B.Sc. FISHERY SCIENCE
LAB MANUAL
4th Semester

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Fishery Science

MIDNAPORE CITY COLLEGE

BFSC SEMESTER IV LAB MANUAL

BFSC-401: Chemotherapy and Drug Administration in Aquaculture

Regulations of drug use. Introduction to antimicrobials, preparation of potassium permanganate solution, preparation of weak Tincture Iodine. Minimum inhibitory concentration (MIC). Five-plate screening test for the detection of antibiotic residue. Calculation of different disinfectants dosage in treating fish ponds. Generic name, patent name, dosage and indications of various aquaculture drugs used in fish health.

BFSC-402: Fish and Shell fish Pathology

Live and post mortem examination of fish and shellfish. Pathology of organ systems. Histopathology of normal and diseases fish and shellfish, Diagnosis of abiotic fish diseases, Nutritional diseases and Non-infectious diseases.

BFSC-403: Finfish Hatchery Management

Study of maturity stages in fishes. Collection and preservation of fish pituitary gland, preparation of PG extract, Hypophysation. Calculation of fecundity. Brood-stock maintenance and selection of breeders for injection. Histological studies of ovary and testes. Different fish hatchery systems, study of fish eggs and embryonic developmental stages. Identification of eggs, spawn, fry and fingerlings of different species. Preparation and management of fish nursery. Fish seed and brood-stock transportation, use of anaesthetics, disinfectants and antibiotics in fish breeding. Water quality monitoring in fish hatcheries and nurseries. Breeding and larval rearing of common finfishes.

BFSC-404: Shellfish Hatchery Management

Identification of brood stock and maturity stages of important crustaceans and mollusks. Observations on gonadal maturation of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and larval rearing of *Macrobrachium rosenbergii* and *Penaeus monodon* P. vannamei. Identification of larval stages of important crustaceans and mollusks. Demonstration of eyestalk ablation in *Penaeus monodon*. Collection, packing and transportation of shrimp/prawn seed and brood stock. Practice in the operation of shrimp and prawn hatcheries. Water treatment and management in shrimp and prawn hatcheries. Different chemicals and drugs used in shrimp/prawn hatchery.

BFSC-405: Fish Nutrition and Feed Technology

Proximate composition analysis of feed ingredients and feeds. Preparation of artificial feeds using locally available feed ingredients. Determination of sinking rate and stability of feeds. Effect of storage on feed quality.

BFSC-406: Freezing Technology

Sanitation and plant housekeeping; chilling and freezing equipment, instruments; packages and product styles; methods of icing fish; cooling rate; preservation by chilled sea water; freezing and thawing curves; freezing of different varieties of fish and shellfish; estimation of drip; determination of quality changes during frozen storage; inspection of frozen fishery products; visits to ice plants, cold storages and freezing plants.

BFSC-407: Fish Canning Technology

Types of cans, canning equipments and layout of cannery. Canning of different varieties of fish and shellfish. Cut out test of canned products. Examination of can double seam. Heat resistance of bacteria. Heat penetration in canned food, thermal process calculation by general method. Study of spoilage condition in canned products. Familiarization with various packaging materials and container for fish products.

BFSC-408: Navigation and Seamanship

Practicing the different types of knots and wire splices, CHART WORK-Finding positions by latitudes and longitudes by position lines by cross bearing, horizontal sextant, angles, vertical sextant angle and by running fix, finding position by speed, distance and time findings set and drift of current and findings course made good speed made good and steering course and finding position by counter acting the current observation of RADAR. Anatomy of magnetic and Gyro compass and their errors calculation.

BFSC-409: Fishing Craft Technology

Studies on traditional fishing crafts; Introduction to drawing and drawing instruments; Lettering, Geometrical construction, Curves. Projections; Projection of points, planes and Projection of solids; lines plan drawing; Drawing of back bone assembly; U & V bottom hull of wooden boat; General view of boat; Drawing of sheer plan, body plan and half breadth plan; Types of marine engines and their installation of engines. Visit to boat building yard and dry dock

BFSC-401: Chemotherapy and Drug Administration in Aquaculture

Introduction

Chemotherapy and drug administration are crucial components in managing health in aquaculture. The use of various medications, antimicrobials, and disinfectants plays a vital role in preventing and treating diseases in aquatic animals. The manual covers topics ranging from the preparation of chemical solutions and the regulation of drug use, to methods of detecting antibiotic residues and calculating disinfectant dosages for treating fish ponds. This lab manual aims to provide practical insights into the safe and effective use of drugs and chemicals in aquaculture.

Experiment 1: Regulations of Drug Use in Aquaculture

Objective

To understand the regulatory framework surrounding the use of drugs and chemicals in aquaculture, ensuring the safety of aquatic products and the environment.

Materials Required

1. National and international regulations on drug use in aquaculture (e.g., FDA, EMA, FAO)
2. Documents on aquaculture drug registration
3. Case studies of drug use violations

Procedure

1. **Study Regulatory Framework**:
    - Review national and international standards, such as the Code of Practice for the Use of Chemicals in Aquaculture (FAO) and national veterinary drug regulations.
    - Focus on the guidelines regarding drug approval, usage limits, withdrawal periods, and residues in aquatic products.
2. **Risk Assessment**:
    - Learn how to assess the risks associated with drug residues, environmental contamination, and human health.
    - Understand the importance of maintaining safe withdrawal times for chemical residues.
3. **Record-Keeping and Compliance**:
    - Study the documentation required for regulatory compliance, including records of drug usage and residue monitoring.

Observations and Results

- Prepare a report summarizing the findings on regulatory standards, focusing on drug approval processes, residue monitoring, and compliance procedures.

Experiment 2: Introduction to Antimicrobials in Aquaculture

Objective

To learn about the types and mechanisms of action of antimicrobials used in aquaculture for disease prevention and treatment.

Materials Required

1. Different types of antimicrobial agents used in aquaculture (antibiotics, antifungals, antivirals)
2. Reference material on antimicrobial resistance (AMR)
3. Laboratory scale equipment for testing antimicrobial activity

Procedure

1. **Types of Antimicrobials**:
    - Discuss the classification of antimicrobial agents: antibiotics (e.g., tetracyclines, sulfonamides), antifungals (e.g., formaldehyde), and antivirals (e.g., interferons).
    - Examine their modes of action, such as inhibiting cell wall synthesis or protein synthesis in pathogens.
2. **Mechanisms of Resistance**:
    - Study how resistance develops in aquatic organisms and the consequences for fish health and human consumption.
3. **Safe Use Practices**:
    - Discuss best practices in antimicrobial use, such as proper dosing, administration, and avoiding overuse to minimize resistance.

Observations and Results

- Prepare a report on the types of antimicrobials used in aquaculture, their modes of action, and resistance management strategies.

Experiment 3: Preparation of Potassium Permanganate Solution

Objective

To learn how to prepare a potassium permanganate solution for use in aquaculture as an oxidizing agent and disinfectant.

Materials Required

1. Potassium permanganate crystals
2. Distilled water
3. Beaker, stirring rod, and gloves
4. Weighing balance

Procedure

1. **Weighing Potassium Permanganate**:
    - Weigh the required amount of potassium permanganate using the analytical balance.
2. **Dissolution**:
    - Dissolve the potassium permanganate in distilled water, stirring until fully dissolved. The solution should appear a light purple color.
3. **Concentration**:
    - Prepare different concentrations depending on the intended use in aquaculture (e.g., 1% solution for disinfecting equipment, 0.1% for treating diseases).
4. **Storage**:
    - Store the solution in a dark container, as potassium permanganate is sensitive to light.

Observations and Results

- Record the concentration of the solution and note the precautions necessary while handling potassium permanganate due to its strong oxidizing properties.

Experiment 4: Preparation of Weak Tincture Iodine

Objective

To prepare a weak tincture of iodine solution, which is commonly used as an antiseptic for fish injuries.

Materials Required

1. Iodine crystals
2. Ethanol (70%)
3. Distilled water
4. Glass container
5. Stirring rod

Procedure

1. **Weighing Iodine**:
    - Weigh the required amount of iodine crystals based on the desired concentration (e.g., 1% tincture).
2. **Preparation of Solution**:
    - Dissolve the iodine crystals in ethanol. Add water to make up the final volume.
    - Stir until the iodine is completely dissolved.
3. **Dilution**:
    - For weaker tinctures, dilute the solution further with water as per the requirement.
4. **Storage**:
    - Store the tincture in a tightly sealed amber bottle to protect it from light.

Observations and Results

- Record the final concentration of the tincture and note its applications in fish health, especially for external parasitic infections or wounds.

Experiment 5: Determination of Minimum Inhibitory Concentration (MIC)

Objective

To determine the minimum inhibitory concentration of an antimicrobial agent against a particular pathogen.

Materials Required

1. Agar plates
2. Bacterial culture (pathogen)
3. Antimicrobial agent
4. Sterile pipettes, petri dishes, and incubator

Procedure

1. **Inoculation**:
    - Prepare an agar plate by evenly spreading the bacterial culture across the surface.
2. **Antimicrobial Disk Application**:
    - Apply antimicrobial agent (e.g., antibiotic) in serial dilutions on the agar plate.
3. **Incubation**:
    - Incubate the plates at a suitable temperature (e.g., 28-30°C) for 24-48 hours.
4. **MIC Determination**:

- Observe the zone of inhibition around the antimicrobial disks and calculate the MIC, which is the lowest concentration that inhibits bacterial growth.

Observations and Results

- Record the MIC values for each antimicrobial agent tested and analyze the results to determine the effectiveness of the agents.

