

SECTION

2

FISH FARMING, PROCESSING AND CONSERVATION



EXPLORING BIOLOGY IN SOCIETY

Biology and Entrepreneurship

INTRODUCTION

Biology and entrepreneurship are two distinct areas brought together to enable us to combine our biological knowledge with skills and knowledge in entrepreneurship. This is to ensure that we are self-motivated, proactive and action-oriented to pursue an innovative product and service. In this section you will learn about Biology and entrepreneurship (bio-entrepreneurship) and the huge potential it offers in the development of new techniques in feed production, care for fingerlings and the creation of the right aquatic environment to increase fish production. Bio-entrepreneurship is frequently credited as a major driver of economic growth, inspiring transformation, the creation of bigger and new markets as well as driving innovation and wealth creation.

At the end of this section, you are expected to demonstrate knowledge of the application of biological concepts and their application to improve fish production. Additionally, you should be able to identify the biological concepts that are used in the nursery and grow-out stages to improve fish production. The interesting thing about this section is that knowledge gained in is related to other subjects such as Business, Home Economics and Economics. Ultimately, you should be able to explain the use of biological principles in the harvesting and processing of fish to improve production.

After this section, you should be able to:

- Identify the biological practices and tools that are used in the nursery and grow-out stages to improve fish production
- Explain the use of biological principles in the harvesting and processing of fish to improve production.
- Identify the biological practices and principles that are used in the management and sustainable exploitation of wild stocks to improve fish production.

Key Ideas

- Biological practices employed at the nursery stage of fish farming include acquisition of fingerlings, routine checking of water quality and level, regular supply of essential feed and other inputs such as aeration and drugs, weaning of fry from natural feed to formulated feed and Recordkeeping on all practices.
- Biological practices employed at the grow-out stage include stocking, feeding, water quality management, disease prevention and management, monitoring and record keeping and good harvesting and processing practices.
- Nets, graders, fish counters, water quality test kits, water pumps, pond liners, aeration machines, filtration systems, algae scrubbers and weighing scales are some of the tools and equipment used in nursery and grow-out stages to improve fish production.
- The use of hooks and lines, traps, and nets are examples of harvesting methods employed in fish farming. Deep-frying, preserving in ice (freezing) and processing such as sun-drying, salting or smoking are some of the ways fish can be preserved and processed.
- Stock assessment, fishing regulation and habitat protection are some of the biological practices used to manage the sustainable exploitation of wild stock to improve fish production

BIOLOGICAL PRACTICES AND TOOLS USED IN FISH FARMING

Biological Practices at the Nursery Stage

Some biological practices employed in the nursery stage in fish farming include:

1. **Selective breeding:** acquisition of fingerlings with best quality and health. Fish farmers selectively choose fish with desirable traits such as growth rate, disease resistance, and size to produce offspring with improved genetic characteristics.

NOTE: Hatcheries are facilities provide controlled conditions for fish eggs to hatch and develop into fry (young fish). Proper water quality, temperature, and nutrition are essential.

2. **Feeding protocols:** Regular supply of essential feed and other inputs such as aeration and drugs when necessary. Specialised diets are formulated for fry, considering their nutritional needs to wean them from natural feed. High-quality feeds with appropriate protein levels are crucial.
3. **Water management:** Routine checking of water quality and level to maintain an optimal environment for growth. Maintaining optimal water quality such as temperature, oxygen levels, and pH ensures healthy fry growth.
4. **Biosecurity measures:** Preventing disease outbreaks is critical. Quarantine procedures, disinfection, and monitoring health are part of biosecurity practices.
5. **Records:** Record keeping on all practices must be done regularly.

Biological Practices at the Grow-Out Stage

Some biological practices employed in the out-grow stage include the following:

1. **Stocking:** there are several types depending on the type of fish being farmed. These include:
 - a) **Pond culture:** Common for species like tilapia and catfish. Ponds are stocked with fingerlings, and water quality, feeding, and disease management are monitored.
 - b) **Cage culture:** Fish are raised in submerged cages or net pens in natural water bodies (lakes, rivers, or coastal areas). Regular feeding and monitoring are essential.

- c) **Raceways and Tanks:** Controlled environments with recirculating water systems. Fish are raised in concrete raceways or tanks. Water quality is essential and is closely monitored.

NOTE: Stocking density management is important because overcrowding can lead to stress, disease, and poor growth. Optimal stocking densities vary by species.

2. **Feeding strategies:** Proper feeding schedules, balanced diets, and efficient feed conversion ratios are crucial for growth.
3. **Water quality management:** This includes water aeration and filtration where oxygen supply and waste removal are critical. Aeration systems and filters maintain water quality.
4. **Disease prevention and management:** As part of health monitoring, regular health checks, disease prevention, and treatment protocols are followed.
5. **Monitoring and record keeping:** Record keeping of all the activities above is needed, and this is done hand-in hand with regular monitoring to ensure optimal conditions.
6. **Good harvesting and processing techniques:** Harvesting methods (seines, nets, or draining ponds) are chosen based on the fish species and facility type.

