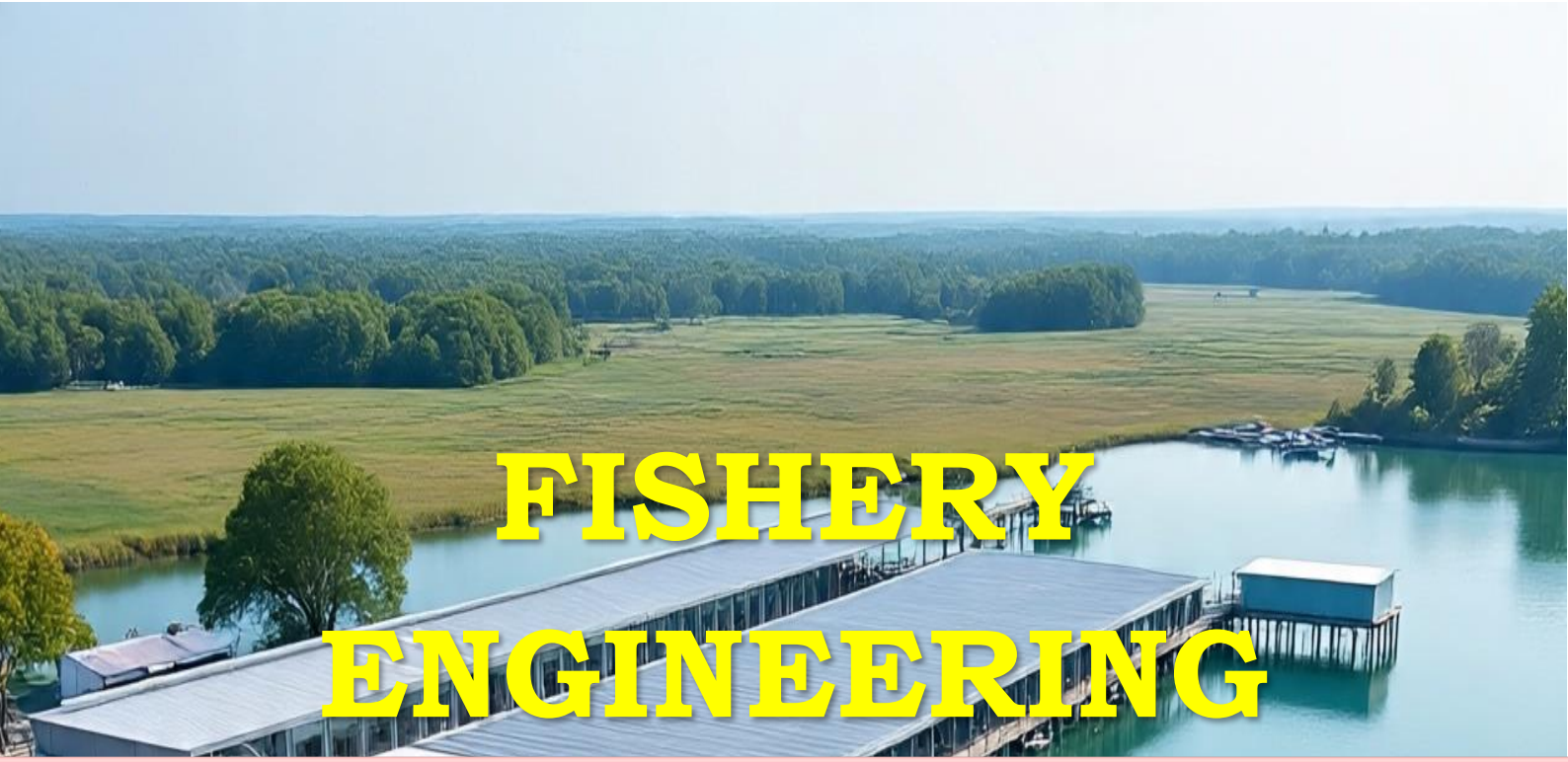

FISHERY ENGINEERING

AQUACULTURE MAJOR- 5th SEMESTER – COURSE 14

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FISHERY ENGINEERING

(AQUACULTURE MAJOR-COURSE-14 e-CONTENT)

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FISHERY ENGINEERING

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UNIT I: FISHING CRAFTS

1-1 Different types of fishing crafts in India- inland and marine traditional, motorized and mechanized.

Fishing craft is a floating device such as boat, vessel, or ship used for fishing activities like, fishing, fish transportation, research and training purpose. These crafts vary in size, design, and equipment, depending on the type of fishing, location, and target species.

Development of Fishing craft

No one knows exactly how the first crafts were made or when they were used. It was certainly in prehistoric times but unfortunately there are no remains of these earliest vessels in existence today to tell us anything of their construction or the men who made them. Primitive man would sit astride the floating tree trunk and either row with his hands or use tree branches or pieces of bark as paddles. This crude form of transport was improved upon by the development of the stable raft. It consists of several tree trunks tied together with strings. This type of boat is called “CATAMARAN”.

1.1.1 Inland Fishing Craft

These crafts are primarily utilized in freshwater bodies such as rivers, ponds, lakes, and reservoirs. Examples are**:**

Coracle: Used in rivers, reservoirs, and canals, propelled by a single oar.
Coracles are light in weight, bowl shaped boats with a frame of woven grass, reeds, or saplings covered with hides.

Over the years, these circular crafts were constructed by interwoven strips of bamboo and covered with water proof materials such as plastic bags coated with a layer of coal tar. The boat size ranges between 1.50 - 2.00 meters dia. The coracle weight ranges between 10 - 15kg. A single oar is used to propel the coracle. Two fishers conduct the fishing in a coracle. Gillnet and long line are the common fishing methods. Apart from being simple and inexpensive, these are durable (2 – 3 years) and have good movability in all water bodies.

Catamarans: Used in reservoirs, propelled by oars and sails. Made of tying 3-4 wooden logs or bamboo poles. Operated by a single oar or with hands. Widely used in the inland waters.

Catamaran

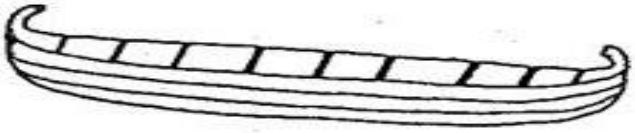
Catamarans are traditional fishing crafts that play a vital role in India's coastal fishing industry, providing a means of livelihood for many fishermen and contributing to the country's food security

Canoes: Hollowed out palm trees, propelled by oars, used with traps, cast nets, and gill nets in reservoirs. It is a long dug-out canoe made from carved out basal part of the trunk of a palmyra tree. It is around 3 - 4m length and with an internal diameter of 0.5m. The major portion of the trunk is longitudinally scooped out for sitting and keep the captured fish. Wooden bar is sometimes fixed in the mid region of the scooped-out part for sitting and to avoid collapse of the canoe. Margins of the scooped-out part is framed by circular iron frames in some canoes to prevent from splitting. It is operated by a single person due to its small size.

Dugout canoe

Dinghy: Plank-built, flat-bottomed canoes used in lakes and rivers. A dinghy is a small boat, typically open-hulled, used for various purposes such as sailing, rowing, or as a tender to a larger vessel. They can be rigid-hulled, inflatable, or a combination of both.

Plank Built Boats: Spindle-shaped boats constructed by joining planks, used for fishing and transport in lakes. These are spindle shaped and constructed by joining quality wooden planks with iron nails. Joints are leak proofed by applying coal tar. Small and large sized plank built rowing boats are commonly used in the lakes. The smaller boats are 5 - 6m long with 80 - 90cm beam width and used for transport of harvested fish and also passengers from village to village within the lake. They are non-mechanized and manually operated. Bigger boats are about 15 - 20m long and are mechanized. They are used to transport fish to landing centers.



Plank built canoe

Thermocol Rafts: Improvised rafts made of used thermocol boxes, operated near the lake shore.

It is an improvised country made fishing craft made of used thermocol boxes and slices (for fish preservation and transport).

The required number of thermocol boxes and slices is tied together with the help of nylon ropes to make a platform of length 4 - 5m length with 1m width. It is commonly operated by children of 10 - 15 years of age for setting and collection of traps, transport of catch and fish capture near the lake shore.

1.1.2. Marine Fishing Craft

Marine fishing crafts, also known as fishing vessels, are boats or ships used to catch fish and other aquatic animals in the ocean. The type of craft used depends on factors like the fishing method, target species, and area of operation.

1.1.2.1. Marine traditional Fishing Crafts:

These are traditional boats that rely on manual power or sails for propulsion.

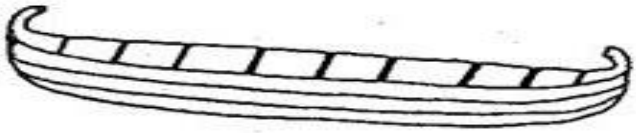
- **Catamarans**: Simple rafts made of logs joined together, prevalent along the east coast of India.

Catamaran

- **Dug-out Canoes**: Small canoes made by scooping out logs, used for fishing near the coast.

Dugout canoe

- **Plank-built Canoes**: Enlarged dug-out canoes with added planks on the sides, commonly used in Kerala.



Plank built canoe

- **Masula Boats**: Boats made of non-rigid planks sewn with coir ropes, used along the Andhra coast.

- **Dhinghi:** Carvel type boats used for various purposes, including fishing.

- **Outrigger Canoes**: Plank-built canoes with a single outrigger for added stability.
- **Built-up Boats**: Boats built with planks using the carvel method.
- **Coracles:** Lightweight, bowl-shaped boats with a frame covered with waterproof materials, often used with gillnets and long lines.
- **Dhoni:** Long dug-out canoes made from a palm tree trunk, operated by a single person.
- **Thermocol Rafts**: Improvised rafts made from thermocol boxes, commonly used in shallow areas.

1.1.2.2. Marine Motorized and mechanised Fishing Craft

These vessels are equipped with engines and advanced technology for efficient fishing operations.

Trawlers:

- Designed for using trawl nets to catch large volumes of fish.
- Equipped with powerful engines and trawl winches.
- Types include stern trawlers, side trawlers, factory trawlers, and pair trawlers.

Seiners:

- Use surrounding and seine nets, ranging from open boats to large ocean-going vessels.
- Equipped with power blocks and/or net drums for hauling nets.
- Examples include purse seiners and ring seiners.

Liners:

- Use lines and hooks for fishing.
- Types include hardliners, longliners, and pole and line vessels.

Gillnetters:

- Use gill nets, which are panels of netting that entangle fish.
- Range in size from open boats to medium-sized vessels operating offshore.

Trap Setters:

- Used for setting pots or traps to catch crustaceans and other species.
- Range in size from open boats to large decked vessels.

Multipurpose Vessels:

- Equipped for using multiple types of fishing gear.
- Examples include trawler/gillnetter combinations.

Fishery Research Vessels:

- Engaged in experimental fishing and research programs.

Technological Advancements:

Modern fishing vessels are increasingly incorporating advanced technologies:

- **Advanced Navigation and Communication**: GPS and satellite communication systems improve efficiency and safety.
- **Fish Finding Technology:** Sonar, fish finders, and echo sounders help locate fish schools.
- **Improved Preservation:** Onboard refrigeration and cold storage extend the shelf life of catches.
- **Environmentally Friendly Practices:** Development of gear modifications and technologies to reduce bycatch and minimize environmental impact.

1-2 Classification of fishing craft.

Classification of fishing craft can be approached in various ways, focusing on different characteristics like **propulsion, fishing methods**, **size, and area of operation**.

1. Based on Propulsion:

Non-mechanized Fishing Crafts: These rely on traditional methods like rowing, paddling, or sailing.

- **Catamaran**: Simple floating raft made of logs, particularly common on the east coast of India. Different types exist based on region, such as Orissa, Andhra, Coromandal, and Kanyakumari.
- **Dug-out Canoes**: Small canoes carved from a single log, used for coastal fishing. "Odams", "Thonies", and "Vanchies" are examples found in India.
- **Plank-built Canoes**: Enlarged dug-out canoes with added planks for increased size and capacity, prevalent in Kerala.
- **Masula Boats**: Made of flexible planks sewn together with coir ropes, used along the Andhra coast.

- **Dhinghi:** Carvel type boats designed for various purposes, including fishing.
- **Outrigger Canoes:** Plank-built canoes with an outrigger on the side for stability, like the "rampani" boats in Karnataka used for mackerel fishing.
- **Built-up Boats:** Constructed with planks using the carvel method, with excellent examples seen on India's northeast coast.
- **Coracles**: Lightweight, round or bowl-shaped boats with a frame covered with waterproof materials, often used in Tamil Nadu, Andhra Pradesh, and Karnataka. A single oar is typically used for propulsion.
- **Dhoni:** A long dug-out canoe made from the trunk of a palmyra tree, usually operated by one person.
- **Thermocol Rafts:** Improvised crafts made of thermocol boxes or slices tied together, used in shallow water areas.

Mechanized Fishing Vessels: Equipped with engines for propulsion and often utilize advanced technology for fishing.

- **Hand Line Boats**: Used for handline fishing, with or without a winch. They are suitable for both shallow and deeper waters.
- **Pole and Line Fishing Vessels:** Feature platforms for fishermen to stand on and specialized equipment like bait tanks and water spray systems to attract tuna and skipjack.
- **Trolling Vessels**: Tow lines with lures attached to outrigger poles, mainly for catching pelagic species like tuna and barracuda.
- **Dol Netters**: Employ dol nets, which are fixed bag nets. These boats range in length from 8-14 meters and can carry between 2-14 tonnes.
- **Gillnetters:** Use gill nets to entangle fish and range in size from open boats to larger offshore vessels, according to the Marine Products Export Development Authority (MPEDA).
- **Trawlers:** Use trawl nets to catch large quantities of fish and require powerful engines for towing.
- **Multipurpose Vessels**: Designed to operate two or more different types of fishing gear.

2. Based on Function/Purpose:

- **Commercial Fishing Vessels**: Mid- to large-sized boats for catching fish and seafood on a large scale for wholesale. They can operate far from shore and in rough weather.
- **Artisanal Fishing Vessels**: Smaller vessels typically used in coastal or inland waters, often with traditional fishing methods.
- **Recreational Fishing Vessels**: Used for sport or hobby fishing.

3. Based on Size/Area of Operation:

- **Small Fishing Vessels**: Primarily operate in freshwater environments.
- **Medium Fishing Vessels**: Operate within Exclusive Economic Zones (EEZ).
- **Large Fishing Vessels:** Operate in the open ocean.

Above classification provides a detailed overview of the various types of fishing crafts and vessels used in marine and other water bodies.

1-3 Boat building materials - wood, steel, FRP, ferro-cement, aluminum etc.,

Building fishing crafts involves a variety of materials, each with its own advantages and disadvantages. Here's a detailed look at the common options:

1. Wood:

- **Advantages:**
  - **Buoyancy:** Wood is naturally buoyant, which is a desirable trait in boat construction.
  - **Workability:** Relatively easy to shape and work with using traditional tools and techniques.
  - **Strength:** Offers good strength, particularly along the grain.
  - **Repair:** Easier and faster to repair with fewer specialized skills compared to metal.
  - Aesthetics: Possesses a classic and aesthetically pleasing appearance.
- **Disadvantages:**
  - **Maintenance:** Requires regular maintenance to prevent rot, decay, and marine borers like Teredo worms.
  - **Durability**: Susceptible to deterioration from fungi, borers, and moisture, especially in freshwater environments.
  - **Cost:** While historically a common material, quality timber is becoming scarce and expensive.
  - **Water Damage**: Can leak if not properly maintained, especially in freshwater.