Experiment 6: Five-Plate Screening Test for the Detection of Antibiotic Residue

Objective

To detect antibiotic residues in fish products using the five-plate screening test.

Materials Required

1. Antibiotic residue test kit
2. Agar plates
3. Fish samples
4. Incubator

Procedure

1. **Sample Preparation**:
   - Take small pieces of fish tissue (e.g., muscle or liver) and homogenize them in a sterile saline solution.
2. **Inoculation**:
   - Spread the homogenized sample evenly on the surface of the agar plates.
3. **Antibiotic Application**:
   - Apply antibiotic disks on the inoculated plates.
4. **Incubation**:
   - Incubate the plates for 24-48 hours at 28-30°C.
5. **Screening**:
   - After incubation, examine the plates for inhibition zones. The presence of a clear zone around the antibiotic disk indicates residue contamination.

Observations and Results

- Record the presence or absence of inhibition zones and identify whether the fish sample contains antibiotic residues.

Experiment 7: Calculation of Disinfectant Dosage for Treating Fish Ponds

Objective

To calculate the correct dosage of disinfectants for treating fish ponds based on pond volume and required concentration.

Materials Required

1. Pond volume calculator (or measured dimensions)
2. Disinfectant (e.g., potassium permanganate)
3. Weighing balance

Procedure

1. **Determine Pond Volume**:
    - Measure the dimensions of the pond (length, width, and depth) and calculate the volume in cubic meters.
2. **Calculate Dosage**:
    - Use the recommended dosage from the chemical manufacturer for the disinfectant to treat the pond.
    - Example: For potassium permanganate, the standard dosage might be 0.1-0.2 mg/L for treating parasites.
    - Calculate the required amount based on the pond volume and disinfectant concentration.

Observations and Results

- Record the calculated disinfectant dosage and ensure proper application in the pond according to the guidelines.

Experiment 8: Identification of Aquaculture Drugs Used in Fish Health

Objective

To identify and understand the generic names, patent names, dosage, and indications of various aquaculture drugs.

Materials Required

1. List of commonly used aquaculture drugs (e.g., formalin, malachite green, oxytetracycline)
2. Drug labels and brochures
3. Reference material on drug indications and dosages

Procedure

1. **Study of Drugs**:

- Review the available literature and drug labels to understand the uses, dosages, and indications for common aquaculture drugs.
- Common drugs include formalin (antifungal), oxytetracycline (antibiotic), and praziquantel (anti-parasitic).

2. **Understanding Dosage**:
    - Learn how dosages are determined based on fish species, weight, and disease condition.

Observations and Results

- Prepare a report on the various aquaculture drugs used for disease management, detailing their generic names, trade names, dosages, and indications.

BFSC-402: Fish and Shell fish Pathology

Introduction

Fish and shellfish pathology is an essential aspect of aquaculture and fisheries management. The health of aquatic animals significantly impacts the productivity and sustainability of the industry. Pathological studies provide insights into diseases caused by various factors, including infections, nutritional deficiencies, and abiotic stresses. This lab manual will cover the methodologies for both live and post-mortem examination of fish and shellfish, examining the pathology of various organ systems, histopathology of normal and diseased fish and shellfish, as well as diagnosing abiotic, nutritional, and non-infectious diseases.

By the end of this manual, students will gain practical knowledge and laboratory skills needed to identify and understand the pathological conditions of fish and shellfish.

Experiment 1: Live and Post-Mortem Examination of Fish and Shellfish

Objective

To perform live and post-mortem examinations on fish and shellfish, identifying external and internal symptoms of disease.

Materials Required

1. Live fish (freshwater and marine)
2. Post-mortem fish samples (fresh or preserved)
3. Dissecting tools (scalpel, scissors, forceps)
4. Magnifying lens or microscope
5. Dissection trays
6. Sterile gloves, lab coat, and face mask
7. Preservation containers (e.g., 10% formalin)

Procedure

1. **Live Examination**:
    - **External Inspection**: Inspect the external surfaces of the fish or shellfish for abnormalities such as lesions, discoloration, abnormal body shape, swelling, or bleeding. Look for signs of skin ulcers, parasites, or fungal infections.
    - **Behavioral Observations**: Monitor the movement, swimming behavior, feeding activity, and responsiveness to stimuli. Abnormal behavior such as erratic swimming, lethargy, or refusal to feed can be indicative of stress or disease.
    - **Gills Examination**: Examine the gills for abnormalities such as excessive mucus, redness, or pale gills, which could suggest respiratory issues like gill disease or hypoxia.

2. **Post-Mortem Examination**:
    - **External Examination**: After euthanizing the fish, examine the body for external lesions, body shape changes, or signs of external parasites (e.g., lice, flukes).
    - **Incision for Internal Examination**: Make a longitudinal incision along the ventral side of the fish to access the internal organs. Inspect the internal organs for abnormalities such as swelling, discolored tissues, or masses.
    - **Examine Specific Organs**: Pay close attention to the liver, kidney, heart, and gastrointestinal tract. Take note of any signs of inflammation, congestion, necrosis, or unusual coloration.
    - **Microscopic Examination**: For histopathological analysis, take small tissue samples from affected areas, such as the liver, gills, skin, and kidney. Place the samples in formalin for further histopathological analysis.

Observations and Results

- Record the external and internal findings of both live and post-mortem examinations. Identify any abnormalities, and suggest possible causes for these conditions based on clinical signs.
- Examine and document any parasitic or fungal infections noted during the post-mortem.

Experiment 2: Pathology of Organ Systems in Fish and Shellfish

Objective

To identify and study the pathological changes in various organ systems of fish and shellfish.

Materials Required

1. Diseased fish or shellfish
2. Dissection tools
3. Slides and staining reagents (e.g., Hematoxylin and Eosin for histology)
4. Microscopes
5. Fixatives (e.g., formalin)
6. Tissue samples from various organs

Procedure

1. **Examine the Liver**:
    - Look for signs of hepatomegaly (enlargement of the liver), discoloration (pale or reddish), or necrosis. These could indicate viral or bacterial infections, or liver dysfunction.
    - Take histological samples for analysis under a microscope.

2. **Examine the Gills**:
    - Check for swelling, inflammation, or excessive mucus production. Gills are often the first organ affected by environmental stressors, such as low oxygen levels, toxins, or pathogens.
    - Tissue samples should be taken for microscopic examination to look for bacterial or parasitic infections.
3. **Examine the Kidneys**:
    - Examine for signs of renal failure, such as swollen kidneys or changes in coloration, which might be indicative of bacterial infections or toxin exposure.
    - Histopathological analysis of kidney tissue can reveal signs of degeneration or infiltration by inflammatory cells.
4. **Examine the Heart**:
    - Inspect the heart for signs of congestion or abnormal coloration, which can be linked to circulatory failure or parasitic infections.
    - Use histological staining to detect any cellular changes in heart tissues, such as myocardial necrosis or inflammation.
5. **Examine the Gastrointestinal System**:
    - Look for distended stomachs, changes in coloration, or signs of infection in the intestines, such as ulcerations or lesions.
    - Microscopic analysis can help in identifying the presence of pathogens like Vibrio spp. or other bacteria.

Observations and Results

- Record any pathological findings in the organs examined. Provide a brief diagnosis based on the observed pathological conditions.
- Compare the findings with known fish diseases that affect these organs, such as vibriosis, myxobacteriosis, or viral hemorrhagic septicemia.

Experiment 3: Histopathology of Normal and Diseased Fish and Shellfish

Objective

To perform histopathological examination of tissue samples from both healthy and diseased fish and shellfish.

Materials Required

1. Tissue samples from healthy and diseased fish or shellfish
2. Fixatives (e.g., formalin, Bouin’s solution)
3. Paraffin wax

4. Microtome
5. Glass slides and cover slips
6. Hematoxylin and Eosin staining reagents
7. Light microscope

Procedure

1. **Tissue Fixation**:
    - Place tissue samples (liver, kidney, gills, skin) in a fixative like 10% formalin for at least 24-48 hours to preserve cellular structures.
    - Ensure that tissues are properly fixed to avoid distortion of the tissue architecture.
2. **Tissue Embedding**:
    - After fixation, dehydrate the tissues using ethanol, clear with xylene, and embed them in paraffin wax.
    - Cut the embedded tissue samples into thin sections (5-7 micrometers) using a microtome.
3. **Staining**:
    - Mount the tissue sections on glass slides and stain them using Hematoxylin and Eosin (H&E) or other specific stains (e.g., periodic acid-Schiff for mucus).
    - Hematoxylin stains the nuclei blue, and eosin stains the cytoplasm and extracellular matrix pink, allowing clear visualization of tissue morphology.
4. **Microscopic Examination**:
    - Examine the stained sections under a light microscope.
    - Compare the histological structures of normal tissue with those from diseased specimens. Look for changes like necrosis, fibrosis, hemorrhage, or inflammatory cell infiltration.

Observations and Results

- Document the histopathological changes observed in the diseased samples. Compare these changes to the typical histology of healthy fish or shellfish tissues.
- Common abnormalities to look for include tissue necrosis, bacterial infiltration, viral inclusions, or fungal growth.

Experiment 4: Diagnosis of Abiotic Fish Diseases

Objective

To diagnose abiotic diseases (non-infectious) in fish, caused by environmental factors such as poor water quality, temperature stress, and pollutants.

