Aquaculture

Junior Farmer Field and Life School – Facilitator's guide

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Module: Aquaculture

Junior Farmer Field and Life School – Facilitator's guide

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Module: Aquaculture

INTRODUCTION

Sustainable capture fisheries and aquaculture play a critical role in food and nutrition security and in providing for the livelihoods of millions of people. Aquaculture accounts for a growing share of the global aquatic food production. The term aquaculture covers all forms of farming of aquatic animals and plants in freshwater, brackish water and saltwater. Aquaculture has the same objective as agriculture – the controlled production of food to improve the supply for our consumption. In the case of aquaculture, the products are aquatic animals and plants that grow in the water.

Even in small quantities, fish can have a positive effect on the overall health and nutrition of humans. Fish is an important source of nutrients such as vitamins A, B and D, calcium, iron and iodine. Fish also provides vital amino acids that are often lacking in staple foods such as rice or cassava. It is therefore vital to the food security of many of the world's poor, especially in coastal areas and in small island developing States. Through aquaculture, we can produce protein and nutrient-rich food throughout the year.

Low-income farmers who invest in fish farming will be able to generate additional income and food for their family and potentially for the market. To be successful, an aquaculture operation requires much careful planning. The available natural resources, such as water and land, but also the local temperature and other factors influence the choice of the species to be farmed and the production system to be used. Climate does not limit the scale of aquaculture but it can determine the species that can be grown. Aquaculture can be done in a pond, a river, a lake, an estuary or in the sea. The availability of high-quality water is usually the most crucial resource when making decisions about where, what and how much fish to farm. The most common small-scale aquaculture systems are small-pond fish farming and fish farming in lakes, rivers, dams and reservoirs.

Climate change may have various negative impacts on aquaculture, including sea-level and temperature rise, rainfall fluctuations, and natural hazards such as floods and drought (FAO, 2009). Sea level rise, for example, may threaten inland freshwater aquaculture by causing saltwater and brackish water to move further upstream and into rivers. Existing waterbodies may also shrink or their water levels may decrease owing to erosion, drought and increasing temperatures. Increasing temperatures may also lead to lower levels of dissolved oxygen in the water, which would increase mortality of fish.

Through various exercises, such as small group discussions, hands-on tasks and demonstrations, Junior Farmer Field and Life School (JFFLS) participants will learn about the various types of aquaculture that can be used to provide new business opportunities for farmers and fishers. They will also learn about the importance of preliminary planning and management of daily activities and procedures to ensure a successful aquaculture business.

At the end of the module participants will:

- be aware of the various types of aquaculture;
- value aquaculture as a means of livelihood diversification and as a business opportunity;
- understand the importance of careful planning.

The purpose of the module is to provide guidance, making available different exercises that facilitators can use as applicable, and adapt as necessary, to the specific socio-economic and cultural contexts and needs of each target group and country in which the module will be used. This JFFLS module is complementary to other JFFLS modules, in particular *Capture fisheries* and *Post-harvest issues in fisheries and aquaculture*, and can be combined with them to enhance economic opportunities.

↘ OPENING ENERGIZER

OBJECTIVE:
Break the ice by getting to know one another and by introducing the topic of aquaculture.

TIME:
30 minutes (15 minutes per exercise).

MATERIALS:
Stopwatch or clock; whistle or other noisemaker.

STEPS (EXERCISE 1):

1. Explain participants that one after the other they should say their name and a food item that begins with the same letter as their name, such as "My name is Elsa and I like to eat eggplant" (alternatively a place or a city can be said, for example, "My name is Brittany, I am from Bangladesh").

2. To make the game more challenging, ask participants to remember all the names and foods/places of all those who speak before them: "The last person will have to try to repeat all the participants' names and foods/places." For young children, it is easier to ask them to only repeat the name of the child who precedes them.

STEPS (EXERCISE 2):

1. Ask students to form pairs of two (ideally a male and female participant), to introduce themselves to their partner and to chat for about 5 minutes about what they know about aquaculture, for example by answering the following questions:

   - What do you think aquaculture means?
   - Do you know somebody who farms fish?
   - How long does it take to grow a fish?
   - Does your family or neighbour or a relative grow fish?