Points to remember for selecting wood for boat building:

- Proper selection, seasoning, and treatment with preservatives can extend the life and usability of wooden boats, even for less durable species.
- Different types of wood are used for specific boat components based on their properties, like strength and resistance to decay.

2. Steel:

- **Advantages**:
  - **Strength and Durability:** Known for its exceptional strength and durability, making it suitable for large vessels and demanding conditions.
  - **Design Versatility**: Allows for the construction of large ships with complex designs due to its strength and formability.
  - **Longevity:** Offers excellent resistance to corrosion and wear and tear with proper maintenance.
  - **Industrialization:** Construction with steel is more easily industrialized, potentially reducing labour costs.
  - **Corrosion Control:** Corrosion can be managed through methods like sacrificial anodes.
- **Disadvantages:**
  - **Corrosion:** Requires careful attention to corrosion control, especially in saltwater environments.
  - **Weight**: Steel is heavy, which can impact fuel efficiency and quality compared to lighter materials like aluminum or FRP.

- **Cost:** Can be more expensive than wood in some instances, although total construction cost differences can be minimal in some analyses.

Points to remember for selecting Steel for boat building

- Steel became widely used in boat building between 1845 and 1880, replacing wood as a primary material.
- Different types of steel exist, ranging from soft and malleable to hard and brittle.

3.Fiber Reinforced Plastic (FRP) / Fiberglass:

- **Advantages:**
  - **Lightweight:** Offers superior weight advantages over steel and even aluminum for smaller vessels.
  - **Durability:** Withstands impact, stress, and harsh conditions well.
  - **Corrosion Resistance**: Resistant to corrosion and osmosis.
  - **Design Flexibility**: Can be moulded into various shapes for custom designs.
  - **Maintenance:** Generally, requires less maintenance than wooden boats.
- **Disadvantages**:
  - **Blistering:** Susceptible to osmosis, which can lead to hull blisters.
  - **Repair Complexity:** Repairing fiberglass can be more complex than wood, especially for structural damage.
  - **Flammability**: More flammable than wood, and the smoke produced during burning is toxic.
- **Things to remember:**
  - FRP uses fibers, typically glass fiber, in a thermosetting resin matrix like polyester resin.
  - The gel coat, a smooth top layer of pigmented resin, protects the underlying fiberglass from UV rays, moisture, and wear.
  - Polyester resin is a common and affordable option for fiberglass repair, while epoxy resin offers better strength and bonding but is more expensive.

4. Ferro-cement:

- **Advantages:**
  - **Durability:** Ferro-cement is known for strength and longevity, resisting water penetration and corrosion when built correctly.
  - **Lightweight:** Relatively lightweight compared to traditional concrete structures.
  - **Versatility:** Can be moulded into various shapes and sizes, suitable for organic forms and curved designs.
  - **Cost-Effective**: It can be a cost-effective choice in areas where traditional materials are expensive.
  - **Repair:** Small cracks and damages are easy to repair.
- **Disadvantages:**
  - **Impact Damage**: More susceptible to impact damage than some other materials.
  - **Construction Expertise**: Requires specialized knowledge and careful construction to avoid issues like voids in the structure.

  - **Fastening Difficulties:** Can be difficult to fasten with bolts, screws, or welding.
  - **Corrosion Risk:** The reinforcing mesh can be prone to corrosion if not fully covered by mortar.
  - **Weight:** Can be heavier than some other materials, especially in smaller vessels.
- **Things to remember**
  - Ferro-cement is made by creating a skeleton of steel bars or mesh and applying a thin layer of cement mortar.
  - Its use in boat building became popular during World War I due to steel shortages.

5. Aluminum:

- **Advantages:**
  - **Strength:** Possesses a high strength-to-weight ratio, making it durable and capable of withstanding demanding environments.
  - **Lightweight:** Significant weight savings compared to steel, leading to better performance and reduced fuel consumption.
  - **Corrosion Resistance**: Offers good resistance to corrosion in marine environments.
  - **Recyclability:** Fully recyclable, making it an environmentally friendly choice.
- **Disadvantages:**
  - **Cost:** Generally, more expensive than steel, although weight savings can partially offset this.
  - **Melting Point:** Low melting point, which can be a concern in naval vessels potentially exposed to onboard fires.
  - **Corrosion Management**: Requires specific precautions to avoid galvanic corrosion, especially when joined with dissimilar metals like steel.
- **Things to remember:**
  - Aluminum alloys offer a good substitute for steel in shipbuilding due to their properties.
  - Advancements in aluminum technology are improving its cost-effectiveness in shipbuilding.

Selection of boat building material depends on factors such as vessel size and type, intended use, budget, and local material and expertise availability. Each material has unique properties, making it suitable for specific uses in marine fishing crafts.

1-4 Mechanization of fishing craft and its impact

Mechanization in Fishing crafts:

Mechanization in fishing refers to the process of introducing mechanical power and devices into fishing operations, primarily the installation of engines for propulsion and mechanical equipment for handling fishing gear.

Different aspects of Mechanization:

- **Propulsion:** Engines (inboard or outboard) allow vessels to travel further and faster to reach fishing grounds.

- **Gear Handling**: Mechanical devices like winches and power blocks assist in deploying and retrieving large or heavy fishing gear.
- **Fish Finding Technology**: Electronic equipment such as echo sounders and sonars helps locate fish schools more effectively.
- **Navigation and Communication**: GPS and advanced communication systems improve safety and efficiency at sea.
- **Catch Preservation**: Onboard refrigeration and freezing facilities allow for longer fishing trips and better preservation of catches.

Impacts of Mechanization of fishing craft:

1. Increased Efficiency and Productivity:

- **Bigger Catches**: Mechanized fishing, particularly with efficient gear like trawls and seine nets, typically leads to larger catches.
- **Expanded Operations**: Vessels can venture to more distant and deeper fishing grounds, accessing previously untapped resources.
- **Improved Output:** Faster operations, better fish finding, and effective gear handling contribute to higher overall productivity.

2. Economic Impacts:

- **Increased Income**: For fishermen who adapt to mechanization, there can be increased income and improved living standards.
- **Shift to Commercial Fishing**: Mechanization facilitates a shift towards larger-scale, commercial fishing operations, often requiring significant investment in vessels and equipment.
- **Rising Costs:** Operating mechanized vessels involves higher costs for fuel, maintenance, and labour compared to traditional fishing methods.

3. Environmental Impacts:

- **Increased Fishing Pressure**: The ability to catch larger quantities of fish raises concerns about overfishing and the sustainability of fish stocks.
- **Bycatch and Habitat Damage**: Certain types of mechanized gear, like trawls, can catch non-target species (bycatch) and potentially damage marine habitats.
- **Need for Sustainable Practices**: There is a growing emphasis on adopting responsible fishing practices, including the use of selective gear and minimizing environmental impact.

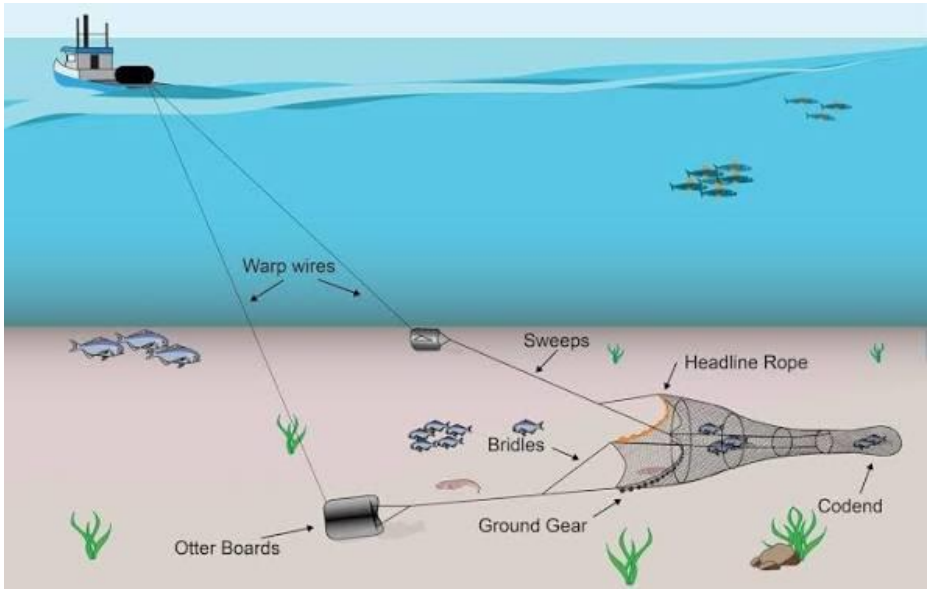
4. Social Impacts:

- **Changes in Livelihoods**: Mechanization can transform the livelihoods of fishermen, requiring new skills for operating and maintaining the equipment.
- **Safety Improvements:** Modern communication and safety equipment contribute to improved safety for fishermen, which is crucial in a challenging occupation.
- **Development of Infrastructure**: The growth of mechanized fishing often leads to the development of supporting infrastructure like harbours, ice factories, and processing plants.

Mechanization has revolutionized the fishing industry, offering significant advantages in terms of efficiency and production.

UNIT II: FISHING GEAR

2-1 Design of fishing gear and fish catching methods



The selection and design of fishing gear are complex processes influenced by a variety of factors related to the target species, fishing environment, and desired outcomes. There's no single "best" gear for all situations, and often a trade-off between different attributes is necessary.

2.1.1. Considerations for design of fishing gear:

1. Target species

- **Biology and Behaviour:** The size and shape of the fish or aquatic organism will determine the appropriate mesh size of the net or the size of the hook required. Understanding their feeding habits, swimming speed, and reactions to stimuli is crucial. For instance, predatory fish respond to baits and lures, making them vulnerable to hook and line methods.
- **Habitat:** Whether the species is demersal (bottom dwelling) or pelagic (midwater to surface) will influence the gear type. Demersal fish are targeted with bottom trawls or traps, while pelagic species might be caught with drift gillnets, purse seines, or midwater trawls.

2. Fishing environment

- **Depth:** The depth of the water dictates the gear type and construction materials. Deep-sea trawls and longlines require robust buoyancy elements to withstand pressure, whereas simpler, lighter gears can be used in surface waters.
- **Currents:** Strong currents can make certain gears, like trawls, difficult to operate. Longlines and gillnets are less affected and might be preferred in such conditions.
- **Seabed Characteristics**: Rocky or uneven bottoms can damage bottom trawls. Traps or pots, which are more resilient, are a better choice in such environments.

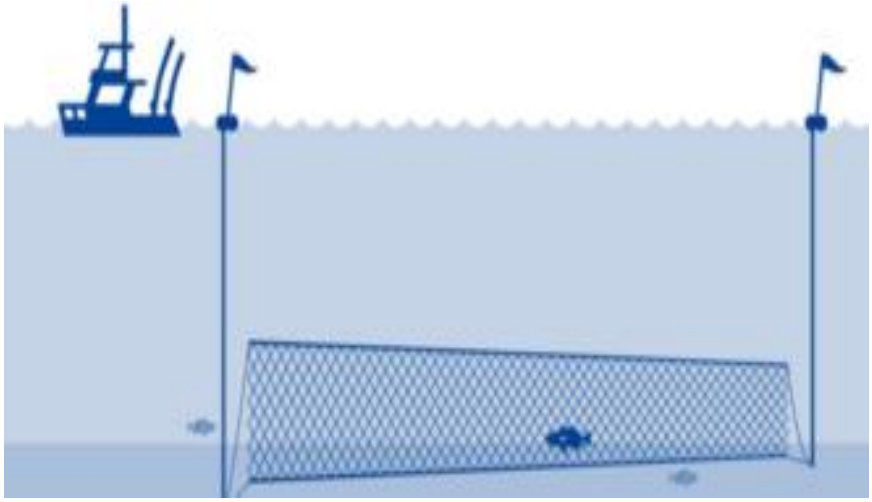
3. Desired outcomes

- Catch Quantity and Value: The value of individual fish caught (e.g., high-value tuna vs. low-value mackerel) influences the chosen gear. Commercial fisheries aiming for bulk catches might opt for large-scale operations and gear like purse seines or trawls.
- **Selectivity:** This refers to the ability of the gear to target specific species and sizes, minimizing the capture of unwanted organisms (bycatch). Different gear designs and modifications, like the use of Trawl Efficiency Devices (TEDs) or Turtle Excluder Devices (TEDs), can enhance selectivity.
- **Efficiency:** This refers to the gear's performance in terms of catch rates, energy consumption, and labor requirements.

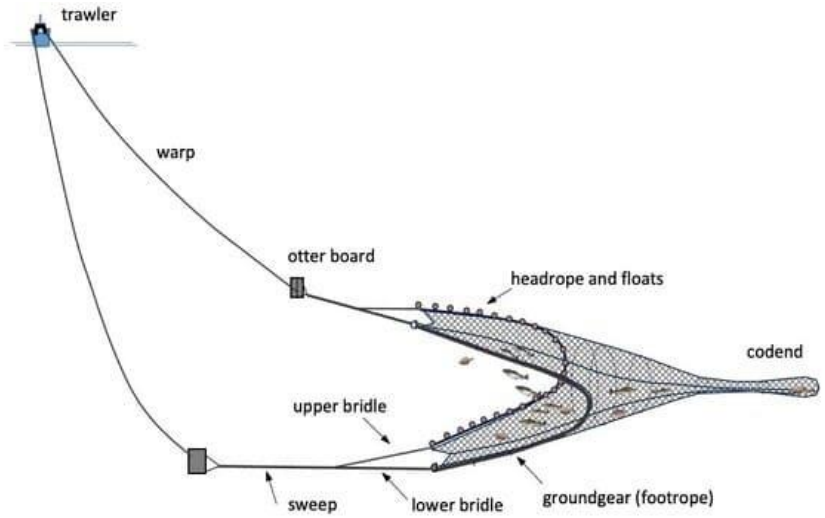
2.1.2 Common fishing gear types and Catching methods

A. Nets

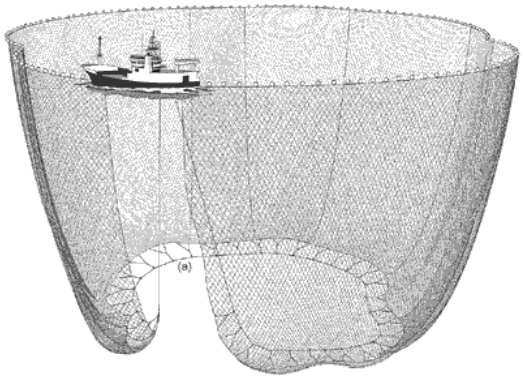
1. **Gillnets:** Vertical walls of netting designed to entangle fish by their gills as they try to swim through. Different types include drift gillnets (free-floating) and set gillnets (anchored). Mesh size varies based on target species.