Materials Required

1. Water quality testing kits (pH, ammonia, dissolved oxygen, nitrite, nitrate)
2. Fish samples showing signs of stress or disease
3. Laboratory equipment for water filtration and treatment
4. Thermometer, salinity meter, and conductivity meter

Procedure

1. **Observation of Fish Symptoms**:
    - Look for signs of environmental stress, such as abnormal swimming behavior, gasping at the surface, or lesions that may indicate poor water quality or other abiotic stressors.
    - Record the physical condition of the fish, including skin color, gill condition, and overall appearance.
2. **Water Quality Testing**:
    - Measure key water quality parameters such as pH, ammonia levels, dissolved oxygen, salinity, and temperature. Ensure that the water conditions are within the optimal range for the species being cultured.
    - High ammonia levels, low oxygen, or extreme pH can cause stress, and such conditions may lead to disease.
3. **Treatment and Mitigation**:
    - If abnormal water quality parameters are detected, take corrective actions such as adjusting water pH, improving aeration, or treating the water with appropriate chemicals.

Observations and Results

- Record the water quality findings and compare them to known thresholds for healthy fish growth.
- Document any visible symptoms of abiotic stress in the fish, including respiratory issues, swelling, or behavioral changes.

Experiment 5: Nutritional Diseases and Non-Infectious Diseases

Objective

To identify and diagnose nutritional and non-infectious diseases in fish and shellfish.

Materials Required

1. Fish or shellfish showing symptoms of nutritional deficiencies or metabolic disorders
2. Reference materials on nutrient requirements for different species
3. Laboratory equipment for examining internal organs
4. Nutrient supplementation (e.g., vitamin and mineral supplements)

Procedure

1. **Examine the Fish or Shellfish**:
    - Look for signs of malnutrition or deficiencies, such as stunted growth, poor coloration, deformities, or abnormal behavior.
    - Check for symptoms of diseases like "liver syndrome" (fatty liver disease) or "pink syndrome" caused by improper nutrient balance.
2. **Analyze the Diet**:
    - Review the fish or shellfish diet to ensure it contains the correct balance of proteins, lipids, vitamins, and minerals.
    - If the fish or shellfish shows signs of nutritional deficiency, recommend appropriate dietary modifications.
3. **Histological and Clinical Examination**:
    - Perform histological analysis to check for organ abnormalities caused by nutritional imbalances, such as fatty liver or skeletal deformities.

Observations and Results

- Document any signs of nutritional deficiencies or metabolic disorders and provide potential solutions, including dietary adjustments.
- Note any specific lesions or organ abnormalities seen under the microscope.

BFSC-403: Finfish Hatchery Management

Introduction

Finfish hatchery management is an essential practice in aquaculture aimed at producing high-quality fish seed for restocking, aquaculture farming, and conservation efforts. This involves understanding the reproductive biology of fish, the maintenance of healthy broodstocks, the management of hatcheries, and the development of fish from eggs to fry. The lab manual for BFSC-403 will guide students through essential practices, including the study of fish maturity stages, the preparation of pituitary gland extracts for hypophysation, calculation of fecundity, and understanding hatchery systems. Students will also learn about the transportation of fish seed, water quality monitoring, and rearing techniques.

Experiment 1: Study of Maturity Stages in Fishes

Objective

To study and identify the different stages of sexual maturity in fish through external and internal examinations.

Materials Required

1. Fish specimens at various stages of maturity (male and female)
2. Dissecting tools (scalpel, scissors, forceps)
3. Microscopes
4. Sample jars for tissue preservation (e.g., 10% formalin)
5. Measuring scale for fish length and weight

Procedure

1. **External Examination**:
    - Examine the fish externally for visible signs of maturity such as changes in body size, shape, and coloration. Female fish will show larger, more distended abdomens as they approach the spawning season.
2. **Gonadal Maturity**:
    - For males: Inspect the testes for size, shape, and texture. As the male approaches sexual maturity, the testes will become more enlarged and creamier white.
    - For females: Inspect the ovaries for the development of eggs. In mature females, the ovaries will appear full and opaque, with visible eggs.
3. **Staging of Gonads**:
    - Identify and record the gonadal stages such as:
        - **Immature**: Small gonads with undeveloped eggs or sperm.

- **Developing**: Enlarged gonads with visible eggs in females or sperm in males.
- **Mature**: Fully developed, ready-to-spawn gonads.
- **Spent**: Gonads showing signs of having released gametes.

4. **Weight and Size Measurement**:
    - Record the length and weight of the fish along with the size of the gonads to correlate maturity with body condition.

Observations and Results

- Document the size and condition of the gonads at different maturity stages.
- Compare the external and internal observations and determine the fish's readiness for breeding.

Experiment 2: Collection and Preservation of Fish Pituitary Gland

Objective

To collect and preserve the pituitary glands of fish for preparation of pituitary gland (PG) extract to induce spawning.

Materials Required

1. Fish species with mature gonads (preferably for hypophysation)
2. Dissecting tools (scalpel, scissors)
3. Glass slides and preservation jars (e.g., 10% formalin)
4. Sterile containers
5. Forceps

Procedure

1. **Fish Selection**:
    - Select healthy, mature fish with well-developed gonads (either male or female depending on the requirement).
2. **Pituitary Gland Removal**:
    - Under aseptic conditions, anesthetize the fish to reduce stress. Using a scalpel, make a small incision on the head of the fish, just below the brain. Carefully extract the pituitary gland located in the brain region.
3. **Preservation**:
    - Place the extracted pituitary gland into a glass vial containing 10% formalin for preservation. Label each vial with the species name, date of collection, and gender of the fish.

4. **Storage**:
    - Store the preserved pituitary glands in a cool place for later use in the preparation of PG extract.

Observations and Results

- Note the condition of the pituitary gland post-extraction.
- Record any unusual anatomical features of the gland and the fish used.

Experiment 3: Preparation of Pituitary Gland Extract (PG Extract)

Objective

To prepare pituitary gland extracts for use in hypophysation for inducing spawning in fish.

Materials Required

1. Preserved fish pituitary glands
2. Sterile scalpel and forceps
3. Distilled water
4. Glass vial or test tube
5. Syringe with needle for injections
6. Microscope (optional for inspecting quality)

Procedure

1. **Preparation of Pituitary Gland**:
    - Retrieve the preserved pituitary glands from formalin and wash them thoroughly with distilled water to remove the preservative.
2. **Extraction**:
    - Using sterile forceps, transfer the pituitary gland to a clean glass surface. Crush the gland gently with a sterile pestle or scalpel to release the hormones.
3. **Suspension**:
    - Add a small volume of distilled water to the crushed gland and mix to form a suspension. Filter the extract through cheesecloth or a fine sieve to remove large debris.
4. **Storage**:
    - Store the pituitary gland extract in sterile glass vials and keep them refrigerated for use within a short time period, typically not more than 24-48 hours.

Observations and Results

- Record the clarity and concentration of the PG extract.
- Determine the efficacy of the extract based on its appearance (cloudy extracts may need to be filtered further).

Experiment 4: Hypophysation for Inducing Spawning in Fish

Objective

To use pituitary gland extract (PG extract) for hypophysation to induce spawning in fish.

Materials Required

1. Pituitary gland extract (PG extract) prepared in previous experiment
2. Healthy broodstock fish (mature male and female)
3. Syringe with needle for injection
4. Anaesthetics (e.g., MS-222 or similar)
5. Fish tanks or breeding tanks

Procedure

1. **Fish Selection**:
    - Select mature male and female fish with fully developed gonads.
2. **Anaesthesia**:
    - Anaesthetize the fish using a mild concentration of MS-222. This is done to reduce stress and make the procedure easier for both the operator and the fish.
3. **Injection**:
    - Using the syringe, inject the female fish with the prepared PG extract. The typical dosage for hypophysation is 0.5-2 mg of PG extract per kg of body weight for females. Males may receive a lower dose.
4. **Observation**:
    - After injection, monitor the fish for signs of spawning readiness. This may include egg release in females or sperm emission in males.

Observations and Results

- Record the fish's response to hypophysation, including the time of egg release (spawning) and any signs of successful fertilization.

Experiment 5: Calculation of Fecundity

Objective

To calculate the fecundity of a fish by counting the number of eggs in a single ovary or the total number of eggs produced by a female.

Materials Required

1. Mature female fish (post-spawning)
2. Dissecting tools
3. Counting chambers or Petri dishes
4. Microscope

Procedure

1. **Dissection**:
    - After spawning, remove the ovaries of the female fish. Carefully extract the eggs for counting.
2. **Counting Eggs**:
    - Place the eggs in a Petri dish or counting chamber. Use a microscope for accurate counting if the eggs are small.
3. **Calculation of Fecundity**:
    - Count the total number of eggs in both ovaries and record the results.
    - Multiply the number of eggs in one ovary by two if both ovaries are healthy and functional. The total number of eggs is considered as the fecundity of the fish.

Observations and Results

- Record the total fecundity based on the egg count. Document any variations between individual fish.

Experiment 6: Brood-stock Maintenance and Selection of Breeders for Injection

Objective

To learn the proper maintenance and selection of broodstock fish for breeding.

Materials Required

1. Healthy broodstock fish (mature male and female)
2. Tank for broodstock maintenance
3. Water quality monitoring tools (pH, temperature, oxygen, etc.)

Procedure

1. **Selection Criteria**:

- Select healthy, mature fish with visible signs of gonadal development. Look for fish that are disease-free, active, and free of deformities.

2. **Brood-stock Maintenance**:
    - Maintain the broodstock in separate tanks with controlled water quality parameters. Provide optimal nutrition and minimize stress to maintain fish health and reproductive capacity.
3. **Pre-Breeding Evaluation**:
    - Perform regular assessments of the broodstock's condition, including checking for signs of maturity, health, and readiness for breeding.

