated production unit.
3. Allows selective harvesting.
4. Reduces disturbance to the surrounding water body when properly conducted.
5. Facilitates large-scale fish production.
6. Allows fish farmers to plan harvesting according to market demand.
7. Can support continuous production.

6.6 Challenges of Cage Harvesting

1. Strong waves and currents may interfere with harvesting.
2. Fish may escape through damaged cage nets.
3. Poor handling may cause injuries to fish.
4. Equipment may be difficult to operate in deep water.
5. Harvesting requires trained labour.
6. Bad weather may interrupt harvesting.
7. Poor water quality may cause fish mortality.
8. Transporting harvested fish from floating cages may be expensive.

7.0 COMPARISON BETWEEN POND AND CAGE HARVESTING

Fish pond harvesting	Fish cage harvesting
Takes place in constructed ponds.	Takes place in floating or fixed net cages.
May involve draining pond water.	Does not normally require draining the water body.
Uses seine and scoop nets.	Uses harvesting nets and scoop nets.
Can involve complete pond drainage.	Fish are collected by concentrating them in the cage.
Water is usually under farm management.	Water is drawn from the surrounding natural or artificial water body.
Common in inland fish farms.	Common in lakes and reservoirs.

8.0 POST-HARVEST HANDLING OF FISH

8.1 Meaning of Post-Harvest Handling

Post-harvest handling refers to the activities carried out immediately after fish has been harvested to preserve its quality, prevent contamination, reduce spoilage and prepare it for consumption, storage, processing or marketing.

Fish is highly perishable. Therefore, it must be handled carefully and cooled immediately after harvesting.

8.2 Importance of Proper Post-Harvest Handling

1. Prevents rapid fish spoilage.
2. Maintains the nutritional value of fish.
3. Preserves the natural flavour and texture.
4. Reduces bacterial contamination.
5. Increases the shelf life of fish.
6. Reduces post-harvest losses.
7. Improves the appearance of fish.
8. Increases market value.
9. Protects consumers against foodborne illnesses.
10. Promotes fish marketing and trade.
11. Reduces wastage of fish resources.
12. Improves farmers' income.

9.0 STEPS UNDERTAKEN DURING POST-HARVEST HANDLING OF FISH

The following are the major steps undertaken after harvesting fish.

9.1 Collection of Harvested Fish

This involves carefully removing harvested fish from the pond or cage and transferring them to the fish handling area.

Good practices:

- Handle fish gently.
- Avoid dropping fish on the ground.
- Use clean collection containers.
- Avoid overcrowding.
- Protect fish from direct sunlight.
- Transfer fish for cooling as quickly as possible.

9.2 Sorting of Fish

Sorting is the process of separating fish into different categories according to specific characteristics.

Fish may be sorted according to:

1. **Size:** Large, medium and small fish.
2. **Species:** Tilapia, catfish, trout and other species.
3. **Weight:** Fish with similar weights are grouped together.
4. **Quality:** Fresh fish are separated from damaged or spoiled fish.
5. **Market requirements:** Fish are grouped according to the preferences of buyers.

Importance of sorting

- Facilitates marketing.
- Helps determine selling prices.
- Makes packaging easier.
- Facilitates processing.
- Separates damaged fish from good-quality fish.
- Helps farmers maintain accurate production records.



Figure 3: Sorting harvested fish according to size and quality.

9.3 Washing of Fish

Washing is the removal of dirt, slime, blood and other unwanted materials from the surface of fish using potable water.

Procedures:

1. Obtain clean potable water.
2. Place fish in clean food-grade containers.
3. Rinse fish carefully.
4. Remove visible dirt and unwanted materials.
5. Avoid using contaminated water.
6. Drain excess water using clean equipment.
7. Transfer fish to the next handling stage.

Importance of washing

- Removes surface dirt.
- Improves fish appearance.
- Removes unwanted materials.
- Supports hygienic handling.
- Reduces some surface contamination.

Note: Washing does not make contaminated or spoiled fish safe for consumption. It cannot replace proper chilling, sanitation and food safety controls.

9.4 Scaling of Fish

Scaling is the removal of scales from fish using a suitable scaling tool or knife.

Not all fish require scaling. For example, catfish do not have the typical external scales found in tilapia.

Procedures for scaling:

1. Place the fish on a clean working surface.
2. Hold the fish firmly.
3. Use an appropriate fish scaler or blunt-edged tool.
4. Remove scales carefully, working from the tail towards the head.
5. Avoid damaging the skin.
6. Rinse the fish with potable water.
7. Collect scales in a suitable waste container.
8. Clean and sanitise the equipment.

Importance of scaling

- Improves fish appearance.
- Makes fish easier to prepare for cooking.
- Removes unwanted scales.
- Facilitates further processing.
- Improves acceptability in some markets.



Figure 4: Removing scales from a tilapia during fish preparation.

9.5 Gutting of Fish

Gutting is the removal of internal organs from the abdominal cavity of fish.

The internal organs include:

- Intestines.
- Stomach.
- Liver.
- Reproductive organs.
- Other internal tissues.

Procedures for gutting:

1. Place the fish on a clean food-grade working surface.
2. Use a clean, sharp knife.
3. Make a careful incision along the abdomen.
4. Open the abdominal cavity.
5. Remove the internal organs carefully.
6. Avoid rupturing the intestines.
7. Remove visible blood and unwanted materials.

8. Wash the abdominal cavity using potable water.
9. Dispose of internal organs hygienically.
10. Clean and sanitise the working area and equipment.

Importance of gutting

1. Removes internal organs that can contribute to spoilage.
2. Improves fish appearance.
3. Prepares fish for further processing.
4. Makes fish easier to cook.
5. Facilitates packaging and storage.
6. Reduces the presence of intestinal contents during handling.

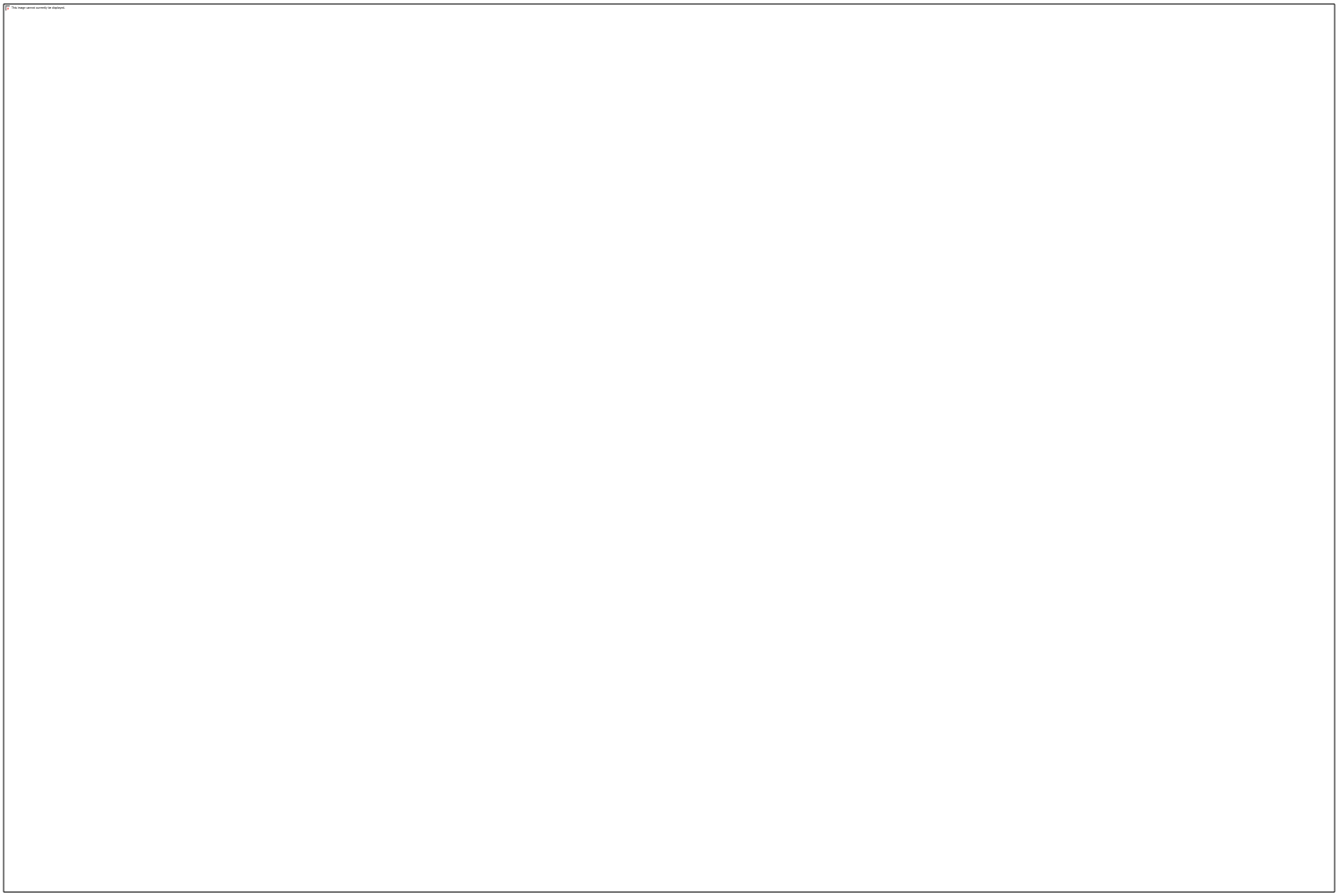


Figure 5: Gutting fish during post-harvest preparation.

9.6 Evisceration

Evisceration is the process of removing the internal organs of fish from the body cavity.

It is closely related to gutting and is commonly used in fish processing terminology.

Importance of evisceration

- Removes internal organs.
- Helps reduce contamination from intestinal contents.

- Prepares fish for further processing.
- Improves the appearance of fish products.
- Facilitates cleaning and packaging.

9.7 Filleting

Filleting is the process of removing boneless or mostly boneless portions of flesh from the sides of fish.

Procedures:

1. Place the fish on a clean cutting board.
2. Use a sharp filleting knife.
3. Make an incision behind the gill region.
4. Cut along the backbone.
5. Separate the flesh from the skeleton.
6. Repeat on the other side.
7. Remove visible bones where necessary.
8. Trim unwanted tissues.
9. Package or chill the fillets immediately.

Importance of filleting

- Produces convenient fish portions.
- Makes fish easier to cook.
- Increases product variety.
- Adds value to fish.
- Facilitates packaging and marketing.

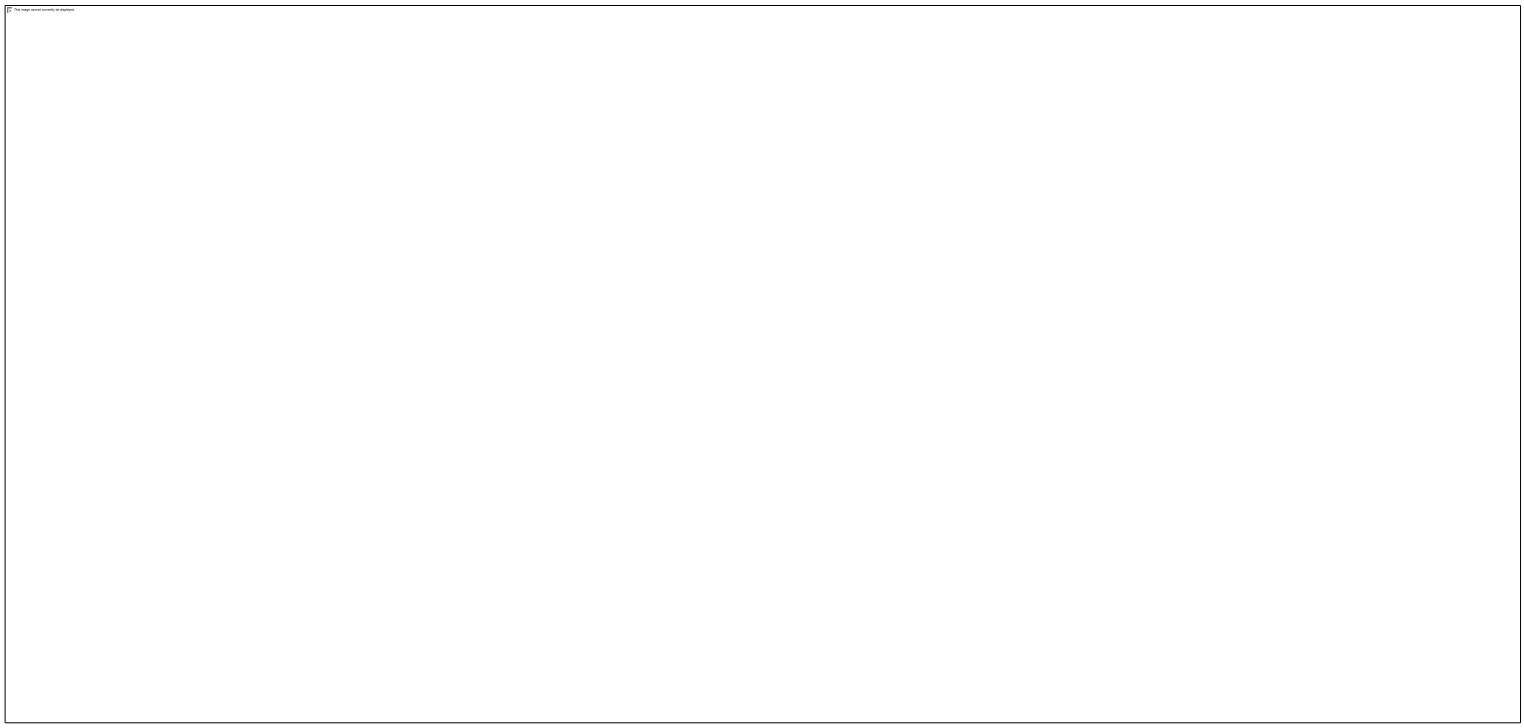


Figure 6: Filleting fish to obtain portions of flesh.

9.8 Grading of Fish

Grading is the classification of fish according to established quality standards.

Fish may be graded according to:

- Size.
- Weight.
- Freshness.
- Physical condition.
- Appearance.
- Species.
- Market specifications.

Importance of grading

1. Promotes uniformity.
2. Helps determine market prices.
3. Facilitates packaging.
4. Improves consumer satisfaction.
5. Supports quality control.
6. Helps processors plan production.

9.9 Icing of Fish

Icing is the process of placing harvested fish in contact with clean ice to reduce its temperature and slow down spoilage.

Ice helps maintain the quality of fish by slowing bacterial growth and enzymatic activities.

Materials used in icing

- Clean crushed ice.
- Insulated fish boxes.
- Food-grade containers.
- Thermometers.
- Clean water for ice production.

Procedures for icing fish:

1. Prepare sufficient clean ice.
2. Clean the insulated containers.
3. Place a layer of crushed ice at the bottom of the container.
4. Arrange fish carefully over the ice.
5. Add another layer of ice.
6. Continue alternating fish and ice layers.

7. Ensure that fish is adequately surrounded by ice.
8. Cover the container.
9. Keep the container in a cool place.
10. Monitor the condition of the ice.
11. Drain meltwater where necessary without exposing fish to contamination.
12. Replace melted ice as required.

Importance of icing

1. Reduces fish temperature rapidly.
2. Slows bacterial multiplication.
3. Slows enzymatic activities.
4. Maintains fish freshness.
5. Reduces spoilage.
6. Extends shelf life.
7. Preserves fish quality during transportation.
8. Maintains the market value of fish.

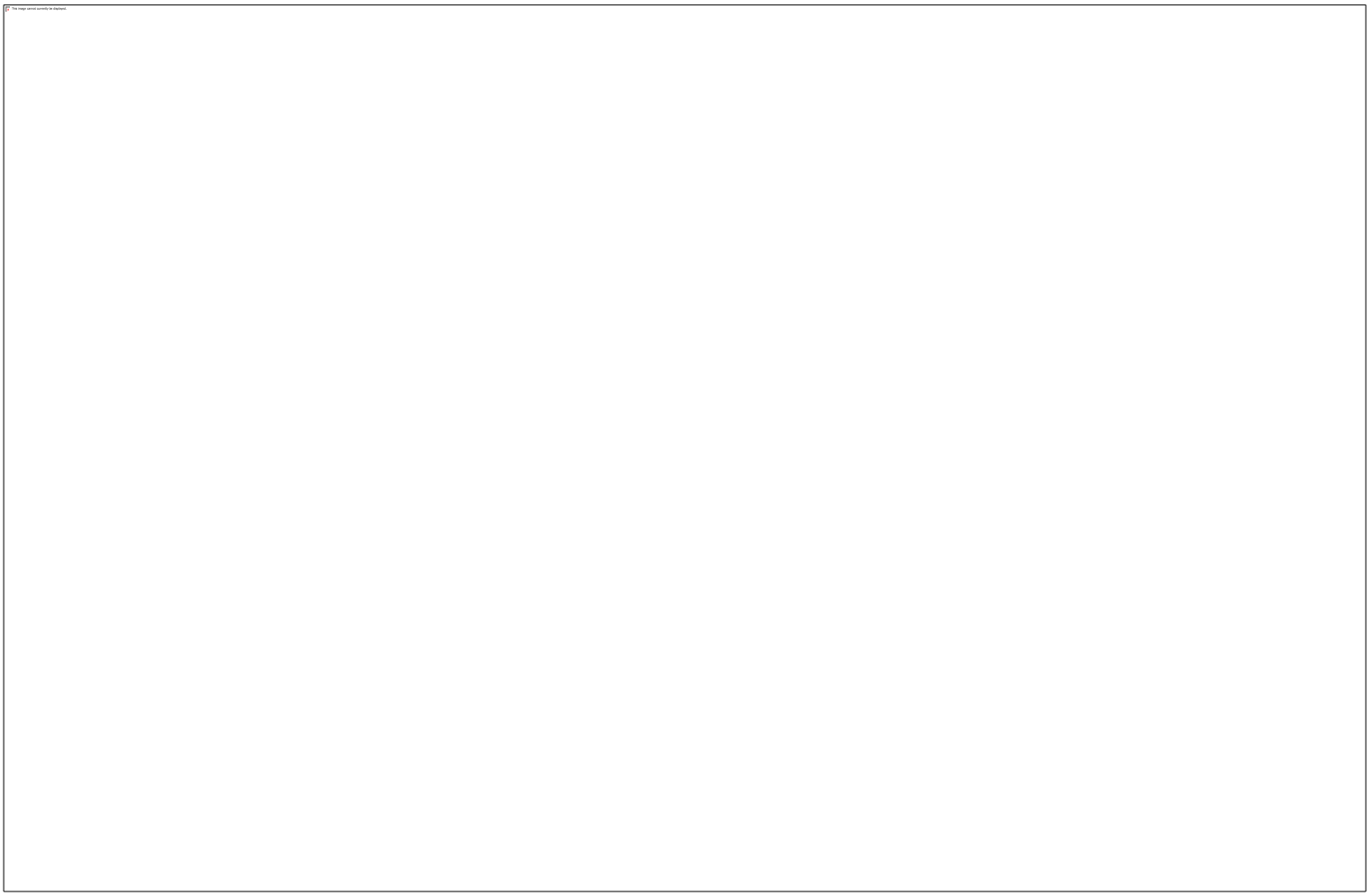


Figure 7: Fish packed in crushed ice for preservation.

9.10 Chilling of Fish

Chilling is the reduction of fish temperature to a low level, generally around the melting point of ice, without freezing the fish.

Fish chilling can be achieved using:

- Crushed ice.
- Refrigerators.
- Chilling rooms.
- Refrigerated storage units.

Importance of chilling

- Slows down bacterial growth.
- Reduces enzymatic activity.
- Maintains fish texture.
- Preserves natural flavour.
- Extends shelf life.
- Maintains fish quality during transportation and storage.

Difference between icing and chilling

Icing	Chilling
Uses ice directly on or around fish.	Refers generally to reducing fish temperature.
Requires clean ice.	May use ice or refrigeration systems.
Commonly used during transportation.	Used during storage, transportation and processing.
Is one method of chilling.	Is the broader process of cooling fish.

9.11 Refrigeration

Refrigeration is the preservation of fish using a refrigerator or cold-storage facility at a controlled low temperature, usually around 0°C to 4°C for short-term storage.

Procedures:

1. Clean the refrigerator or cold room.
2. Place fish in clean food-grade containers.
3. Ensure fish has been properly prepared.
4. Set and monitor the required temperature.
5. Arrange fish to allow effective cooling.
6. Keep containers covered.
7. Avoid mixing raw fish with ready-to-eat foods.
8. Monitor temperature regularly.
9. Use stored fish within an appropriate safe storage period.

Importance of refrigeration

- Slows microbial growth.
- Maintains fish quality.
- Extends shelf life.
- Allows temporary storage.
- Reduces immediate marketing pressure.

Important: Refrigeration does not kill all microorganisms. Fish must still be handled hygienically and cooked properly.

9.12 Packaging of Fish

Packaging is the process of placing fish in suitable materials or containers to protect it during storage, transportation and marketing.

Examples of packaging materials include:

- Food-grade plastic bags.
- Insulated fish boxes.
- Food-grade trays.
- Vacuum packaging materials.
- Suitable sealed containers.

Qualities of good fish packaging materials

1. Should be clean.
2. Should be food-grade.
3. Should not react with fish.
4. Should prevent contamination.
5. Should be strong enough to protect fish.
6. Should be easy to handle.
7. Should be suitable for the required storage temperature.

Importance of packaging

- Protects fish from contamination.
- Prevents physical damage.
- Facilitates transportation.
- Improves product presentation.
- Helps maintain product quality.
- Supports marketing and identification.

9.13 Labelling of Fish Products

Labelling involves providing relevant information on packaged fish products.

Information may include:

- Name of the fish product.
- Species.
- Net weight.
- Date of packaging.
- Expiry or use-by information where applicable.
- Storage instructions.
- Name and address of the processor.
- Batch or lot identification.
- Required regulatory information.

Importance of labelling

1. Helps identify the fish product.
2. Provides consumers with useful information.
3. Facilitates product traceability.
4. Supports quality control.
5. Promotes responsible marketing.

9.14 Transportation of Fish

Transportation is the movement of harvested fish from the production area to processing facilities, markets, hotels, shops or consumers.

Good practices during fish transportation

1. Use clean, insulated containers.
2. Maintain appropriate low temperatures.
3. Use sufficient clean ice.
4. Avoid overcrowding.
5. Protect fish from direct sunlight.
6. Avoid transporting fish with chemicals.
7. Use clean vehicles.
8. Minimise transportation delays.
9. Prevent physical damage.
10. Maintain the cold chain.



Figure 8: Transportation of chilled fish in insulated containers.

10.0 METHODS OF FISH PRESERVATION

Fish preservation involves methods used to slow down or prevent spoilage.

10.1 Chilling

Chilling involves maintaining fish at low temperatures, usually close to 0°C.

Advantages

- Maintains natural fish quality.
- Slows bacterial growth.
- Requires relatively simple equipment.

- Suitable for short-term preservation.

Limitations

- Requires a continuous supply of ice or electricity.
- Does not prevent spoilage indefinitely.
- Requires proper temperature monitoring.

10.2 Freezing

Freezing is the preservation of fish by reducing its temperature below its freezing point so that much of the water in the fish becomes ice.

Fish is commonly stored at approximately -18°C or lower for long-term frozen storage.

Advantages

1. Extends shelf life considerably.
2. Slows microbial and enzymatic activities.
3. Maintains much of the nutritional value.
4. Allows fish to be transported over long distances.
5. Supports large-scale fish marketing.

Limitations

1. Requires freezers and electricity.
2. Equipment may be expensive.
3. Poor freezing may damage fish texture.
4. Repeated thawing and refreezing can reduce quality.

10.3 Drying

Drying is the removal of moisture from fish to reduce the conditions needed for microorganisms to grow.

Methods include:

- Sun drying.
- Solar drying.
- Mechanical drying.

Advantages

1. Reduces moisture content.
2. Extends shelf life when properly done.
3. Reduces transportation weight.
4. Does not necessarily require refrigeration during storage.
5. Provides products that can be marketed over long distances.

Limitations

1. May be affected by rain and humidity.

2. Poor drying may encourage mould growth.
3. Fish may be contaminated by dust and insects.
4. Some nutrients may be lost during processing.



Figure 9: Drying fish on raised clean drying racks.

10.4 Smoking

Smoking is a fish preservation method in which fish is exposed to smoke produced by controlled burning of suitable wood or other approved materials.

Smoking may involve:

- Hot smoking.
- Cold smoking.

Advantages

- Adds characteristic flavour.
- Reduces moisture depending on the process.
- Helps preserve fish when properly conducted.
- Increases product variety.
- Can add market value.

Limitations

- Requires suitable smoking equipment.
- Poor smoking practices may contaminate fish.
- Some traditional methods expose fish to excessive smoke.
- The product may require additional storage controls.

10.5 Salting

Salting is the preservation of fish by applying salt to reduce the amount of water available for microbial growth.

Methods include:

- Dry salting.
- Wet salting or brining.

Advantages

1. Reduces microbial growth.
2. Extends shelf life when properly done.
3. Requires relatively simple equipment.
4. Can be used in areas with limited refrigeration.
5. Adds a distinctive taste to fish products.

Limitations

1. Excessive salt may affect taste.
2. Requires suitable storage.
3. Poor salting may lead to spoilage.
4. Some consumers avoid highly salted foods.

10.6 Canning

Canning is the preservation of fish by sealing it in airtight containers and processing it using an appropriate heat treatment to destroy harmful microorganisms and prevent recontamination.

Advantages

- Allows long-term storage.
- Facilitates transportation.
- Produces convenient ready-to-use products.
- Reduces dependence on refrigeration before opening.
- Supports commercial fish processing.

Limitations

- Requires specialised equipment.
- Has high initial investment costs.
- Requires trained personnel.
- Incorrect processing can result in serious food safety hazards.

Important: Commercial fish canning must follow validated time, temperature and pressure requirements.

11.0 DETERMINING FISH FRESHNESS USING SENSORY METHODS

11.1 Meaning of Sensory Evaluation

Sensory evaluation is the assessment of food quality using human senses such as sight, smell and touch.

In fish handling, sensory evaluation is used to identify changes in fish appearance, odour and texture that may indicate deterioration.

It is an important method of assessing fish freshness.

The main sensory methods include:

1. Sight.
2. Smell.
3. Touch.
4. Taste under professionally controlled conditions.

Food safety alert

Learners must NEVER taste raw fish when assessing freshness. Raw fish may contain harmful microorganisms, parasites or toxins. Taste evaluation, where appropriate, should only be conducted by trained professionals using properly prepared samples.

11.2 Assessment of Fish Freshness Using Sight

Sight involves examining the physical appearance of fish.

Features of fresh fish:

1. **Eyes:** Clear, bright and full rather than cloudy and sunken.
2. **Skin:** Shiny and moist.
3. **Scales:** Firmly attached to the body.
4. **Gills:** Usually bright red or pink and moist, depending on the species and condition.
5. **Body:** Has a natural appearance without unusual discolouration.
6. **Abdomen:** Firm and not excessively swollen.
7. **Surface:** Free from unusual stains or excessive discolouration.

Features of spoiled fish:

1. Cloudy and sunken eyes.
2. Dull skin.
3. Loose or easily detached scales.
4. Brownish or greyish gills.
5. Discoloured body.
6. Damaged or swollen abdomen.
7. Unusual surface appearance.

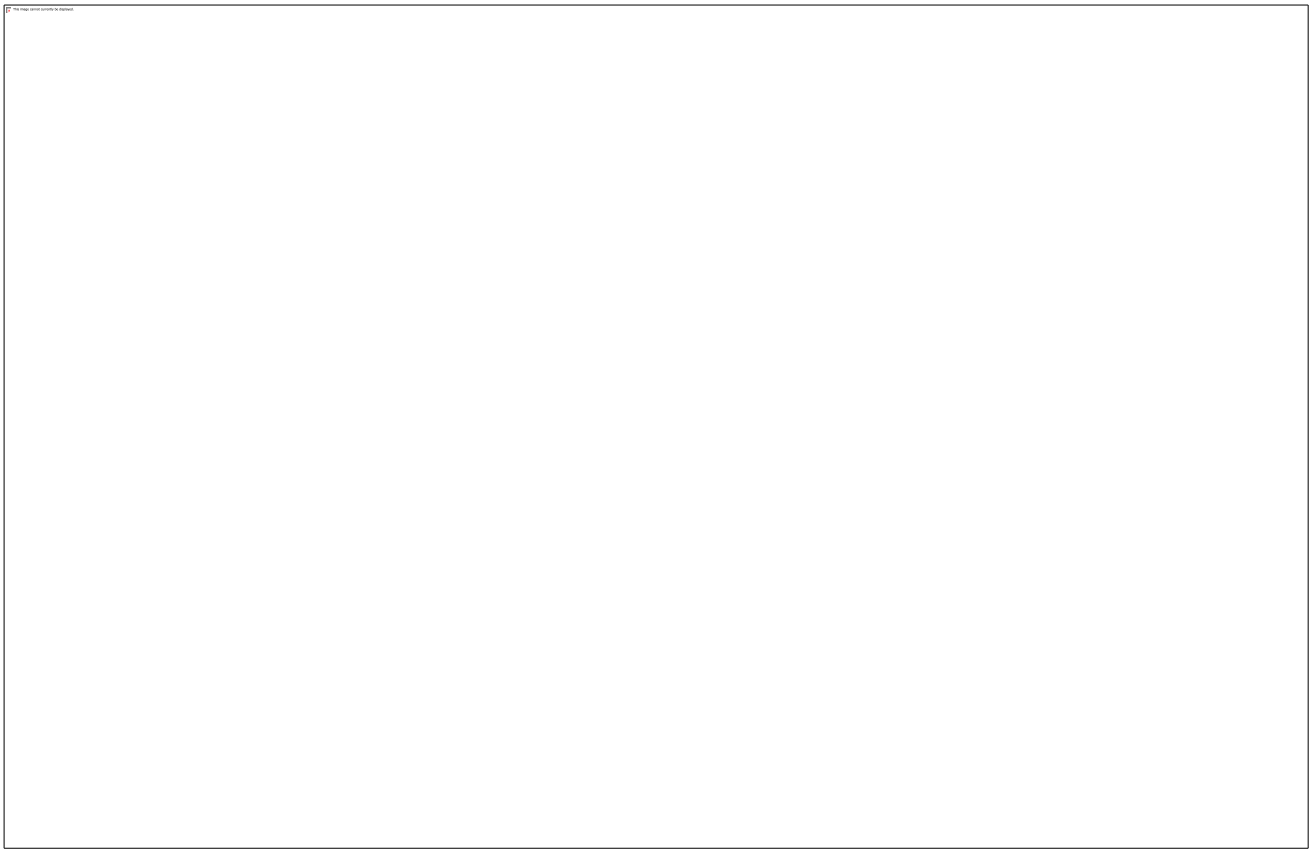


Figure 10: Visual comparison of fresh and spoiled fish.

11.3 Assessment of Fish Freshness Using Smell

Smell involves detecting the odour produced by fish.

Characteristics of fresh fish

- Has a mild, clean smell.
- May have a fresh aquatic or sea-like smell depending on the species.
- Does not have a strong unpleasant odour.

Characteristics of spoiled fish

- Has a strong unpleasant smell.
- May produce an ammonia-like odour.
- May have a rotten or putrid smell.
- May produce sour or offensive odours.

Importance of smell assessment

It helps identify fish that may have undergone spoilage. However, the absence of an unpleasant smell does not guarantee that fish is safe to eat.

11.4 Assessment of Fish Freshness Using Touch

Touch involves examining the texture and firmness of fish using clean hands or appropriate food-handling gloves.

Characteristics of fresh fish

1. Flesh is firm.

2. Flesh springs back when gently pressed.
3. Skin is moist and intact.
4. Body structure is reasonably firm.
5. Scales are generally firmly attached.

Characteristics of spoiled fish

1. Flesh is soft and mushy.
2. Flesh may retain an indentation after pressing.
3. Skin may become excessively slimy.
4. Scales may detach easily.
5. Body may lose its normal firmness.

11.5 Assessment of Fish Freshness Using Taste

Taste assessment involves evaluating the flavour of a properly prepared fish sample.

Characteristics of acceptable fish flavour

- Has a normal flavour for the fish species.
- Does not have an unusual sour or bitter taste.
- Does not have a putrid or otherwise abnormal flavour.

Characteristics of spoiled fish

- May have an unusual sour taste.
- May have a bitter or unpleasant flavour.
- May have an abnormal or putrid taste.

Safety precautions:

- Never taste raw fish.
- Do not taste fish suspected of spoilage.
- Do not taste fish to determine whether it contains toxins or harmful microorganisms.
- Only trained professionals should conduct controlled sensory taste evaluation of properly prepared samples.

11.6 Summary of Sensory Differences Between Fresh and Spoiled Fish

Feature	Fresh fish	Spoiled fish
Eyes	Clear and bright	Cloudy and sunken
Gills	Usually bright red or pink	Brownish, greyish or discoloured
Skin	Shiny and moist	Dull and discoloured
Scales	Firmly attached	Easily detached
Smell	Mild and fresh	Strong and unpleasant
Flesh	Firm and elastic	Soft and mushy
Abdomen	Firm	May be swollen or damaged
Surface	Normal appearance	May be excessively slimy

Important food safety note: Sensory assessment is a useful quality-screening method, but it cannot reliably detect all foodborne pathogens, chemical contaminants, parasites or toxins. Fish that appears fresh can still be unsafe.

12.0 FACTORS THAT CAUSE FISH SPOILAGE

Fish spoils due to several biological, chemical and environmental factors.

12.1 Microbial Activities

Microorganisms such as bacteria multiply on fish and break down its tissues.

This may cause:

- Unpleasant smells.
- Slime formation.
- Changes in colour.
- Changes in texture.
- Production of undesirable substances.

12.2 Enzymatic Activities

Enzymes naturally present in fish continue acting after death.

They break down tissues and cause:

- Softening of flesh.
- Changes in texture.
- Breakdown of proteins.
- Deterioration in quality.

12.3 Chemical Reactions

Chemical reactions, including oxidation of fats, can cause fish quality to deteriorate.

They may result in:

- Rancid odours.
- Unpleasant flavours.
- Changes in colour.
- Reduced product quality.

12.4 High Temperatures

Fish exposed to high temperatures spoils more rapidly because microbial growth and enzymatic activities increase.

12.5 Physical Damage

Rough handling may cause bruising, cuts and tissue damage.

This may encourage microbial contamination and accelerate deterioration.

12.6 Poor Hygiene

Dirty hands, equipment, containers and water introduce contaminants that may cause fish spoilage.

12.7 Delayed Cooling

When harvested fish is left without adequate cooling, microorganisms multiply rapidly and spoilage increases.

13.0 FACTORS THAT INFLUENCE FISH QUALITY AFTER HARVESTING

1. **Harvesting method:** Rough harvesting causes injuries and damages fish tissues.
2. **Water quality:** Fish raised in polluted water may be exposed to harmful contaminants.
3. **Temperature:** High temperatures accelerate spoilage.
4. **Handling practices:** Poor handling increases contamination and physical damage.
5. **Storage conditions:** Inadequate storage reduces shelf life.
6. **Transportation:** Long delays without proper cooling accelerate deterioration.
7. **Personal hygiene:** Dirty hands and clothing may contaminate fish.
8. **Quality of ice:** Contaminated ice can introduce microorganisms.
9. **Fish species:** Different species have different compositions and storage characteristics.
10. **Fish size:** Size may influence cooling time and processing requirements.
11. **Packaging:** Poor packaging exposes fish to contamination and physical damage.
12. **Processing methods:** Improper cleaning, gutting and preservation can reduce quality.

14.0 POST-HARVEST LOSSES IN FISH

14.1 Meaning of Post-Harvest Losses

Post-harvest losses are reductions in the quantity, quality or economic value of fish after harvesting due to poor handling, preservation, storage, transportation or marketing.

14.2 Types of Post-Harvest Losses

A. Physical Losses

These occur when fish is physically damaged, discarded, eaten by pests or lost during transportation.

Examples:

- Fish falling from containers.
- Fish being eaten by animals.
- Fish being discarded due to severe damage.
- Fish escaping during harvesting.

B. Quality Losses

These occur when fish loses its desirable characteristics.

Examples:

- Development of unpleasant odours.
- Discolouration.
- Softening of flesh.
- Loss of freshness.

- Contamination.

C. Economic Losses

These occur when the market value of fish decreases.

Examples:

- Selling spoiled fish at lower prices.
- Rejection of fish by buyers.
- Increased costs of handling and preservation.
- Reduced income due to wastage.

14.3 Ways of Reducing Post-Harvest Losses

1. Harvest fish using appropriate equipment.
2. Handle fish carefully.
3. Maintain high hygiene standards.
4. Use clean potable water.
5. Cool fish immediately after harvesting.
6. Use sufficient clean ice.
7. Use insulated containers.
8. Avoid unnecessary delays.
9. Improve storage facilities.
10. Train fish handlers.
11. Use suitable packaging materials.
12. Maintain accurate harvesting records.
13. Improve transportation facilities.
14. Observe recommended food safety standards.

15.0 OCCUPATIONAL HEALTH AND SAFETY DURING FISH HARVESTING AND HANDLING

Occupational health and safety refers to the practices used to protect workers from injuries, accidents and health risks during harvesting and handling activities.

15.1 Safety Measures

1. Wear protective clothing.
2. Use gloves when handling fish and equipment.
3. Wear non-slip footwear.
4. Handle sharp knives carefully.
5. Use appropriate lifting techniques.
6. Avoid standing on unstable platforms.
7. Keep electrical equipment away from water.

8. Maintain clean working areas.
9. Use first-aid facilities.
10. Avoid working alone in dangerous aquatic environments.
11. Use life jackets during cage harvesting where there is a risk of falling into water.
12. Avoid overcrowding on floating platforms.
13. Store chemicals safely.
14. Report accidents and injuries immediately.

15.2 Common Hazards During Fish Handling

Hazard	Possible injury or effect	Preventive measure
Sharp knives	Cuts	Use knives carefully
Slippery floors	Falls	Keep floors clean and dry where possible
Fish spines	Puncture wounds	Wear protective gloves
Heavy fish containers	Back injuries	Use proper lifting methods
Deep water	Drowning	Wear life jackets
Electrical equipment	Electric shock	Use properly maintained equipment
Chemicals	Poisoning or irritation	Follow chemical safety instructions
Dirty fish waste	Infection	Use protective clothing and proper disposal

16.0 ROLE OF FOOD SAFETY IN FISH HANDLING

Food safety plays a major role in the aquaculture value chain.

Its importance includes:

1. Protecting consumers from foodborne illnesses.
2. Maintaining fish quality.
3. Preventing contamination.
4. Reducing post-harvest losses.
5. Increasing the marketability of fish.
6. Supporting public health.
7. Promoting responsible fish processing.
8. Increasing consumer confidence.
9. Supporting local and international fish trade.
10. Improving farmers' economic returns.
11. Promoting sustainable use of fish resources.
12. Encouraging professional standards in aquaculture.

17.0 PRACTICAL ACTIVITY: HARVESTING FISH FROM A FISH POND

Activity: Learners work in groups to observe or participate in fish harvesting from a demonstration pond.

Requirements:

- Harvesting net.
- Scoop net.
- Fish baskets.
- Clean water.
- Protective clothing.
- Weighing scale.
- Clean ice.
- Insulated container.

Procedure:

1. Wear appropriate protective clothing.
2. Assemble the required harvesting equipment.
3. Inspect the harvesting net.
4. Observe the fish in the pond.
5. Demonstrate the use of a seine net.
6. Collect fish carefully.
7. Sort fish according to size.
8. Weigh the harvested fish.
9. Place fish in clean containers.
10. Chill the fish using clean ice.
11. Clean the equipment after use.
12. Record the observations.

Expected learning outcomes:

By the end of the activity, learners should be able to:

- Demonstrate safe fish harvesting.
- Identify harvesting equipment.
- Sort fish according to size.
- Weigh harvested fish.
- Demonstrate hygienic fish handling.
- Explain the importance of immediate chilling.

PRACTICAL ACTIVITY: DETERMINING FISH FRESHNESS

Activity: Learners examine samples or photographs of fresh and spoiled fish using sensory methods.

Requirements:

- Fresh fish sample.
- Photographs of spoiled fish.
- Protective gloves.
- Observation sheet.
- Clean working surface.

Procedure:

1. Wear appropriate protective clothing.
2. Observe the eyes of the fish.
3. Examine the gills.
4. Observe the skin and scales.
5. Assess the firmness using a safe handling method.
6. Observe the external appearance.
7. Assess odour only where safe and appropriate.
8. Record the findings.
9. Compare the observations with the freshness characteristics provided.
10. Discuss the importance of proper fish preservation.

Safety precautions:

- Never taste raw fish.
- Avoid direct contact with spoiled fish.
- Wash hands after the activity.
- Dispose of fish waste properly.
- Do not use fish suspected of spoilage for consumption.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Each question carries 1 mark.

1. Fish harvesting refers to the process of:

A. Feeding fish in a pond.

B. Collecting mature fish from a production system.

C. Constructing fish ponds.

D. Treating fish diseases.

2. Which of the following is a common fish species cultured in Kenyan fish ponds?

A. Nile tilapia.

B. Whale shark.

C. Dolphin.

D. Octopus.

3. The main purpose of food safety standards during fish handling is to:

A. Increase the size of fish.

B. Prevent contamination and protect consumers.

C. Increase pond water levels.

D. Improve fish reproduction.

4. Which of the following is an example of personal hygiene?

A. Wearing dirty clothes.

B. Handling fish with unwashed hands.

C. Washing hands before handling fish.

D. Placing fish on the ground.

5. Which equipment is commonly used for harvesting fish from a pond?

A. Seine net.

B. Watering can.

C. Wheelbarrow.

D. Spade.

6. Partial harvesting involves:

A. Removing all fish from a pond.

B. Removing only some marketable fish.

C. Destroying the pond.

D. Removing all pond water.

7. Complete harvesting involves:

A. Removing only undersized fish.

B. Removing all or nearly all fish from a pond.

C. Feeding fish daily.

D. Increasing pond water levels.

8. Fish cages are commonly used in Kenya in:

A. Lake Victoria.

B. Deserts.

C. Dry valleys.

D. Mountain peaks.

9. Which equipment is used to measure the weight of harvested fish?

A. Thermometer.

B. Weighing scale.

C. Scoop net.

D. Knife.

10. The process of separating fish according to size and quality is called:

A. Smoking.

B. Sorting.

C. Gutting.

D. Freezing.

11. The removal of scales from fish is known as:

A. Scaling.

B. Filleting.

C. Chilling.

D. Grading.

12. The removal of internal organs from fish is known as:

A. Sorting.

B. Gutting.

C. Packaging.

D. Smoking.

13. Which of the following is the main purpose of icing fish?

A. To increase fish weight.

B. To accelerate bacterial growth.

C. To lower fish temperature and slow spoilage.

D. To change the fish species.

14. The recommended temperature for maintaining chilled fish is generally close to:

A. 40°C.

B. 30°C.

C. 0°C.

D. 60°C.

15. Which of the following is a method of preserving fish?

A. Freezing.

B. Overcrowding.

C. Contamination.

D. Exposure to sunlight without protection.

16. The removal of moisture from fish to reduce microbial growth is called:

A. Gutting.

B. Drying.

C. Sorting.

D. Grading.

17. Which of the following is an example of cross-contamination?

A. Using clean containers.

B. Washing hands before handling fish.

C. Using a dirty knife to handle clean fish.

D. Keeping fish in clean ice.

18. Which feature is commonly associated with fresh fish?

A. Cloudy sunken eyes.

B. Strong rotten smell.

C. Firm flesh.

D. Loose scales.

19. Which of the following indicates possible fish spoilage?

A. Bright eyes.

B. Firm flesh.

C. Unpleasant smell.

D. Shiny skin.

20. Which sensory organ is used to assess fish odour?

A. Nose.

B. Eyes.

C. Ears.

D. Hands.

21. The assessment of fish freshness using human senses is called:

A. Chemical testing.

B. Sensory evaluation.

C. Pond fertilisation.

D. Fish grading.

22. Why should learners avoid tasting raw fish during freshness assessment?

A. Raw fish is always sweet.

B. It may contain harmful microorganisms or parasites.

C. It has no nutritional value.

D. It is difficult to chew.

23. Which of the following is a characteristic of spoiled fish?

A. Firm flesh.

B. Clear eyes.

C. Cloudy and sunken eyes.

D. Mild fresh smell.

24. Which preservation method uses smoke produced by burning suitable wood?

A. Smoking.

B. Freezing.

C. Chilling.

D. Refrigeration.

25. The process of removing fish flesh from the backbone is called:

A. Scaling.

B. Filleting.

C. Sorting.

D. Washing.

26. Which of the following helps prevent fish contamination during transportation?

A. Using dirty containers.

B. Exposing fish to sunlight.

C. Using clean insulated containers.

D. Mixing fish with chemicals.

27. One major advantage of freezing fish is that it:

A. Increases microbial growth.

B. Extends shelf life.

C. Causes immediate spoilage.

D. Removes all bones.

28. Which of the following causes rapid fish spoilage?

A. Immediate icing.

B. Proper refrigeration.

C. Exposure to high temperatures.

D. Hygienic handling.

29. The transfer of harmful microorganisms from one surface to another is called:

A. Cross-contamination.

B. Filleting.

C. Grading.

D. Harvesting.

30. The continuous maintenance of low temperatures from harvesting to consumption is known as:

A. Fish grading.

B. Cold chain.

C. Fish sorting.

D. Complete harvesting.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions.

QUESTION 1: FOOD SAFETY IN FISH HANDLING (8 MARKS)

a) Define the term food safety as used in fish handling. (2 marks)

b) State four personal hygiene practices that should be observed by fish handlers. (4 marks)

c) Give two reasons why clean water is important during fish handling. (2 marks)

QUESTION 2: FISH HARVESTING (8 MARKS)

a) Differentiate between partial harvesting and complete harvesting. (4 marks)

b) State four pieces of equipment used when harvesting fish from a fish pond. (4 marks)

QUESTION 3: HARVESTING FISH FROM A FISH CAGE (8 MARKS)

a) Explain four procedures followed when harvesting fish from a fish cage. (4 marks)

b) State four challenges that may be experienced during fish cage harvesting. (4 marks)

QUESTION 4: POST-HARVEST HANDLING OF FISH (10 MARKS)

a) Define post-harvest handling. (2 marks)

b) Explain four activities undertaken during post-harvest handling of fish. (4 marks)

c) State four importance of proper post-harvest handling of fish. (4 marks)

QUESTION 5: FISH PRESERVATION (8 MARKS)

a) Explain four methods used in preserving harvested fish. (4 marks)

b) State four advantages of icing fish immediately after harvesting. (4 marks)

QUESTION 6: DETERMINING FISH FRESHNESS (8 MARKS)

a) State four sensory characteristics of fresh fish. (4 marks)

b) Give two characteristics of spoiled fish. (2 marks)

c) Explain why learners should not taste raw fish when determining freshness. (2 marks)

ANSWER GUIDE / MARKING SCHEME

SECTION A: MULTIPLE-CHOICE ANSWERS

Question	Answer	Question	Answer
1	B	16	B
2	A	17	C
3	B	18	C
4	C	19	C
5	A	20	A
6	B	21	B
7	B	22	B
8	A	23	C
9	B	24	A
10	B	25	B
11	A	26	C
12	B	27	B
13	C	28	C
14	C	29	A
15	A	30	B

SECTION B: SUGGESTED MARKING SCHEME

QUESTION 1: FOOD SAFETY IN FISH HANDLING (8 MARKS)

a) Food safety refers to practices and conditions necessary to ensure that fish does not cause harm to consumers when handled and consumed as intended. (2 marks)

b) Personal hygiene practices:

- Washing hands with soap and clean water.
- Wearing clean protective clothing.
- Keeping fingernails short and clean.
- Covering cuts and wounds.

- Wearing clean gloves where appropriate.
- Avoiding handling fish when suffering from infectious illnesses.

Award 1 mark each for any four. (4 marks)

c) Importance of clean water:

- Prevents microbial contamination.
- Removes dirt and unwanted materials.
- Maintains fish hygiene.
- Prevents contamination from unsafe water sources.

Award 1 mark each for any two. (2 marks)

QUESTION 2: FISH HARVESTING (8 MARKS)

a) Differences:

Partial harvesting

- Involves removing only some marketable fish from a pond.
- Remaining fish are left to continue growing.

Complete harvesting

- Involves removing all or nearly all fish from a pond.
- Usually takes place at the end of a production cycle.

Award 1 mark for each valid difference. (4 marks)

b) Equipment:

- Seine net.
- Scoop net.
- Fish baskets.
- Weighing scales.
- Plastic fish crates.
- Water drainage equipment.

Award 1 mark each for any four. (4 marks)

QUESTION 3: HARVESTING FISH FROM A FISH CAGE (8 MARKS)

a) Procedures:

- Plan harvesting and prepare equipment.
- Inspect the cage for damage.
- Concentrate fish in a section of the cage.
- Carefully raise or draw the harvesting net.
- Collect fish using scoop nets.
- Sort fish according to size.

- Weigh harvested fish.
- Transfer fish into clean containers and chill immediately.

Award 1 mark each for any four well-explained procedures. (4 marks)

b) Challenges:

- Strong waves and currents.
- Fish escaping through damaged nets.
- Difficult weather conditions.
- Fish injuries during harvesting.
- High equipment costs.
- Lack of trained workers.
- Poor water quality.
- Difficulty transporting fish from cages.

Award 1 mark each for any four. (4 marks)

QUESTION 4: POST-HARVEST HANDLING OF FISH (10 MARKS)

a) Post-harvest handling refers to activities undertaken immediately after harvesting fish to maintain quality, prevent contamination and prepare fish for storage, transportation, processing or sale. (2 marks)

b) Activities:

- **Sorting:** Separating fish according to size, species and quality.
- **Washing:** Removing dirt and unwanted materials using potable water.
- **Scaling:** Removing scales from fish using suitable equipment.
- **Gutting:** Removing internal organs from fish.
- **Icing:** Placing fish in clean ice to lower its temperature.
- **Packaging:** Placing fish in suitable food-grade containers.

Award 1 mark each for any four well-explained activities. (4 marks)

c) Importance:

- Prevents fish spoilage.
- Maintains fish quality.
- Extends shelf life.
- Reduces contamination.
- Increases market value.
- Protects consumers.
- Reduces post-harvest losses.

Award 1 mark each for any four. (4 marks)

QUESTION 5: FISH PRESERVATION (8 MARKS)

a) Methods:

1. **Chilling:** Maintaining fish at low temperatures close to 0°C to slow bacterial growth.
2. **Freezing:** Reducing fish temperature below its freezing point to preserve it for longer periods.
3. **Drying:** Removing moisture from fish to reduce microbial growth.
4. **Smoking:** Exposing fish to smoke through a controlled preservation process.
5. **Salting:** Applying salt to reduce water availability for microorganisms.
6. **Canning:** Sealing fish in airtight containers and applying validated heat treatment.

Award 1 mark each for any four correct methods with explanations. (4 marks)

b) Advantages of icing:

- Reduces fish temperature.
- Slows bacterial growth.
- Slows enzymatic activities.
- Maintains freshness.
- Extends shelf life.
- Reduces spoilage.
- Maintains market quality.

Award 1 mark each for any four. (4 marks)

QUESTION 6: DETERMINING FISH FRESHNESS (8 MARKS)

a) Characteristics:

- Clear and bright eyes.
- Firm flesh.
- Shiny skin.
- Scales firmly attached.
- Gills usually bright red or pink.
- Mild fresh smell.

Award 1 mark each for any four. (4 marks)

b) Characteristics of spoiled fish:

- Cloudy and sunken eyes.
- Unpleasant smell.
- Soft and mushy flesh.
- Discoloured gills.
- Dull skin.
- Easily detached scales.

Award 1 mark each for any two. (2 marks)

c) Learners should not taste raw fish because:

- It may contain harmful microorganisms that cause foodborne diseases. (1 mark)
- It may contain parasites or toxins that can cause illness. (1 mark)

25.0 CAREER OPPORTUNITIES RELATED TO FISH HARVESTING AND POST-HARVEST HANDLING

Learners who develop skills in this sub-strand may pursue careers such as:

1. Aquaculture technician.
2. Fish farm manager.
3. Fish processing technician.
4. Fish quality-control officer.
5. Fish preservation specialist.
6. Fisheries officer.
7. Fish marketing entrepreneur.
8. Seafood handling technician.
9. Cold-storage technician.
10. Aquaculture business owner.

SUB-STRAND 2.3: FISH VALUE ADDITION

1.0 INTRODUCTION TO FISH VALUE ADDITION

1.1 Meaning of Fish Value Addition

Fish value addition refers to the process of changing raw fish into more useful, attractive, convenient, durable and marketable products through various processing, preservation, packaging and presentation techniques.

- Fish value addition involves improving the quality, appearance, taste, texture, shelf life and market value of fish.
- It transforms freshly harvested fish into products that can be stored, transported, prepared and consumed more conveniently.
- It helps reduce post-harvest losses by making fish available for consumption over a longer period.
- It creates opportunities for employment and income generation in fisheries and aquaculture.

Examples of fish value-added products include:

1. Fish fillets.
2. Fish fingers.
3. Fish sausages.
4. Fish balls.
5. Fish cakes.
6. Fish burgers.
7. Fish samosas.
8. Smoked fish.
9. Salted fish.
10. Sun-dried fish.

1.2 Meaning of Value-Added Fish Products

These are fish products that have undergone one or more processing operations to improve their quality, usefulness, convenience, durability or market value.

For example:

- Fresh tilapia can be processed into boneless fillets.
- Fresh Nile perch can be processed into fish fingers.
- Fresh omena can be dried, sorted and packaged for sale.
- Fresh catfish can be processed into fish sausages.
- Fresh tilapia can be smoked and packaged for sale.

2.0 REASONS FOR ADDING VALUE TO FISH PRODUCTS

Fish value addition is important to fish farmers, processors, traders, consumers and the fishing industry.

2.1 Improving the Quality of Fish Products

- Processing can improve the appearance, taste, texture and presentation of fish.

- Removing bones, scales, fins and unwanted parts makes fish easier to consume.
- Proper smoking, drying and packaging can improve product quality.
- Proper handling reduces contamination and deterioration.
- Quality products attract more customers.

Example: Tilapia processed into clean, boneless fillets is more convenient for consumers than whole fish.

2.2 Increasing the Selling Price

- Processed fish products often fetch higher prices than raw fish.
- Processing requires additional skills, labour, equipment and packaging.
- Attractive presentation can increase customer interest.
- Specialised products may attract customers willing to pay more.
- Fish processors can earn additional income from the same quantity of harvested fish.

Example: Fish processed into fillets and packed hygienically may fetch a higher selling price than unprocessed whole fish.

2.3 Extending the Shelf Life of Fish

- Fresh fish deteriorates quickly because of microbial activity, enzyme action and unsuitable storage conditions.
- Processing methods such as smoking, salting and drying help slow down spoilage.
- Refrigeration and freezing help maintain fish quality.
- Proper packaging protects processed products from contamination and moisture.
- Longer shelf life allows fish to be stored and transported over greater distances.

Example: Properly dried omena can be stored for longer than fresh fish when protected from moisture and pests.

2.4 Reducing Post-Harvest Losses

- Fish is highly perishable and may spoil when not handled properly.
- Processing surplus fish helps prevent wastage.
- Fish harvested in large quantities can be preserved for future consumption.
- Value addition allows fish farmers to sell products even when fresh fish demand is low.
- It reduces economic losses associated with unsold fish.

Example: During periods of high fish production in Lake Victoria, some fish can be smoked, dried or frozen instead of being discarded.

2.5 Improving Consumer Convenience

- Processed fish products require less preparation time.
- Fillets are easier to cook than whole fish.
- Fish fingers and fish burgers are convenient for quick meals.
- Boneless fish products are suitable for consumers who dislike fish bones.

- Ready-to-cook products simplify food preparation at home, hotels and restaurants.

Example: Frozen fish fingers can be cooked directly by frying or baking according to the manufacturer's instructions.

2.6 Broadening the Market Base

- Processing creates products suitable for different groups of consumers.
- Hotels, restaurants, supermarkets and catering businesses can purchase processed fish products.
- Different products attract different age groups and consumer preferences.
- Packaging makes products easier to distribute to distant markets.
- Value addition creates opportunities for accessing regional and international markets where standards are met.

2.7 Creating Employment Opportunities

Fish value addition creates employment in:

- Fish harvesting and transportation.
- Fish cleaning and preparation.
- Filleting and cutting.
- Smoking and drying.
- Packaging and labelling.
- Refrigeration and storage.
- Marketing and distribution.
- Fish processing equipment maintenance.

Kenyan context: Fish processing enterprises around Kisumu, Homa Bay, Siaya, Busia, Nakuru and the coastal counties can create employment opportunities for young people and local communities.

2.8 Promoting Entrepreneurship

- Fish value addition encourages individuals and groups to establish small-scale businesses.
- It provides opportunities for youth and women to engage in income-generating activities.
- Processors can develop unique products for local markets.
- Fish processing businesses can grow into larger enterprises.
- It promotes innovation and creativity in the fisheries sector.

2.9 Improving Food and Nutrition Security

- Fish provides high-quality proteins.
- It contains essential vitamins and minerals.
- Some fish species provide omega-3 fatty acids.
- Processing and preservation make fish available beyond harvesting periods.
- Diversification increases the range of fish foods available to consumers.

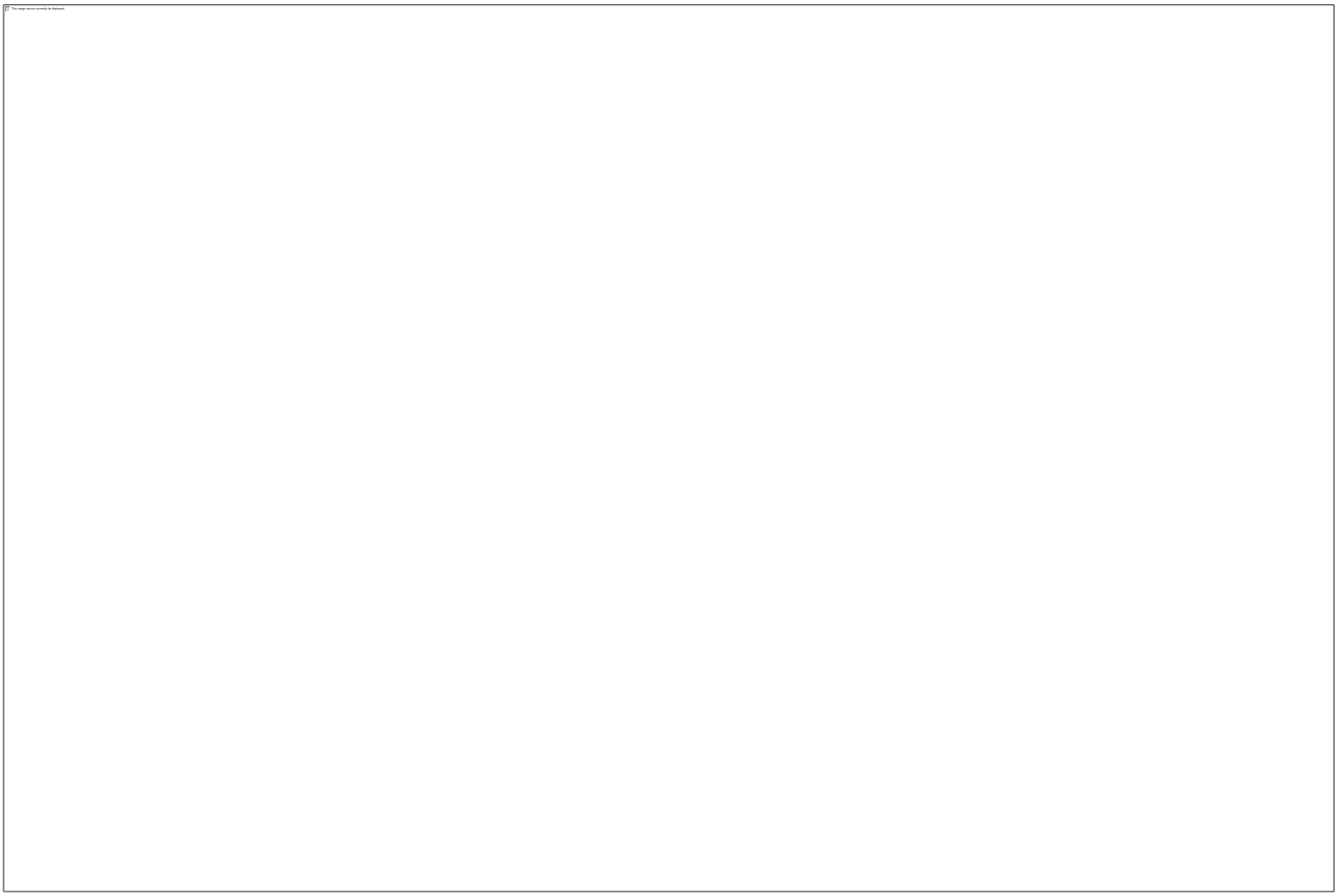
2.10 Making Use of Available Fish Resources

- Value addition allows different fish species to be processed into suitable products.
- Small fish can be dried, salted or processed into other products.
- Fish trimmings can be used in suitable fish-based products where food safety requirements are met.
- Appropriate processing helps reduce unnecessary wastage.

3.0 TYPES OF FISH VALUE-ADDED PRODUCTS

Fish can be processed into different products depending on the fish species, consumer preferences, available equipment and intended market.

3.1 Fish Fillets



Meaning: Fish fillets are boneless or nearly boneless pieces of fish obtained by cutting flesh away from the backbone and other major bones.

Characteristics:

- Usually consist of flesh from the sides of the fish.
- May have the skin removed or retained.
- Are easy to prepare and cook.
- Can be fresh, chilled or frozen.
- Are commonly used in hotels, restaurants and homes.

Fish species used:

- Nile perch.
- Tilapia.
- Salmon.
- Cod.
- Catfish.

Uses of fish fillets:

1. Frying.
2. Grilling.
3. Baking.
4. Steaming.
5. Preparation of fish fingers.
6. Preparation of fish burgers.

3.2 Fish Fingers



Meaning: Fish fingers are elongated pieces of fish flesh that are coated with batter or breadcrumbs and then cooked or prepared for freezing.

Characteristics:

- Have a finger-like shape.

- Are commonly coated with breadcrumbs.
- Have a crispy outer surface when fried.
- Have a soft fish flesh interior.
- May be sold frozen or chilled.

Main ingredients:

- Fish fillets.
- Wheat flour.
- Breadcrumbs.
- Eggs or suitable batter ingredients.
- Salt.
- Spices and seasonings.

Uses:

- Served as snacks.
- Served in hotels and restaurants.
- Used in school meals.
- Served with chips, vegetables or salads.

3.3 Fish Cakes



Meaning: Fish cakes are food products made by mixing minced or flaked fish with ingredients such as mashed potatoes, flour, eggs, herbs and spices before shaping and cooking.

Ingredients:

- Minced fish.
- Mashed potatoes or other suitable binders.
- Eggs.
- Wheat flour or breadcrumbs.
- Salt.
- Onions.
- Herbs and spices.

Characteristics:

- Usually round, oval or flattened.
- Have a soft interior.
- Can have a crispy outer surface.
- Can be fried, baked or otherwise cooked.

Importance:

- Provide a convenient way of consuming fish.
- Allow the use of suitable fish trimmings.
- Can be produced in different flavours.
- Provide opportunities for small-scale fish processing businesses.

3.4 Fish Balls



Meaning: Fish balls are small, round food products made from minced fish mixed with seasonings and binding ingredients.

Ingredients:

- Minced fish.

- Salt.
- Starch.
- Spices.
- Suitable binding ingredients.
- Water or other formulation ingredients.

Characteristics:

- Usually spherical in shape.
- Have a smooth or slightly firm texture.
- Can be boiled, fried or added to soups.
- Can be sold fresh, chilled or frozen.

Uses:

- Preparation of soups.
- Preparation of stews.
- Snacks.
- Restaurant meals.

3.5 Fish Sausages



Meaning: Fish sausages are processed fish products made by mixing minced fish with seasonings, suitable binding ingredients and other approved ingredients before filling into sausage casings or moulds.

Ingredients:

- Minced fish.
- Salt.
- Spices.
- Approved food additives where permitted.
- Binding ingredients.

- Suitable casings.