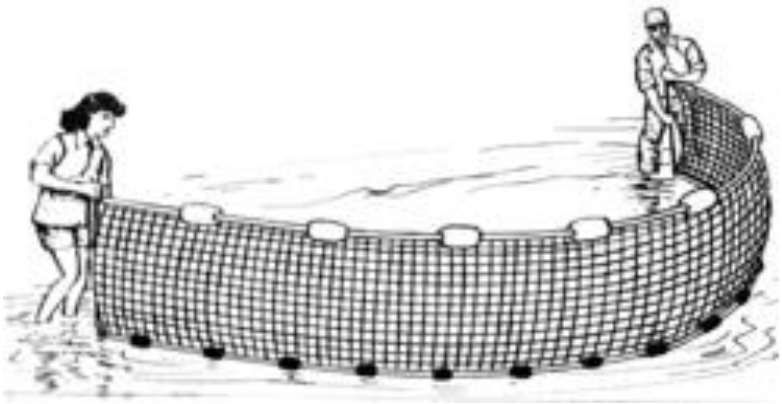
2. **Trawls:** Cone-shaped nets dragged through the water, either along the seabed (bottom trawls) or in midwater (midwater trawls). The mouth of the net is kept open by otter boards, a beam, or two boats towing apart.



3. **Purse Seines:** Large nets used to encircle schools of fish, then closed from the bottom using a purse line to prevent escape. Highly effective for shoaling species like tuna and mackerel.



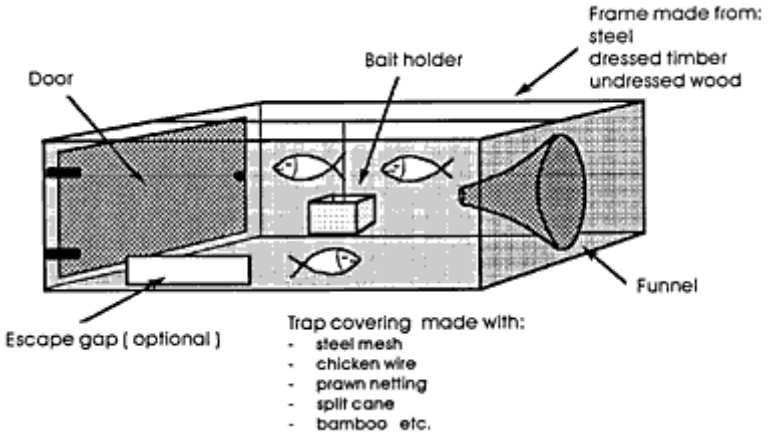
4. **Seine Nets:** Long walls of netting, with or without a bag, used to surround fish in coastal or shallow waters, and hauled ashore or onto a boat. Examples include beach seines and boat seines.



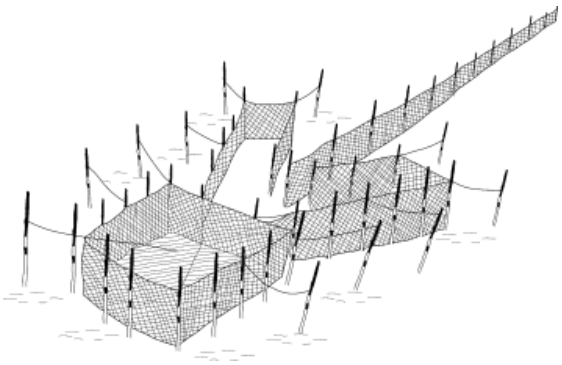
5. **Cast Nets:** Circular nets with weights on the perimeter, thrown from shore or a boat to cover and trap fish in shallow waters.

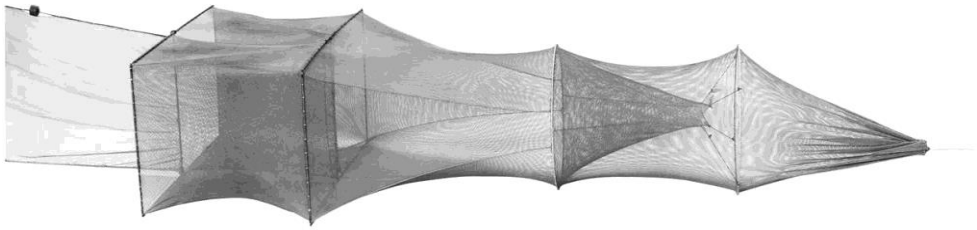
B. Traps

1. **Box Traps**: Enclosures that entice fish to enter but prevent their escape. Often baited to attract fish.

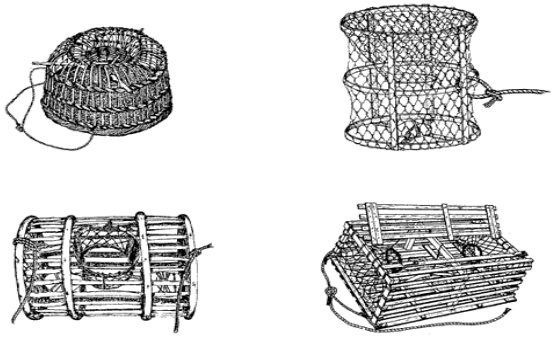


2. **Fyke Nets:** Cone-shaped nets with rigid rings, used in shallow waters to guide fish into the bag.



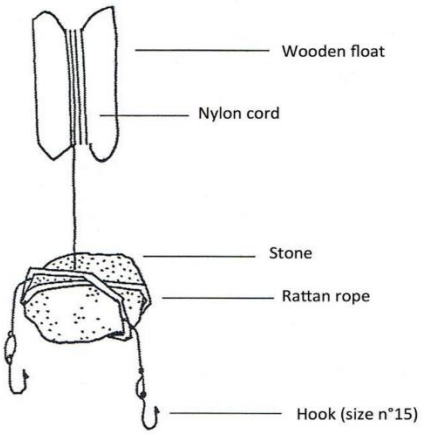


3. **Pots and Creels:** Enclosed structures, often baited, used to trap crustaceans like lobsters and crabs.

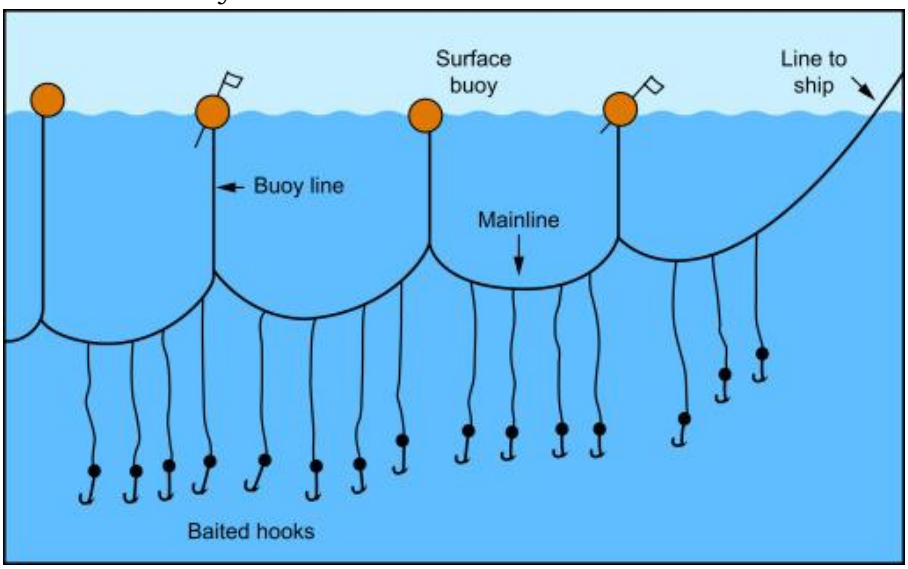


C. Lines

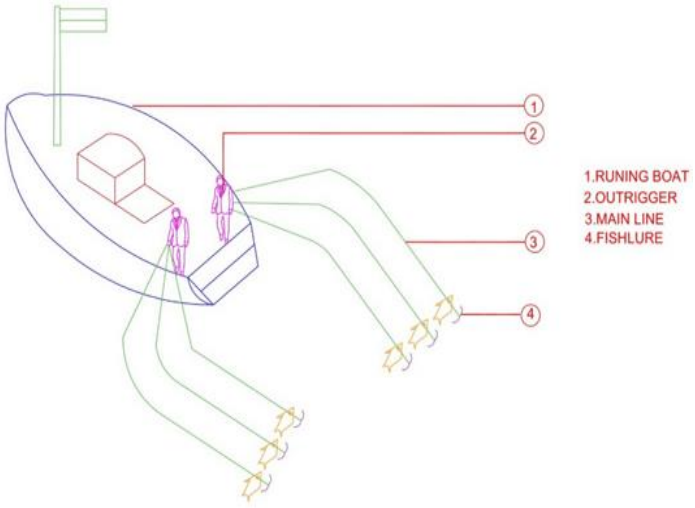
1. **Handlines**: Simple fishing lines held by hand, often with a single hook and bait.



2. **Longlines:** Main lines with numerous baited hooks attached at intervals, used to catch fish individually over extended distances.

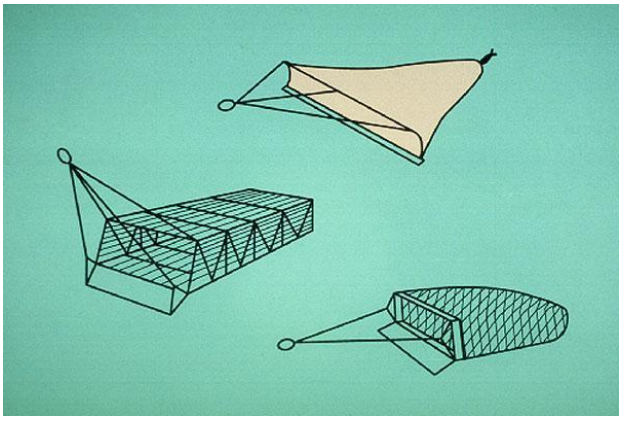


3. **Trolling Lines**: Lines with lures or bait towed behind a moving boat to attract and catch predatory fish.



D. Other methods

1. **Dredges:** Heavy frames with mesh bags dragged along the seabed to collect shellfish.



2. **Lift Nets:** Nets submerged and then quickly lifted to capture fish gathered over them.

3. **Stupefying Devices:** Methods to temporarily incapacitate fish, including mechanical (throwing stones, beating with sticks), chemical (using natural poisons like saponin), and electrical methods.

2.1.3. Factors influencing fishing gear design and effectiveness

- **Gear Construction:** Materials used, knotting patterns, mesh size and shape, and hanging ratios influence the net's effectiveness and selectivity. Synthetic fibers like nylon are commonly used due to their strength, durability, and resistance to rot.
- **Fish Behaviour:** The efficiency of fishing gear is linked to how fish react to the gear's visibility, colour, sound, and movement patterns. For example, gillnets might be designed with nearly invisible monofilament nylon, while guiding nets may be made more visible.
- **Environmental Factors:** Water temperature, light levels, and habitat structure (e.g., coral reefs) can influence gear choice and design.

2.1.3.1. Innovations in fishing gear design

Fishing industry is continuously evolving with technological advancements and a growing focus on sustainability.

- **Advanced Sonar Technology:** Sophisticated sonar systems provide real-time, 3D views of the underwater environment, enabling fishermen to locate and differentiate fish species, identify bait balls, and map the seabed.
- **GPS and Chart Plotting:** GPS and advanced chart plotters offer precise location information, allowing fishermen to mark optimal fishing spots and navigate hazardous areas with confidence.
- **Electric Outboard Motors:** Electric motors provide a quiet and eco-friendly propulsion option, especially advantageous when fishing for skittish species or in sensitive environments.
- **Selective Fishing Gears:** Innovations like Turtle Excluder Devices (TEDs) in shrimp trawls and circle hooks on longlines reduce the capture of non-target species, promoting biodiversity conservation.
- **Automated Fishing Systems:** Automation of tasks like net setting, hauling, processing, and packaging enhances efficiency and reduces labor intensity.
- **Sustainable and Eco-Friendly Materials**: The use of biodegradable lures, recycled materials in rods and reels, and eco-friendly fishing lines reduces the environmental impact of fishing gear.

These innovations contribute to more efficient, sustainable, and responsible fishing practices, helping to address challenges like overfishing, bycatch, and habitat destruction.

2-2 Fishing accessories, Netting materials natural and synthetic fishing gear materials and yarn numbering system

2.2.1. Fishing accessories

Fishing accessories are the additional equipment used in combination with crafts and gears to enhance fishing efficiency, ensure safety, and improve fish quality. These can vary significantly depending on the type of fishing operation and scale.

- **Floats and Sinkers**: Essential for keeping nets in the desired position in the water column. Floats, typically made of plastic, cork, or sealed tins, are attached

to the headrope to provide buoyancy. Sinkers, made of lead or other heavy materials, are attached to the footrope to make t he net sink to the desired depth.

- **Ropes and Lines:**
- Used for various purposes like hauling nets, attaching floats and sinkers, and for handling the catch. Ropes are also used to tow nets in certain fishing methods like drag nets.

Fishing rope:

- **Primary function:** Used for heavier-duty applications in commercial and aquaculture fishing, such as nets, trawls, pots, and cage constructions.
- **Characteristics:** Generally thicker, stronger, and more durable than fishing lines, with resistance to abrasion and environmental factors.
- **Types:** Made from materials like nylon, polypropylene, polyester, and UHMWPE (Dyneema).

Rope

Line

Line:

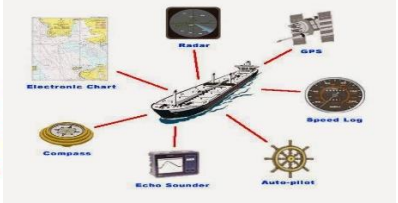
- **Primary function:** To connect the angler's reel to the fishing lure or bait, and ultimately, to the fish.
- **Characteristics:** Typically, thinner in diameter and designed for optimal casting, sensitivity to detect bites, and suitable breaking strength for target species.
- **Baits**: Used to attract fish to hooks or traps, varying based on the target species. Common baits include earthworms, grasshoppers, and small fish pieces.

- **Buoys and Markers:** Used to mark the location of nets or traps, especially in gillnet or longline fishing.

- **Net Repair and Maintenance Tools:** Tools like needles, knives, and mending twine are essential for maintaining and repairing nets.

- **Fish Handling and Storage:** Accessories like baskets, tubs, and iceboxes are used to store and transport the catch, ensuring freshness and quality.

- **Safety Equipment:** Life jackets, navigation equipment, and signalling devices are crucial for the safety of fishermen, particularly in offshore operations.



2.2 2. Netting materials

Netting materials are broadly classified into natural and synthetic fibers. For thousands of years, natural fibers were the primary material for fishing nets before the introduction of synthetics in the 1950s.