Observations and Results

- Document the health, appearance, and suitability of the selected broodstock for breeding.

Experiment 7: Histological Studies of Ovary and Testes

Objective

To conduct histological studies of the gonads (ovary and testes) of fish to understand the process of gametogenesis.

Materials Required

1. Gonadal tissues (ovaries or testes) from mature fish
2. Fixative (e.g., formalin)
3. Microtome and slides
4. Hematoxylin and eosin staining reagents

Procedure

1. **Tissue Preparation**:
    - Remove gonadal tissues from the fish. Fix the tissues in formalin to preserve their structure.
2. **Sectioning**:
    - Using a microtome, cut thin sections of the tissues and mount them on glass slides.
3. **Staining**:
    - Stain the tissue sections with hematoxylin and eosin for clear visualization of cellular structures.
4. **Microscopic Examination**:

- Examine the stained sections under a microscope to observe the stages of gametogenesis (oogenesis or spermatogenesis).

Observations and Results

- Record the presence of different stages of gametogenesis, such as oogonia, oocytes, and mature eggs in females, and spermatogonia, spermatozoa, and mature sperm in males.

BFSC-404: Shellfish Hatchery Management

Introduction

Shellfish hatchery management involves understanding the biology, reproductive processes, and cultivation techniques of crustaceans and mollusks. The focus of this lab manual is on the breeding, larval rearing, and management of two important species in aquaculture: *Penaeus monodon* (black tiger shrimp), *Macrobrachium rosenbergii* (giant river prawn), and *Penaeus vannamei* (whiteleg shrimp). Students will be introduced to the identification of broodstock, gonadal maturation, breeding practices, and the different stages of larval development. Additionally, practical skills such as eyestalk ablation, water quality management, and shrimp hatchery operations will be covered.

Experiment 1: Identification of Broodstock and Maturity Stages of Important Crustaceans and Mollusks

Objective

To identify and study the maturity stages of broodstock in crustaceans and mollusks, with a focus on *Penaeus monodon* and *Macrobrachium rosenbergii*.

Materials Required

1. Specimens of *Penaeus monodon* and *Macrobrachium rosenbergii*
2. Dissecting tools (scalpel, forceps, scissors)
3. Microscope
4. Measuring scale for size assessment
5. Data recording sheets

Procedure

1. **External Examination**:
    - Observe the external features of the broodstock. Female *Penaeus monodon* will show a larger, swollen abdomen when gravid, while males will have smaller abdomens.
    - In *Macrobrachium rosenbergii*, observe the large chelae (claws) of males, which can be used to identify gender.
2. **Gonadal Examination**:
    - Dissect the abdomen of the female crustaceans to examine the ovaries. Mature ovaries in *Penaeus monodon* will appear orange or yellow when gravid. *Macrobrachium rosenbergii* females will have similar gonadal colorations when mature.
    - The presence of eggs or spermatophore indicates maturity in both species.
3. **Maturity Staging**:

- Stage the gonads based on their size, color, and appearance:
  - **Immature**: Small, transparent gonads.
  - **Developing**: Gonads with visible eggs or sperm, but not fully developed.
  - **Mature**: Full, opaque ovaries in females or large, well-formed spermatophore in males.
  - **Spent**: Gonads showing signs of egg release or sperm emission.

Observations and Results

- Record the color, size, and appearance of the gonads in males and females of both species.
- Document the maturity stage of each specimen.

Experiment 2: Observations on Gonadal Maturation of *Penaeus monodon* and *Macrobrachium rosenbergii*

Objective

To observe and document the gonadal maturation process of *Penaeus monodon* and *Macrobrachium rosenbergii* over time.

Materials Required

1. Broodstock of *Penaeus monodon* and *Macrobrachium rosenbergii*
2. Dissecting tools
3. Microscopes
4. Observation tanks or breeding tanks
5. Data recording sheets

Procedure

1. **Observation Over Time**:
   - Over several weeks, monitor the broodstock for signs of gonadal maturation. Record the changes in external and internal appearance as the gonads develop.
2. **Dissection for Gonadal Staging**:
   - At regular intervals, dissect female and male broodstock to assess gonadal development. Measure the size and color of the ovaries in females and the size of the testes or spermatophore in males.
3. **Water Quality Monitoring**:
   - Monitor water quality parameters (e.g., pH, salinity, temperature, and dissolved oxygen) as these affect gonadal maturation.

Observations and Results

- Record the progression of gonadal development at different stages, noting the size, color, and texture of the gonads.
- Correlate gonadal maturity with environmental factors and broodstock health.

Experiment 3: Breeding and Larval Rearing of *Macrobrachium rosenbergii* and *Penaeus monodon* / *P. vannamei*

Objective

To understand the breeding process and larval rearing of *Macrobrachium rosenbergii* and *Penaeus monodon* / *P. vannamei* in a hatchery environment.

Materials Required

1. Broodstock of *Macrobrachium rosenbergii* and *Penaeus monodon* / *P. vannamei*
2. Hatchery tanks
3. Water quality monitoring tools
4. Larval rearing tanks
5. Microalgae or other larval food

Procedure

1. **Spawning**:
    - In a controlled environment, place female broodstock with mature gonads and male shrimp into separate tanks for controlled spawning.
    - For *Penaeus monodon*, ensure that the water temperature and salinity are ideal for egg fertilization.
    - For *Macrobrachium rosenbergii*, observe the natural mating behavior between males and females.
2. **Egg Collection**:
    - Collect fertilized eggs after spawning and transfer them to larval rearing tanks with appropriate water conditions.
3. **Larval Rearing**:
    - Use microalgae or other appropriate feeds to nourish the larvae. Maintain ideal water conditions, including temperature, salinity, and dissolved oxygen levels.
    - Record the growth and development of larvae from nauplius to post-larval stages.
4. **Monitoring**:

- Observe and record the development stages of larvae, including moulting and feeding behavior.

Observations and Results

- Record the time taken for eggs to hatch and the progress of larval development. Note the feeding behaviors and any issues in larval survival.
- Document the water quality parameters and their impact on larval growth.

Experiment 4: Identification of Larval Stages of Important Crustaceans and Mollusks

Objective

To identify and understand the different larval stages of *Penaeus monodon*, *Penaeus vannamei*, and *Macrobrachium rosenbergii*.

Materials Required

1. Larvae of *Penaeus monodon*, *Penaeus vannamei*, and *Macrobrachium rosenbergii*
2. Microscope
3. Stereoscopic magnifier
4. Larval development chart for identification

Procedure

1. **Collection of Larvae**:
   - Collect larvae from the rearing tanks after they have hatched from the fertilized eggs.
2. **Identification of Stages**:
   - Using a microscope, examine the larvae for characteristic features such as the number of appendages, presence of eyes, and shape of the body.
   - Identify the different larval stages, including:
     - **Nauplius**: The first larval stage with a single eye.
     - **Zoea**: The second larval stage with more developed appendages.
     - **Mysis**: The stage before metamorphosis to post-larvae.
     - **Post-larvae**: Fully formed juvenile shrimp ready to transition to nursery tanks.
3. **Recording**:
   - Document the key features and approximate duration of each stage. Record any changes observed in body size and appendage development.

Observations and Results

- Record the identification features of each larval stage.
- Note the time duration of each stage and any challenges in identifying different stages.

Experiment 5: Demonstration of Eyestalk Ablation in *Penaeus monodon*

Objective

To demonstrate the process of eyestalk ablation in *Penaeus monodon* to induce spawning in females.

Materials Required

1. *Penaeus monodon* broodstock (female)
2. Surgical instruments (scalpel, forceps)
3. Anaesthetics (e.g., MS-222)
4. Sterile saline solution
5. Eyestalk ablation equipment

Procedure

1. **Anesthesia**:
    - Anaesthetize the female shrimp using a mild dose of MS-222 to reduce stress and prevent injury during the procedure.
2. **Ablation**:
    - Using sterile tools, carefully remove one eyestalk from the female shrimp. The eyestalk is located near the base of the antenna.
3. **Post-Ablation Care**:
    - After ablation, place the shrimp in a recovery tank with optimal water conditions. Monitor for signs of stress or infection.
4. **Observation**:
    - Over the following weeks, observe for signs of gonadal maturation and eventual spawning in the ablated female.

Observations and Results

- Record the time taken for the ablated shrimp to spawn and the outcome of the procedure.
- Document any abnormal responses or complications in the post-ablation phase.

Experiment 6: Collection, Packing, and Transportation of Shrimp/Prawn Seed and Broodstock

Objective

To understand the proper techniques for collecting, packing, and transporting shrimp/prawn seed and broodstock.

Materials Required

1. Live shrimp/prawn seed or broodstock
2. Water containers or bags
3. Oxygen tanks or aerators
4. Packing materials (e.g., Styrofoam boxes)

Procedure

1. **Collection**:
    - Carefully collect the shrimp or prawn seed from hatchery tanks using a net.
    - Select healthy and mature broodstock, ensuring they are disease-free.
2. **Packing**:
    - Place the shrimp or prawn seed in water-filled bags with sufficient oxygen.
    - For long-distance transportation, add ice or cold packs to maintain water temperature.
3. **Transportation**:
    - Transport the packed shrimp/prawn seed and broodstock to their destination, ensuring minimal stress and temperature fluctuations.

Observations and Results

- Record the survival rate of the shrimp during transport.
- Note any signs of stress or health deterioration during the process.

Experiment 7: Water Treatment and Management in Shrimp and Prawn Hatcheries

Objective

To study the different methods of water treatment and management in shrimp and prawn hatcheries.