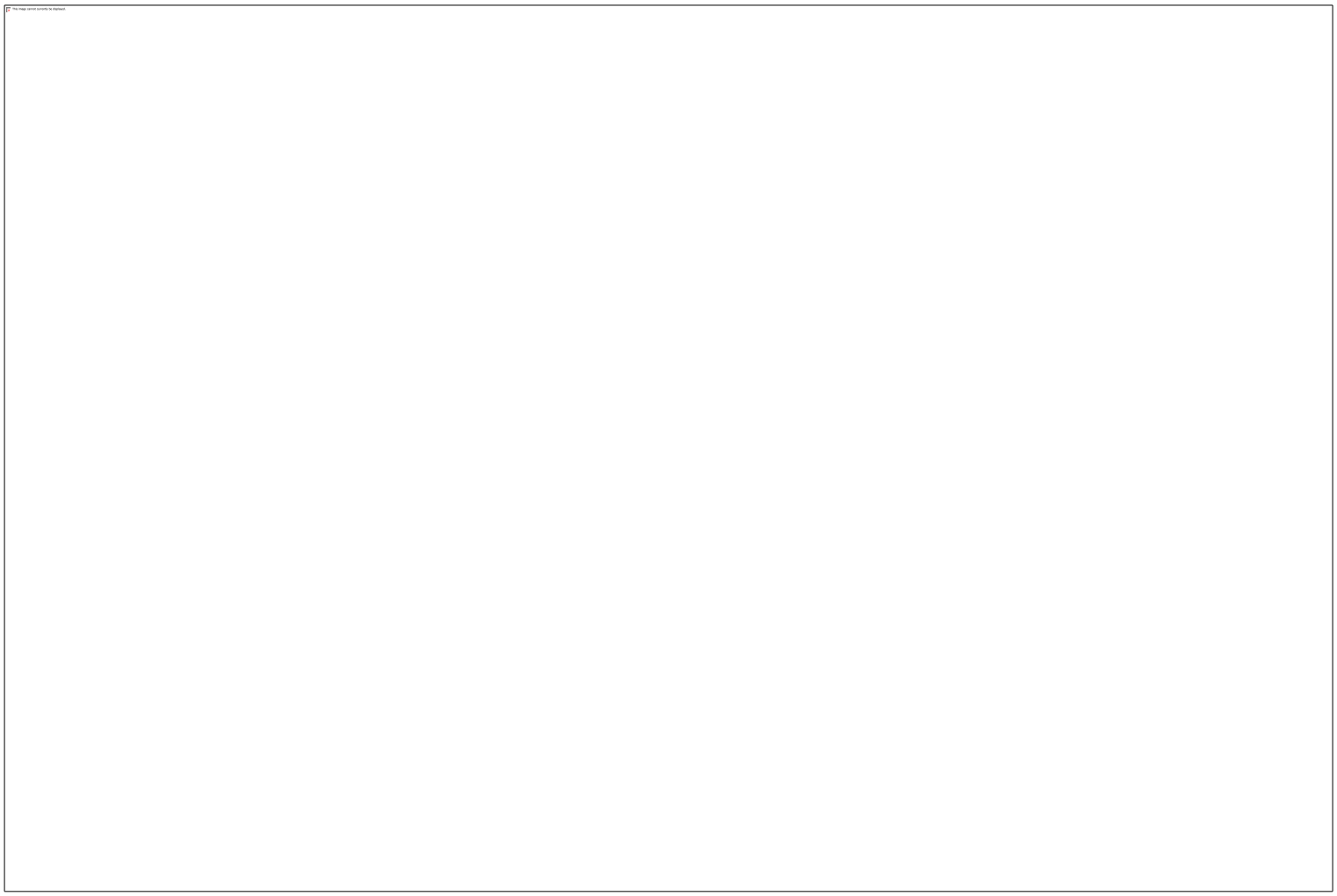
Characteristics:

- Have an elongated shape.
- Have a uniform texture.
- Can be cooked by boiling, frying or grilling, depending on the product.
- Can be packaged for chilled or frozen storage.

Importance:

- Provide an alternative to meat sausages.
- Increase the variety of fish products.
- Provide opportunities for food processing enterprises.

3.6 Fish Burgers



Meaning: Fish burgers are food products made from minced or formed fish flesh shaped into round patties and cooked or prepared for cooking.

Ingredients:

- Minced fish.
- Breadcrumbs.
- Salt.

- Eggs or suitable binders.
- Spices.
- Onions.

Characteristics:

- Usually round and flattened.
- Have a soft fish interior.
- Can be grilled, baked or fried.
- Can be served in bread buns.

3.7 Fish Samosas



Meaning: Fish samosas are triangular or other shaped pastry products filled with seasoned cooked or properly prepared fish mixture.

Ingredients:

- Fish flesh.
- Wheat flour pastry.
- Onions.
- Salt.
- Spices.
- Cooking oil.
- Vegetables, where appropriate.

Characteristics:

- Usually have a triangular shape.

- Have a crispy outer pastry.
- Contain seasoned fish filling.
- Are commonly deep-fried or baked.

Importance:

- Provide convenient snacks.
- Add variety to fish products.
- Can be sold in schools, hotels and food outlets.
- Provide income-generating opportunities.

3.8 Smoked Fish



Meaning: Smoked fish is fish that has been exposed to smoke produced by controlled burning or smouldering of suitable fuel under appropriate processing conditions.

Characteristics:

- Has a characteristic smoky flavour.
- May have a golden, brown or darker appearance.
- Can have an extended shelf life when properly processed and stored.
- Can be sold whole or in pieces.

Examples:

- Smoked tilapia.
- Smoked catfish.
- Smoked Nile perch.

3.9 Salted Fish



Meaning: Salted fish is fish preserved through the application of salt to reduce available moisture and inhibit the growth of many spoilage microorganisms.

Characteristics:

- Has a salty taste.
- Can be stored for longer when properly processed.
- May be dried after salting.
- Requires suitable packaging and storage.

3.10 Dried Fish

Meaning: Dried fish is fish from which moisture has been removed through sun drying, mechanical drying or other appropriate drying techniques.

Examples in Kenya:

- Sun-dried omena.
- Dried small sardines.

- Dried tilapia pieces.

Importance:

- Reduces moisture content.
- Helps reduce microbial spoilage.
- Makes transportation easier.
- Provides fish products during periods of low fish supply.

4.0 METHODS OF FISH VALUE ADDITION

The major methods of fish value addition include:

1. Filleting.
2. Frying.
3. Smoking.
4. Salting.
5. Sun drying.

Other methods include freezing, chilling, canning, mincing, fermentation and packaging.

4.1 Fish Filleting



Meaning: Filleting is the process of removing the flesh from the backbone of a fish to produce fish fillets.

Equipment and materials used

- Sharp fish filleting knife.
- Cutting board.
- Clean water.
- Food-grade trays.
- Protective gloves where appropriate.
- Apron.
- Weighing scale.

- Refrigeration equipment.

Procedure for filleting fish

1. Select fresh, healthy fish from an approved source.
2. Inspect the fish for freshness and signs of spoilage.
3. Wash the fish using potable water.
4. Place the fish on a clean cutting board.
5. Remove scales where necessary.
6. Remove the fins and head where appropriate.
7. Make a careful cut behind the gills towards the backbone.
8. Run the knife along the backbone to separate the flesh.
9. Repeat the process on the opposite side.
10. Remove remaining bones using suitable tools.
11. Remove the skin if required.
12. Trim unwanted parts.
13. Rinse the fillets using potable water where appropriate.
14. Place the fillets in clean food-grade containers.
15. Chill or freeze promptly.

Advantages of filleting

- Produces convenient fish portions.
- Removes major bones.
- Increases consumer convenience.
- Creates products suitable for hotels and restaurants.
- Provides raw material for fish fingers and fish burgers.

Challenges of filleting

- Requires skilled labour.
- Requires sharp and appropriate equipment.
- May result in flesh wastage if poorly done.
- Requires proper hygiene.
- Needs cold storage to maintain freshness.

4.2 Fish Frying



Meaning: Frying is a cooking and processing method in which fish is exposed to heated cooking oil or fat to produce a cooked product with desirable flavour, colour and texture.

Types of frying

a) Deep frying

- Fish is completely or almost completely immersed in hot cooking oil.
- It produces a relatively uniform cooked surface.
- Commonly used for fish fingers, fish samosas and fish balls.

b) Shallow frying

- A small amount of oil is used.
- Fish is cooked on one side and turned to cook the other side.
- Commonly used for fish cakes and fish fillets.

Equipment and materials

- Frying pan or deep fryer.
- Cooking oil.
- Fish portions.
- Cooking thermometer.
- Food-grade trays.
- Cooking utensils.
- Protective clothing.

Procedure for frying fish

1. Select fresh fish.
2. Clean and prepare the fish.
3. Cut the fish into suitable portions.
4. Season the fish with appropriate ingredients.
5. Coat the fish with flour, batter or breadcrumbs if required.

6. Heat clean cooking oil to a suitable frying temperature.
7. Place the fish carefully into the hot oil.
8. Fry until thoroughly cooked.
9. Remove the fish using clean utensils.
10. Allow excess oil to drain.
11. Serve immediately or cool rapidly using appropriate food-safe procedures before chilled storage.
12. Package and store under recommended conditions if not consumed immediately.

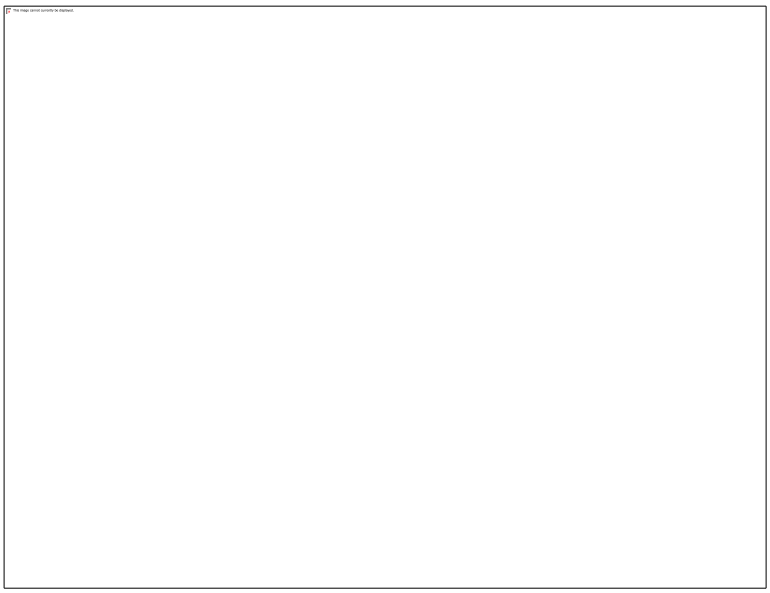
Advantages of frying

- Improves taste and flavour.
- Produces an attractive golden colour.
- Provides a convenient ready-to-eat product when fully cooked.
- Creates variety in fish products.
- Can increase the market appeal of fish.

Disadvantages of frying

- Requires cooking oil.
- May increase the fat content of the product.
- Excessive frying can reduce product quality.
- Hot oil can cause burns.
- Fried products may deteriorate if stored improperly.

4.3 Fish Smoking



Meaning: Fish smoking is a preservation and processing method in which fish is exposed to smoke from controlled combustion or smouldering of suitable wood or other approved fuel.

Smoking can provide flavour, colour and preservation benefits.

Types of fish smoking

a) Hot smoking

- Fish is exposed to heat and smoke.
- The fish is cooked during processing.
- It produces a characteristic smoky flavour.
- The product usually requires refrigeration unless another validated preservation system is used.

b) Cold smoking

- Fish is exposed to smoke at relatively low temperatures.
- It does not fully cook the fish.
- It mainly develops flavour and surface characteristics.
- It requires carefully controlled processing and strict food safety measures because harmful microorganisms may survive.

Equipment and materials

- Smoking kiln.
- Smoking racks.
- Suitable wood or approved fuel.
- Clean water.
- Knives.
- Food-grade containers.
- Protective clothing.

Procedure for smoking fish

1. Select fresh fish.
2. Wash the fish using potable water.
3. Remove scales and unwanted parts where necessary.
4. Split or cut the fish into suitable portions.
5. Apply salt or an appropriate preparation treatment if required.
6. Arrange the fish on clean smoking racks.
7. Prepare the smoking kiln using suitable fuel.
8. Control the heat and smoke conditions.
9. Smoke the fish for the required period under a validated process.
10. Remove the fish after the desired processing conditions have been achieved.
11. Cool the product hygienically.
12. Package in suitable food-grade materials.
13. Store under appropriate temperature and moisture conditions.

Advantages of smoking fish

- Develops a desirable flavour.
- Produces an attractive appearance.
- Can reduce moisture content.
- Helps inhibit spoilage microorganisms.
- Extends shelf life when properly controlled.
- Makes fish products easier to market.

Disadvantages of smoking fish

- Requires smoking equipment.
- Poorly controlled smoking can produce unsafe products.
- Excessive smoke exposure may result in undesirable chemical contaminants.
- Requires fuel.
- Traditional smoking may cause environmental pollution.
- Inadequate processing may lead to spoilage.

4.4 Fish Salting



Meaning: Fish salting is a preservation method in which salt is applied to fish to reduce the amount of water available for microbial growth.

Ways of salting fish

a) Dry salting

- Dry salt is applied directly to the fish.
- Salt draws moisture from the fish.
- The fish may be layered with salt in suitable containers.
- It is suitable for different fish species and product types.

b) Brining

- Fish is immersed in a prepared salt solution.

- Salt penetrates the fish flesh.
- The concentration and processing time must be controlled.

Equipment and materials

- Food-grade salt.
- Clean containers.
- Weighing scale.
- Knives.
- Cutting boards.
- Potable water.
- Food-grade trays.

Procedure for dry salting

1. Select fresh fish.
2. Clean the fish thoroughly.
3. Remove scales and internal organs where appropriate.
4. Cut the fish into suitable portions.
5. Weigh the fish.
6. Measure the required quantity of food-grade salt.
7. Apply salt evenly to the fish.
8. Place the fish in clean food-grade containers.
9. Allow salt to penetrate under controlled conditions.
10. Drain excess liquid where required.
11. Dry or package the fish depending on the intended product.
12. Store under appropriate conditions.

Advantages of salting

- Reduces water available for microbial growth.
- Helps extend shelf life.
- Requires relatively simple equipment.
- Can be carried out by small-scale processors.
- Makes fish easier to preserve for transportation and marketing.

Disadvantages of salting

- Excess salt may affect taste.
- Requires proper control of salt concentration.
- Some consumers prefer low-salt foods.
- Poor hygiene may cause contamination.

- Salted fish may still spoil if not properly dried and stored.

4.5 Sun Drying of Fish



Meaning: Sun drying is a fish preservation method in which moisture is removed from fish through exposure to solar heat and moving air.

Requirements for sun drying

- Adequate sunlight.
- Good air circulation.
- Clean drying racks.
- Potable water.
- Food-grade containers.
- Suitable protective covers or mesh.
- A clean drying environment.

Procedure for sun drying fish

1. Select fresh fish.
2. Sort the fish according to size and species.
3. Wash using potable water.
4. Remove unwanted parts where necessary.
5. Cut large fish into suitable pieces.
6. Apply salt where appropriate.
7. Arrange the fish in a single layer on clean raised drying racks.
8. Expose the fish to adequate sunlight and air circulation.
9. Protect the fish from flies, birds, dust and other contaminants.
10. Turn the fish periodically where necessary.
11. Continue drying until the required moisture level is achieved.

12. Allow the fish to cool in a clean protected environment.
13. Package in moisture-resistant food-grade packaging.
14. Store in a cool, dry and pest-free environment.

Advantages of sun drying

- Uses naturally available solar energy.
- Requires relatively low operating costs.
- Reduces moisture content.
- Helps extend shelf life.
- Suitable for small-scale fish processors.
- Can be used for omena and other small fish.

Disadvantages of sun drying

- Depends on weather conditions.
- Rain may interrupt the drying process.
- Dust and insects may contaminate fish.
- Drying may be uneven.
- Requires adequate drying space.
- Poor drying may lead to mould growth.

4.6 Fish Chilling



Meaning: Chilling is the process of lowering the temperature of fish to slow down microbial growth and enzyme activity.

Procedure:

1. Select fresh fish.
2. Wash using potable water where necessary.
3. Place the fish in clean insulated containers.
4. Add clean ice in suitable proportions.

5. Maintain the fish at a temperature close to melting ice.
6. Drain melted water to prevent contamination.
7. Monitor temperature regularly.
8. Transport the fish under chilled conditions.

Importance:

- Maintains freshness.
- Slows spoilage.
- Preserves desirable quality.
- Supports transportation to distant markets.

4.7 Fish Freezing



Meaning: Freezing is the process of lowering the temperature of fish below its freezing point so that much of the water in the fish becomes ice.

Importance:

- Extends storage life.
- Slows microbial growth.
- Allows storage during periods of low demand.
- Supports long-distance transportation.
- Helps maintain product quality when correctly performed.

Procedure:

1. Select fresh fish.

2. Clean and prepare the fish.
3. Cut into appropriate portions.
4. Package using suitable food-grade packaging.
5. Freeze rapidly using suitable equipment.
6. Maintain frozen storage at the recommended temperature, commonly -18°C or colder.
7. Avoid repeated thawing and refreezing.

5.0 GENERAL HYGIENE AND SAFETY DURING FISH VALUE ADDITION

Fish is highly perishable. Therefore, hygiene and safety must be maintained throughout processing.

5.1 Personal Hygiene

Fish processors should:

- Wash hands with soap and clean water before handling fish.
- Wear clean protective clothing.
- Use hairnets or suitable head coverings.
- Keep fingernails short and clean.
- Cover wounds using waterproof dressings.
- Avoid handling fish when suffering from illnesses that may contaminate food.
- Avoid eating, smoking or spitting in processing areas.
- Maintain clean footwear.

5.2 Equipment Hygiene

- Clean knives and cutting boards before and after use.
- Use food-grade processing equipment.
- Wash containers using suitable cleaning procedures.
- Sanitise equipment where appropriate.
- Store equipment in clean, dry places.
- Maintain processing machines in good working condition.

5.3 Processing Area Hygiene

- Maintain clean floors and walls.
- Provide adequate drainage.
- Ensure proper ventilation.
- Prevent access by rodents and insects.
- Separate raw fish from cooked products.
- Provide adequate handwashing facilities.
- Dispose of waste properly.

5.4 Fish Handling Safety

- Use fresh fish from approved sources.
- Maintain the cold chain.
- Avoid cross-contamination.
- Use potable water.
- Protect fish from flies and dust.
- Use appropriate packaging.
- Observe recommended cooking temperatures and processing conditions.

5.5 Common Hazards in Fish Processing

Hazard	Possible effect	Control measure
Biological	Food poisoning	Hygiene and temperature control
Chemical	Chemical contamination	Use approved cleaning agents and food-grade materials
Physical	Injury or choking	Remove bones and foreign materials
Thermal	Burns from hot oil or kilns	Use protective equipment
Mechanical	Cuts from knives	Proper knife handling

6.0 FISH VALUE ADDITION EQUIPMENT AND THEIR USES

Equipment	Main use
Filleting knife	Cutting fish into fillets
Cutting board	Providing a cutting surface
Weighing scale	Measuring fish and ingredients
Smoking kiln	Smoking fish
Drying rack	Drying fish
Deep fryer	Frying fish products
Refrigerator	Chilling fish
Freezer	Freezing fish
Food-grade containers	Holding fish and ingredients
Packaging machine	Sealing packaged products
Thermometer	Monitoring temperature
Protective gloves	Protecting hands during handling

7.0 PACKAGING OF VALUE-ADDED FISH PRODUCTS

7.1 Meaning of Packaging

Packaging refers to the process of enclosing fish products in suitable materials to protect them from contamination, physical damage, moisture loss or gain and other factors that may affect quality.

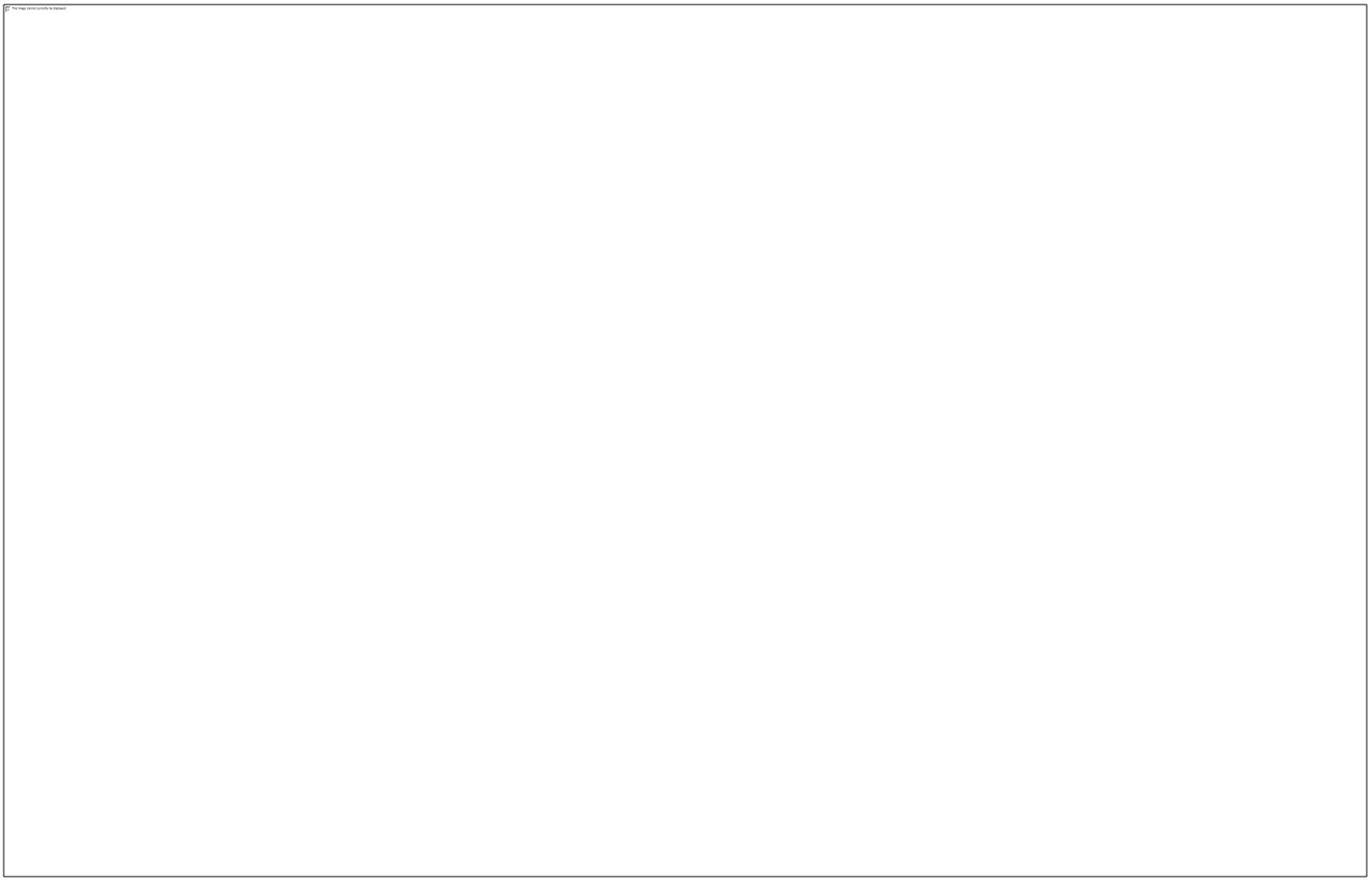
7.2 Importance of Packaging

1. Protects fish from contamination.
2. Improves product appearance.
3. Makes handling and transportation easier.
4. Helps maintain product quality.
5. Provides space for product information.

6. Supports product identification and branding.
7. Helps prevent physical damage.
8. Can extend shelf life when combined with appropriate processing and storage.

7.3 Types of Packaging Materials





a) Plastic packaging

- Used for fresh, chilled and frozen fish products.
- Can be transparent.
- Helps protect fish from external contamination.
- Must be suitable for food contact.

b) Vacuum packaging

- Air is removed from the package before sealing.
- Helps reduce oxidation and certain forms of spoilage.
- Requires strict temperature control.
- Does not eliminate all food safety risks.

c) Aluminium foil

- Can protect fish from light and moisture.
- Can be used in suitable food packaging applications.
- Must be appropriate for the product and processing conditions.

d) Carton packaging

- Used for transporting and presenting packaged fish products.
- Can provide protection against physical damage.
- Often used together with inner food-grade packaging.

7.4 Information on Fish Product Labels

A properly labelled fish product should include:

- Name of the product.
- Name and address of the manufacturer.
- Net weight.
- Ingredients.
- Batch or lot number.
- Date of manufacture.
- Expiry date or best-before date, as applicable.
- Storage instructions.
- Preparation or cooking instructions where necessary.
- Allergen information.
- Relevant certification or regulatory information.

8.0 STORAGE OF VALUE-ADDED FISH PRODUCTS

Storage is important in maintaining the quality and safety of processed fish.

8.1 Chilled Storage

- Used for fresh and certain processed fish products.
- Maintains low temperatures.
- Slows microbial growth.
- Requires proper refrigeration.
- Temperature should be monitored regularly.

8.2 Frozen Storage

- Used for frozen fish fillets, fish fingers, fish balls and other frozen products.
- Commonly maintained at -18°C or colder.
- Prevents the growth of most microorganisms while the product remains frozen.
- Helps maintain quality over an extended period.

8.3 Dry Storage

- Used for properly dried and packaged fish.
- Products should be kept in a cool, dry environment.
- Stores should be free from rodents and insects.
- Products should be protected from moisture.
- Storage containers should be clean and properly covered.

8.4 Factors Affecting Storage Life of Fish Products

1. Moisture content.

2. Storage temperature.
3. Processing method.
4. Packaging quality.
5. Initial freshness of fish.
6. Hygiene during processing.
7. Exposure to air.
8. Presence of microorganisms.
9. Storage humidity.
10. Handling and transportation conditions.

9.0 MARKETING OF VALUE-ADDED FISH PRODUCTS

Marketing involves identifying customers, promoting products, setting prices and distributing products to consumers.

9.1 Potential Markets for Value-Added Fish Products in Kenya

- Supermarkets.
- Hotels.
- Restaurants.
- Schools and institutions.
- Fish shops.
- Local markets.
- Online food businesses.
- Catering companies.
- Tourist establishments.
- Households.

9.2 Marketing Strategies

a) Product branding

- Giving the product a unique name.
- Using attractive labels.
- Maintaining consistent product quality.

b) Advertising

- Using social media platforms.
- Displaying products in shops.
- Distributing brochures.
- Participating in agricultural exhibitions.

c) Competitive pricing

- Considering processing costs.
- Considering packaging costs.
- Studying competitors' prices.
- Setting prices that provide reasonable profit.

d) Product diversification

- Producing different fish products.
- Offering different package sizes.
- Developing products to meet customer preferences.

e) Customer service

- Responding to customer feedback.
- Maintaining consistent quality.
- Delivering products on time.
- Handling complaints professionally.

10.0 CHALLENGES FACING FISH VALUE ADDITION IN KENYA

10.1 High Cost of Equipment

- Smoking kilns, freezers and packaging machines may be expensive.
- Small-scale processors may lack sufficient capital.
- Maintenance costs may be high.

Possible solution: Establish cooperative processing facilities and access affordable credit.

10.2 Unreliable Electricity Supply

- Refrigerators and freezers depend on electricity.
- Power interruptions can affect product quality.
- Electricity costs may increase production expenses.

Possible solution: Use backup power systems and energy-efficient equipment.

10.3 Inadequate Processing Skills

- Some processors may lack modern processing knowledge.
- Poor techniques may result in low-quality products.
- Inadequate hygiene may cause contamination.

Possible solution: Provide regular training and technical support.

10.4 Limited Access to Markets

- Some processors may lack reliable buyers.
- Transport challenges may limit market access.
- Competition from other food products may affect sales.

Possible solution: Improve marketing, branding and distribution networks.

10.5 Poor Infrastructure

- Some fishing communities lack proper roads.
- Inadequate storage facilities may cause losses.
- Poor access to clean water may affect processing hygiene.

Possible solution: Invest in cold-chain facilities, roads and clean water supplies.

10.6 Inadequate Capital

- Fish processing requires money for raw materials and equipment.
- Small enterprises may struggle to expand.
- Packaging and certification may increase operational costs.

Possible solution: Form savings groups, cooperatives and seek appropriate financial support.

10.7 Consumer Preferences

- Some consumers prefer fresh fish.
- Others may be unfamiliar with new fish products.
- Some may perceive processed fish as expensive.

Possible solution: Conduct consumer education, product demonstrations and market research.

11.0 ENVIRONMENTAL CONSERVATION DURING FISH VALUE ADDITION

Fish processing should be conducted in ways that protect the environment.

11.1 Proper Disposal of Fish Waste

- Collect fish scales, bones, fins and other waste.
- Avoid dumping fish waste into rivers, lakes and drainage systems.
- Dispose of waste according to environmental regulations.
- Suitable fish by-products may be processed into approved animal feed or other useful products.

11.2 Efficient Use of Water

- Avoid unnecessary water wastage.
- Repair leaking taps and pipes.
- Use water efficiently during washing and cleaning.
- Ensure wastewater is properly treated before discharge.

11.3 Proper Use of Fuel

- Use energy-efficient smoking kilns.
- Avoid excessive burning of firewood.
- Use approved sustainable fuel sources.
- Maintain smoking equipment to reduce smoke pollution.

11.4 Proper Waste Management

- Separate organic and non-organic waste.
- Recycle suitable packaging materials.
- Use reusable containers where appropriate.
- Maintain clean surroundings.

12.0 PRACTICAL ACTIVITY: PREPARATION OF FISH FINGERS



Aim

To prepare fish fingers using fresh fish fillets.

Requirements

- Fresh fish fillets.
- Wheat flour.
- Eggs.
- Breadcrumbs.
- Salt.
- Suitable spices.
- Cooking oil.
- Knife.

- Cutting board.
- Mixing bowls.
- Frying pan or deep fryer.
- Food thermometer.
- Clean plates.
- Protective clothing.

Procedure

1. Wash hands using soap and clean water.
2. Clean and sanitise the working surfaces and equipment.
3. Select fresh fish fillets.
4. Cut the fillets into elongated finger-shaped pieces.
5. Season the fish with salt and suitable spices.
6. Place wheat flour in a clean bowl.
7. Beat eggs in another bowl.
8. Place breadcrumbs in a separate bowl.
9. Coat each fish strip in flour.
10. Dip the coated fish into the beaten eggs.
11. Roll the fish in breadcrumbs.
12. Heat cooking oil to a suitable temperature.
13. Fry the fish fingers until thoroughly cooked.
14. Remove them using clean utensils.
15. Drain excess oil.
16. Present the finished fish fingers attractively.
17. Clean the working area and equipment.

Observations

Learners should observe:

- Shape of the fish fingers.
- Colour of the outer coating.
- Texture of the cooked product.
- Aroma of the finished product.
- Taste of the product.
- Uniformity of the pieces.

Safety Precautions

- Handle knives carefully.

- Avoid splashing hot oil.
- Use clean equipment.
- Do not taste raw fish.
- Ensure fish is thoroughly cooked.
- Avoid cross-contamination between raw and cooked fish.

Expected Outcomes

The learner should be able to:

- Prepare fish fingers.
- Identify ingredients used.
- Demonstrate proper hygiene.
- Apply appropriate cooking techniques.
- Appreciate fish value addition as an income-generating activity.

13.0 ENTREPRENEURSHIP OPPORTUNITIES IN FISH VALUE ADDITION

Fish value addition offers many opportunities for business development in Kenya.

13.1 Small-Scale Fish Processing Enterprise

An individual or group can establish a small business processing fish into:

- Fish fingers.
- Fish samosas.
- Fish cakes.
- Fish balls.
- Smoked fish.
- Dried fish.

13.2 Fish Packaging Business

- Buying processed fish from approved processors.
- Packaging fish into appropriate quantities.
- Labelling and branding products.
- Supplying supermarkets and local shops.

13.3 Fish Distribution Business

- Buying fish products from processors.
- Maintaining chilled or frozen transportation.
- Supplying hotels and restaurants.
- Distributing products to different counties.

13.4 Fish Snack Production

- Preparing fish samosas.

- Preparing fish burgers.
- Preparing fish cakes.
- Preparing fish fingers.
- Supplying schools, hotels and food outlets.

13.5 Importance of Entrepreneurship in Fish Value Addition

1. Creates employment.
2. Generates income.
3. Promotes innovation.
4. Reduces post-harvest losses.
5. Improves food availability.
6. Promotes local industries.
7. Encourages responsible use of fish resources.

REVISION QUESTIONS

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer all questions. Choose the best answer in each case.

1. What is meant by fish value addition?

A. Catching fish from natural water bodies.

B. Transforming raw fish into more useful and marketable products.

C. Releasing fish into rivers and lakes.

D. Feeding fish in aquaculture ponds.

2. Which one of the following is a fish value-added product?

A. Fish pond.

B. Fishing net.

C. Fish sausage.

D. Fish feed.

3. Which of the following is a major reason for adding value to fish?

A. Increasing fish spoilage.

B. Reducing fish quality.

C. Improving marketability.

D. Increasing fish wastage.

4. Which fish product is obtained by separating flesh from the backbone?

A. Fish fillet.

B. Fish sausage.

C. Fish samosa.

D. Fish burger.

5. The process of removing moisture from fish through exposure to sunlight is called:

A. Filleting.

B. Frying.

C. Drying.

D. Mincing.

6. Which method of fish processing involves exposing fish to smoke?

A. Freezing.

B. Smoking.

C. Filleting.

D. Chilling.

7. Which of the following is an example of a fish product commonly made using minced fish?

A. Fish balls.

B. Fish pond.

C. Fishing boat.

D. Fish feed.

8. Which equipment is most appropriate for measuring the weight of fish during processing?

A. Filleting knife.

B. Smoking kiln.

C. Weighing scale.

D. Frying pan.

9. Which of the following is a major advantage of fish filleting?

A. Increasing the number of bones.

B. Making fish difficult to prepare.

C. Producing convenient fish portions.

D. Increasing fish contamination.

10. Which method involves immersing fish in hot cooking oil?

A. Frying.

B. Smoking.

C. Drying.

D. Salting.

11. What is the main purpose of salting fish?

A. Increasing moisture content.

B. Reducing water available for microbial growth.

C. Increasing fish weight.

D. Increasing fish spoilage.

12. Which of the following is commonly used as a coating material when preparing fish fingers?

A. Soil. B. Sand.

C. Breadcrumbs. D. Sawdust.

13. Which fish product consists of a seasoned filling enclosed in pastry?

A. Fish fillet.

B. Fish samosa.

C. Smoked fish.

D. Salted fish.

14. Which of the following is a method of preserving fish?

A. Filleting only.

B. Smoking.

C. Cutting only.

D. Weighing.

15. What is the major importance of chilling fish?

A. Increasing microbial growth.

B. Slowing down spoilage.

C. Increasing moisture loss through burning.

D. Increasing fish contamination.

16. Which of the following is a suitable storage temperature for frozen fish products?

A. 25°C.

B. 15°C.

C. 5°C.

D. -18°C or colder.

17. Which of the following is an example of hot smoking?

A. Exposing fish to controlled smoke and heat until cooked.

B. Keeping fish in ordinary room conditions.

C. Washing fish with cold water.

D. Cutting fish into pieces.

18. Which of the following should be worn by fish processors to maintain hygiene?

A. Dirty clothes.

B. Hairnet and clean protective clothing.

C. Open shoes in wet processing areas.

D. Loose jewellery.

19. What is the purpose of packaging fish products?

A. Increasing contamination.

B. Exposing fish to dust.

C. Protecting products from contamination.

D. Increasing physical damage.

20. Which of the following is suitable for storing dried fish?

A. A damp open area.

B. A clean, dry and pest-free store.

C. An uncovered drainage area.

D. A dirty container.

21. Which of the following is an ingredient commonly used in preparing fish cakes?

A. Mashed potatoes.

B. Soil.

C. Kerosene.

D. Sand.

22. Which of the following is a challenge facing fish value addition in Kenya?

A. Availability of fish species.

B. High cost of processing equipment.

C. Availability of consumers.

D. Availability of local markets.

23. Which of the following is a good environmental practice during fish processing?

A. Dumping waste into rivers.

B. Burning plastic packaging.

C. Proper disposal of fish waste.

D. Releasing untreated wastewater into lakes.

24. Which of the following products is commonly prepared by shaping minced fish into elongated portions and coating them with breadcrumbs?

A. Fish fingers.

B. Salted fish.

C. Dried fish.

D. Smoked fish.

25. Which factor is most important when selecting fish for value addition?

A. Degree of spoilage.

B. Freshness and quality.

C. Presence of dirt.

D. Unpleasant smell.

26. What is the main purpose of a smoking kiln?

A. Freezing fish.

B. Weighing fish.

C. Smoking fish.

D. Packaging fish.

27. Which of the following is a possible market for value-added fish products in Kenya?

A. Hotels and restaurants.

B. Abandoned mines.

C. Empty ponds.

D. Forest reserves.

28. Which of the following is a benefit of fish value addition to young people?

A. Increased unemployment.

B. Reduced business opportunities.

C. Employment and entrepreneurship opportunities.

D. Increased post-harvest losses.

29. Why should raw fish and cooked fish be handled separately?

A. To increase contamination.

B. To prevent cross-contamination.

C. To increase spoilage.

D. To reduce product quality.

30. Which of the following best demonstrates appreciation of fish value addition?

A. Wasting harvested fish.

B. Avoiding fish processing.

C. Supporting hygienically processed fish products.

D. Discarding surplus fish.

SECTION B: STRUCTURED QUESTIONS – 50 MARKS

Answer all questions.

QUESTION 1: INTRODUCTION TO FISH VALUE ADDITION (8 MARKS)

a) Define fish value addition. (2 marks)

b) State four reasons for adding value to fish products. (4 marks)

c) Give two examples of fish value-added products. (2 marks)

QUESTION 2: FISH VALUE-ADDED PRODUCTS (8 MARKS)

a) Identify four fish value-added products. (4 marks)

b) Explain two characteristics of fish fillets. (2 marks)

c) State two ingredients used in the preparation of fish cakes. (2 marks)

QUESTION 3: METHODS OF FISH VALUE ADDITION (10 MARKS)

a) Explain the meaning of fish smoking. (2 marks)

b) Outline four steps followed when smoking fish. (4 marks)

c) State two advantages of drying fish. (2 marks)

d) Differentiate between dry salting and brining. (2 marks)

QUESTION 4: FISH PROCESSING HYGIENE AND SAFETY (8 MARKS)

a) State four personal hygiene practices that should be observed by fish processors. (4 marks)

b) Give two reasons why fish processing equipment should be cleaned regularly. (2 marks)

c) State two safety precautions when frying fish. (2 marks)

QUESTION 5: PACKAGING, STORAGE AND MARKETING (8 MARKS)

a) State three importance of packaging fish products. (3 marks)

b) Give two examples of information that should appear on fish product labels. (2 marks)

c) State three potential markets for value-added fish products in Kenya. (3 marks)

QUESTION 6: PRACTICAL APPLICATION AND ENVIRONMENTAL CONSERVATION (8 MARKS)

a) Outline four steps involved in preparing fish fingers. (4 marks)

b) State two challenges facing fish value addition in Kenya. (2 marks)

c) Give two environmentally friendly practices that should be observed during fish processing. (2 marks)

ANSWER KEY AND MARKING SCHEME

SECTION A: MULTIPLE CHOICE ANSWERS

Question	Answer	Question	Answer
1	B	16	D
2	C	17	A
3	C	18	B
4	A	19	C
5	C	20	B
6	B	21	A
7	A	22	B
8	C	23	C
9	C	24	A
10	A	25	B
11	B	26	C
12	C	27	A
13	B	28	C
14	B	29	B
15	B	30	C

SECTION B: SUGGESTED MARKING SCHEME

QUESTION 1 (8 MARKS)

a) Fish value addition is the process of transforming raw fish into more useful, convenient, durable and marketable products through processing and preservation. (2 marks)

b) Reasons:

- Improving fish quality.
- Increasing selling price.
- Extending shelf life.

- Reducing post-harvest losses.
- Improving consumer convenience.
- Broadening the market base.
- Creating employment.
- Improving food security.

Award 1 mark for each of any four correct points. (4 marks)

c) Examples:

- Fish fillets.
- Fish fingers.
- Fish sausages.
- Fish cakes.
- Fish balls.
- Fish burgers.
- Fish samosas.

Award 1 mark for each of any two. (2 marks)

QUESTION 2 (8 MARKS)

a) Any four:

- Fish fillets.
- Fish fingers.
- Fish cakes.
- Fish balls.
- Fish sausages.
- Fish burgers.
- Fish samosas.
- Smoked fish.
- Salted fish.
- Dried fish.

(4 marks)

b) Characteristics of fish fillets:

- Consist of flesh separated from the backbone.
- Usually contain few or no bones.
- May have the skin removed or retained.
- Are convenient to prepare and cook.
- Can be chilled or frozen.

Award 1 mark for each of any two. (2 marks)

c) Ingredients:

- Minced fish.
- Mashed potatoes.
- Eggs.
- Breadcrumbs.
- Wheat flour.
- Salt.
- Onions.
- Herbs and spices.

Award 1 mark for each of any two. (2 marks)

QUESTION 3 (10 MARKS)

a) Fish smoking is the process of exposing fish to smoke from controlled combustion or smouldering of suitable fuel to improve flavour and preserve the fish. (2 marks)

b) Steps:

- Select fresh fish.
- Wash fish using potable water.
- Remove unwanted parts.
- Cut into suitable portions.
- Apply salt if required.
- Arrange fish on smoking racks.
- Prepare the smoking kiln.
- Control heat and smoke.
- Smoke fish under appropriate conditions.
- Cool and package hygienically.

Award 1 mark for each of any four. (4 marks)

c) Advantages:

- Reduces moisture content.
- Helps extend shelf life.
- Reduces spoilage when properly done.
- Makes transportation easier.
- Uses solar energy.

Award 1 mark for each of any two. (2 marks)

d) Differences:

- **Dry salting:** Salt is applied directly to the surface of fish.
- **Brining:** Fish is immersed in a prepared salt solution.

(2 marks)

QUESTION 4 (8 MARKS)

a) Personal hygiene:

- Washing hands with soap and clean water.
- Wearing clean protective clothing.
- Wearing hairnets.
- Keeping fingernails short and clean.
- Covering wounds.
- Avoiding handling fish when ill.
- Avoiding eating and smoking in processing areas.

Award 1 mark for each of any four. (4 marks)

b) Reasons:

- To prevent contamination.
- To reduce the spread of microorganisms.
- To maintain product quality.
- To prevent cross-contamination.
- To maintain safe processing conditions.

Award 1 mark for each of any two. (2 marks)

c) Safety precautions:

- Use protective clothing and appropriate gloves.
- Avoid splashing hot oil.
- Use suitable frying equipment.
- Handle hot utensils carefully.
- Keep water away from hot oil.

Award 1 mark for each of any two. (2 marks)

QUESTION 5 (8 MARKS)

a) Importance of packaging:

- Protects fish from contamination.
- Improves product appearance.
- Makes transportation easier.
- Provides product information.
- Helps maintain product quality.

- Supports branding.
- Reduces physical damage.

Award 1 mark for each of any three. (3 marks)

b) Label information:

- Product name.
- Manufacturer's details.
- Net weight.
- Ingredients.
- Batch number.
- Date of manufacture.
- Expiry or best-before date.
- Storage instructions.
- Allergen information.

Award 1 mark for each of any two. (2 marks)

c) Markets:

- Hotels.
- Restaurants.
- Supermarkets.
- Schools.
- Fish shops.
- Local markets.
- Households.
- Catering businesses.

Award 1 mark for each of any three. (3 marks)

QUESTION 6 (8 MARKS)

a) Steps:

- Select fresh fish fillets.
- Cut into finger-shaped pieces.
- Season with salt and spices.
- Coat with wheat flour.
- Dip in beaten eggs.
- Coat with breadcrumbs.
- Fry until thoroughly cooked.
- Drain excess oil.

- Present attractively.

Award 1 mark for each of any four. (4 marks)

b) Challenges:

- High cost of equipment.
- Inadequate capital.
- Unreliable electricity.
- Inadequate processing skills.
- Poor infrastructure.
- Limited markets.
- High transportation costs.

Award 1 mark for each of any two. (2 marks)

c) Environmental practices:

- Proper disposal of fish waste.
- Treating wastewater before discharge.
- Using energy-efficient smoking kilns.
- Recycling suitable packaging materials.
- Avoiding unnecessary water wastage.
- Using sustainable fuel sources.

Award 1 mark for each of any two. (2 marks)

STRAND 2.0: AQUACULTURE

SUB-STRAND 2.4: FISH MARKETING

1.0 INTRODUCTION TO FISH MARKETING

Fish marketing refers to all activities involved in moving fish and fish products from the producer to the final consumer. It includes preparing fish for sale, determining prices, packaging, transportation, advertising, distribution and selling.

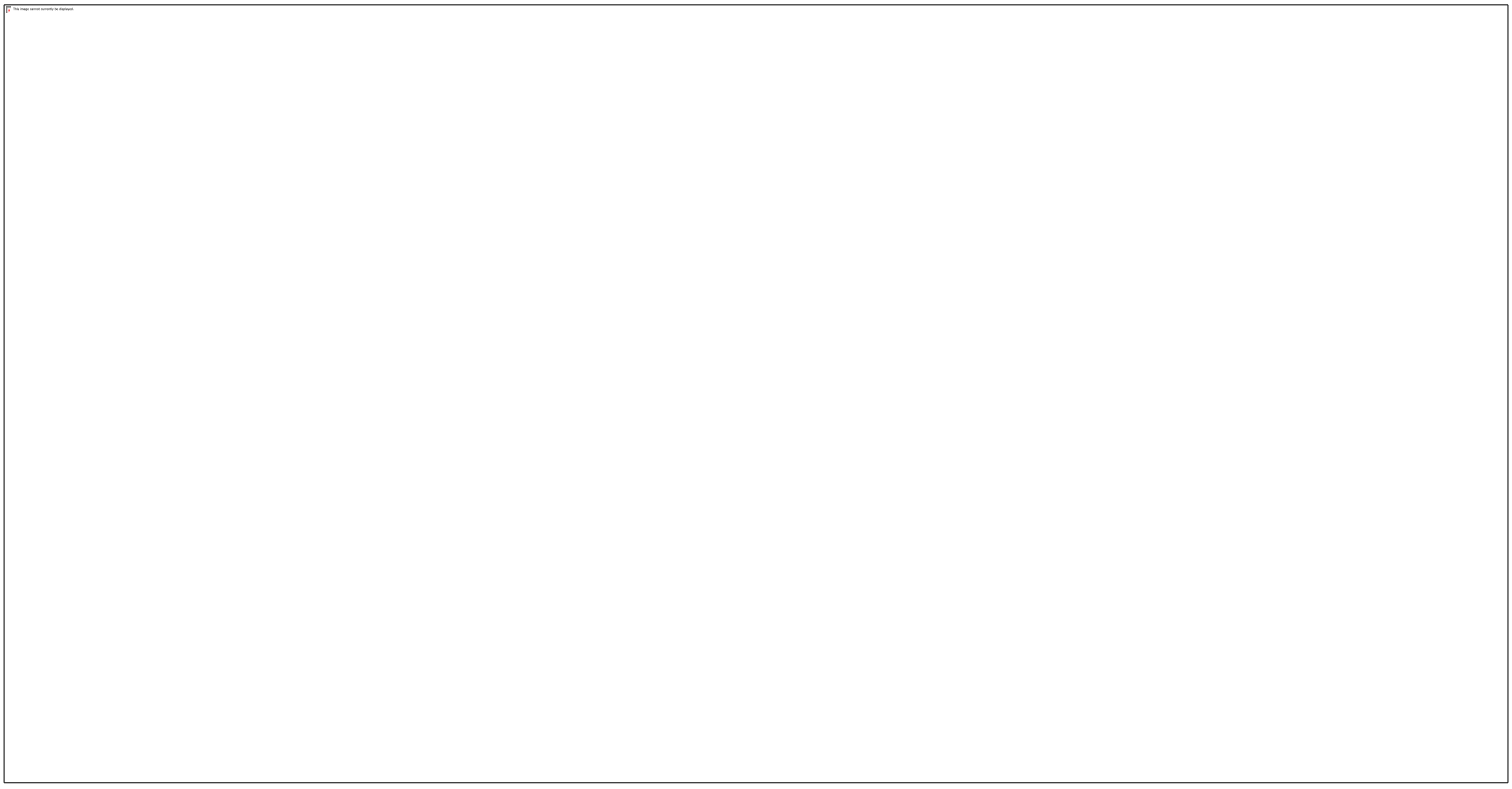
Fish marketing is an important activity in aquaculture because it enables fish farmers to earn income from their production activities.

In Kenya, fish marketing is practised by:

- Fish farmers operating fish ponds and cages.
- Fishermen operating in lakes, rivers and the Indian Ocean.
- Fish processors and fish traders.
- Supermarkets, hotels and restaurants.
- Fish wholesalers and retailers.
- Fish export companies.

Examples of fish commonly marketed in Kenya include:

- Nile tilapia.
- African catfish.
- Nile perch.
- Rainbow trout.
- Marine fish such as tuna and kingfish.
- Freshwater ornamental fish.





1.1 Importance of Fish Marketing

Fish marketing is important because it:

1. **Provides income to fish farmers:** Farmers earn money by selling harvested fish and fish products.
2. **Creates employment:** Marketing creates jobs for fish processors, transporters, wholesalers, retailers and shop attendants.
3. **Promotes aquaculture:** Reliable markets encourage farmers to increase fish production.
4. **Improves food security:** Fish becomes available to consumers as a source of nutritious food.
5. **Reduces post-harvest losses:** Proper marketing ensures fish is sold or processed before it spoils.
6. **Promotes trade:** Fish and fish products can be sold in local, regional and international markets.
7. **Encourages investment:** Profitable fish marketing attracts investors into aquaculture.
8. **Promotes value addition:** Fish can be processed into different products, increasing its market value.
9. **Improves livelihoods:** Income earned from fish sales helps households meet their needs.
10. **Promotes economic development:** Fish marketing contributes to national income and the growth of the blue economy.

2.0 PREPARATION OF FISH FOR MARKETING

Fish preparation for marketing refers to the activities carried out after harvesting to make fish suitable, attractive, safe and acceptable to consumers.

Proper preparation improves the quality, appearance, shelf life and marketability of fish.

Fish is highly perishable because it contains a lot of moisture and nutrients that support microbial growth. Therefore, proper handling and preservation are necessary immediately after harvesting.

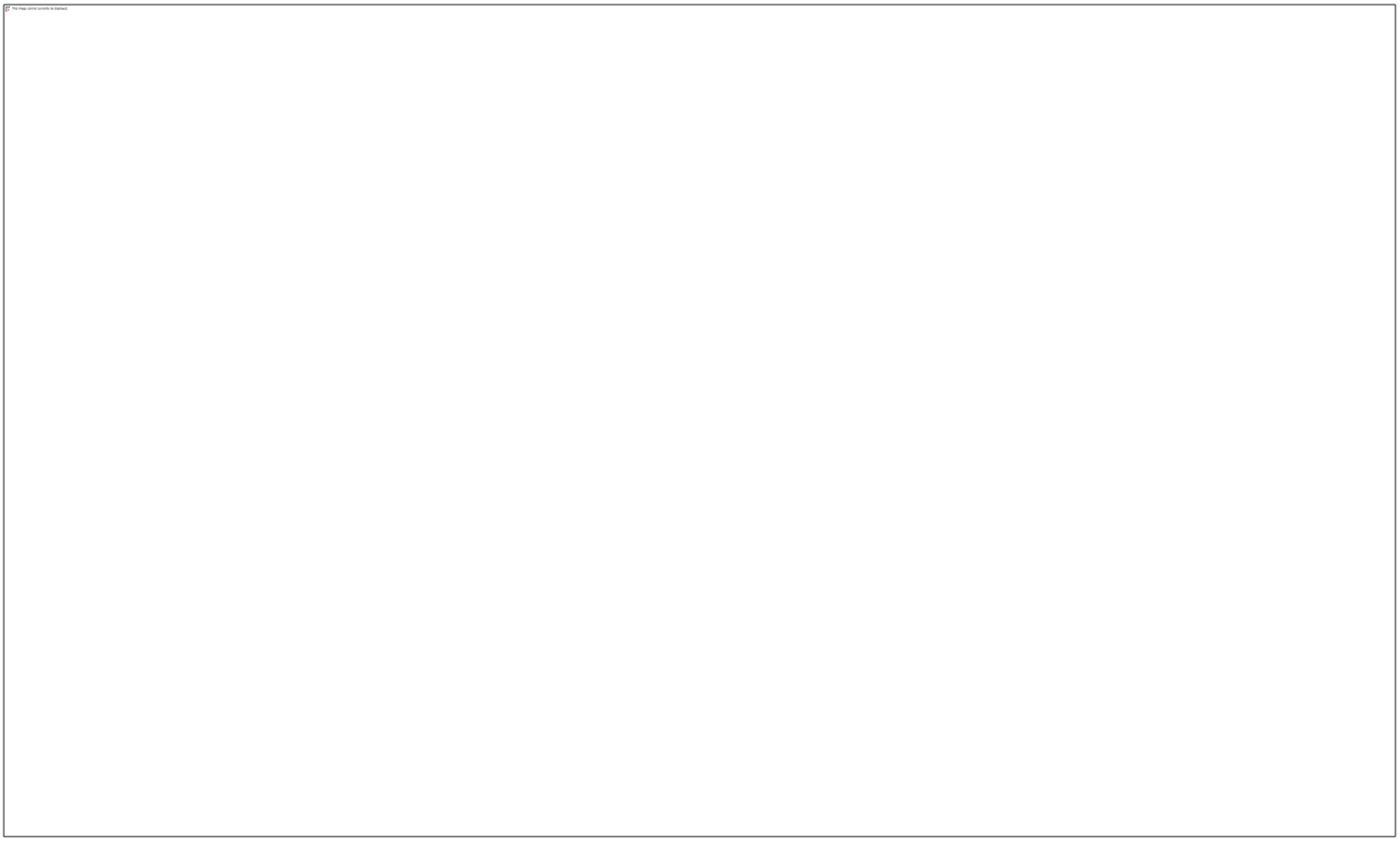
The main ways of preparing fish for marketing include:

1. Weighing.
2. Sorting.
3. Grading.
4. Cleaning and preparation.
5. Preservation and chilling.
6. Packaging.
7. Branding.
8. Labelling.

2.1 Weighing of Fish

Definition: Weighing is the process of determining the mass of harvested fish using an appropriate weighing instrument.

Weighing is carried out to establish the quantity of fish available for sale and determine its selling price.



Importance of weighing fish

1. **Determining selling price:** Fish is commonly sold according to its weight, for example, price per kilogram.
2. **Establishing quantity:** Helps farmers determine the total quantity of fish harvested.
3. **Ensuring fair trade:** Both buyers and sellers can agree on the actual weight of fish.
4. **Keeping production records:** Farmers record the weight of fish harvested during each production cycle.
5. **Planning transportation:** Knowing the weight helps determine the appropriate transport capacity.
6. **Monitoring productivity:** Helps farmers assess fish growth and production performance.
7. **Facilitating packaging:** Determines the amount of fish to be packed in each package.

Equipment used in weighing fish

- Digital weighing scales.
- Platform scales.
- Hanging scales.
- Electronic commercial scales.
- Balance scales.

Procedures for weighing fish

1. Select a suitable weighing scale.
2. Place the weighing scale on a stable and level surface.

3. Check that the scale is functioning correctly.
4. Place a clean container on the scale.
5. Tare the scale to remove the weight of the empty container.
6. Place the fish carefully in the container.
7. Allow the reading to stabilise.
8. Record the weight.
9. Repeat the procedure for other batches.
10. Clean the equipment after use.

Precautions when weighing fish

- Use clean weighing equipment.
- Avoid placing fish directly on dirty surfaces.
- Ensure the scale is properly calibrated.
- Avoid overloading the scale.
- Record accurate measurements.
- Handle fish gently to prevent physical damage.

Example: A farmer harvests 80 kg of tilapia from a fish pond. If the selling price is KSh 350 per kilogram:

Total sales = 80 × 350

= KSh 28,000.

2.2 Sorting of Fish

Definition: Sorting is the process of separating harvested fish into different groups based on identifiable characteristics such as species, size, shape, colour and physical condition.

Sorting helps fish farmers organise their products according to the requirements of different customers.



Characteristics used in sorting fish

1. **Species:** Fish are separated according to their species, such as tilapia, catfish and Nile perch.
2. **Size:** Fish are separated into small, medium and large sizes.
3. **Shape:** Fish with similar body shapes may be grouped together.
4. **Colour:** Fish may be separated according to their natural colour or appearance where relevant.
5. **Physical condition:** Healthy and undamaged fish are separated from damaged fish.
6. **Freshness:** Fish are separated according to their freshness and condition.

Importance of sorting fish

- Makes fish easier to market.
- Helps meet customer preferences.
- Facilitates accurate pricing.
- Makes packaging easier.
- Reduces mixing of different fish species.
- Helps identify damaged fish.
- Improves the appearance of fish products.
- Facilitates further processing.
- Makes stock management easier.

Examples of sorting

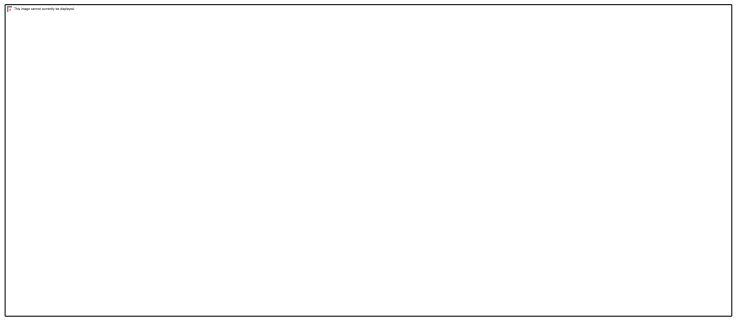
A fish farmer harvesting tilapia may sort the fish into:

- Small tilapia.
- Medium-sized tilapia.
- Large tilapia.
- Damaged tilapia.
- Tilapia suitable for processing.

2.3 Grading of Fish

Definition: Grading is the process of classifying fish into different quality categories according to established standards or specifications.

Unlike sorting, which mainly separates fish according to observable characteristics, grading assesses the quality and market acceptability of fish.



Factors considered when grading fish

1. **Freshness:** Fish should have a fresh smell and firm flesh.
2. **Physical appearance:** Fish should have an attractive and natural appearance.
3. **Size:** Fish may be graded according to weight or length.
4. **Physical damage:** Fish with bruises, cuts or broken fins may receive a lower grade.
5. **Texture:** Fresh fish should have firm flesh.
6. **Odour:** Fresh fish should not have unpleasant or putrid smells.
7. **Eyes:** Fresh whole fish generally have clear, bright and relatively prominent eyes.
8. **Gills:** Fresh fish generally have reddish or pinkish, moist gills.
9. **Cleanliness:** Fish should be free from excessive dirt and unwanted materials.
10. **Temperature history:** Fish should have been properly chilled and handled.

Common fish grading categories

The categories may vary depending on the buyer and applicable market standards.

Grade A – Premium quality

- Fresh and properly handled.
- Attractive appearance.
- Free from significant physical damage.
- Meets the buyer's quality requirements.

Grade B – Good quality

- Generally acceptable quality.
- May have minor physical defects.
- Suitable for ordinary fresh fish markets.

Grade C – Lower commercial quality

- May have noticeable physical defects.
- May be suitable for processing if safe.
- Must meet applicable food safety requirements.

Fish that is spoiled or unsafe must never be sold for human consumption.

Importance of grading

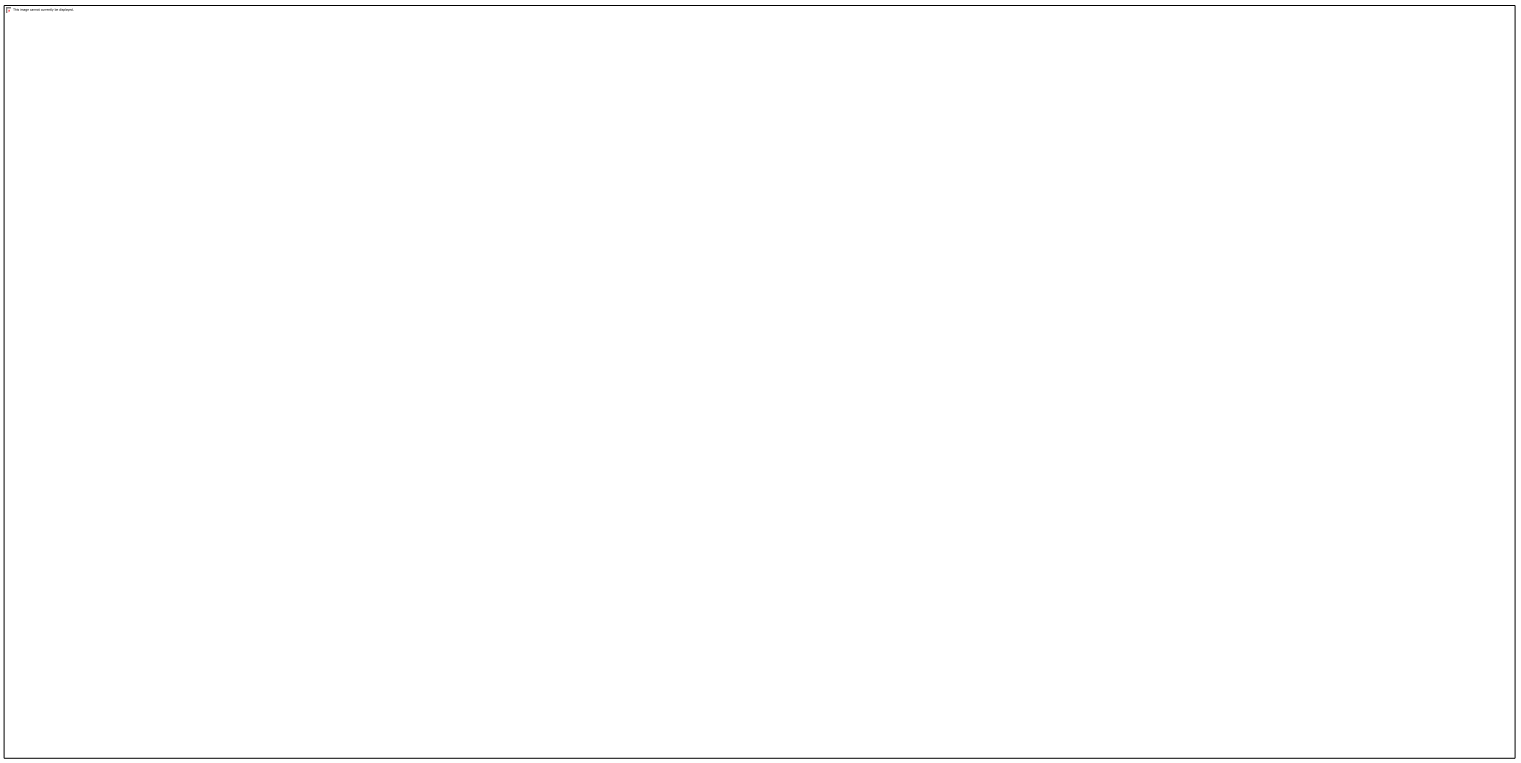
- Promotes fair pricing.
- Helps consumers select fish according to their needs.
- Promotes quality assurance.
- Improves customer confidence.
- Facilitates export trade.
- Encourages proper fish handling.

- Reduces disputes between buyers and sellers.

2.4 Cleaning and Preparation of Fish

Cleaning refers to removing unwanted materials from harvested fish to improve hygiene and prepare it for sale or further processing.

Depending on the product and customer requirements, fish may be marketed whole, gutted, scaled, filleted or cut into portions.





Activities involved in cleaning fish

1. **Washing:** Removing dirt, slime and other unwanted materials using safe, potable water.
2. **Scaling:** Removing fish scales where required.
3. **Gutting:** Removing internal organs from the abdominal cavity.
4. **Descaling:** Ensuring that remaining scales are removed where a scaled product is required.
5. **Head removal:** Removing the head depending on the customer's preference.
6. **Filleting:** Separating the edible flesh from the bones.
7. **Portioning:** Cutting fish into smaller pieces of suitable sizes.
8. **Trimming:** Removing unwanted fins, damaged parts and excess tissue.
9. **Final inspection:** Checking the fish for cleanliness and quality.

Importance of cleaning fish

- Improves the appearance of fish.
- Removes unwanted materials.
- Makes fish easier to prepare for cooking.
- Meets different consumer preferences.
- Facilitates packaging.
- Supports hygienic food handling.

- Adds value to fish products.

