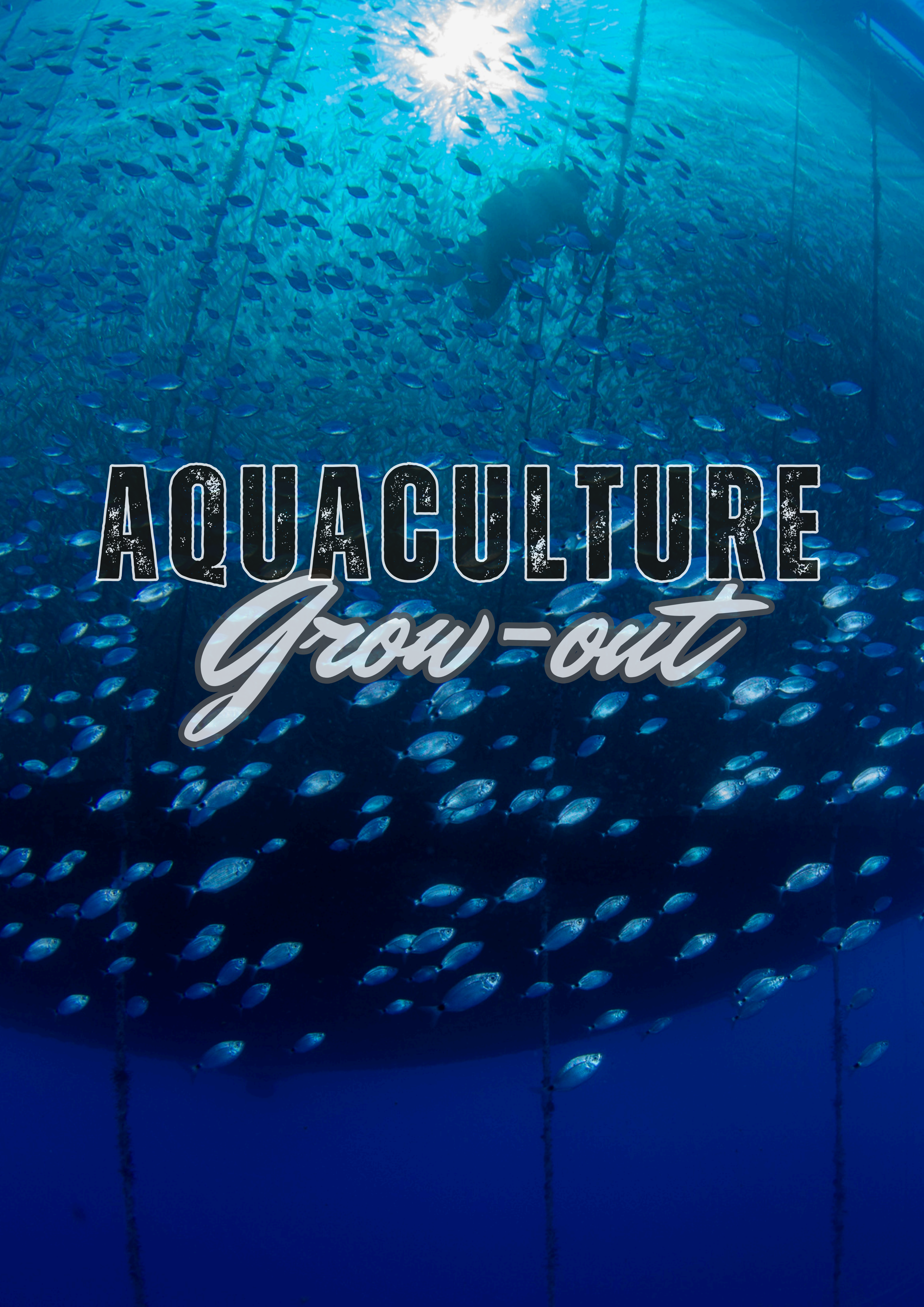

AQUACULTURE
Grow-out

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AQUACULTURE GROW-OUT

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Preword

Aquaculture is not only about the cultivation of aquatic species but also about building sustainable food systems and empowering communities. This book combines insights from two pivotal subjects—Aquaculture Grow-out and Aquaculture Shared Farm 2—to provide a comprehensive guide for students and aspiring aquaculturists.