Materials Required

1. Hatchery tanks with water
2. Chemicals for water treatment (e.g., chlorine, sodium thiosulfate)
3. Water quality monitoring tools
4. Filtration systems

Procedure

1. **Water Quality Monitoring**:
    - Regularly test water quality parameters such as pH, salinity, ammonia, nitrites, and dissolved oxygen.
2. **Water Treatment**:
    - Use appropriate chemicals to treat water for pathogens or excess nutrients. For example, treat water with chlorine and neutralize with sodium thiosulfate.
3. **Water Filtration**:
    - Employ filtration systems (e.g., UV filters, biofilters) to maintain water quality in hatchery systems.

Observations and Results

- Record the effectiveness of water treatment methods in maintaining optimal water quality.
- Note any changes in the health and growth of the larvae or broodstock based on water quality adjustments.

BFSC-405: Fish Nutrition and Feed Technology

Introduction

Fish nutrition and feed technology are key areas in aquaculture that focus on formulating nutritionally balanced diets for fish to ensure optimal growth, health, and productivity. In this lab manual, students will learn how to analyze the proximate composition of feed ingredients, prepare artificial feeds, evaluate the sinking rate and stability of feeds, and understand the effects of storage on feed quality. This practical knowledge is essential for developing cost-effective, high-quality feeds that support sustainable aquaculture practices.

Experiment 1: Proximate Composition Analysis of Feed Ingredients and Feeds

Objective

To analyze the proximate composition of feed ingredients and finished feeds, including the determination of moisture, crude protein, fat, crude fiber, ash, and nitrogen-free extract.

Materials Required

1. Feed ingredients (e.g., fish meal, soybean meal, cornmeal, etc.)
2. Feed samples (both artificial and natural feeds)
3. Analytical balance
4. Oven (for drying)
5. Soxhlet extractor (for fat extraction)
6. Kjeldahl apparatus (for protein determination)
7. Muffle furnace (for ash determination)
8. Fiber analyzer (for crude fiber determination)
9. Weighing dishes
10. Distilled water
11. Reagents (e.g., sodium hydroxide, hydrochloric acid, solvents for extraction)

Procedure

1. **Moisture Content**:
    - Weigh a clean, dry dish. Add approximately 10-20g of feed ingredient or feed sample to the dish.
    - Dry the sample in an oven at 105°C for 24 hours or until constant weight is achieved.
    - Calculate the moisture content using the formula:

$$\text{Moisture content}(\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

2. **Crude Protein** (using the Kjeldahl method):
    - Weigh a known quantity (about 1g) of the feed sample.
    - Digestion: Add the sample to a digestion flask with sulfuric acid and a catalyst.
    - Distillation: Distill the ammonia released and collect it in a boric acid solution.
    - Titration: Titrate the ammonia solution with a standard acid to determine the amount of nitrogen.
    - Calculate crude protein as follows:

$$\text{Crude protein}(\%) = \text{Nitrogen content}(\%) \times 6.25$$

3. **Crude Fat** (using Soxhlet extraction):
    - Weigh a sample of feed (1-2g) and place it in the Soxhlet extractor.
    - Extract fat using an appropriate solvent (e.g., petroleum ether) for several hours.
    - Evaporate the solvent and weigh the remaining fat.
    - Calculate crude fat content:

$$\text{Crude fat}(\%) = \frac{\text{Weight of fat}}{\text{Initial weight of sample}} \times 100$$

4. **Crude Fiber**:
    - Weigh a sample of feed (about 5g).
    - Boil the sample in dilute acid and alkali solutions, followed by filtration.
    - Dry the residue in an oven at 105°C and weigh it.
    - Calculate crude fiber content:

$$\text{Crude fiber}(\%) = \frac{\text{Dry residue weight}}{\text{Initial weight}} \times 100$$

5. **Ash Content**:
    - Weigh a clean crucible and add 1-2g of the feed sample.
    - Incinerate the sample in a muffle furnace at 550°C for 4-5 hours.
    - Cool the crucible in a desiccator and weigh the remaining ash.
    - Calculate ash content:

$$\text{Ash content}(\%) = \frac{\text{Weight of ash}}{\text{Initial weight of sample}} \times 100$$

6. **Nitrogen-Free Extract (NFE)**:

- NFE can be calculated by subtracting the sum of moisture, protein, fat, crude fiber, and ash from 100%:

$$\text{NFE}(\%) = 100 - (\text{Moisture} + \text{Protein} + \text{Fat} + \text{Fiber} + \text{Ash})$$

Observations and Results

- Record the values of each component (moisture, protein, fat, fiber, ash, NFE) in a table.
- Compare the proximate composition of various feed ingredients to assess their nutritional value.

Experiment 2: Preparation of Artificial Feeds Using Locally Available Feed Ingredients

Objective

To prepare artificial fish feeds using locally available ingredients and evaluate their potential nutritional quality.

Materials Required

1. Locally available ingredients (e.g., rice bran, soybean meal, fish meal, cornmeal, wheat flour)
2. Binder (e.g., starch or wheat flour)
3. Water
4. Feed pelletizer or grinder
5. Oven (for drying)
6. Weighing balance

Procedure

1. **Selection of Ingredients**:
   - Choose locally available ingredients based on their nutritional value (protein, fat, etc.).
   - Common choices include fish meal, soybean meal, rice bran, and cornmeal.
2. **Preparation of Feed Mixture**:
   - Weigh appropriate quantities of each ingredient to achieve a balanced nutritional profile.
   - Add water to create a dough-like consistency. If necessary, use a binder (e.g., wheat flour or starch) to hold the feed together.
3. **Pelletizing**:
   - Feed the mixture into a pelletizer or grinder to form pellets of uniform size.
   - If a pelletizer is unavailable, the feed can be rolled into small balls or cakes.

4. **Drying**:
    - Dry the pellets in an oven at 50-60°C for 24-48 hours or until completely dry.
5. **Storage**:
    - Store the prepared feed in airtight containers to prevent moisture absorption and degradation.

Observations and Results

- Record the size and texture of the pellets.
- Compare the composition and quality of the artificial feed with commercially available feeds.
- Assess the nutritional adequacy of the prepared feed based on proximate composition analysis.

Experiment 3: Determination of Sinking Rate and Stability of Feeds

Objective

To determine the sinking rate and stability of fish feeds to evaluate their performance in water.

Materials Required

1. Fish feed samples (both commercial and prepared feeds)
2. Water tanks or containers
3. Stopwatch
4. Ruler or measuring scale
5. Sieve or net for collecting sinking feeds

Procedure

1. **Sinking Rate Test**:
    - Place a known quantity of feed pellets in a tank filled with water.
    - Observe the time it takes for the pellets to sink to the bottom of the tank. Use a stopwatch to record the time.
    - Measure the sinking depth at regular intervals (e.g., every 10 seconds) until the feed reaches the bottom.
2. **Stability Test**:
    - Monitor the feed for its ability to maintain its structure once submerged in water.
    - Measure how long it takes for the pellets to disintegrate or lose their shape.
    - Record the time it takes for the pellets to break down completely.

Observations and Results

- Record the sinking time for each type of feed.
- Note any differences in the rate of sinking and stability between different feed types.
- Calculate the average sinking rate and stability time for each feed type.

Experiment 4: Effect of Storage on Feed Quality

Objective

To study the effects of different storage conditions on the quality of fish feeds.

Materials Required

1. Fish feed samples (both commercial and prepared feeds)
2. Storage containers (airtight bags or boxes)
3. Temperature-controlled storage units (e.g., refrigerator, room temperature)
4. Proximate composition analysis tools (as described in Experiment 1)
5. Moisture analyzer

Procedure

1. **Storage Conditions**:
    - Divide the feed samples into separate batches for different storage conditions (e.g., room temperature, refrigerated, or frozen).
    - Store the samples for varying periods (e.g., 1 week, 1 month, 3 months).
2. **Quality Assessment**:
    - After each storage period, analyze the stored feed samples for moisture content, nutritional composition, and physical quality (e.g., pellet integrity, color, smell).
    - Compare the stored feeds with fresh feeds to determine any degradation in quality.
3. **Proximate Composition Analysis**:
    - Perform proximate composition analysis on stored feeds to determine if any nutritional changes have occurred due to storage.

Observations and Results

- Record any changes in the feed's appearance, texture, and smell after storage.
- Document any differences in the proximate composition of stored feeds compared to fresh feeds.
- Analyze how different storage conditions impact the shelf life and quality of the feed.

BFSC-406: Freezing Technology

Introduction

Freezing technology plays a vital role in the preservation of fish and shellfish, helping maintain their quality, nutritional value, and safety during storage and transportation. The freezing process involves lowering the temperature of seafood products to preserve them by inhibiting the growth of microorganisms and slowing down enzymatic activities that can cause spoilage. This lab manual provides students with practical knowledge on the different aspects of freezing technology, including chilling and freezing equipment, methods of icing fish, preservation using chilled seawater, freezing and thawing curves, estimation of drip, and inspection of frozen fishery products.

Experiment 1: Sanitation and Plant Housekeeping

Objective

To understand the importance of sanitation and proper plant housekeeping in ensuring the safety and quality of frozen fishery products.

Materials Required

1. Cleaning agents (detergents, sanitizers)
2. Cleaning tools (brooms, mops, brushes)
3. Sanitizing equipment (foggers, sprays)
4. Personal protective equipment (PPE)
5. Documentation tools (checklists, logs)

Procedure

1. **Plant Housekeeping**:
    - Maintain cleanliness in all areas of the plant, including production, storage, and packaging areas.
    - Ensure proper waste disposal and the cleaning of surfaces that come into contact with raw materials.
    - Implement regular cleaning schedules to avoid contamination.
2. **Sanitization**:
    - Use appropriate cleaning agents for different surfaces, such as stainless steel, plastic, or concrete.
    - Ensure all equipment used for fish processing, including knives, scales, and packing machines, is sanitized regularly.
    - Perform sanitizing procedures after every shift or batch to prevent cross-contamination.