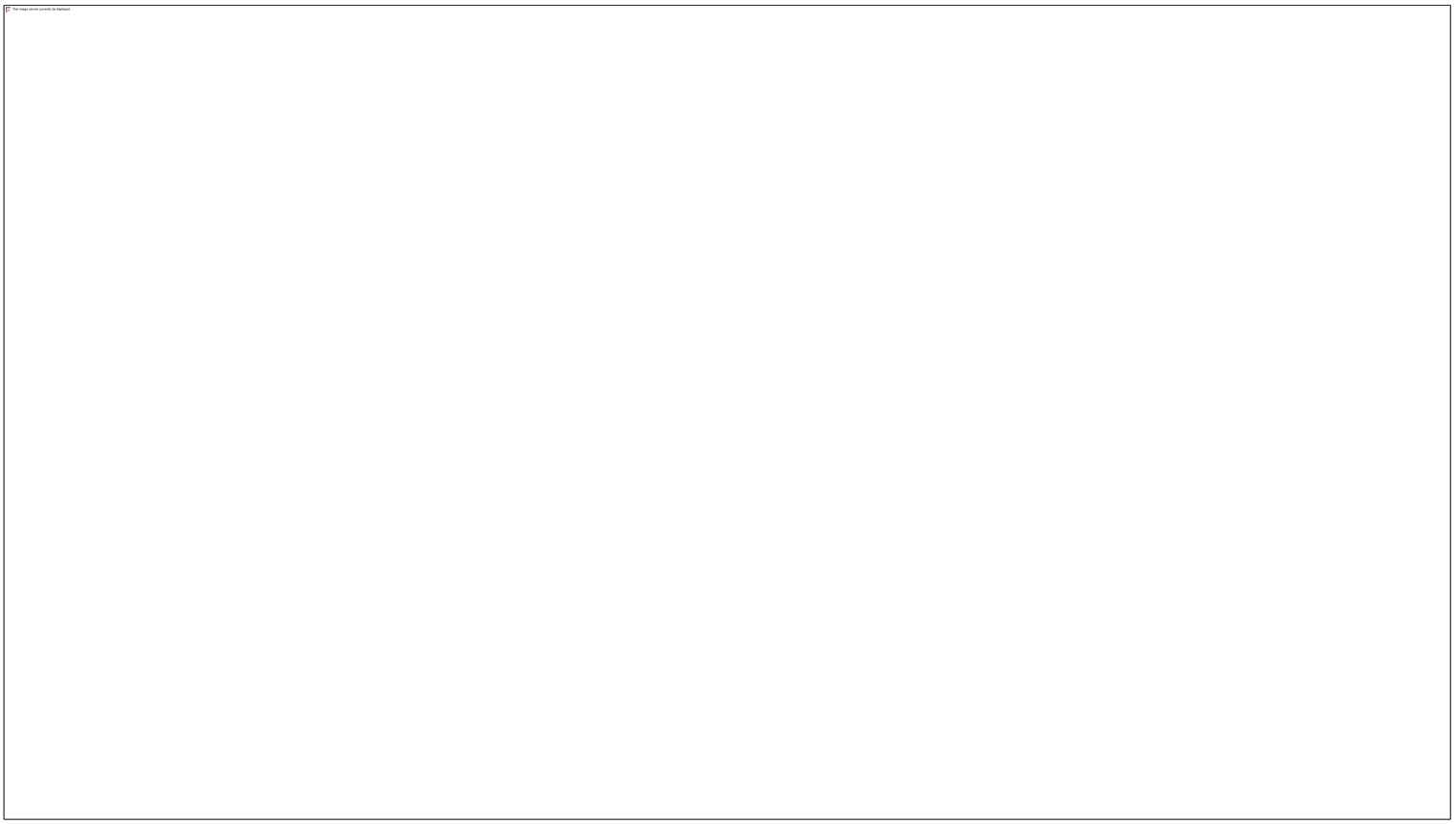
Hygiene precautions during cleaning

- Use clean, sanitised knives and working surfaces.
- Wash hands before handling fish.
- Use potable water.
- Wear clean protective clothing.
- Prevent contamination from raw waste.
- Keep cleaned fish chilled.
- Separate raw fish from ready-to-eat products.

2.5 Preservation and Chilling of Fish

Definition: Fish preservation refers to the methods used to prevent or slow down spoilage and maintain fish quality for a longer period.

Fish should be cooled immediately after harvesting because high temperatures accelerate bacterial growth and spoilage.







Methods of preserving fish before marketing

1. Chilling

- Involves reducing the temperature of fish using ice or refrigeration.
- Slows down bacterial growth and enzymatic activities.
- Maintains freshness during transportation and storage.
- Commonly used for fresh tilapia, Nile perch and marine fish.

2. Freezing

- Involves lowering the temperature of fish below its freezing point.
- Converts much of the water in fish tissues into ice.
- Slows down microbial and enzymatic activities.
- Allows fish to be stored for longer periods when properly maintained.

3. Smoking

- Involves exposing fish to smoke from burning wood or other suitable materials under controlled conditions.
- Helps reduce moisture depending on the smoking method.
- Adds a characteristic flavour.
- Can increase the storage life of fish.

4. Salting

- Involves applying salt to fish.
- Salt reduces the amount of water available for microbial growth.
- Helps delay spoilage.

5. Drying

- Involves removing moisture from fish.
- Reduces conditions favourable for microbial growth.
- May be done using solar dryers or mechanical dryers.

6. Canning

- Involves processing fish in sealed containers through appropriate heat treatment.
- Produces products that can be stored for extended periods when properly processed.
- Examples include canned tuna and sardines.

Importance of fish preservation

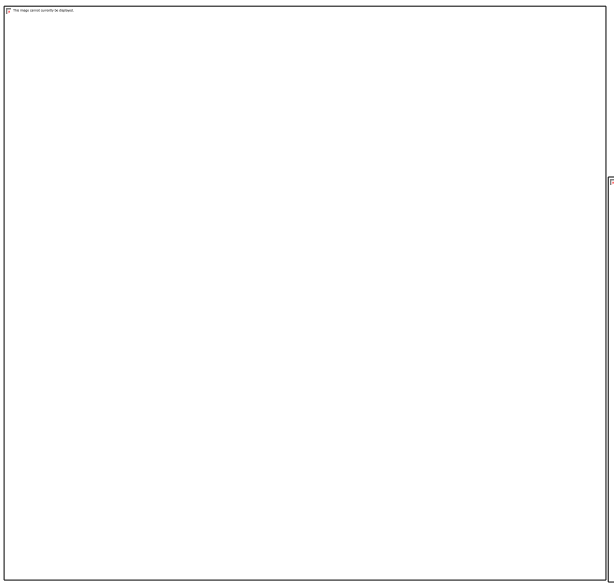
- Extends shelf life.
- Reduces post-harvest losses.
- Maintains product quality.
- Allows transportation over long distances.

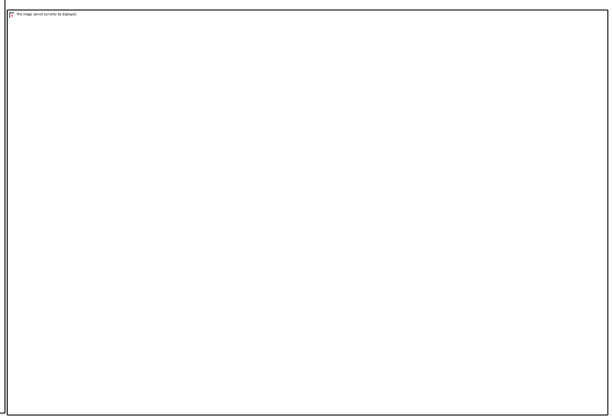
- Ensures continuous availability of fish.
- Supports access to distant markets.
- Increases the range of fish products available to consumers.

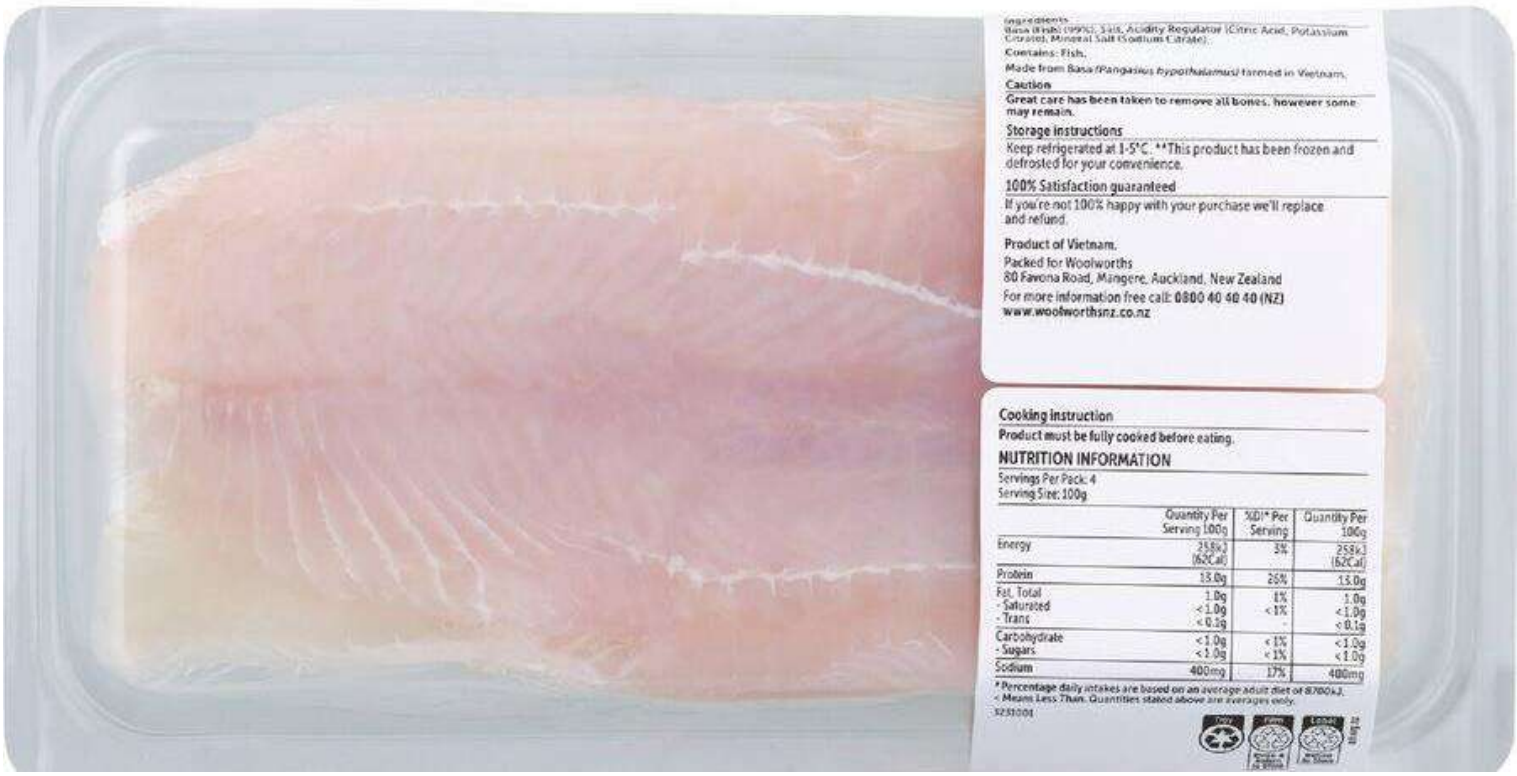
2.6 Packaging of Fish

Definition: Packaging is the process of enclosing fish or fish products in suitable materials to protect them from contamination, physical damage and deterioration during storage, transportation and marketing.

Packaging also improves the appearance of fish products and makes handling easier.







Types of fish packaging materials

1. **Food-grade plastic bags**

- Used for packing fresh and frozen fish.

- Lightweight and easy to handle.
- Must be suitable for food contact.

2. **Vacuum packaging materials**
   - Air is removed from the package before sealing.
   - Helps reduce oxidation and slows quality deterioration.
   - Commonly used for fish fillets.
3. **Insulated fish boxes**
   - Used to transport fresh fish.
   - Help maintain low temperatures.
   - Often used together with ice.
4. **Plastic crates**
   - Used for handling and transporting fish.
   - Durable and reusable when properly cleaned.
5. **Cardboard cartons**
   - Used for packing processed or frozen fish products.
   - Can carry product information.
   - Must be protected from moisture.
6. **Cans**
   - Used for commercially processed fish products.
   - Provide protection when properly sealed and heat processed.

Functions of packaging fish

- Protects fish from contamination.
- Prevents physical damage.
- Reduces moisture loss.
- Helps maintain product quality.
- Makes transportation easier.
- Facilitates storage.
- Provides space for branding and labelling.
- Improves product presentation.
- Helps portion fish into convenient quantities.

Characteristics of good fish packaging

Good packaging should be:

- Clean and hygienic.
- Strong and durable.

- Leak-proof where necessary.
- Food-grade and non-toxic.
- Suitable for the storage temperature.
- Easy to handle and transport.
- Appropriate for the type of fish product.
- Properly sealed.
- Clearly labelled.

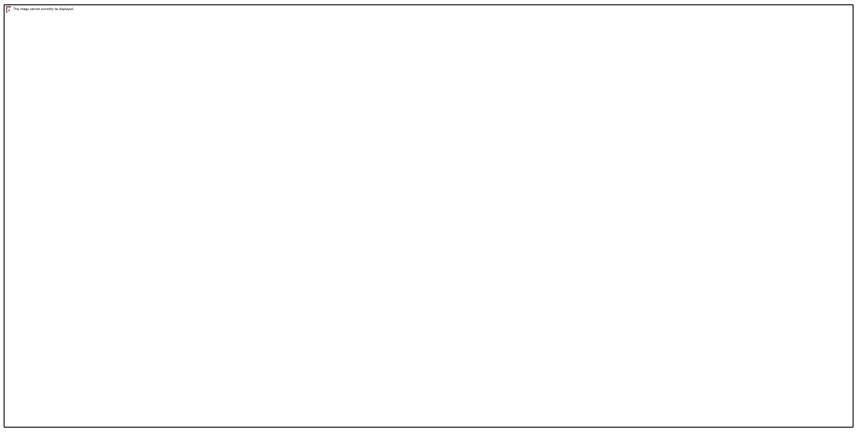
Factors influencing the choice of packaging materials

1. Nature of the fish product.
2. Cost of packaging materials.
3. Distance to the market.
4. Storage temperature requirements.
5. Expected shelf life.
6. Consumer preferences.
7. Environmental considerations.
8. Government food safety requirements.

2.7 Branding of Fish Products

Definition: Branding is the process of giving a fish product a unique identity through a name, symbol, logo, design or other distinguishing features.

Branding helps consumers identify a particular fish product and distinguish it from competing products.



Examples of fish product brands

A fish farmer or processor may develop brands such as:

- Lake Fresh Tilapia.
- Premium Farmed Catfish.
- Victoria Fresh Fish.
- Ocean Harvest Fish Fillets.

These are illustrative brand names.

Elements of branding

1. **Brand name:** The name used to identify the fish product.
2. **Logo:** A symbol or design representing the product.
3. **Colour:** Colours that make the product recognisable.
4. **Packaging design:** The appearance and style of the package.
5. **Slogan:** A short statement that communicates the product's promise.
6. **Brand identity:** The overall image that distinguishes the product.

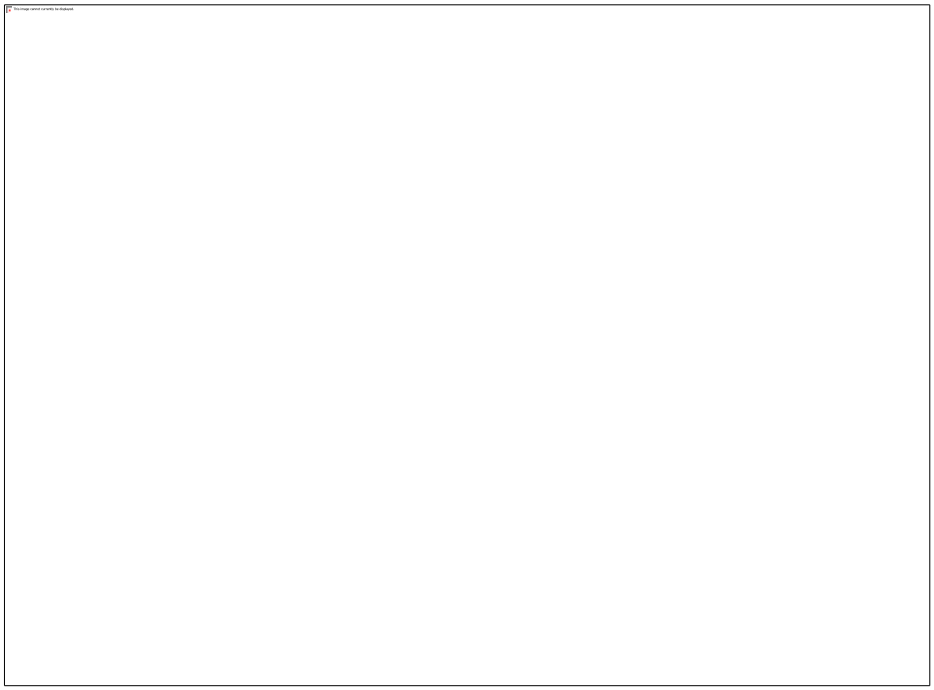
Importance of branding fish products

- Makes products easily identifiable.
- Differentiates products from competitors.
- Builds customer loyalty.
- Promotes consumer confidence.
- Supports advertising activities.
- Improves product recognition.
- Helps establish a market reputation.
- Can increase the perceived value of products.

2.8 Labelling of Fish Products

Definition: Labelling is the process of displaying important product information on the packaging or container of fish products.

Labelling helps consumers make informed purchasing decisions.



Information included on fish product labels

1. **Product name:** Identifies the fish product.
2. **Fish species:** Indicates the type of fish, where required.

3. **Net weight:** Shows the actual weight of the fish excluding packaging.
4. **Ingredients:** Lists ingredients used in processed fish products.
5. **Date of production or packing:** Shows when the product was processed or packed.
6. **Expiry date or best-before date:** Provides the relevant date information according to the product and applicable standards.
7. **Storage instructions:** Indicates whether the product should be refrigerated or frozen.
8. **Name and address of manufacturer:** Identifies the producer or processor.
9. **Batch or lot number:** Helps trace the product during distribution.
10. **Country of origin:** Indicates where the product was produced, where required.
11. **Food safety information:** Includes relevant warnings and allergen information.
12. **Certification marks:** Displays applicable approved certification marks where authorised.

Importance of labelling fish products

- Provides information to consumers.
- Helps identify the fish product.
- Promotes transparency.
- Supports traceability.
- Helps consumers follow proper storage instructions.
- Facilitates stock management.
- Builds consumer confidence.
- Supports compliance with food safety regulations.

Difference between branding and labelling

Branding	Labelling
Creates a unique identity for a product.	Provides information about a product.
Uses brand names, symbols and logos.	Uses written information and symbols.
Helps differentiate products.	Helps consumers understand the product.
Promotes recognition and loyalty.	Promotes informed purchasing and traceability.

3.0 FISH MARKETING CHANNELS

Definition: A fish marketing channel is the route or pathway through which fish moves from the producer to the final consumer.

Marketing channels involve different individuals or organisations that participate in buying, selling, processing and distributing fish.

The choice of marketing channel depends on:

- Quantity of fish produced.
- Distance to the market.
- Availability of buyers.

- Transportation facilities.
- Storage facilities.
- Nature of the fish product.
- Market demand.
- Marketing costs.

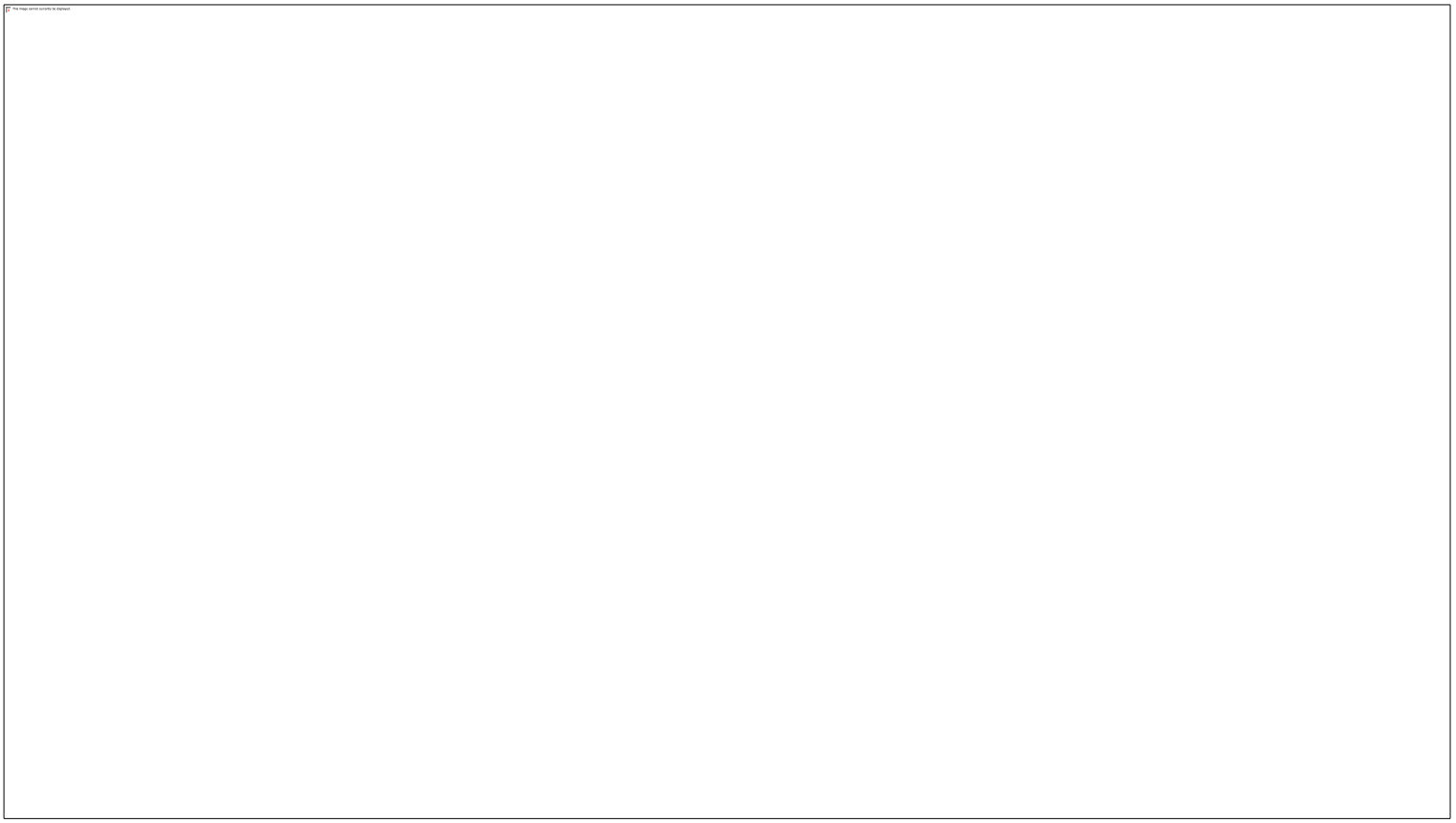
There are two major fish marketing channels:

1. Short marketing channels.
2. Long marketing channels.

3.1 Short Marketing Channels

Definition: A short marketing channel is a distribution pathway in which fish moves from the producer to the consumer through few or no intermediaries.

The producer sells directly to the consumer or uses only one intermediary.



Examples of short marketing channels

Channel 1: Direct selling

Fish farmer → Consumer

Channel 2: Selling through one retailer

Fish farmer → Retailer → Consumer

Channel 3: Selling through a local restaurant

Fish farmer → Restaurant → Consumer

Advantages of short marketing channels

1. **Higher profit margins:** Farmers may retain a larger proportion of the final selling price.
2. **Direct customer contact:** Farmers interact directly with consumers.
3. **Immediate feedback:** Consumers provide information about their preferences.
4. **Reduced marketing costs:** Fewer intermediaries may reduce commissions and handling costs.
5. **Better control:** Farmers have greater control over product presentation and pricing.
6. **Faster distribution:** Fish may reach consumers quickly.
7. **Customer relationships:** Direct interaction helps build customer loyalty.

Disadvantages of short marketing channels

1. Limited market coverage.
2. Farmers may spend more time looking for customers.
3. Requires the farmer to organise transportation and selling.
4. May be difficult to sell large quantities.
5. Requires suitable storage and display facilities.
6. Farmers may lack marketing expertise.
7. Demand may fluctuate in small local markets.

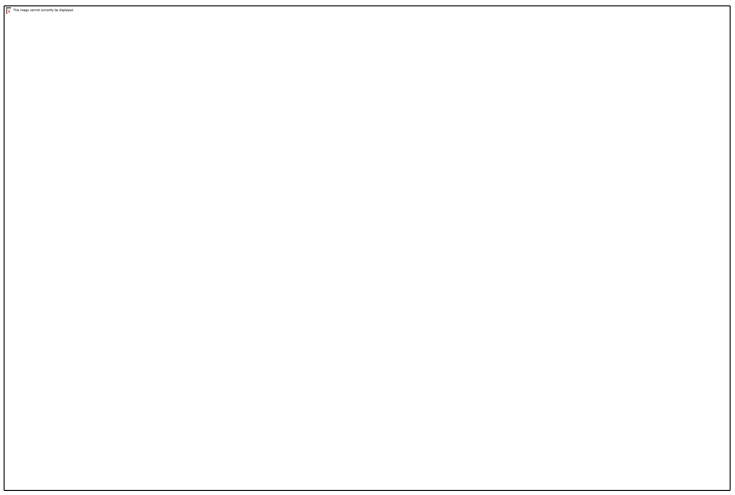
Examples in Kenya

- A tilapia farmer selling fish directly to households around a fish pond.
- A catfish farmer supplying fish directly to a nearby hotel.
- A fish farmer selling fresh fish at a local market.

3.2 Long Marketing Channels

Definition: A long marketing channel is a distribution pathway involving several intermediaries between the producer and the final consumer.

The fish passes through different market participants before reaching the consumer.



Examples of long marketing channels

Channel 1: Through wholesalers and retailers

Fish farmer → Wholesaler → Retailer → Consumer

Channel 2: Through processors

Fish farmer → Processor → Distributor → Retailer → Consumer

Channel 3: Through exporters

Fish farmer → Aggregator → Processor → Exporter → International distributor → Consumer

Advantages of long marketing channels

1. **Wider market coverage:** Fish can reach consumers in distant towns and regions.
2. **Large-volume sales:** Wholesalers can purchase large quantities.
3. **Specialisation:** Different intermediaries perform specialised marketing activities.
4. **Reduced marketing responsibilities:** Farmers may concentrate on fish production.
5. **Access to distant markets:** Products can reach regional and international markets.
6. **Continuous distribution:** Established distributors can supply markets regularly.
7. **Access to processing facilities:** Processors can convert fish into different products.

Disadvantages of long marketing channels

1. **Reduced farmer profit:** Intermediaries may increase the final selling price.
2. **Higher marketing costs:** Transportation, storage and handling costs may increase.
3. **Delayed payments:** Farmers may not receive immediate payment.
4. **Poor handling risks:** More handling stages may expose fish to contamination or damage.
5. **Limited control:** Farmers may have little influence over the final selling price.
6. **Communication challenges:** Farmers may receive limited information about consumers.
7. **Price exploitation:** Some intermediaries may take advantage of farmers.

3.3 Comparison Between Short and Long Marketing Channels

Short marketing channel	Long marketing channel
Involves few intermediaries.	Involves several intermediaries.
Usually covers a smaller market.	Can cover wider geographical markets.
Promotes direct contact with consumers.	Limited direct contact with consumers.
May provide higher farmer margins.	Profit is shared among intermediaries.
Often suitable for small-scale farmers.	Often suitable for large-scale distribution.
Easier to monitor the product route.	Requires coordination among many participants.
May involve lower intermediary costs.	May involve higher distribution costs.

3.4 Factors to Consider When Choosing a Fish Marketing Channel

1. **Market size:** The farmer should consider the number of potential consumers.
2. **Production volume:** Large quantities may require wholesalers and distributors.
3. **Distance:** Distant markets may require organised distribution networks.
4. **Transportation:** Availability of suitable transport affects the choice of channel.

5. **Storage facilities:** Availability of refrigeration and cold rooms is important.
6. **Market prices:** Farmers should choose channels that offer reasonable returns.
7. **Product perishability:** Highly perishable products require quick distribution.
8. **Consumer preferences:** The channel should reach the intended consumers.
9. **Marketing skills:** Farmers should consider their ability to market products directly.
10. **Reliability of buyers:** Farmers should work with dependable customers and distributors.

4.0 STRATEGIES FOR IMPROVING OR INCREASING SALES OF FISH PRODUCTS

Fish farmers and traders use different marketing strategies to attract customers, increase demand and improve profitability.

One important approach is the **4Ps Marketing Mix**, which consists of:

1. Product.
2. Price.
3. Place.
4. Promotion.

4.1 Product Strategy

Definition: Product strategy refers to decisions and activities aimed at improving the quality, design, variety, packaging and presentation of fish products to satisfy consumer needs.

The product is the fish or fish-based item being offered for sale.

Strategies for improving fish products

1. **Improving quality**
   - Farmers should ensure that fish is fresh and properly handled.
   - High-quality products attract customers and encourage repeat purchases.
2. **Product diversification**
   - Farmers should produce different fish products to satisfy different customer preferences.
   - Examples include fresh fish, smoked fish, dried fish, frozen fish and fish fillets.
3. **Value addition**
   - Fish can be processed into products with greater convenience and market value.
   - Examples include fish sausages, fish fingers and fish cakes.
4. **Improving packaging**
   - Attractive and hygienic packaging improves product presentation.
   - Packaging should protect fish from contamination.
5. **Branding**
   - Unique brand names and logos help consumers recognise products.
   - Strong brands help businesses compete effectively.

6. **Consistent supply**

- Farmers should plan production to ensure regular availability of fish.
- Customers prefer reliable suppliers.

7. **Product innovation**

- Businesses can develop new fish products to meet changing consumer preferences.

8. **Improving product convenience**

- Ready-to-cook and portioned fish products may attract busy consumers.

9. **Maintaining food safety**

- Safe handling and proper preservation increase consumer confidence.

10. **Obtaining customer feedback**

- Customer opinions help producers improve their products.

4.2 Price Strategy

Definition: Price strategy refers to the methods used by a business to determine the amount charged for its fish products.

The price should be attractive to consumers while enabling the business to recover costs and make a profit.

Strategies for pricing fish products

1. Cost-plus pricing

- The farmer calculates the total production and marketing costs.
- A profit margin is added to determine the selling price.

Example:

If the cost of producing and marketing 1 kg of fish is KSh 250 and the farmer adds KSh 50 profit:

Selling price = KSh 300 per kilogram.

2. Competitive pricing

- The farmer sets prices based on the prices charged by competitors.
- Helps the business remain competitive.

3. Penetration pricing

- A business introduces a product at a relatively low price to attract customers and gain market share.
- The price may be adjusted later.

4. Promotional pricing

- Products are sold at temporarily reduced prices to attract more customers.
- For example, offering a discount during a market promotion.

5. Value-based pricing

- Prices are determined according to the value consumers attach to the product.
- Premium-quality, properly packaged and processed fish may attract higher prices.

6. Bulk pricing

- Discounts are offered to customers who purchase large quantities.
- Encourages wholesalers, hotels and restaurants to buy more fish.

7. Differential pricing

- Different prices are charged for different product sizes, qualities or customer categories.
- For example, premium fish may cost more than smaller fish.

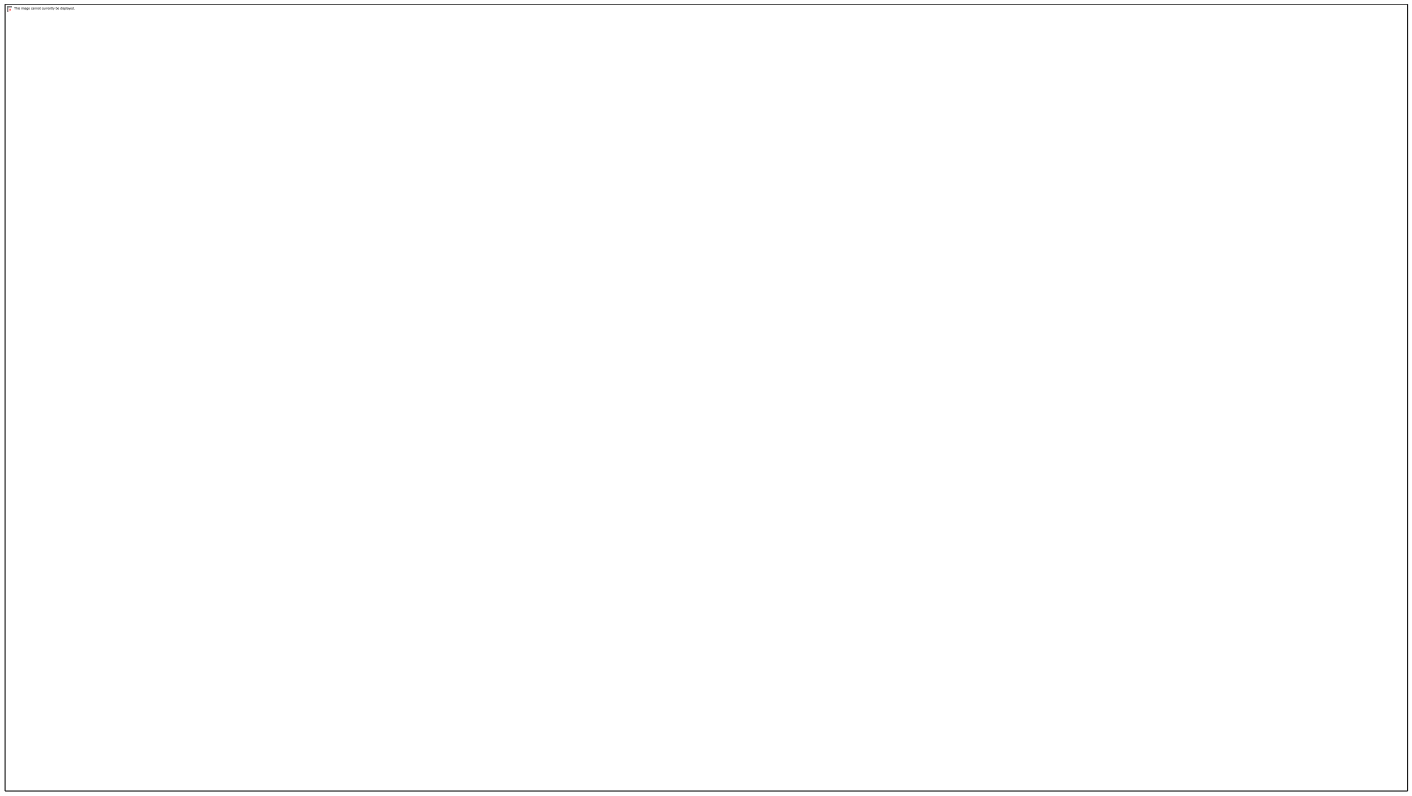
Factors influencing fish prices

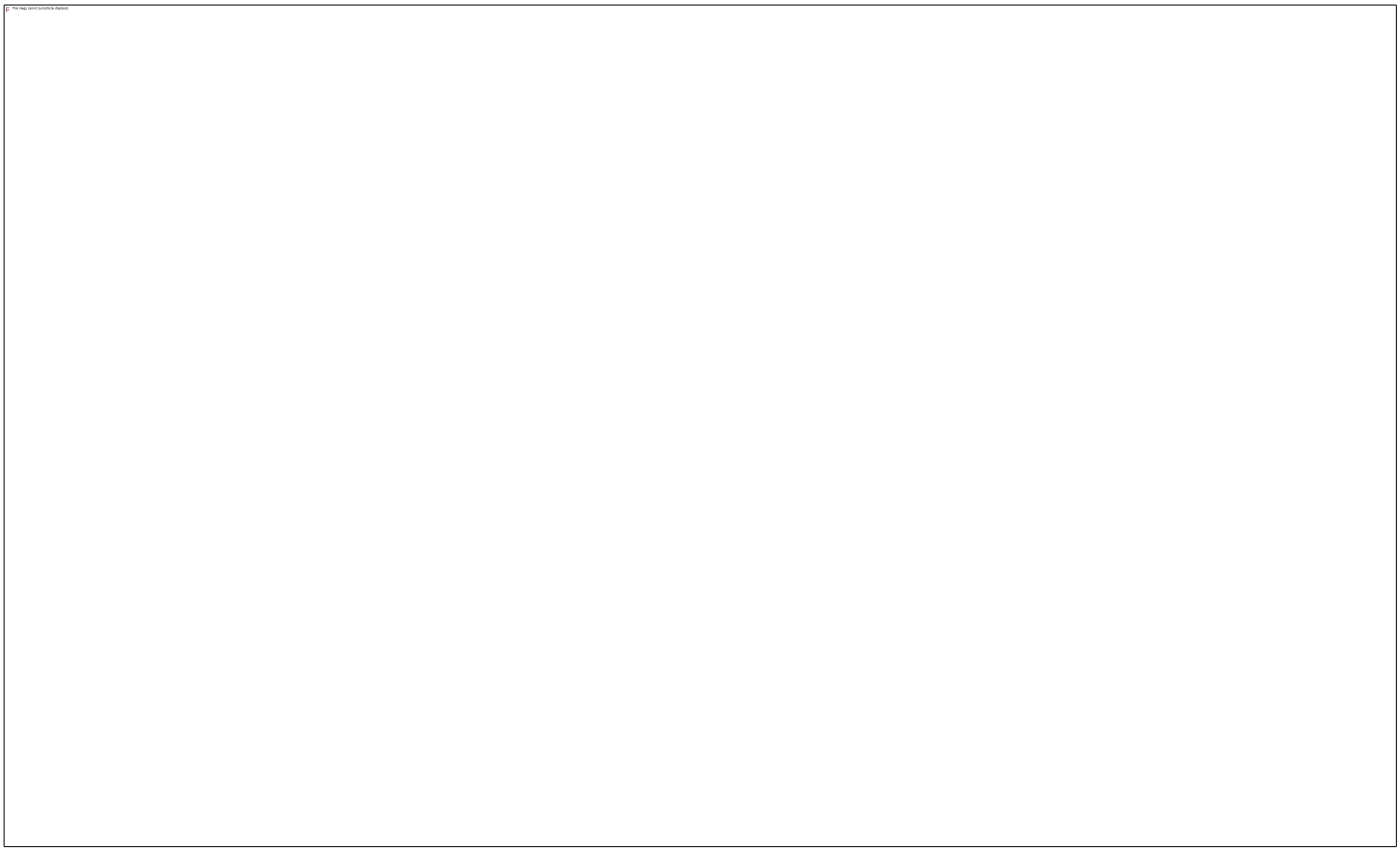
1. Cost of production.
2. Market demand.
3. Availability of fish.
4. Quality and size of fish.
5. Transportation expenses.
6. Storage and preservation costs.
7. Prices charged by competitors.
8. Seasonality.
9. Consumer purchasing power.
10. Government regulations and market requirements.

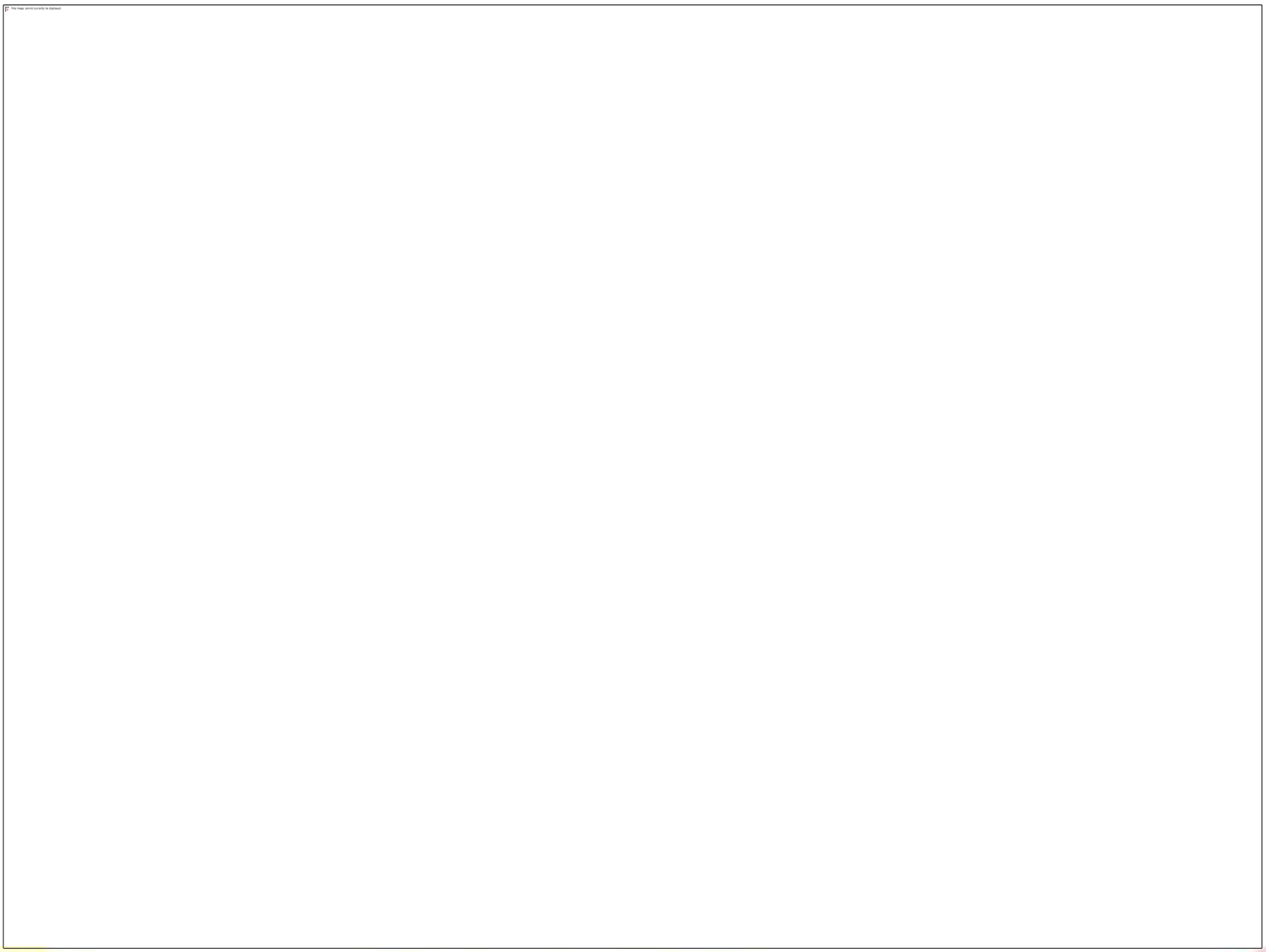
4.3 Place Strategy

Definition: Place strategy refers to decisions concerning where and how fish products are distributed and made available to consumers.

It ensures that the right fish product reaches the right consumer at the right place and time.







Strategies for improving distribution of fish products

1. Selecting suitable market locations

- Farmers should identify areas with high demand for fish.
- Examples include urban centres, trading centres and towns.

2. Establishing distribution networks

- Farmers should work with wholesalers, retailers and distributors.
- This helps fish reach more customers.

3. Using appropriate transportation

- Insulated vehicles and containers help maintain fish quality.
- Refrigerated vehicles are useful for long-distance transportation.

4. Opening retail outlets

- Businesses may establish fish shops and selling points.
- This improves accessibility.

5. Supplying institutions

- Fish farmers can supply schools, hospitals, hotels and restaurants, subject to their procurement and food safety requirements.

6. Using online selling platforms

- Businesses can advertise and receive orders through websites and other digital platforms.
- This can connect farmers to consumers beyond their immediate locations.

7. Maintaining cold-chain systems

- Fish should remain at appropriate chilled or frozen temperatures throughout storage and distribution.
- This prevents rapid deterioration.

8. Expanding geographical coverage

- Farmers can identify new markets in other counties and regions.

9. Establishing collection centres

- Collection centres help farmers consolidate fish from different production units.
- This makes bulk distribution easier.

10. Timely delivery

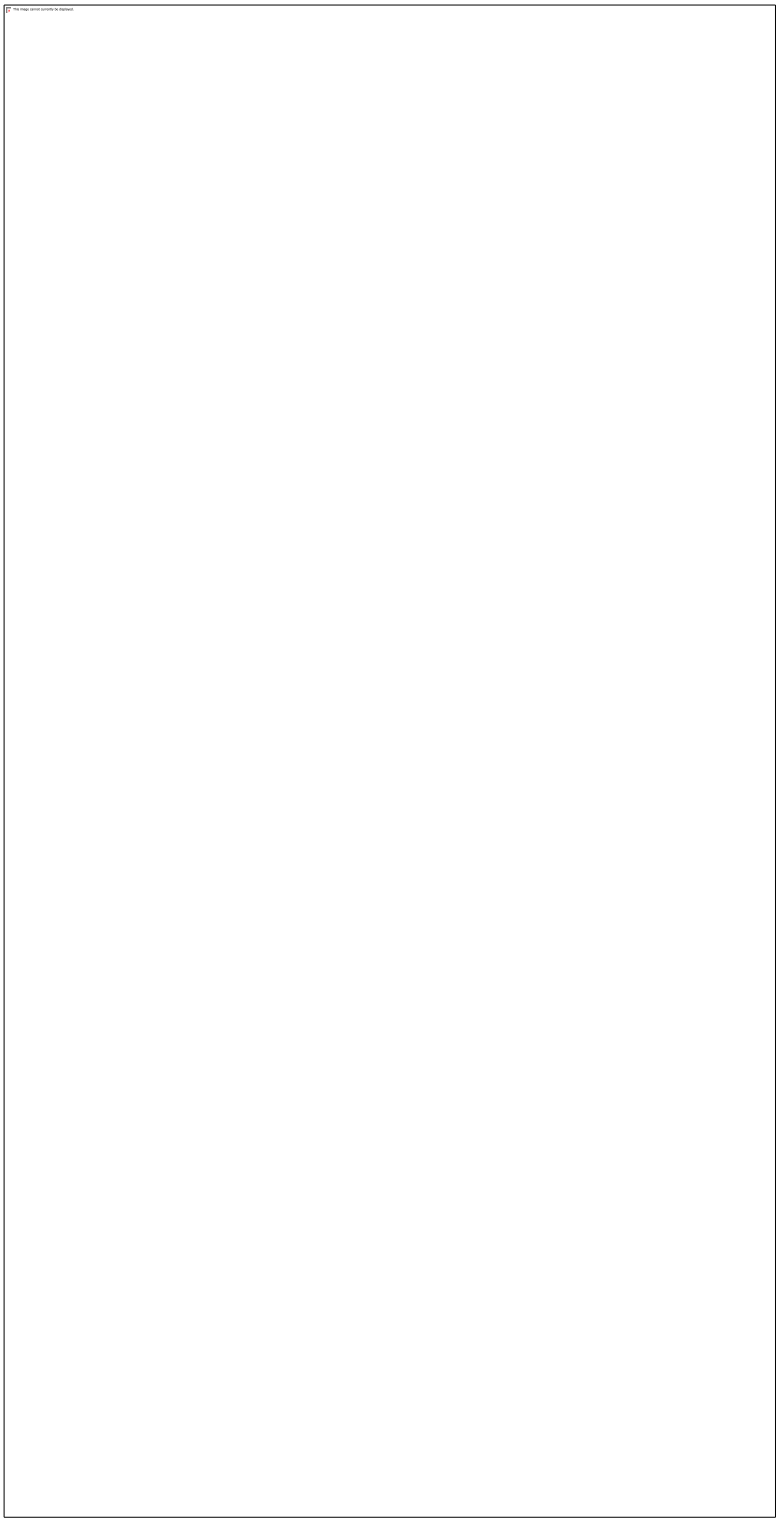
- Fish should be delivered promptly to maintain quality and customer satisfaction.

4.4 Promotion Strategy

Definition: Promotion refers to communication activities used to inform, persuade and remind consumers about the availability and benefits of fish products.

Promotion helps create awareness and encourage consumers to purchase fish.


MN
Fresh Tilapia
Place Your ORDER
0537441047
0241461623
Email: mnaconsultghanaltd@gmail.com



Methods of promoting fish products

1. Advertising

- Involves communicating information about fish products through paid media.
- Advertising can be done through radio, television, newspapers, posters and online platforms.
- Example: Advertising fresh tilapia through a local radio station.

2. Social media marketing

- Uses digital platforms to reach potential customers.
- Farmers can use Facebook, Instagram, TikTok and WhatsApp Business.
- Product photographs, prices and contact information can be shared.

3. Personal selling

- Involves direct interaction between the seller and potential buyers.
- The seller explains the quality, price and benefits of the fish products.

4. Sales promotion

- Involves short-term incentives designed to increase sales.
- Examples include discounts, special offers and free samples where hygienically appropriate.

5. Public relations

- Involves activities aimed at building a positive public image.
- Fish farmers may participate in agricultural exhibitions and community events.

6. Trade exhibitions

- Farmers display fish products at agricultural shows and trade fairs.
- This allows them to interact with potential buyers.

7. Word-of-mouth marketing

- Satisfied customers recommend products to other people.
- This can help a business gain new customers.

8. Product demonstrations

- Sellers demonstrate how fish products can be prepared or cooked.
- This encourages consumers to try different fish products.

9. Posters and brochures

- Printed materials provide information about products, prices and locations.

10. Customer loyalty programmes

- Businesses reward regular customers through discounts or other benefits.
- This encourages repeat purchases.

Importance of promotion in fish marketing

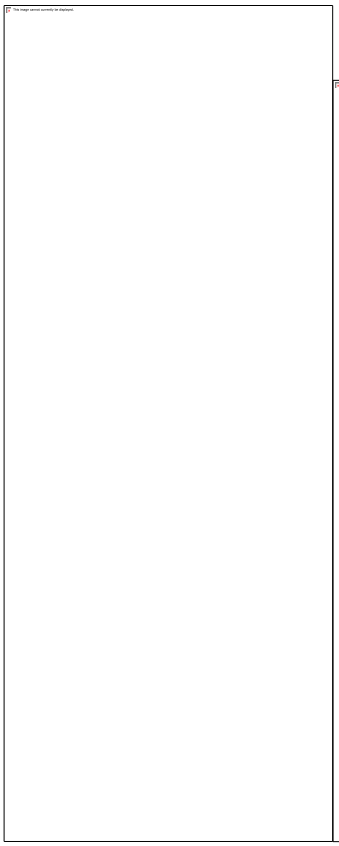
- Creates awareness about fish products.
- Attracts new customers.
- Increases product demand.
- Encourages repeat purchases.
- Helps introduce new products.
- Improves brand recognition.
- Enables businesses to compete effectively.
- Increases sales and revenue.

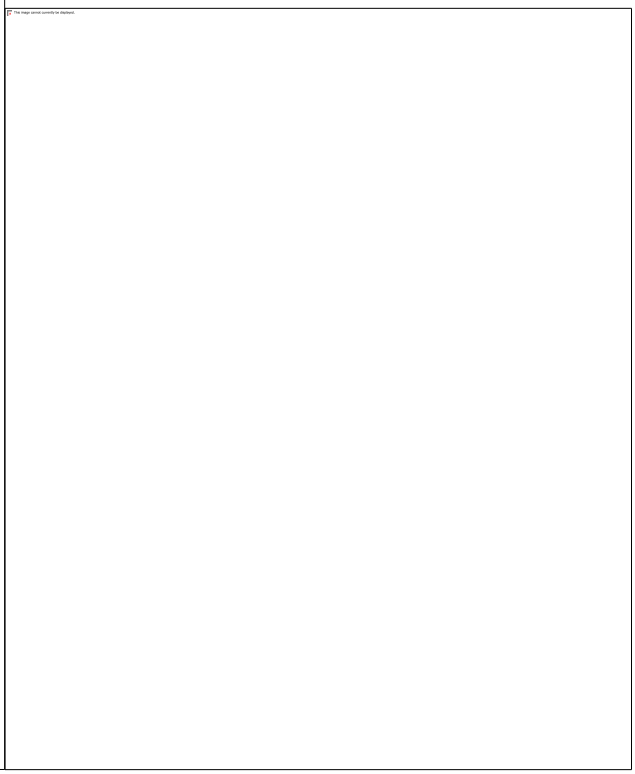
5.0 VARIETY OF VALUE-ADDED FISH PRODUCTS

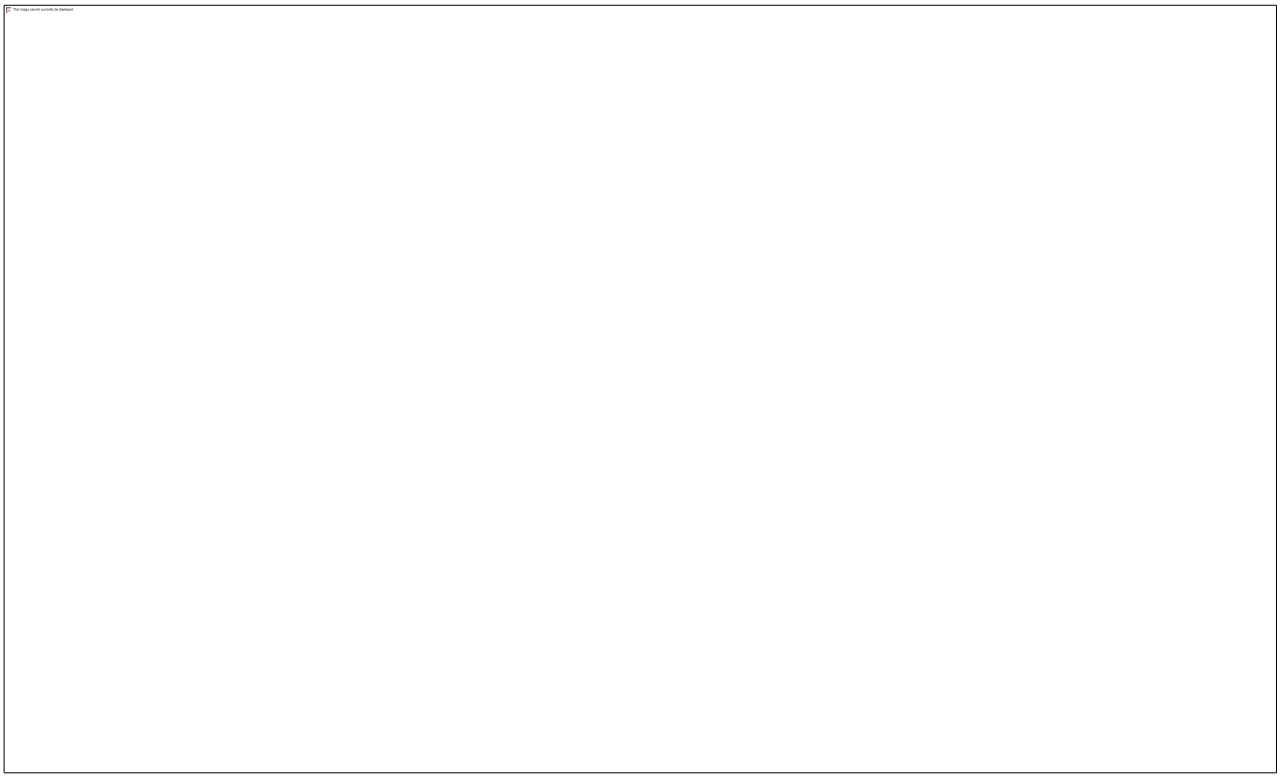
Definition: Value addition refers to the process of transforming raw fish into more useful, attractive, convenient or higher-value products through processing, packaging, preservation and other improvements.

Value-added fish products are products made from raw fish through different processing activities to improve their marketability and economic value.

Value addition enables fish farmers and processors to earn more income and reduce post-harvest losses.







5.1 Examples of Value-Added Fish Products

1. Smoked fish



Smoked fish is produced by exposing fish to smoke under controlled processing conditions.

Production process:

1. Select fresh fish.
2. Wash and clean the fish.
3. Remove unwanted parts where necessary.
4. Apply salt if required.
5. Place fish in a suitable smoking chamber.
6. Smoke under controlled conditions.
7. Cool the product hygienically.
8. Package and label appropriately.

Advantages:

- Improves flavour.
- Can extend shelf life.
- Creates a marketable product.
- Reduces losses when properly processed.

- Provides variety to consumers.

2. Dried fish



Dried fish is produced by removing moisture from fish through sun drying, solar drying or mechanical drying.

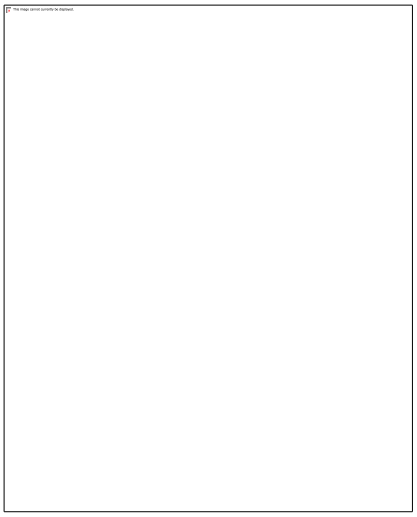
Examples:

- Dried omena.
- Dried tilapia.
- Dried small marine fish.

Advantages:

- Reduces moisture content.
- Makes transportation easier.
- Reduces storage space requirements.
- Can extend shelf life when properly dried and stored.
- Provides a convenient food product.

3. Frozen fish

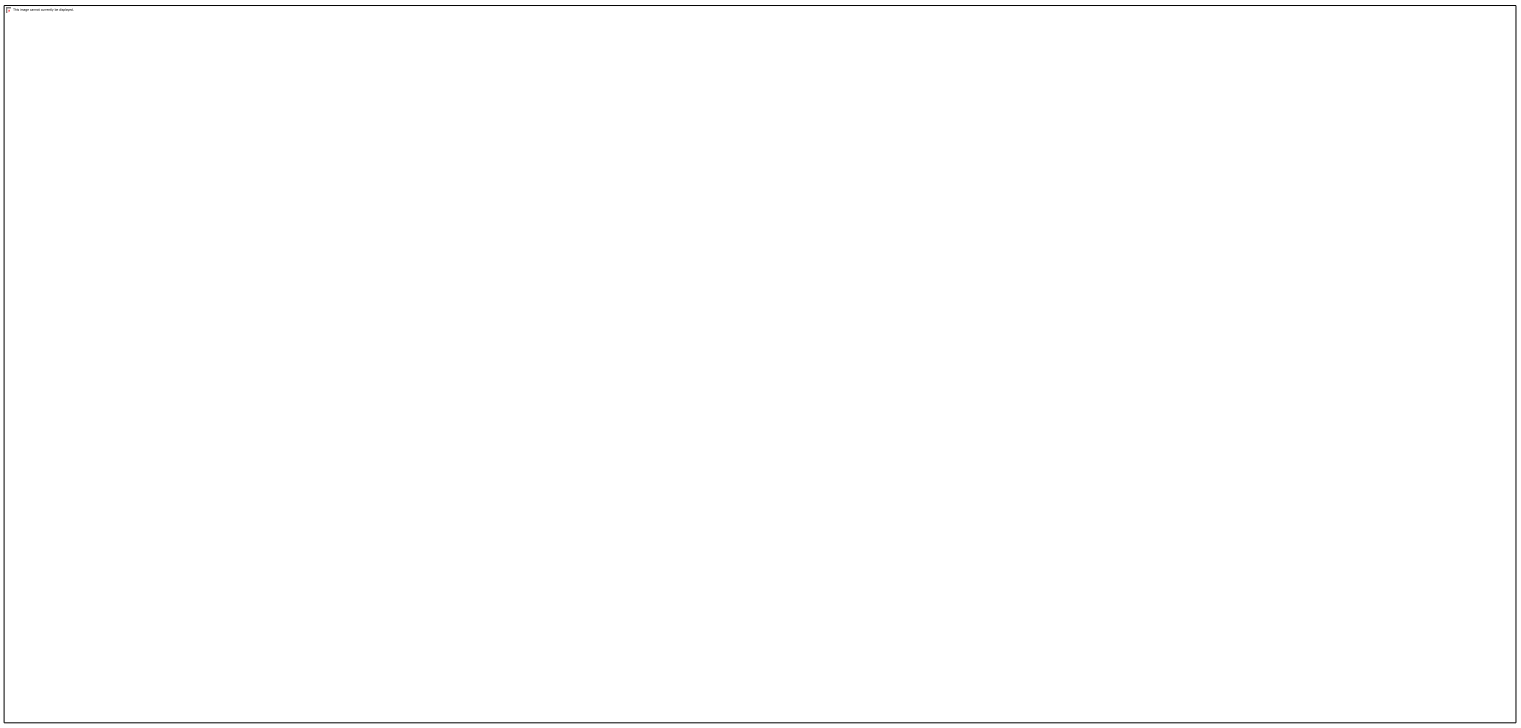


Frozen fish is fish preserved through freezing at appropriately low temperatures.

Advantages:

- Extends storage life.
- Helps maintain product availability.
- Allows transportation over long distances.
- Reduces spoilage when the cold chain is maintained.
- Provides convenience to consumers.

4. Fish fillets



Fish fillets are boneless or largely boneless portions of fish flesh cut from the sides of the fish.

Production process:

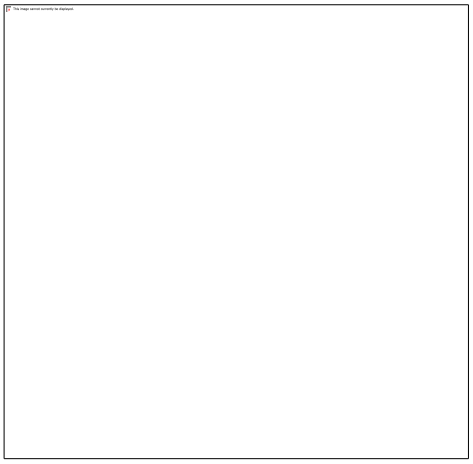
1. Select suitable fresh fish.
2. Wash the fish.
3. Remove scales if necessary.
4. Remove the head and internal organs.
5. Cut the flesh along the backbone.
6. Remove bones as required.
7. Trim and inspect the fillets.
8. Package and chill or freeze.

Advantages:

- Convenient to prepare.
- Attracts consumers who prefer boneless fish.
- Can fetch higher prices.
- Suitable for hotels and restaurants.

- Provides a standardised product.

5. Fish fingers

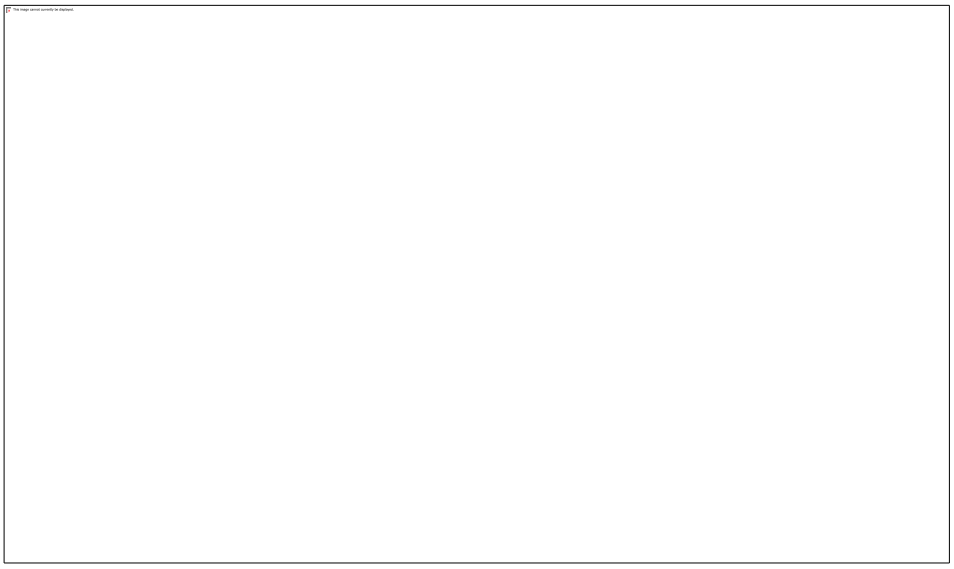


Fish fingers are processed portions of fish flesh that are shaped into elongated pieces, coated with batter and breadcrumbs, then chilled or frozen as appropriate.

Advantages:

- Convenient to prepare.
- Attractive to children and families.
- Provides variety.
- Can be sold in supermarkets and food outlets.