In Aquaculture Grow-out, we focus on the processes involved in raising juvenile fish to harvest size, exploring the essentials of species selection, water quality management, and feeding practices. This phase is crucial for ensuring a healthy, high-yield crop and requires a deep understanding of both biological and environmental factors.

Aquaculture Shared Farm 2 builds on these principles with a community-oriented approach, introducing collaborative practices that foster shared responsibility and resources among aquaculturists. This model offers students a unique perspective on how shared farms operate, promoting sustainable practices, resource optimization, and economic cooperation within aquaculture communities.

The combination of these subjects in this textbook provides a practical foundation and holistic understanding of modern aquaculture. Additionally, interactive elements, such as QR codes, allow readers to access supplementary resources and real-world case studies, offering a dynamic and engaging learning experience.

By integrating these disciplines, we aim to equip students with the skills and knowledge needed to thrive in both individual and shared aquaculture systems, preparing them to be leaders in sustainable aquaculture practices.

TABLE OF CONTENT

1. Aquaculture

Have you ever wondered where the fish you eat comes from? Many of them are raised on farms, just like cows and chickens. This farming of aquatic organisms, such as fish, crustaceans, mollusks, and aquatic plants, is called aquaculture.

As the global population continues to grow, so does the demand for food, including seafood. To meet this demand while reducing reliance on the ocean, alternative methods must be developed. Aquaculture provides a sustainable solution, helping to fulfill this need. Overfishing has significantly reduced many wild fish populations, and aquaculture offers a way to meet seafood demands without further straining these natural resources.

Aquaculture plays a vital role in creating jobs and strengthening local economies, especially in coastal and rural communities where traditional employment opportunities may be limited. By establishing aquaculture farms, these regions can benefit from a steady source of income and new job opportunities in areas like fish farming, feed production, processing, and transportation.

This economic boost not only supports individuals directly involved in aquaculture but also creates a ripple effect that benefits local businesses, such as equipment suppliers, logistics providers, and local markets.

As aquaculture continues to evolve with advancements in sustainable practices, its role in local economies is expected to grow, providing stable, long-term economic benefits and contributing to food security for coastal populations. To give you a clearer picture of the importance of aquaculture, please scan the QR code below.

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Phase in aquaculture

Hatchery

An aquaculture hatchery is a specialized facility where various aquatic species, including fish, shellfish, and crustaceans, are bred, hatched, and nurtured through their early stages of life. These hatcheries are essential to the aquaculture industry, supplying a steady stream of juvenile species to fish farms and other aquaculture ventures.

Hatcheries typically function as:

- **Breeding and Hatching**: Hatcheries focus on controlled breeding and hatching of aquatic species. This includes preparing broodstock (adult fish) to produce high-quality eggs and sperm.
- **Larval Rearing**: After hatching, larvae are grown in carefully managed environments to ensure high survival rates, with precise control over light, temperature, salinity, and food.
- **Genetic Improvement**: Some hatcheries conduct selective breeding programs to enhance traits like growth rate, disease resistance, and survival.
- **Stock Enhancement**: Hatcheries also support conservation by raising endangered species or restoring depleted wild populations.
- **Economic Importance**: The aquaculture industry depends on hatcheries to meet the rising demand for seafood, making them essential for both commercial production and conservation.

Nursery

An aquaculture nursery is a specialized facility designed to raise young aquatic organisms such as fish, shellfish, and crustacean. These processes continue until the juveniles are large enough to be moved to grow-out systems. A nursery should have:

- **Controlled Environment**: Nurseries maintain optimal conditions to support the growth and health of juveniles by regulating water quality, temperature, and lighting.
- **Feeding**: Juveniles receive a diet tailored to their specific nutritional needs, which is essential for their growth and development in early life stages.
- **Monitoring**: Regular checks on water quality parameters (such as pH, oxygen levels, and temperature) and health assessments help ensure high survival rates and reduce the risk of disease.
- **Growth Stages**: During the nursery stage, organisms are reared from larvae or fry until they are resilient enough to be transferred to grow-out systems. The duration of this stage varies by species.
- **Transfer to Grow-Out Systems**: Once they reach a robust size, the juveniles are moved to grow-out systems, where they continue growing until they reach market size or are ready for release into the wild.

Aquaculture nurseries are essential for sustainable and efficient aquaculture, ensuring a steady supply of healthy juveniles for ongoing growth and production.