3. **Personal Hygiene**:
    - Maintain proper personal hygiene by wearing gloves, masks, and clean uniforms.
    - Regular hand washing and disinfection are essential before and after handling fish products.
4. **Record Keeping**:
    - Maintain logs of cleaning activities and plant conditions. Document the frequency and method of cleaning to ensure consistency and compliance with health standards.

Observations and Results

- Record the overall cleanliness and sanitization levels of various plant areas.
- Document the cleaning schedule and the effectiveness of sanitation practices in maintaining a hygienic environment.

Experiment 2: Chilling and Freezing Equipment and Instruments

Objective

To familiarize students with the chilling and freezing equipment used in the preservation of fish and shellfish.

Materials Required

1. Refrigeration and freezing units (blast freezers, plate freezers, spiral freezers)
2. Temperature measurement tools (thermometers, data loggers)
3. Cooling baths or chillers
4. Ice-making machines
5. Fish or shellfish samples

Procedure

1. **Chilling Equipment**:
    - Inspect the operation of various chilling equipment, including refrigeration units and cooling tanks.
    - Measure the cooling rates of different chilling systems and observe how effectively they bring the temperature of fish down to the required levels (0°C to 4°C).
2. **Freezing Equipment**:
    - Observe the operation of freezing units, such as blast freezers, plate freezers, and spiral freezers.

- Discuss the differences in freezing methods and their suitability for different types of seafood products.
- Measure temperature variations in the freezing process using thermometers and data loggers.

3. **Testing Freezing and Thawing Performance**:
    - Place fish or shellfish samples in different types of freezing equipment and monitor the time taken to freeze the product completely.
    - After freezing, measure thawing times to observe the effects of freezing method on thawing performance.

Observations and Results

- Record the time taken for chilling and freezing.
- Note temperature variations during chilling and freezing cycles.
- Compare the efficiency and speed of different equipment in terms of chilling and freezing.

Experiment 3: Methods of Icing Fish

Objective

To understand and practice the different methods of icing fish and shellfish to maintain freshness before freezing.

Materials Required

1. Fresh fish or shellfish samples (e.g., finfish, shrimp, shellfish)
2. Ice (crushed or block)
3. Containers or fish bins
4. Thermometers
5. Stopwatch

Procedure

1. **Icing Process**:
    - Lay fish samples on a layer of crushed or block ice in containers. Ensure that the fish are completely covered with ice.
    - Monitor the temperature of the fish and ice using thermometers to ensure the fish is chilled to an optimal temperature (0°C).
    - Use different icing methods: direct contact with ice, partial immersion, or a layer of fish with ice in between.
2. **Storage and Monitoring**:

- Store the iced fish in a cool storage room or freezer. Measure and record the temperature every few hours to ensure consistent chilling.
- Keep track of how quickly the ice melts and how it affects the fish quality.

Observations and Results

- Record the time it takes for the ice to reach the desired temperature.
- Note the overall condition of the fish after icing for different periods (e.g., 6 hours, 12 hours, 24 hours).
- Assess the effectiveness of icing in preserving the quality of fish and shellfish.

Experiment 4: Cooling Rate

Objective

To determine the cooling rate of fish or shellfish under different chilling and freezing conditions.

Materials Required

1. Fish or shellfish samples
2. Thermocouples or temperature loggers
3. Ice, chilled water, or freezing units
4. Stopwatch

Procedure

1. **Cooling with Ice**:
   - Place fish or shellfish samples on ice and record the temperature at different time intervals (e.g., 0, 10, 20, 30 minutes).
   - Plot the cooling curve to determine the rate at which the fish cools down.
2. **Cooling with Chilled Sea Water**:
   - Repeat the procedure with chilled sea water instead of ice and observe the cooling rate.
   - Record the time taken for the product to reach optimal chilling temperature (0°C).
3. **Freezing Rate**:
   - Place samples in a freezer and monitor the freezing rate. Record the time it takes to reach the required freezing temperature (-18°C or lower).

Observations and Results

- Document the cooling rate for each method.

- Analyze which cooling method is most efficient for preserving the quality of the product.
- Compare the cooling and freezing rates between different chilling methods.

Experiment 5: Preservation by Chilled Sea Water

Objective

To understand the preservation process using chilled sea water and evaluate its effectiveness in preserving seafood.

Materials Required

1. Fish or shellfish samples
2. Chilled seawater or seawater-based cooling systems
3. Thermometers
4. Containers

Procedure

1. **Preparation of Chilled Sea Water**:
    - Prepare chilled sea water by cooling seawater to around 0°C to 4°C using a refrigeration system.
    - Immerse the fish or shellfish in the chilled seawater and monitor the temperature.
2. **Storage**:
    - Store the samples in the chilled seawater for a specific period (e.g., 24 hours) and record the temperature throughout the storage time.
    - Compare the preservation quality of seafood in chilled seawater with those stored using traditional ice or refrigeration.

Observations and Results

- Record the temperature and condition of the seafood during storage.
- Evaluate the effectiveness of chilled seawater in preserving the freshness of seafood compared to other methods.

Experiment 6: Freezing and Thawing Curves

Objective

To study the freezing and thawing curves of fish and shellfish to understand the effect of these processes on product quality.

Materials Required

1. Fish or shellfish samples
2. Freezer (blast freezer)
3. Thawing chamber (or warm water bath)
4. Thermometers
5. Stopwatch

Procedure

1. **Freezing Curve**:
    - Place fish or shellfish in a freezer and monitor the temperature every few minutes until the product reaches a stable frozen state.
    - Plot the freezing curve to identify the time required for complete freezing.
2. **Thawing Curve**:
    - After freezing, thaw the product using a warm water bath or at room temperature.
    - Record the time it takes for the product to thaw completely and monitor any changes in texture or quality.

Observations and Results

- Plot freezing and thawing curves.
- Document any significant changes in the texture, color, or appearance of the seafood during freezing and thawing.

Experiment 7: Estimation of Drip

Objective

To determine the amount of water loss (drip) from frozen fish and shellfish after thawing.

Materials Required

1. Frozen fish or shellfish samples
2. Thawing chamber or controlled room temperature
3. Weighing scale
4. Containers for collecting drip

Procedure

1. **Thawing**:
    - Thaw frozen fish or shellfish samples at room temperature or using a warm water bath.

- Place the thawed product on a clean, dry surface and collect any dripping water in a container.

2. **Weighing and Calculation**:
    - Weigh the thawed fish or shellfish before and after thawing.
    - Calculate the amount of drip by subtracting the final weight from the initial weight.

Observations and Results

- Record the amount of water lost during thawing as drip.
- Analyze how different species or freezing methods affect the drip loss.

BFSC-407: Fish Canning Technology

Introduction

Fish canning is one of the most important methods of preserving seafood for long-term storage and transportation. The process involves sealing fish or shellfish in cans, followed by a thermal treatment to kill microorganisms, enzymes, and other potential spoilage agents. This ensures the safety, quality, and shelf-life of the product. The lab exercises in this manual will provide students with practical knowledge about different aspects of fish canning technology, including can types, canning equipment, heat penetration, thermal processing, and spoilage conditions in canned products.

Experiment 1: Types of Cans, Canning Equipment, and Layout of Cannery

Objective

To understand the various types of cans and canning equipment used in fish preservation and the layout of a canning facility.

Materials Required

1. Different types of cans (e.g., tinplate, aluminum, steel)
2. Canning machines (e.g., can seamers, can fillers)
3. Canning line setup
4. Fish and shellfish samples
5. Packaging materials (e.g., labels, box packaging)

Procedure

1. **Cans Types**:
    - Examine and categorize various types of cans used for fish canning, including tinplate, aluminum, and steel cans.
    - Study the advantages and disadvantages of each type of can in terms of durability, cost, and suitability for different fish and shellfish species.
2. **Canning Equipment**:
    - Observe the operation of canning equipment such as can seamers, fillers, and lid sealers.
    - Understand the steps involved in sealing cans, including filling, vacuum sealing, and crimping.
3. **Layout of Cannery**:
    - Study the typical layout of a fish canning facility, including raw material storage, cleaning, processing, sealing, and storage areas.

- Observe the flow of materials from raw fish to canned product and identify areas for efficiency improvements.

Observations and Results

- Record the types of cans used for different fish species.
- Analyze the efficiency of canning equipment and their role in ensuring quality and safety.
- Discuss the layout and workflow of a canning facility.

Experiment 2: Canning of Different Varieties of Fish and Shellfish

Objective

To practice the canning process for different varieties of fish and shellfish, including preparation, canning, and sealing.

Materials Required

1. Fresh fish and shellfish (e.g., mackerel, tuna, shrimp)
2. Cans, lids, and sealing equipment
3. Canning machines (e.g., can seamer, filler)
4. Heat source (boiling water or steam)
5. Brine, oil, or sauce for packing

Procedure

1. **Preparation**:
    - Clean, gut, and cut the fish or shellfish into suitable portions.
    - Prepare the brine, oil, or sauce for packing based on the recipe for the species being canned.
2. **Canning Process**:
    - Fill the prepared cans with the fish or shellfish, ensuring proper packing to avoid air pockets.
    - Add brine, oil, or sauce to the can and leave an appropriate headspace for expansion.
    - Seal the cans using a can seamer and check for proper sealing.
3. **Sterilization**:
    - Subject the sealed cans to a heat process (usually in a retort or pressure cooker) for sterilization. Monitor temperature and pressure according to the species' thermal processing requirements.