1.Natural fibres:

- **Cotton:** Known for its softness, breathability, and absorbency. However, it is prone to rotting and heavy water absorption, requiring significant maintenance. Cotton nets are still used in some traditional fisheries, but their use has declined.
- **Linen (Flax):** Strong, durable, and absorbent, with good resistance to dirt and stains. Like cotton, linen was widely used in traditional fishing nets but has been largely replaced by synthetics due to durability issues in humid environments.
- **Hemp:** Strong and durable, with natural resistance to rotting and mildew. Hemp was historically used for ropes and nets, particularly for its strength and durability.
- **Sisal:** Strong, coarse, and resistant to saltwater damage, primarily used for ropes and coarser netting.
- **Jute:** Strong, durable, breathable, and biodegradable, used for ropes, sacks, and some types of nets.
- **Coir:** Coarse, strong fiber from coconut husks, highly resistant to abrasion and water damage, used for ropes and mats, and also in fishing nets, particularly for its durability.

2.Synthetic fibers:

Synthetic fibers have revolutionized fishing gear due to their superior properties compared to natural fibers.

- **Nylon (Polyamide - PA):** A strong, elastic, and abrasion-resistant synthetic polymer. Nylon multifilament and monofilament are widely used for fishing nets and twines due to their high tensile strength and durability. It is resistant to UV radiation and water, making it ideal for various fishing environments. However, some types of nylon can degrade due to solar radiation over time.
- **Polyethylene (HDPE, LDPE):** Known for good chemical resistance, low cost, and low density. It is preferred for its high breaking strength, durability, and high resistance to abrasion, especially in cage aquaculture.

  Ultra-high molecular weight polyethylene (UHMWPE) offers exceptional strength and durability, about 5 times that of other materials, leading to lighter and more fuel-efficient nets, particularly for trawling and deep-sea cages, despite its higher initial cost.
- **Polyester (PET):** Offers excellent mechanical and thermal resistance, and is used in next-generation nets. Polyester is known for its softness, reducing damage to fish, and has high strength, making it suitable for deep-sea applications.
- **Polypropylene (PP):** Lighter than polyethylene but less resistant to UV radiation. It is used in ropes and twines, particularly for its lightness.

2.2.3. Yarn numbering system

Yarn numbering systems are used to express the thickness or fineness of a yarn, a crucial factor in selecting the appropriate netting material for specific fishing gear. Since yarn is compressible, its diameter cannot be directly measured with instruments

like micrometers. Therefore, systems based on linear density (length per unit mass or mass per unit length) are used.

There are two main types of yarn numbering systems:

1. Direct yarn numbering system (mass per unit length)

In this system, a higher number indicates a coarser or thicker yarn.

- **Tex:** The universal yarn numbering system recommended by the International Standards Organization (ISO). 1 Tex = the weight in grams of 1000 meters (1 km) of yarn. Higher Tex indicates a coarser yarn.
- **Denier** (Td or d): Widely used for continuous filament synthetic threads. 1 Denier = the weight in grams of 9000 meters of yarn. Higher Denier indicates a coarser yarn.
- **Spyndle Count:** Used for jute, hemp, or dry-spun linen yarn. 1 Spyndle = weight in pounds per 14,400 yards of yarn.
- **Decitex (dTex**): Weight in grams of 10,000 meters of yarn.
- **Militex (mTex**): Weight in milligrams of 1000 meters of yarn.
- **Kilotex (kTex):** Weight in kilograms of 1000 meters of yarn.

2. Indirect yarn numbering system (length per unit mass)

In this system, a higher number indicates a finer or lighter yarn.

- **English Cotton Count (Ne):** Number of hanks (840 yards) which weigh one pound. Higher Ne indicates finer yarn.
- **Metric Count (Nm):** Number of kilometers of yarn which weigh one kilogram. Higher Nm indicates finer yarn.
- **Worsted Count (NeK):** Number of hanks (560 yards) that weigh one pound.

Significance in fishing gear selection:

Understanding yarn numbering systems is crucial for:

- **Purchasing and selecting netting yarns:** Allows fishermen and manufacturers to choose the appropriate yarn size for specific fishing gears and target species.
- **Determining net properties:** The yarn count influences the strength, durability, flexibility, and mesh stability of the net.
- **Cost-effectiveness:** Selecting the right yarn count can optimize material usage and reduce costs, potentially leading to more fuel-efficient nets in the case of lighter materials like UHMWPE.

Considering the choice of fishing accessories, netting materials, twine construction, and yarn numbering systems, fisheries professionals can design and utilize fishing gear that is efficient, durable, and sustainable.

2.3 Active fishing gear - classification and description of modern fishing gears. - Design and operation of trawls, purse seines, ring seines, beach / shore seine, boat seine, pole and line, squid jigs, trolling.

2.3.1 Classification and description of modern fishing gears in India

Modern fishing gears in India represent a blend of traditional knowledge and technological advancements, aiming for increased efficiency, better catch quality, and sustainable fishing practices. These gears can be broadly classified based on their operating principles and methods.

A. Classification based on operating principles

1. **Passive Fishing Gears**: These gears do not actively move to capture fish. Instead, they are set in the water and rely on the fish to encounter and become entangled or trapped in them. Examples include gillnets, traps, and hooks and lines.
2. **Active Fishing Gears:** These gears are actively moved through the water to search for and capture fish. They generally consume more energy but can be highly productive. Examples include trawls and seine nets.

B. Description of major modern fishing gears in India

1. Trawls

Trawls are conical, bag-shaped nets dragged through the water, primarily for catching fish and other aquatic animals dwelling on or near the seabed.

- **Operation:** They are typically operated by mechanized boats or trawlers, equipped with powerful engines to tow the net.
- **Classification:**
- **Bottom Trawls:** Operated along the seabed to catch demersal species.
- **Midwater Trawls (Pelagic Trawls):** Designed to capture fish in the mid-water column.
- **Beam Trawls:** The mouth of the trawl is kept open by a rigid beam.
- **Otter Trawls:** Otter boards (large, flat wooden or metal plates) are used to spread the mouth of the net horizontally.
- **Pair Trawls (Bull Trawls):** Operated by two boats, which spread the trawl mouth by towing the net apart.
- **Innovations:** Modern trawls incorporate features like large meshes in the forepart to minimize drag and reduce fuel consumption. Devices like Juvenile Fish Excluder cum Shrimp Sorting Devices (JFE-SSD) and Turtle Excluder Devices (TEDs) are being developed and implemented to reduce bycatch and protect vulnerable species like sea turtles.

2. Seine nets

Seine nets are long walls of netting, with or without a bag, used to encircle a school of fish. They are operated by hauling ropes attached to the wings of the net.

- **Operation:** Seines are typically used in coastal or shallow waters where the bottom and surface can act as natural barriers for the encircled fish.
- **Classification:**
- **Beach Seines (Shore Seines):** Operated from the shore in shallow waters. Rampani nets are a well-known example of this type of gear used on the southwest coast of India.
- **Boat Seines:** Operated from boats in deeper waters compared to beach seines. Danish seine is an example of a boat seine.

3. Purse seines

Purse seines are large surrounding nets, roughly rectangular in shape, rigged with floats on the headrope and sinkers in the footrope.

- **Operation:** After encircling a school of fish, typically pelagic species like sardines and mackerel, a purse line at the bottom of the net is hauled in, closing the net and preventing fish from escaping downwards.
- **Impact:** Purse seines are highly efficient for catching shoaling fish, but their use needs careful management to prevent overfishing and impacts on non-target species.

4. Gillnets and entangling nets

Gillnets are vertical walls of netting kept erect in the water column using floats and sinkers. They are set perpendicular to the movement of fish, which become snagged by their gills or entangled in the mesh as they try to swim through it.

- **Operation**: Gillnets can be operated in various ways:
- **Drift Gillnets:** Allowed to drift with the water current, often attached to a boat or marked by buoys.
- **Set Gillnets**: Anchored at the surface, midwater, or bottom to maintain a fixed position.
- **Encircling Gillnets:** Used to surround a school of fish and then hauled in.
- **Trammel Nets:** A type of entangling net, consisting of three layers of netting (two outer layers of larger mesh and an inner layer of smaller mesh). Fish get entangled in the inner small-meshed net after passing through the outer large meshes.

5. Hooks and lines

Line fishing uses hooks baited with natural or artificial lures to attract and catch fish individually.

- **Operation:** Lines are used in both traditional and modern fishing sectors.
- **Types:**
- **Pole and Line:** Used to catch fish individually, popular in the Lakshadweep islands.
- **Jig Lines:** Often used with lights to attract and catch squids.
- **Troll Lines:** Lines with hooks and bait, dragged through the water to catch predatory fishes like Spanish mackerel and barracuda.
- **Hand Lines:** Simple lines held by hand, with or without a pole.
- **Long Lines:** Long main lines with numerous branch lines, each carrying a baited hook. Tuna long lines are a significant example of this gear.

6. Traps

Traps are stationary fishing gears into which fish are voluntarily enticed but are then prevented from escaping due to their design.

- **Operation:** Traps are set in water and rely on the behaviour of fish to enter.
- **Types:**
- **Fyke Nets:** Cone-shaped nets with rigid rings, used in shallow waters to guide fish into a bag.
- **Pound Nets:** Large, fixed or anchored traps used to capture fish, often with compartments that prevent escape.
- **Basket Traps:** Traps with small entrances, allowing fish to enter but not exit.

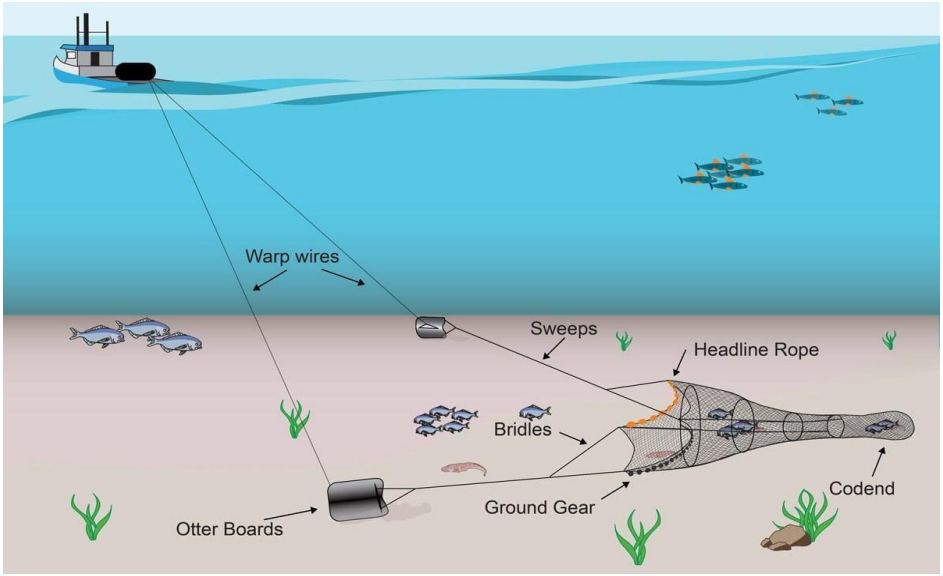
Other modern fishing technologies

Beyond traditional gears, India's fisheries sector is embracing technologies like sonar and GPS for fish detection and navigation, refrigerated vessels for better preservation of catch, and the use of satellite communication for real-time information exchange. The government is also promoting sustainable practices and innovations in gear design to address challenges like overfishing and bycatch.

2.3.2.1 Design and operation of Trawls

1. Trawls

- Design: Trawls are large, conical bag-shaped nets with two wings and a cod end (the bag where the catch accumulates). They are designed to be towed or dragged through the water column. The mouth of the trawl is kept open either by a rigid beam (beam trawl) or by otter boards (otter trawls), which use hydrodynamic forces to spread the net horizontally.
- **Net Parts: Key components include:**
    - Warp: The rope or cable used for towing the net, often with distinguishing marks at regular intervals.
    - Otter Board: Devices used in pairs to horizontally open the mouth of the net.
    - Sweep Lines: Ropes connecting the net's wings to the otter boards.
    - Wings: Side extensions of the net.
    - Head Rope and Foot Rope: Ropes along the top and bottom edges of the net's mouth, respectively.
    - Cod end: The terminal part of the net where the fish collect.

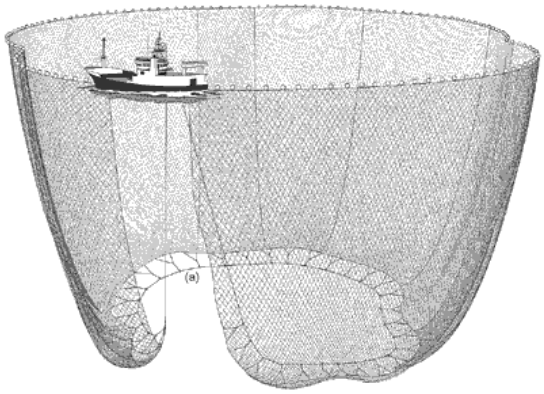


- Operation: Trawls are operated from fishing vessels (trawlers) equipped with powerful engines to tow the net at appropriate speeds. Trawlers are fitted with winches and a mast and boom arrangement to haul the net aboard and lift the cod end over the deck.
- Classification by operation:
    - Bottom Trawls: Operated along the seabed for demersal species.
    - Midwater or Pelagic Trawls: Operate in the mid-water column.
- Classification by vessels:
    - One-Boat Trawl: Operated by a single vessel.
    - Two-Boat Trawl or Pair Trawl (Bull Trawl): Two trawlers are used to spread the net by towing the warps between them.
- Example: Squid and cuttlefish trawls operated along the Kerala coast have head rope lengths ranging from 54.0-57.6m and use HDPE webbing.

2.3.2.2 Design and operation of Purse seines

Design: Purse seines are long walls of netting with float lines at the top and lead lines through rings on the bottom. A purse line allows the net's bottom to be closed like a purse. Thicker twine and smaller mesh are often used in the bunt region. Common netting materials include polyamide, polyester, and polyvinyl alcohol.

- Operation: This method is efficient for catching schooling fish, especially pelagic species. It involves locating fish, encircling the school with the net, pulling the purse line to close the bottom, and hauling in the net or bringing it alongside the vessel. Locating fish can involve natural cues, helicopters, and radar.
- Vessels: Boats used are called purse seiners, ranging from small open boats to large ocean-going vessels.
- Systems: Operations can be conducted by one boat, sometimes with a skiff, or by two boats.
- Example: Purse seines off Ratnagiri, Maharashtra, target oil sardine and mackerel and have specific dimensions.