Grow-out

The grow-out phase in aquaculture is the stage where juvenile aquatic organisms are raised to market size. This phase is crucial as it involves the longest period of the production cycle and requires significant resources and management.

Quarantine

The quarantine stage in aquaculture is a vital process to keep diseases from spreading within facilities. Key points about quarantine include:

- **Isolation**: New animals are kept separately from the main population to prevent any diseases they might carry from spreading.
- **Observation**: Animals in quarantine are closely watched for signs of disease or stress, allowing for early detection of health issues.
- **Testing and Treatment**: Health tests may be done to check for diseases. If needed, animals are treated with antibiotics or other medications to address any infections or parasites.
- **Biosecurity Measures**: Strict procedures are in place to prevent cross-contamination, such as using dedicated equipment, disinfecting thoroughly, and limiting access to quarantine areas.
- **Duration**: The quarantine period can last from a few weeks to several months, depending on the species and health risks.
- **Effluent Treatment**: Waste and water from quarantine areas are treated to remove pathogens before they are released, protecting other animals and the environment.

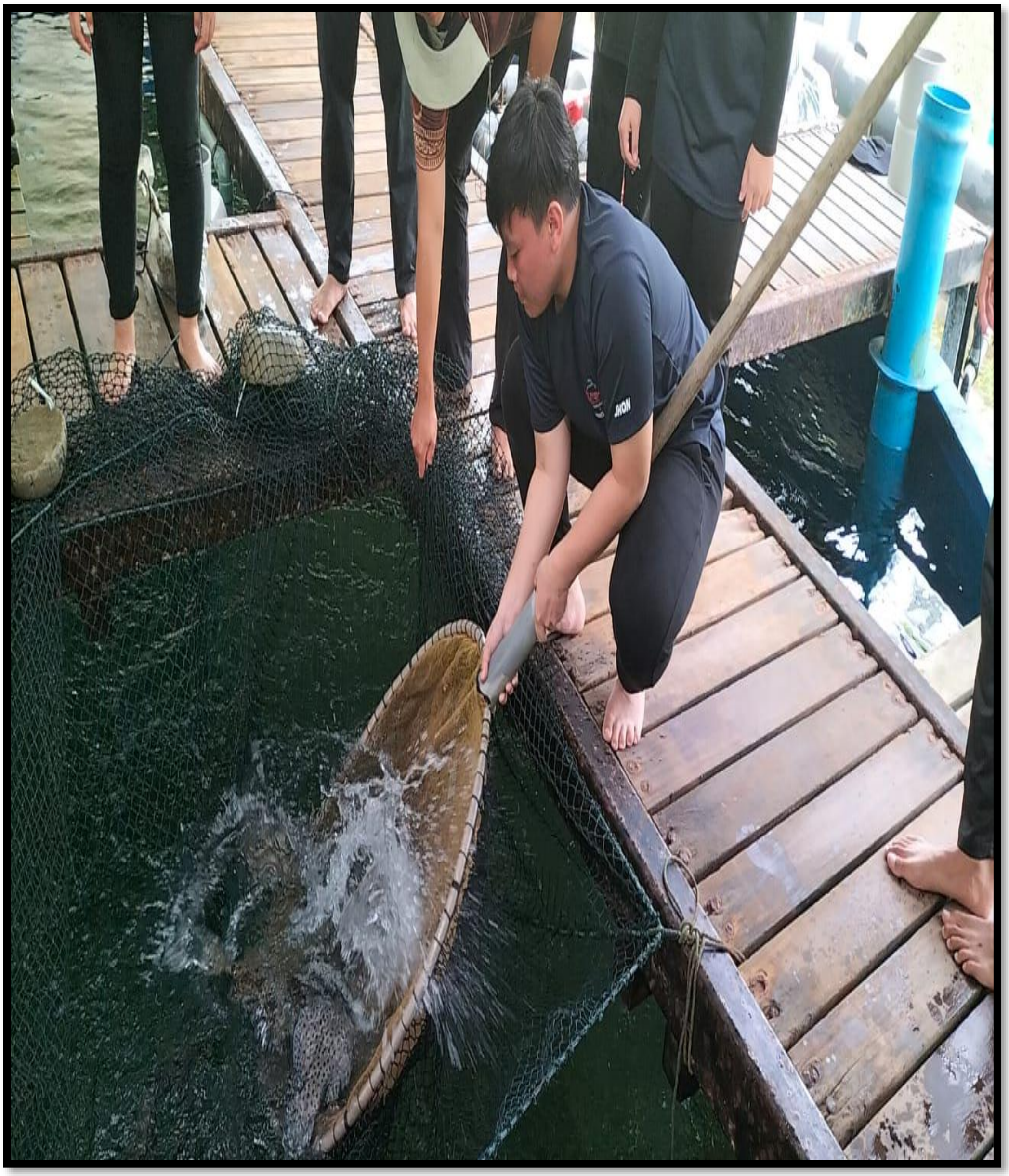
A strong quarantine process is crucial for the health and safety of aquaculture facilities.