6. Fish sausages

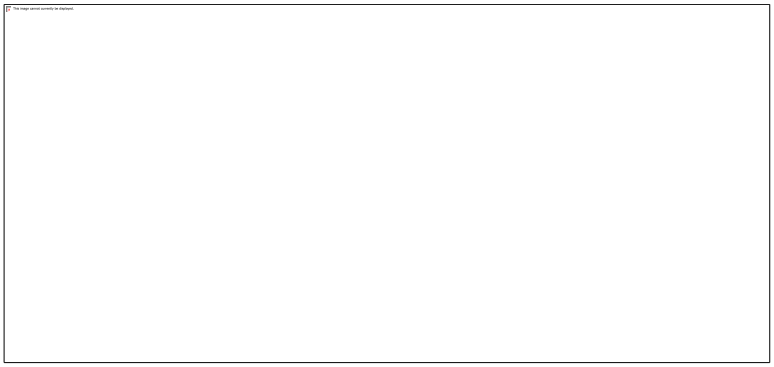


Fish sausages are processed products made by mincing fish flesh, mixing it with suitable ingredients and shaping it into sausage forms.

Advantages:

- Provides an alternative to meat sausages.
- Utilises fish flesh efficiently.
- Adds value to fish.
- Can attract new consumer groups.

7. Fish cakes

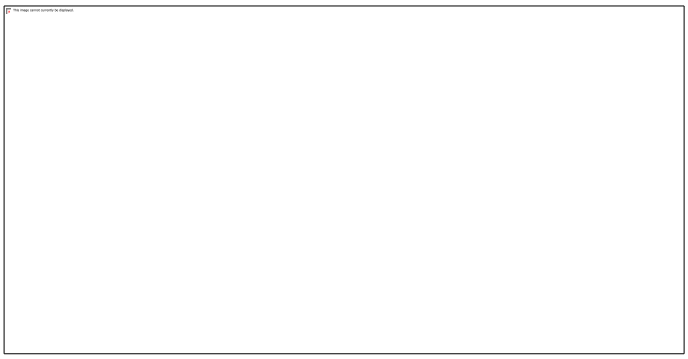


Fish cakes are prepared by mixing minced or mashed fish with suitable ingredients such as potatoes, spices and other food components before shaping and cooking.

Advantages:

- Provides a convenient food product.
- Makes use of suitable fish flesh.
- Offers variety.
- Can be supplied to restaurants and food outlets.

8. Canned fish



Canned fish is produced by processing fish and sealing it in airtight containers before applying an appropriate commercial heat treatment.

Examples:

- Canned tuna.
- Canned sardines.
- Canned mackerel.

Advantages:

- Provides convenience.
- Has an extended shelf life when correctly processed.
- Can be distributed over long distances.
- Provides ready-to-use fish products.

9. Fish powder



Fish powder is produced by drying suitable fish and grinding it into a fine powder.

Uses:

- Used as a food ingredient.
- Can be added to soups and sauces.
- Can be used in formulated food products.
- Provides a way of utilising suitable fish materials.

10. Fish oil



Fish oil is obtained by extracting and processing oil from suitable fish materials.

Uses:

- Used in the manufacture of nutritional products.
- Used in some food and industrial applications.
- Can be used in animal feed formulations.

Fish oil intended for human consumption must meet the relevant quality and safety standards.

11. Fish skin products

Fish skin can be processed into leather and other products.

Examples:

- Fish leather.
- Decorative materials.
- Craft products.

Advantages:

- Utilises fish by-products.
- Reduces waste.
- Creates additional income opportunities.

12. Fish meal



Fish meal is a protein-rich product produced by processing suitable fish materials through cooking, pressing, drying and grinding.

Uses:

- Used in animal feeds.
- Used in aquaculture feeds.
- Used in poultry feeds.
- Used in livestock feed formulations.

5.2 Importance of Value Addition in Fish Marketing

1. **Increases income:** Processed fish products may attract higher prices than raw fish.
2. **Reduces post-harvest losses:** Surplus fish can be processed instead of being wasted.
3. **Extends shelf life:** Preservation methods increase the storage period of fish products.
4. **Creates employment:** Processing creates opportunities for workers and entrepreneurs.
5. **Improves market access:** Different products can reach different consumer groups.
6. **Promotes innovation:** Farmers and processors develop new products.
7. **Improves convenience:** Consumers can purchase ready-to-cook or ready-to-use products.
8. **Utilises fish by-products:** Suitable fish waste can be converted into useful products.
9. **Promotes exports:** Properly processed products may access regional and international markets.
10. **Promotes industrial development:** Value addition encourages investment in fish processing industries.

5.3 Challenges Facing Fish Value Addition in Kenya

1. High cost of processing equipment.
2. Inadequate electricity supply in some production areas.
3. Limited access to cold storage facilities.
4. Shortage of skilled fish processors.
5. High transportation costs.
6. Limited access to affordable credit.
7. Inadequate packaging materials.
8. Strict food safety and quality requirements.
9. Limited consumer awareness of some processed fish products.
10. Competition from other protein sources.
11. Fluctuating supply of raw fish.
12. Poor access to established markets.

5.4 Ways of Improving Fish Value Addition in Kenya

- Training farmers in modern fish processing techniques.
- Establishing community fish processing centres.
- Improving access to affordable processing equipment.
- Investing in cold storage facilities.
- Encouraging fish farmer cooperatives.
- Improving access to affordable financing.
- Promoting research and innovation.
- Improving packaging and branding.
- Creating consumer awareness.
- Strengthening food safety inspection and quality control.
- Establishing partnerships with supermarkets and hotels.
- Encouraging the use of appropriate renewable energy technologies.

6.0 FOOD SAFETY AND HYGIENE IN FISH MARKETING

Food safety refers to the handling, preparation, storage and distribution of fish in ways that prevent contamination and protect consumers from foodborne illnesses.

Fish is a highly perishable food product. Poor handling can result in spoilage and contamination.

6.1 Sources of contamination during fish marketing

1. Dirty water.
2. Contaminated equipment.
3. Unwashed hands.

4. Dirty packaging materials.
5. Flies and other insects.
6. Dust and soil.
7. Improper storage temperatures.
8. Contaminated transportation containers.
9. Cross-contamination from other foods.
10. Poor waste disposal.

6.2 Ways of maintaining hygiene during fish marketing

1. Wash hands thoroughly before handling fish.
2. Use clean protective clothing.
3. Use clean and sanitised equipment.
4. Store fish at appropriate chilled or frozen temperatures.
5. Use potable water when cleaning fish.
6. Keep fish covered during transportation and display.
7. Use food-grade packaging materials.
8. Separate raw fish from cooked or ready-to-eat foods.
9. Dispose of fish waste properly.
10. Control pests in processing and storage areas.
11. Clean and disinfect working surfaces regularly.
12. Observe applicable food safety regulations.

6.3 Importance of maintaining fish hygiene

- Prevents foodborne diseases.
- Maintains fish quality.
- Increases consumer confidence.
- Reduces product rejection.
- Improves business reputation.
- Supports access to formal markets.
- Promotes public health.

7.0 RECORD KEEPING IN FISH MARKETING

Record keeping refers to the systematic collection and storage of information about fish production, harvesting, processing, sales and distribution.

Accurate records help fish farmers make informed business decisions.

7.1 Types of records maintained

1. **Harvest records:** Show the quantity and species of fish harvested.

2. **Weighing records:** Show the weight of harvested fish.
3. **Sales records:** Indicate quantities sold and money received.
4. **Customer records:** Contain details of regular customers and buyers.
5. **Stock records:** Show the quantity of fish products available.
6. **Processing records:** Show the quantity of raw fish processed and products obtained.
7. **Transport records:** Show quantities transported and delivery details.
8. **Expense records:** Show costs incurred during marketing.
9. **Loss records:** Show fish damaged, spoiled or rejected.
10. **Payment records:** Show money received and outstanding payments.

7.2 Importance of record keeping

- Helps determine business profitability.
- Supports planning and budgeting.
- Helps monitor sales performance.
- Assists in stock management.
- Helps identify losses.
- Supports business expansion.
- Improves accountability.
- Helps in decision-making.
- Facilitates financial reporting.
- Supports traceability of fish products.

8.0 PRACTICAL APPLICATION: DEVELOPING A FISH MARKETING PLAN

A fish marketing plan is a document that describes how a fish farmer or business intends to sell its fish products.

It identifies target customers, products, prices, distribution channels and promotional activities.

Steps in developing a fish marketing plan

Step 1: Identify the fish product

Determine the product to be marketed, for example, fresh tilapia, smoked catfish or frozen fillets.

Step 2: Conduct market research

Find out:

- Who buys fish?
- What type of fish do consumers prefer?
- What quantities do they purchase?
- How much are they willing to pay?
- Where do they purchase fish?

Step 3: Identify target customers

Examples:

- Households.
- Hotels.
- Restaurants.
- Schools.
- Supermarkets.
- Fish retailers.
- Wholesalers.

Step 4: Determine the selling price

Calculate production, processing, packaging and transportation costs before deciding on the selling price.

Step 5: Choose a marketing channel

Select direct selling, retail selling, wholesale distribution or other appropriate channels.

Step 6: Decide on promotional methods

Choose suitable advertising and promotion methods.

Step 7: Plan packaging and branding

Select appropriate packaging materials and develop a product identity.

Step 8: Organise transportation and storage

Ensure that fish products are transported and stored under appropriate conditions.

Step 9: Maintain marketing records

Record all purchases, sales, expenses and customer orders.

Step 10: Evaluate marketing performance

Assess whether the marketing activities are increasing sales and generating profits.

9.0 REVISION SUMMARY

Concept	Main meaning
Fish marketing	Activities involved in moving fish from producers to consumers.
Weighing	Determining the mass of fish.
Sorting	Separating fish according to identifiable characteristics.
Grading	Classifying fish according to quality standards.
Packaging	Enclosing fish in suitable protective materials.
Branding	Giving fish products a unique identity.
Labelling	Displaying product information on packaging.
Marketing channel	Route through which fish moves to consumers.
Short channel	Marketing route with few intermediaries.
Long channel	Marketing route with several intermediaries.
Product	Fish or fish-based item offered for sale.
Price	Amount charged for a fish product.

Place	Distribution and availability of fish products.
Promotion	Communication activities used to attract customers.
Value addition	Improving raw fish through processing and other activities.

Key inquiry question

How do strategies of marketing improve or increase sales of fish products?

Marketing strategies increase sales by:

1. Improving product quality and attractiveness.
2. Setting competitive and affordable prices.
3. Making fish products available in convenient locations.
4. Creating awareness through advertising and promotion.
5. Introducing different fish products to meet consumer preferences.
6. Improving packaging, branding and labelling.
7. Establishing reliable distribution channels.
8. Maintaining customer satisfaction and loyalty.
9. Reducing post-harvest losses.
10. Expanding access to local, regional and international markets.

REVISION EXERCISES

SECTION A: MULTIPLE-CHOICE QUESTIONS

30 MARKS

Choose the correct answer from the alternatives provided.

1. What is fish marketing?

A. The process of breeding fish in ponds.

B. Activities involved in moving fish products from producers to consumers.

C. The process of constructing fish ponds.

D. The process of feeding fish.

2. Which activity involves determining the mass of harvested fish?

A. Sorting.

B. Branding.

C. Weighing.

D. Grading.

3. The process of separating fish according to species and size is known as:

A. Sorting.

B. Packaging.

C. Labelling.

D. Advertising.

4. Which of the following is mainly used to determine the quality category of fish?

A. Transportation.

B. Branding.

C. Weighing.

D. Grading.

5. Which equipment is most suitable for accurately determining the weight of fish?

A. Thermometer.

B. Digital weighing scale.

C. Measuring tape.

D. Hygrometer.

6. One major importance of weighing fish is to:

A. Increase fish reproduction.

B. Improve water quality.

C. Determine the selling price.

D. Prevent fish diseases.

7. Which of the following is a suitable packaging material for fresh fish?

A. Food-grade plastic packaging.

B. Used fertiliser bags.

C. Dirty sacks.

D. Contaminated paper.

8. Branding is mainly intended to:

A. Increase the weight of fish.

B. Remove fish scales.

C. Reduce fish production.

D. Give a product a unique identity.

9. Which information should be displayed on a fish product label?

A. The farmer's favourite colour.

B. Net weight and storage instructions.

C. The name of the nearest school.

D. The number of fish ponds on the farm.

10. Which of the following is an example of a short marketing channel?

A. Farmer → Wholesaler → Retailer → Consumer.

B. Farmer → Processor → Distributor → Retailer → Consumer.

C. Farmer → Consumer.

D. Farmer → Aggregator → Exporter → Consumer.

11. A long marketing channel is characterised by:

A. Several intermediaries.

B. No transportation.

C. Direct selling only.

D. Absence of retailers.

12. One advantage of short marketing channels is that they:

A. Always eliminate storage costs.

B. Guarantee international markets.

C. Eliminate all marketing activities.

D. Allow direct interaction with consumers.

13. Which of the following is a disadvantage of long marketing channels?

A. Wider market coverage.

B. Reduced farmer control over the final selling price.

C. Specialisation among intermediaries.

D. Access to distant markets.

14. Which of the following represents the 4Ps of marketing?

A. Production, Preservation, Processing and Packaging.

B. Planning, Purchasing, Production and Profit.

C. Product, Price, Place and Promotion.

D. Packaging, Preservation, Profit and Planning.

15. Which marketing strategy involves setting prices based on production costs and adding a profit margin?

A. Cost-plus pricing.

B. Penetration pricing.

C. Promotional pricing.

D. Competitive advertising.

16. A fish farmer offers a temporary discount to attract more buyers. This is an example of:

A. Grading.

B. Branding.

C. Sorting.

D. Promotional pricing.

17. Which of the following is an example of a place strategy?

A. Designing a new fish logo.

B. Establishing distribution outlets in different towns.

C. Giving a product a new name.

D. Improving the taste of smoked fish.

18. Which of the following is an example of promotion?

A. Weighing fish.

B. Gutting fish.

C. Advertising fish products on radio.

D. Freezing fish.

19. Which of the following is a value-added fish product?

A. Fish fingers.

B. Raw pond water.

C. Fish pond soil.

D. Fish feed ingredients.

20. The process of removing moisture from fish to extend its storage life is called:

A. Branding.

B. Sorting.

C. Weighing.

D. Drying.

21. Which method of fish preservation involves exposing fish to smoke?

A. Freezing.

B. Smoking.

C. Chilling.

D. Canning.

22. Fish fillets are best described as:

A. Whole fish covered with scales.

B. Fish eggs.

C. Portions of fish flesh cut from the sides of fish.

D. Fish bones mixed with water.

23. Which product is commonly produced by grinding suitable dried fish materials?

A. Fish powder.

B. Fish leather.

C. Fish fillets.

D. Frozen fish.

24. One major benefit of value addition is that it:

A. Eliminates the need for marketing.

B. Increases fish mortality.

C. Reduces all production costs to zero.

D. Can increase the economic value of fish.

25. Which of the following is an important characteristic of good fish packaging?

A. It should be contaminated.

B. It should be food-grade and hygienic.

C. It should allow unnecessary leakage.

D. It should be difficult to handle.

26. Which of the following helps maintain the freshness of fish during transportation?

A. Exposure to direct sunlight.

B. Keeping fish in dirty containers.

C. Use of insulated containers with ice.

D. Storing fish near waste materials.

27. A fish farmer supplies fresh fish directly to a nearby hotel. This is an example of:

A. A short marketing channel.

B. A long marketing channel.

C. International distribution.

D. Indirect export marketing.

28. Which of the following is a fish marketing record?

A. Fish pond construction plan.

B. School attendance register.

C. Personal diary.

D. Sales record.

29. Which of the following is a source of fish contamination?

A. Clean packaging materials.

B. Dirty processing equipment.

C. Proper refrigeration.

D. Clean protective clothing.

30. Why is customer feedback important in fish marketing?

A. It increases fish mortality.

B. It prevents fish harvesting.

C. It helps improve products and customer satisfaction.

D. It eliminates the need for packaging.

SECTION B: STRUCTURED QUESTIONS 50 MARKS

Answer all questions.

QUESTION 1: PREPARATION OF FISH FOR MARKETING (8 MARKS)

a) Define fish marketing. (2 marks)

b) State three activities involved in preparing fish for marketing. (3 marks)

c) Explain three importance of weighing fish before selling. (3 marks)

QUESTION 2: SORTING, GRADING AND PACKAGING (8 MARKS)

a) Differentiate between sorting and grading of fish. (2 marks)

b) State three factors considered when grading fish. (3 marks)

c) Explain three functions of packaging in fish marketing. (3 marks)

QUESTION 3: FISH MARKETING CHANNELS (8 MARKS)

a) Define a fish marketing channel. (2 marks)

b) Using diagrams, illustrate:

i. A short fish marketing channel. (2 marks)

ii. A long fish marketing channel. (2 marks)

c) State two advantages of using short marketing channels. (2 marks)

QUESTION 4: MARKETING MIX (8 MARKS)

a) What is meant by the 4Ps of marketing? (2 marks)

b) Explain three strategies a fish farmer can use to promote fish products. (3 marks)

c) State three factors that influence the pricing of fish products. (3 marks)

QUESTION 5: VALUE-ADDED FISH PRODUCTS (9 MARKS)

a) Define value addition in fish marketing. (2 marks)

b) Identify four examples of value-added fish products. (4 marks)

c) Explain three benefits of value addition to fish farmers. (3 marks)

QUESTION 6: FOOD SAFETY AND MARKETING (9 MARKS)

A fish farmer in Kisumu harvests 200 kg of tilapia for sale to customers in Nairobi. The farmer intends to transport the fish over a long distance.

a) State three preparations that should be carried out before transporting the fish. (3 marks)

b) Explain three ways of maintaining fish quality during transportation. (3 marks)

c) State three records that the fish farmer should maintain during the marketing process. (3 marks)

ANSWERS AND MARKING SCHEME

SECTION A: MULTIPLE-CHOICE ANSWERS

Question	Answer	Question	Answer
1	B	16	D
2	C	17	B
3	A	18	C
4	D	19	A
5	B	20	D
6	C	21	B
7	A	22	C
8	D	23	A
9	B	24	D
10	C	25	B
11	A	26	C
12	D	27	A
13	B	28	D
14	C	29	B
15	A	30	C

SECTION B: SUGGESTED MARKING SCHEME

QUESTION 1 (8 MARKS)

a) Fish marketing refers to activities involved in moving fish and fish products from producers to final consumers. (2 marks)

b) Any three:

- Weighing.
- Sorting.
- Grading.

- Cleaning.
- Packaging.
- Branding.
- Labelling.
- Preservation.

(1 mark each = 3 marks)

c) Any three explained points:

- Determines the selling price according to the weight of fish.
- Promotes fair trade between buyers and sellers.
- Helps establish the total quantity harvested.
- Facilitates accurate production records.
- Helps determine transportation requirements.
- Facilitates proper packaging.

(1 mark each = 3 marks)

QUESTION 2 (8 MARKS)

a)

- Sorting: Separating fish according to characteristics such as species, size and physical condition. (1 mark)
- Grading: Classifying fish according to quality and established standards. (1 mark)

b) Any three:

- Freshness.
- Size.
- Physical appearance.
- Texture.
- Odour.
- Physical damage.
- Cleanliness.

(1 mark each = 3 marks)

c) Any three explained points:

- Protects fish from contamination.
- Prevents physical damage during transportation.
- Maintains product quality.
- Makes storage easier.
- Improves product presentation.

- Provides space for branding and labelling.

(1 mark each = 3 marks)

QUESTION 3 (8 MARKS)

a) A fish marketing channel is the route through which fish moves from the producer to the final consumer. (2 marks)

b)

i. Short channel:

Fish farmer → Consumer. (2 marks)

ii. Long channel:

Fish farmer → Wholesaler → Retailer → Consumer. (2 marks)

c) Any two:

- Allows direct contact with consumers.
- May increase the farmer's profit margin.
- Reduces the number of intermediaries.
- Allows farmers to obtain direct customer feedback.
- May reduce intermediary marketing costs.

(1 mark each = 2 marks)

QUESTION 4 (8 MARKS)

a) The 4Ps refer to the four major elements of the marketing mix:

- Product.
- Price.
- Place.
- Promotion.

(½ mark each = 2 marks)

b) Any three explained points:

- Advertising through radio, television and social media to create awareness.
- Offering discounts to attract more customers.
- Participating in agricultural exhibitions to display products.
- Using personal selling to persuade potential buyers.
- Providing product samples where hygienically appropriate.
- Using posters and brochures to communicate product information.

(1 mark each = 3 marks)

c) Any three:

- Production costs.

- Market demand.
- Fish quality.
- Competitor prices.
- Transportation costs.
- Availability of fish.
- Storage expenses.
- Consumer purchasing power.

(1 mark each = 3 marks)

QUESTION 5 (9 MARKS)

a) Value addition refers to processing or improving raw fish to produce products with increased usefulness, convenience, quality or economic value. (2 marks)

b) Any four:

- Smoked fish.
- Dried fish.
- Frozen fish.
- Fish fillets.
- Fish sausages.
- Fish fingers.
- Fish cakes.
- Canned fish.
- Fish powder.
- Fish meal.

(1 mark each = 4 marks)

c) Any three explained points:

- Increases income through the sale of higher-value products.
- Reduces post-harvest losses by processing surplus fish.
- Extends shelf life through preservation.
- Creates employment opportunities.
- Promotes access to wider markets.
- Improves consumer convenience.
- Encourages product diversification.

(1 mark each = 3 marks)

QUESTION 6 (9 MARKS)

a) Any three:

- Weigh and record the harvested fish.
- Sort and grade the fish.
- Clean and prepare the fish according to market requirements.
- Pack fish in suitable food-grade containers.
- Chill the fish using sufficient ice.
- Arrange appropriate transportation.

(1 mark each = 3 marks)

b) Any three explained points:

- Use insulated containers with sufficient ice to maintain appropriate temperatures.
- Use refrigerated transportation where available to maintain the cold chain.
- Avoid exposing fish to direct sunlight and high temperatures.
- Ensure containers are clean to prevent contamination.
- Minimise unnecessary handling to prevent physical damage.
- Deliver fish promptly to reduce deterioration.

(1 mark each = 3 marks)

c) Any three:

- Harvest records.
- Weighing records.
- Sales records.
- Transportation records.
- Customer records.
- Expense records.
- Stock records.
- Payment records.

(1 mark each = 3 marks)

STRAND 3.0: CAPTURE FISHERIES

SUB-STRAND 3.1: FUNDAMENTALS OF FISHERIES MANAGEMENT

1.0 INTRODUCTION TO FISHERIES MANAGEMENT

1.1 Meaning of Fisheries

A fishery refers to an activity, industry or system concerned with catching, harvesting, processing and marketing fish and other useful aquatic organisms from natural water bodies or managed aquatic environments.

Fisheries involve the exploitation of aquatic resources for food, income, employment, recreation and other economic purposes.

Examples of fisheries in Kenya include:

- Lake Victoria fisheries, where Nile perch, tilapia and dagaa are harvested.
- Lake Turkana fisheries, where Nile tilapia and other freshwater fish are caught.
- Indian Ocean fisheries, where tuna, kingfish, prawns, lobsters and octopus are harvested.
- River fisheries, where freshwater fish are caught for domestic consumption and sale.
- Coastal shellfish fisheries, where crabs, prawns, oysters and other shellfish are harvested.

1.2 Meaning of Fisheries Management

Fisheries management refers to the planning, regulation, monitoring and control of fishing activities to ensure that fish and other aquatic resources are harvested responsibly and remain available for present and future generations.

It involves putting in place rules, practices and strategies that control how, when, where and how much fishing takes place.

Fisheries management aims at maintaining healthy fish populations, protecting aquatic habitats, reducing overfishing and ensuring that fishing communities benefit economically and socially from fisheries resources.

Example:

In Lake Victoria, fisheries management involves regulating fishing nets, controlling illegal fishing activities, monitoring fish catches and protecting breeding areas to ensure sustainable populations of Nile perch, tilapia and dagaa.

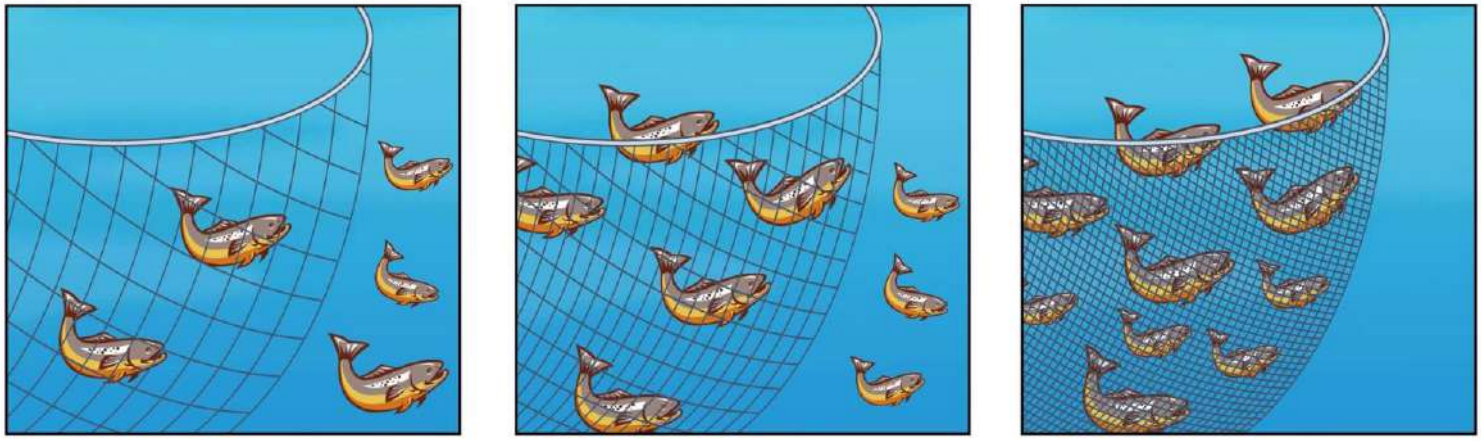
1.3 Meaning of Sustainable Fisheries

Sustainable fisheries are fisheries that are managed and harvested in a manner that allows fish populations and aquatic ecosystems to remain productive and healthy over a long period.

Sustainable fishing ensures that:

- Fish are not harvested faster than they can reproduce and replace their populations.
- Breeding and nursery grounds are protected.
- Fishing methods do not cause unnecessary damage to aquatic ecosystems.
- Fishing communities continue earning income.
- Future generations can access fish resources.





1.4 Importance of Fisheries Management

Fisheries management is important because aquatic resources are limited and can become depleted when harvesting is not properly controlled.

The following are the main reasons for managing fisheries resources:

1. Preventing overfishing

- Overfishing occurs when fish are harvested at a rate higher than their natural ability to reproduce and replace their population.
- It leads to a decline in fish stocks and may eventually cause the collapse of fisheries.
- Fisheries management controls the quantity and size of fish harvested.
- For example, regulating Nile perch harvesting in Lake Victoria helps maintain fish populations.

2. Protecting endangered aquatic species

- Some aquatic species have small populations and are at risk of extinction.
- Management measures help protect threatened fish, marine mammals, turtles and other aquatic organisms.
- Fishing activities that accidentally capture endangered species can be regulated.
- For example, protecting sea turtles along the Kenyan coast helps conserve marine biodiversity.

3. Conserving breeding and nursery grounds

- Breeding grounds are places where aquatic organisms reproduce.
- Nursery grounds are areas where young fish grow and develop.
- These areas are important for the continuation of fish populations.
- Fisheries management protects such habitats from destructive fishing, pollution and other disturbances.

4. Maintaining aquatic biodiversity

- Biodiversity refers to the variety of living organisms found in a particular environment.
- Proper fisheries management protects different species of fish, shellfish, aquatic plants and other organisms.

- It prevents the disappearance of species from aquatic ecosystems.

5. Ensuring food security

- Fish provide proteins, vitamins, minerals and essential fatty acids.
- Proper management ensures a continuous supply of fish for human consumption.
- This contributes to food and nutritional security in Kenya.

6. Promoting employment and income generation

- Fisheries provide employment to fishermen, fish processors, traders, boat builders and transporters.
- Sustainable management ensures that fishing activities continue providing livelihoods.
- It supports economic development in fishing communities such as those around Lake Victoria and the Kenyan coast.

7. Reducing destruction of aquatic habitats

- Some fishing practices destroy coral reefs, seagrass beds and lake-bottom habitats.
- Management controls destructive fishing methods.
- This allows aquatic organisms to survive and reproduce in healthy environments.

8. Controlling illegal fishing activities

- Illegal fishing involves fishing in violation of established fisheries laws and regulations.
- Examples include using prohibited fishing gear, fishing in closed areas and catching undersized fish.
- Management helps enforce fishing regulations and protect aquatic resources.

9. Maintaining ecological balance

- Aquatic organisms depend on one another through food chains and food webs.
- Excessive harvesting of one species may affect other organisms.
- Fisheries management maintains balanced populations and healthy aquatic ecosystems.

10. Promoting tourism and recreation

- Healthy aquatic ecosystems attract tourists and recreational activities.
- Marine parks, sport fishing and recreational boating generate income.
- Conservation of marine biodiversity supports tourism along the Kenyan coast.

11. Preventing conflicts among resource users

- Fisheries resources are shared by different groups of people.
- Competition may arise between fishermen, tourism operators, conservation agencies and other users.
- Management establishes rules that promote fair and responsible use of aquatic resources.

12. Promoting intergenerational equity

- Intergenerational equity means ensuring that present generations use resources responsibly without denying future generations the opportunity to benefit from them.
- Fisheries management ensures that aquatic resources remain available for future generations.

2.0 TYPES OF FISHERIES RESOURCES

2.1 Meaning of Fisheries Resources

Fisheries resources are living aquatic organisms and other useful biological materials found in water bodies that can be harvested, processed or utilised for economic, nutritional, scientific and environmental purposes.

They include fish, shellfish, marine mammals, aquatic plants, freshwater invertebrates and other aquatic organisms.

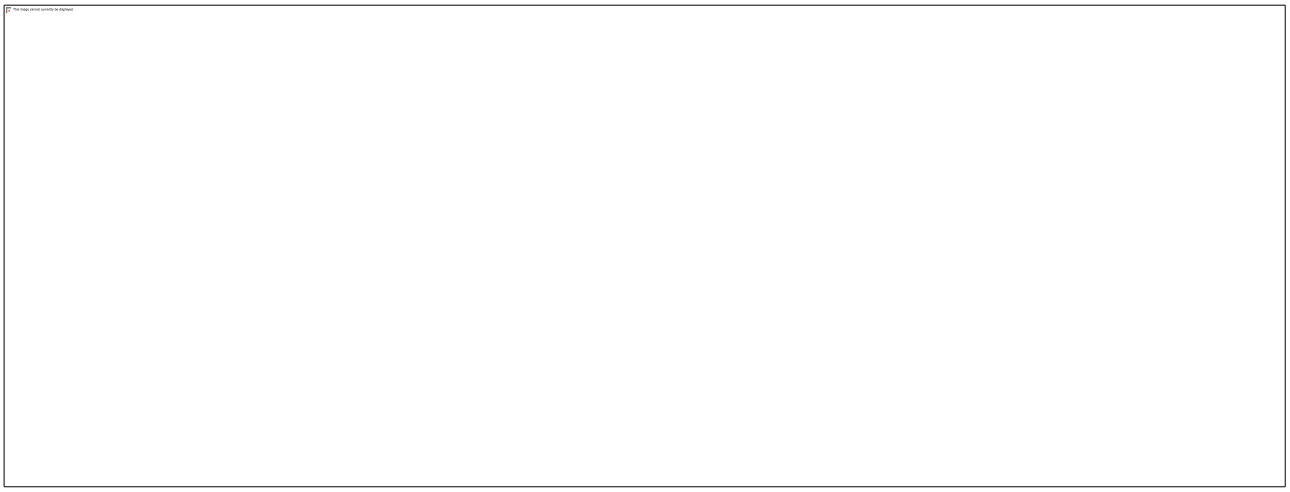
Fisheries resources are broadly classified into the following categories:

1. Finfish.
2. Shellfish.
3. Marine mammals.
4. Aquatic plants.
5. Freshwater invertebrates.
6. Echinoderms.

2.2 Finfish







Meaning of finfish

Finfish are aquatic vertebrates that have fins for movement and gills for breathing. Most have streamlined bodies covered with scales, although some species have different body coverings.

They are the most commonly harvested fisheries resources in many parts of the world.

Characteristics of finfish

- They possess a backbone and an internal skeleton.
- Most have streamlined bodies that reduce resistance when swimming.
- They possess fins that help in movement, balance and steering.
- They use gills to extract dissolved oxygen from water.
- Most reproduce by laying eggs, although some species give birth to live young.
- Most are cold-blooded animals, meaning their body temperature changes with the surrounding water temperature.
- Their bodies may be covered with scales, mucus or other protective structures.
- They have specialised sensory organs for detecting movement, vibrations and changes in their environment.

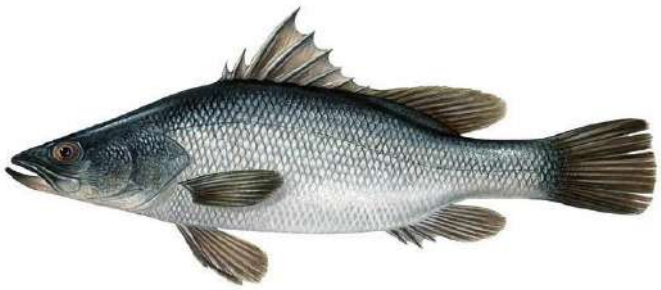
Examples of finfish in Kenya

A. Nile tilapia



- Scientific name: *Oreochromis niloticus*.
- Commonly found in Lake Victoria and other freshwater bodies.
- It is an important food fish in Kenya.
- It feeds on algae, plankton and other organic materials.
- It is widely cultured in fish ponds and cages.
- It is valued for its taste, nutritional value and commercial importance.

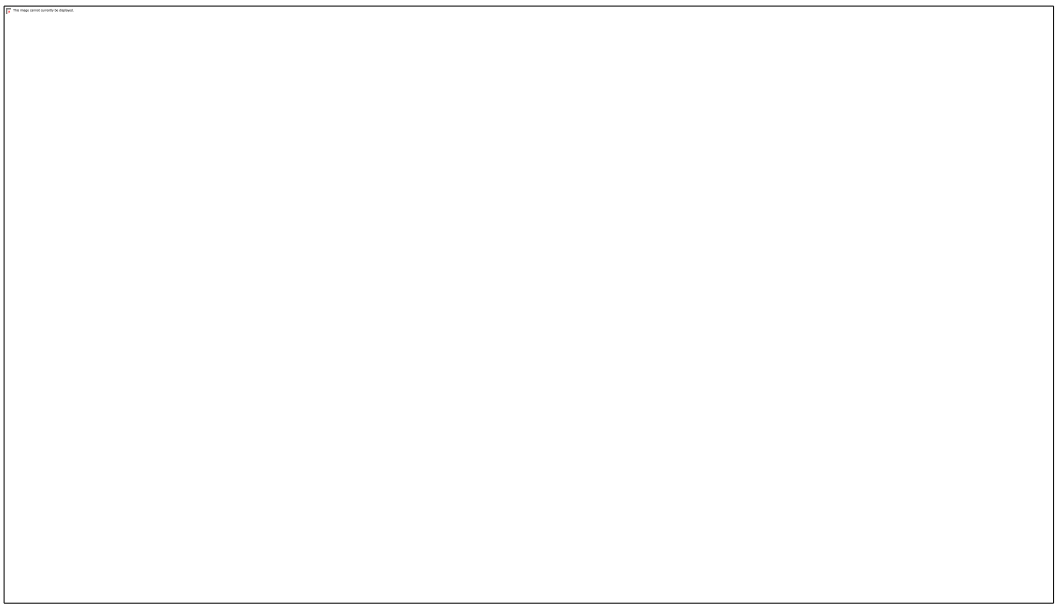
B. Nile perch



- Scientific name: *Lates niloticus*.
- Found in Lake Victoria and other freshwater systems.
- It is a large predatory fish.
- It feeds mainly on other fish.

- It supports commercial fishing and fish-processing industries.
- It is an important export commodity in Kenya.

C. Dagaa (Omena)



- Commonly called omena in Kenya.
- Scientific name: *Rastrineobola argentea*.
- It is a small, silvery freshwater fish found in Lake Victoria.
- It is harvested in large quantities using appropriate small-mesh fishing methods.
- It is an important source of protein and income for fishing communities.
- It is commonly dried and sold in local markets.

D. Tuna

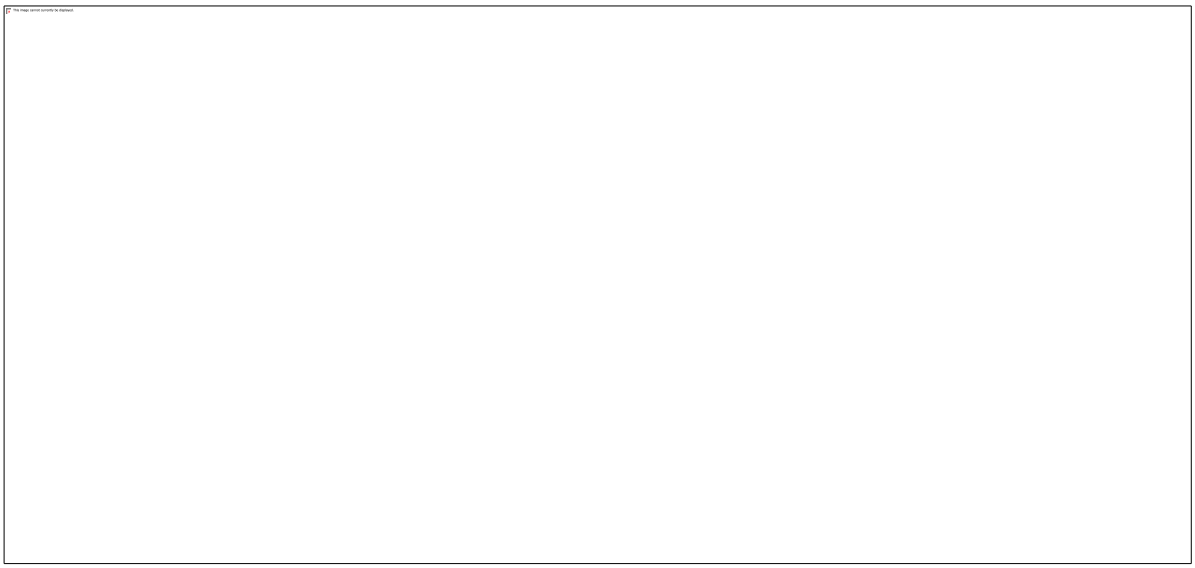


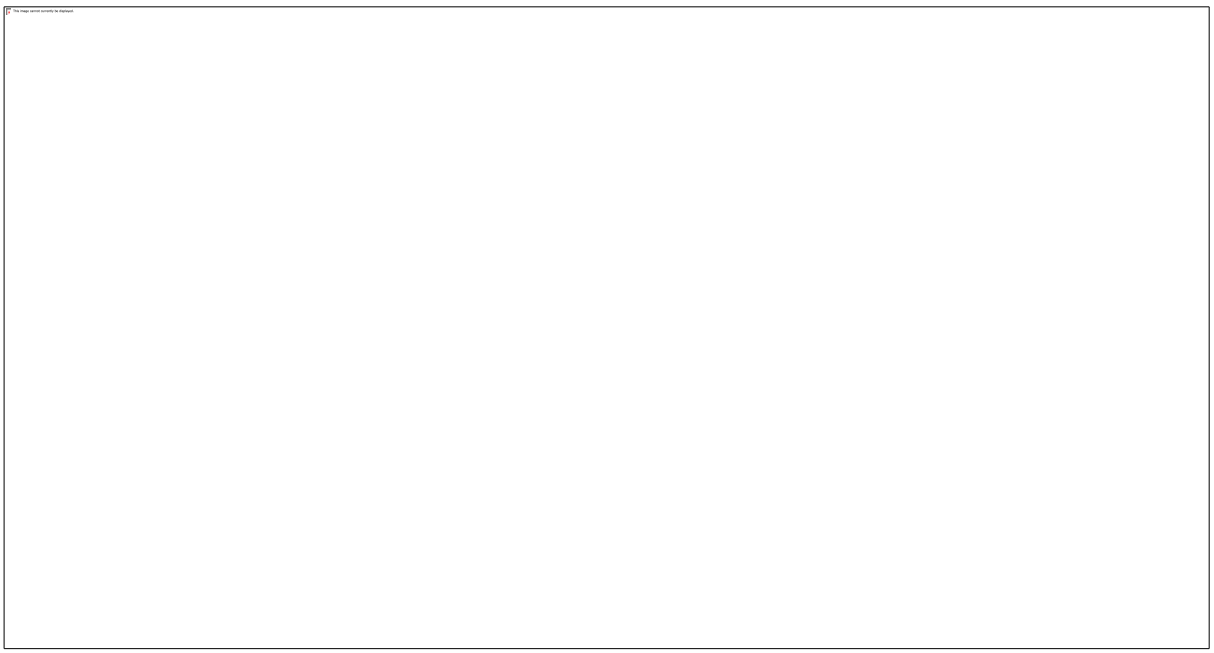
- Tuna are marine finfish found in the Indian Ocean.
- They are strong swimmers and migrate over long distances.
- They are commercially important because of their high market value.
- They are harvested using methods such as longlining and purse seining.
- They support commercial fishing and international fish trade.

Other examples of finfish include:

- Kingfish.
- Marlin.
- Sardines.
- Mackerel.
- Grouper.
- Snapper.
- Catfish.
- Mudfish.
- Rainbow trout.

2.3 Shellfish







Meaning of shellfish

Shellfish are aquatic invertebrates that usually possess hard external shells or protective coverings. They include molluscs and crustaceans.

Unlike finfish, shellfish do not have a backbone.

Shellfish are important sources of food, income and employment in coastal and inland fisheries.

Shellfish are classified into two main groups:

A. Molluscs

Meaning of molluscs

Molluscs are soft-bodied invertebrate animals, many of which possess a hard external shell made mainly of calcium carbonate.

Some molluscs have two shells, while others have one shell or no external shell.

Characteristics of molluscs

- They have soft bodies.
- Many possess a hard external shell for protection.
- They are invertebrates and lack a backbone.
- Most have a muscular foot used for movement.
- Many possess a mantle that produces the shell.
- They may live in freshwater, seawater or moist terrestrial environments.
- Some feed by filtering microscopic organisms from water.

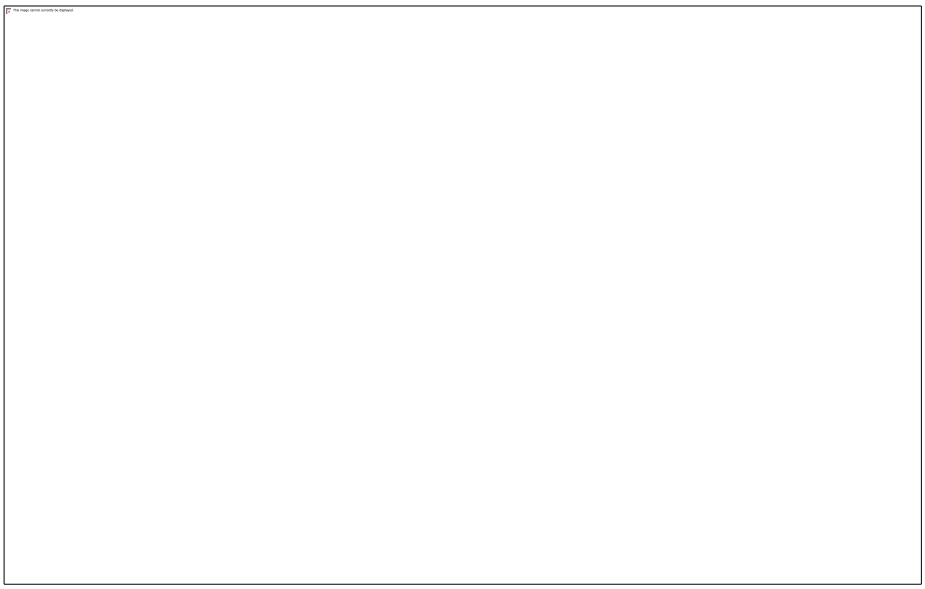
Examples of molluscs

1. Oysters



- Oysters are marine bivalve molluscs.
- Their bodies are protected by two hard shells.
- They attach themselves to rocks, reefs and other hard surfaces.
- They feed by filtering microscopic organisms and organic particles from water.
- They are harvested for food and sometimes for pearl production, depending on the species.

2. Mussels



- Mussels are bivalve molluscs.
- They possess two hinged shells.
- They attach to surfaces using strong thread-like structures called byssal threads.
- They feed by filtering suspended particles from water.
- They are used as food in some coastal communities.

3. Octopus



- Octopuses are soft-bodied marine molluscs.
- They possess eight arms with suckers.
- They have no external shell.
- They use camouflage to hide from predators.
- They are harvested for food in some Kenyan coastal communities.

4. Squid



- Squid are marine molluscs.
- They have elongated bodies and tentacles.
- They use jet propulsion to move through water.
- They can release ink to confuse predators.
- They are commercially harvested for food.

Other examples of molluscs include:

- Clams.

- Snails.
- Cockles.
- Cuttlefish.
- Scallops.

B. Crustaceans

Meaning of crustaceans

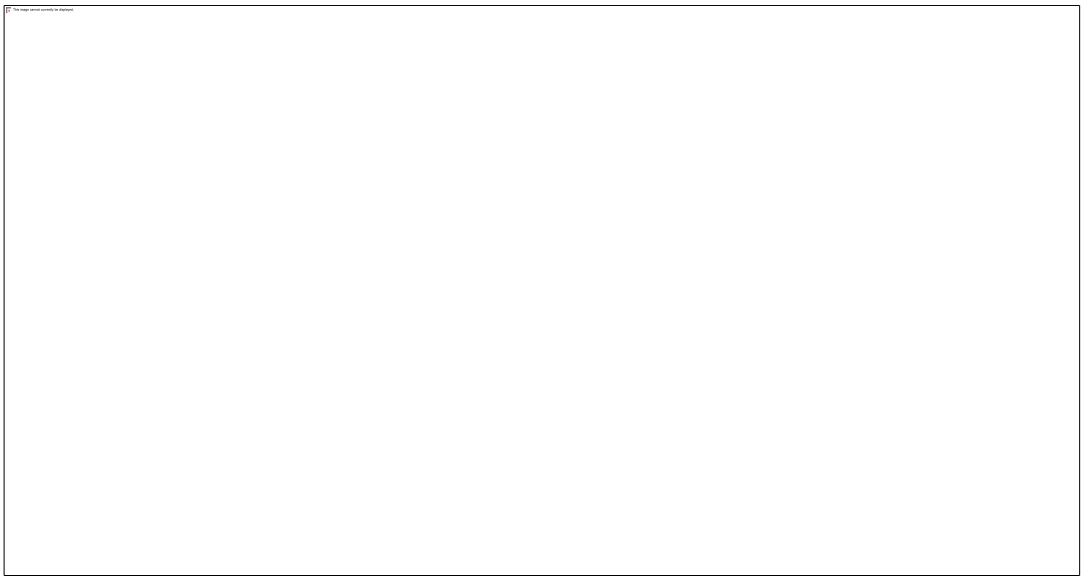
Crustaceans are aquatic or moisture-dependent invertebrate animals belonging to the group Arthropoda. They have segmented bodies, jointed appendages and a hard external covering called an exoskeleton.

Characteristics of crustaceans

- They possess hard external skeletons.
- Their bodies are segmented.
- They have jointed legs and appendages.
- Most have two pairs of antennae.
- They breathe using gills.
- Many undergo moulting as they grow.
- Most aquatic species reproduce by laying eggs.
- They occupy freshwater, marine and brackish-water environments.

Examples of crustaceans

1. Prawns



- Prawns are aquatic crustaceans.
- They possess elongated bodies and several pairs of legs.
- They have a hard external covering.
- They are found in marine and brackish-water environments.
- They are harvested for human consumption and commercial purposes.

2. Crabs



- Crabs have broad bodies protected by hard shells.
- They possess five pairs of walking legs in most adult true crabs.
- The first pair is usually modified into claws.
- They are found in mangroves, estuaries, beaches and other aquatic habitats.
- Mud crabs are commercially important along the Kenyan coast.

3. Lobsters



- Lobsters are marine crustaceans.
- Their bodies are protected by a hard exoskeleton.
- They possess several pairs of legs.
- They live mainly on rocky seabeds and coral reef habitats.
- They are valuable seafood products.

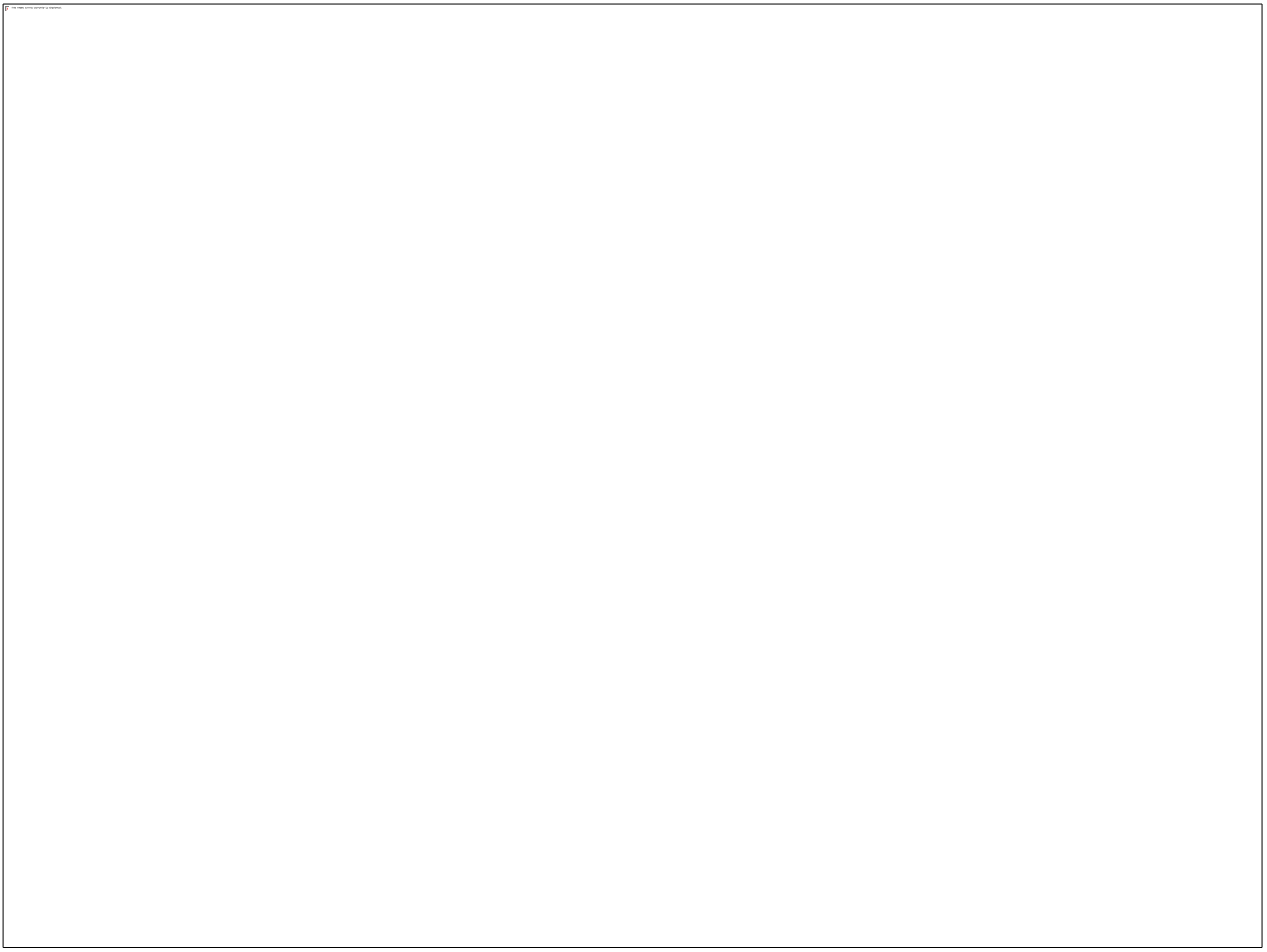
4. Shrimps

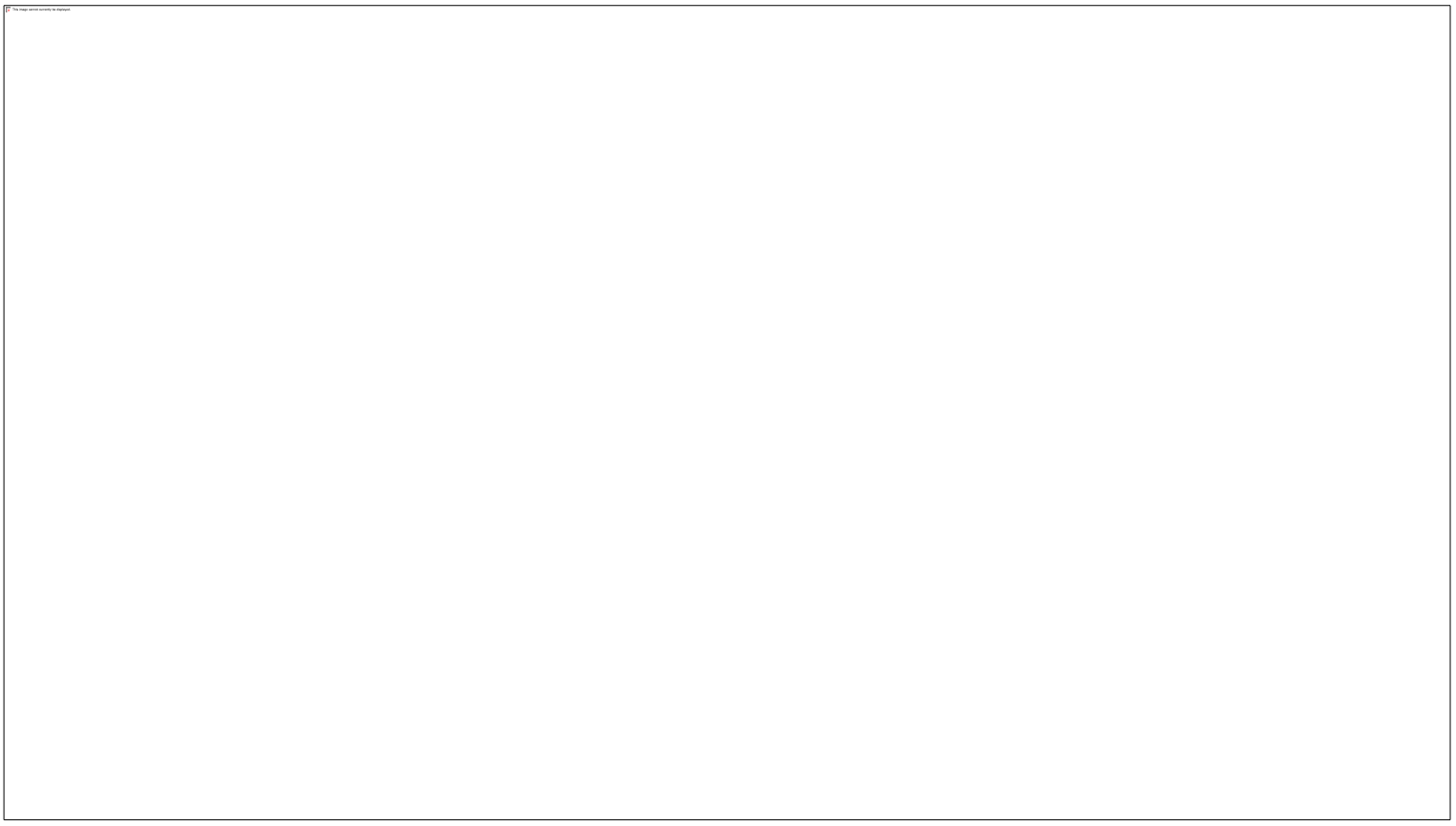


- Shrimps are small aquatic crustaceans.
- They possess segmented bodies.
- They are important components of aquatic food chains.
- They are harvested for food and commercial purposes.

Other examples include crayfish, krill and freshwater prawns.

2.4 Marine Mammals





Meaning of marine mammals

Marine mammals are warm-blooded vertebrate animals that depend on marine or coastal environments for most or all of their lives.

They breathe air using lungs, give birth to live young in most cases and feed their young with milk produced by mammary glands.

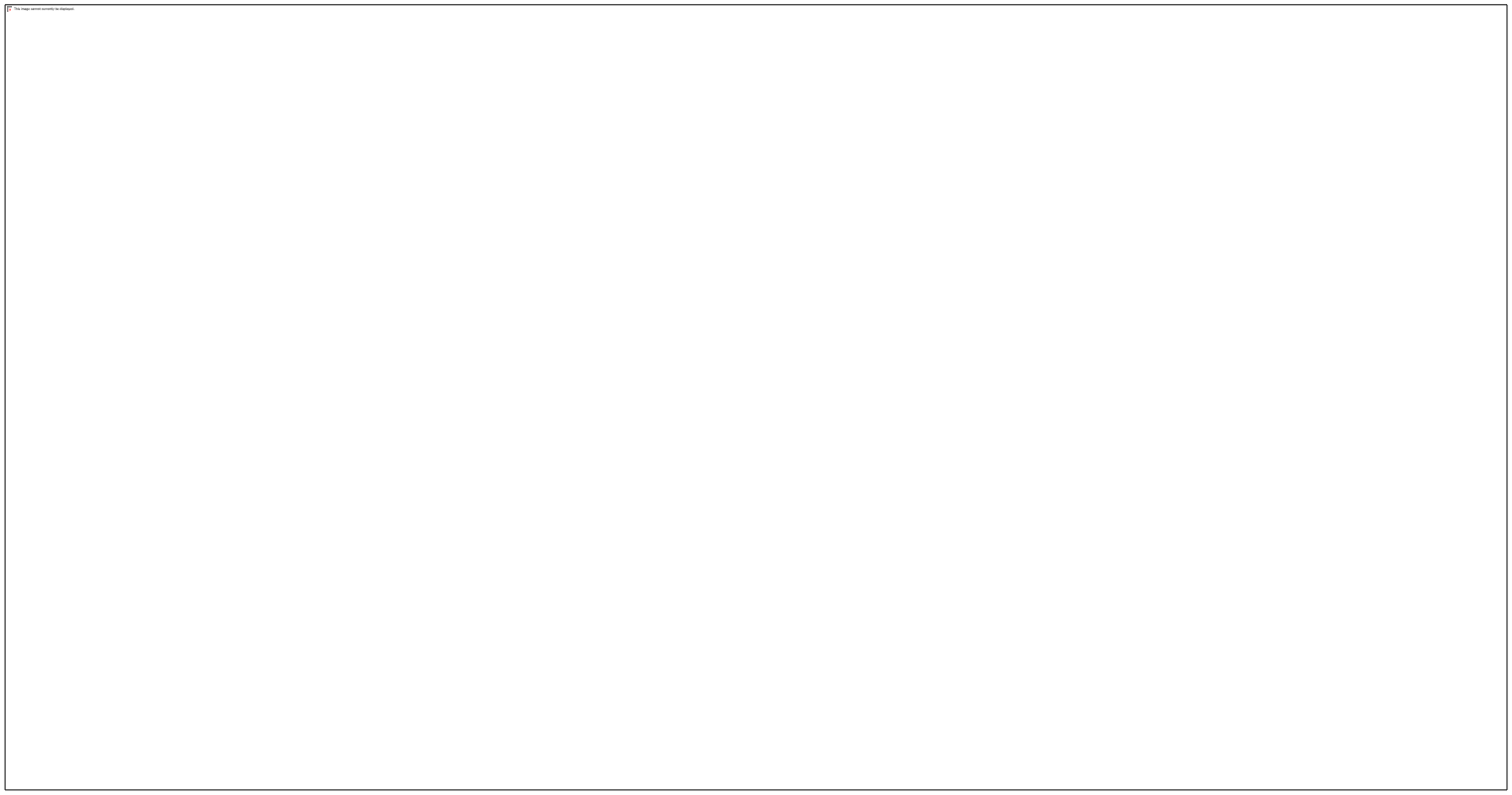
Marine mammals are important components of marine ecosystems, although they are generally protected wildlife rather than ordinary commercial fisheries targets.

Characteristics of marine mammals

- They are vertebrates with backbones.
- They breathe atmospheric oxygen using lungs.
- They are warm-blooded animals.
- Most give birth to live young.
- Females produce milk to feed their young.
- Their bodies are adapted to swimming in water.
- Many have streamlined bodies that reduce water resistance.
- They possess specialised adaptations for diving and conserving oxygen.
- They may have thick layers of fat called blubber for insulation.

Examples of marine mammals

1. Dolphins



- Dolphins are highly intelligent marine mammals.
- They breathe through blowholes located on top of their heads.
- They use echolocation to locate prey and navigate.

- They feed mainly on fish and squid.
- They are important indicators of marine ecosystem health.

2. Whales

- Whales are large marine mammals.
- They breathe air through blowholes.
- Some feed on plankton and small aquatic organisms, while others feed on fish and squid.
- Humpback whales migrate through parts of the western Indian Ocean.
- They contribute to marine biodiversity and tourism.

3. Dugongs



- Dugongs are herbivorous marine mammals.
- They feed mainly on seagrass.

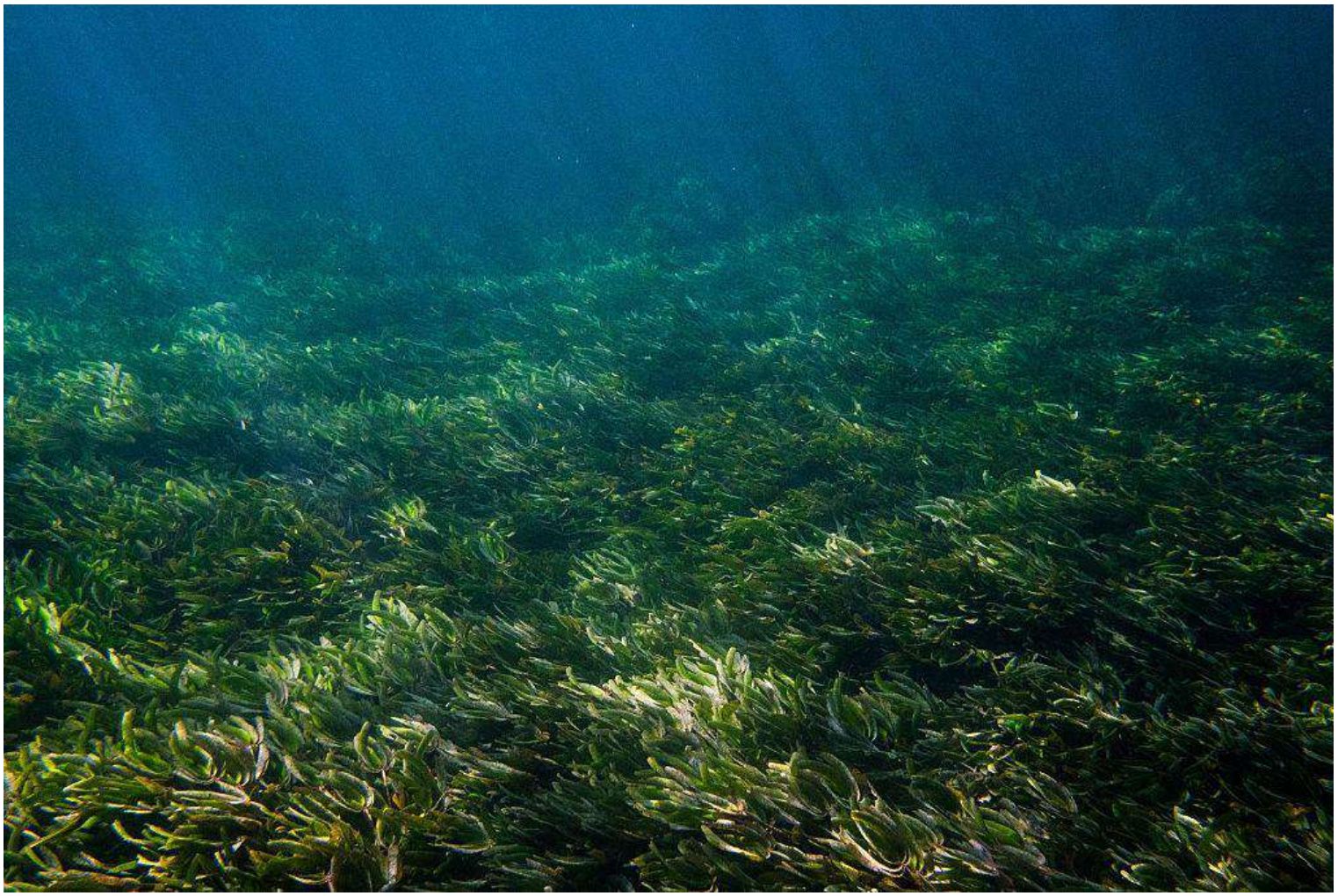
- They inhabit shallow coastal waters.
- They are important for maintaining the ecological balance of seagrass ecosystems.
- They are vulnerable to habitat degradation and accidental capture in fishing gear.