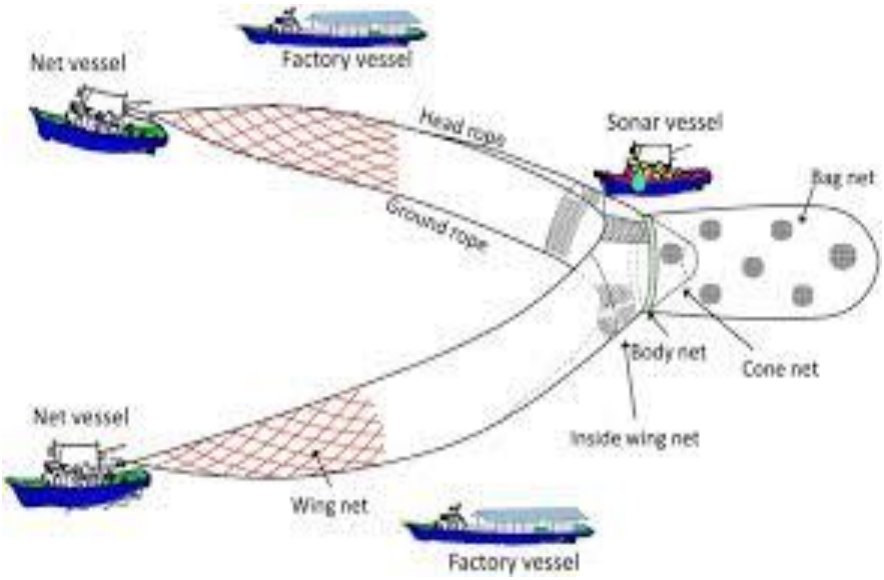
2.3.2.3 Design and operation of Ring seines (or mini-purse seines)

- Design: Ring seines are similar to mini-purse seines for capturing shoaling pelagic fish. They are circular nets with floats, weights, purse rings, and lines, creating a closed area around fish schools. Mesh size varies by target species.
- Operation: Fish schools are located visually, the net is deployed in a circle, and the catch is hauled in.
- Evolution: Originally used with canoes, they now use medium-sized boats with outboard engines.
- Examples: In Kerala, different sizes and mesh sizes of ring seines are used for specific species like anchovies, perch lets, oil sardine, and mackerel.

2.3.2.4. Design and operation of Beach / Shore seine

- Design: Operated from shore, beach seines consist of a bag or loose netting (bunt), two long wings with ropes, a headrope with floats, and a footrope on the bottom, forming a barrier to enclose fish. Some have a cod end.
- Operation: A boat lays the net in a semi-circle from the beach, and both hauling ropes are pulled simultaneously onto the beach to encircle the fish.
- Catch: Targets coastal pelagic and can catch a variety of species, but bycatch, including juveniles, is a significant issue.
- Role: While less prevalent than in the past, it remains socio-economically important for marginalized fishing communities, especially on the east coast.

2.3.2.5. Design and operation of Boat seine



- Design: Boat seines are operated from boats, often with the help of two canoes.
- Operation: They are used off the bottom to encircle schooling fish by being shot and hauled with the help of the boats.
- Impact: Like trawls, the small meshes can catch undersized fish and non-target species.
- Usage: Used throughout the year, with peak seasons during monsoon and post-monsoon.

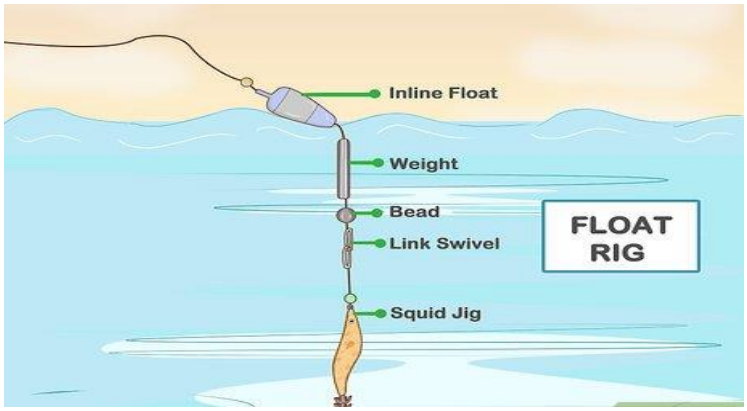
2.3.2.6. Design and operation of Pole and line

- Design: This method catches fish individually using a pole with a hook and line, often baited.
- Operation: Baitfish are caught, used to attract tuna schools, and then tuna are caught one at a time using poles with hooks and lines.
- Sustainability: Known for being selective, targeting individual tuna and minimizing bycatch.
- Example: This is a sustainable practice, particularly important in Lakshadweep.

2.3.2.7. Design and operation of Squid jigs

- Design: Squid jigs are lures designed to mimic squid prey. They are made of various materials with sharp hooks to entangle squid.
- Operation: Artificial lights attract squid, and lines with jigs are hauled vertically through the concentration. Squids are hooked and removed with a scoop net.

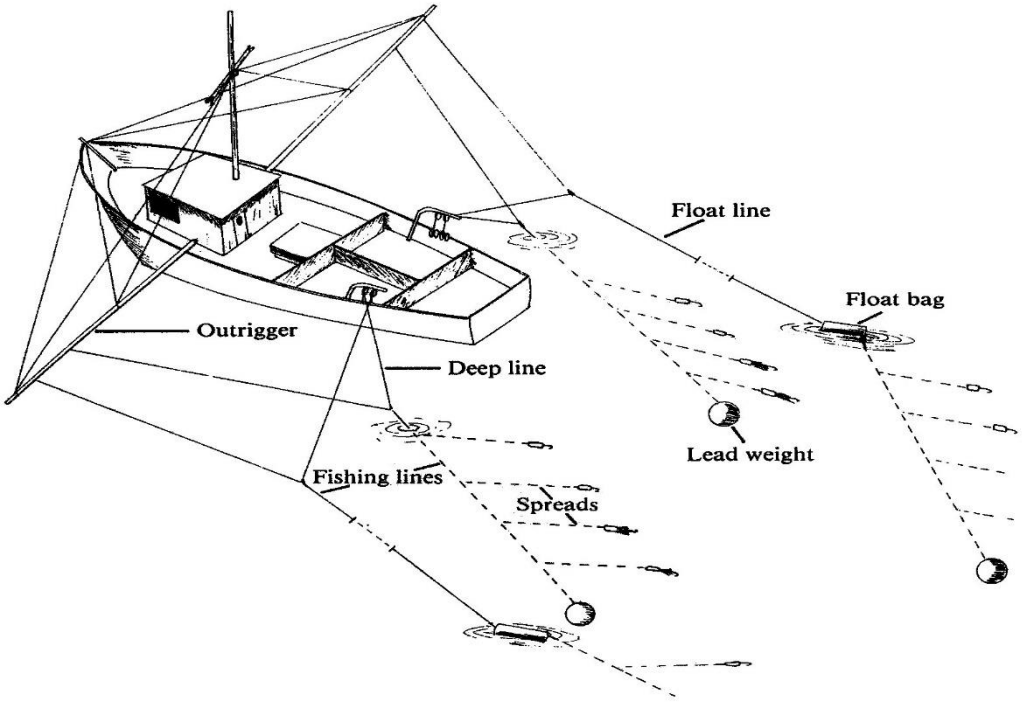
- Evolution: Designs have progressed from manual operation to automated reels and high-illumination lights.



2.3.2.8. Design and operation of Trolling

- Design: This method involves dragging one or more fishing lines with lures or bait behind a moving boat.
- Operation: The boat moves at a speed appropriate for the target species. Outriggers can be used to separate multiple lines.
- Vessels: Trollers vary in size from small open boats to large refrigerated vessels.
- Efficiency: Considered an economical and efficient way to catch tuna, mackerel, and other surface-dwelling pelagic fish.
- Versatility: Can be used inshore and offshore, reaching deeper waters than some methods.

These fishing gears and methods in India are evolving, with focus on sustainability, selective designs, and technology for healthy fish stocks and marine ecosystems while supporting fishing communities' livelihoods.



UNIT III: ANCHORS, FISH FINDING & NAVIGATIONAL EQUIPMENT

3-1 Types of Anchors Chains, ropes, blocks, leads and drogues

These are essential components of fishing operations, each playing a distinct role in safely and efficiently deploying and retrieving fishing gear, securing vessels, and handling the catch.

3.1.1. Anchors

Anchors are used to secure vessels to the seabed, preventing drift due to currents or wind. Different types are employed depending on the vessel size, seabed conditions, and whether the anchorage is temporary or permanent.

A. Temporary Anchors: Used for shorter periods and easier retrieval.

- **Danforth Anchors:** Lightweight, compact, and designed for small to medium-sized vessels. They feature sharp, triangular flukes that dig into sandy or muddy bottoms, offering good holding power.
- **Plow Anchors (CQR/Delta):** Designed to penetrate the seabed deeply and provide strong holding power in various seabed conditions like sand, mud, and gravel.
- **Bruce Anchors** (Claw Anchors): Known for their ability to set quickly in rocky or weedy bottoms.
- **Grapnel Anchors**: Lightweight and easy to retrieve, making them suitable for smaller boats operating in rocky or weedy bottoms. They have a shank with four or more tines or flukes that grip onto the seabed.

B. Permanent Anchors: Used for long-term anchorages, such as for buoys, navigational aids, or fish farms.

- **Mushroom Anchors**: Rely on their shape and weight to sink into soft sea beds and create suction, commonly used in calm, sheltered waters.
- **Deadweight Anchors**: Similar to mushroom anchors, they use weight to hold down the vessel. They can function in a wider range of seabed conditions but can be difficult to handle due to their large size.
- **Auger Anchors:** Screw into the seabed with pitched threads, providing high holding power, particularly effective for permanent moorings in various environments.

3.1.2. Chains and ropes (Anchor rode)

Anchor rode, composed of chains, ropes, or a combination of both, connects the anchor to the vessel. Its strength and length are critical for effective anchoring.

- **Anchor Chains:** Anchor chains, typically made of galvanized steel, provide weight at the anchor end, helping the anchor set and maintain its grip on the seabed. The thickness of the chain is determined by the vessel's size and weight.
- **Anchor Ropes:** Commonly made of materials like nylon, which provides strength and elasticity to absorb shock loads and prevent jerking. Ropes are generally lighter than chains but require greater length for the same holding power.
- **Chain Fore-runner:** A length of anchor chain used with anchor lines, particularly on heavier boats. It helps pull down the anchor shank, increasing static friction and anchor effectiveness. It also protects the anchor line from rubbing on rocky sea beds.
- **Rope Length:** Generally, the longer the anchor rode (chain or line), the better the anchor will hold, as it creates a lower angle of pull on the anchor. For optimal

mooring, a chain length 5 to 7 times the water depth is sufficient, while an anchor line requires at least 10 times the water depth.

3.1.3. Blocks

Blocks are essentially pulleys used to change the direction of a rope's pull or to gain mechanical advantage, making it easier to haul heavy fishing gear or nets.

- **Usage in Fishing Operations:** Blocks are commonly used with fishing gear like trawl nets and seine nets. For example, in pair trawling, two trawlers are used to spread the net, and a block and tackle system with a winch is employed to haul in the gear.
- **Boat Construction:** Blocks can also be used in the construction of fishing boats, like catamarans, where blocks of wood are used to hold the logs together with coir ropes passing through grooves.

3.1.4. Leads (Sinkers)

Leads, or sinkers, are weights used to sink fishing lines, nets, or bait to the desired depth.

- **Material:** Traditionally, lead has been the primary material for sinkers due to its density. However, due to environmental concerns, there is a push towards eco-friendly alternatives.
- **Shapes and Sizes:** Sinkers are available in various shapes and sizes, from small split shots for freshwater fishing to large weights for deep-sea applications. Examples include pipe-shaped lead sinkers for fishing lines and spherical sinkers for nets.

- **Usage:**
  - **Nets:** Sinkers are attached to the footrope of nets like gillnets, ensuring they reach the desired depth and maintain their vertical position in the water column.
  - **Lines:** Used in conjunction with fishing lines and hooks or lures to increase the rate of sink, improve casting distance, or provide anchoring ability, depending on the fishing technique.

3.1.5. Drogues (Sea Anchors)

Drogues, often referred to as sea anchors, are devices used to stabilize a vessel and reduce its drift in heavy weather conditions. They work on the principle of hydrodynamic drag.

- **Design:** Sea anchors are parachute-like devices, typically made of sturdy fabric, that are deployed off the bow (front) of the vessel. They are attached by a rode (rope or line) and are designed to fill with water, creating resistance and slowing down the vessel's movement.
- **Operation:** When deployed, the sea anchor keeps the vessel's bow facing into the waves, preventing it from turning side-on and reducing the risk of capsizing or pitchpoling. They can significantly reduce drift, particularly during deep-sea fishing operations.
- **Distinction from Drogue (Speed Limiting):** While the term "sea anchor drogue" is used, it's important to distinguish the sea anchor (deployed from the bow to reduce drift) from a speed-limiting drogue, which is smaller and typically deployed off the stern to slow the vessel down during a storm or when hauling in a catch.
- **Materials:** Sea anchors can be made from various materials, with nylon and rayon being common choices. The ropes used with them should not increase in weight significantly when immersed in seawater.

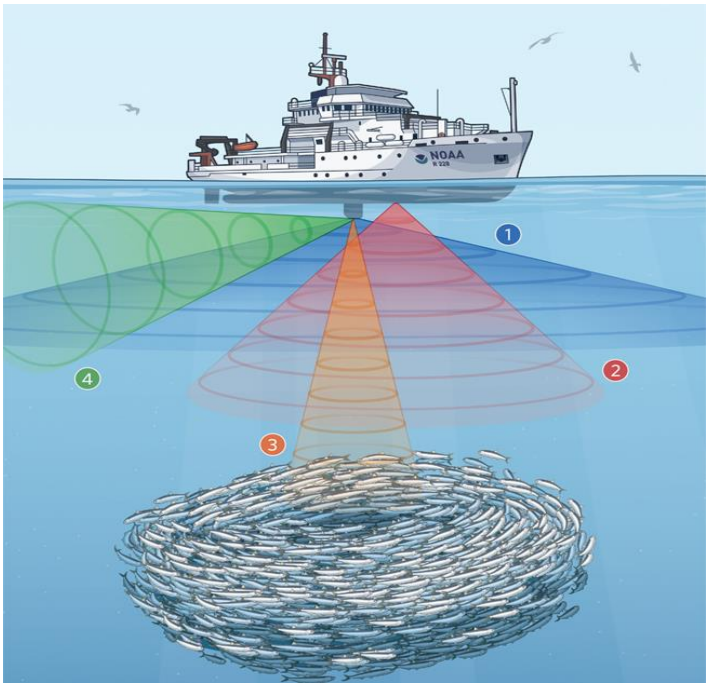
By understanding the types, functions, and proper use of these essential components, fishermen in India can enhance the efficiency, safety, and sustainability of their fishing operations.

3-2 Echo sounders, fish finders, sonar and net sonde

These electronic instruments play a crucial role in modern Indian fisheries by helping fishermen locate fish, navigate safely, and optimize their fishing operations. They all operate on the principle of sonar (Sound Navigation and Ranging), but with different applications and capabilities.

3.2.1. Sonar

- **Principle:** Sonar utilizes sound waves to detect and locate underwater objects. Active sonar systems transmit sound pulses and listen for the echoes, while passive sonar systems only receive sounds generated by underwater objects or other sound sources.



- **Applications in Indian Fisheries:**
  - **Fish Detection and Abundance Estimation:** Sonar is employed to detect the presence of fish schools, estimate their size and density, and monitor their movement.
  - **Navigation and Safety:** Sonar can be used to map the seabed, detect underwater obstacles like rocks and wrecks, and ensure safe navigation, especially in unfamiliar waters.
  - **Targeted Fishing:** By providing information on fish location and behaviour, sonar assists fishermen in making informed decisions about when and where to deploy their nets or gear.
  - **Resource Management:** Sonar data can contribute to a better understanding of fish stocks and aid in their sustainable management.
- **Types:** Sonars can be broadly categorized as:
  - **Searchlight Sonar:** Displays underwater information in a 360-degree view around the vessel by rotating the sensor.
  - **Scanning Sonar:** Emits ultrasonic waves in all directions simultaneously, providing faster and instant detection.