Observations and Results

- Record the canning time and conditions for each type of fish and shellfish.
- Examine the appearance and texture of the canned products after the process.
- Ensure that cans are sealed correctly and the headspace is adequate.

Experiment 3: Cut-out Test of Canned Products

Objective

To perform a cut-out test to assess the quality and consistency of the contents inside the canned products.

Materials Required

1. Canned fish or shellfish products
2. Sharp knives or scissors
3. Ruler or caliper for measurement
4. Food safety gloves

Procedure

1. **Cutting Open the Can**:
    - Open the cans carefully without damaging the contents.
    - Examine the can's contents, including the fish or shellfish and the packing liquid (oil, brine, or sauce).
2. **Examination of Quality**:
    - Check the uniformity and consistency of the product inside the can. Evaluate the texture, color, and overall condition of the fish or shellfish.
    - Measure the headspace to ensure it complies with standard canning guidelines.
3. **Cut-out Analysis**:
    - Measure the size of fish or shellfish pieces and check for any signs of overcooking, undercooking, or damage during the canning process.

Observations and Results

- Record the size, texture, and appearance of the cut-out samples.
- Note any abnormalities or quality issues in the canned product.

Experiment 4: Examination of Can Double Seam

Objective

To examine the double seam of canned products for proper sealing and to ensure the integrity of the can.

Materials Required

1. Canned products (e.g., fish or shellfish)
2. Seam gauge or micrometer
3. Magnifying glass or microscope
4. Can opener

Procedure

1. **Examine Can Seams**:
    - Open the can and use a seam gauge or micrometer to measure the double seam. The double seam ensures a strong and airtight seal between the lid and the body of the can.
2. **Seam Integrity Check**:
    - Inspect the seams for any gaps, dents, or improper crimping. Measure the thickness of the seam at different points to check for consistency.
    - Use a magnifying glass or microscope to closely examine the seams for any signs of leakage or poor sealing.
3. **Document Findings**:
    - Record the measurements of the double seam and note any discrepancies in sealing.

Observations and Results

- Note the thickness and uniformity of the double seam.
- Identify any cans with faulty seams or poor seals that might compromise the quality and shelf life of the product.

Experiment 5: Heat Resistance of Bacteria in Canned Fish

Objective

To understand the heat resistance of different types of bacteria commonly found in canned fish products.

Materials Required

1. Canned fish samples
2. Bacterial culture medium
3. Incubator

4. Thermocouple or data logger

Procedure

1. **Bacterial Inoculation**:
    - Prepare bacterial cultures (e.g., *Clostridium botulinum*, *Salmonella*) and inoculate the canned fish samples with these cultures.
2. **Heat Treatment**:
    - Subject the inoculated canned samples to various temperatures for different periods to simulate the thermal processing used in canning.
3. **Bacterial Growth**:
    - After heat treatment, transfer the inoculated samples to a bacterial growth medium and incubate.
    - Monitor bacterial growth and determine the heat resistance of the bacteria by assessing their ability to grow after exposure to the heat treatment.

Observations and Results

- Record the temperature and duration of heat treatment.
- Assess bacterial growth post-treatment to determine the heat resistance of different bacterial strains.

Experiment 6: Heat Penetration in Canned Food

Objective

To study the heat penetration in canned fish or shellfish during the thermal processing stage.

Materials Required

1. Canned fish or shellfish products
2. Thermocouples or temperature loggers
3. Pressure cooker or retort for thermal processing
4. Stopwatch

Procedure

1. **Setup**:
    - Insert thermocouples into the center of a can of fish or shellfish and seal it.
2. **Thermal Processing**:
    - Place the cans in a pressure cooker or retort and heat them under controlled conditions.
    - Monitor the temperature at different locations in the can during the process, especially the core temperature.

3. **Analysis**:
    - Record the time it takes for heat to penetrate the center of the can and bring it to the desired temperature (typically around 121°C).
    - Analyze the time-temperature profile of heat penetration.

Observations and Results

- Document the heat penetration data and determine if the thermal process is adequate for ensuring product safety.
- Assess the uniformity of heat distribution within the can.

Experiment 7: Study of Spoilage Conditions in Canned Products

Objective

To identify spoilage conditions in canned fish or shellfish products and understand the causes of spoilage.

Materials Required

1. Canned fish or shellfish samples
2. Magnifying glass or microscope
3. Growth medium for bacterial cultures
4. Temperature-controlled storage chamber

Procedure

1. **Examine Cans for Spoilage**:
    - Open cans that have been stored for various periods and examine for signs of spoilage such as discoloration, off smells, or gas buildup.
2. **Microbial Growth**:
    - Transfer any spoiled contents to a bacterial growth medium and incubate to identify the microorganisms responsible for spoilage.
3. **Storage Conditions**:
    - Store cans under various temperature conditions (room temperature, refrigeration) to study how temperature influences spoilage.

Observations and Results

- Record the signs of spoilage observed in the canned products.
- Identify the microorganisms responsible for spoilage and discuss their growth conditions.
- Analyze the impact of storage conditions on spoilage rates.

BFSC-408: Navigation and Seamanship

Introduction

Navigation and seamanship are fundamental components of maritime operations. Navigators use a variety of tools and techniques to determine a vessel's position, course, and speed at sea. This manual covers a series of exercises that familiarize students with the practice of navigation, including knot tying, chart work, use of the sextant, compass navigation, and radar observations. It also provides an in-depth understanding of the anatomy and functioning of magnetic and gyro compasses, error calculations, and methods for determining position and course at sea.

Experiment 1: Practicing Different Types of Knots and Wire Splices

Objective

To practice and understand the use of various knots and wire splices commonly used in seamanship.

Materials Required

1. Ropes (various sizes)
2. Wire (for splicing)
3. Splicing tools (fid, marlinspike, scissors)
4. Knot diagrams and reference materials

Procedure

1. **Knots Practice**:
    - Learn and practice the following knots:
        - **Bowline Knot**: Used to form a loop that does not slip.
        - **Clove Hitch**: Used for securing a rope to a post, rail, or similar object.
        - **Figure-eight Knot**: Used as a stopper knot to prevent the rope from slipping through a hole or a cleat.
        - **Sheet Bend**: Used for joining two ropes of unequal thickness.
        - **Reef Knot**: Used for joining two ropes of equal thickness.
2. **Wire Splicing**:
    - Learn the technique of splicing wires using a fid or marlinspike.
    - Practice creating **eye splices**, **short splices**, and **back splices**.
3. **Test and Evaluate**:
    - Once the knots and splices are made, test them for their strength and effectiveness under tension.

- Assess the appearance and functionality of the splices and knots for seamanship tasks.

Observations and Results

- Record the time taken to tie each knot or complete a splice.
- Evaluate the durability of knots and splices by applying weight or tension to them.

Experiment 2: Chart Work – Finding Positions by Latitudes and Longitudes

Objective

To understand and practice determining a vessel's position using latitudes and longitudes and finding positions using position lines, cross bearings, and running fixes.

Materials Required

1. Nautical charts
2. Dividers
3. Parallel rulers
4. Compass
5. Protractor
6. Pencil and eraser
7. Chart plotting tools

Procedure

1. **Finding Position by Latitudes and Longitudes**:
   - Locate a known position on the chart using the latitude and longitude coordinates.
   - Use a compass or dividers to measure the distance between the latitude and longitude lines.
2. **Position Lines and Cross Bearings**:
   - Use a bearing compass to measure the direction to a fixed landmark (e.g., lighthouse, buoy).
   - Plot the position lines on the chart based on the measured bearings.
   - Use cross bearings from two different landmarks to triangulate and determine the vessel's position.
3. **Running Fix**:
   - Identify two landmarks and take the bearing to each at different time intervals.

- Plot the bearings on the chart, adjusting for the vessel's movement.
- Determine the position by intersecting the bearings from both times.

4. **Speed, Distance, and Time**:
    - Use the formula **Speed = Distance / Time** to calculate the speed of the vessel.
    - Determine the distance covered over a given period of time using the vessel's speed.

Observations and Results

- Record the position found using latitude and longitude, position lines, and cross bearings.
- Compare the calculated position using different methods to assess their accuracy.

Experiment 3: Finding Position by Speed, Distance, and Time

Objective

To practice finding the vessel's position by calculating the speed, distance, and time and adjusting for set and drift.

Materials Required

1. Nautical charts
2. Speed log or timepiece
3. Dividers
4. Compass

Procedure

1. **Determining Speed and Distance**:
    - Use the vessel's log to record speed (in knots) and time (in hours).
    - Calculate the distance traveled using the formula: **Distance = Speed × Time**.
2. **Set and Drift**:
    - Consider the effects of the current on the vessel's movement.
    - Measure the angle of the vessel’s movement with respect to the true course (drift).
    - Adjust the vessel’s course by calculating the angle of drift and the current’s speed.
3. **Course Made Good**:
    - Plot the true course of the vessel on the chart.

- Determine the course made good, factoring in set and drift.

4. **Steering Course**:
    - Adjust the vessel's steering course to counteract the drift and maintain the intended course.

Observations and Results

- Calculate the distance covered and adjust for current drift.
- Determine the course made good and compare it to the planned course.
- Assess the effect of current on the vessel's navigation.

Experiment 4: Observation of RADAR

Objective

To understand and practice using RADAR for navigation and observation at sea.