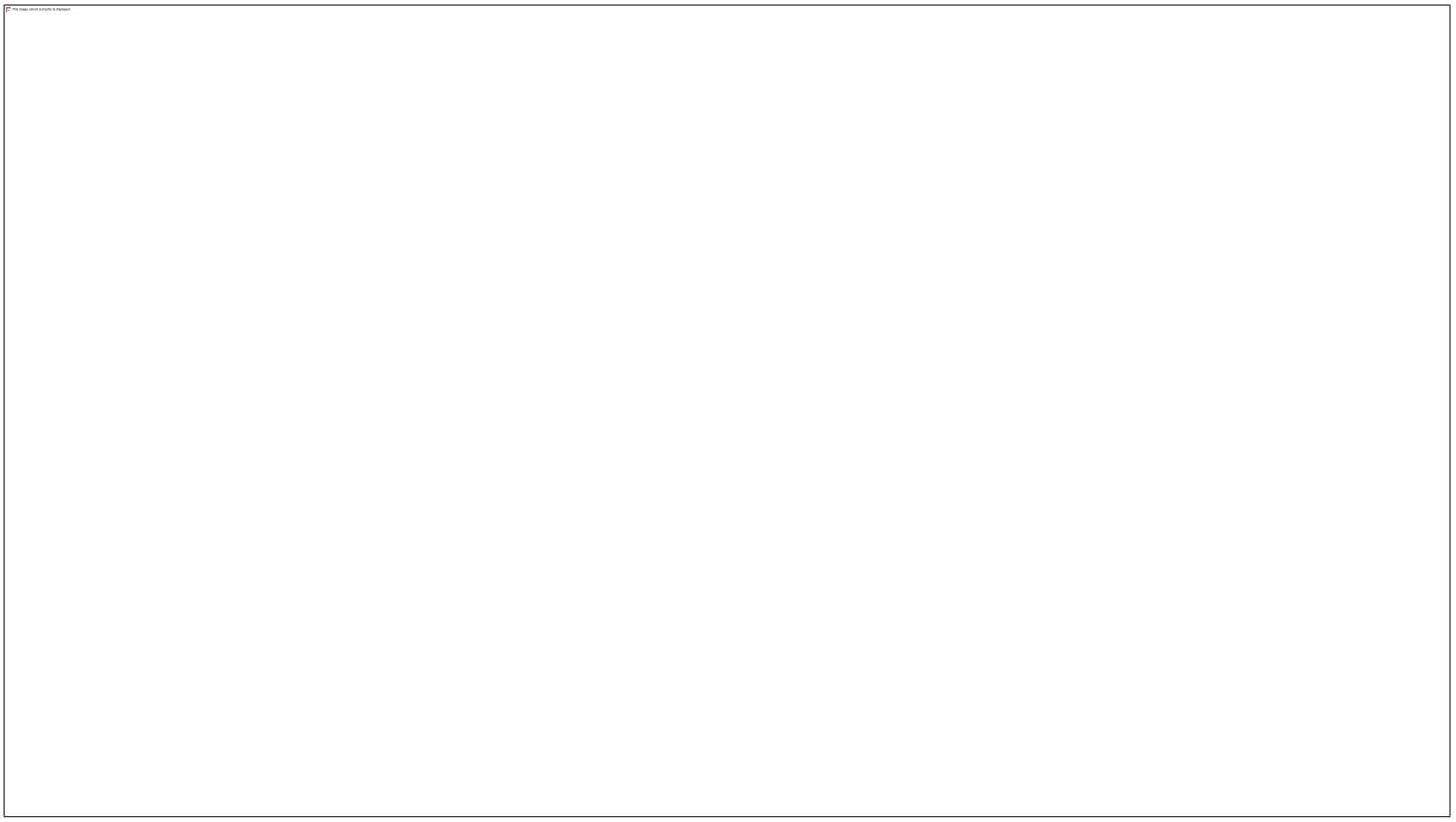
Importance of marine mammals in fisheries ecosystems

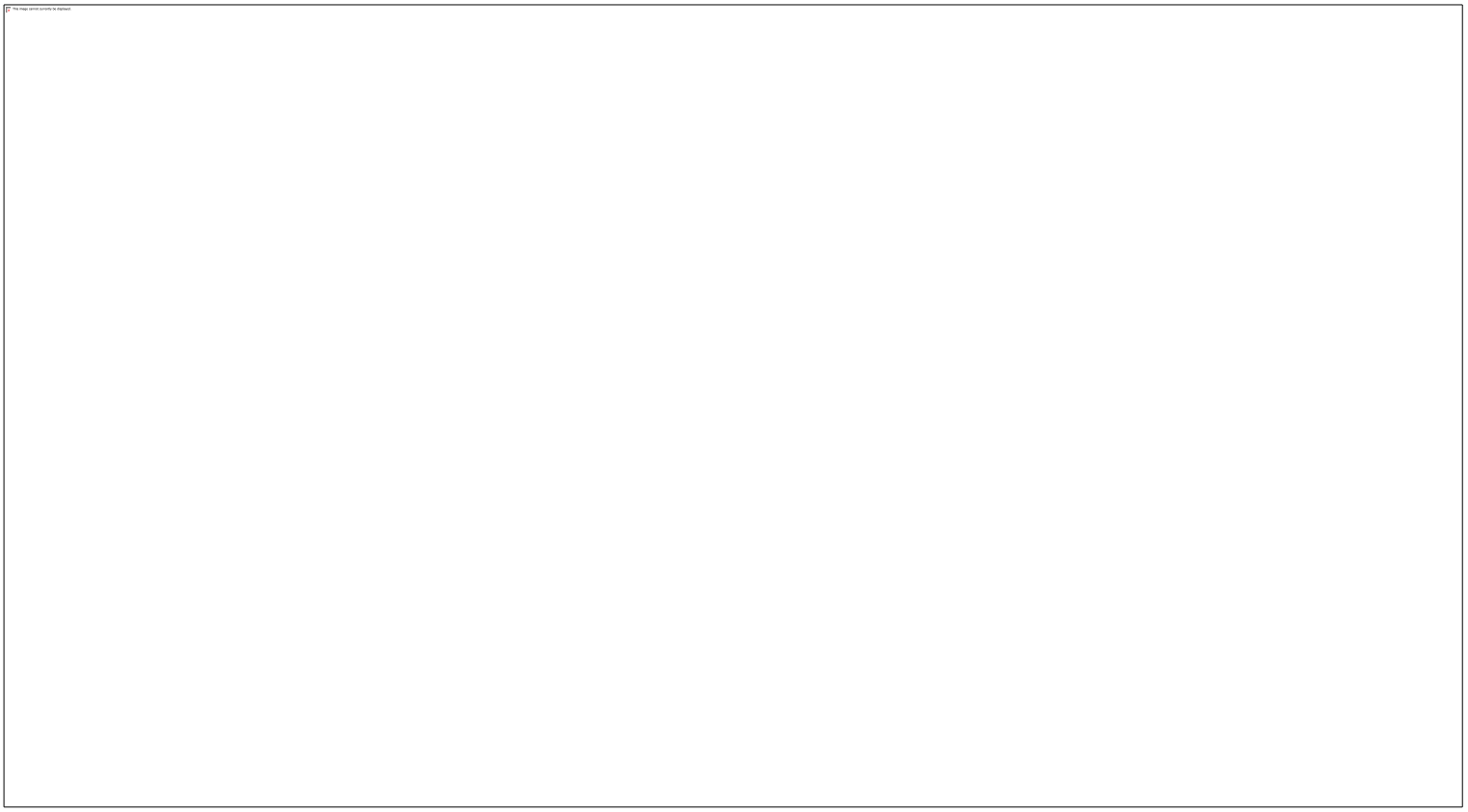
- They help maintain marine food-chain relationships.
- They contribute to ecological balance.
- They attract tourists and support marine tourism.
- They indicate the health of marine habitats.
- They contribute to scientific research and environmental education.

Conservation note: Marine mammals such as dolphins and dugongs should be protected. They should not be treated as ordinary fishery commodities. Accidental capture should be minimised and reported to the relevant authorities.

2.5 Aquatic Plants







Meaning of aquatic plants

Aquatic plants are plants that grow in water or in waterlogged environments. They may be completely submerged, partially submerged or floating on the water surface.

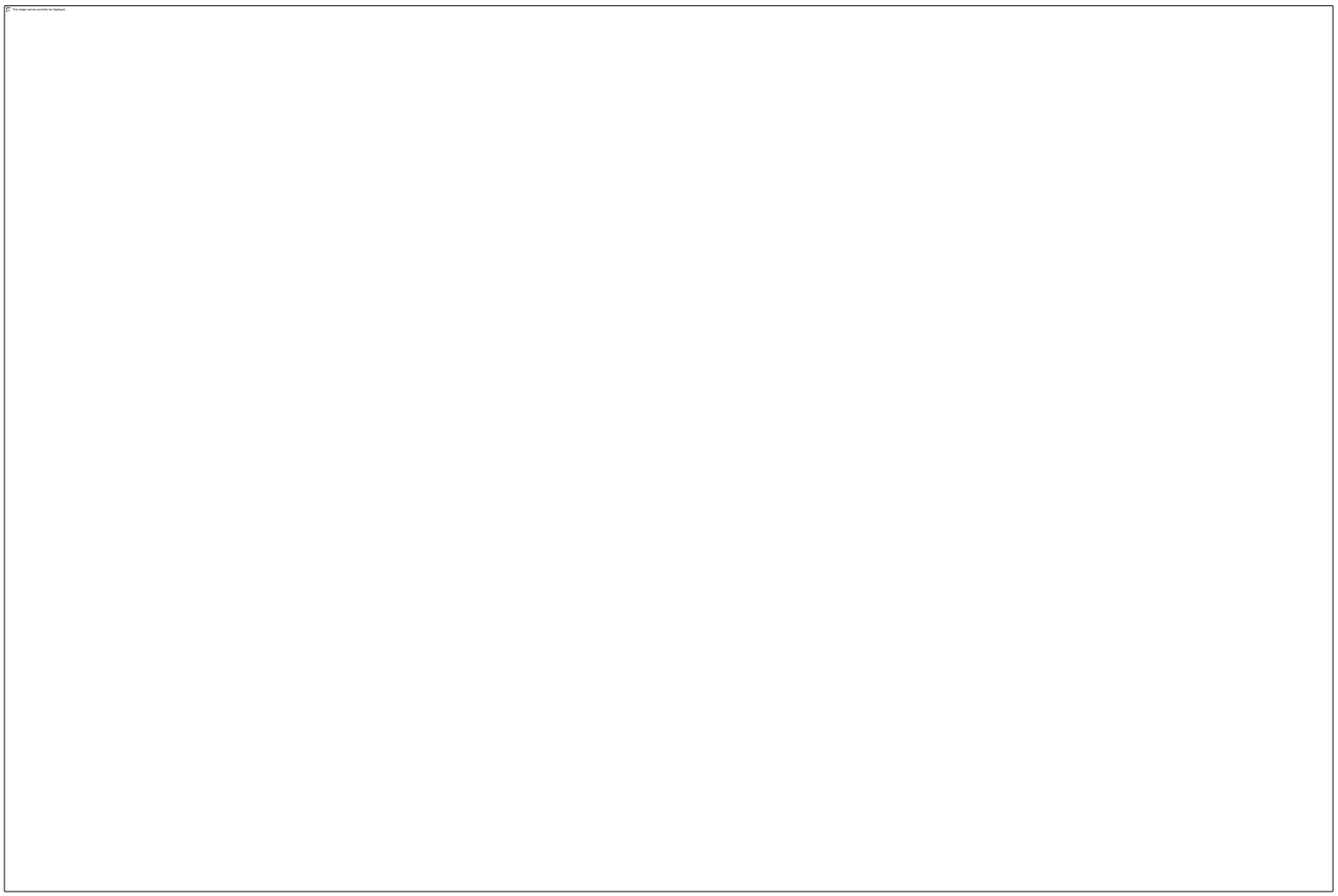
They are important fisheries resources because they provide food, habitats, breeding grounds and raw materials for various industries.

Characteristics of aquatic plants

- They grow in freshwater, brackish water or marine environments.
- Many possess specialised structures for surviving in water.
- Some are completely submerged.
- Others float on the water surface.
- Some grow along shorelines and in tidal environments.
- Most contain chlorophyll and manufacture food through photosynthesis.
- They provide shelter and breeding habitats for aquatic organisms.

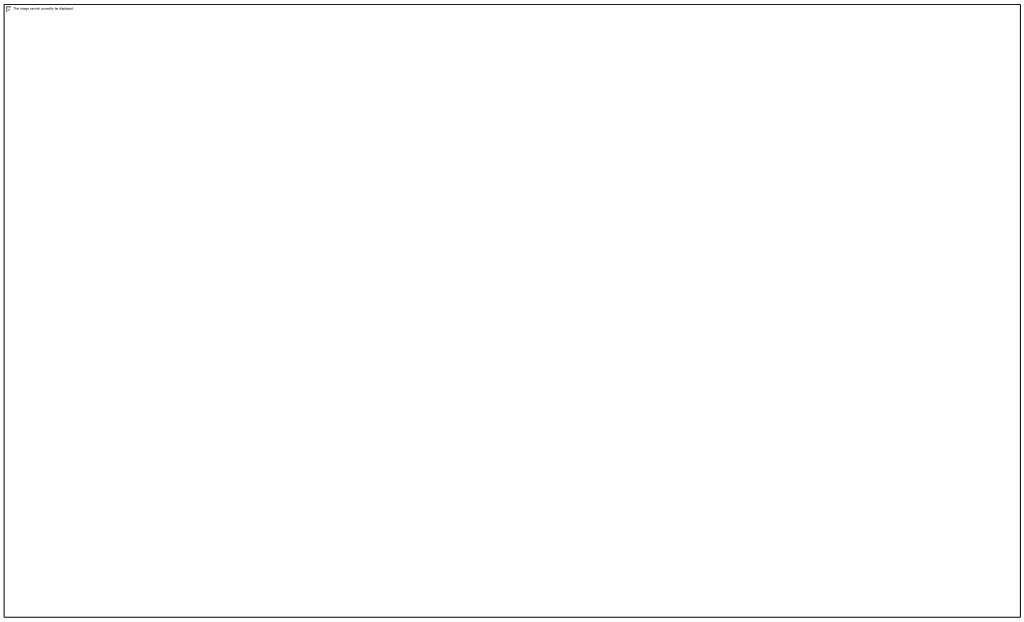
Types and examples of aquatic plants

1. Seagrasses



- Seagrasses are flowering plants that grow completely submerged in shallow marine waters.
- They possess roots, stems and leaves.
- They form underwater meadows.
- They provide feeding grounds for dugongs and green sea turtles.
- They provide nursery habitats for young fish, prawns and other organisms.
- They help stabilise sediments and reduce coastal erosion.

2. Mangroves



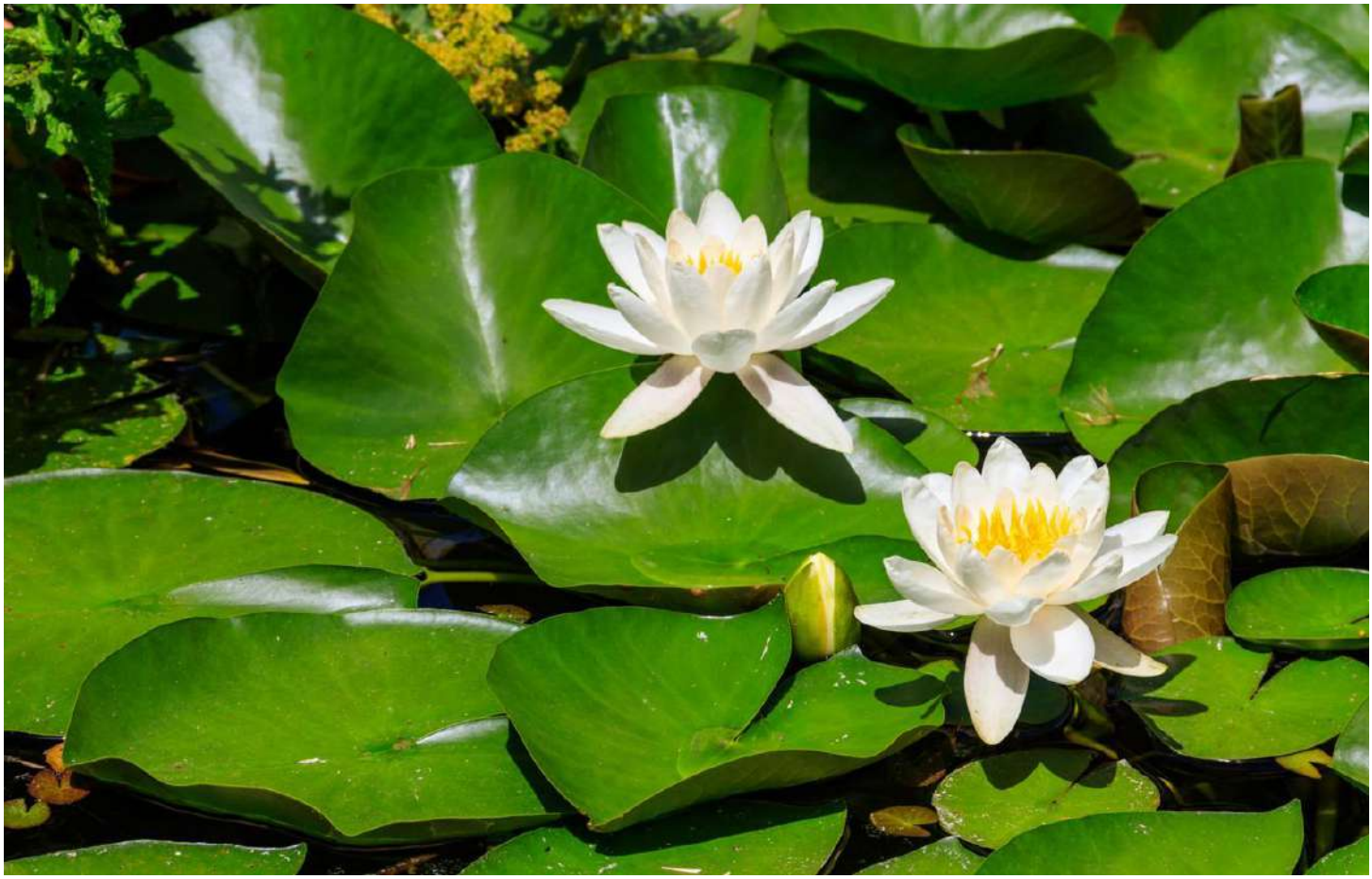
- Mangroves are salt-tolerant trees and shrubs found along tropical and subtropical coastlines.
- They grow in intertidal areas where seawater and freshwater may mix.
- They possess specialised roots adapted to waterlogged soils.
- They provide breeding and nursery habitats for fish, crabs and prawns.
- They trap sediments and help protect coastlines from erosion.
- They support coastal livelihoods through sustainable use.

3. Seaweeds



- Seaweeds are large marine algae.
- They do not possess true roots, stems or leaves like flowering plants.
- They absorb nutrients directly from surrounding water.
- They manufacture food through photosynthesis.
- They are used in food production, cosmetics, pharmaceuticals and industrial processing.
- Some species are cultivated commercially along the Kenyan coast.

4. Freshwater aquatic plants



Examples include:

- Water lilies.
- Water hyacinth.
- Duckweed.
- Papyrus.
- Reeds.

Some provide habitats and food for aquatic organisms, while invasive species such as water hyacinth may interfere with fishing, navigation and oxygen availability when they spread excessively.

Importance of aquatic plants in fisheries

- They provide food for herbivorous fish and other aquatic organisms.
- They provide shelter for juvenile fish.
- They serve as breeding and nursery grounds.
- They absorb carbon dioxide during photosynthesis.
- They release oxygen into the environment.
- They help stabilise aquatic sediments.
- They provide raw materials for food and industrial products.
- They support biodiversity and ecological balance.

2.6 Freshwater Invertebrates



Meaning of freshwater invertebrates

Freshwater invertebrates are animals without backbones that live in freshwater environments such as rivers, lakes, ponds, dams, streams and wetlands.

They form an important part of aquatic food chains and may be harvested for food, research and other uses.

Characteristics of freshwater invertebrates

- They lack a backbone.
- They inhabit freshwater environments.
- They may possess hard external coverings or soft bodies.
- Some breathe using gills, while others use different respiratory structures.
- They occupy different habitats, including sediments, aquatic vegetation and open water.
- Some feed on algae, organic matter and smaller organisms.
- They form food sources for fish, birds and other aquatic animals.

Examples of freshwater invertebrates

1. Freshwater prawns



- They are crustaceans that live in freshwater.
- They possess segmented bodies and jointed legs.

- They have a hard external skeleton.
- Some species are harvested for food and commercial purposes.
- They are also cultured in suitable aquaculture systems.

2. Freshwater snails



- Freshwater snails are molluscs.
- Many have coiled shells.
- They live in ponds, lakes and rivers.
- They feed on algae and decaying organic matter.
- They form part of the diet of some fish and aquatic birds.

3. Freshwater mussels

- They are bivalve molluscs.
- They possess two shells joined by a hinge.
- They live mainly on or within freshwater sediments.
- They filter suspended particles from water.
- They contribute to water filtration and aquatic ecosystem functioning.

4. Freshwater crayfish

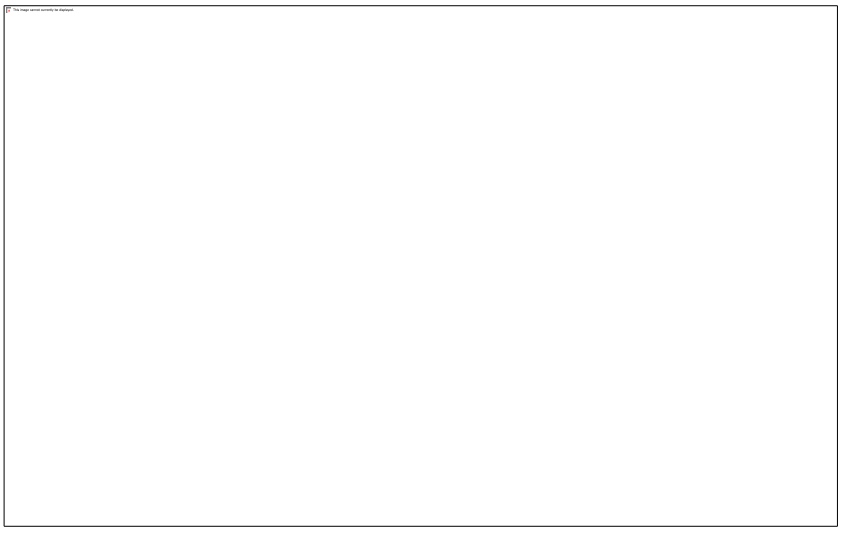


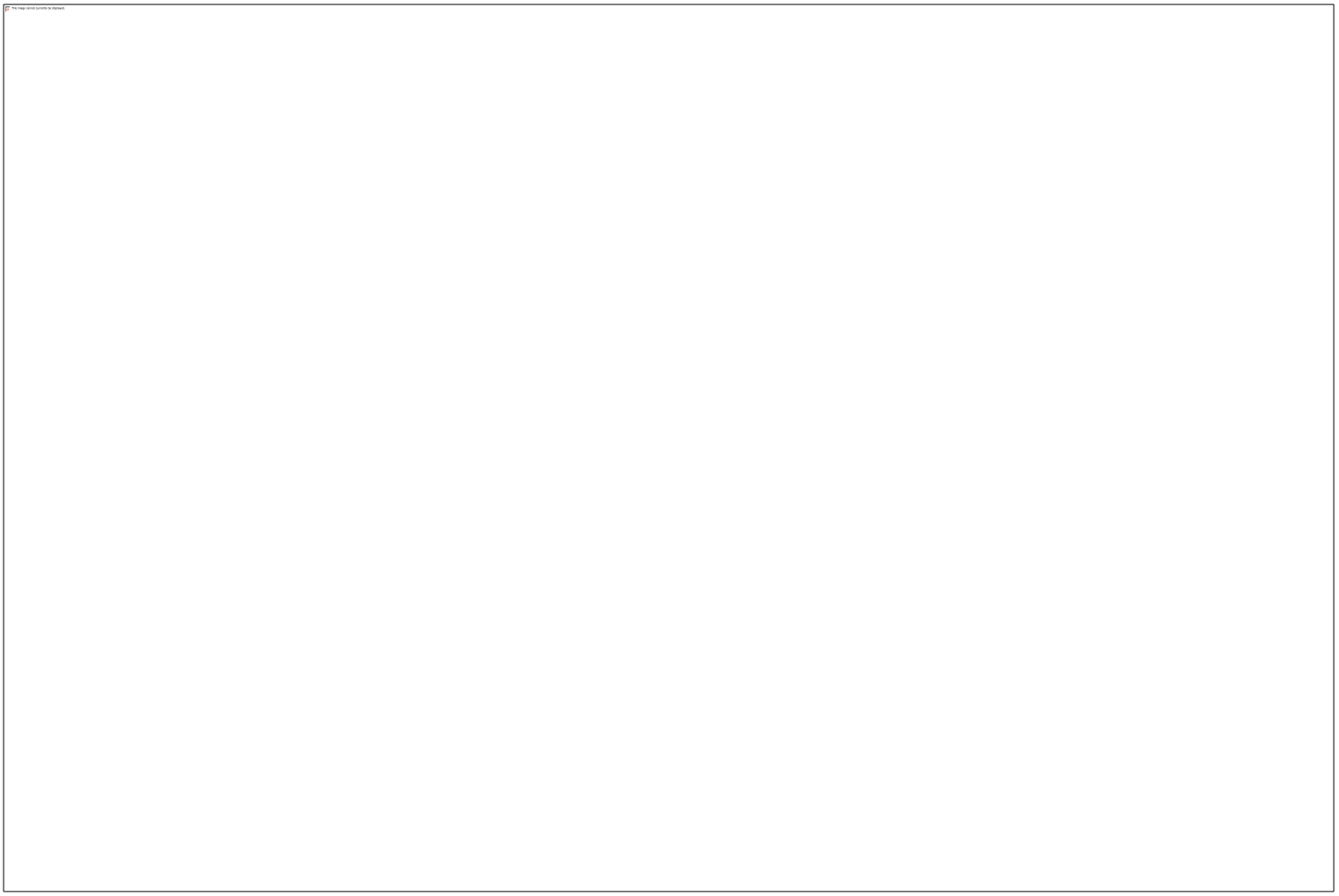
- Crayfish are freshwater crustaceans.
- They have hard exoskeletons.
- They possess claws used for feeding and defence.
- They feed on plants, small animals and decaying organic matter.
- Some species are harvested or cultured for food.

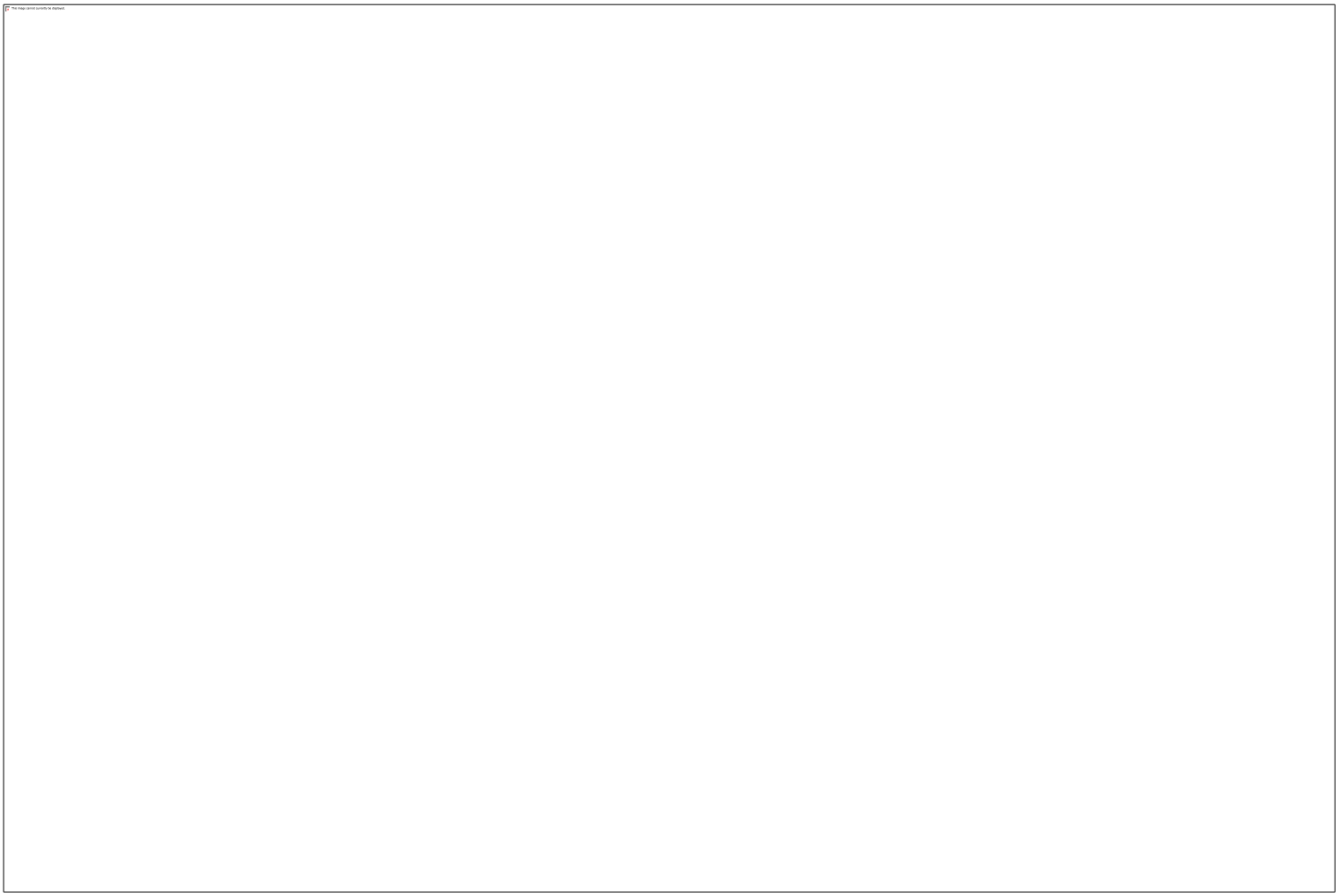
Importance of freshwater invertebrates

- They provide food for fish and other aquatic organisms.
- Some species are harvested for human consumption.
- They contribute to the decomposition of organic matter.
- They help recycle nutrients in aquatic environments.
- They can be used as indicators of water quality.
- Some species support commercial aquaculture.

2.7 Echinoderms







Meaning of echinoderms

Echinoderms are marine invertebrates belonging to the phylum Echinodermata. They usually possess spiny skin, a water vascular system and a body plan arranged around a central axis in adults.

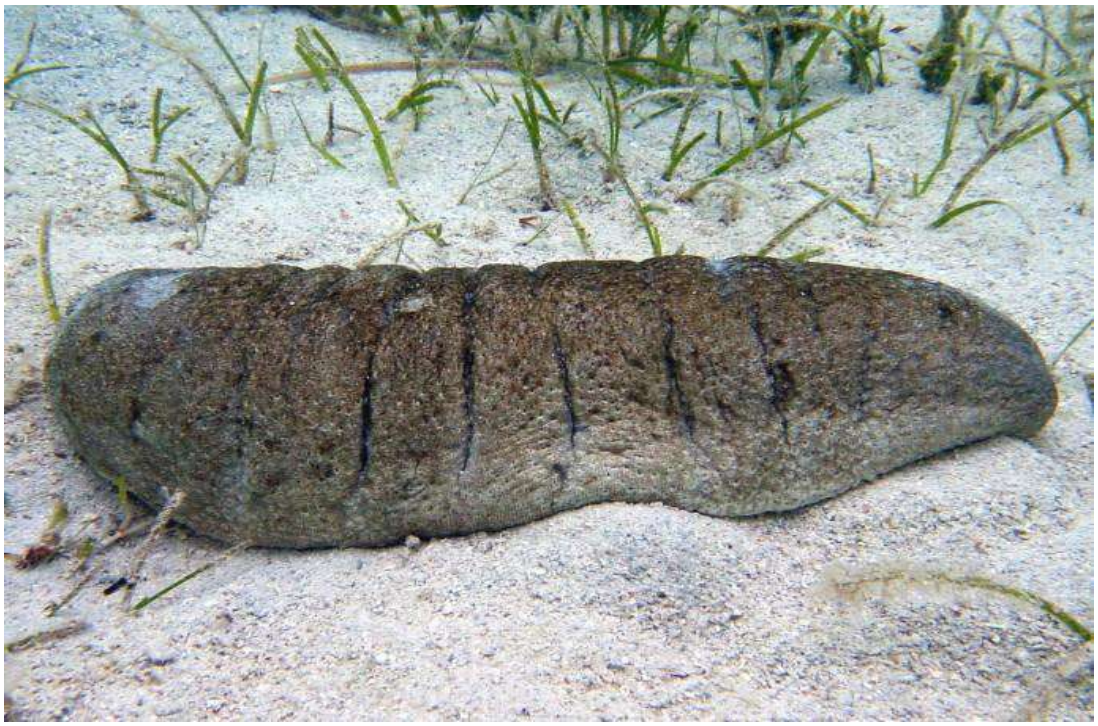
They are exclusively marine animals and are found in habitats such as coral reefs, rocky shores and sandy seabeds.

Characteristics of echinoderms

- They are exclusively marine organisms.
- They lack a backbone.
- Their bodies are generally arranged in five-part radial symmetry as adults.
- They possess a water vascular system used for movement, feeding and gas exchange.
- Many have tube feet for movement and attachment.
- Some possess spines for protection.
- Many feed on organic matter, algae or other marine organisms.
- Some species can regenerate lost body parts.

Examples of echinoderms

1. Sea cucumbers



- Sea cucumbers have elongated, soft bodies.
- They live mainly on the seabed.
- They feed on organic particles in marine sediments.
- They help recycle nutrients in marine ecosystems.
- Some species are commercially harvested in international seafood markets.
- They require careful management because excessive harvesting can reduce their populations.

2. Starfish (sea stars)



- Starfish usually possess five or more arms.
- They move using tube feet.
- They live on rocky shores, coral reefs and seabeds.
- Many feed on molluscs and other small marine organisms.
- They play important roles in marine food webs.

3. Sea urchins



- Sea urchins have rounded bodies covered with spines.
- They use tube feet for movement.
- Many feed on algae and seagrasses.
- They form part of marine food chains.
- Some species are harvested for their edible reproductive organs.

4. Brittle stars

- They possess a central disc and long, slender arms.
- They use their arms for movement and feeding.
- They live under rocks, among coral reefs and on the seabed.
- They feed on small organisms and organic particles.

3.0 DIVERSITY AND DISTRIBUTION OF FISHERIES RESOURCES

3.1 Meaning of Diversity of Fisheries Resources

Diversity of fisheries resources refers to the variety of aquatic organisms found in different water bodies and aquatic habitats.

Kenya has diverse fisheries resources because it has freshwater lakes, rivers, dams, wetlands, coastal waters, coral reefs, mangrove forests and the Indian Ocean.

3.2 Major Fisheries Environments in Kenya





A. Freshwater fisheries

Freshwater fisheries involve the harvesting of aquatic organisms from water bodies with low salt concentrations.

Examples of freshwater environments in Kenya include:

- Lake Victoria.
- Lake Turkana.
- Lake Naivasha.
- Lake Baringo.
- Lake Jipe.
- Tana River.
- Athi River.
- Various dams and reservoirs.

Common freshwater fisheries resources include:

- Nile perch.
- Nile tilapia.
- Dagaa (omena).
- Catfish.
- Mudfish.
- Freshwater prawns.
- Freshwater snails.

B. Marine fisheries

Marine fisheries involve the harvesting of aquatic organisms from salty seawater.

In Kenya, marine fisheries are found along the Indian Ocean coastline.

Important marine fishing areas include:

- Lamu.
- Kiunga.
- Malindi.
- Watamu.
- Kilifi.
- Mombasa.
- Diani.
- Shimoni.
- Vanga.

Common marine fisheries resources include:

- Tuna.
- Kingfish.
- Marlin.
- Lobsters.

- Prawns.
- Crabs.
- Octopus.
- Squid.
- Oysters.
- Sea cucumbers.

C. Estuarine fisheries

An estuary is a coastal water body where freshwater from rivers mixes with seawater.

Examples of estuarine environments in Kenya include river mouths and coastal creeks.

Common fisheries resources include:

- Mud crabs.
- Prawns.
- Juvenile fish.
- Molluscs.
- Various small marine and freshwater fish.

D. Wetland fisheries

Wetlands are areas where land is permanently or seasonally covered with water or saturated with water.

Examples include:

- Yala Swamp.
- Tana River Delta.
- Sio-Siteko wetlands.
- Other riverine and lake-associated wetlands.

Wetlands provide breeding, feeding and nursery habitats for many aquatic organisms.

3.3 Factors Affecting the Distribution of Fisheries Resources

Fisheries resources are not evenly distributed in all aquatic environments. Their distribution depends on several environmental and biological factors.

1. Water temperature

- Different aquatic organisms survive within different temperature ranges.
- Temperature influences growth, reproduction, metabolism and feeding.
- Some fish prefer warm tropical waters, while others survive better in cooler waters.

2. Availability of dissolved oxygen

- Fish and many other aquatic organisms require dissolved oxygen for respiration.
- Areas with sufficient oxygen generally support more aquatic life.
- Low oxygen levels may cause stress, migration or death of aquatic organisms.

3. Availability of food

- Aquatic organisms require food for growth and reproduction.
- Areas with abundant plankton, algae and smaller organisms may support large fish populations.
- Food availability influences the distribution of fish species.

4. Water salinity

- Salinity refers to the concentration of dissolved salts in water.
- Marine organisms are adapted to seawater, while freshwater organisms are adapted to low-salinity conditions.
- Some organisms tolerate a wide range of salinities.

5. Water depth

- Different species occupy different water depths.
- Some fish live near the surface, others occupy middle waters, while others live close to the bottom.
- Water depth also influences light penetration, pressure and temperature.

6. Nature of the aquatic substrate

- Substrate refers to the material covering the bottom of a water body.
- It may consist of sand, mud, gravel, rocks or coral.
- Different organisms prefer different substrates for feeding, shelter and reproduction.

7. Water currents

- Currents influence the movement and distribution of aquatic organisms.
- They transport nutrients, plankton and fish eggs.
- Strong currents may favour some species while discouraging others.

8. Availability of breeding habitats

- Aquatic organisms require suitable areas for reproduction.
- Mangroves, seagrass beds, wetlands and submerged vegetation provide important breeding and nursery habitats.
- Destruction of these habitats reduces the survival of young organisms.

9. Pollution

- Pollution changes the physical and chemical conditions of water.
- Toxic substances may kill aquatic organisms.
- Excess nutrients may cause algal blooms and oxygen depletion.

10. Human activities

- Fishing pressure, habitat destruction, coastal development and pollution affect the distribution of fisheries resources.
- Conservation measures help maintain suitable habitats.

4.0 FISHERIES MANAGEMENT MEASURES

4.1 Meaning of Fisheries Management Measures

Fisheries management measures are specific rules, regulations, restrictions and practices established to control fishing activities and conserve aquatic resources.

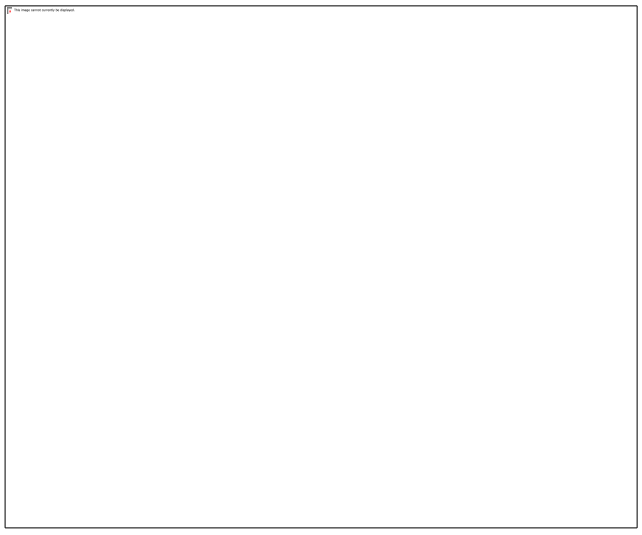
They help determine:

- Who is allowed to fish.
- Where fishing is permitted.
- When fishing is allowed.
- Which fishing methods can be used.
- What sizes of fish can be harvested.
- How much fish can be caught.

The main fisheries management measures include:

1. Closed seasons.
2. Closed areas.
3. Licensing and registration.
4. Fishing gear restrictions.
5. Catch limits and quotas.
6. Minimum fish size limits.
7. Protection of breeding grounds.
8. Monitoring, control and surveillance.
9. Habitat conservation.
10. Bycatch reduction.

4.2 Closed Seasons



Meaning of closed seasons

A closed season is a specified period during which fishing activities are temporarily prohibited or restricted in a particular fishery or area.

It is introduced to allow fish and other aquatic organisms to reproduce, spawn and replenish their populations.

Reasons for establishing closed seasons

- To protect fish during breeding periods.
- To allow young fish to grow and mature.
- To increase the number of fish available for future harvesting.
- To reduce fishing pressure during sensitive biological periods.
- To support recovery of declining fish populations.
- To maintain the long-term productivity of fisheries.

Examples of closed seasons

- Temporary restrictions on harvesting certain species during their breeding periods.
- Seasonal restrictions on harvesting particular shellfish species.
- Temporary fishing closures in selected marine or freshwater fishing grounds.

Advantages of closed seasons

- Allow fish populations to recover.
- Increase successful reproduction.
- Protect juvenile fish.
- Promote sustainable harvesting.
- Improve future fish catches.
- Protect vulnerable aquatic species.

Challenges associated with closed seasons

- Fishermen may lose income during the closure.
- Some fishing communities may lack alternative sources of livelihood.
- Enforcement may be difficult in remote fishing areas.
- Fish may migrate across different fishing zones.
- Non-compliance may occur when regulations are poorly communicated.

4.3 Closed Areas







Meaning of closed areas

Closed areas are specific aquatic locations where fishing is completely prohibited or restricted to certain fishing activities.

They are established to protect important habitats and allow aquatic populations to reproduce and grow without excessive disturbance.

Closed areas may be permanent or temporary.

Types of closed areas

1. Permanent closed areas

- These are locations where fishing is prohibited throughout the year.
- They protect sensitive habitats and vulnerable species.
- They may include designated marine protected areas and fish breeding sanctuaries.

2. Temporary closed areas

- These are locations where fishing is prohibited for a specified period.
- They allow fish stocks and habitats to recover.
- They may be established during breeding seasons or after serious environmental disturbances.

Reasons for establishing closed areas

- To protect breeding grounds.
- To conserve nursery habitats.
- To protect endangered species.
- To allow fish populations to increase.
- To protect coral reefs and seagrass beds.
- To reduce damage caused by fishing activities.
- To support scientific research and conservation.

Examples in Kenya

- Kisite-Mpunguti Marine National Park and Reserve.
- Malindi Marine National Park.
- Watamu Marine National Park.

These protected areas contribute to marine biodiversity conservation. The precise fishing restrictions differ between protected zones and permitted-use areas.

Advantages of closed areas

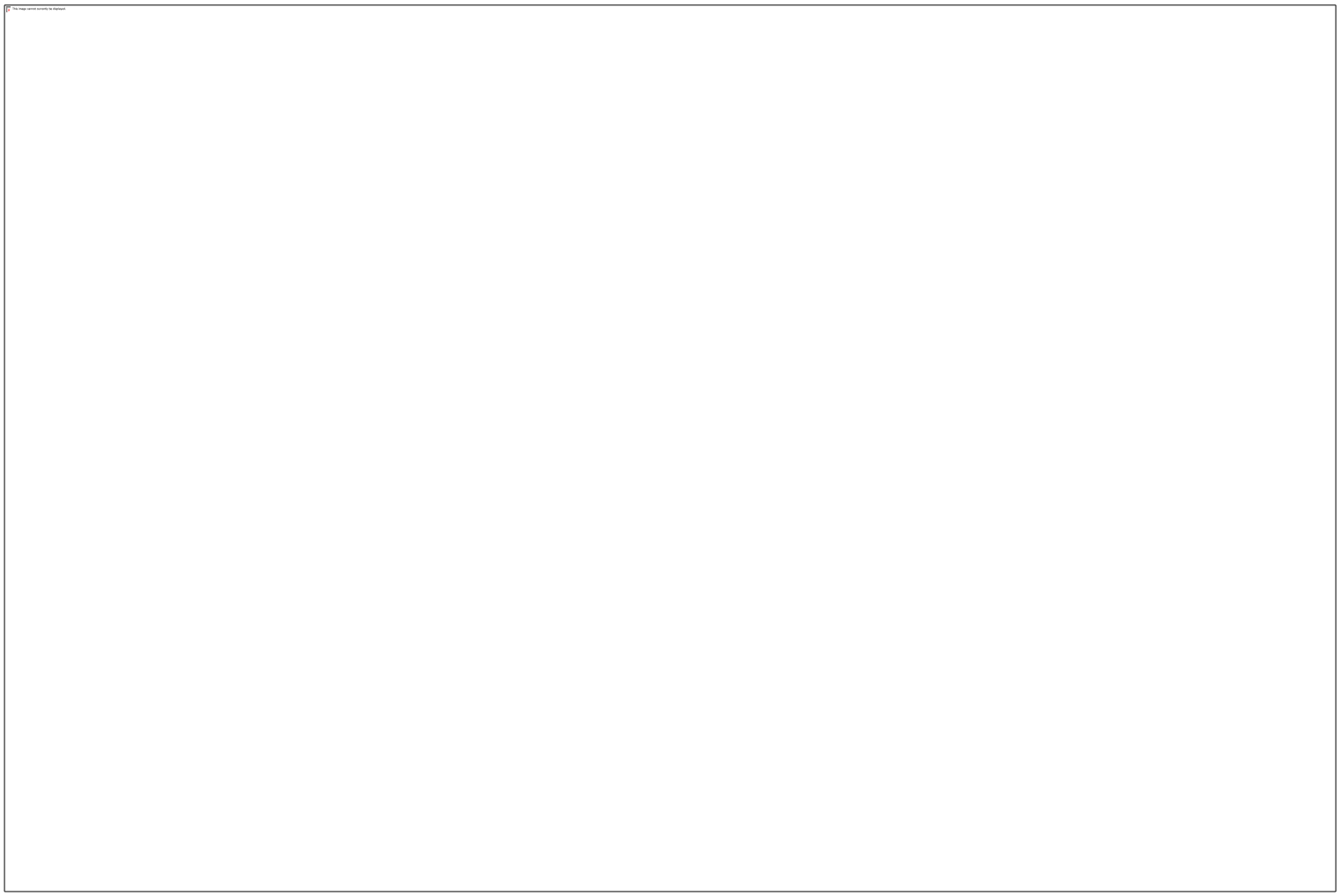
- Protect fish breeding and nursery grounds.
- Allow fish populations to recover.
- Conserve marine biodiversity.
- Protect coral reefs and other sensitive habitats.
- Support marine tourism.
- Provide areas for scientific research.

Challenges of closed areas

- They may reduce access to traditional fishing grounds.

- They may cause conflicts between fishermen and conservation authorities.
- Establishing and maintaining protected areas requires resources.
- Illegal fishing may continue where enforcement is weak.
- Benefits may take time to reach surrounding communities.

4.4 Licensing of Fishing Activities



Meaning of fishing licence

A fishing licence is an official authorisation issued by the relevant fisheries authority allowing an individual, group or fishing enterprise to undertake specified fishing activities under stated conditions.

Licensing is used to regulate fishing effort and ensure that fishing activities comply with established laws and regulations.

Information considered during licensing

- Identity of the fisher or fishing enterprise.
- Type of fishing activity.
- Fishing vessel identification.
- Fishing location or authorised fishing zone.
- Type of fishing gear.
- Species targeted.
- Validity period of the licence.

- Compliance with fisheries regulations.

Reasons for licensing fishing activities

- To control the number of fishermen and fishing vessels.
- To monitor fishing activities.
- To prevent illegal fishing.
- To collect information on fish harvesting.
- To promote responsible fishing.
- To facilitate enforcement of fisheries laws.
- To improve planning and management of fisheries resources.

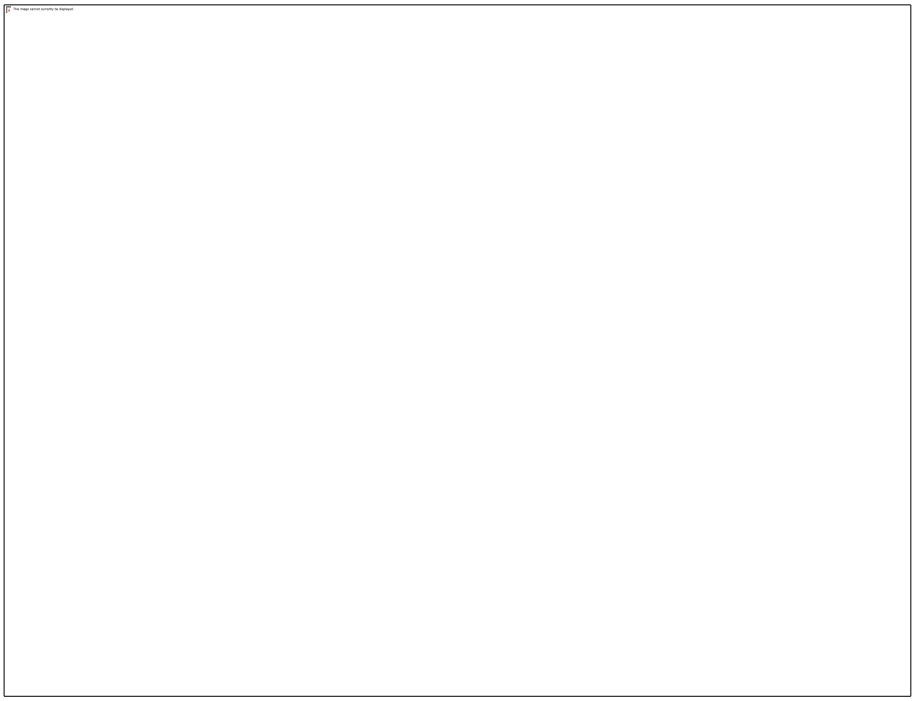
Advantages of fishing licences

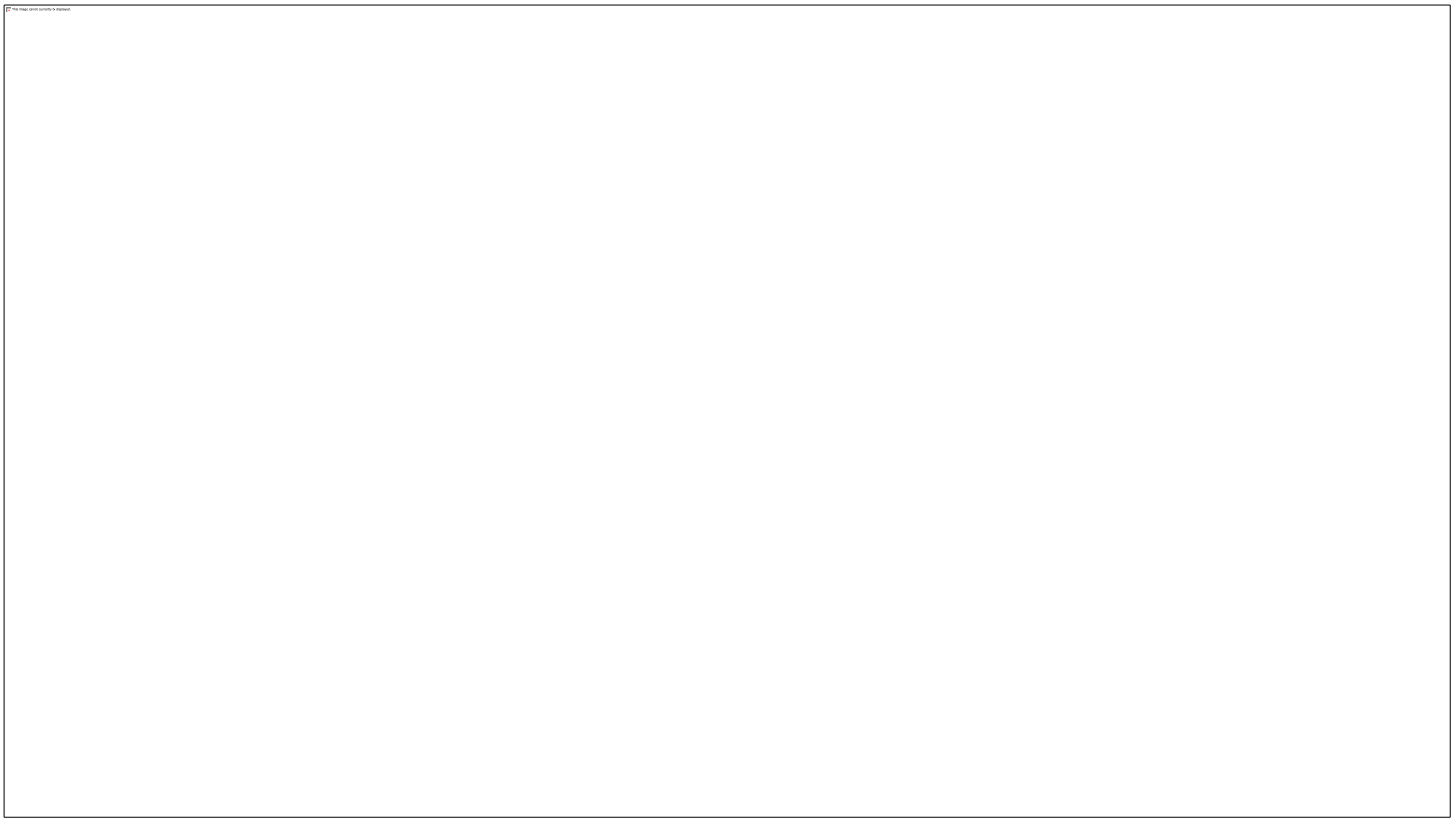
- They help authorities monitor fishing activities.
- They make it easier to identify authorised fishers.
- They help control excessive fishing pressure.
- They support collection of fisheries statistics.
- They encourage compliance with regulations.
- They promote accountability in the fishing industry.

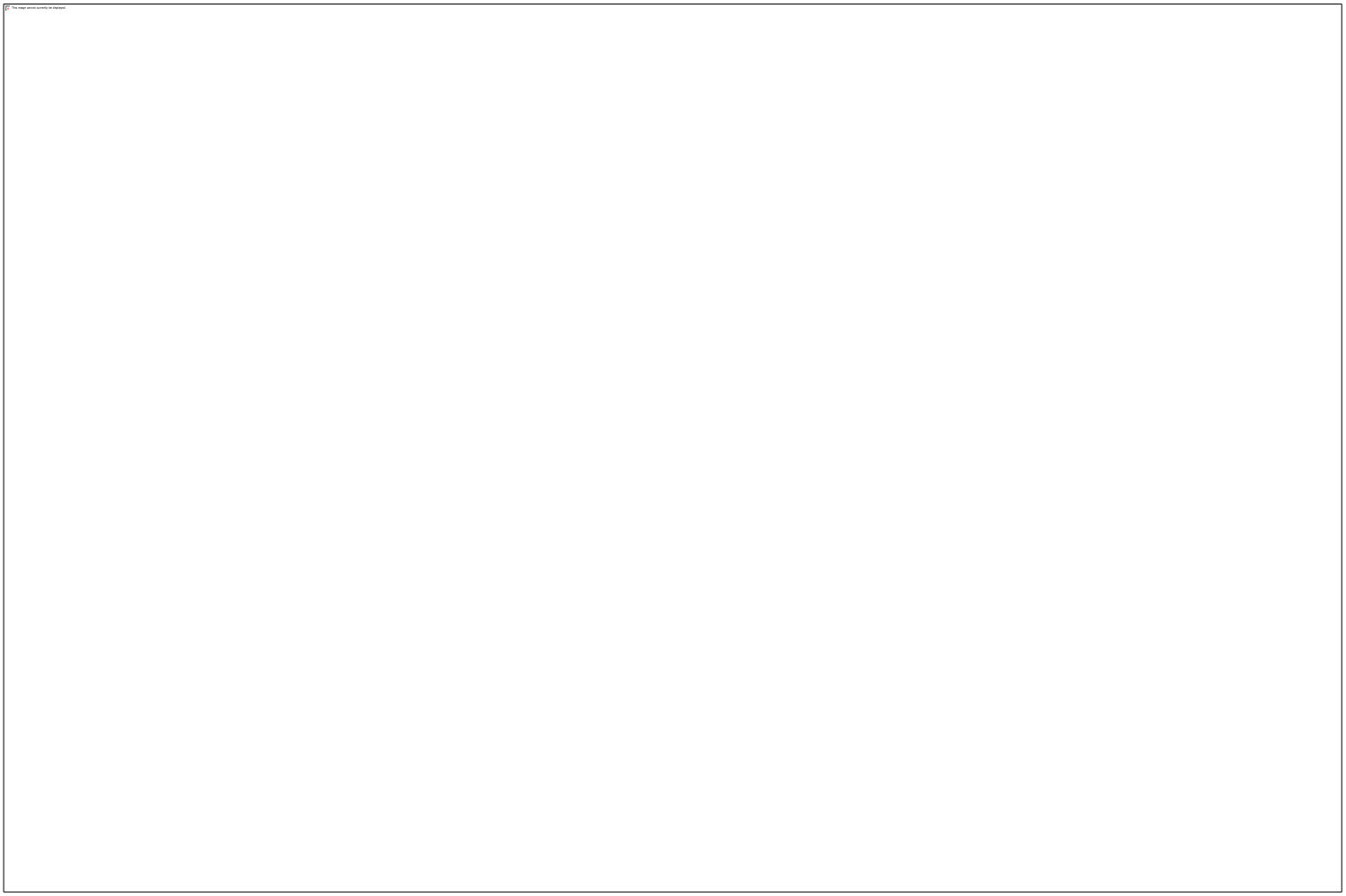
Challenges of licensing

- Some fishermen may lack awareness of licensing requirements.
- The cost of licensing may affect small-scale fishers.
- Illegal operators may avoid registration.
- Monitoring a large number of fishing activities may be difficult.

4.5 Fishing Gear Restrictions







Meaning of fishing gear restrictions

Fishing gear restrictions are regulations that control the types, sizes, designs and methods of fishing equipment that may legally be used.

They aim to prevent destructive fishing practices and reduce the capture of undersized fish and non-target species.

Common types of fishing gear

1. Gill nets

- Gill nets are vertical nets suspended in water.
- Fish become entangled when they attempt to swim through the mesh.
- Mesh size determines the size of fish that can be captured.
- Regulations control the mesh size and where the nets can be used.

2. Hook and line

- This method involves using hooks attached to lines to capture fish.
- It may be used by individual fishermen or commercial fishing vessels.
- It can target particular species depending on the bait and hook size.
- Properly designed hook-and-line fishing may reduce the capture of non-target organisms.

3. Longlines

- Longlines consist of a main fishing line carrying many baited hooks.
- They are used to capture tuna and other large marine fish.
- They may be operated near the surface or deeper in the water.
- Regulations may control the number of hooks, their design and their deployment.

4. Purse seines

- Purse seines are large nets used to surround schools of fish.
- The bottom of the net is drawn together to prevent fish from escaping.
- They are commonly used to capture schooling fish.
- Their use requires appropriate regulation to prevent excessive harvesting.

5. Fish traps

- Fish traps are devices designed to attract and capture fish or crustaceans.
- They may be made from wire, wood or other suitable materials.
- They are used in freshwater and marine fisheries.
- Trap design and entrance sizes can be regulated.

6. Trawl nets

- Trawl nets are dragged through water or along the seabed to capture aquatic organisms.
- They are used in some commercial fisheries.
- Bottom trawling can damage sensitive seabed habitats if poorly managed.
- Their use requires strict controls on location, design and operation.

Fishing gear that may be prohibited or restricted

- Very small-mesh nets that capture juvenile fish.
- Explosives used to stun or kill fish.
- Poisonous substances used to kill aquatic organisms.
- Destructive methods that damage coral reefs.
- Illegal electrical fishing equipment.
- Gear that causes excessive capture of protected species.

Importance of fishing gear restrictions

- They prevent the capture of immature fish.
- They reduce the destruction of aquatic habitats.
- They minimise bycatch.
- They improve the sustainability of fish harvesting.
- They protect endangered species.
- They promote responsible fishing practices.

4.6 Catch Limits and Quotas



Meaning of catch limits

Catch limits are restrictions placed on the quantity of fish or other aquatic organisms that may be harvested within a specified period, area or fishery.

Meaning of fishing quota

A fishing quota is a specified share or quantity of the total allowable catch allocated to an individual, group, vessel or fishing enterprise.

Types of catch limits

1. Individual catch limits

- These specify the maximum quantity that an individual fisher may harvest.
- They help control the amount of fish taken by each fisher.

2. Vessel catch limits

- These specify the maximum catch permitted for a particular fishing vessel.
- They are commonly applied in regulated commercial fisheries.

3. Total allowable catch

- This is the maximum quantity of a particular species that may be harvested from a fishery during a specified period.
- It is usually determined using scientific information on fish populations and stock conditions.

4. Daily or seasonal catch limits

- These restrict the amount of fish harvested within a day or a particular season.
- They help control fishing pressure over time.

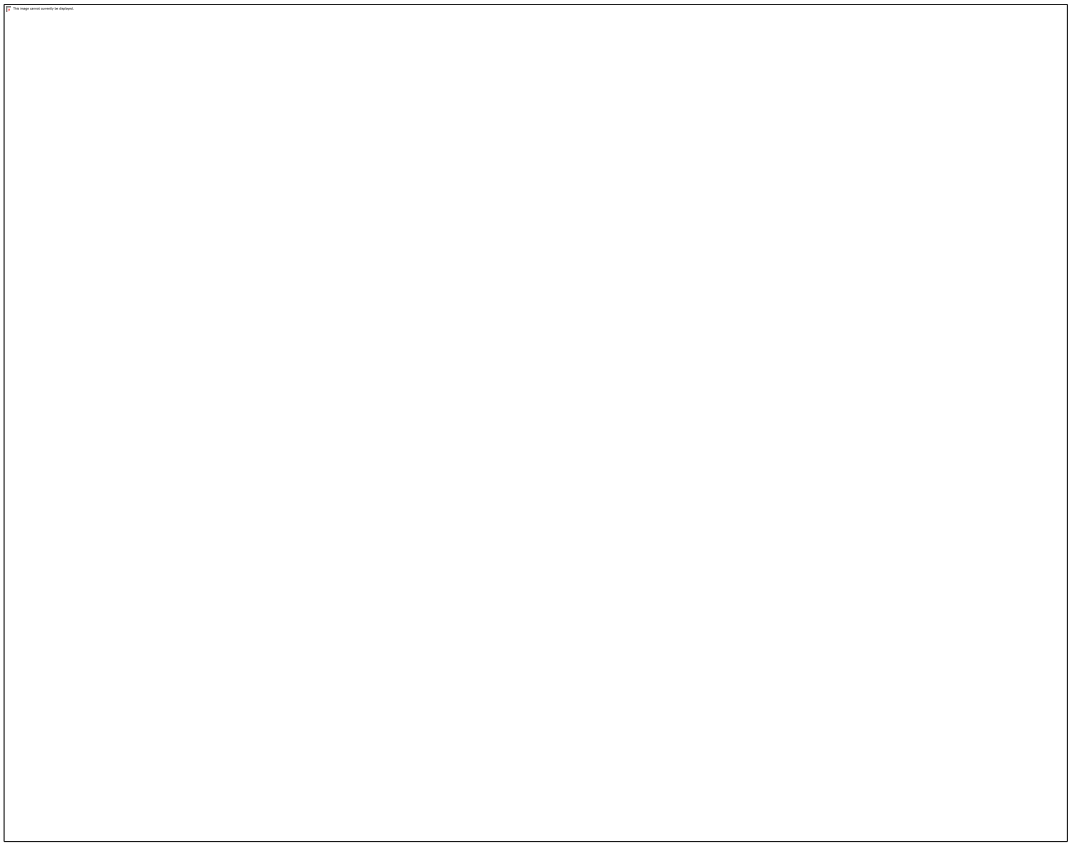
Importance of catch limits

- Prevent excessive harvesting.
- Maintain fish populations.
- Reduce pressure on vulnerable species.
- Support long-term fisheries planning.
- Promote fair allocation of fishery resources.
- Improve the collection of fishery data.