3.2.2. Echo sounders (Fish Finders)

- **Principle:** An echo sounder is a type of sonar that primarily transmits sound pulses vertically downwards into the water. It then measures the time taken for the echoes to return after reflecting off the seabed or underwater objects, like fish schools.
- **Components:** A typical echo sounder consists of a transmitter, transducer, receiver, and a display unit or recorder.
- **Applications in Indian Fisheries:**
    - **Depth Measurement:** Primarily used to determine the water depth beneath the vessel.
    - **Seabed Mapping:** Provides information on the seafloor contours and bottom composition.
    - **Fish Detection:** Detects and records traces of fish schools below the surface.
    - **Trawl Operations:** Essential for bottom trawling operations, helping fishermen detect fish close to the bottom and avoid damaging the gear on an uneven seabed.
    - **Resource Assessment:** Data from echo sounders can be used to assess the relative abundance of fish at a particular depth.
- **Types:** Include single beam and multi-beam echo sounders, each with varying capabilities for depth measurement and seabed mapping.
- **White Line Feature:** Modern echo sounders may include a "white line" recording facility to highlight fish close to the seabed by clipping off stronger bottom signals, making the fish echoes more prominent.

3.2.3. Net sonde

- Functionality: A net sonde is a specialized acoustic sensor attached to the trawl net's headrope or other parts. It provides real-time information about the net's behaviour and the fish entering it.
- **Data Provided:**
    - **Vertical Opening of the Trawl:** Helps fishermen monitor if the net's mouth is open optimally.
    - **Fishing Depth:** Provides data on the depth at which the net is operating.
    - **Fish Behaviour in Front of the Net:** Gives insights into how fish are reacting to the net, allowing for adjustments to optimize capture.
    - **Catch Entering the Net:** Indicates the quantity of fish entering the net, aiding in decisions about hauling.

- **Benefits in Indian Fisheries:**
  - **Optimizing Trawl Operations:** By providing crucial data, net sondes help fishermen make timely decisions for successful gear maneuvers.
  - **Increased Efficiency and Catch Rates**: Ensures the net is working effectively and improves the chances of a good catch.
  - **Reducing Bycatch (Potentially):** Can help fishermen adjust net deployment and retrieval based on fish behaviour, potentially reducing the capture of non-target species.

3-3 Chronometer, gyro compass, radar, decca, omega etc.

Indian fisheries sector is increasingly adopting various electronic navigation and communication systems to enhance safety, efficiency, and sustainability. While some older technologies are being replaced by more advanced systems, their historical significance and the principles they introduced are still relevant.

1. Chronometer

- **Role in Traditional Navigation:** Historically, the marine chronometer, a highly accurate timepiece, played a crucial role in celestial navigation.
- **Modern Relevance:** With the widespread availability of Global Positioning System (GPS) and other modern navigation systems, the need for chronometers for primary navigation has diminished.

2. Gyro Compass

- **Role in Modern Navigation:** A gyro compass is a non-magnetic compass that relies on a fast-spinning gyroscope wheel and the Earth's rotation to determine true north.
- **Integration with Other Systems:** Gyro compasses are often integrated with other navigation systems like Electronic Chart Display and Information Systems (ECDIS) and radar systems to enhance accuracy and provide a unified view of navigational data.

3. Radar

- **Role in Safety and Navigation:**

  Marine radar uses radio waves to detect and locate objects in the vicinity of the vessel, including other vessels, landmasses, and navigational hazards.

  It is a vital tool for maintaining a proper lookout, especially in low visibility conditions like fog or darkness, and plays a crucial role in collision avoidance.
- **Applications in Fisheries:**
  - **Collision Avoidance:** Helps fishermen detect approaching vessels and avoid collisions, ensuring the safety of the crew and gear.
  - **Navigation:** Assists in navigating in coastal areas and identifying the position of the vessel relative to landmasses or other fixed targets.
  - **Fishing Gear Monitoring:** Can be used to monitor the position of fishing gear, especially in congested areas with multiple fishing vessels.

4. Decca and Omega

- **Role in the Past:** Decca and Omega were early radio navigation systems that provided position-fixing capabilities by measuring the time difference between signals received from a network of shore-based transmitters.
- **Declining Use:** With the advent of satellite-based navigation systems like GPS, these older systems have largely become obsolete and are no longer widely used in the Indian fisheries sector.

5. Modern Systems (e.g., GPS, NAVIC, Transponders)

- **GPS (Global Positioning System):** GPS, a satellite-based navigation system, provides highly accurate position information, revolutionizing navigation in fisheries. It helps fishermen navigate to potential fishing zones, avoid restricted areas, and ensure safe return to shore.
- **NAVIC (Navigation with Indian Constellation):** India's own regional navigation satellite system, NAVIC, provides accurate real-time positioning information, enhancing safety and navigation for Indian fishermen and reducing dependence on foreign systems.
- **Transponders:** Devices like the second-generation distress alert transmitter (DAT-SG) developed by ISRO, are installed on fishing vessels for monitoring, control, and surveillance, enhancing safety, providing weather alerts, and helping fishermen stay within national boundaries.

While traditional navigation tools like chronometers are still relevant for backup purposes and training, modern electronic systems like GPS, NAVIC, and radar have revolutionized navigation and safety in the Indian fisheries sector.

These technologies, combined with other tools like transponders and advanced communication systems, play a critical role in optimizing fishing operations, ensuring the safety of fishermen, and promoting sustainable fisheries management.

UNIT IV: EXPLORATION OF FISH AND CONSERVATION

4-1 Remote sensing applications in fish finding and catching

Remote sensing, especially satellite-based remote sensing, has become an indispensable tool in modern Indian fisheries for locating fish aggregation zones and optimizing fishing operations. It helps fishermen reduce investigation time, save fuel, and make more informed decisions, ultimately leading to increased catch efficiency and better resource management.

1. Remote sensing parameters for fish finding

Remote sensing techniques primarily infer the location of fish by measuring various oceanographic parameters that influence fish distribution, rather than directly detecting fish schools.

- **Sea Surface Temperature (SST):**
    - Fish species are often sensitive to specific temperature ranges and tend to aggregate near ocean thermal fronts where conditions are optimal or prey is abundant.

    - Satellite infrared thermal data is used to generate SST maps that delineate these thermal boundaries. Fishermen can use these charts to locate areas with temperature ranges preferred by their target species.
- **Ocean Colour (Chlorophyll Concentration):**
    - Ocean colour, measured by sensors like the Ocean Colour Monitor (OCM) on satellites like Oceansat-2, provides information on the concentration of chlorophyll pigments (chlorophyll-a).
    - Chlorophyll concentration is an indicator of phytoplankton biomass and primary productivity, which forms the base of the marine food web. Areas with higher chlorophyll concentrations often correspond to rich feeding grounds for fish.
    - Integrated charts combining chlorophyll and SST information provide a more comprehensive picture of potential fishing zones.
- **Oceanic Fronts and Circulation Features:**
    - Remote sensing data, particularly from SST and ocean colour, helps in identifying and monitoring dynamic oceanographic features like frontal boundaries, gyres, eddies, inversions, and upwelling areas.
    - These features are important in defining marine fish habitats as they can lead to aggregations of fish and their prey.
    - SAR equipped aircraft or satellites can survey the sea state of fishing grounds in near-real time, which is known to influence the distribution of fish.
- **Water Turbidity and Other Parameters:**
    - Ocean colour data can also be used to estimate water turbidity, which can be correlated with the presence of certain fish species.
    - While not yet operational, research indicates the potential of using microwave sensors to measure salinity, which is another environmental factor influencing fish distribution.

2. Potential fishing zone (PFZ) advisories

- **Generation:** Indian National Centre for Ocean Information Services (INCOIS), with assistance from the Indian Space Research Organization (ISRO), generates and disseminates daily Potential Fishing Zone (PFZ) advisories.
- **Data Integration:** These advisories are prepared by integrating satellite-derived information on SST and chlorophyll-a concentration.
- **Dissemination:** PFZ information is disseminated to the fishing community through various channels, including fax, telephone/cell phone, radio, television, electronic display boards, email, and websites.
- **Information on Advisories**: PFZ maps include information on the location of potential fishing zones relative to fishing centers, validity period, latitude and longitude, and in some cases, wind speed and direction to account for potential shifts in the zones.

PFZ advisories help fishermen reduce their search time for fish, leading to significant savings in fuel and operational costs. Studies have validated the effectiveness of these advisories, showing higher fish catches in PFZ areas compared to non-PFZ areas.

3. Remote sensing in fish catching

While remote sensing primarily aids in finding fish, it indirectly contributes to fish catching by guiding fishing efforts to areas of high fish aggregation.

- **Optimizing Fishing Operations:** By providing information on the location of PFZs, remote sensing helps fishermen plan their fishing trips more effectively, reducing the time spent searching for fish.
- **Decision-Making:** The knowledge derived from remote sensing data assists fishermen in making informed decisions about where and when to deploy their fishing gear, maximizing the chances of a good catch.
- **Resource Management:** Remote sensing data on fish distribution and abundance can be used to inform fishery management decisions and develop efficient harvesting strategies for fishery resources.

Challenges and limitations

Despite the significant benefits, the adoption of remote sensing in Indian fisheries faces some challenges:

- **Technological and Data Limitations:** Complexity of data interpretation, the need for advanced processing methods, and the difficulty in monitoring small fishing vessels that may not be equipped with GPS transponders.
- **Geographic and Research Gaps:** There is an unequal distribution of remote sensing research and applications, with significant gaps in some regions and limited local studies.
- **Integration and Accessibility:** Robust and accessible applications for direct use by fisheries managers are still limited, and there is a need for better integration with in situ data and management systems.
- **Resource Constraints:** Many areas lack the human, technical, and financial resources needed to effectively collect, analyse, and apply remote sensing data.
- Cloud Cover: In certain oceanic areas, like the southwest coast of India, frequent cloud cover can affect sensor detection and make predictions difficult or impossible.

Remote sensing technology, particularly satellite-based SST and chlorophyll data, is a powerful tool revolutionizing fish finding and catching in the Indian fisheries sector. By providing timely and crucial information, it empowers fishermen to optimize their operations, enhance safety, and contribute to the sustainable management of marine resources, despite facing certain challenges that need to be addressed for broader adoption and impact.

4.2 Turtle exclusion devices

Turtle Excluder Devices (TEDs) are specialized gear modifications designed to reduce the incidental capture and mortality of sea turtles, which are endangered and protected species under the Indian Wildlife Protection Act of 1972, in trawl fisheries.

These devices are particularly relevant for shrimp trawlers, which are legally mandated to use them in several Indian coastal states, although implementation remains a challenge.

1. Design and types of TEDs

- TEDs are designed based on the size difference and escape behaviour of sea turtles compared to target species like shrimp.

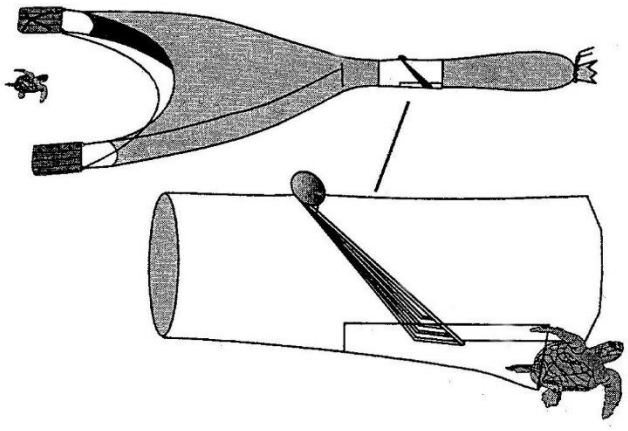
- They consist of a panel of large mesh netting or a rigid grid of deflector bars installed before the cod end (the end of the trawl net) at an angle.
- When a sea turtle enters the net, it is deflected by the grid or panel towards an escape opening, allowing it to exit the net.
- Hard TEDs: Feature a rigid frame and grid, often made of metal components like stainless steel or aluminium alloy.
- Soft TEDs: Utilize flexible components like netting and rope.
- Example: The Central Institute of Fisheries Technology (ICAR-CIFT) developed and standardized an indigenous TED (CIFT-TED) made of stainless-steel rod, with a specific size and deflector bar spacing.

2. Effectiveness of TEDs

- Studies and field trials in India have shown that CIFT-TEDs are effective in excluding sea turtles from trawl nets.
- Trials off the Dhamra coast in Odisha revealed 100% exclusion of turtles that entered the trawl system with a CIFT-TED installed.
- TEDs also help reduce the exclusion of marine debris and bycatch species like jellyfish.

3. Implementation and challenges

- Despite TED regulations in several maritime states (e.g., Andhra Pradesh, West Bengal, Odisha, and Kerala), their implementation has not been sufficiently effective.
- Concerns about potential catch loss have been a major reason for the fishing industry's initial resistance to adopting TEDs.
- Factors like poor construction, installation, or blockages can affect TED performance and lead to catch loss.



4. Addressing implementation barriers

- **Incentive Schemes:** Implementing attractive incentive schemes, such as better price realization for fish caught with TEDs or fuel subsidies linked to TED use, is seen as crucial for encouraging adoption.
- **Enforcement:** Effective enforcement of TED regulations is essential.
- **Co-management:** A co-management regime involving all stakeholders, including fishermen, government agencies, and NGOs, can facilitate better implementation.

- **Training and Awareness:** Organizations like the Marine Products Export Development Authority (MPEDA) and the Central Institute of Fisheries Technology (ICAR CIFT) are conducting training and awareness programs on the fabrication, installation, and operation of CIFT-TEDs for fishermen and other stakeholders.
- Awareness programs can address these beliefs and emphasize the benefits of TEDs.

Turtle Excluder Devices are a vital tool for sea turtle conservation and sustainable fisheries management in India.

A multi-faceted approach involving incentives, strong enforcement, stakeholder collaboration, and continued research and awareness programs is crucial to promote the widespread adoption of TEDs and ensure the long-term protection of sea turtles while supporting the livelihoods of fishing communities.

4-3 By-catch reduction devices

Bycatch reduction devices (BRDs) in the Indian fisheries sector

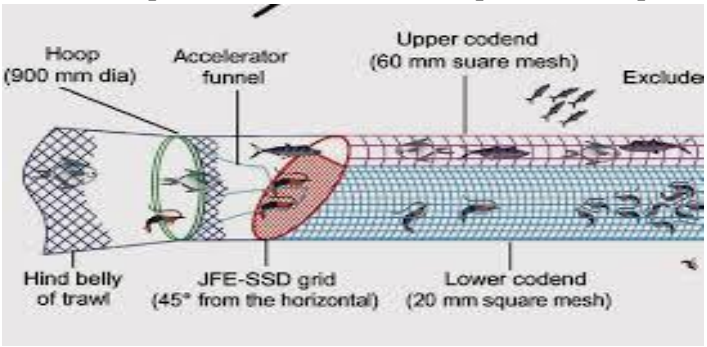
Bycatch refers to the capture of non-target species during fishing operations. It's a significant concern in trawl fisheries, particularly shrimp trawling, due to its potential impact on marine ecosystems, biodiversity, and the sustainability of fisheries resources.