Test your understanding by answering the quiz! Simply scan the QR code below to get started

SCAN ME!

2. The Grow-Out Phase in Aquaculture

The grow-out phase is a critical stage in aquaculture in which juvenile fish, crustaceans, or mollusks are cultivated until they reach market size. During this phase, the organisms are moved from the nursery stage into larger rearing environments, such as ponds, cages, or raceways.



Factors critical to a successful grow-out.

Culture system

This refers to the environment where aquatic organisms are raised. Types of cultures system:

Intensive

- **High Productivity:** Intensive aquaculture systems are designed to maximize production by raising aquatic organisms at high densities under controlled conditions.
- **Cultured System:** High-density farming in controlled environments like tanks, raceways and Recirculation Aquaculture System (RAS).
- **Controlled Environment:** These systems allow for precise control over environmental conditions, leading to more predictable and efficient production.
- **Formulated Feeds:** Intensive systems rely on formulated feeds to meet the nutritional needs of the organisms. Proper feed management is crucial to ensure growth and health
- **High Initial Set-up Cost:** Setting up intensive systems can be expensive due to the need for specialized equipment and infrastructure.

Semi-intensive

Semi-intensive aquaculture is a farming approach that blends features of both extensive and intensive systems. It aims to boost production by enhancing natural food sources and providing additional feed. Key aspects of semi-intensive aquaculture include:

- **Natural and Supplementary Feeding**: Natural plankton serves as the main food source, supported by pond fertilization. Supplementary feeds, such as agricultural by-products, grains, and formulated feeds, are also provided to promote growth.
- **Moderate Production**: Semi-intensive systems achieve yields higher than extensive systems but lower than intensive ones, typically producing between 3 and 10 tons per hectare.
- **Cost-Effectiveness**: Semi-intensive systems are generally more economical than intensive systems due to lower feed and infrastructure costs, offering a balance between productivity and resource use.

Extensive

Extensive aquaculture is a traditional method of farming aquatic species in natural or semi-natural water bodies with limited human intervention. Extensive aquaculture leverages the natural environment to raise aquatic species sustainably, with minimal human input.

- **Natural Environment**: This approach relies on the environment's natural productivity. Fish or shellfish are raised in open areas like ponds, lakes, rivers, or coastal waters.
- **Low Stocking Density**: Organisms are stocked at low densities, reducing the need for artificial feeding and intensive management compared to intensive systems.
- **Minimal Inputs**: External inputs such as feed, fertilizers, or chemicals are rarely used. Instead, organisms feed on natural sources available in the environment, like plankton and detritus.
- **Sustainability**: Extensive aquaculture is considered more eco-friendly, as it has a lower impact on ecosystems, helping to maintain water quality and biodiversity.
- **Lower Yields**: Although it typically produces lower yields than intensive systems, extensive aquaculture is more cost-effective and suited for small-scale or subsistence farming.

Test your understanding by answering the quiz! Simply scan the QR code below to get started.

3. Species Selection for Grow-Out

Species selection is a critical decision in aquaculture. The chosen species must be well-suited to the specific culture environment, possess desirable growth characteristics, and have a strong market demand. Considering the following factors:

Biological Factors.

- **Growth Rate:** Faster growth leads to quicker harvests.
- **Feed Efficiency:** Lower feed needs mean more efficient growth.
- **Disease Resistance:** Resilience to diseases reduces losses.
- **Environmental Tolerance:** Ability to handle changes in water conditions.
- **Reproductive Ease:** Ease of breeding and propagation methods.

Scan the QR code to watch the video on selecting broodstock for tilapia.