NOTE: Remember that specific practices and tools may vary depending on the fish species, local conditions, and available resources. Always consult with aquaculture experts or fisheries professionals for site-specific recommendations.

In summary, the biological processes employed at the grow-out stage include:

- a) Stocking
- b) Feeding
- c) Water quality management
- d) Disease prevention and management
- e) Monitoring and record keeping
- f) Good harvesting and processing practices

Tools and Equipment used in Fish Farming and their Functions

The functions of tools and equipment used in nursery and grow-out stages to improve fish production include:

1. **Nets:** Used for harvesting and transferring fish between ponds. They are also used to remove debris from ponds and make hapas or cages.
2. **Graders:** They are used to sort fish by their sizes in order to manage stock densities and optimise growth.
3. **Fish counters:** They are used to count fish during harvesting and management practices.
4. **Water quality test kits:** are used for testing water quality such as pH, dissolved oxygen, ammonia, nitrite and nitrate levels.
5. **Water pump:** for pumping water in and out of the pond.
6. **Pond liners:** used to prevent water seepage and to facilitate proper water management in the fishponds. Also used to prevent contamination by ground water.
7. **Aeration machine:** used to increase oxygen levels in the water.
8. **Filtration systems:** used to remove solid waste and organic matter from the fishpond thereby increasing water quality.
9. **Algae scrubbers:** used to scrub/remove excess algae from pond in order to prevent algal blooms and maintain water quality for healthy fish.
10. **Weighing Scale:** used to weigh fish accurately and to monitor the growth rate.



Figure 2.1: A water pumping machine



Figure 2.2: A fishing net with harvested fish



Figure 2.3: A algae scrubber



Figure 2.4: A fish counter

Activity 2.1

1. Name at least three tools required in nursery and grow-out stages to improve fish production by Searching from textbooks and other relevant resources
2. State one function each of the tools identified in (1) above.
3. Visit a nearby fish farming centre to:
 - a) Identify and observe the tools (identified in (1) above) in use
 - b) Observe the biological practices employed in the nursery and grow-out stages in fish farming and note the contribution of each of the practices in fish production.
 - c) Note your findings and share them with your colleagues.

HARVESTING, PROCESSING AND MARKETING FISH

When to Harvest

Fish are normally harvested for **domestic use, sale, or transfer**. Deciding the right time to harvest fish is greatly influenced by various factors that guarantee the quality and economic viability of the fish product.

Key considerations needed to decide on harvesting time

1. **Fish Size and Maturity:** When the fish have attained the right size to give maximum profit in the market. The harvested fish must meet market size requirements and consumer preferences for specific fish species.
2. **Market Demand:** When the prevailing market opportunities offer highest profit (for instance during festivities and national occasions such as

Christmas, Easter and festivals). Harvesting should align with the highest market demand to ensure the best prices and reduce the need for storage.

NOTE: Other factors may include:

Fish Health: The health of the fish at the time of harvest is crucial to the quality of the final product. Healthy fish with no disease or stress will yield a better-quality product.

Resource Availability: Resources such as labour and equipment can influence the timing of the harvest.

Understanding and managing these factors can lead to more successful and sustainable fish farming and optimise the profitability of the harvest.

Equipment Used in Harvesting Fish in a Pond/ Aquaculture Farm

The methods and equipment for harvesting fish in their holding facilities depend on the size of the pond, the type of harvest and the purpose of the harvest. Some of these are the hook and line, traps, nets and aerators (see Figures 2.5-2.7) among others.



Figure 2.5: Using hook and line for fishing



Figure 2.6: A bamboo trap for fishing



Figure 2.7: Using the fishing net for fishing

Harvesting Tools

Some harvesting tools and their techniques are mentioned below.

1. **Seines:** These are large nets used to concentrate and capture fish during the final drainage of the pond. In small ponds, seines can be pulled by hand, but larger ponds require vehicles to drag the net.
2. **Fish Graders:** Fish graders help group and sort fish based on their sizes and weights.
3. **Net and Seine:** Nets are essential for capturing fish during harvest.
4. **Bamboo Screen Trap:** A trap made of bamboo or other materials can be used to catch fish efficiently
5. **Aerators:** These devices oxygenate the water, especially during transportation or handling.

Methods of Processing and Preserving Fish

Whenever possible, it is best to present fish for sale in their freshest form. Live fish are in the freshest state.

Fish can be processed for immediate consumption or for later consumption.

Boiling/steaming, frying, and roasting/grilling are some ways of processing fish for consumption.