Bycatch reduction devices (BRDs) are specialized modifications to fishing gear designed to reduce unwanted catches and improve the selectivity of fishing operations.

Types of BRDs used in India

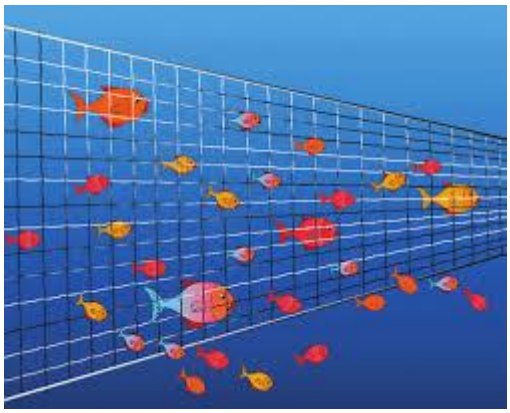
ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) has been at the forefront of developing and evaluating various BRDs suitable for Indian fisheries, especially shrimp trawling. Some of the BRDs tested and implemented in India include:

- **Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD):**
  - This award-winning design from ICAR-CIFT reduces bycatch of juveniles and small non-target species in shrimp trawls.
  - It also allows for the retention of commercially valuable fish and shrimp.
  - It features an integrated in situ shrimp sorting mechanism, making it highly suitable for adoption in Indian and tropical shrimp fisheries.



- **Square Mesh Cod end:**
  - Square mesh cod ends are proven technology for reducing bycatch of juvenile and sub-adult fish.
  - Unlike traditional diamond meshes that tend to close under tension, square meshes remain open, facilitating the escape of smaller fish and allowing market-sized fish to be retained.

- This also leads to reduced trawl drag, shorter sorting times, and improved quality and value of the catch.



- **Bigeye BRD:**
  - This device involves a horizontal slit in the upper cod end or hind belly, allowing fish that swim back to escape while shrimps are retained.
  - It is simple to design, fabricate, and install, making it a potential option for reducing finfish bycatch in shrimp trawls.
- **Fisheye BRD:**
  - This BRD utilizes an oval-shaped rigid structure in the cod end to facilitate the escape of actively swimming fish.
  - It's an important BRD for reducing bycatch and can be used in the top or sides of the cod end.
- **Oval Grid BRD:**
  - This rigid grid device effectively separates shrimp from non-shrimp resources, minimizing disturbance to water flow and retaining target species.
- **Sieve Net BRD:**
  - This BRD consists of a large mesh funnel within the trawl that directs fish to a second cod end with larger diamond mesh netting, allowing shrimps to pass through and accumulate in the main cod end.

Benefits of using BRDs

- **Environmental conservation:** Reduces the impact of trawling on non-target species and marine ecosystems.
- **Sustainable fisheries:** Promotes responsible fishing practices, reduces growth overfishing, and aids in the long-term sustainability of marine resources.
- **Economic benefits:** Increased revenue from enhanced target species catch and potential utilization of retained bycatch.
- **Biodiversity protection**: Minimizes the impact on non-target species and juveniles, contributing to the conservation of marine biodiversity.

Challenges in implementation

- **Perceived catch loss:** Fishermen may be hesitant to adopt BRDs due to concerns about potential loss of marketable species.
- **Cost and complexity:** Initial costs of acquiring and installing BRDs can be a barrier for some fishermen.

- **Lack of awareness and training:** There is a need for greater awareness and training programs to educate fishermen on the benefits and proper use of BRDs.
- **Enforcement of regulations:** Effective enforcement of BRD regulations is crucial to ensure widespread adoption.
- **Need for incentives:** Financial incentives and subsidies can encourage fishermen to adopt BRDs and overcome concerns about potential short-term income loss.

Research institutions like ICAR-CIFT continue to play a vital role in developing and evaluating BRDs. By addressing the challenges and promoting the benefits, India can significantly reduce bycatch and ensure the long-term health of its marine ecosystems and fisheries resources.

4-4 Destructive and prohibited fishing practices

Indian fisheries sector, while vital for livelihoods and food security, faces significant challenges from destructive and prohibited fishing practices that undermine the sustainability of marine and inland ecosystems.

These practices are outlawed under various regulations at both central and state levels, including the National Policy on Marine Fisheries, 2017 (NPMF, 2017). However, their persistence remains a concern.

4.4.1. Destructive fishing practices (DFPs)

Destructive fishing practices are fishing methods that cause irreversible damage to marine habitats, ecosystems, and fish populations.

Bottom Trawling: Dragging heavy weighted nets across the seabed, often to catch ground fish, shrimp, or crabs.

- **Impact:** Causes physical damage to the seabed and habitats like coral reefs and seagrass beds. It disrupts the ocean floor, releases carbon dioxide from sediments, and leads to excessive bycatch of non-target species, including juveniles. This practice is still widespread in India, although it is considered destructive.
- **Regulation:** While bottom trawling is not entirely banned in India, there are regulations regarding mesh size, seasonal bans, and efforts to promote alternatives like deep-sea fishing.

Blast Fishing (Dynamite Fishing): Using explosives to kill or stun fish, which are then collected.

- Impact: Indiscriminately kills fish and other marine life in the blast area, including eggs, plankton, and corals. It causes severe damage to habitats, particularly coral reefs.
- Prohibition: This practice is illegal in India and many parts of the world.

Cyanide Fishing (Poison Fishing): Spraying a sodium cyanide mixture into a fish habitat to stun fish for easier collection, often for the live fish trade (aquarium and food).

- **Impact:** Kills not only the target fish but also many other marine organisms, including coral and coral reefs, causing irreversible damage. Coral polyps, young fish, and spawn are highly vulnerable. Studies show high mortality rates (up to 75%) within 48 hours of capture for fish caught with cyanide.
- **Prohibition:** Cyanide fishing is illegal in India and other countries.

Muro-ami: An artisan fishing method used on coral reefs, where pounding devices (like large stones or cement blocks) are used to smash corals and scare fish into nets.

- **Impact:** Causes long-lasting and practically total destruction of coral reefs.
- **Prohibition:** This practice is outlawed in many countries, and its use is likely prohibited in India's protected areas or zones under strict regulations.

Use of Fine Mesh Nets (including Mosquito Nets): Using nets with very small mesh sizes that capture even juvenile and undersized fish.

- **Impact:** Leads to growth overfishing, depleting fish stocks before they reach reproductive age, thus impacting future generations.
- **Regulation:** Minimum legal size (MLS) regulations and mesh-size regulations are implemented to prevent the capture of juveniles and ensure sustainable fishing. However, the use of mosquito nets, often by marginalized fishers due to economic constraints, remains a challenge.

4.4.2. Prohibited fishing practices

In addition to the destructive practices listed above, several other methods are prohibited or restricted in Indian fisheries to promote conservation and sustainable management.

- **Bull or Pair Trawling:** Dragging a single large trawl net between two vessels. This practice is prohibited in the Exclusive Economic Zone (EEZ) beyond India's territorial waters, and similar prohibitions are imposed within territorial waters by coastal States/UTs.
- **Use of Artificial Lights / LED Lights for Fishing:** Attracting fish using powerful lights, which can disrupt fish behaviour and lead to unsustainable catches, particularly of shoaling pelagic species. This practice is prohibited in the Indian EEZ and territorial waters. Several states, including Maharashtra and Karnataka, have specific bans on LED light fishing.
- **Fishing during Closed Seasons:** Imposing bans on fishing during the monsoon season to protect breeding fish species and allow them to reproduce and replenish their stocks.
- **Fishing in Restricted Areas:** Prohibiting fishing in designated areas like marine protected areas (MPAs) or near spawning/nursery grounds to protect critical habitats and vulnerable life stages.
- **Fishing of Prohibited Species:** Implementing bans on the fishing of certain species like endangered sharks and rays, marine mammals, turtles, and specific invasive or ecologically damaging species (e.g., African catfish, bighead carp).
- **Non-compliance with Turtle Excluder Device (TED) Regulations:** Shrimp trawlers are legally mandated to use TEDs in several coastal states to prevent the accidental capture of sea turtles. Non-compliance is a violation of these regulations.

Government initiatives to counter destructive practices

The Indian government has launched various initiatives to promote responsible fishing and counter destructive practices, including:

- **National Policy on Marine Fisheries (NPMF), 2017:** Provides a framework for sustainable and responsible fishing practices.
- **Pradhan Mantri Matsya Sampada Yojana (PMMSY):** A flagship scheme promoting sustainable fishing, reducing post-harvest losses, enhancing production, and providing support for alternative livelihoods and infrastructure development, including deep-sea fishing vessels and artificial reefs.

- **Installation of Artificial Reefs:** Supported under PMMSY to enhance fish stocks and reduce fishing pressure in nearshore waters.
- **Support for Deep-Sea Fishing Vessels:** Replacing trawling boats with deep-sea fishing vessels that use targeted methods like gillnets and tuna longlining.
- **Use of Technology:** Implementing satellite-based vessel monitoring systems and providing safety kits and communication systems to enhance safety and enforce regulations.

Addressing destructive and prohibited fishing practices requires a multi-pronged approach involving strict enforcement, community participation, awareness campaigns, economic incentives, and the promotion of sustainable alternatives

UNIT V: FISH PROCESSING EQUIPMENT

5-1 Ice making machinery, Brine tank

Ice and brine tanks are crucial for the preservation of fish and other seafood in India, playing a vital role in maintaining freshness from the point of harvest through processing, transportation, and retail.

5.1.1. Ice making machinery

Maintaining the quality and shelf life of seafood, particularly in a tropical country like India, relies heavily on efficient chilling. Ice plants are thus essential infrastructure for the fisheries sector. They produce various forms of ice tailored to specific needs along the seafood value chain.

Types of ice and corresponding machinery

- **Block Ice:** Traditionally manufactured as large blocks, often weighing 25, 50, 100, or 150 kg. These blocks are subsequently crushed into smaller pieces before being used for icing.
    - **Machinery:** Block ice makers typically consist of a brine tank where ice cans, filled with water, are submerged in circulating refrigerated brine (sodium or calcium chloride solution). A crane lifts rows of cans to a thawing tank, where warm water releases the ice blocks, which are then refilled and returned to the brine tank for a new cycle. Rapid block ice plants can form blocks in a few hours.
    - **Features:** Block ice plants are available in various sizes, ranging from 1 to 65 tons per 24 hours. They can be custom-made to meet specific requirements.
    - **Advantages:** Suitable for long-distance transportation and bulk seafood storage, especially for export.
    - **Disadvantages:** Requires crushing before use, and the crushed ice may not be uniformly sized.
- **Flake Ice:** Thin, dry, sub-cooled flakes with a high surface area, making them ideal for rapid cooling and gentle on fish. They have a temperature of about -6.6°C (20°F).
    - **Machinery:** Flake ice is typically made by spraying water onto a refrigerated drum, where an ice sheet forms and is then scraped off as flakes.

- **Advantages:** Rapid cooling, maximum contact with fish, gentle on the product, and easy to handle. Flake ice machines are available in various capacities and are praised for their reliability and durability. They are common at fish auctions and on fishing boats.

- **Plate Ice:** Description: Flat sheets of ice, similar to flake ice but with a thickness that can be varied.
  - **Machinery:** Water is sprayed onto vertical hollow plates containing a refrigerant, forming a sheet of ice that is released by a hot gas defrost.
  - **Advantages:** Quick production, similar benefits to flake ice, and customizable thickness.
- **Tube Ice:** Hollow cylinders of ice with a specific wall thickness, often 10 to 12 mm.
  - **Machinery:** Formed on the inner surface of hollow cylinders surrounded by refrigerant, then chopped into smaller pieces after being released by a hot gas defrost.
  - **Advantages:** Used in seafood processing plants for chilling during various stages of production.
- **Slurry Ice (Liquid Ice or Flow Ice):** A mixture of microscopic ice crystals suspended in a non-corrosive, non-toxic solution, resembling jelly. It offers superior cooling efficiency.
  - **Machinery:** Generated by systems that produce tiny ice particles, which are then suspended in a solution.
  - **Advantages:** Rapid and even cooling, completely engulfs the fish, causes no damage due to sharp edges, and can be pumped. It is particularly effective for delicate seafood and can be generated onboard fishing vessels using seawater.

5.1.2. Brine tanks

Brine tanks in fisheries serve various purposes, primarily related to chilling and freezing fish.

- **Immersion Freezing:**
  - **Mechanism**: Fish or prawns, often placed in perforated bags, are immersed in a highly concentrated or saturated salt solution (brine) that has been cooled to very low temperatures (e.g., as low as -22°C).
  - **Freezing Process**: The brine absorbs heat from the fish, causing it to freeze rapidly. The freezing time depends on the brine temperature and the size of the fish or bags.
  - **Salt Absorption:** Brine freezing is rapid and suitable for continuous operation, but the fish may absorb some salt, potentially affecting its flavour. This can be mitigated by using a mixture of glucose or corn syrup and salt.
  - **Usage:** Commonly used for onboard freezing of fish and shrimp on vessels that have the necessary refrigeration and circulation systems.
- **Chilling and Pre-freezing:** Brine tanks can be used for pre-freezing seafood or for maintaining precise temperatures for delicate seafood.
- **Processing:** Brining (soaking food in brine) is also used in food processing to extend shelf life by reducing water activity and inhibiting microbial growth. This

applies to fish processing as well, where brine penetration helps preserve the fish and adds a glossy appearance.

- **Water Softening:** While not directly related to fish preservation, brine tanks are commonly used in water softening systems to regenerate the resin beads by flushing them with a concentrated salt or potassium solution.

The Indian fisheries sector faces challenges related to infrastructure, including the lack of sufficient ice plants and cold chain facilities. To address this, the government, through schemes like the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and the Fisheries and Aquaculture Infrastructure Development Fund (FIDF), provides financial assistance for the establishment and modernization of ice plants, cold storages, and other essential infrastructure.

These initiatives are crucial for improving post-harvest handling, reducing spoilage, and ensuring that high-quality seafood reaches consumers both domestically and in international markets.

5-2 Arrangements for leak detection

Arrangements for leak detection in freezing systems of fisheries

Leak detection is critical for the safe, efficient, and compliant operation of freezing systems in fisheries, ranging from onboard freezing units on vessels to onshore cold storage facilities and processing plants.

Refrigerant leaks can significantly impact system performance, lead to increased energy consumption, damage equipment, and pose environmental and safety risks. For example, in the presence of water, Ammonia is corrosive to many non-ferrous metals.

Arrangements for leak detection in these freezing systems:

1. Visual inspection

- **Method** This is the most basic and initial step in leak detection. It involves visually checking for signs of leaks, such as oil spots or residue around refrigerant lines, connections, fittings, and components like compressors and condensers.
- **Limitations:** While quick and free, visual inspection is not effective for detecting small or hidden leaks, especially those inside evaporators, condensers, or concealed lines.