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Market Factors

- **Consumer Demand:** Popularity of the species in the market.
- **High Market Value:** Species with strong potential for high returns.
- **Low Production Costs:** Affordable feed, labour, and maintenance costs.
- **Profitability:** Potential for a good profit margin.
- **Value-Added Products:** Processing for added value and market appeal.
  Selecting suitable species and adopting sound practices can lead to a profitable and sustainable aquaculture venture.

Technical Factors

- **Culture Techniques:** Established practices for growing the species.
- **Infrastructure Needs:** Available resources for water, feed, and processing.
- **Labor Skills:** Availability of skilled workers for management.

Popular Aquaculture Species for Grow-Out

Freshwater Species

- Carps
- Tilapia
- Catfish

Marine Species:

- Shrimp
- Salmon
- Seabass and Seabream
- Oysters and Mussels

4. Grow-Out System Design and Setup

Aquaculture grow-out systems are environments where aquatic organisms, such as fish, shrimp, or mollusks, are raised to market size. The choice of system depends on various factors like species, water quality, and production goals.

Types of Grow-Out Systems

Pond Aquaculture

- **Earthen Ponds**
  Earthen ponds are artificial water bodies formed by creating an embankment of soil around a depression or low-lying area. They serve various purposes, including irrigation, livestock watering, aquaculture, and recreational activities such as fishing and swimming.

  Benefits of Earthen Ponds

  - **Cost-effective:** They are relatively low-cost to build and maintain.
  - **Eco-friendly:** Constructed from natural materials, they contribute to the local ecosystem.
  - **Versatile:** They can be used for irrigation, fisheries, and recreational activities.

  Construction and Maintenance Building an earthen pond involves excavating soil, shaping it into a basin, and lining it with a waterproof material to prevent water loss. Ongoing maintenance includes monitoring water levels, clearing debris, and managing aquatic vegetation to ensure the pond remains healthy and sustainable.

- **Concrete Ponds**

  Concrete ponds are robust and adaptable water features used for a range of purposes, including aquaculture, irrigation, and decorative landscaping.

Advantages of Concrete Ponds

- **Long-Lasting**: Built to endure, concrete ponds are resistant to wear and can handle extreme weather better than many other pond types.
- **Flexible Design Options:** They provide room for creative enhancements, such as stone borders, walls, and waterfall elements.
- **Minimal Upkeep:** With proper construction, concrete ponds require relatively low maintenance compared to other pond varieties.

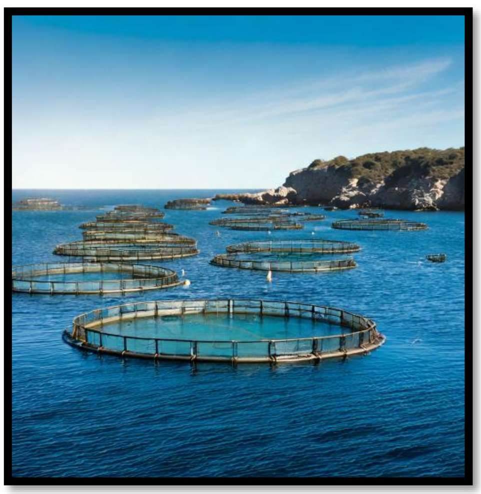
Cage Culture

Cage culture is an aquaculture technique in which fish or shellfish are raised in mesh enclosures suspended in natural water bodies, such as ponds, rivers, lakes, or oceans. This setup restricts the movement of the fish while allowing water to flow freely, supplying oxygen and removing waste.

Cages are usually constructed from materials like wire mesh, nylon, or other synthetic meshes, built to endure water currents and keep fish safe from predators. Regular upkeep includes inspecting for damage, ensuring consistent feeding, and monitoring water quality.

Types of Cage Culture

Offshore Cages: Large cages placed in open waters.
Inshore Cages: Smaller cages located in sheltered coastal areas.




Benefits of Cage Culture

- **Efficient Use of Water Resources:** Makes use of existing water bodies without requiring extensive land modifications.
- **Ease of Management:** Simplifies tasks such as feeding, monitoring, and harvesting.
- **Flexibility:** Can be implemented in various water environments, including those unsuitable for traditional pond culture.