In situations where this is not possible, several methods can be used to preserve the fish. Preserving fish will help for the fish to be stored for a longer period for later/long term consumption.

Some major fish preservation methods are discussed below.

1. **Salting:** Salt is a common preservative agent. Wet salting involves keeping fish in brine (a mixture of water and salt) for an extended period. The brine (concentrated salt solution) dehydrates fish and prevents micro-organisms that may be present to cause spoilage from growing. Dry salting is another technique where salt is directly applied to the fish and dried.
2. **Dehydration:** Removing water content from fish helps prevent spoilage. This can be done by sun-drying or using industrial dehydrators.
3. **Lowering temperature:** Cold storage or refrigeration slows down bacterial growth. (e.g. freezing, putting ice on them)
4. **Increasing temperature:** Cooking in various forms such as boiling/steaming, frying or smoking fish can preserve it.

5. **Wet Salting:** In wet salting, fish are immersed in brine. The equipment needed includes watertight containers (e.g., tins, drums, and barrels). To make brine, mix four parts of clean water (sea or freshwater) with one part of salt. Wet salting is cost-effective and requires less salt compared to dry salting.
6. **Canning:** Fish may also be canned for later consumption (e.g. canned tuna, sardines, etc)
7. **Processing (sun-dried, salted or smoked);** and at higher industrial levels, may be filleted (remove bones) and chilled for supermarkets or export.

Remember that proper handling and preservation techniques are crucial for maintaining fish quality and safety. Whether you are a fisherman or a consumer, understanding these principles ensures that fish remains fresh and delicious beyond the shoreline.

Activity 2.2

1. Visit a nearby river side or lake or sea shore where people fish.
2. Carefully observe the activities that go on there.
3. List at least two methods of harvesting fish in their natural habitat.
4. Describe at least two techniques used in harvesting fish in their holding facilities.
5. Explain at least three ways of processing and preserving fish, highlighting the biological principles involved in each case.
6. Think critically about how to increase the market value of fish and share your ideas with your friends.

NB: For learners in areas without natural water bodies, search and watch videos on the activity above on the internet. You may input “*Fishing in Ghana*”/ “*A fishing community in Ghana*” in the search bar while surfing the internet.

THE VARIOUS WAYS OF FISH STOCK MANAGEMENT AND CONSERVATION

Sustainable fish farming requires effective fish stock management and conservation. It involves monitoring and regulating fish populations to ensure their long-term viability. This includes techniques such as setting catch limits, establishing protected areas, and employing aquaculture practices that minimise environmental impact. We can preserve marine ecosystems, protect biodiversity, and ensure a steady supply of seafood for future generations by managing fish stocks correctly.

Management practices of fish populations in their habitats

As mentioned earlier, several practices need to be used to maintain and sustain a fish farm. As part of these practices, habitat restoration to improve spawning grounds and feeding areas, stocking to replenish depleted populations, and monitoring to track fish health and abundance are considered management practices we must use in different fish habitats to maintain a healthy population. By effectively managing fish populations, we can ensure their long-term survival and maintain the ecological balance of their habitats. There are two main fish habitats: *Natural habitat* and *Artificial habitat*.

Natural habitats include the following:

1. Freshwater bodies such as rivers, lakes, ponds and springs.
2. Brackish-water bodies such as lagoons and restricted estuaries
3. Marine habitats such as mudflats, mangroves, coral reefs, oyster beds, and kelp forests.

Some management practices of fish populations in their natural habitats include the following:

- a) Keeping accurate and current data on the fish populations.
- b) Regulating commercial fishing activities to avoid overfishing.
- c) Enforcing enacted laws to protect fish populations.
- d) Desilting and removal of weeds must be done periodically to ensure easy movement of fish and adequate penetration of sunlight to the bottom of the water body. This will ensure increased primary productivity and high dissolved oxygen concentrations, necessary for fish growth and health.

- e) Regular control of harvesting should be carried out to avoid overpopulation, cannibalism and disease outbreaks.
- f) Practise aquaculture to reduce over-dependency on wild fish stock.

Artificial habitats include the following:

1. Aquaculture facilities where fish are raised for commercial purposes
2. Re-circulating aquaculture system (RAS). This is where water is continuously filtered and reused to raise fish in a controlled environment
3. Artificial reefs: These are made from materials such as concrete and steel and are used underwater to provide a suitable habitat for fish and other marine organisms.

Activity 2.3

1. Search from textbooks and name at least two water bodies where fish populations can be found.
2. Watch a video on fish farming and describe four management practices of fish populations in their natural habitats.
3. Embark on a project of rearing fingerlings in an aquarium. Record the results obtained from the project of rearing fingerlings in your aquarium tank and analyse and discuss the findings with your friends.