2. Soap bubble solution

- **Method:** A simple and cost-effective method where a solution of soap and water is applied to suspected leak points. The escaping refrigerant will create bubbles in the solution, indicating the presence and location of the leak.
- **Procedure:** Mix dish soap with water and apply generously to suspect areas using a brush or spray bottle.
- **Limitations:** Only works for surface leaks and may not detect very small or internal leaks. When the system is off, it can only be used on hot gas lines.

3. Electronic leak detectors

- Method: These are highly sensitive instruments that use sensors (e.g., infrared, heated diode, or semiconductor) to detect refrigerant gases in the air. They are designed to find even tiny leaks.

- **Operation:** The detector is moved slowly around suspected leak areas. It provides audible or visual alerts when a leak is detected, with the signal strength often indicating proximity to the leak.
- **Advantages:** Highly sensitive, accurate, and can detect small leaks.
- **Considerations:** Can be expensive and may require regular calibration. Care must be taken not to expose the sensors to combustible gases, as this can be dangerous and costly.

4. Dye testing (Fluorescent dye method)

- **Method:** A fluorescent dye is added to the refrigerant and becomes visible under UV light at leak points.
- **Procedure:** Inject the dye, circulate it, and scan with a UV light.
- **Advantages:** Helps find leaks in hard-to-reach areas.
- **Limitations:** The process can be time-consuming and messy, requiring system discharge and recharge.

5. Pressure testing (Nitrogen detection method)

- **Method:** The system is pressurized with dry nitrogen, and a pressure drop indicates a leak. A nitrogen water detection method also exists.
- **Procedure:** Evacuate refrigerant, pressurize with nitrogen, and monitor pressure.
- **Advantages:** Checks the entire system.
- **Limitations:** Requires specialized equipment and expertise; does not pinpoint the leak location. Water detection carries the risk of water entering the system.

6. Vacuum testing

- **Method:** A vacuum pump is used, and a failure to hold vacuum indicates a leak.
- **Limitations:** Only confirms a leak exists, not its location.

7. Ultrasonic leak detectors

- **Method:** These devices detect high-frequency sound waves from escaping refrigerants.
- **Advantages:** Can be effective in noisy environments and detect small leaks.
- **Limitations:** Can be expensive and may require training; effectiveness is reduced in noisy settings.

8. Ammonia leak detection

- **Specific Properties of Ammonia (R717):** Ammonia is common in large industrial systems due to efficiency but is toxic, corrosive, and flammable. Small leaks have a strong odour.
- **Detection Methods:**
  - **Ammonia Detectors:** Fixed and portable electronic detectors are used, with thresholds for alarms and ventilation.
  - **Phenolphthalein Paper**: Changes colour with ammonia.
  - Sulphur Candle: Creates a white cloud with ammonia.

Regulatory requirements and best practices

- **Regulations:** Regulations often require periodic leak checks based on refrigerant quantity, with more frequent checks for larger systems. Permanent leak detection systems can reduce inspection frequency.
- **Preventive Maintenance:** Regular maintenance, including daily, weekly, and seasonal inspections, is key to preventing leaks.

- **Operator Training:** Trained personnel are crucial for effective and safe procedures.
- **Record Keeping:** Maintaining records of inspections and repairs is important for compliance and tracking.
- **Advanced Systems:** Modern AI-powered systems can enhance detection and proactive maintenance.

Implementing these detection methods and following best practices helps the Indian fisheries sector minimize leaks, ensuring safety, environmental protection, and system efficiency.

5-3 Operation of various freezing machinery

Standard operating procedures (SOPs) for freezing machinery in fisheries

The operation of freezing machinery in the Indian fisheries sector, whether onboard vessels or in land-based processing plants, is governed by Standard Operating Procedures (SOPs) designed to ensure product quality, food safety, and operational efficiency.

1. General principles for operating freezers in fisheries

Regardless of the freezer type, some fundamental principles underpin all freezing operations:

- **Quick Freezing:** Fish should be frozen rapidly to pass quickly through the zone of maximum ice crystal formation (-1°C to -5°C). This minimizes damage to cell structure and helps retain the quality, texture, and nutritional value of the fish.
- **Low and Constant Temperatures**: The freezer should operate at temperatures low enough to achieve the required core temperature (typically -18°C or colder) rapidly and efficiently.
- **Optimal Temperature Management:** Maintaining a low and constant temperature throughout the freezing process, storage, and transportation is crucial for preserving quality and preventing dehydration and oxidation.
- **Minimize Time before Freezing**: The time elapsed between catching the fish and the completion of freezing should be kept to a minimum to preserve product quality.
- **High Standards of Hygiene:** Strict adherence to hygiene during handling and processing is essential to prevent bacterial contamination and spoilage.
- **Packaging**: Proper packaging is necessary to prevent dehydration, discoloration, and quality deterioration during freezing and frozen storage.

2. Operation of specific freezer types

a) Air blast freezers

- **Batch Type:**
    1. **Loading:** Fish, in trays or packages, are loaded onto trolleys, pallets, or shelves inside the freezing chamber. The freezer should be fully loaded to optimize efficiency.
    2. **Freezing:** Close the freezer door and operate the refrigeration system to circulate cold air (typically -35°C to -40°C or lower) at high velocity over the product. The air picks up heat from the fish, causing it to freeze rapidly.

3. **Monitoring:** Monitor the freezing time, which can range from a few hours to several days depending on the conditions and product size. Ensure the core temperature reaches -18°C or colder.
4. **Unloadin**g: Once freezing is complete, unload the frozen product and prepare for the next batch.

- **Continuous Type (Tunnel Freezers/IQF Freezers):**
  1. **Preparation:** Fish, often in small pieces like shrimp, are prepared and potentially placed on a conveyor belt.
  2. **Loading:** The conveyor belt moves the product through the insulated tunnel or chamber.
  3. **Freezing:** Cold air is continuously blown over the product, typically at -35°C to -40°C, and at high velocity (e.g., 150-300 m/sec). The air flow is often counter-current to the movement of the product.
  4. **Freezing Rate:** The high air velocity ensures rapid freezing, producing Individual Quick Frozen (IQF) products where each piece is frozen separately.
  5. **Discharge:** The frozen product is discharged at the other end of the tunnel, ready for packaging and storage.
- **Fluidized Bed Freezers:**
  - **Operation:** A stream of cold air is forced upwards through a perforated mesh belt, partially lifting and suspending the product (like small fish or shrimp) in the air stream. This ensures intimate contact with the cold air and very rapid freezing.

b) Contact plate freezers

- **Types:** Available in horizontal and vertical configurations.
- **Batch Operation (Horizontal Plate Freezers - HPF):**
  1. **Preparation:** Fish, often in flat packs or trays, are prepared for freezing. typical blocks are 25-30 mm thick. Ensure the packaging materials are tight and void spaces are avoided for optimal heat transfer.
  2. **Loading:** Products are placed between refrigerated plates, typically 15-20 in number.
  3. **Contact:** The plates are closed, and slight hydraulic pressure is applied to ensure firm contact between the plates and the product surfaces, facilitating heat transfer.
  4. **Freezing:** Refrigerant circulates through the hollow plates, cooling them (typically -35°C to -40°C or lower). Freezing time can be 1-2 hours or more, depending on thickness and conditions.
  5. **Unloading:** After the freezing cycle, the plates are lifted and opened, and the frozen blocks or trays are unloaded.
- **Vertical Plate Freezers (VPF):**
  1. **Loading**: Fish (whole, gutted, or headed and gutted) are loaded directly into the spaces between the vertical plates, often without wrapping or arranging on trays.
  2. **Freezing:** Refrigerant circulates through the plates, freezing the fish into large blocks (e.g., 25 or 50 kg).

3. **Unloading:** The plates are moved apart, and the frozen blocks are released, often by spraying the underside with cold water.

- **Automatic Plate Freezers**: Similar to HPF but designed for continuous processing lines, reducing the labor required for loading and unloading.

c) Brine freezers (Immersion freezers)

- **Principle:** Fish or shrimp are rapidly frozen by immersion in or spraying with a refrigerated liquid, typically a highly concentrated salt solution (brine) cooled to low temperatures (e.g., -21°C or lower).
- **Batch Immersion**:
  1. **Preparation:** Products are placed in perforated plastic or stainless-steel baskets.
  2. **Immersion:** Baskets are lowered into the chilled brine tank using a hoist or crane system.
  3. **Freezing:** The brine, cooled by refrigerated coils and agitated, absorbs heat from the fish, freezing them rapidly (e.g., 15-20 minutes under ideal conditions).
  4. **Draining and Rinsing:** Frozen products are removed, drained to remove excess brine, and potentially rinsed quickly to prevent excessive salt absorption and residue buildup.
- **Continuous Immersion/Shower Systems:**
  1. **Conveyor Belt:** Products are placed on a moving conveyor belt.
  2. **Immersion/Spraying:** The belt carries the products through a chilled brine bath (continuous immersion) or past spray nozzles that spray cold brine over them (continuous shower).
  3. **Rapid Cooling:** The brine rapidly reduces the product temperature.
  4. **Hardening:** Products are drained and then typically passed through a hardening tunnel for final freezing to -18°C or below.
- **Brine Management:** Regular monitoring of brine temperature and concentration is essential for efficient and effective freezing. Brine can be used for several months but needs monitoring for bacterial contamination and replacement when necessary.

3. Post-freezing procedures

- **Glazing:** Applying a protective ice glaze to frozen fish helps prevent dehydration (freezer burn) during storage.
- **Packaging:** Proper packaging in moisture-vapor-proof materials is essential to protect the product from dehydration and oxidation during storage and transport.
- **Coding and Labelling**: Frozen blocks or packages should be clearly marked with coding information including the processor code, product type, year, month, and date of production.
- **Frozen Storage:** Frozen products must be stored at low temperatures (typically -18°C or colder) to maintain quality and extend shelf life. Strict control over storage temperature and avoiding fluctuations are crucial.

Adhering to these SOPs for operating various freezing machinery, coupled with robust quality control measures and continuous training, is vital for the Indian fisheries

sector to produce high-quality, safe, and commercially viable frozen fish and seafood products for both domestic and international markets.

5-4 Special equipment for freeze-drying, irradiation and cryogenics

Special equipment for freeze-drying, irradiation, and cryogenics in Indian fisheries

These advanced technologies are used in the Indian fisheries sector for preserving and processing seafood, offering advantages in terms of quality retention, shelf-life extension, and food safety.

5.4.1. Freeze-drying equipment (Lyophilization)

Freeze-drying is a process where moisture is removed from a material by sublimation, initially freezing the material and then reducing the surrounding pressure to allow the frozen water to transition directly from solid to gas phase. This results in a high-quality product with minimal loss of nutrients, flavour, and texture.

- **Equipment:**
  - **Freeze dryer**: A vacuum chamber where the product is placed on trays. It includes a source of heat for sublimation, refrigeration coils to condense water vapor, and a vacuum pump to maintain the low-pressure environment.
  - **Accelerated freeze dryers:** Utilize expanded metal mesh for efficient heat transfer.
  - **Radiation freeze dryers**: Use paired radiations for more uniform heating without direct contact between the food and the heat source.
  - **Microwave and dielectric freeze dryers**: Utilize microwave or dielectric heating for efficient sublimation.
  - **Vacuum band dryer:** Features food-grade conveyor bands and customizable dimensions, designed for high-efficiency and noiseless operation.
- **Application in fisheries**: Freeze-dried fishery products remained in good edible condition for a long period. It can be used for preserving various seafood products, although it can be costly for large-scale production. Several Indian companies manufacture and supply freeze-drying equipment for food and laboratory use.

5.4. 2. Irradiation facilities

Irradiation is a non-additive process that uses ionizing radiation (like gamma rays, electron beams, or X-rays) to preserve food by killing microorganisms and insects, extending shelf life, and improving safety.

- **Equipment:**
  - **Gamma irradiators:** Typically use Cobalt-60 or Caesium-137 as the radiation source. Gamma rays have high penetration power, making them suitable for irradiating bulk products.
  - **Electron accelerators:** Generate electron beams, with limited penetration power.
  - **X-ray machines:** Generate X-rays, with greater penetration power than electron beams.
- **Application in fisheries:**

- **Shelf-life extension and microbial decontamination:** Irradiation can extend the shelf life of fresh and dried seafood by reducing the microbial load and inactivating pathogens.
- **Quarantine treatment:** It can be used for disinfestation of dried seafood for export, meeting quarantine requirements.
- **Improved hygiene and safety:** Irradiation helps in minimizing organism activities and ensures a safer food product.
- **India's role:** India has established irradiation facilities and regulations for food irradiation, including seafood. The Board of Radiation and Isotope Technology (BRIT) supports the establishment of such facilities.

- **Advantages:**
  - Effective at low doses (1-10 kGy).
  - Does not significantly alter the quality or nutritional value of seafood.
  - Can be used on bulk and pre-packaged products.
- **Challenges:**
  - **Consumer acceptance**: Misconceptions about food irradiation can be a barrier to market acceptance.
  - **Logistics and infrastructure:** The availability and accessibility of irradiation facilities, particularly in coastal areas, need improvement.
  - **Regulatory compliance:** Ensuring adherence to regulations and quality standards is essential for the success of irradiated seafood products.

5.4.3. Cryogenic freezing equipment

Cryogenic freezing is a method that utilizes extremely low temperatures (typically -60°C to -100°C) with cryogenic gases like liquid nitrogen or carbon dioxide to freeze seafood rapidly. This quick-freezing process helps preserve the quality of the product.

- **Equipment:**
  - **Cryogenic freezers:** Available in various configurations, including tunnel freezers and spiral freezers, for freezing a wide range of seafood products like shrimp and fish fillets.
  - **Liquid nitrogen spray freezers:** Spray pressurized liquid nitrogen onto the product, causing rapid freezing.
- **Application in fisheries:**
  - **Individually Quick Frozen (IQF) products:** Cryogenic freezers are well-suited for producing IQF seafood products like shrimp, where each piece is frozen separately.
  - **Improved quality:** Rapid freezing minimizes ice crystal formation, preserving the texture, flavour, and nutrients of the seafood.
  - **Reduced dehydration losses:** Cryogenic freezing reduces dehydration losses compared to conventional freezing methods.
  - **Glazing:** Cryogenic freezers can also be used to lower temperatures for applying protective glazes to fish.
- **Challenges:**
  - **Cost:** Cryogenic freezing can be the most expensive freezing method.
  - **Surface damage:** The extreme cold temperatures can sometimes cause surface damage to delicate seafood.

- **Thawing loss and enzymatic changes:** While cryogenic freezing offers many benefits, some drawbacks include potential thawing loss and enzymatic changes in food products.

Specialized equipment for freeze-drying, irradiation, and cryogenic freezing is available in India and plays an important role in the country's fisheries sector. These technologies enable the production of high-quality, safe, and value-added seafood products with extended shelf life. However, challenges related to cost, infrastructure, consumer acceptance, and addressing potential quality drawbacks need to be considered for their widespread adoption and to fully realize their benefits for the Indian fisheries sector.

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