Challenges

- **Water Quality:** Maintaining good water quality can be difficult in high-density enclosures.
- **Disease Management:** High density and confinement increase the risk of disease.
- **Predation and Vandalism:** Cages are susceptible to damage from predators and human interference.

Raceway Culture

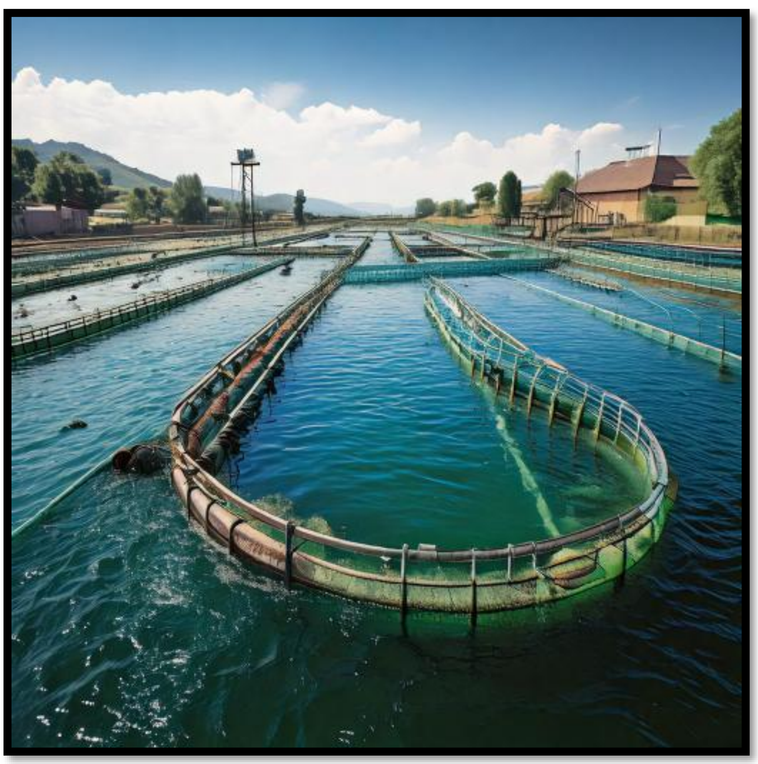
Raceway culture, also called flow-through aquaculture, involves raising fish in long, narrow channels with continuous water flow. This method suits species like trout, catfish, and tilapia that thrive in flowing water environments.

Advantages of Raceway Culture

- **High Stocking Density:** Supports higher fish densities than traditional pond systems.
- **Improved Water Quality:** Constant water flow enhances water quality by providing oxygen and removing waste.
- **Simplified Management:** Makes feeding, monitoring, and harvesting more efficient.

Construction and Operation

- **Site Selection:** Ideal sites have a reliable water source, such as a stream, spring, or well.
- **Design:** Channels or basins are typically rectangular and made of concrete, with designated inlets and outlets for water flow.
- **Water Flow:** A steady flow is crucial to meet the fish's oxygen needs and to flush out waste.
- **Stocking:** Fish are added at densities that support growth and health.



Challenges

- **Water Supply:** Requires a substantial amount of high-quality water, which can be a limiting factor.
- **Disease Control:** High stocking densities may elevate the risk of disease.
- **Environmental Impact:** Proper management of effluents is essential to prevent pollution of nearby water bodies.

Recirculating Aquaculture Systems (RAS)

Recirculating Aquaculture Systems (RAS) are innovative fish farming systems that recycle water within the system, creating a controlled and sustainable environment for raising fish and other aquatic organisms.

Benefits of RAS

- **Water Conservation:** Greatly reduces water usage compared to traditional aquaculture practices.
- **Environmental Control:** Enables precise regulation of water quality, temperature, and other environmental conditions.
- **Biosecurity:** Lowers the risk of disease by keeping the system closed and isolated from external sources.

Key Components

- **Tanks:** The main housing for fish, often made from materials like fiberglass or plastic.
- **Mechanical Filtration:** Removes solid waste from the water.
- **Biofiltration:** Converts harmful ammonia from fish waste into less toxic nitrate.
- **Oxygenation:** Maintains adequate oxygen levels for fish health.
- **Disinfection:** Uses UV light or ozone to eliminate pathogens and preserve water quality.

Challenges

- **High Initial Costs:** Requires substantial investment in infrastructure and technology.
- **Operational Complexity:** Needs skilled personnel for effective management and maintenance.
- **Energy Consumption:** Often energy-intensive due to the need for continuous water circulation and treatment.