Hint:

Step-by-Step guide to start an Aquarium

- a) Research and planning (consider size of aquarium determines the quantity of fingerlings to be stocked).
- b) Set up the Aquarium (use any container that can comfortably hold the fish)
- c) Cycle the Aquarium (use an aerator such as a rubber tube)
- d) Introduce Fingerlings
- e) Ongoing Maintenance

REVIEW QUESTIONS

Review Question 2.1

1. As a fish farmer what are some of the tools you would require in nursery and grow-out stages to improve fish production.
2. Describe the function of at least two tools for harvesting fish.
3. As a resource person from the Ministry of Agriculture, you have been invited to speak on the topic, “The use of biological principles in the harvesting and processing of fish”. Elaborate on at least four basic principles used in the final processing of fish.
4. A learner is provided with fingerlings and mature fish to cater for. Explain why these two should be kept in different aquaria/ponds.
5. Describe the essential features of a healthy aquarium, describing three bad practices that would result in poor fish health.
6. On a trip to two different fishing centers, A and B, you observed that the fingerlings and mature fish produced at Centre A grew larger and healthier than those from Centre B. Describe the factors that could lead to these two different scenarios.
7. In harvesting fish to be processed and exported to another country, the following practices were carried out by the harvesters:
 - a) Increasing fish feed two weeks before harvesting
 - b) Starving the fish on the day of harvesting
 - c) Draining the pond
 - d) Removing scales
 - e) Removing the intestines
 - f) Freezing the fish.

Suggest how and/or why each of these processes was carried out.

8. Describe some practices that should be promoted or discouraged in sustainable fish farming.

9. Explain the significance of biological practices and principles in the sustainable management and conservation of fish.
10. Alidu and Dede carried out practices that included the removal of natural predators of fish and preventing algal blooms, to increase the productivity of their school's fishpond. Explain the relevance of these practices in aquaculture and give the biological terminology of these processes.

ANSWERS TO REVIEW QUESTIONS

Review Questions 2.1

1.

- **Nets:** Used for harvesting and transferring fish between ponds. They are also used for removing debris from ponds and used in making hapas or cages.
- **Graders:** They are used to sort fish by their sizes in order to manage stock densities and optimise growth.
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- **Weighing Scale:** used to weigh fish accurately, and to monitor growth rate

2.

- **Net and Seine:** Nets are essential for capturing fish during harvest.
- **Bamboo Screen Trap:** A trap made of bamboo or other materials used to catch fish efficiently

3.

- **Salting:** Salt is a common preservative agent. Wet salting involves keeping fish in brine (a mixture of water and salt) for an extended period. The brine (concentrated salt solution) dehydrates fish and micro-organisms that may be present to cause spoilage. Dry salting is another technique where salt is directly applied to the fish.
- **Dehydration:** Removing water content from fish helps prevent spoilage.
- **Lowering temperature:** Cold storage or refrigeration slows down bacterial growth.
- **Increasing temperature:** Cooking or smoking fish can preserve it.

4. Putting them in different aquaria will help in:

- reducing fish losses through cannibalism;
- improving supplementary feeding efficiency through adequate food ration;
- increasing the accuracy of stock estimates for monitoring
- reducing the proportion of small fish at harvest of fattening ponds;

5.

- **Organic Aquaculture:** Organic fish farming is an ecosystem-based management system that aims to address environmental constraints faced by intensive aquaculture. It combines best environmental practices, maintains biodiversity, conserves natural resources, and ensures high fish welfare. However, transitioning from conventional aquaculture to organic aquaculture is complex and expensive.
- **Biological Filtration:** Proper biological filtration helps maintain water quality by removing excess nutrients and waste products. This is essential for healthy fish growth.
- **Aeration and Water Circulation:** Adequate oxygen levels are crucial for fish health. Aeration systems ensure sufficient dissolved oxygen, while water circulation prevents stagnation and promotes uniform distribution of nutrients.
- **Temperature Control:** Different fish species have specific temperature requirements. Maintaining optimal water temperatures enhances growth and reproduction.

6. Farm A observed the good fish health practices and Farm B had poor fish health practices
7. *Hint:* refer to content.
8. *Hint:* refer to content.
9. *Hint:* refer to content.
10. *Hint:* refer to content.

EXTENDED READING

- Taylor, C.J., Green, N.P.O & Stout, G.W. (2010). Biological Science. Cambridge University Press

REFERENCES

1. Jegede, O.J. (1982). Tropical biology (A Practical Course).Macmillan publishers.
2. Sadick, A. A.; Nyavor, C.B. and Sedoh, S. (2016). Biology for Senior High Schools (GAST). WINMAT Publishers Ltd.
3. Ofori Yeboah, S; Owusu, E; Adjibolosoo, S.V.K; Agamloh, R.B. & Meteku, B.K. (2010). Excellent Biology. Excellent Publishing and Printing.

ACKNOWLEDGEMENTS



Ghana Education Service (GES)



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