Challenges of catch limits

- Accurate fish population estimates may be difficult to obtain.
- Illegal catches may not be reported.
- Monitoring commercial and small-scale catches requires resources.
- Changes in weather and fish migration may affect catches.

4.7 Minimum Fish Size Limits



Meaning of minimum fish size limit

A minimum fish size limit is the smallest permitted length or size of a fish that may legally be harvested and retained.

Fish below the specified minimum size should be returned to the water where survival is reasonably possible and where regulations permit.

Reasons for establishing minimum size limits

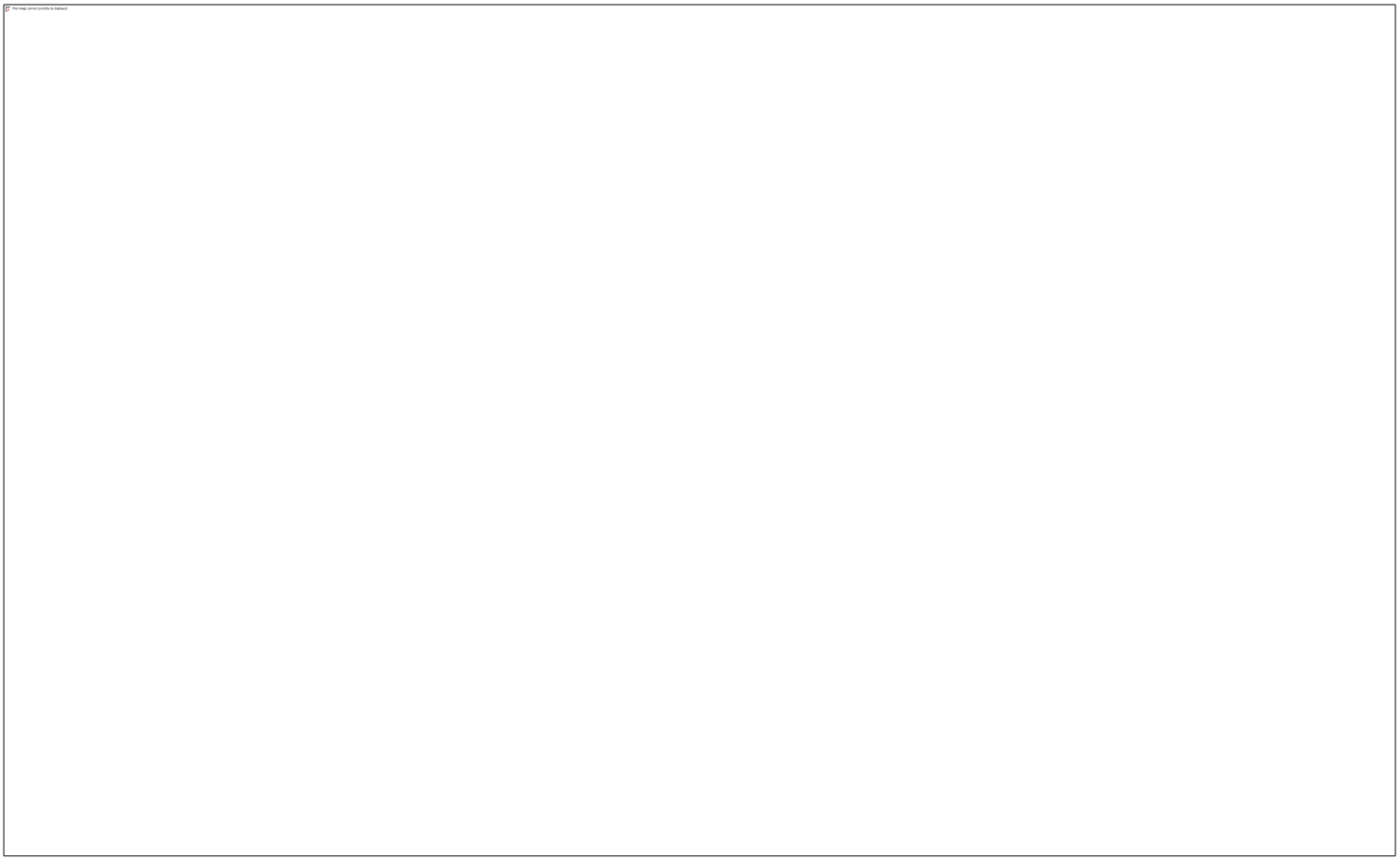
- To allow fish to reach sexual maturity before harvesting.
- To increase the chances of successful reproduction.
- To protect juvenile fish.
- To maintain healthy breeding populations.
- To ensure future fish production.
- To reduce recruitment overfishing.

Measuring fish size

Fish length may be measured using a fish measuring board or measuring tape.

Common measurements include:

- Total length: measured from the tip of the snout to the end of the tail fin.
- Fork length: measured from the tip of the snout to the fork of the tail.
- Standard length: measured from the tip of the snout to the base of the tail fin.



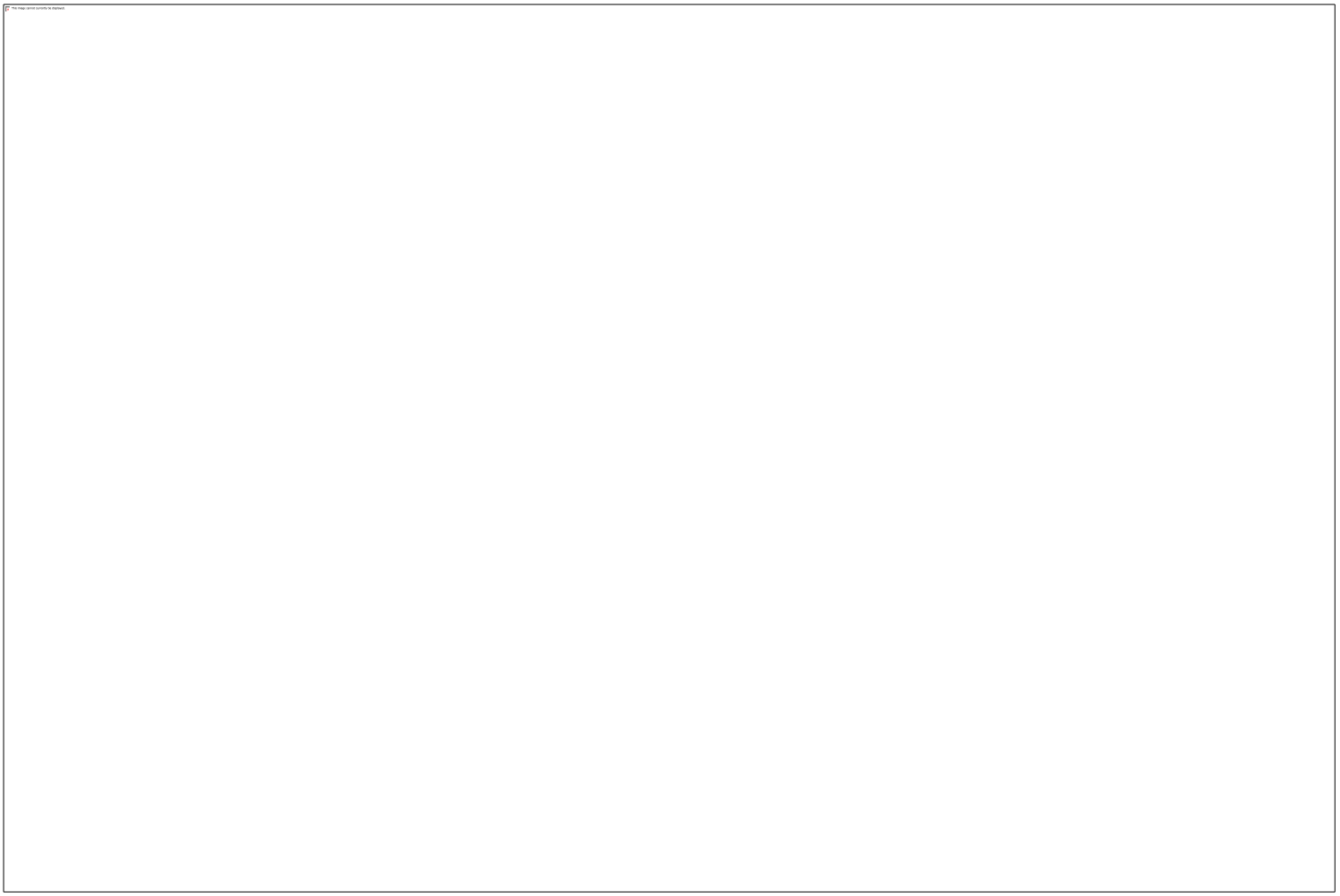
Important: The measurement used depends on the species and the applicable fisheries regulation. Learners should not assume that one minimum size applies to all fish species.

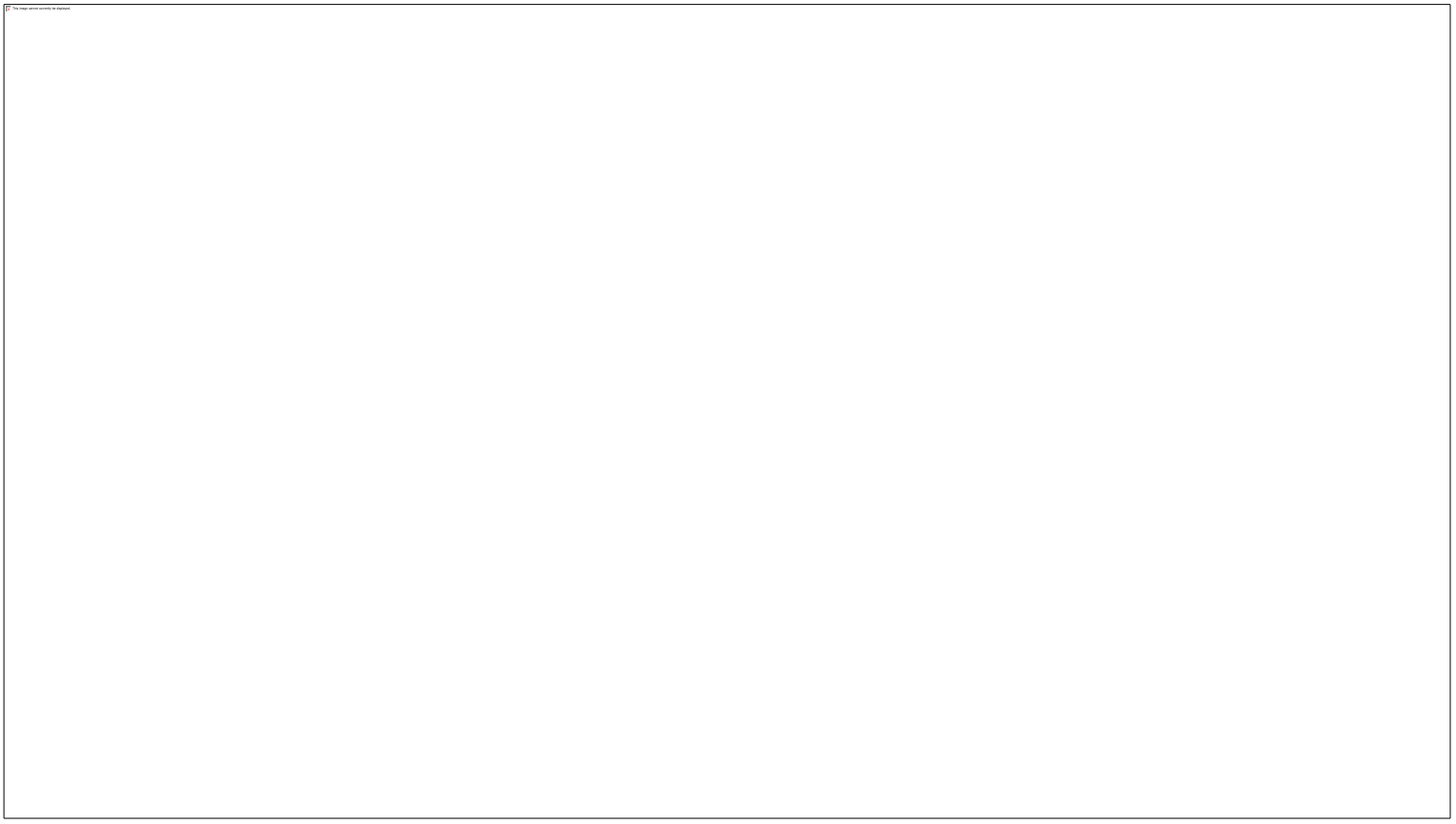
Advantages of minimum size limits

- Protect young fish.
- Allow fish to reproduce before harvesting.
- Improve the future availability of fish.
- Promote sustainable fisheries.
- Reduce the harvesting of immature fish.

4.8 Protection of Breeding and Nursery Grounds







Meaning of breeding grounds

Breeding grounds are aquatic habitats where fish and other aquatic organisms reproduce and lay eggs or give birth to young ones.

Meaning of nursery grounds

Nursery grounds are habitats where juvenile aquatic organisms find food, shelter and suitable conditions for growth and development.

Examples of important breeding and nursery habitats

- Mangrove forests.
- Seagrass beds.
- Coral reefs.
- Freshwater wetlands.
- River mouths.
- Shallow lake margins.
- Submerged aquatic vegetation.

Measures used to protect breeding and nursery grounds

- Restricting fishing in sensitive habitats.
- Preventing destruction of mangrove forests.
- Controlling coastal development.
- Reducing pollution.
- Preventing destructive fishing methods.
- Establishing protected breeding zones.
- Restoring degraded habitats.
- Promoting community participation in conservation.

4.9 Monitoring, Control and Surveillance (MCS)

Meaning of monitoring

Monitoring involves collecting and analysing information about fishing activities, fish catches, fishing effort and the condition of aquatic resources.

Meaning of control

Control involves ensuring that fishing activities comply with established laws, regulations and management plans.

Meaning of surveillance

Surveillance refers to observing and inspecting fishing activities to detect and prevent illegal fishing.

Activities involved in MCS

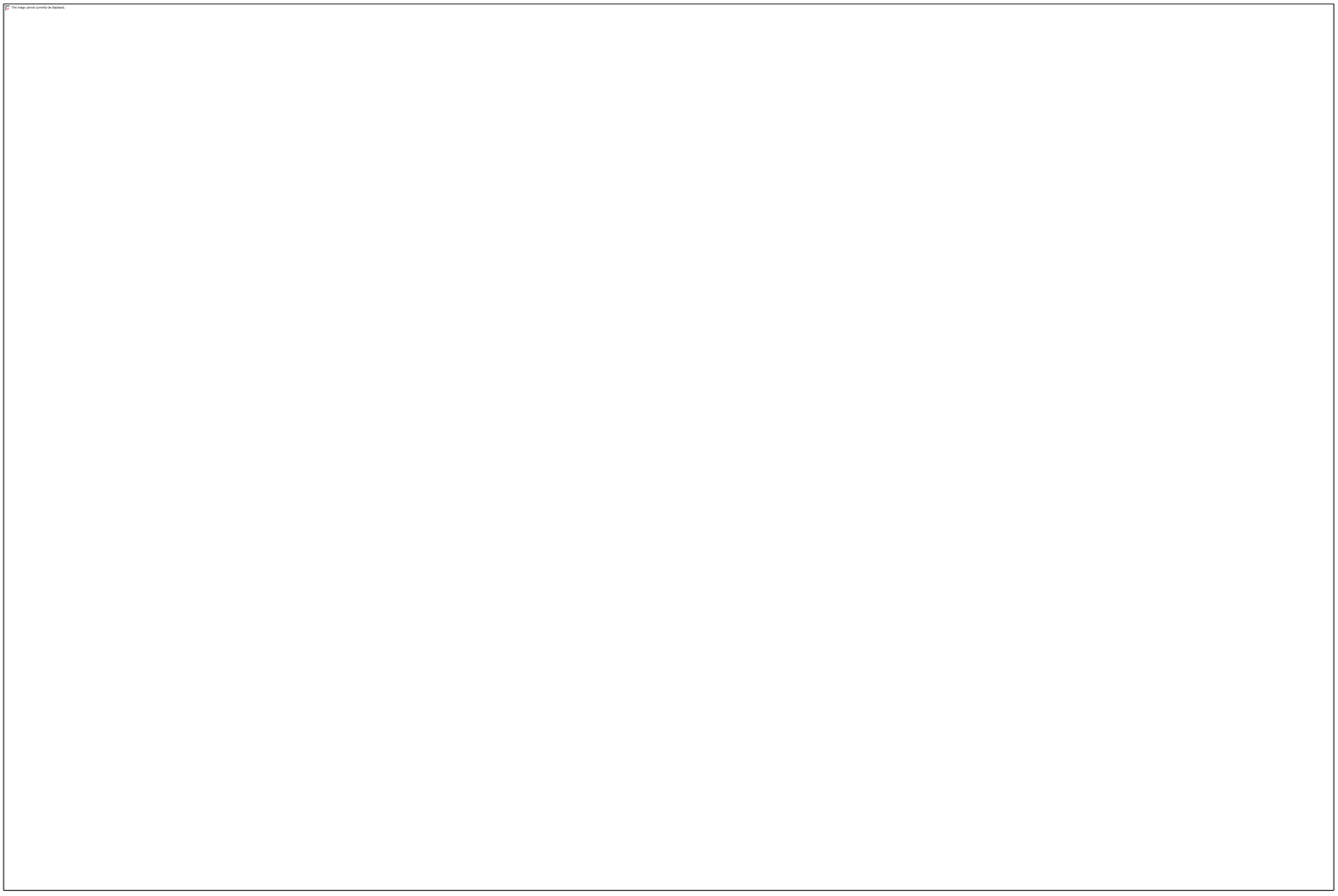
- Inspecting fishing vessels.
- Checking fishing licences.
- Monitoring fishing gear.
- Recording fish catches.
- Inspecting fish landing sites.

- Conducting patrols in fishing areas.
- Investigating reports of illegal fishing.
- Monitoring fishing activities using appropriate technology.
- Enforcing fisheries regulations.

Importance of MCS

- Helps prevent illegal fishing.
- Ensures compliance with fisheries regulations.
- Provides reliable information for fisheries planning.
- Protects breeding grounds.
- Reduces destructive fishing activities.
- Promotes accountability among fishing operators.

4.10 Bycatch Reduction



Meaning of bycatch

Bycatch refers to aquatic organisms accidentally captured during fishing activities when they are not the main intended target species.

Examples include:

- Sea turtles accidentally caught in fishing nets.

- Dolphins entangled in fishing gear.
- Juvenile fish captured together with mature fish.
- Non-target sharks and rays caught during fishing.
- Seabirds caught on longline hooks.

Methods of reducing bycatch

- Using selective fishing gear.
- Using appropriate hook sizes and designs.
- Installing turtle excluder devices where applicable.
- Avoiding fishing in areas with high concentrations of protected species.
- Using appropriate net mesh sizes.
- Releasing accidentally captured protected animals safely where possible.
- Training fishermen on responsible fishing practices.
- Monitoring and reporting bycatch incidents.

Importance of reducing bycatch

- Protects endangered species.
- Reduces unnecessary deaths of aquatic organisms.
- Maintains aquatic biodiversity.
- Improves fishing efficiency.
- Promotes responsible fishing practices.

5.0 APPROACHES TO FISHERIES MANAGEMENT

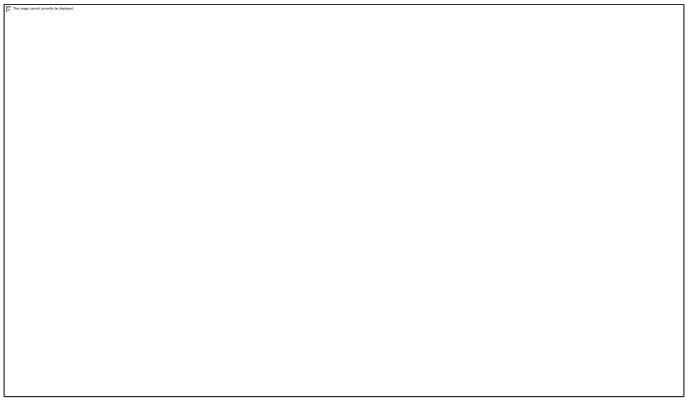
5.1 Meaning of Fisheries Management Approaches

Fisheries management approaches are the different ways or systems used by governments, fishing communities, organisations and other stakeholders to plan, organise and implement fisheries management activities.

The two major approaches in the Grade 11 curriculum are:

1. Top-down approach.
2. Co-management approach.

5.2 Top-Down Approach to Fisheries Management



Meaning of top-down approach

The top-down approach is a fisheries management system in which decisions, regulations and policies are mainly made by the central government or relevant management authorities and then communicated to fishing communities for implementation.

Under this approach, the government takes the leading role in establishing fisheries laws, determining fishing restrictions and enforcing regulations.

Features of the top-down approach

- Management decisions are mainly made by government authorities.
- Fisheries laws and regulations are established centrally.
- Fishing communities are expected to comply with established regulations.
- Government officers supervise fishing activities.
- Enforcement is mainly carried out by authorised government agencies.
- Management policies may apply to large geographical areas.
- Technical and scientific information may guide decision-making.

Examples of top-down fisheries management activities

- Government declaring a particular fishing area closed.
- Authorities restricting the use of certain fishing nets.
- Government establishing minimum fish size requirements.
- Government issuing fishing licences.
- Fisheries officers inspecting landing sites.
- Authorities imposing penalties for illegal fishing.

Advantages of the top-down approach

1. Clear authority

- It establishes a clear management structure.
- Government agencies have the authority to introduce and enforce fisheries regulations.

2. Consistency in regulations

- Similar rules can be applied across different fishing areas.
- This reduces confusion when managing shared resources.

3. Access to scientific expertise

- Government institutions can use scientific research to develop management plans.
- Fisheries experts can provide information on fish stocks and aquatic ecosystems.

4. Legal enforcement

- The government can enforce regulations through authorised officers and legal systems.
- Offenders may face penalties according to applicable laws.

5. Protection of national interests

- It helps the government protect fisheries resources as national assets.
- It supports national food security and economic planning.

6. Coordination of large-scale fisheries management

- Government authorities can coordinate management across different counties, lakes and coastal regions.
- This is important where fish populations move across administrative boundaries.

Disadvantages of the top-down approach

1. Limited community participation

- Fishing communities may have little influence on decisions.
- This can reduce their willingness to support management programmes.

2. Limited understanding of local conditions

- Central authorities may not fully understand local fishing practices and community needs.
- Regulations may not always suit local circumstances.

3. High enforcement costs

- Government agencies require funds, personnel, vessels and equipment.
- Large fishing areas are difficult to monitor continuously.

4. Resistance from fishermen

- Fishermen may oppose restrictions they consider unfair.
- Some may continue illegal fishing activities.

5. Slow decision-making

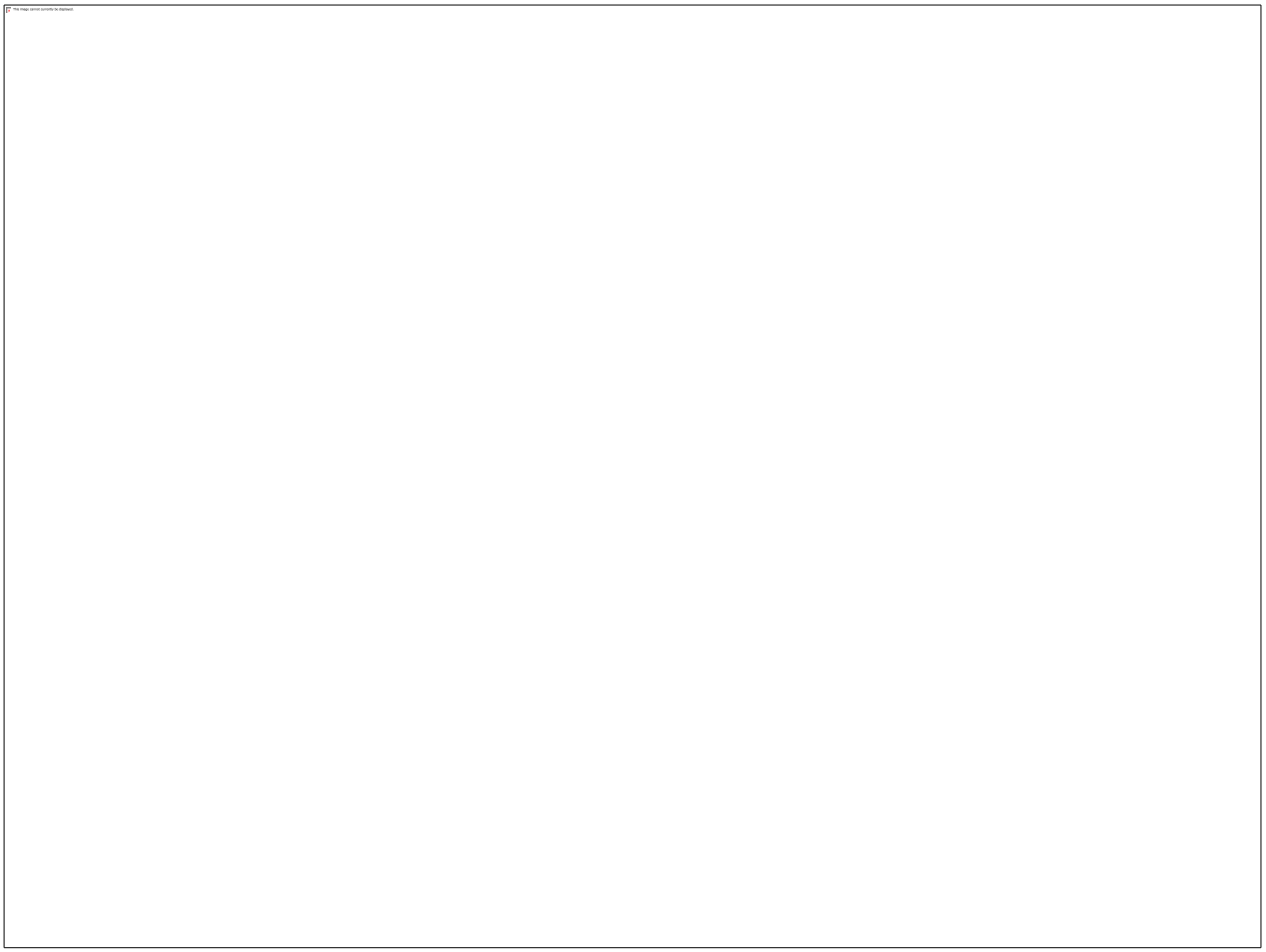
- Centralised decision-making may delay responses to local fisheries problems.

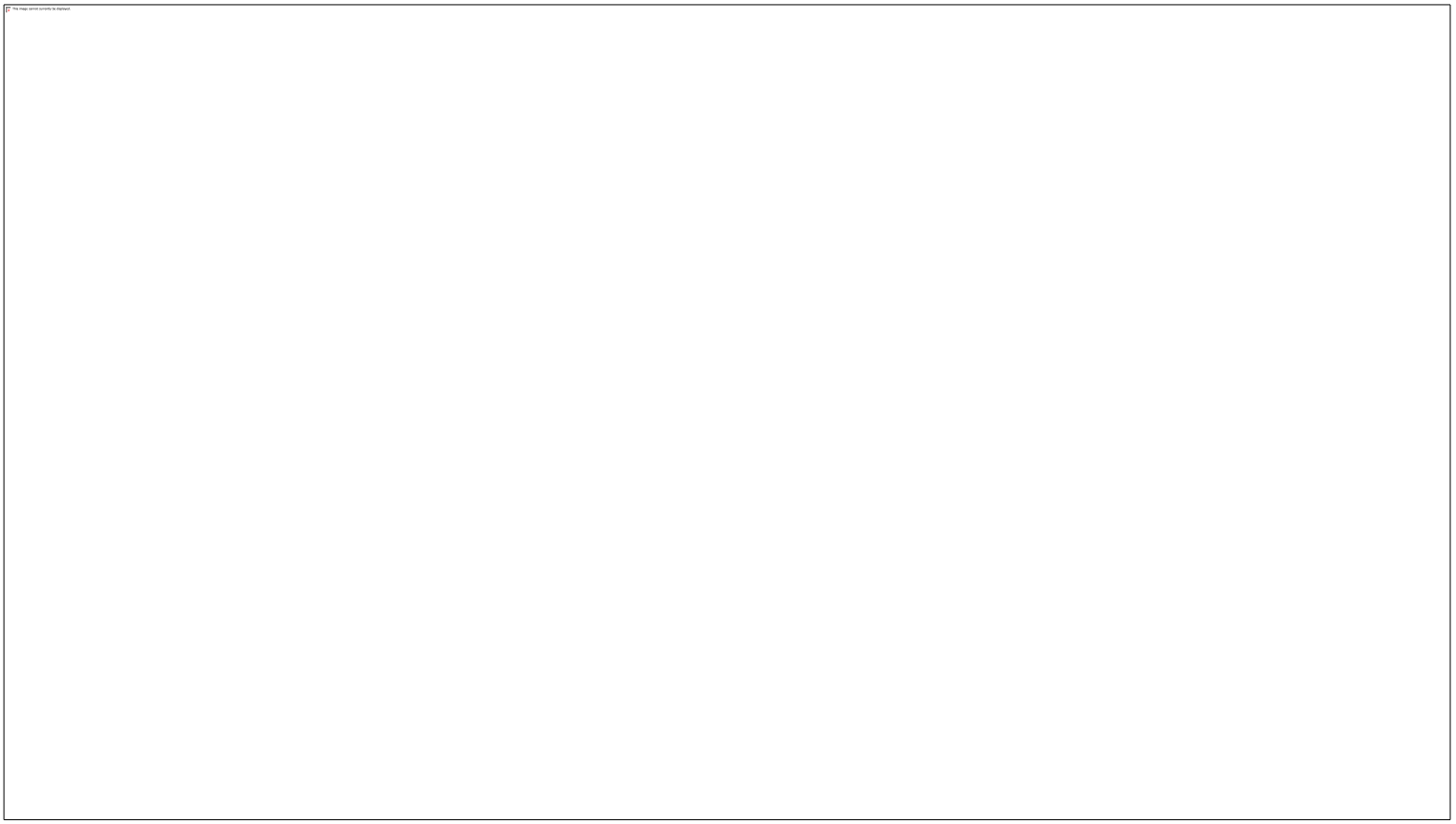
6. Limited ownership

- Communities may view fisheries regulations as government instructions rather than shared responsibilities.

5.3 Co-management Approach to Fisheries Management







Meaning of co-management

Co-management is a fisheries management approach in which government authorities, fishing communities and other relevant stakeholders share responsibilities, decision-making and management activities.

It recognises that fisheries resources can be managed more effectively when people who depend on them participate in their conservation and sustainable utilisation.

In Kenya, Beach Management Units (BMUs) provide an important framework for involving fishing communities in the management of fisheries resources.

Main participants in fisheries co-management

- Government fisheries departments.
- Beach Management Units.
- Local fishermen.
- Fish traders.
- Fish processors.
- Boat owners.
- Community leaders.
- Conservation organisations.
- Researchers and fisheries experts.
- Other relevant resource users.

Features of co-management

- Shared decision-making.
- Active community participation.
- Joint development of management rules.
- Shared responsibility for fisheries conservation.
- Cooperation between government and fishing communities.
- Exchange of scientific and local knowledge.
- Joint monitoring of fishing activities.
- Conflict resolution through consultation.

Examples of co-management activities in Kenya

- Fishermen participating in developing local fishing regulations.
- BMUs helping to monitor fishing activities at landing sites.
- Community members reporting illegal fishing.
- Fishermen participating in mangrove restoration.
- Joint management of fishing zones.
- Community awareness programmes on sustainable fishing.
- Fishermen working with fisheries officers to protect breeding grounds.

Advantages of co-management

1. Community participation

- Fishermen participate in decisions affecting their livelihoods.

- This increases acceptance of fisheries regulations.

2. Local knowledge is utilised

- Fishermen understand local fishing grounds, fish behaviour and seasonal changes.
- Their knowledge supports better management decisions.

3. Shared responsibility

- Government and communities share the responsibility of protecting fisheries resources.
- This reduces dependence on government enforcement alone.

4. Improved compliance

- People are more likely to follow regulations they helped develop.
- Community monitoring can discourage illegal fishing.

5. Reduced management costs

- Community participation can reduce the burden on government officers.
- Local monitoring supports the efficient use of resources.

6. Conflict resolution

- Stakeholders can discuss their differences and agree on acceptable management practices.
- This promotes cooperation among resource users.

7. Improved livelihoods

- Sustainable management protects the resources on which fishing communities depend.
- It supports long-term income and employment.

8. Environmental conservation

- Communities can participate in restoring mangroves, seagrass beds and other aquatic habitats.
- This improves the condition of aquatic ecosystems.

Disadvantages of co-management

1. Conflicts among stakeholders

- Different groups may have competing interests.
- Fishermen, traders and conservation organisations may disagree on management priorities.

2. Unequal participation

- Some community members may dominate decision-making.
- Women, young people and small-scale fishermen may be underrepresented.

3. Limited technical knowledge

- Some community members may lack the scientific information required for complex fisheries decisions.
- Training and technical support may be necessary.

4. Financial limitations

- Community management activities may lack sufficient funds.
- Monitoring and conservation programmes may require external support.

5. Slow decision-making

- Consultation among many stakeholders may take time.
- This can delay implementation of management measures.

6. Weak enforcement

- Community members may be unwilling to report or take action against offenders they know personally.
- Strong cooperation with authorised enforcement agencies is therefore necessary.

5.4 Differences Between Top-Down and Co-management Approaches

Top-down approach	Co-management approach
Decisions are mainly made by government authorities.	Decisions are shared among government and stakeholders.
Limited community participation.	Active community participation.
Government takes the leading management role.	Responsibilities are shared.
Regulations are mainly developed centrally.	Regulations are developed through consultation.
Local knowledge may be underutilised.	Local and scientific knowledge are combined.
Enforcement is mainly government-led.	Monitoring and management involve communities and government.
May face community resistance.	Often encourages community ownership.
Can provide uniform regulations.	Can adapt management to local conditions.

5.5 Role of Beach Management Units (BMUs) in Fisheries Management



Meaning of a Beach Management Unit

A Beach Management Unit is a community-based fisheries management organisation that brings together people involved in fisheries activities at a fish landing site to participate in the management, conservation and sustainable utilisation of fisheries resources.

BMUs are important in implementing fisheries co-management in Kenya.

Roles of BMUs

1. **Promoting responsible fishing**
   - Encourage fishermen to use permitted fishing gear.
   - Discourage illegal fishing practices.
2. **Monitoring fishing activities**
   - Assist in observing fishing activities at landing sites.
   - Report suspected illegal fishing to the relevant authorities.
3. **Collecting fisheries information**
   - Assist in recording fish catches and fishing activities.
   - Provide information useful for fisheries planning.
4. **Promoting hygiene at landing sites**
   - Encourage proper fish handling and sanitation.
   - Promote cleanliness around fish landing facilities.
5. **Resolving local conflicts**
   - Help address disagreements among fishermen and other fisheries stakeholders.
   - Promote peaceful cooperation.
6. **Creating environmental awareness**
   - Educate communities on the importance of aquatic resource conservation.
   - Promote protection of breeding and nursery grounds.
7. **Supporting fisheries regulations**
   - Encourage members to comply with established fisheries laws.
   - Cooperate with fisheries officers during enforcement activities.
8. **Promoting community participation**
   - Involve local resource users in fisheries management decisions.
   - Encourage shared responsibility.
9. **Supporting conservation programmes**
   - Participate in mangrove restoration.
   - Promote protection of aquatic habitats.
10. **Promoting sustainable livelihoods**
    - Encourage responsible harvesting and value addition.

- Support initiatives that improve the income of fishing communities.

6.0 KEY STAKEHOLDERS IN FISHERIES MANAGEMENT IN KENYA

6.1 Meaning of Fisheries Stakeholders

Fisheries stakeholders are individuals, organisations, institutions and groups that influence, participate in or are affected by the management and utilisation of fisheries resources.

6.2 Examples of Fisheries Management Stakeholders in Kenya

1. National government

- Develops national fisheries policies and laws.
- Provides the overall legal framework for fisheries management.
- Coordinates fisheries conservation and development.
- Supports research and enforcement.

2. County governments

- Participate in fisheries development and management within their respective areas of responsibility.
- Support local fisheries infrastructure.
- Promote community participation and extension services.
- Work with national institutions to improve fisheries activities.

3. Kenya Fisheries Service (KeFS)

- Supports the development and management of fisheries and aquaculture.
- Participates in fisheries regulation and compliance activities.
- Supports fisheries data collection.
- Promotes sustainable utilisation of fisheries resources.

4. Kenya Marine and Fisheries Research Institute (KMFRI)

- Conducts marine and freshwater fisheries research.
- Provides scientific information on fisheries resources.
- Studies fish populations and aquatic ecosystems.
- Supports evidence-based fisheries management.

5. Beach Management Units

- Mobilise fishing communities.
- Support responsible fishing.
- Participate in local monitoring and conservation.
- Help communicate fisheries regulations.

6. Fishing communities

- Harvest fish and other aquatic organisms.
- Participate in resource conservation.

- Provide local knowledge.
- Report illegal fishing activities.

7. Non-governmental organisations

- Support environmental education.
- Promote conservation programmes.
- Provide technical and financial assistance.
- Support sustainable livelihood projects.

8. Research and learning institutions

- Conduct research on aquatic resources.
- Train fisheries professionals.
- Develop improved fishing technologies.
- Provide scientific information to decision-makers.

6.3 Fisheries Laws and Regulations in Kenya

Fisheries management in Kenya is guided by national legislation, regulations and institutional frameworks.

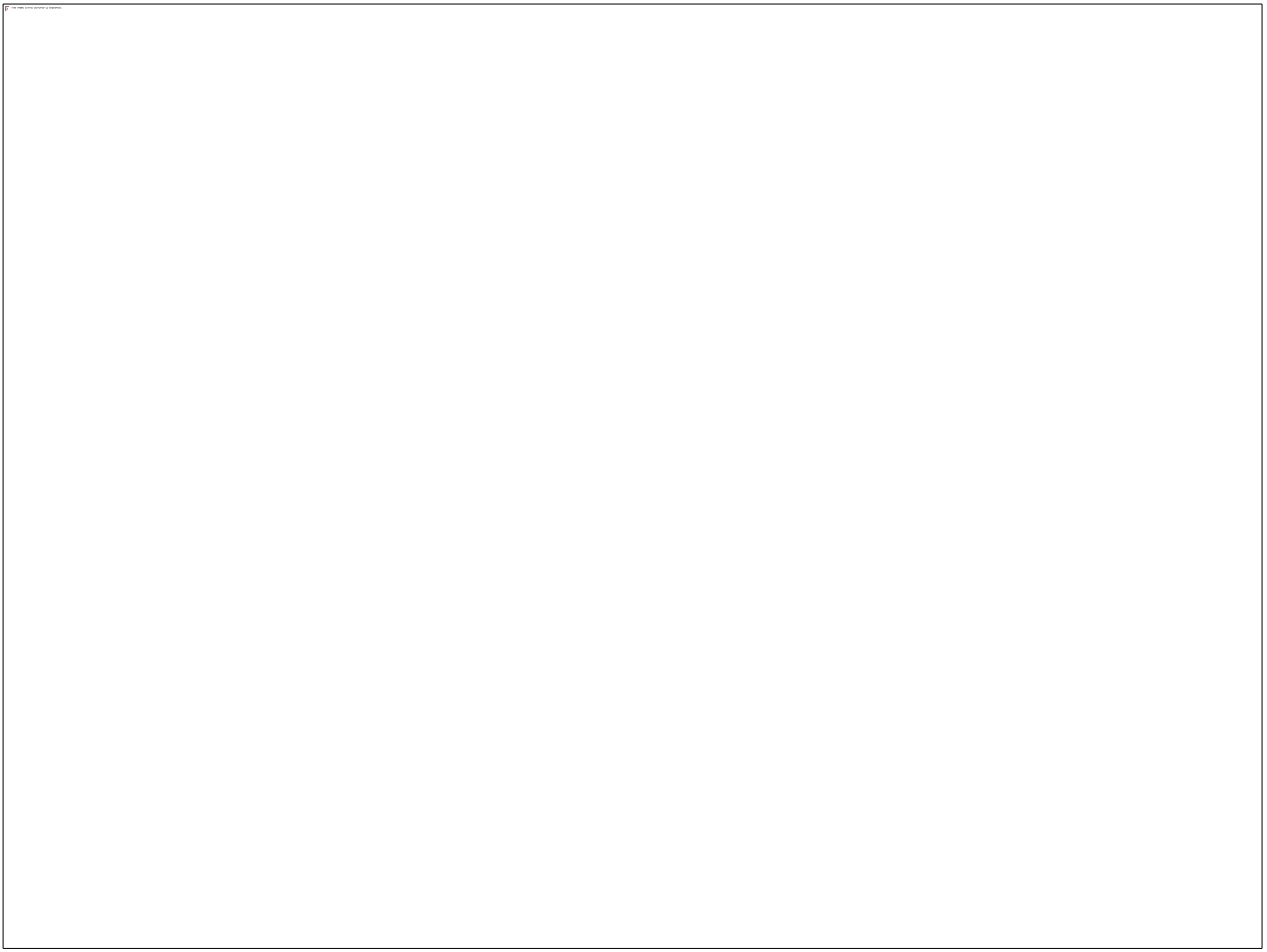
Examples include:

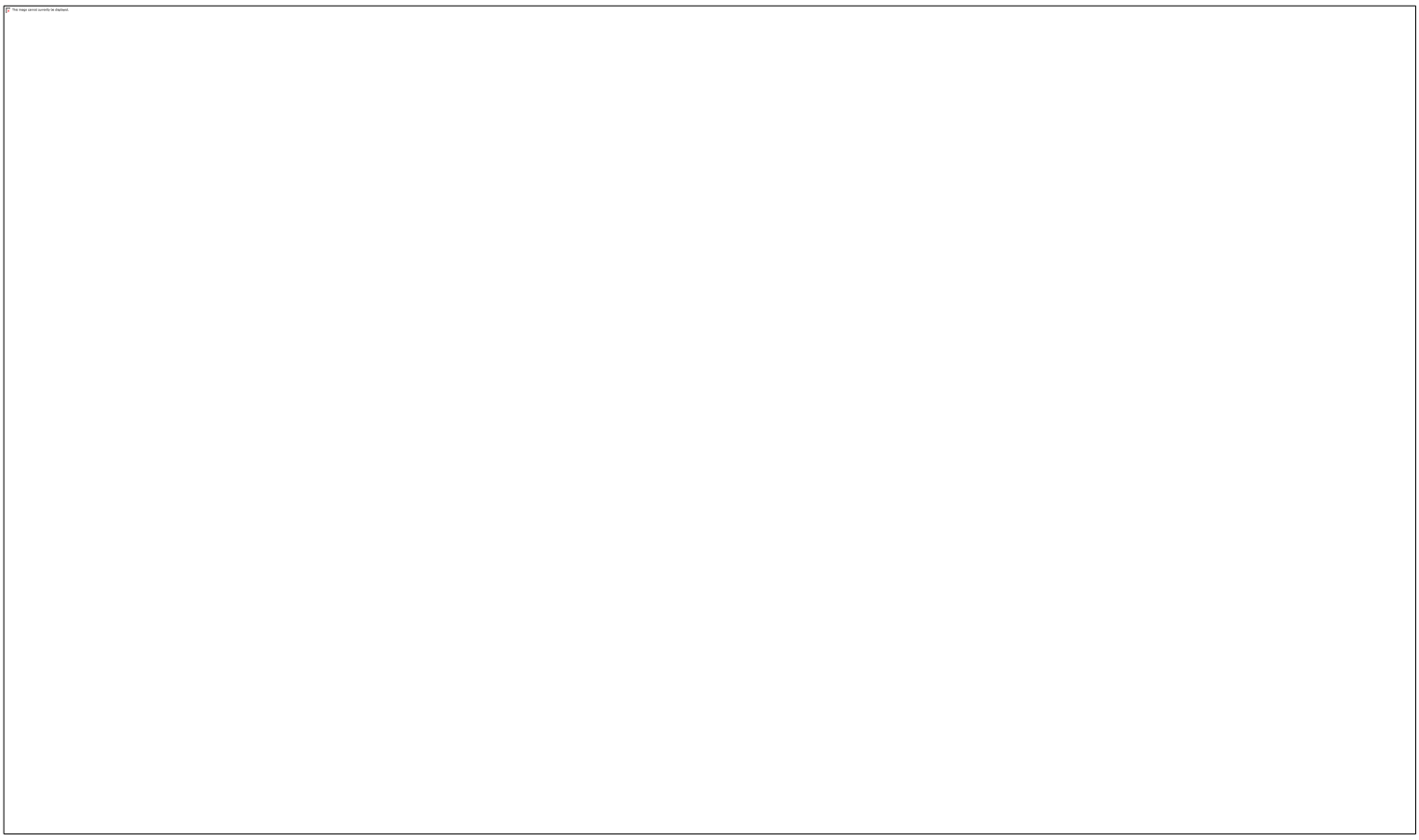
- Fisheries Management and Development Act, 2016.
- Applicable fisheries regulations and licensing requirements.
- Environmental laws governing the protection of aquatic habitats.
- Wildlife conservation laws applicable to protected marine wildlife.
- Regulations governing marine protected areas and reserves.

Learners should understand that fisheries regulations may change and that the specific requirements for fishing gear, fish sizes, licensing and protected areas must be confirmed with the relevant authorities.

7.0 CHALLENGES FACING FISHERIES MANAGEMENT IN KENYA







Despite the existence of fisheries management measures, Kenya faces several challenges in managing its aquatic resources.

7.1 Overfishing

- Excessive harvesting reduces fish populations.
- It may cause the disappearance of commercially valuable species from certain areas.
- It reduces the future productivity of fisheries.
- It threatens the livelihoods of fishing communities.

7.2 Illegal Fishing

- Some fishermen use prohibited fishing gear.
- Others fish in restricted areas or during closed seasons.
- Illegal fishing reduces the effectiveness of management programmes.
- It may cause the capture of juvenile and endangered species.

7.3 Destruction of Aquatic Habitats

- Mangrove forests may be cleared for settlement and other activities.
- Coral reefs may be damaged by destructive fishing.
- Seagrass beds may be disturbed by coastal development and inappropriate fishing practices.
- Habitat destruction reduces breeding and nursery areas.

7.4 Water Pollution

- Agricultural chemicals may enter water bodies through runoff.
- Industrial waste may contaminate aquatic environments.
- Plastic waste may injure or kill aquatic organisms.
- Oil spills may damage marine ecosystems.
- Sewage may increase disease-causing organisms and reduce water quality.

7.5 Climate Change

- Rising water temperatures affect fish growth and reproduction.
- Changes in rainfall affect lake and river water levels.
- Ocean warming may affect marine species distribution.
- Coral bleaching threatens coral reef ecosystems.
- Extreme weather events may disrupt fishing activities.

7.6 Inadequate Funding

- Fisheries departments may lack sufficient resources.
- Monitoring equipment and patrol vessels can be expensive.
- Research and conservation programmes require financial support.
- Some communities lack funds to implement local management activities.

7.7 Limited Awareness

- Some fishermen may not understand the importance of fisheries regulations.
- Lack of awareness can lead to non-compliance.
- Environmental education is therefore important.

7.8 Weak Enforcement

- Large water bodies are difficult to monitor.
- Remote fishing areas may be inaccessible.
- Limited personnel and equipment may reduce enforcement effectiveness.
- Corruption and non-compliance may undermine fisheries regulations.

7.9 Conflicts Among Resource Users

- Fishermen may compete for access to fishing grounds.
- Conservation measures may conflict with some livelihood activities.
- Different groups may disagree on resource-use priorities.
- Effective consultation helps reduce these conflicts.

7.10 Poor Fisheries Data

- Incomplete catch records make it difficult to estimate fish populations.
- Some catches may not be reported.
- Lack of reliable information affects management decisions.
- Regular data collection and scientific research are essential.

8.0 STRATEGIES FOR IMPROVING SUSTAINABLE FISHERIES MANAGEMENT IN KENYA

8.1 Promoting Responsible Fishing Practices

- Encourage the use of approved fishing gear.
- Discourage destructive fishing methods.
- Promote selective fishing methods.
- Encourage proper handling and release of protected species.
- Educate fishermen on sustainable harvesting.

8.2 Strengthening Fisheries Law Enforcement

- Increase fisheries inspections.
- Provide adequate equipment to fisheries officers.
- Conduct regular patrols.
- Prosecute offenders according to applicable laws.
- Strengthen cooperation between communities and enforcement agencies.

8.3 Promoting Community Participation

- Strengthen Beach Management Units.

- Involve fishermen in management decisions.
- Encourage local conservation initiatives.
- Support community-based monitoring.
- Promote fair representation of all stakeholders.

8.4 Protecting Aquatic Habitats

- Restore degraded mangrove forests.
- Protect seagrass beds.
- Conserve coral reefs.
- Prevent destruction of wetlands.
- Control pollution and inappropriate coastal development.

8.5 Improving Fisheries Research

- Conduct regular fish population assessments.
- Monitor fish breeding patterns.
- Study the effects of climate change.
- Develop appropriate fishing technologies.
- Use scientific information to establish management measures.

8.6 Promoting Fisheries Education

- Train fishermen on responsible fishing.
- Conduct environmental awareness campaigns.
- Teach communities about protected species.
- Promote school and community conservation programmes.
- Share information on fisheries regulations.

8.7 Improving Fisheries Data Collection

- Maintain accurate landing-site records.
- Record fish species and quantities harvested.
- Monitor fishing effort.
- Report illegal fishing and bycatch.
- Use digital tools where appropriate.

8.8 Supporting Alternative Livelihoods

- Promote sustainable aquaculture.
- Encourage fish processing and value addition.
- Support eco-tourism.
- Promote seaweed farming where environmentally suitable.
- Train fishing communities in alternative income-generating activities.

8.9 Promoting Regional and International Cooperation

- Cooperate with neighbouring countries in managing shared fish stocks.
- Exchange information on illegal fishing.
- Support international agreements on responsible fishing.
- Participate in regional fisheries conservation programmes.

9.0 PRACTICAL LEARNING ACTIVITIES

The following activities enable learners to apply the knowledge gained in this sub-strand.

Activity 1: Identification of Fisheries Resources

Requirements:

- Pictures of aquatic organisms.
- Reference books.
- Charts.
- Digital devices.
- Specimens where safely and legally available.

Procedure:

1. Observe pictures or specimens of different aquatic organisms.
2. Identify the organisms.
3. Classify them into finfish, molluscs, crustaceans, marine mammals, aquatic plants, freshwater invertebrates and echinoderms.
4. Record their common names.
5. Identify their habitats.
6. Discuss their importance to fisheries.

Expected learning outcomes:

- Ability to identify fisheries resources.
- Ability to classify aquatic organisms.
- Appreciation of fisheries biodiversity.

Activity 2: Investigating Fisheries Management Measures

Requirements:

- Fisheries regulations.
- Pictures of fishing equipment.
- Internet-enabled devices.
- Resource person such as a fisheries officer.

Procedure:

1. Identify common fishing methods used in Kenya.

2. Investigate regulations controlling fishing activities.
3. Discuss closed seasons and closed areas.
4. Examine examples of fishing gear restrictions.
5. Explain the importance of minimum fish size limits.
6. Present findings to the class.

Expected learning outcomes:

- Understanding of fisheries management measures.
- Ability to explain the purpose of fishing regulations.
- Appreciation of sustainable fishing.

Activity 3: Field Visit to a Fish Landing Site

Procedure:

1. Visit a nearby fish landing site under appropriate supervision.
2. Observe the fishing vessels and equipment.
3. Identify different fish species landed.
4. Observe fish handling and storage practices.
5. Interview fishermen about fishing regulations.
6. Find out how the landing site manages illegal fishing.
7. Record the findings and prepare a report.

Expected learning outcomes:

- Understanding real fishing activities.
- Identification of common fisheries resources.
- Appreciation of fisheries management in practice.

Activity 4: Comparing Fisheries Management Approaches

Procedure:

1. Divide learners into groups.
2. Assign one group the top-down approach.
3. Assign another group the co-management approach.
4. Let each group identify the characteristics, advantages and disadvantages of its approach.
5. Conduct a class debate on which approach encourages better community participation.
6. Summarise the findings.

Expected learning outcomes:

- Ability to differentiate management approaches.
- Development of communication and collaboration skills.
- Appreciation of shared responsibility in fisheries management.

Activity 5: Designing a Fisheries Conservation Campaign

Procedure:

1. Identify a fisheries management problem in the local community.
2. Discuss its causes and effects.
3. Suggest practical solutions.
4. Prepare posters, slogans or messages.
5. Present the campaign to the school or community.

Suggested campaign messages:

- Protect fish today for tomorrow's generations.
- Say no to illegal fishing.
- Keep our rivers, lakes and oceans clean.
- Protect breeding grounds and save fish populations.
- Sustainable fishing, sustainable livelihoods.

10.0 SUMMARY OF THE SUB-STRAND

By studying the fundamentals of fisheries management, learners should understand that:

1. Fisheries resources include finfish, shellfish, marine mammals, aquatic plants, freshwater invertebrates and echinoderms.
2. Fisheries resources occur in freshwater, marine, estuarine and wetland environments.
3. Fisheries management ensures responsible harvesting of aquatic organisms.
4. Fisheries resources require management because they can become depleted through overfishing and habitat destruction.
5. Important management measures include closed seasons, closed areas, licensing, gear restrictions, catch limits and minimum fish size limits.
6. Fisheries management approaches include top-down management and co-management.
7. Co-management encourages shared responsibility between government and fishing communities.
8. Beach Management Units support community participation in fisheries management.
9. Kenya's fisheries resources are important for food security, employment, trade and tourism.
10. Sustainable fisheries management protects aquatic biodiversity and ensures that future generations benefit from fisheries resources.

REVISION QUESTIONS

GRADE 11 – MARINE TECHNOLOGY

STRAND 2.0: FISHERIES MANAGEMENT

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. Which of the following best defines fisheries management?

A. The process of increasing the number of fishing boats in water bodies.
B. The planning and regulation of fishing activities to ensure sustainable utilisation of aquatic resources.
C. The process of converting freshwater into seawater.
D. The practice of harvesting only large fish.

2. Which of the following is a freshwater fish commonly harvested from Lake Victoria?

A. Tuna.
B. Marlin.
C. Nile perch.
D. Lobster.

3. Which of the following aquatic organisms belongs to the mollusc group?

A. Crab.
B. Oyster.
C. Tilapia.
D. Sea cucumber.

4. Which characteristic distinguishes finfish from shellfish?

A. Finfish possess a backbone.
B. Finfish have hard external shells.
C. Finfish live exclusively in seawater.
D. Finfish lack respiratory organs.

5. Which of the following organisms is classified as a crustacean?

A. Octopus.
B. Oyster.
C. Prawn.
D. Squid.

6. Which marine mammal is herbivorous and feeds mainly on seagrass?

A. Dolphin.
B. Dugong.
C. Tuna.
D. Shark.

7. Which of the following coastal plants provides important nursery grounds for juvenile fish?

A. Maize.
B. Mangroves.
C. Wheat.
D. Cactus.

8. Sea cucumbers belong to which group of aquatic organisms?

A. Crustaceans.
B. Finfish.
C. Echinoderms.
D. Marine mammals.

9. What is one of the main objectives of fisheries resource management?

A. To encourage unrestricted fishing activities.
B. To prevent overfishing and depletion of fish stocks.
C. To increase pollution in aquatic environments.
D. To eliminate all fishing activities.

10. Which of the following is an example of a marine fisheries resource?

A. Nile perch.
B. Catfish.
C. Yellowfin tuna.
D. Freshwater snail.

11. What is meant by a closed season in fisheries management?

A. A period when all fishing vessels must be sold.
B. A period when fishing is temporarily prohibited or restricted.
C. A period when fish processing industries are established.
D. A period when fish are transported to foreign markets.

12. Why are closed fishing areas established?

A. To encourage fishing in breeding grounds.
B. To protect important aquatic habitats and fish populations.
C. To increase the number of fishing vessels.
D. To prevent fish from reproducing.

13. Which fisheries management measure requires fishermen to obtain official permission before engaging in specified fishing activities?

A. Licensing.
B. Aquaculture.
C. Fish processing.
D. Fish transportation.

14. What is the main purpose of regulating fishing gear?

A. To encourage the capture of juvenile fish.
B. To promote destructive fishing practices.
C. To reduce the capture of undersized fish and protect aquatic habitats.
D. To increase the use of poisonous substances.

15. Why are minimum fish size limits established?

A. To ensure fish are harvested before reaching maturity.
B. To allow fish to reach maturity and reproduce before harvesting.
C. To prevent fish from growing.
D. To increase the capture of juvenile fish.

16. Which fishing method involves surrounding a school of fish with a large net?

A. Hook and line fishing.
B. Purse seining.
C. Hand gathering.
D. Fish trapping.

17. What is the term used to describe the accidental capture of non-target aquatic organisms during fishing?

A. Overfishing.
B. Bycatch.
C. Stock assessment.
D. Aquaculture.

18. Which of the following devices is used to reduce the accidental capture of marine turtles during fishing?

A. Turtle excluder device.
B. Poisonous fishing chemicals.
C. Explosives.
D. Very small-mesh nets.

19. Which statement best describes the top-down approach to fisheries management?

A. Management decisions are made mainly by government authorities.
B. Fishermen have exclusive control over all fishing regulations.
C. Fisheries management is carried out without laws.
D. Aquatic resources are harvested without restrictions.

20. What does co-management in fisheries involve?

A. Government managing fisheries without consulting stakeholders.
B. Fishermen managing resources without any regulations.
C. Government and stakeholders sharing fisheries management responsibilities.
D. Foreign companies controlling all fishing activities.

21. Which organisation provides an important framework for community participation in fisheries management in Kenya?

A. Beach Management Unit.
B. Kenya National Examinations Council.
C. National Transport and Safety Authority.
D. Kenya Revenue Authority.

22. What is one of the main roles of a Beach Management Unit (BMU)?

A. Encouraging illegal fishing activities.
B. Promoting responsible fishing and community participation.
C. Destroying mangrove forests.
D. Preventing the collection of fisheries information.

23. Which of the following habitats serves as an important nursery ground for marine fish?

A. Desert.
B. Mangrove forest.
C. Rocky mountain.
D. Agricultural field.

24. Which environmental parameter directly determines the amount of oxygen available for fish respiration?

A. Dissolved oxygen concentration.
B. Soil colour.
C. Wind direction alone.
D. Moonlight intensity.

25. Which of the following human activities contributes directly to the destruction of fisheries habitats?

A. Mangrove restoration.
B. Establishment of marine protected areas.
C. Destructive fishing practices.
D. Community environmental education.

26. Which institution in Kenya is responsible for conducting marine and freshwater fisheries research?

A. Kenya Marine and Fisheries Research Institute.
B. Kenya National Highways Authority.
C. Kenya Institute of Curriculum Development.
D. Teachers Service Commission.

27. What is one major economic benefit of sustainable fisheries management?

A. Increased unemployment in fishing communities.
B. Continuous employment and income generation.
C. Complete disappearance of commercial fish species.
D. Increased aquatic pollution.

28. Which of the following is a major challenge affecting fisheries management in Kenya?

A. Excessive availability of fisheries research.
B. Complete absence of fishing activities.
C. Illegal fishing and inadequate enforcement of fisheries regulations.
D. Unlimited availability of fish stocks.

29. Which activity would best promote sustainable fisheries management in a Kenyan coastal community?

A. Cutting down mangrove forests.
B. Using explosives to capture fish.
C. Restoring seagrass beds and mangrove habitats.
D. Harvesting juvenile fish.

30. What is the main reason for promoting co-management in fisheries?

A. To eliminate government participation.
B. To encourage shared responsibility and community ownership.
C. To increase conflicts among fishermen.
D. To prevent local communities from participating in decision-making.

SECTION B: STRUCTURED QUESTIONS 50 MARKS

Instructions: Answer all questions. Write your answers clearly and provide relevant examples where necessary.

QUESTION 1: TYPES OF FISHERIES RESOURCES (10 MARKS)

a) Define the term fisheries resources. (2 marks)

b) Identify four major categories of fisheries resources. (4 marks)

c) Give two examples of crustaceans found in fisheries environments. (2 marks)

d) State two characteristics of marine mammals. (2 marks)

QUESTION 2: IMPORTANCE OF FISHERIES MANAGEMENT (8 MARKS)

a) Explain four reasons why fisheries resources should be managed sustainably. (4 marks)

b) Explain four factors that influence the distribution of fisheries resources in aquatic environments. (4 marks)

QUESTION 3: FISHERIES MANAGEMENT MEASURES (8 MARKS)

a) Explain the meaning of a closed season in fisheries management. (2 marks)

b) Describe three ways through which fishing gear restrictions promote sustainable fisheries management. (3 marks)

c) Explain three reasons why minimum fish size limits are important in fisheries management. (3 marks)

QUESTION 4: FISHERIES MANAGEMENT APPROACHES (8 MARKS)

a) Define the term top-down approach to fisheries management. (2 marks)

b) State three advantages of the top-down approach. (3 marks)

c) Give three differences between top-down management and co-management approaches. (3 marks)

QUESTION 5: CO-MANAGEMENT AND FISHERIES CONSERVATION (8 MARKS)

a) Explain the meaning of fisheries co-management. (2 marks)

b) Describe four roles played by Beach Management Units in promoting sustainable fisheries management in Kenya. (4 marks)

c) State two challenges that may affect the successful implementation of co-management. (2 marks)

QUESTION 6: SUSTAINABLE FISHERIES MANAGEMENT IN KENYA (8 MARKS)

a) Identify four challenges facing fisheries management in Kenya. (4 marks)

b) Suggest four strategies that can be adopted to improve sustainable management of fisheries resources in Kenya. (4 marks)

MARKING SCHEME

GRADE 11 – MARINE TECHNOLOGY

STRAND 2.0: FISHERIES MANAGEMENT

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Award 1 mark for each correct answer.

Question	Answer
1	B
2	C
3	B
4	A
5	C
6	B
7	B
8	C
9	B
10	C
11	B
12	B
13	A
14	C
15	B
16	B
17	B
18	A
19	A
20	C
21	A
22	B
23	B
24	A
25	C
26	A
27	B

28	C
29	C
30	B

SECTION A TOTAL: 30 MARKS

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

QUESTION 1: TYPES OF FISHERIES RESOURCES (10 MARKS)

a) Define the term fisheries resources. (2 marks)

- Fisheries resources are aquatic organisms and other resources found in freshwater and marine environments that are useful to humans for food, income, employment, recreation and other economic activities. (2 marks)

b) Identify four major categories of fisheries resources. (4 marks)

Award 1 mark for each correct response.

1. Finfish.
2. Crustaceans.
3. Molluscs.
4. Echinoderms.

Accept: Marine mammals as another category of aquatic resources.

c) Give two examples of crustaceans found in fisheries environments. (2 marks)

Award 1 mark each.

1. Prawns.
2. Crabs.

Accept: Lobsters, crayfish and shrimps.

d) State two characteristics of marine mammals. (2 marks)

Award 1 mark each.

1. They breathe using lungs.
2. They give birth to live young.
3. They feed their young with milk.
4. They are warm-blooded.
5. They possess specialised adaptations for living in aquatic environments.

QUESTION 2: IMPORTANCE OF FISHERIES MANAGEMENT (8 MARKS)

a) Explain four reasons why fisheries resources should be managed sustainably. (4 marks)

Award 1 mark for each well-explained point.

1. Prevention of overfishing: Ensures fish populations are not depleted through excessive harvesting.
2. Conservation of biodiversity: Protects different aquatic species from extinction.
3. Protection of breeding populations: Allows fish to reproduce and maintain their populations.

4. Food security: Ensures continuous availability of fish as a source of food.
5. Employment creation: Supports livelihoods of fishermen and other people working in the fisheries sector.
6. Income generation: Promotes continued earnings from fishing and related activities.
7. Habitat conservation: Protects important aquatic ecosystems such as mangroves and coral reefs.
8. Sustainable development: Ensures fisheries resources remain available for future generations.

b) Explain four factors that influence the distribution of fisheries resources in aquatic environments. (4 marks)

Award 1 mark for each correctly explained factor.

1. Water temperature: Different aquatic organisms thrive within specific temperature ranges.
2. Dissolved oxygen: Fish are more abundant in areas with sufficient dissolved oxygen for respiration.
3. Food availability: Aquatic organisms concentrate in areas where sufficient food is available.
4. Water salinity: Different species prefer different levels of salt concentration.
5. Water depth: Some aquatic organisms prefer shallow waters, while others inhabit deeper waters.
6. Habitat availability: Mangroves, coral reefs and seagrass beds provide shelter, breeding and feeding grounds.
7. Water currents: Currents influence the distribution of nutrients, food and aquatic organisms.
8. Water pollution: Polluted environments may reduce the abundance and distribution of aquatic organisms.