Site Selection

Site selection is crucial for successful aquaculture operations.

Water Quality:

- Sufficient water supply with good quality.
- Low levels of pollutants and pathogens.
- Appropriate water temperature and salinity.

Topography:

- Suitable land for pond construction or cage deployment.
- Adequate water depth and flow.

Climate:

- Favorable climatic conditions for species growth.
- Minimal extreme weather events.

Infrastructure:

- Access to roads, electricity, and other essential services.
- Proximity to processing facilities and markets.

Test your understanding by answering the quiz! Simply scan the QR code below to get started

5. Nutrition and Feeding Practices

Nutritional Needs

The nutritional needs of aquatic organisms vary depending on their species, life stage, and environmental conditions. However, they generally require a balanced diet consisting of:

- Proteins: Essential for growth and tissue repair.
- Carbohydrates: A primary energy source.
- Lipids: Provide energy and essential fatty acids.
- Vitamins and Minerals: Required for various metabolic processes.

Curious about measuring moisture content in fish pellets? Just scan the QR code!

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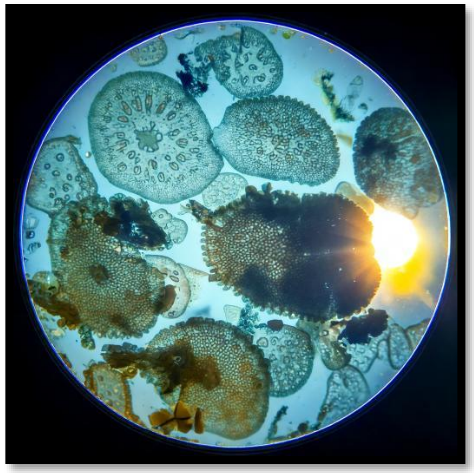
Feed Types

Live Feeds

- Small organisms like zooplankton, rotifers, and Artemia nauplii.
- Ideal for larval stages and early juvenile stages.
- High nutritional value but can be costly to produce.



Artificial Feeds

- Manufactured feeds formulated to meet specific nutritional requirements.
- Available in various forms: pellets, crumbles, and microdiets.
- Can be customized to different species and life stages.

Feed Management

- **Feed Quality:** Ensure high-quality feed with appropriate nutrient levels and palatability.
- **Feed Storage:** Store feed in a cool, dry place to prevent spoilage.
- **Feeding Frequency:** Adjust feeding frequency based on species, life stage, and water temperature.
- **Feeding Rate:** Determine the optimal feeding rate to maximize growth and minimize waste.
- **Water Quality:** Monitor water quality parameters like dissolved oxygen, pH, and temperature to optimize feed utilization.
- **Feed Conversion Ratio (FCR):** Calculate the FCR to assess feed efficiency. Formula to calculate FCR is:

$$\text{Feed Conversion Rate} = \frac{\text{Total feed (g)}}{\text{Weight gain (g)}}$$

- Waste Management: Implement strategies to minimize feed waste and water pollution.

By understanding the nutritional needs of aquatic organisms and implementing effective feeding strategies, aquaculture farmers can improve growth rates, reduce production costs, and enhance the overall sustainability of their operations.

Test your understanding by answering the quiz! Simply scan the QR code below to get started

6. Sampling, Health Management and Biosecurity

Growth sampling is a crucial technique in aquaculture to monitor the performance of cultured species. It helps assess the effectiveness of feeding regimes, water quality management, and overall health of the population.

Random Sampling

- **Purpose:** To obtain a representative sample of the population.
- **Procedure:**
    1. Use a random number generator or a systematic sampling approach to select fish from different parts of the pond or tank.
    2. Capture the selected fish using appropriate nets or other tools.
    3. Measure and record relevant parameters like length, weight, and condition factor.
    4. Release the fish back into the water or euthanize them for further analysis.

Parameters to Measure

- Length: Measured using a fish measuring board or caliper.
- Weight: Measured using a digital scale.
- Condition Factor: A measure of the overall health and well-being of the fish.
- The growth and survival rates of fish are calculated using the following formula.