Materials Required

1. RADAR system
2. Radar screen
3. Control panel for adjusting RADAR settings
4. Test objects (e.g., buoys, ships, landmasses)

Procedure

1. **Introduction to RADAR**:
    - Familiarize yourself with the RADAR system, including the basic controls, settings, and interpretation of the RADAR display.
    - Learn how to adjust the gain, range, and heading of the RADAR for optimal visibility.
2. **RADAR Observation**:
    - Identify nearby objects, such as buoys, vessels, or landmasses, using RADAR.
    - Use the RADAR screen to track their movement and determine their position relative to the vessel.
3. **Interpretation**:
    - Record the bearing and distance of observed objects.
    - Practice identifying targets on the RADAR screen and evaluating their position and movement.

Observations and Results

- Record the distance and bearing of observed objects.
- Analyze the effectiveness of RADAR in navigation and collision avoidance.

Experiment 5: Anatomy of Magnetic and Gyro Compasses

Objective

To understand the anatomy, functioning, and error calculation for magnetic and gyro compasses.

Materials Required

1. Magnetic compass
2. Gyro compass
3. Error calculation charts
4. Test equipment (e.g., slant angle for error detection)

Procedure

1. **Magnetic Compass**:
    - Familiarize yourself with the parts of a magnetic compass (e.g., needle, compass card, lubber line, gimbals).
    - Test the compass for deviations by using different headings and recording the observed errors.
2. **Gyro Compass**:
    - Examine the components of a gyro compass (e.g., gyroscope, rotor, gimbal).
    - Understand the principles of gyrocompass functioning, which does not rely on Earth's magnetic field.
3. **Error Calculation**:
    - Measure the difference between the indicated direction and the true heading using both the magnetic and gyro compasses.
    - Calculate the deviation (magnetic compass error) and gyro error (drift).

Observations and Results

- Record the errors and deviations for both the magnetic and gyro compasses.
- Analyze the sources of error and determine methods to minimize them in real-world navigation.

BFSC-409: Fishing Craft Technology

Introduction

Fishing Craft Technology involves the study of the design, construction, and maintenance of fishing boats and vessels, including the integration of various components such as hull design, engine installation, and overall construction. This course provides a theoretical and practical understanding of traditional and modern fishing crafts, teaching students the basic skills needed for the design and drawing of boat components and the understanding of different types of fishing vessels and engines.

The manual will cover exercises related to drawing techniques, including projections, curves, and different boat plans, and it will also provide a hands-on understanding of fishing craft construction through visits to boat building yards and dry docks.

Experiment 1: Studies on Traditional Fishing Crafts

Objective

To study the design and construction techniques of traditional fishing crafts used in different regions, focusing on their hull design, material, and functionality.

Materials Required

1. Sketches or blueprints of traditional fishing crafts (local, regional, and international).
2. Measuring tools (tape measure, calipers, protractor).
3. Reference books on traditional boatbuilding.

Procedure

1. **Research and Collection**:
    - Gather different types of traditional fishing boats (e.g., canoes, catamarans, dhows) and their characteristics (materials used, design features, types of fishing).
    - Study the construction methods and the types of wood or materials used in traditional fishing boats.
2. **Hull Shape and Material Study**:
    - Examine the hull shapes, including round, V-bottom, and flat-bottom designs.
    - Study how the shape and materials (wood, fiber, etc.) affect the boat's performance on different water bodies.
3. **Functional Study**:
    - Understand how the design of traditional fishing boats contributes to their usability for different fishing methods (netting, trawling, or longlining).

Observations and Results

- Record the design features and material choices of each type of traditional craft.
- Compare the functionality and adaptability of traditional crafts for various aquatic environments.

Experiment 2: Introduction to Drawing and Drawing Instruments

Objective

To familiarize students with the basic drawing tools and techniques used in creating technical drawings for fishing craft design.

Materials Required

1. Drawing board
2. Set squares (30°-60° and 45°)
3. T-square
4. Compass
5. French curve
6. Pencil, erasers
7. Scale ruler
8. Paper for sketches

Procedure

1. **Lettering and Geometrical Construction**:
    - Practice technical lettering (capital letters and numerals used in engineering drawings).
    - Construct basic geometric shapes such as triangles, circles, rectangles, and polygons.
    - Learn how to use the T-square and set squares to create accurate and precise lines.
2. **Projections**:
    - Understand orthographic projections, including front, top, and side views.
    - Practice projecting points and planes on the paper to create 2D representations of objects.
3. **Curves and Construction**:
    - Use French curves to draw arcs and curves accurately for hull designs.
    - Practice constructing curves used in boat designs, such as arcs for hull forms.

Observations and Results

- Evaluate the accuracy and clarity of the geometric shapes and projections.

- Practice drawing basic shapes and projections as the foundation for more complex fishing craft designs.

Experiment 3: Projections – Projection of Points, Planes, and Solids

Objective

To understand the concept of projections in technical drawing, especially in the context of fishing craft design.

Materials Required

1. Drawing tools (as mentioned above)
2. Technical drawing sheets

Procedure

1. **Projection of Points**:
    - Mark a point on the drawing sheet and practice projecting the point to its top view and side view.
2. **Projection of Planes**:
    - Draw a simple plane and project it to both its top and front views using orthogonal projection techniques.
3. **Projection of Solids**:
    - Draw a solid object (like a cube or cone) and practice projecting the object's views (front, top, side) on the drawing sheet.
    - Focus on correctly interpreting the three-dimensional shape in two dimensions.

Observations and Results

- Record how well the points, planes, and solids are represented in different projections.
- Note any difficulty in visualizing the 3D shape on a 2D surface and the strategies used to overcome it.

Experiment 4: Drawing of Back Bone Assembly

Objective

To understand and practice the drawing of the backbone assembly of a wooden boat, which is a crucial component of the craft's structural design.

Materials Required

1. Reference drawings or plans of wooden boats
2. Drawing instruments

Procedure

1. **Backbone Structure**:
    - Understand the concept of the backbone, which includes the keel and ribs of the boat.
    - Draw the keel, which runs along the length of the boat, and practice drawing the ribbing structure that supports the hull.
2. **Assembly Details**:
    - Draw the backbone assembly with accurate projections of the keel and ribs, ensuring the correct angles and measurements.
3. **Detailing**:
    - Add measurements and labels to the drawing, ensuring the correct scale is used.

Observations and Results

- Compare the accuracy of the drawn backbone structure with a real or reference model.
- Assess the level of detail required for accurate representation in boat design drawings.

Experiment 5: U & V Bottom Hull of Wooden Boat

Objective

To practice drawing the U-bottom and V-bottom hull designs commonly used in wooden boat construction.

Materials Required

1. Reference drawings of U-bottom and V-bottom hulls
2. Drawing instruments

Procedure

1. **U-Bottom Hull**:
    - Draw a cross-section of a U-bottom hull.
    - Focus on the symmetrical shape and ensure proper angles between the sides of the hull.
2. **V-Bottom Hull**:
    - Draw a cross-section of a V-bottom hull, which is used for higher stability and more control in rough waters.
    - Ensure that the V-shape is accurately represented in the drawing.
3. **Comparison**:

- Compare the U-bottom and V-bottom hull shapes and their respective benefits.

Observations and Results

- Assess the difference in hull shapes and their impact on stability and functionality.
- Record the ease of drawing the different hull shapes and any difficulties encountered in the process.

Experiment 6: Drawing of Sheer Plan, Body Plan, and Half-Breadth Plan

Objective

To learn how to create a sheer plan, body plan, and half-breadth plan, which are essential views in boat design.

Materials Required

1. Reference drawings of fishing boats
2. Drawing instruments

Procedure

1. **Sheer Plan**:
    - Draw the sheer plan, which shows the side profile of the boat and outlines the curves of the deck and the hull.
2. **Body Plan**:
    - Draw the body plan, which shows the shape of the boat at different sections along the length of the hull.
3. **Half-Breadth Plan**:
    - Draw the half-breadth plan, which shows the boat's shape from the top view and provides a clear view of the width at various sections.

Observations and Results

- Assess the accuracy of the drawings and their clarity in representing the boat's structure.
- Compare the plans to determine how each view provides essential information for boat construction.

Experiment 7: Types of Marine Engines and Their Installation

Objective

To understand the types of marine engines used in fishing crafts and how they are installed and maintained.

Materials Required

1. Marine engine models or diagrams
2. Installation manuals

Procedure

1. **Types of Marine Engines**:
    - Study different types of marine engines (inboard, outboard, diesel, etc.) used in fishing boats.
2. **Engine Installation**:
    - Understand the principles of engine installation, including the positioning of the engine in the hull and the connection to the boat's propeller.
3. **Maintenance**:
    - Learn basic maintenance procedures for marine engines, including routine checks and servicing.

Observations and Results

- Record the key differences between types of marine engines and their suitability for different fishing craft.
- Note the steps involved in the installation and maintenance of the engines.

Experiment 8: Visit to Boat Building Yard and Dry Dock

Objective

To observe the practical aspects of boat building, including construction, repairs, and maintenance.

Procedure

1. **Boat Building Yard**:
    - Visit a local boat building yard to observe the process of constructing fishing crafts.
    - Take notes on the materials, tools, and techniques used in the construction of boats.
2. **Dry Dock**:
    - Visit a dry dock facility to observe the maintenance and repair procedures for boats, including hull cleaning, engine repairs, and re-coating.

Observations and Results

- Record the steps involved in the boat building and maintenance processes.
- Assess the importance of regular maintenance in extending the lifespan of fishing crafts.