QUESTION 3: FISHERIES MANAGEMENT MEASURES (8 MARKS)

a) Explain the meaning of a closed season in fisheries management. (2 marks)

- A closed season is a specified period during which fishing activities are temporarily prohibited or restricted in a particular water body or fishing area. (2 marks)

b) Describe three ways through which fishing gear restrictions promote sustainable fisheries management. (3 marks)

Award 1 mark for each correctly described point.

1. Preventing the capture of juvenile fish: Appropriate mesh sizes allow young fish to escape and grow to maturity.
2. Protecting endangered species: Restrictions on harmful fishing gear reduce the accidental capture of threatened aquatic organisms.
3. Reducing habitat destruction: Prohibiting destructive gear helps protect sensitive aquatic habitats such as coral reefs and seagrass beds.
4. Reducing bycatch: Selective fishing gear reduces the capture of non-target organisms.
5. Preventing destructive fishing: Restrictions discourage the use of explosives and poisonous substances.

c) Explain three reasons why minimum fish size limits are important in fisheries management. (3 marks)

Award 1 mark for each correctly explained point.

1. Allowing fish to reproduce: Ensures fish reach sexual maturity and reproduce before being harvested.

2. Maintaining fish populations: Protects juvenile fish and supports the replacement of harvested fish.
3. Preventing recruitment overfishing: Reduces excessive harvesting of young fish before they contribute to future generations.
4. Promoting sustainable harvesting: Ensures fish stocks remain productive over time.

QUESTION 4: FISHERIES MANAGEMENT APPROACHES (8 MARKS)

a) Define the term top-down approach to fisheries management. (2 marks)

- The top-down approach is a fisheries management system in which decisions, policies and regulations are mainly formulated and implemented by government authorities or central management institutions. (2 marks)

b) State three advantages of the top-down approach. (3 marks)

Award 1 mark for each correct response.

1. Promotes uniform fisheries regulations across different fishing areas.
2. Facilitates enforcement of fisheries laws and regulations.
3. Enables coordinated management of fisheries resources.
4. Provides clear leadership and administrative authority.
5. Allows government authorities to mobilise resources for fisheries conservation.
6. Facilitates the establishment of national fisheries policies.

c) Give three differences between top-down management and co-management approaches. (3 marks)

Award 1 mark for each correctly stated difference.

Top-down management	Co-management
1. Decisions are mainly made by government authorities.	Decisions are shared between government and stakeholders.
2. Community participation is usually limited.	Local communities actively participate in decision-making.
3. Management responsibilities are mainly centralised.	Management responsibilities are shared among stakeholders.
4. Regulations are mainly formulated by government institutions.	Regulations are developed through consultation and collaboration.
5. May have limited consideration of local knowledge.	Incorporates local knowledge and experiences.

Accept any three correct differences.

QUESTION 5: CO-MANAGEMENT AND FISHERIES CONSERVATION (8 MARKS)

a) Explain the meaning of fisheries co-management. (2 marks)

- Fisheries co-management is an approach in which government authorities, fishing communities and other stakeholders share responsibilities and decision-making powers in managing and conserving fisheries resources. (2 marks)

b) Describe four roles played by Beach Management Units (BMUs) in promoting sustainable fisheries management in Kenya. (4 marks)

Award 1 mark for each correctly described role.

1. Monitoring fishing activities: Help monitor fishing activities and promote compliance with fisheries regulations.
2. Combating illegal fishing: Identify and report illegal and destructive fishing practices.
3. Promoting community participation: Involve local fishing communities in fisheries management decisions.
4. Collecting fisheries information: Assist in gathering information on fish catches and fishing activities.
5. Conflict resolution: Help resolve disputes among fishermen and other fisheries stakeholders.
6. Environmental conservation: Promote the protection of mangroves, coral reefs and other aquatic habitats.
7. Sensitisation and education: Educate fishing communities on sustainable fishing practices.
8. Promoting responsible fishing: Encourage the use of approved fishing methods and equipment.

c) State two challenges that may affect the successful implementation of co-management. (2 marks)

Award 1 mark for each correct response.

1. Inadequate financial resources.
2. Conflicts among fisheries stakeholders.
3. Limited community participation.
4. Lack of awareness of fisheries regulations.
5. Political interference.
6. Poor enforcement of fisheries regulations.
7. Corruption and lack of accountability.
8. Inadequate technical knowledge and training.

QUESTION 6: SUSTAINABLE FISHERIES MANAGEMENT IN KENYA (8 MARKS)

a) Identify four challenges facing fisheries management in Kenya. (4 marks)

Award 1 mark for each correct response.

1. Illegal, unreported and unregulated fishing.
2. Overfishing and depletion of fish stocks.
3. Destruction of aquatic habitats such as mangroves and coral reefs.
4. Water pollution from industrial, agricultural and domestic waste.
5. Inadequate funding for fisheries management and research.
6. Weak enforcement of fisheries laws and regulations.
7. Climate change and rising water temperatures.
8. Conflicts among fishermen and other resource users.
9. Inadequate fisheries management equipment and technology.
10. Limited awareness of sustainable fishing practices.

b) Suggest four strategies that can be adopted to improve sustainable management of fisheries resources in Kenya. (4 marks)

Award 1 mark for each correctly suggested strategy.

1. Strengthening fisheries regulations: Enforce existing laws and penalties against illegal fishing.
2. Promoting co-management: Encourage active participation of local fishing communities in decision-making.
3. Establishing closed seasons: Restrict fishing during critical breeding and spawning periods.
4. Creating marine protected areas: Protect important breeding, feeding and nursery habitats.
5. Promoting aquaculture: Encourage fish farming to reduce pressure on wild fish stocks.
6. Restoring aquatic habitats: Rehabilitate degraded mangroves, coral reefs and seagrass beds.
7. Promoting environmental education: Educate fishermen on sustainable fishing methods.
8. Strengthening fisheries research: Support institutions such as Kenya Marine and Fisheries Research Institute (KMFRI) to improve fisheries information and management.
9. Controlling water pollution: Enforce proper waste disposal and pollution control measures.
10. Improving monitoring and surveillance: Use appropriate technology and patrols to detect illegal fishing activities.
11. Promoting selective fishing gear: Encourage fishing equipment that reduces bycatch and capture of juvenile fish.
12. Supporting fishing communities: Provide training, alternative livelihoods and appropriate fishing technologies.

STRAND 3.0: CAPTURE FISHERIES

SUB-STRAND 3.2: FISHING GEARS AND METHODS

1.0 INTRODUCTION TO FISHING GEARS AND METHODS

Fishing is an important economic activity in Kenya. It provides food, employment, income and raw materials for industries. It also contributes to tourism, trade and national economic development.

Fishing activities in Kenya take place in:

- The Indian Ocean along the Kenyan coastline.
- Lake Victoria, which supports a large freshwater fishing industry.
- Lake Turkana.
- Lake Naivasha.
- Lake Baringo.
- Rivers, dams and other inland water bodies.

Fishing involves the use of specialised equipment and techniques to catch fish and other aquatic organisms. The equipment used is referred to as fishing gear, while the techniques employed to capture fish are known as fishing methods.

Examples of fishing activities in Kenya include:

- Gill net fishing on Lake Victoria.
- Beach seine fishing in selected fishing areas.
- Longline fishing in marine waters.
- Handline fishing along the Indian Ocean coast.
- Trap fishing in shallow waters.
- Trawling in appropriate offshore fishing grounds.

1.1 Meaning of fishing gear

Fishing gear refers to the equipment, tools or devices used to capture fish and other aquatic organisms from water bodies.

Fishing gears are designed to capture fish of different sizes and species in different aquatic environments.

Examples include:

1. Fishing nets.
2. Hooks and lines.
3. Fish traps.
4. Harpoons and spears.
5. Trawl nets.
6. Seine nets.
7. Gill nets.
8. Longlines.

1.2 Meaning of fishing method

A **fishing method** refers to the technique or procedure used by fishers to catch fish using particular fishing gears.

Fishing methods explain how fishing equipment is operated to capture fish.

Examples include:

- Gill netting.
- Trawling.
- Longlining.
- Seining.
- Handlining.
- Trapping.
- Spearfishing.

1.3 Difference between fishing gear and fishing method

Fishing gear	Fishing method
Refers to equipment used to catch fish.	Refers to the technique used to catch fish.
Examples include nets, hooks and traps.	Examples include trawling, seining and longlining.
It is the physical fishing equipment.	It explains how the equipment is used.

Example: A gill net is fishing gear, while gill netting is the fishing method.

1.4 Relationship between fishing gear, fishing method and fishing environment

Fishing gear and methods must be suitable for the environment in which fishing takes place.

The fishing environment influences:

- The type of fishing gear selected.
- The fishing method employed.
- The size and design of fishing vessels.
- The type of fish species targeted.
- The depth at which fishing takes place.
- The safety measures required.

For example:

- Gill nets can be used in freshwater lakes and marine environments.
- Trawl nets are commonly operated by motorised fishing vessels.
- Fish traps are suitable for selected shallow-water environments.
- Longlines can be used in both marine and freshwater fisheries, depending on their design.

2.0 TYPES OF FISHING GEARS

Fishing gears can broadly be classified into two main categories:

1. Traditional fishing gears.
2. Modern fishing gears.

2.1 Traditional fishing gears

Traditional fishing gears are locally developed fishing equipment that have been used by fishing communities for many generations.

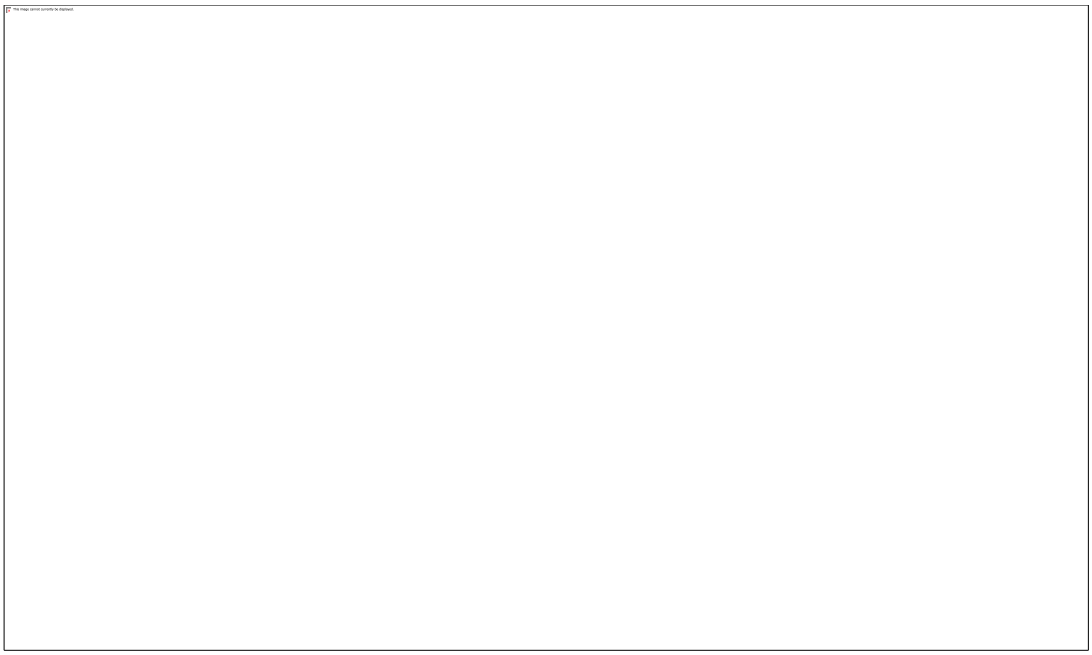
They are often constructed using locally available materials and operated manually.

Examples include:

- Fish pots and traps.
- Harpoons and spears.
- Traditional hooks and lines.
- Basket traps.
- Traditional cast nets.
- Hand-operated fishing nets.

A. Fish pots and traps

Definition: A fish trap is a device designed to attract and capture fish or other aquatic organisms while allowing them to enter but making it difficult for them to escape.



Materials used in constructing fish traps

Fish traps may be constructed using:

1. Bamboo.
2. Wooden strips.
3. Reeds.
4. Woven plant fibres.
5. Wire mesh.
6. Plastic mesh.

7. Metal frames.

Main parts of a fish trap

1. **Trap body:** The main enclosure where captured fish are retained.
2. **Entrance funnel:** A narrow opening that guides fish into the trap.
3. **Bait compartment:** A section where bait may be placed to attract fish.
4. **Escape opening:** An appropriately designed opening that may allow undersized fish to escape.
5. **Cover or closure:** Prevents captured fish from escaping.
6. **Anchoring system:** Holds the trap in the desired position.
7. **Marker float:** Helps fishers locate the trap.

How fish traps operate

1. The fisher prepares the trap.
2. Suitable bait is placed inside where necessary.
3. The trap is lowered into the water.
4. It is positioned in an area where the target fish are likely to occur.
5. Fish are attracted by the bait or enter while searching for food.
6. The entrance funnel makes it difficult for fish to swim out.
7. The fisher retrieves the trap after an appropriate period.
8. Captured fish are removed, sorted and handled properly.

Advantages of fish traps

- They are relatively easy to construct.
- They can be made using locally available materials.
- They can be reused.
- They may have low operating costs.
- They can be suitable for small-scale fishing.
- Properly designed traps can reduce damage to fish.

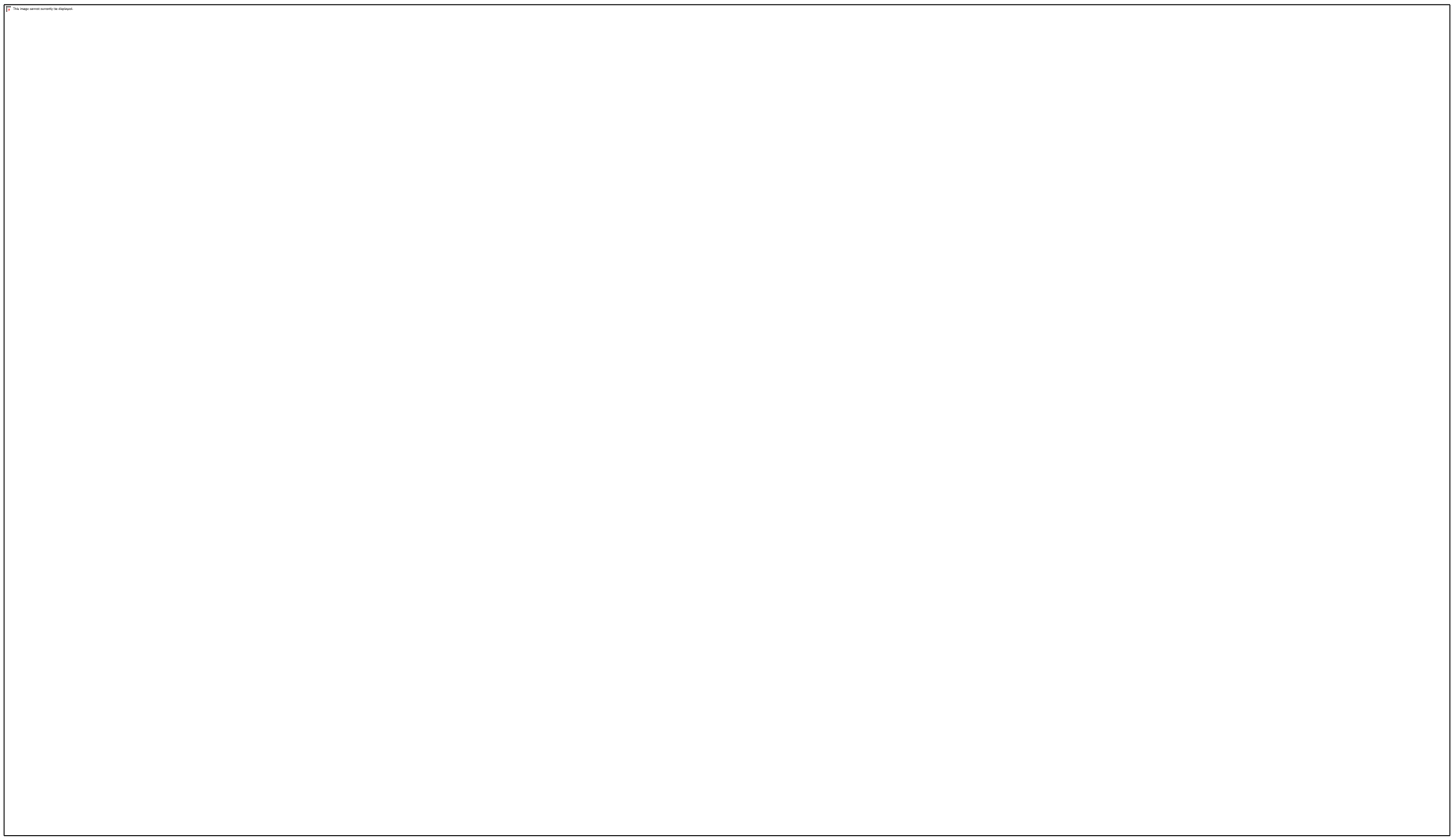
Disadvantages of fish traps

- They may capture relatively small quantities of fish.
- Some traps can be lost in water.
- Lost traps may continue capturing fish, a problem known as ghost fishing.
- They require regular inspection.
- They may capture unwanted species.
- Poorly designed traps may retain undersized fish.

Examples of use in Kenya: Traditional fish traps are used in some inland and coastal fishing communities, depending on local fishing practices and regulations.

B. Harpoons and spears

Definition: A harpoon is a pointed fishing instrument designed to pierce and secure a fish or other aquatic animal. A spear is a pointed tool used to strike and capture fish.



Main parts of a harpoon

1. Shaft or handle.
2. Pointed head.
3. Barbs or retaining mechanism, where fitted.
4. Connecting rope or line, where fitted.

How harpoon fishing is carried out

1. The fisher identifies the target fish.
2. The fish is observed carefully.
3. The fisher positions themselves at a suitable distance.
4. The harpoon is directed towards the target.
5. The instrument is released or thrust towards the fish.
6. The captured fish is secured and retrieved.

Advantages

- It is relatively simple to operate.
- It does not require complicated machinery.
- It allows the fisher to target individual fish.
- It may be inexpensive to maintain.

- It can be useful in clear, shallow water.

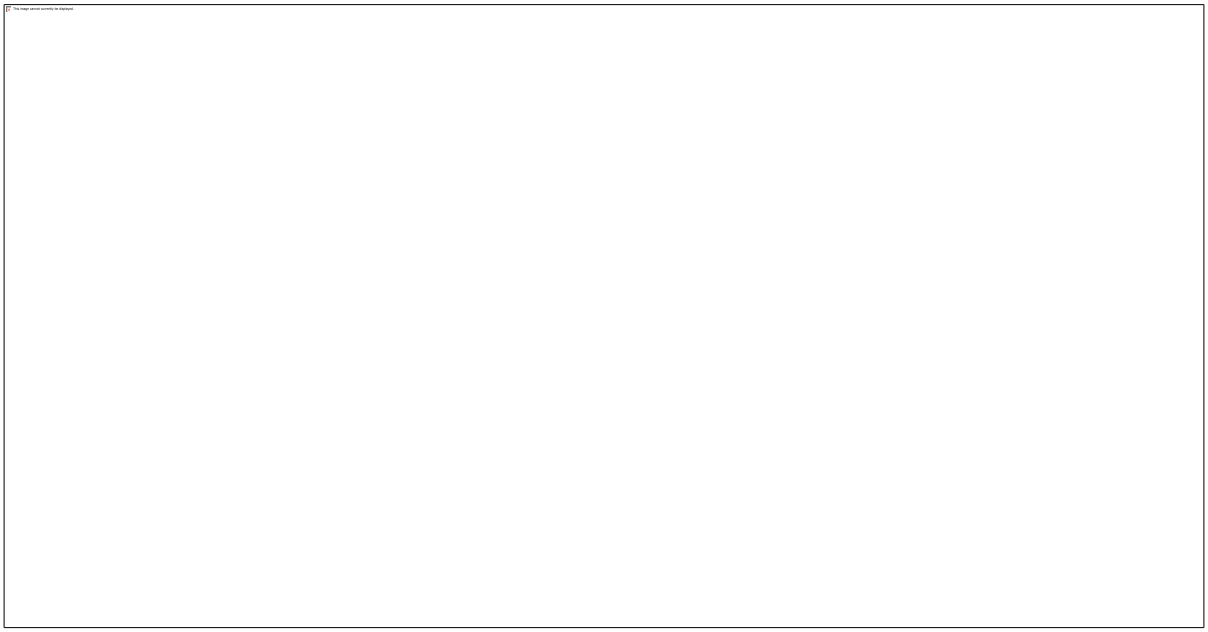
Disadvantages

- It requires considerable skill and accuracy.
- It may be dangerous to the fisher.
- It is difficult to use in deep or turbid water.
- It has a low catching capacity compared with some commercial gears.
- It may injure non-target aquatic animals.

Safety consideration: Fishers should use appropriate protective equipment and avoid spearfishing in prohibited areas or using prohibited techniques.

C. Traditional hooks and lines

This method uses a hook attached to a line, often with bait to attract fish.



Main components

- Fishing hook.
- Fishing line.
- Bait.
- Sinkers.
- Float, where required.
- Rod or handline holder, where applicable.

How it operates

1. Bait is attached to the hook.
2. The line is cast or lowered into the water.
3. The fisher waits for a fish to take the bait.
4. The fish bites and becomes hooked.
5. The line is pulled carefully.

6. The fish is removed from the hook.

Advantages

- It is affordable.
- It is easy to transport.
- It can target specific fish species.
- It may cause relatively little environmental disturbance.
- It is suitable for small-scale fishing.

Disadvantages

- It can be time-consuming.
- Catch quantities may be low.
- Fishers require patience and skill.
- Hooks may be lost in water.
- It may cause injury if handled carelessly.

2.2 Modern fishing gears

Modern fishing gears are improved fishing equipment designed using advanced materials, technology and construction techniques.

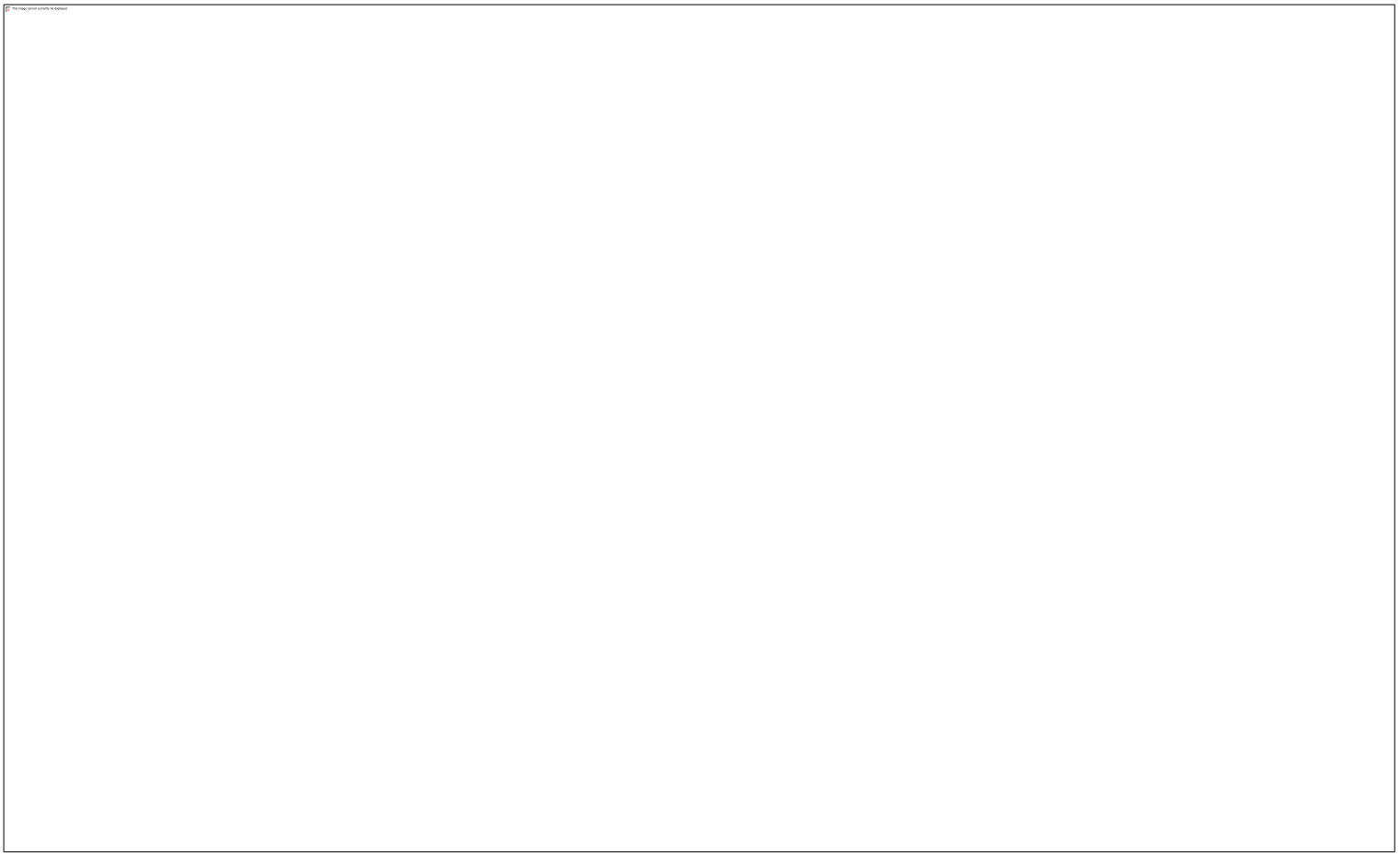
They may be operated manually or mechanically, depending on their design.

Examples include:

1. Gill nets.
2. Longlines.
3. Seine nets.
4. Trawl nets.
5. Purse seine nets.
6. Cast nets.
7. Lift nets.

A. Gill nets

Definition: A gill net is a fishing net designed to capture fish when they attempt to swim through its mesh openings and become entangled, commonly around their gills.



Main parts of a gill net

1. **Float line:** A rope fitted with floats to keep the upper part of the net near the water surface.
2. **Floats:** Devices that provide buoyancy.
3. **Netting panel:** The mesh material that captures fish.
4. **Sinker line:** A rope fitted with weights to keep the lower part of the net down.
5. **Sinkers:** Weights that help maintain the net's vertical position.
6. **End ropes:** Ropes used for handling and securing the net.
7. **Marker buoys:** Help identify the position of the net.

How gill net fishing is carried out

1. The fisher selects an appropriate fishing location.
2. The net is inspected to ensure that it is in good condition.
3. The net is deployed into the water.
4. Floats support the upper section.
5. Sinkers hold the lower section down.
6. Fish swimming into the net become entangled.
7. The net is retrieved.
8. Fish are carefully removed and sorted.

Types of gill nets

- **Surface gill nets:** Operate near the water surface.
- **Mid-water gill nets:** Operate within the middle water column.
- **Bottom-set gill nets:** Operate close to the bottom of the water body.
- **Drift gill nets:** Move with water currents or are allowed to drift in a controlled manner.

Advantages

- They can capture different fish species depending on mesh size.
- They are relatively easy to transport.
- They can be operated from small fishing boats.
- They can be used in freshwater and marine fisheries.
- They may have relatively low fuel requirements.

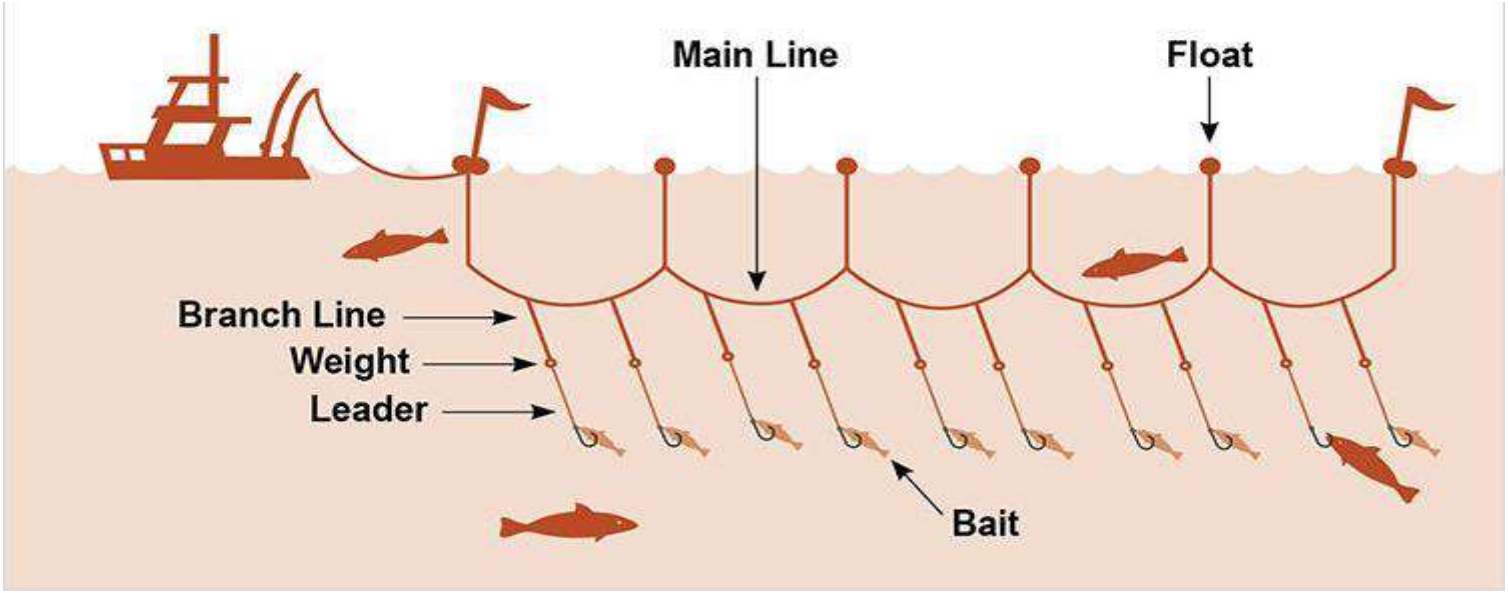
Disadvantages

- They may capture undersized fish.
- They may accidentally capture non-target species.
- Lost nets can cause ghost fishing.
- They may become damaged by rocks and submerged objects.
- They require proper inspection and maintenance.

Environmental consideration: Mesh size, net length, fishing location and soak time should comply with fisheries regulations to minimise bycatch and capture of immature fish.

B. Longlines

Definition: A longline is a fishing gear consisting of a long main line carrying several branch lines fitted with baited hooks.



Main parts of a longline

1. **Main line:** The long horizontal line supporting the fishing gear.
2. **Branch lines:** Short lines attached to the main line.
3. **Hooks:** Devices used to catch fish.

4. **Bait:** Material attached to hooks to attract fish.
5. **Floats:** Support the line and indicate its position.
6. **Weights:** Help maintain the desired fishing depth.
7. **Marker buoys:** Identify the position of the longline.
8. **Anchors:** Hold the gear in position where required.

Types of longlines

- **Surface longlines:** Operate near the water surface.
- **Mid-water longlines:** Operate within the water column.
- **Bottom longlines:** Operate close to the bottom of the water body.

How longline fishing is carried out

1. The fisher prepares the main line.
2. Branch lines are attached at suitable intervals.
3. Bait is fixed onto the hooks.
4. The longline is deployed into the water.
5. Floats and weights maintain the intended position.
6. Fish are attracted by the bait.
7. Fish take the bait and become hooked.
8. The longline is retrieved.
9. Captured fish are removed and the gear is prepared for reuse.

Advantages

- It can catch relatively large fish.
- It allows fishers to target particular species.
- It can be used in deep waters.
- It can cover extensive fishing grounds.
- It may produce high-quality fish when properly handled.

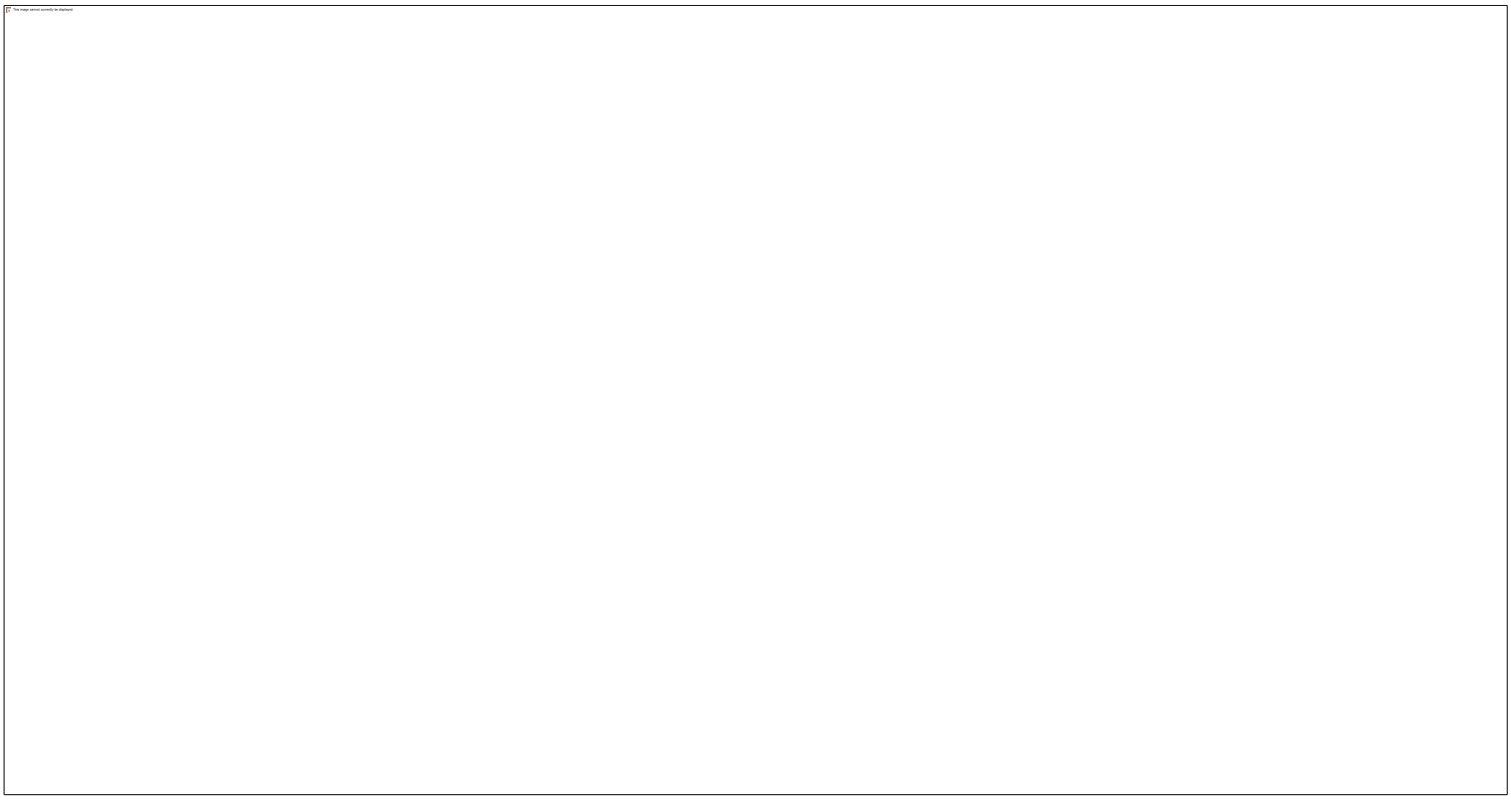
Disadvantages

- Hooks can capture non-target species.
- It requires careful bait preparation.
- Lost hooks and lines can pollute the environment.
- It requires considerable time to deploy and retrieve.
- It may capture seabirds, turtles and other protected animals if poorly managed.

Examples of fish caught using longlines: Tuna, swordfish and selected demersal fish, depending on the location and gear design.

C. Seine nets

Definition: A seine net is a fishing net designed to surround a group of fish and capture them by gradually bringing the net together.



Main parts of a seine net

1. **Wings:** The extended sections that guide and surround fish.
2. **Bunt:** The central section where fish are concentrated.
3. **Float line:** Supports the upper edge of the net.
4. **Floats:** Keep the upper edge near the water surface.
5. **Lead line:** The lower rope fitted with weights.
6. **Sinkers:** Keep the lower edge down.
7. **Hauling ropes:** Used to pull the net.
8. **Mesh:** The netting material used to retain fish.

Types of seine nets

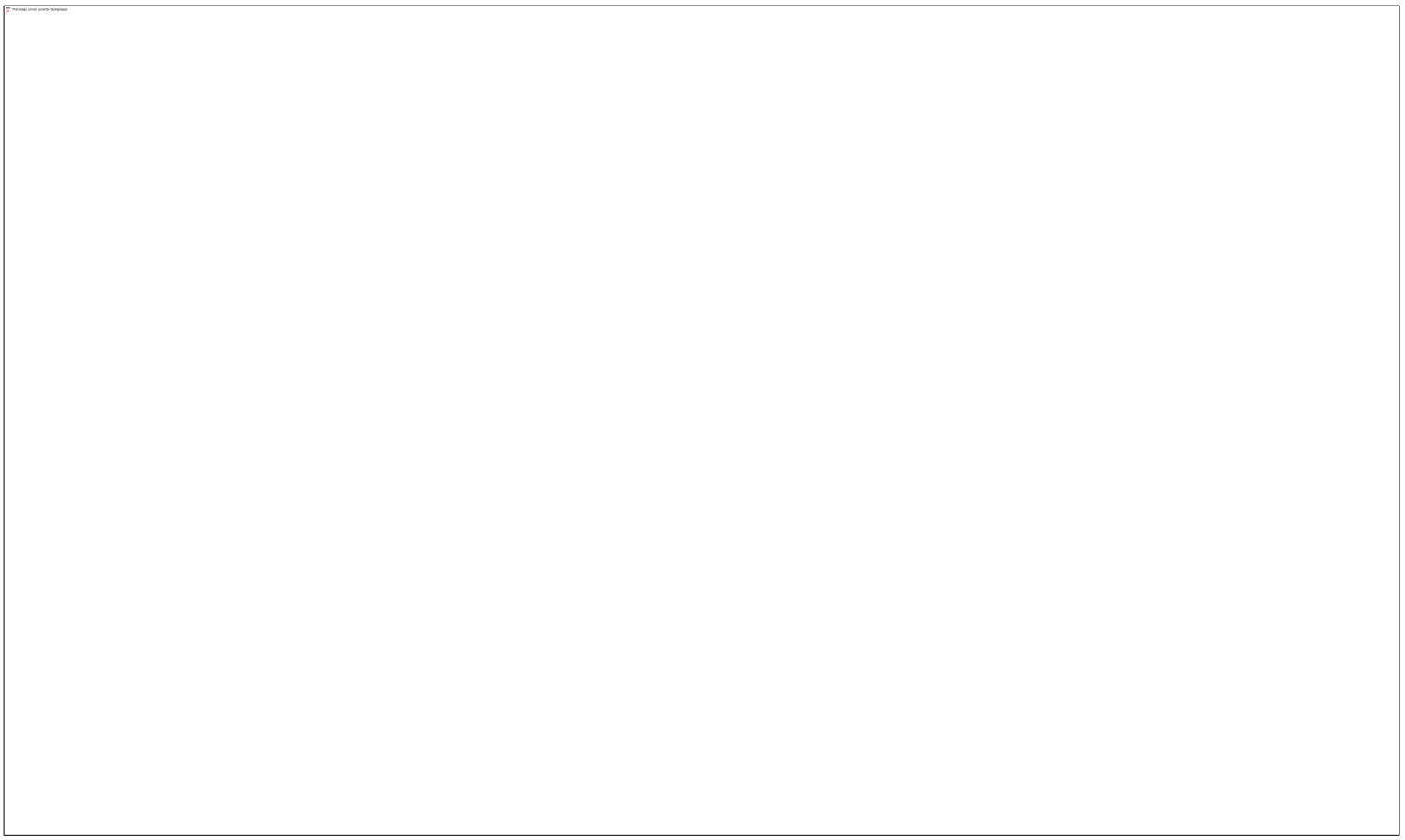
1. Beach seine

- It is operated from the shore.
- One end of the net is held on the beach.
- The net is taken around a group of fish using a boat or by wading where safe.
- The net is gradually hauled towards the shore.
- Fish are collected from the central section.

2. Purse seine

- It is operated from a fishing vessel.
- The net is deployed around a school of fish.

- The lower part of the net is drawn together using a purse line.
- This closes the bottom of the net, forming a purse-like enclosure.
- Fish are concentrated and brought aboard.



Advantages of seine nets

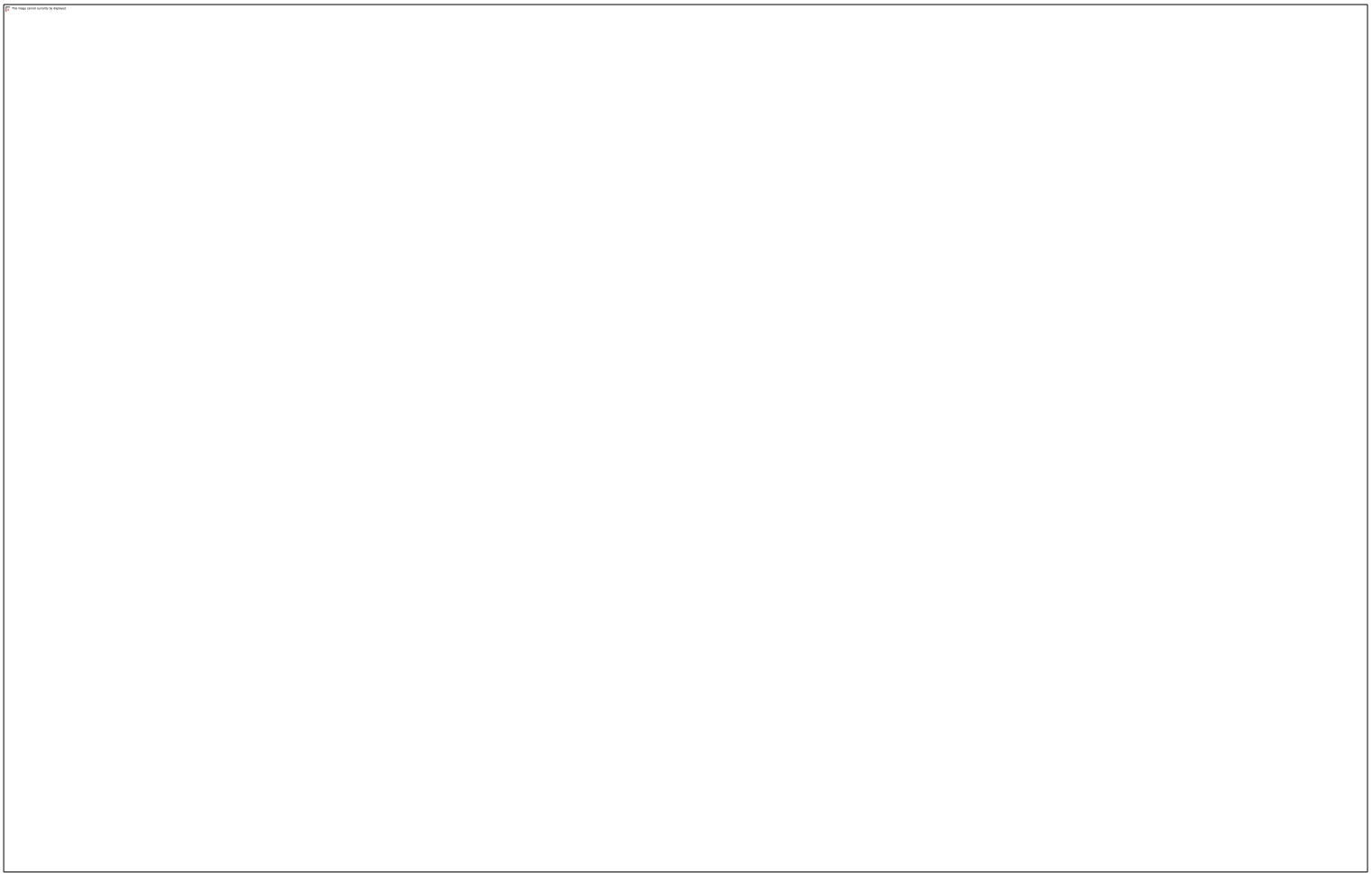
- They can capture large quantities of fish.
- They are effective when fish occur in schools.
- They can be used in different water environments.
- Purse seines can be efficient in commercial fishing.
- They allow fish to be harvested in groups.

Disadvantages

- They may capture juvenile fish.
- They may catch non-target species.
- Beach seining can disturb shallow-water habitats.
- They require several workers or specialised vessels.
- Poorly managed operations can cause overfishing.

D. Trawl nets

Definition: A trawl net is a cone-shaped fishing net towed through water by a fishing vessel to capture fish and other aquatic organisms.



Main parts of a trawl net

1. **Headline:** The upper rope of the net.
2. **Footrope or ground rope:** The lower rope of the net.
3. **Wings:** The side sections that guide fish towards the net opening.
4. **Net body:** The main section through which fish move.
5. **Codend:** The closed rear section where captured fish accumulate.
6. **Otter boards:** Boards that spread the net horizontally.
7. **Towing warps:** Strong cables connecting the trawl gear to the vessel.
8. **Floats:** Help keep the upper opening of the net raised.

Types of trawl nets

1. Bottom trawl

- It is dragged along or close to the seabed.
- It captures fish and other organisms living near the bottom.
- It is used to target selected demersal species.
- It can disturb seabed habitats if poorly managed.

2. Mid-water trawl

- It operates within the water column.
- It does not normally drag along the seabed.

- It captures fish swimming away from the bottom.
- It can be used to catch pelagic fish.

How trawl fishing is carried out

1. The fishing vessel moves to a suitable fishing ground.
2. The trawl net is prepared.
3. The net is lowered into the water.
4. Towing cables connect the net to the vessel.
5. Otter boards help spread the net.
6. The vessel tows the net through the water.
7. Fish enter through the net opening.
8. Captured fish move towards the codend.
9. The net is hauled aboard.
10. The fish are removed, sorted and stored.

Advantages

- It can capture large quantities of fish.
- It is suitable for commercial fishing.
- It can operate in deep waters.
- It can target particular groups of fish through appropriate gear design.
- It can be used with specialised fish-finding technology.

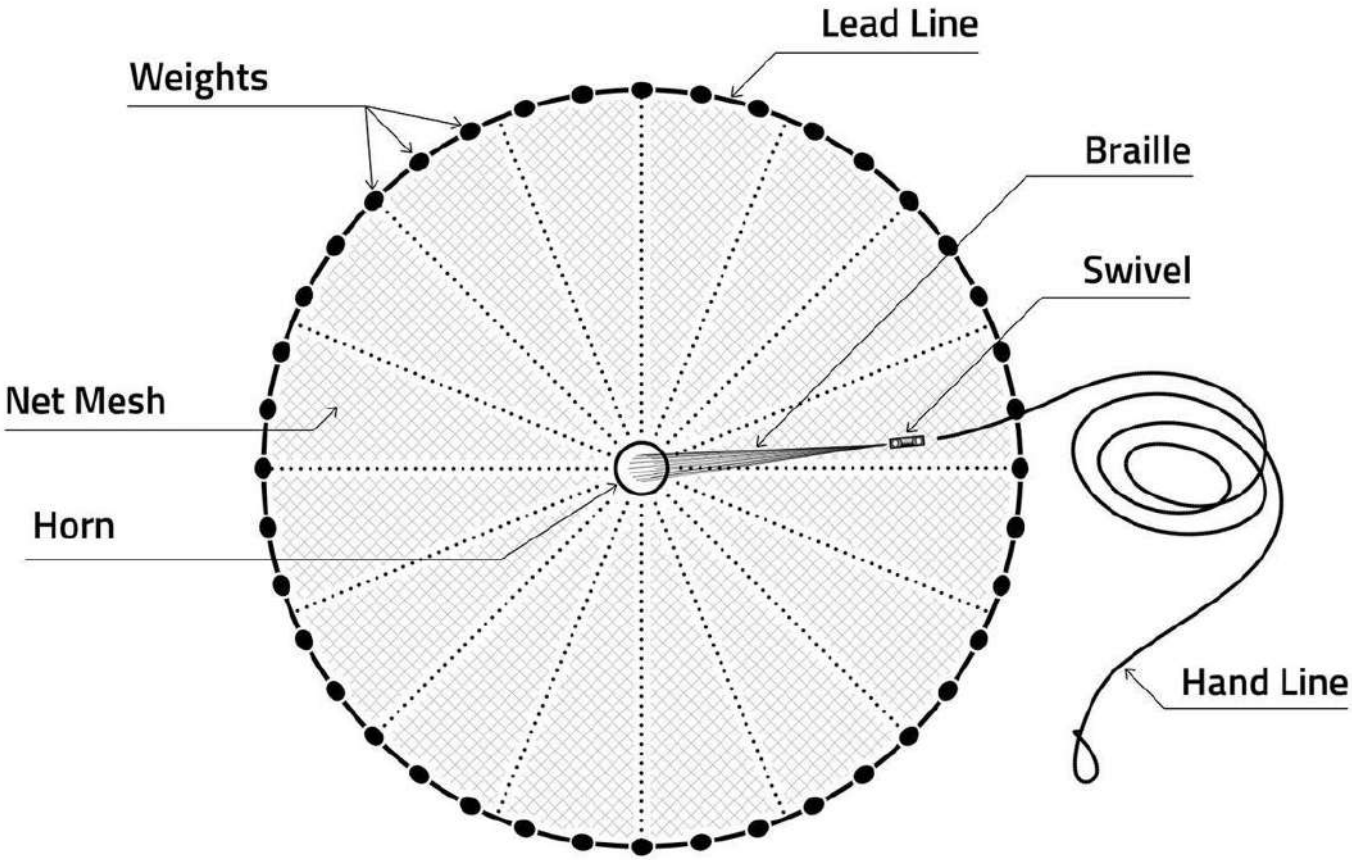
Disadvantages

- It requires expensive fishing vessels.
- It consumes considerable fuel.
- Bottom trawling can disturb seabed habitats.
- It may capture unwanted species.
- It requires trained crew members.
- It can contribute to overfishing if not properly regulated.

Environmental consideration: Trawling must be conducted in permitted areas using approved gear and methods. Sensitive habitats and protected areas must be avoided.

E. Cast nets

Definition: A cast net is a circular fishing net designed to be thrown by hand over a group of fish. It spreads out on the water surface and sinks around the fish.



Main parts

1. Netting material.
2. Central gathering line.
3. Lead weights.
4. Handline or retrieval rope.
5. Mesh openings.

How cast net fishing is carried out

1. The fisher prepares and folds the net properly.
2. The net is held carefully using the retrieval line.
3. The fisher identifies a suitable fishing area.
4. The net is thrown over the water.
5. It spreads into a circular shape.
6. The weighted edges sink and surround fish.
7. The fisher pulls the retrieval line.
8. The net closes and traps the fish.
9. The net is retrieved and the fish removed.

Advantages

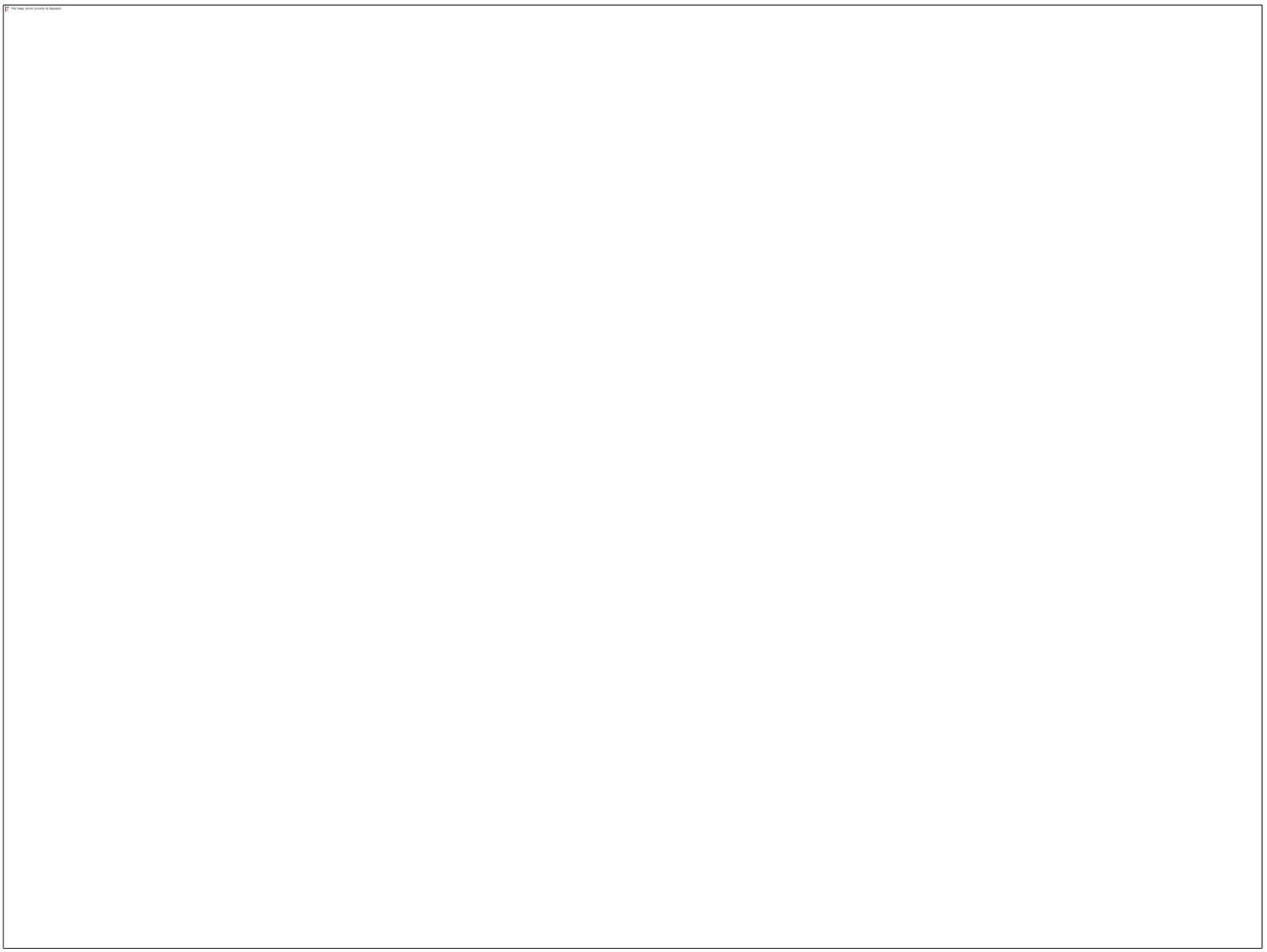
- It is relatively inexpensive.
- It can be operated by one person.
- It does not require a motorised vessel.
- It is easy to transport.
- It is suitable for small-scale fishing.

Disadvantages

- It requires skill to throw correctly.
- It may catch only small quantities of fish.
- It is less effective in very deep water.
- It may become entangled in underwater vegetation.
- It can capture undersized fish if inappropriate mesh is used.

F. Lift nets

Definition: A lift net is a fishing net that is lowered into water and later lifted to capture fish that have gathered above it.



Main parts

- Netting panel.
- Supporting frame.
- Lifting ropes.
- Supporting poles or mechanism.
- Bait or light source, where used.
- Retrieval mechanism.

How lift net fishing is carried out

1. The net is lowered into the water.
2. Fish are attracted above the net using bait or light where appropriate.
3. The fisher waits until sufficient fish gather.
4. The net is lifted quickly.
5. Fish are retained within the net.
6. The catch is removed.

Advantages

- It can be operated in selected shallow or sheltered waters.
- It is relatively simple to understand.
- It can be used for small-scale fishing.
- It allows fishers to monitor their catch.

Disadvantages

- It may have a limited catching capacity.
- It requires suitable fishing conditions.
- It may be less effective where fish do not gather above the net.
- It requires regular maintenance.

3.0 FACTORS TO CONSIDER WHEN SELECTING FISHING GEAR

The choice of fishing gear determines the efficiency, safety, profitability and sustainability of fishing operations.

Fishers should select equipment that suits the target species, fishing environment and applicable fisheries regulations.

3.1 Type and species of fish targeted

Different fish species have different body shapes, sizes, feeding habits and swimming behaviours.

Therefore, fishing gear should be selected according to the characteristics of the target fish.

Examples:

- Gill nets can be selected for fish of appropriate body size and shape.
- Longlines are suitable for fish attracted to bait.

- Purse seines are suitable for schooling fish.
- Trawl nets are used to capture selected fish species in the water column or near the bottom.
- Fish traps can capture fish that enter enclosed spaces.

3.2 Size of fish

The size of fish determines the appropriate mesh size, hook size and trap entrance dimensions.

- Large fish may require larger hooks.
- Small fish may escape through larger net meshes.
- Mesh sizes should be selected to minimise the capture of immature fish.
- Fishers should observe legal minimum size requirements.

3.3 Fishing environment

The physical characteristics of the fishing environment influence gear selection.

Factors include:

- Water depth.
- Water currents.
- Wave action.
- Water temperature.
- Visibility.
- Presence of aquatic vegetation.
- Nature of the seabed.
- Presence of rocks and submerged objects.

Examples:

- Strong currents may affect the positioning of gill nets.
- Rocky seabeds can damage bottom-set fishing gear.
- Shallow waters may be suitable for selected traps and cast nets.
- Deep-water fishing may require specialised vessels and longlines.

3.4 Availability and cost of fishing gear

The fisher should consider the purchase, repair and replacement costs of fishing equipment.

- Affordable equipment may be suitable for small-scale fishers.
- Expensive mechanised gear may be suitable for commercial fishing enterprises.
- Availability of spare parts should be considered.
- The cost of ropes, hooks, floats and netting should be evaluated.
- Long-term maintenance expenses should be considered.

3.5 Availability of fishing vessels

Some fishing gears require specialised fishing vessels.

Examples:

- Small canoes can support handline fishing.
- Motorised boats can support selected gill net and longline operations.
- Large trawlers are required for commercial trawling.
- Purse seiners are designed to operate purse seine nets.

The fisher should select gear that can be safely operated using the available vessel.

3.6 Skills and experience of fishers

Different fishing gears require different levels of technical knowledge.

- Trawling requires trained crew members.
- Longlining requires knowledge of hook arrangement and baiting.
- Gill netting requires knowledge of mesh sizes and net deployment.
- Spearfishing requires accuracy and safety awareness.
- Boat operators require knowledge of navigation and vessel handling.

3.7 Fishing regulations

Fishing equipment must comply with fisheries laws and regulations.

Fishers should consider:

- Permitted mesh sizes.
- Minimum legal fish sizes.
- Restricted fishing areas.
- Closed fishing seasons.
- Protected species.
- Permitted fishing methods.
- Licensing requirements.
- Restrictions on destructive fishing practices.

In Kenya, fishers should follow applicable national and county fisheries requirements and guidance from relevant fisheries authorities, including the Kenya Fisheries Service.

3.8 Catching capacity

The amount of fish expected to be caught should influence gear selection.

- Commercial fishers may require higher-capacity equipment.
- Small-scale fishers may use handlines and traps.
- Large schools of fish may be targeted using suitable purse seine nets.
- Individual fish may be targeted using hooks and lines.

3.9 Selectivity of fishing gear

Selectivity refers to the ability of fishing gear to capture the intended species and sizes while allowing unwanted fish and other organisms to escape.

Highly selective fishing gear helps reduce:

- Capture of juvenile fish.
- Bycatch.
- Capture of protected species.
- Wastage of unwanted fish.

3.10 Environmental impact

Fishing gear should cause minimal damage to aquatic ecosystems.

The fisher should consider:

- Whether the gear damages coral reefs.
- Whether it disturbs aquatic vegetation.
- Whether it causes seabed disturbance.
- Whether it captures non-target organisms.
- Whether lost equipment may continue trapping fish.
- Whether it contributes to habitat destruction.

3.11 Weather and water conditions

Fishing gear should be suitable for the prevailing weather and water conditions.

For example:

- Strong winds may make certain net operations dangerous.
- High waves may affect small fishing boats.
- Strong currents may move fishing gear away from the intended position.
- Poor visibility may make underwater operations difficult.

3.12 Labour requirements

Some fishing gears require many workers, while others can be operated by one or two fishers.

Examples:

- Handlines can be operated by an individual.
- Large seine nets may require several workers.
- Commercial trawling requires a trained crew.
- Mechanised longlining may require specialised equipment and crew.

3.13 Summary of factors to consider when selecting fishing gear

Factor	Explanation
Fish species	Gear should suit the targeted species.
Fish size	Mesh and hook sizes should be appropriate.
Water depth	Gear must operate effectively at the required depth.
Water conditions	Currents, waves and visibility influence gear choice.

Cost	Purchase and maintenance costs should be affordable.
Vessel availability	Gear should match the available fishing vessel.
Skills	Fishers must understand how to operate the gear.
Regulations	Gear must comply with fishing laws.
Selectivity	Gear should minimise unwanted catches.
Environment	Gear should minimise ecosystem damage.
Labour	Available workers should be sufficient.
Catching capacity	Gear should meet the intended fishing scale.

4.0 FISHING METHODS

Fishing methods refer to the techniques used to capture fish from aquatic environments.

The choice of method depends on the fishing gear, target species, fishing ground and available resources.

4.1 Gill netting

Gill netting is a fishing method in which fish are captured by becoming entangled in a vertically suspended net.

Procedure

1. Select a suitable fishing ground.
2. Prepare the gill net.
3. Check the mesh size and condition.
4. Deploy the net at the required depth.
5. Secure the net where necessary.
6. Allow fish to encounter the net.
7. Retrieve the net carefully.
8. Remove and sort the catch.
9. Record the catch and maintain the equipment.

Applications

- Capture of selected freshwater fish.
- Capture of selected marine fish.
- Small-scale and commercial fishing, where permitted.

4.2 Longline fishing

Longline fishing involves the use of a main line fitted with several baited hooks.

Procedure

1. Prepare the main fishing line.
2. Attach branch lines.
3. Fix bait onto the hooks.
4. Attach appropriate floats and weights.

5. Deploy the line into the water.
6. Allow fish to take the bait.
7. Retrieve the longline.
8. Remove captured fish.
9. Store and maintain the gear.

Applications

- Capture of tuna.
- Capture of swordfish.
- Capture of selected demersal fish.

4.3 Trawling

Trawling involves towing a cone-shaped fishing net through water using a fishing vessel.

Procedure

1. Identify a suitable fishing ground.
2. Prepare the trawl net.
3. Lower the net into the water.
4. Connect the towing cables.
5. Tow the net at an appropriate speed.
6. Allow fish to enter the net.
7. Haul the net onto the vessel.
8. Empty the codend.
9. Sort, preserve and store the catch.

Applications

- Commercial capture fisheries.
- Capture of selected bottom-dwelling fish.
- Capture of selected mid-water fish.

4.4 Seining

Seining involves surrounding fish with a net and gradually bringing the net together to capture them.

Procedure

1. Identify a school of fish.
2. Prepare the seine net.
3. Deploy the net around the fish.
4. Enclose the target fish.
5. Haul the net towards the boat or shore.
6. Concentrate fish in the central section.

7. Remove and sort the catch.

Applications

- Capture of schooling fish.
- Small-scale beach fishing.
- Commercial fishing using purse seine vessels.

4.5 Handline fishing

Handline fishing involves using a single fishing line or a small number of lines fitted with hooks.

Procedure

1. Prepare the fishing line.
2. Attach the appropriate hook.
3. Fix bait onto the hook.
4. Cast or lower the line.
5. Wait for fish to bite.
6. Pull the line carefully.
7. Remove the captured fish.

Applications

- Fishing in coastal waters.
- Fishing in lakes and rivers.
- Small-scale subsistence fishing.

4.6 Trapping

Trapping involves placing fish traps in suitable locations to capture fish entering them.

Procedure

1. Construct or prepare a trap.
2. Place bait inside if required.
3. Lower the trap into the water.
4. Secure it appropriately.
5. Leave it for the required period.
6. Retrieve and inspect the trap.
7. Remove captured fish.
8. Return undersized or unwanted fish where survival is likely and regulations permit.

4.7 Spearfishing

Spearfishing involves using a spear or harpoon to capture fish individually.

Procedure

1. Identify a suitable fishing area.
2. Locate the target fish.
3. Approach the fish carefully.
4. Aim the spear.
5. Strike the target accurately.
6. Secure the captured fish.
7. Retrieve and handle the catch safely.

Important safety measures

- Observe diving safety requirements.
- Avoid fishing alone when diving.
- Use suitable protective equipment.
- Never use spears in restricted areas.
- Avoid targeting protected aquatic species.