Daily weight gain

$$\text{Daily weight gain (g/day)} = \frac{\text{(Final weight (g) – initial weight(g)}}{\text{Day}}$$

and survival rate

$$\text{Survival Rate (\%)} = \frac{\text{Number of animals survived}}{\text{Total number of number animal at the beginning}} \text{X100}$$

Health Monitoring

Regular health monitoring is crucial to detect and prevent diseases. Key monitoring practices include:

- **Visual Inspections:**
  - Observing fish behaviour, appearance, and appetite.
  - Checking for signs of disease, such as lesions, abnormal swimming, or loss of appetite.
- **Water Quality Monitoring:**
  - Measuring parameters like temperature, pH, dissolved oxygen, and salinity.
  - Identifying potential stressors that can compromise fish health.
- **Laboratory Testing:**
  - Conducting water and tissue samples for pathogen detection.
    - Using techniques like polymerase chain reaction (PCR) and histopathology.

Common Diseases

Aquaculture operations are susceptible to various diseases that can significantly impact production. Some of the most common diseases include:

- **Bacterial Diseases:**
  - Vibriosis
  - *Aeromonas* infections
  - Furunculosis
- **Viral Diseases:**
  - Viral nervous necrosis (VNN)
  - Infectious hematopoietic necrosis (IHN)
  - White spot syndrome virus (WSSV)
- **Parasitic Diseases:**
  - *Ichthyophthirius multifiliis* (Ich)
  - *Costia necatrix*
  - *Dactylogyrus* spp.

Biosecurity Measures

Biosecurity is essential to prevent the introduction and spread of diseases. Important biosecurity measures include:

- **Quarantine:** Isolating newly introduced organisms to prevent disease transmission.
- **Disinfection:** Cleaning and disinfecting equipment, vehicles, and personnel to eliminate pathogens.
- **Pest Control:** Controlling pests like insects and rodents that can carry diseases.

- **Water Quality Management:** Maintaining optimal water quality to minimize stress and disease susceptibility.

- **Vaccination:** Administering vaccines to protect fish against specific diseases.
- **All-In, All-Out Production:** Emptying and cleaning ponds or tanks between production cycles to reduce disease risk.
- **Emergency Response Plans:** Developing plans to respond to disease outbreaks quickly and effectively.

By implementing effective health monitoring and biosecurity measures, aquaculture farmers can minimize disease outbreaks and ensure the health and productivity of their cultured organisms. Scan the QR code to be directed to a video on the sampling procedure.

7. Harvesting and Post-Harvest Management

Harvesting

The optimal time for harvesting fish depends on various factors:

- **Market Demand:** Harvesting can be timed to meet specific market demands, such as holidays or seasonal preferences.
- **Fish Size:** Fish are typically harvested when they reach a marketable size, which varies depending on the species and market requirements.
- **Fish Condition:** Healthy, well-nourished fish with good flesh quality are ideal for harvesting.

Harvest Methods

Several methods are used to harvest fish, including:

- **Seining:** A large net is drawn through the water to capture fish.
- **Draining Ponds:** Water is drained from ponds to concentrate fish in a small area for easy capture.
- **Gillnetting:** Gillnets are used to capture fish that swim into the net and get entangled in the gills.
- **Trap Nets:** Fish are lured into enclosed traps with bait.
- **Hand-Catching:** Fish are caught individually by hand or with specialized tools.

Post-Harvest Handling

Proper post-harvest handling is crucial to maintain the quality of fish:

- **Immediate Killing:** Fish should be killed humanely to minimize stress and improve meat quality.
- **Bleeding:** Bleeding removes blood from the fish, which can affect the flavor and appearance of the meat.
- **Icing:** Fish should be immediately iced to reduce spoilage and maintain freshness.

- **Cleaning:** Fish can be scaled, gutted, and filleted as needed.
- **Packing:** Fish should be packed in appropriate containers to prevent damage and contamination.

Storage

Proper storage is essential to preserve the quality of harvested fish:

- **Chilled Storage:** Fish can be stored in refrigerated conditions at temperatures between 0°C and 4°C.
- **Frozen Storage:** Fish can be frozen at temperatures below -18°C to extend shelf life.
- **Processing:** Fish can be processed into various products, such as fillets, smoked fish, or fishmeal.

By following these guidelines for harvest timing, methods, post-harvest handling, and storage, aquaculture producers can ensure the quality and value of their products.

Test your understanding by answering the quiz! Simply scan the QR code below to get started

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