5.0 TYPES OF FISHING VESSELS

5.1 Meaning of a fishing vessel

A **fishing vessel** is a boat or ship designed, adapted or used for fishing activities, including the capture, handling, transportation and storage of fish.

Fishing vessels differ in:

- Size.
- Shape.
- Construction materials.
- Propulsion systems.
- Fishing equipment.
- Storage facilities.
- Fishing range.
- Intended fishing method.

In Kenya, fishing vessels are used in inland water bodies and along the Indian Ocean coastline.

5.2 Types of fishing vessels

A. Canoe

Definition: A canoe is a small, narrow boat traditionally made from a hollowed tree trunk or constructed using other suitable materials.



Characteristics

- Usually small in size.
- Narrow and elongated.
- May be constructed from wood or other materials.
- Often operated by one or a few fishers.
- Can be paddled or fitted with an engine.
- Suitable for selected nearshore fishing activities.

Uses

- Handline fishing.
- Selected gill net operations.
- Transportation of fishers and fishing equipment.
- Small-scale fishing in lakes and sheltered coastal waters.

Advantages

- Relatively affordable.
- Easy to handle in suitable conditions.
- Requires limited storage space.
- Can operate in shallow waters.

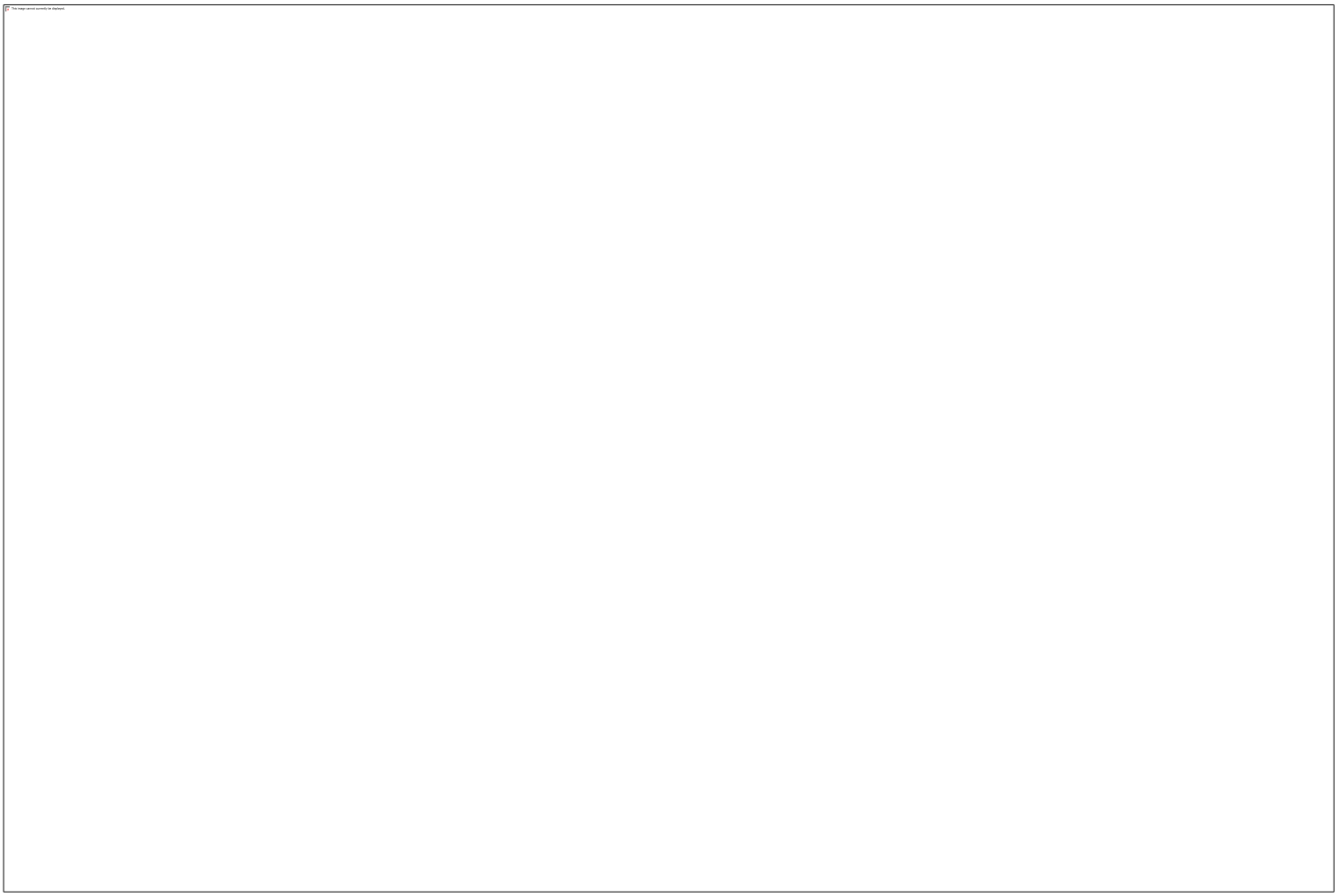
Disadvantages

- Limited carrying capacity.
- May be unstable in rough waters.

- Has limited operating range.
- Offers limited protection against bad weather.

B. Sailboat

Definition: A sailboat is a vessel that uses wind energy acting on sails to move through water.



Main parts

1. Hull.
2. Mast.
3. Sail.
4. Boom, where fitted.
5. Rudder.
6. Steering system.
7. Keel or centreboard, depending on design.
8. Ropes and rigging.

Characteristics

- Uses wind as its main source of propulsion.
- Requires knowledge of wind direction.
- Can operate without continuous engine fuel consumption.

- May be fitted with an auxiliary engine.
- Can be used in selected marine fishing activities.

Advantages

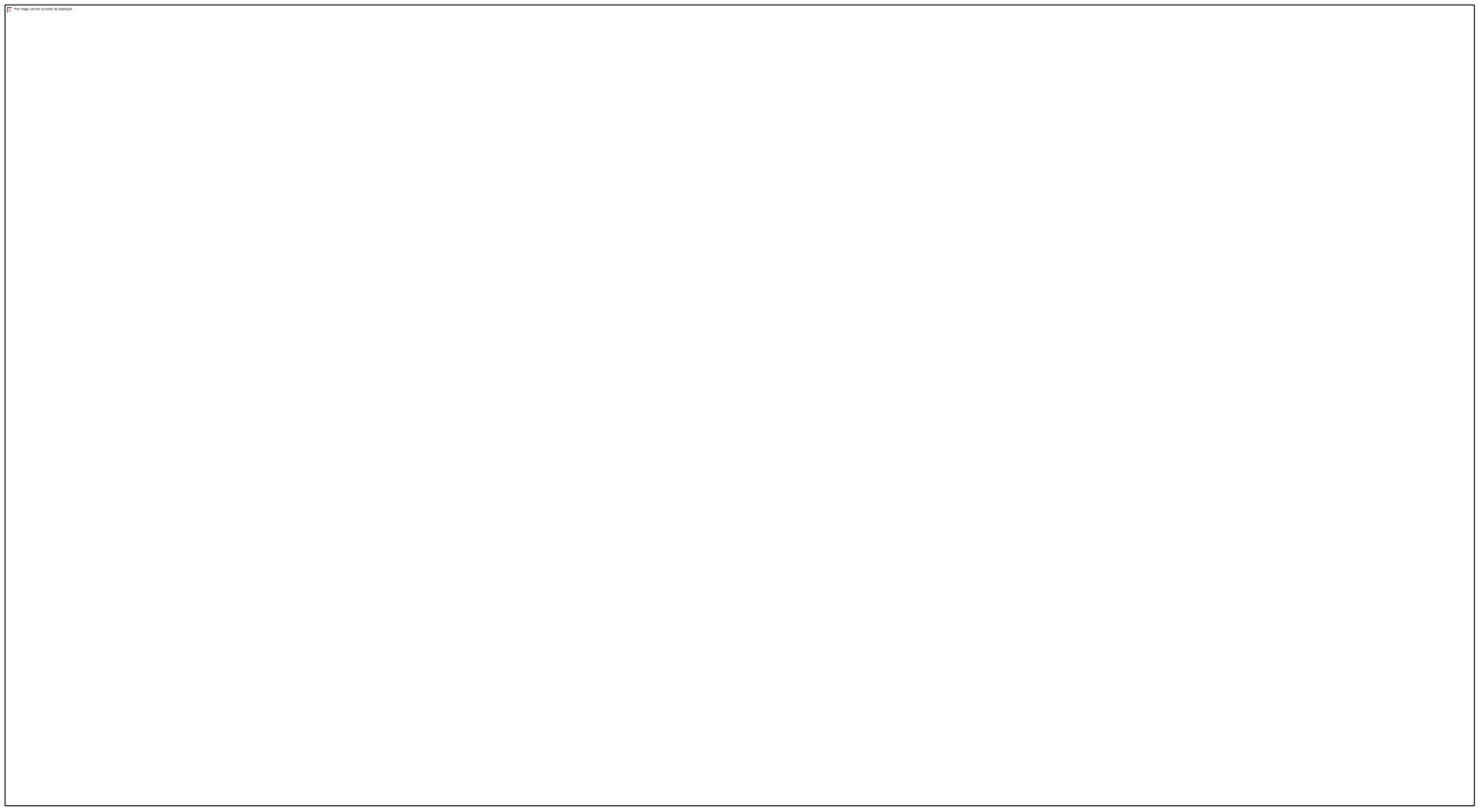
- Low fuel consumption.
- Uses renewable wind energy.
- Can cover considerable distances under favourable conditions.
- Has relatively low operating costs where maintained properly.

Disadvantages

- Depends on wind availability.
- Movement may be slow.
- Requires sailing skills.
- Strong winds and storms can make sailing dangerous.

C. Trawler

Definition: A trawler is a fishing vessel designed to tow trawl nets through water to capture fish.



Characteristics

- Usually motorised.
- Has a strong hull.
- Contains equipment for deploying and retrieving nets.
- May have fish storage and refrigeration facilities.
- Can operate offshore.

- Requires a trained crew.

Main equipment

- Trawl winches.
- Towing cables.
- Net handling equipment.
- Navigation instruments.
- Fish-finding equipment.
- Refrigeration or ice storage.

Uses

- Bottom trawling.
- Mid-water trawling.
- Commercial fishing.

Advantages

- Can operate over extensive fishing grounds.
- Can capture large quantities of fish.
- Supports mechanised fishing operations.
- Can have onboard fish preservation facilities.

Disadvantages

- High construction and maintenance costs.
- High fuel consumption.
- Requires specialised crew.
- May cause environmental damage if fishing is poorly managed.

D. Longliner

Definition: A longliner is a fishing vessel designed to deploy, operate and retrieve longline fishing gear.



Characteristics

- Has equipment for handling long fishing lines.
- May have bait preparation areas.
- Contains storage facilities for hooks and lines.
- May have refrigeration facilities.
- Can operate in offshore fishing grounds.

Uses

- Tuna fishing.
- Swordfish fishing.
- Selected deep-water fishing activities.

Advantages

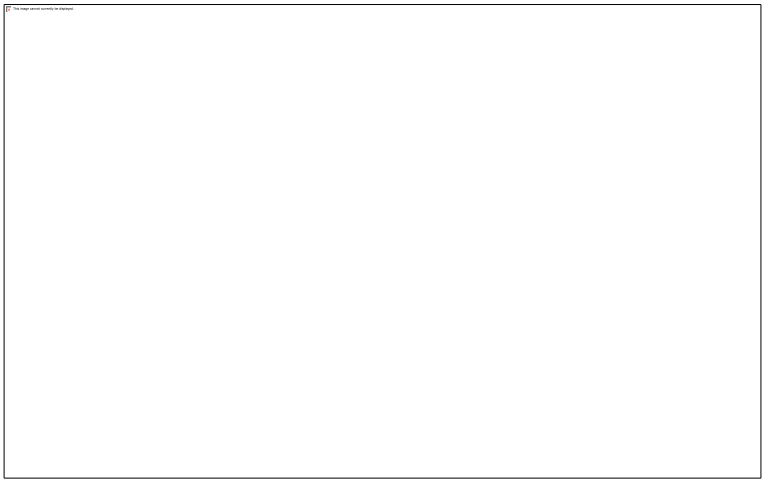
- Suitable for targeted fishing.
- Can operate over extensive fishing grounds.
- Can catch valuable commercial fish.
- Allows the use of different longline designs.

Disadvantages

- Requires trained operators.
- Hooks and lines can be lost.
- May capture seabirds and other non-target animals.
- Requires proper gear maintenance.

E. Purse seiner

Definition: A purse seiner is a fishing vessel designed to use purse seine nets to surround and capture schools of fish.



Characteristics

- Has a large deck.
- Carries specialised purse seine nets.
- Has net hauling equipment.

- Uses winches and power blocks.
- May use fish-finding equipment.
- Has fish storage facilities.

Uses

- Capture of schooling fish.
- Commercial fishing.
- Capture of selected pelagic species.

Advantages

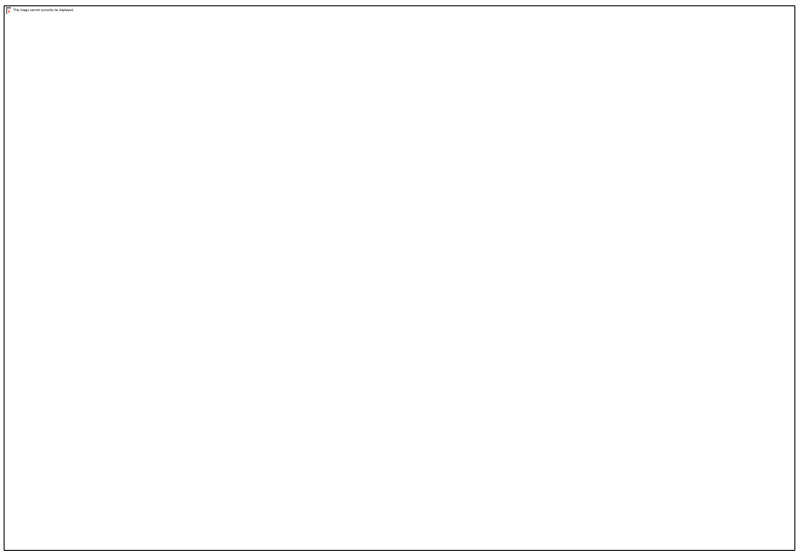
- Can capture large schools of fish.
- Efficient for suitable schooling species.
- Can support large-scale fishing enterprises.
- May reduce the need to chase individual fish.

Disadvantages

- Expensive to purchase and operate.
- Requires skilled crew.
- May capture unwanted species.
- Requires careful management to avoid excessive harvesting.

F. Gill netter

Definition: A gill netter is a fishing vessel specially designed or adapted to deploy and retrieve gill nets.



Characteristics

- Has space for storing nets.
- May have net hauling equipment.
- Contains suitable deck arrangements.
- Can be motorised or manually operated depending on size.
- May be fitted with navigation equipment.

Uses

- Gill net fishing.
- Selected freshwater fishing operations.
- Selected marine fishing operations.

Advantages

- Designed specifically for gill net operations.
- Can improve net handling.
- Can operate in different fishing environments.
- May be less expensive than large commercial trawlers.

Disadvantages

- Lost nets can cause ghost fishing.
- Requires frequent net inspection.
- May capture non-target species.
- Its effectiveness depends on suitable fishing conditions.

5.3 Comparison of fishing vessels

Fishing vessel	Main fishing activity	Typical propulsion
Canoe	Handline and selected net fishing	Paddles or engine
Sailboat	Selected marine fishing	Wind
Trawler	Trawling	Motorised engine
Longliner	Longline fishing	Motorised engine
Purse seiner	Purse seine fishing	Motorised engine
Gill netter	Gill net fishing	Engine or other suitable means

6.0 MODES OF PROPULSION OF FISHING VESSELS

6.1 Meaning of propulsion

Propulsion refers to the force or mechanism that moves a vessel through water.

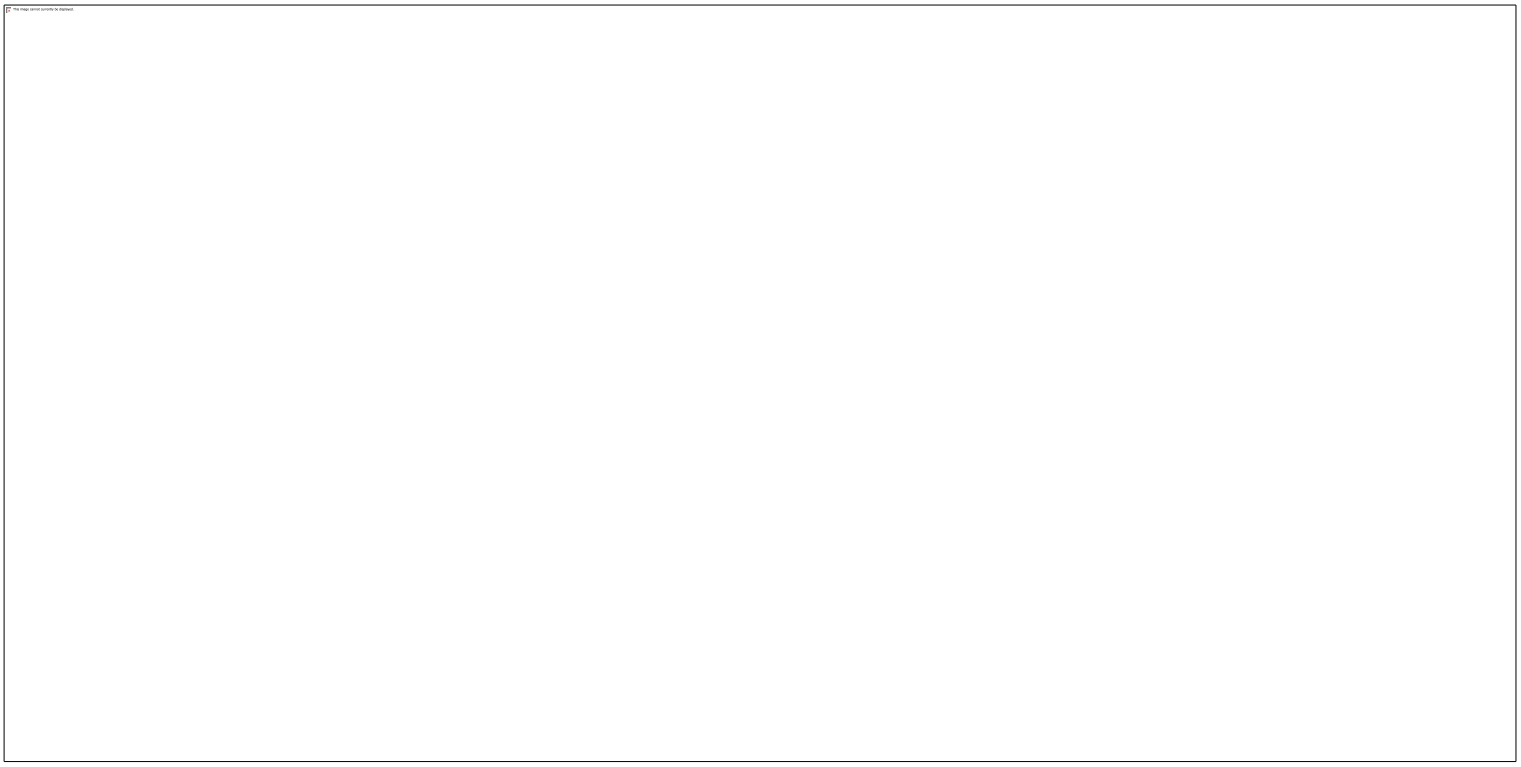
Fishing vessels use different propulsion systems depending on their size, design, fishing location and intended activities.

The main modes of propulsion include:

1. Paddling.
2. Sailing.
3. Motorised propulsion.

A. Paddled propulsion

Paddled propulsion involves moving a boat through water using paddles operated by human effort.



How it works

1. The paddler holds a paddle firmly.
2. The paddle blade is placed into the water.
3. The paddler pushes water backwards.
4. The reaction force moves the boat forwards.
5. The process is repeated to maintain movement.

Characteristics

- Depends on human energy.
- Suitable for small boats.
- Does not require fuel.
- Operates best in relatively calm waters.

Advantages

- Low operating cost.
- Simple equipment.
- No fuel pollution.
- Easy to maintain.
- Suitable for small-scale fishing.

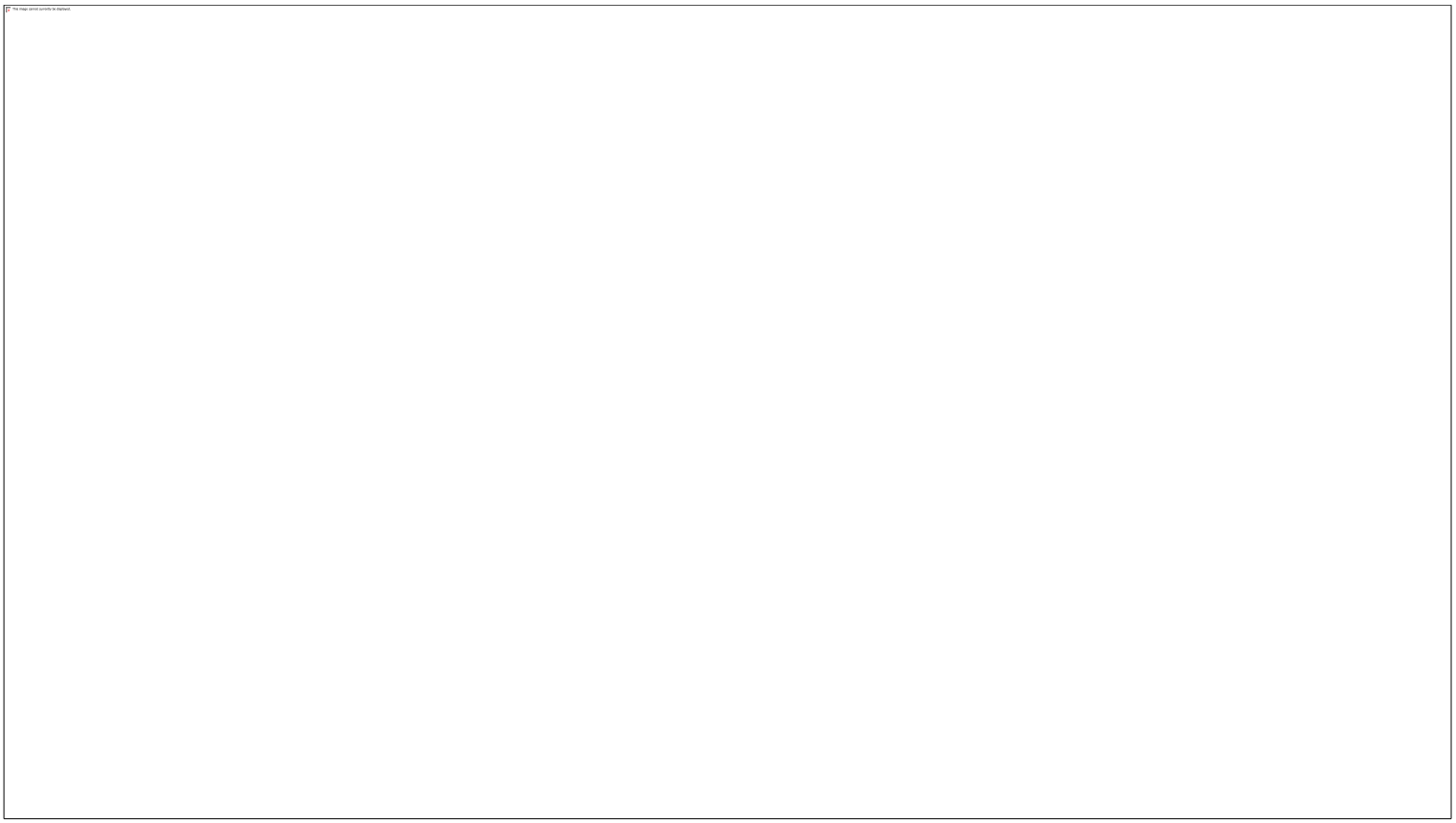
Disadvantages

- Requires physical strength.

- Movement is relatively slow.
- Limited travelling distance.
- Not suitable for heavy loads.
- Difficult to operate in rough waters.

B. Sail propulsion

Sail propulsion uses wind energy to move a vessel.



How it works

1. Wind acts on the sail.
2. The sail produces a force.
3. The hull and underwater surfaces help the vessel respond to the force.
4. The vessel moves in a direction determined by wind conditions and sailing technique.
5. The sailor adjusts the sail to control movement.

Advantages

- Uses renewable wind energy.
- Reduces fuel costs.
- Can operate over long distances under suitable conditions.
- Produces no direct engine exhaust emissions.

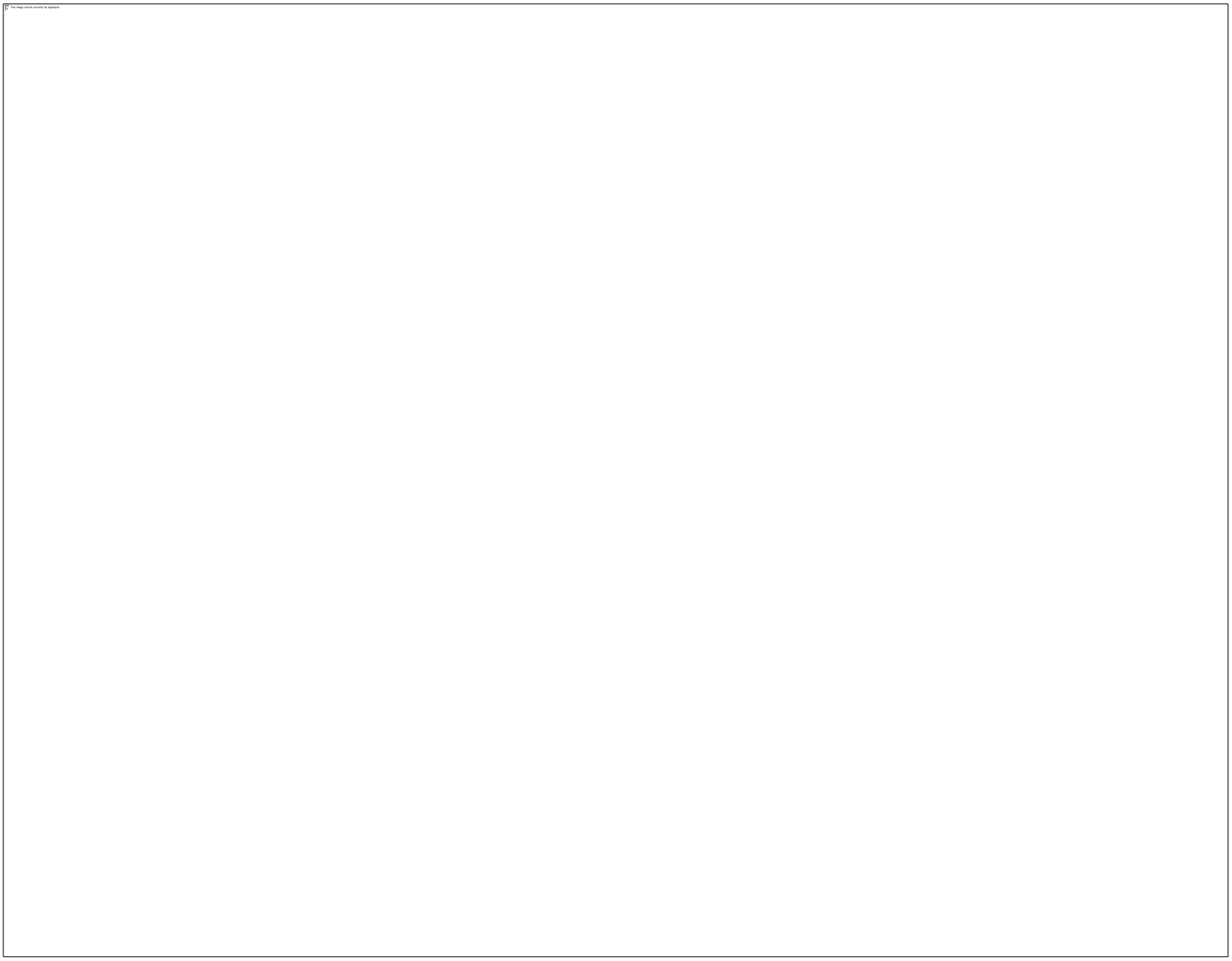
Disadvantages

- Depends on wind availability.
- Requires sailing skills.

- May be difficult to manoeuvre in some conditions.
- Strong winds can create safety risks.
- Movement may be slow during calm weather.

C. Motorised propulsion

Motorised propulsion uses an engine to drive a propeller or another propulsion device that moves the vessel.



Main components

1. Engine.
2. Fuel system.
3. Transmission system.
4. Propeller or propulsion device.
5. Steering mechanism.
6. Cooling system.
7. Exhaust system.

How it works

1. Fuel or electrical energy powers the engine.
2. The engine produces mechanical energy.
3. The transmission system transfers rotational movement to the propeller or propulsion device.
4. The propeller pushes water backwards.
5. The reaction force moves the vessel forwards.
6. The steering system controls the direction of movement.

Types of motorised propulsion

1. Outboard engine

- Mounted outside the rear of a boat.
- Contains the engine and propeller assembly.
- Can be tilted out of the water.
- Commonly used on small fishing boats.

2. Inboard engine

- Installed inside the hull.
- Connected to a propeller shaft.
- Commonly used on larger vessels.

3. Inboard-outboard engine

- Engine is installed inside the boat.
- The drive unit is fitted through the rear section of the vessel.
- Combines features of inboard and outboard systems.

4. Electric motor

- Uses electrical energy stored in batteries.
- Drives a propeller.
- May be suitable for small boats and selected fishing operations.

Advantages of motorised propulsion

- High speed.
- Suitable for long-distance fishing.
- Can carry heavier loads.
- Reduces physical effort.
- Supports commercial fishing operations.
- Can operate under different wind conditions.

Disadvantages

- High initial purchase cost.
- Requires fuel or electrical charging.

- Requires regular servicing.
- Engine breakdowns may interrupt fishing.
- Fuel leakage and exhaust emissions may pollute water.
- Noise may disturb aquatic organisms.

6.2 Comparison of propulsion modes

Feature	Paddled	Sail	Motorised
Source of energy	Human effort	Wind	Fuel or electricity
Speed	Low	Variable	Generally high
Operating cost	Low	Relatively low	Relatively high
Skills required	Basic paddling skills	Sailing skills	Engine operation skills
Suitable vessel	Canoe	Sailboat	Motorised boat
Fuel required	No	Not normally	Depends on engine type
Weather dependence	Water conditions	Wind conditions	Less dependent on wind

7.0 PARTS OF A FISHING BOAT

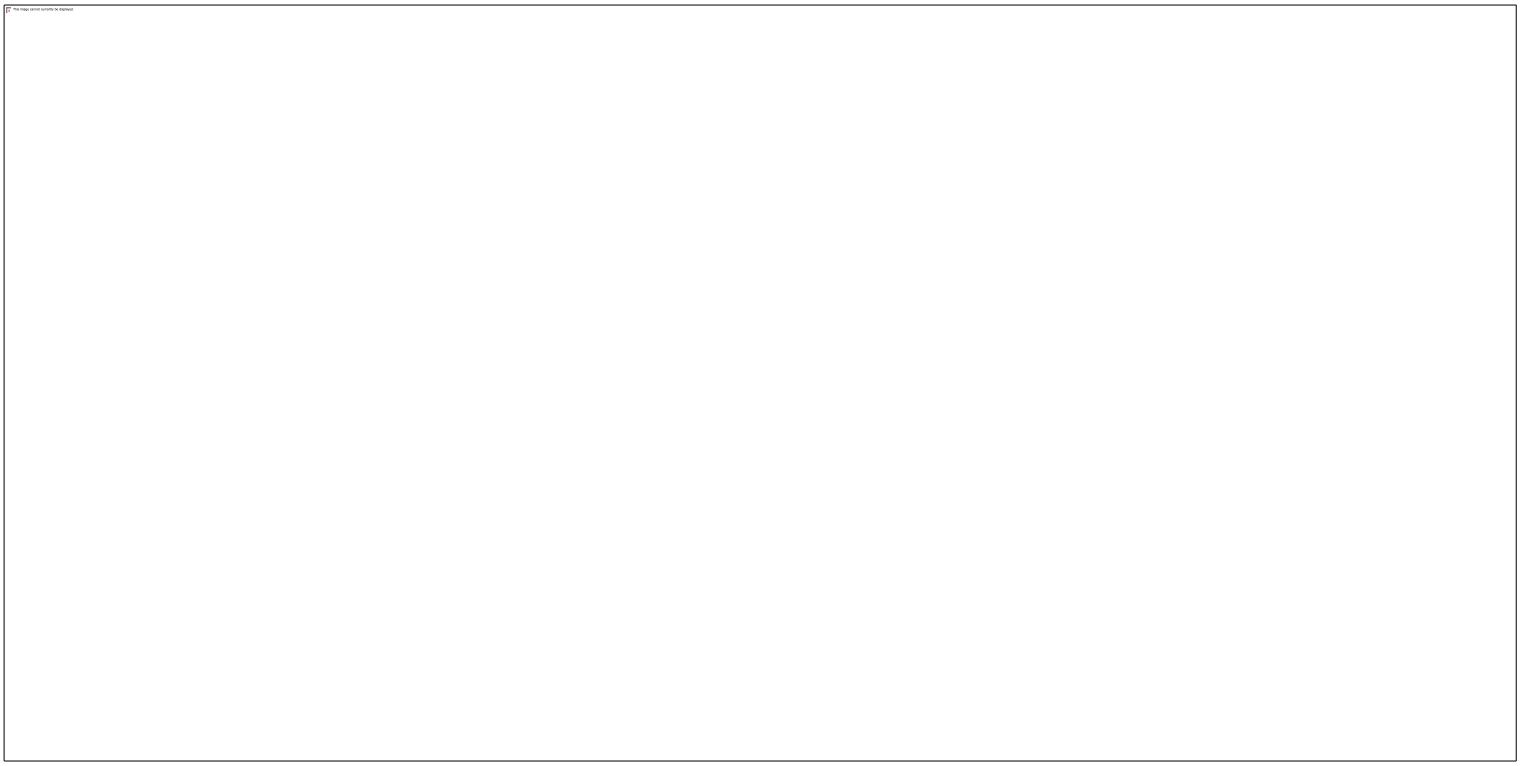
7.1 Meaning of a fishing boat

A fishing boat is a watercraft used by fishers to travel to fishing grounds, deploy fishing equipment, capture fish and transport the catch to landing sites.

Fishing boats are designed to provide:

- Stability.
- Buoyancy.
- Safety.
- Ease of movement.
- Adequate storage.
- Space for fishing equipment.
- Protection against water conditions.

7.2 Basic parts of a fishing boat



The following are the major parts of a typical fishing boat.

1. Bow

The bow is the front section of a boat.

Functions:

- Cuts through water as the boat moves.
- Helps determine the direction of movement.
- Is designed to reduce water resistance.
- Provides the forward section of the hull.

2. Stern

The stern is the rear section of a boat.

Functions:

- Provides space for mounting an outboard engine in suitable boats.
- Supports the steering and propulsion systems.
- Provides access for certain fishing operations.
- Forms the rear part of the hull.

3. Hull

The hull is the main body or outer structure of a boat that floats on water.

Functions:

- Provides buoyancy.
- Supports the weight of the boat, crew and equipment.
- Protects internal components.

- Determines much of the boat's shape and water resistance.

4. Keel

The keel is a structural member running along the bottom centreline of a boat.

Functions:

- Strengthens the boat's structure.
- Helps maintain directional stability.
- Reduces sideways movement in certain boat designs.
- Supports the lower structure of the hull.

5. Gunwale

The gunwale is the upper edge or reinforced rim of the sides of a boat.

Functions:

- Strengthens the upper edges.
- Provides support to the boat's sides.
- Helps protect the edges from damage.
- May provide attachment points for equipment.

6. Deck

The deck is the horizontal surface covering part or all of the upper section of a boat.

Functions:

- Provides working space for fishers.
- Provides space for handling fishing gear.
- Supports crew movement.
- May provide access to storage compartments.

7. Transom

The transom is the relatively flat or shaped structural section forming the rear end of many boats.

Functions:

- Supports an outboard engine where fitted.
- Strengthens the rear of the hull.
- Provides mounting points for selected equipment.

8. Rudder

A rudder is a movable underwater steering surface used to control the direction of a vessel.

Functions:

- Changes the direction of the vessel.
- Helps maintain the desired course.
- Improves manoeuvrability.

9. Propeller

A propeller is a rotating device with blades that pushes water backwards to move a motorised boat forwards.

Functions:

- Produces thrust.
- Moves the vessel through water.
- Supports controlled vessel movement.

10. Mast

A mast is a vertical pole that supports sails and related equipment on a sailing vessel.

Functions:

- Supports the sail.
- Provides attachment points for rigging.
- Helps maintain the sail's position.

11. Sail

A sail is a fabric or other suitable material designed to capture wind energy to propel a sailing vessel.

Functions:

- Captures wind energy.
- Produces force for vessel movement.
- Helps control the sailing direction and speed.

12. Anchor

An anchor is a heavy device connected to a rope or chain and lowered into water to hold a vessel in position.

Functions:

- Prevents unwanted drifting.
- Holds the vessel in a selected position.
- Supports safe stopping during fishing operations.

13. Bilge

The bilge is the lowest internal section of a boat where water may collect.

Functions:

- Collects water entering the boat.
- Provides an area from which unwanted water can be removed.
- Helps with water management inside the vessel.

14. Fish hold

A fish hold is a storage compartment used to keep harvested fish before they are unloaded.

Functions:

- Stores the catch.
- Protects fish from damage.
- May contain ice or refrigeration facilities.
- Helps maintain fish quality.

15. Steering system

The steering system consists of equipment used to control the direction of a boat.

It may include:

- Steering wheel.
- Steering cables.
- Rudder.
- Control mechanisms.

Functions:

- Controls the direction of travel.
- Supports navigation.
- Helps avoid obstacles.

7.3 Drawing and labelling a simple fishing boat

A learner should be able to draw a simple fishing boat and identify its major parts.



Procedure for drawing a fishing boat

1. Draw an elongated boat-shaped outline.

2. Shape the front section to represent the bow.
3. Draw the rear section to represent the stern.
4. Draw the upper edge of the hull.
5. Indicate the deck.
6. Draw the keel underneath the hull.
7. Draw the steering system.
8. Add an outboard engine or propeller where appropriate.
9. Add a fish storage compartment.
10. Draw clear label lines pointing to each part.

Important drawing skills

- Use a sharp pencil.
- Draw clear outlines.
- Use straight label lines.
- Avoid crossing label lines.
- Write labels neatly.
- Ensure that all parts are correctly positioned.

8.0 FISHING GEAR HANDLING, MAINTENANCE AND STORAGE

Fishing gears are valuable assets in fishing enterprises. Proper handling and maintenance increase their lifespan and improve fishing efficiency.

8.1 Importance of maintaining fishing gears

1. **Improves efficiency:** Well-maintained equipment performs its intended function effectively.
2. **Reduces repair costs:** Early identification of damage prevents expensive repairs.
3. **Improves safety:** Damaged ropes, nets and hooks may cause accidents.
4. **Increases durability:** Proper maintenance extends equipment lifespan.
5. **Reduces environmental pollution:** Proper storage prevents gear loss.
6. **Maintains catch quality:** Functional equipment helps reduce unnecessary damage to fish.

8.2 Methods of maintaining fishing gears

A. Cleaning

- Remove mud, seaweed and other materials from nets.
- Wash equipment after use.
- Remove fish remains and other organic matter.
- Use suitable cleaning materials.

B. Drying

- Dry nets and ropes properly before storage.

- Avoid leaving wet equipment in enclosed spaces for long periods.
- Store equipment in a dry, ventilated area.

C. Repairing damaged equipment

- Repair torn netting.
- Replace broken floats.
- Repair damaged ropes.
- Replace blunt, corroded or damaged hooks.
- Check trap entrances and closures.

D. Proper storage

- Store nets in a clean, dry place.
- Keep hooks in secure containers.
- Coil ropes neatly.
- Protect equipment from direct sunlight where necessary.
- Keep sharp equipment away from children.

E. Inspection

- Inspect nets before and after fishing.
- Check knots and connections.
- Examine ropes for signs of wear.
- Check floats and sinkers.
- Inspect engines and other mechanical components.

8.3 Consequences of poor fishing gear maintenance

- Reduced fishing efficiency.
- Increased operational costs.
- Frequent equipment breakdowns.
- Loss of fishing gear.
- Accidents and injuries.
- Environmental pollution.
- Reduced income.
- Poor quality of harvested fish.

9.0 SAFETY MEASURES WHEN USING FISHING GEARS AND VESSELS

Fishing involves risks associated with water, machinery, sharp equipment and changing weather conditions.

Fishers should observe safety measures to prevent accidents.

9.1 Personal safety measures

1. Wear an appropriate life jacket when on a boat.

2. Wear suitable protective clothing.
3. Use gloves when handling fishing nets and hooks.
4. Avoid standing on unstable sections of a boat.
5. Avoid handling sharp hooks carelessly.
6. Follow instructions from the vessel operator.
7. Avoid overloading fishing boats.
8. Maintain communication with people on shore.
9. Carry first-aid supplies.
10. Avoid fishing during dangerous weather conditions.

9.2 Vessel safety measures

- Inspect the hull before departure.
- Check the engine and fuel system.
- Carry suitable navigation equipment.
- Ensure that safety equipment is available.
- Check weather forecasts.
- Carry communication devices.
- Ensure that the vessel has adequate fuel.
- Check the condition of ropes and anchors.
- Ensure that the vessel has appropriate emergency equipment.

9.3 Environmental safety measures

- Avoid fishing in protected areas without authorisation.
- Do not use poisonous substances to catch fish.
- Avoid destructive fishing practices.
- Use appropriate mesh sizes.
- Retrieve lost fishing equipment where safe and practical.
- Avoid capturing protected species.
- Dispose of waste properly.
- Follow sustainable fishing regulations.

10.0 ADVANTAGES AND DISADVANTAGES OF DIFFERENT FISHING GEARS

Fishing gear	Advantages	Disadvantages
Fish traps	Reusable and relatively inexpensive	May cause ghost fishing if lost
Harpoons	Targets individual fish	Requires accuracy and skill
Gill nets	Can capture several fish at once	May cause bycatch
Longlines	Can target valuable fish species	May capture non-target animals
Seine nets	Can capture schools of fish	May capture immature fish
Trawl nets	Suitable for commercial fishing	Can disturb aquatic habitats
Cast nets	Affordable and portable	Limited catching capacity
Lift nets	Simple to operate in suitable conditions	Requires fish to gather above the net

11.0 IMPORTANCE OF FISHING GEARS AND METHODS IN KENYA

Fishing gears and methods contribute to the development of Kenya's fisheries sector.

11.1 Provision of food

- Fishing gears enable the harvesting of fish for human consumption.
- Fish provide proteins and other important nutrients.
- Fishing supports food security in fishing communities.

11.2 Employment creation

Fishing activities provide employment opportunities for:

- Fishers.
- Boat operators.
- Net makers.
- Fish processors.
- Fish traders.
- Boat repairers.
- Fish transporters.

11.3 Income generation

- Fishers earn income through the sale of fish.
- Fishing equipment supports commercial enterprises.
- Fish trading creates business opportunities.
- Fishing supports household livelihoods.

11.4 Development of coastal and inland communities

Fishing supports communities around Lake Victoria, Lake Turkana and the Indian Ocean coastline.

It contributes to:

- Development of landing sites.
- Construction of fish markets.
- Development of cold storage facilities.
- Improvement of transport services.
- Expansion of fish processing industries.

11.5 Foreign exchange earnings

Marine fisheries and fish products can contribute to export earnings when harvested, processed and marketed according to the required standards.

11.6 Tourism development

Fishing activities may support tourism through:

- Recreational fishing.
- Cultural fishing activities.
- Boat tours.
- Sport fishing.
- Coastal tourism.

12.0 SUSTAINABLE USE OF FISHING GEARS AND METHODS

Sustainable fishing refers to fishing practices that allow fish populations and aquatic ecosystems to remain productive for present and future generations.

12.1 Practices that promote sustainable fishing

1. Use legally approved fishing gears.
2. Observe the required mesh sizes.
3. Avoid catching immature fish.
4. Avoid fishing in closed areas.
5. Observe closed fishing seasons.
6. Avoid capturing endangered and protected species.
7. Use selective fishing methods.
8. Retrieve lost fishing gears.
9. Avoid damaging coral reefs and other sensitive habitats.
10. Follow fishing quotas and other management measures where applicable.

12.2 Effects of destructive fishing methods

Destructive fishing methods may lead to:

- Overfishing.
- Declining fish populations.
- Destruction of breeding grounds.
- Loss of aquatic biodiversity.
- Habitat degradation.
- Capture of juvenile fish.
- Reduction in fishers' income.
- Disruption of aquatic food chains.

12.3 Role of fishers in conserving aquatic resources

Fishers should:

- Follow fisheries regulations.
- Report illegal fishing activities.
- Participate in beach management activities.
- Use approved fishing equipment.
- Avoid polluting water bodies.
- Educate other community members.
- Participate in fisheries conservation programmes.

13.0 PRACTICAL PROJECT: CONSTRUCTING A MODEL OF A SIMPLE FISHING BOAT

CBE Practical Project

Project: Construct a model of a simple fishing boat using locally available materials.



13.1 Project objectives

By completing this project, the learner should be able to:

1. Identify locally available materials for constructing a fishing boat model.
2. Select appropriate materials and tools.
3. Design a simple fishing boat.
4. Construct a model of a fishing boat.
5. Identify and label the main parts of a fishing boat.
6. Demonstrate creativity and practical skills.
7. Appreciate the importance of fishing vessels in capture fisheries.

13.2 Materials required

- Cardboard.
- Light wood.
- Recycled plastic bottles.
- Ice cream sticks.
- Glue.
- Adhesive tape.
- String.
- Paper.
- Small pieces of fabric.
- Paint.
- Scissors.
- Ruler.
- Pencil.

13.3 Construction procedure

1. Collect suitable locally available materials.
2. Draw a simple design of the fishing boat.
3. Measure and mark the required dimensions.
4. Cut the cardboard or wood to form the hull.
5. Join the sections to form the boat body.
6. Construct the bow and stern.
7. Attach the deck.
8. Make a small steering structure.
9. Construct a mast and sail where required.
10. Add a model engine or propeller where appropriate.
11. Create a small fish storage compartment.
12. Paint and decorate the boat.

13. Label the major parts.

14. Present the completed model to the class.

13.4 Safety precautions during construction

- Handle scissors carefully.
- Use glue in a well-ventilated area.
- Avoid sharp materials.
- Work under teacher supervision.
- Keep the working area clean.
- Dispose of waste appropriately.

13.5 Testing the model

Learners may test the model in a basin of water under teacher supervision.

Observe:

- Whether the model floats.
- Whether it remains balanced.
- Whether the hull is watertight.
- Whether the structure is stable.
- Whether the weight is evenly distributed.

Do not test models in deep or open water.

13.6 Project assessment criteria

Assessment area	What the teacher observes
Design	Correct fishing boat design
Material selection	Appropriate locally available materials
Construction	Neatness and strength
Identification	Correctly labelled boat parts
Creativity	Originality of design
Functionality	Ability to float and remain stable
Safety	Proper use of tools and materials
Presentation	Clear explanation of the model

REVISION EXERCISES

STRAND 2.0: FISHERIES MANAGEMENT

SUB-STRAND: FISHING GEARS, METHODS AND VESSELS

PART I: REVISION EXERCISES

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. Which of the following best describes fishing gear?

A. The methods used to preserve fish after harvesting.
B. Equipment used to capture fish and other aquatic organisms.
C. The process of transporting fish to markets.
D. The structures used to construct fish ponds.

2. Which of the following is an example of traditional fishing gear?

A. Trawl net.
B. Purse seine net.
C. Fish trap.
D. Mechanised longline.

3. What is the main function of a float line in a gill net?

A. To keep the net at the bottom of the water.
B. To support the upper section of the net.
C. To attract fish using bait.
D. To prevent the net from being retrieved.

4. Which fishing gear consists of a main line carrying several branch lines fitted with baited hooks?

A. Gill net.
B. Cast net.
C. Longline.
D. Seine net.

5. What is the section of a trawl net where captured fish accumulate called?

A. Headline.
B. Wing.
C. Codend.
D. Float line.

6. Which fishing method involves surrounding a school of fish with a net?

A. Spearfishing.
B. Seining.
C. Handlining.
D. Trapping.

7. Which fishing gear allows fish to enter through a narrow opening but makes it difficult for them to escape?

A. Gill net.
B. Fish trap.
C. Longline.
D. Cast net.

8. Which fishing gear is commonly used to capture individual fish using a pointed instrument?

A. Purse seine.
B. Trawl net.
C. Harpoon.
D. Gill net.

9. Which factor should be considered when selecting appropriate fishing gear?

A. Colour of the fisher's clothes.
B. Type and size of fish targeted.
C. Distance between fishing villages.
D. Number of fish markets in a town.

10. What is the ability of fishing gear to capture target fish while allowing unwanted fish to escape known as?

A. Buoyancy.
B. Selectivity.
C. Propulsion.
D. Navigation.

11. Which fishing gear is commonly used to capture fish swimming in schools?

A. Purse seine.
B. Hand spear.
C. Single hook.
D. Fish pot.

12. What does bottom trawling involve?

A. Dragging a net near or along the seabed.
B. Throwing a net from the shore.
C. Using baited hooks at the water surface.
D. Paddling a canoe around fish.

13. Which of the following is a major disadvantage of poorly managed bottom trawling?

A. It uses no fishing equipment.
B. It destroys all engine components.
C. It may disturb seabed habitats.
D. It prevents fish from swimming.

14. What is a fishing vessel designed to operate purse seine nets called?

A. Canoe.
B. Longliner.
C. Purse seiner.
D. Sailboat.

15. Which fishing vessel is specifically designed to tow trawl nets?

A. Trawler.
B. Canoe.
C. Sailboat.
D. Gill netter.

16. What is the front section of a fishing boat known as?

A. Stern.
B. Bow.
C. Keel.
D. Transom.

17. Which part of a fishing boat is responsible for controlling its direction?

A. Fish hold.
B. Anchor.
C. Rudder.
D. Mast.

18. What is the main body of a fishing boat that provides buoyancy called?

A. Hull.
B. Sail.
C. Gunwale.
D. Propeller.

19. Which part of a fishing boat supports the sail?

A. Rudder.
B. Mast.
C. Keel.
D. Bilge.

20. What is the main function of an anchor?

A. To increase the speed of a boat.
B. To store harvested fish.
C. To hold a vessel in position.
D. To control the engine temperature.

21. Which mode of propulsion uses human energy to move a fishing boat?

A. Sailing.
B. Motorised propulsion.
C. Paddling.
D. Jet propulsion.

22. Which source of energy is primarily used by a sailboat?

A. Wind.
B. Diesel.
C. Electricity.
D. Human muscular energy.

23. Which component of a motorised fishing boat pushes water backwards to produce forward movement?

A. Rudder.
B. Propeller.
C. Anchor.
D. Fish hold.

24. Which of the following is an advantage of motorised propulsion?

A. It always operates without maintenance.
B. It is independent of all mechanical failures.
C. It allows relatively high-speed movement.
D. It does not require an energy source.

25. Which of the following is a characteristic of a traditional fishing canoe?

A. It is always operated using a diesel engine.
B. It is usually small and narrow.
C. It is designed specifically for bottom trawling.
D. It carries large industrial refrigeration systems.

26. What is the main purpose of a fish hold in a fishing vessel?

A. To support the mast.
B. To store harvested fish.
C. To control the direction of movement.
D. To provide propulsion.

27. Which practice helps to extend the lifespan of fishing nets?

A. Storing them while wet and dirty.
B. Leaving them exposed to harsh weather.
C. Cleaning, drying and repairing them properly.
D. Dragging them over sharp rocks.

28. What is a possible consequence of losing fishing nets in water?

A. Increased water clarity.
B. Ghost fishing.
C. Improved fish reproduction.
D. Reduced water currents.

29. Which safety equipment should a fisher wear when travelling in a fishing boat?

A. Life jacket.
B. Ordinary sandals only.
C. Cotton gloves only.
D. Protective spectacles only.

30. Which of the following practices promotes sustainable fishing?

A. Using prohibited fishing methods.
B. Capturing immature fish.
C. Fishing in restricted areas.
D. Using legally approved selective fishing gear.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions. Write your answers clearly and provide labelled diagrams where required.

QUESTION 1: TYPES OF FISHING GEARS (8 MARKS)

a) Define the term fishing gear. (2 marks)

b) Identify four examples of traditional fishing gears used in capture fisheries. (2 marks)

c) State four advantages of using fish traps in fishing activities. (4 marks)

QUESTION 2: FISHING GEARS AND SELECTION (8 MARKS)

a) Differentiate between fishing gear and fishing method. (2 marks)

b) Explain three factors that should be considered when selecting appropriate fishing gear. (3 marks)

c) State three advantages of using gill nets in capture fisheries. (3 marks)

QUESTION 3: FISHING METHODS (8 MARKS)

a) Explain how longline fishing is carried out. (4 marks)

b) Distinguish between bottom trawling and mid-water trawling. (2 marks)

c) State two disadvantages of using seine nets. (2 marks)

QUESTION 4: FISHING VESSELS (8 MARKS)

a) Define the term fishing vessel. (2 marks)

b) Identify three types of fishing vessels used in capture fisheries. (3 marks)

c) State three characteristics of a commercial fishing trawler. (3 marks)

QUESTION 5: PROPULSION AND PARTS OF A FISHING BOAT (9 MARKS)

a) Identify three modes of propulsion used by fishing vessels. (3 marks)

b) Explain two advantages of motorised propulsion over paddled propulsion. (2 marks)

c) Draw a well-labelled diagram of a simple fishing boat showing the following parts: (4 marks)

- Bow.
- Stern.
- Hull.
- Rudder.

QUESTION 6: FISHING GEAR MANAGEMENT AND SUSTAINABILITY (9 MARKS)

a) Explain three methods of maintaining fishing gears. (3 marks)

b) State three safety precautions that fishers should observe when using fishing vessels. (3 marks)

c) Explain three practices that promote sustainable fishing in Kenya. (3 marks)

TOTAL: 80 MARKS

PART II: MARKING SCHEME

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Award 1 mark for each correct answer.

Question	Answer
1	B
2	C
3	B
4	C
5	C
6	B
7	B
8	C
9	B
10	B
11	A
12	A
13	C
14	C
15	A
16	B
17	C
18	A
19	B
20	C
21	C
22	A
23	B
24	C
25	B
26	B
27	C
28	B
29	A
30	D

SECTION A TOTAL: 30 MARKS

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

QUESTION 1: TYPES OF FISHING GEARS (8 MARKS)

a) Define the term fishing gear. (2 marks)

- Fishing gear refers to equipment, tools or devices used to capture fish and other aquatic organisms from freshwater or marine environments. (2 marks)

b) Identify four examples of traditional fishing gears used in capture fisheries. (2 marks)

Award ½ mark for each correct response.

1. Fish traps.
2. Basket traps.
3. Handlines.
4. Spears.
5. Harpoons.
6. Traditional hooks.
7. Cast nets.
8. Hand-operated scoop nets.

Accept any four correct examples.

c) State four advantages of using fish traps in fishing activities. (4 marks)

Award 1 mark for each correct response.

1. They are relatively easy to construct and operate.
2. They can be made using locally available materials.
3. They can capture fish without requiring continuous supervision.
4. They can be reused for several fishing operations.
5. They can be selective when designed with appropriate entrance sizes.
6. They can reduce damage to fish compared to some active fishing methods.
7. They require relatively little energy to operate.
8. They can be used in shallow waters and nearshore environments.

QUESTION 2: FISHING GEARS AND SELECTION (8 MARKS)

a) Differentiate between fishing gear and fishing method. (2 marks)

- Fishing gear: The equipment or tools used to capture fish and other aquatic organisms. (1 mark)
- Fishing method: The technique or procedure used to operate fishing gear to capture aquatic organisms. (1 mark)

b) Explain three factors that should be considered when selecting appropriate fishing gear. (3 marks)

Award 1 mark for each correctly explained factor.

1. Target fish species: The gear should be suitable for the type of fish being targeted.

2. Size of fish: The mesh size and hook size should be appropriate for the size of fish being captured.
3. Fishing environment: The gear should suit the depth, currents, seabed conditions and nature of the water body.
4. Cost of equipment: The gear should be affordable to acquire, operate and maintain.
5. Selectivity: The gear should minimise the capture of unwanted fish and juvenile organisms.
6. Fishing regulations: The gear must comply with existing fisheries laws and regulations.
7. Availability of materials: The equipment should be accessible and easy to replace or repair.
8. Fishing operation: The gear should be appropriate for the intended fishing technique and scale of operation.

c) State three advantages of using gill nets in capture fisheries. (3 marks)

Award 1 mark for each correct response.

1. They are relatively easy to operate.
2. They can capture different fish species depending on mesh size and placement.
3. They can be used in freshwater and marine environments.
4. They require relatively little energy to operate.
5. They are comparatively affordable.
6. They can be used to target fish of particular sizes through appropriate mesh selection.
7. They can cover relatively large fishing areas.

QUESTION 3: FISHING METHODS (8 MARKS)

a) Explain how longline fishing is carried out. (4 marks)

Award 1 mark for each correctly explained stage.

1. A strong main fishing line is prepared and laid out in the water.
2. Several branch lines called snoods or gangions are attached to the main line at intervals.
3. Baited hooks are attached to the branch lines to attract fish.
4. Floats and weights may be attached to position the fishing line at the required depth.
5. The longline is deployed in the selected fishing area and left for a specified period.
6. The longline is retrieved, and captured fish are removed from the hooks.

Marking: Any four correctly described stages. Maximum 4 marks.

b) Distinguish between bottom trawling and mid-water trawling. (2 marks)

- Bottom trawling: Involves dragging a trawl net along or close to the seabed to capture bottom-dwelling fish and other organisms. (1 mark)
- Mid-water trawling: Involves towing a trawl net through the water column, away from the seabed, to capture fish swimming in open water. (1 mark)

c) State two disadvantages of using seine nets. (2 marks)

Award 1 mark for each correct response.

1. They may capture non-target species.
2. They may capture juvenile fish when inappropriate mesh sizes are used.
3. They require considerable labour during deployment and retrieval.
4. They may disturb aquatic habitats when dragged along the bottom.
5. They may become entangled in underwater obstacles.
6. They may cause fish injuries during capture and handling.

QUESTION 4: FISHING VESSELS (8 MARKS)

a) Define the term fishing vessel. (2 marks)

- A fishing vessel is any boat, ship or watercraft designed, equipped or used for carrying out fishing activities, including capturing, transporting or handling fish and other aquatic organisms. (2 marks)

b) Identify three types of fishing vessels used in capture fisheries. (3 marks)

Award 1 mark for each correct response.

1. Trawlers.
2. Purse seiners.
3. Longliners.
4. Gill netters.
5. Traditional fishing canoes.
6. Trolling vessels.
7. Pole-and-line fishing vessels.

Accept any three.

c) State three characteristics of a commercial fishing trawler. (3 marks)

Award 1 mark for each correct response.

1. It is fitted with a powerful engine for towing fishing nets.
2. It has equipment for deploying and retrieving trawl nets.
3. It has a strong hull designed to withstand fishing operations.
4. It may have winches and net-handling equipment.
5. It has storage facilities for harvested fish.
6. It may have refrigeration or freezing facilities to preserve fish.
7. It has navigation and communication equipment.
8. It has safety equipment for the crew.

QUESTION 5: PROPULSION AND PARTS OF A FISHING BOAT (9 MARKS)

a) Identify three modes of propulsion used by fishing vessels. (3 marks)

Award 1 mark for each correct response.

1. Paddling.

2. Sailing.
3. Motorised propulsion.

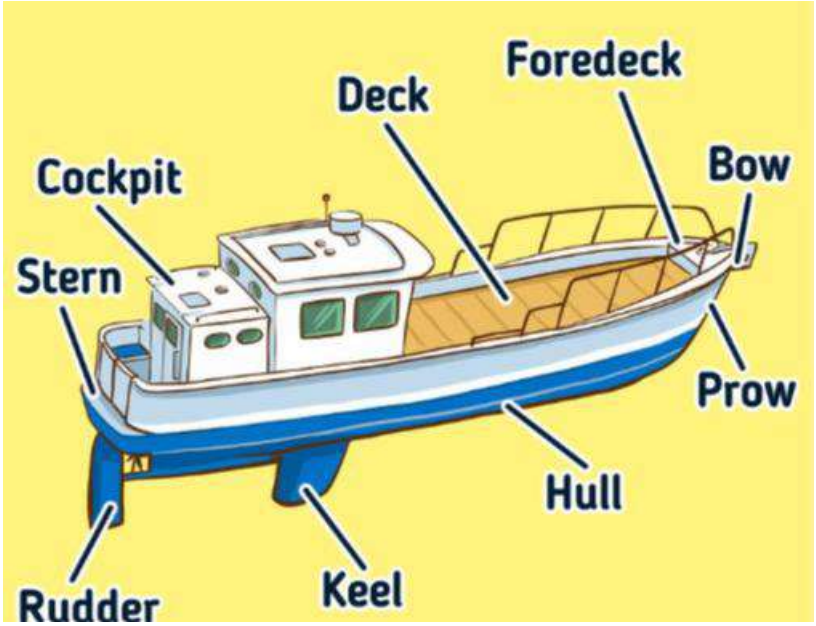
Accept: Rowing as a form of human-powered propulsion.

b) Explain two advantages of motorised propulsion over paddled propulsion. (2 marks)

Award 1 mark for each correctly explained advantage.

1. Higher speed: Motorised boats can travel faster and reach fishing grounds within a shorter time.
2. Greater distance: They can travel longer distances without exhausting the crew.
3. Ability to carry heavier loads: They can transport more fishing equipment, fish and supplies.
4. Reduced physical effort: They require less manual energy from fishers.
5. Better operational efficiency: They can support larger-scale fishing operations.

c) Draw a well-labelled diagram of a simple fishing boat showing the following parts. (4 marks)



Mark allocation:

Part	Marks
Correct outline of a simple fishing boat	1
Correct identification of the bow	1
Correct identification of the stern	1
Correct identification of the hull and rudder	1
Total	4

Award marks for correctly positioned labels. Accept a neat, clearly labelled hand-drawn diagram.

QUESTION 6: FISHING GEAR MANAGEMENT AND SUSTAINABILITY (9 MARKS)

a) Explain three methods of maintaining fishing gears. (3 marks)

Award 1 mark for each correctly explained method.

1. Cleaning: Remove mud, seaweed, algae and other materials from fishing nets and equipment after use.
2. Drying: Dry fishing nets properly before storage to prevent rotting, mould growth and deterioration.
3. Repairing: Mend torn nets and replace damaged ropes, hooks and other components.
4. Proper storage: Keep fishing equipment in a dry, secure and well-ventilated place.
5. Inspection: Regularly examine fishing equipment to identify damage and wear.
6. Protection from chemicals: Keep fishing equipment away from corrosive substances that may weaken materials.

b) State three safety precautions that fishers should observe when using fishing vessels. (3 marks)

Award 1 mark for each correct response.

1. Wear properly fitted life jackets while on board.
2. Check weather forecasts before going out fishing.
3. Avoid overloading the fishing vessel.
4. Carry first-aid kits and emergency supplies.
5. Ensure the vessel has functional communication equipment.
6. Inspect the boat and engine before departure.
7. Avoid fishing during severe storms and dangerous weather conditions.
8. Carry adequate fuel and fresh drinking water.
9. Ensure that emergency and rescue equipment is available.
10. Avoid operating fishing vessels under the influence of alcohol or drugs.

c) Explain three practices that promote sustainable fishing in Kenya. (3 marks)

Award 1 mark for each correctly explained practice.

1. Using approved fishing gear: Use legally permitted and selective fishing equipment to reduce the capture of juvenile and non-target fish.
2. Observing closed seasons: Avoid fishing during designated breeding periods to allow fish populations to reproduce.
3. Observing minimum size limits: Avoid harvesting undersized fish so that they can mature and reproduce.
4. Protecting breeding grounds: Avoid fishing in restricted breeding and nursery areas.
5. Avoiding destructive fishing methods: Do not use explosives, poisonous chemicals or other prohibited methods.
6. Reducing ghost fishing: Retrieve lost fishing nets and equipment to prevent continued accidental capture of aquatic organisms.
7. Protecting aquatic habitats: Support conservation of mangroves, coral reefs and seagrass beds.
8. Reporting illegal fishing: Report illegal fishing activities to relevant fisheries authorities.
9. Practising responsible harvesting: Harvest fish at sustainable levels to prevent depletion of fish stocks.

GRADE 11