2. When 5 minutes are up, blow the whistle and gather as one big group.

3. Ask each of the participants to introduce his/her partner to the whole group and to briefly report on what the partner knows about aquaculture.

Exercises

FACTORS FOR SUCCESS

Globally, an enormous variety of waterbodies, including rivers, irrigation canals, flood plains, lakes and ponds, can be used for fish farming. To be successful, it is very important to focus aquaculture production on species that are easy to maintain and that can live with available resources (e.g. natural habitat, feed, including household waste). Some fish and shellfish are relatively easy to breed and grow and require no or little technology or intervention. Normally, it is easier to farm fish that eat plants rather than fish that eat smaller fish species and can have complex life cycles that are difficult to recreate in our aquaculture systems. A little homework ahead of time to understand which species can be farmed with locally available resources will save money, time and frustration.

exercise 1

MAKE YOUR OWN MINI POND IN A BOTTLE

OBJECTIVE:

Recreate and observe the fish life cycle to understand the complexities of growing fish on a small scale and the importance of having a balanced ecosystem.

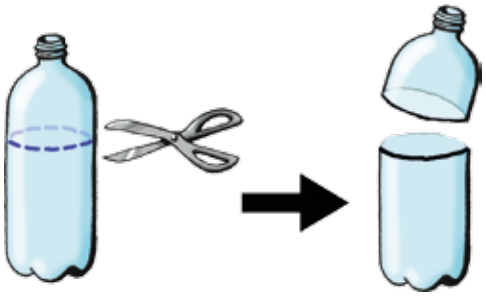
TIME:

About 2 hours and additional observations for 4 weeks.

MATERIALS:

- 2 two-litre transparent bottles, clean and without label (one bottle for each group of 5–6 people).
- Thermometer.
- Pipette or straw or piece of tubing.
- Tape.
- Pond water.
- Sand.
- Two species of juvenile fish from a local pond (for example, cichlids and catfish; three for each bottle).
- Pond cultures of algae (if available).
- Water plants (for example, African elodea or water hyacinth).
- Aquatic snails and other invertebrates (for example, pond snails , apple snails or pulmonate snails).
- Scissors.
- Writing support.
- Pens.

STEPS:



1. Divide the group into small gender-balanced groups of 5-6 people, depending on class size.

2. Have each group cut the top curved portion of the bottle off and keep it.

3. Ask participants to put about 7.5 cm of sand into the bottom of the bottle and carefully add the pond water until the bottle is about half-full.

4. Invite participants to plant the water plants. A good rule of thumb is to plant two plants for each fish.

5. Participants should slowly add more pond water, being careful not to disturb the sand or plants, and fill the bottle to within 2.5 cm of the top.

6. Ask participants to add the snails and any other invertebrates (maximum of 5 invertebrates per bottle).

7. Place the bottles in a safe and dry place and leave them undisturbed overnight.

8. The following day, participants should add two or three small fish to each bottle. After the fish are in the water, the top with the bottle cap can be put back on the bottle and sealed with tape.

9. The bottle ecosystem should be placed near a light source, but be careful that the temperature does not go above 25°C. Algae growth should be encouraged. Feed the fish only if you feel they cannot survive.

10. Once a week each group should add a few drops of water with the pipette, straw or piece of tubing.

11. Invite each group to observe the ecosystem in their bottles over the following weeks and to register their observations (e.g. temperature, water level, condensation, general health of animals). It would be best if a different group member could take the bottle home for a week and make daily observations. The bottle can then be passed to another group member the following week, etc.

12. After a few weeks, discuss the following:
    - Is one ecosystem developing better than the others?
    - Is one species in the bottles more aggressive?
    - If too many fish are in the bottle, what happens?
    - If the fish are dying, what should be done to correct it?
    - If too many decomposers are in the system, the water may become cloudy. What should be done?

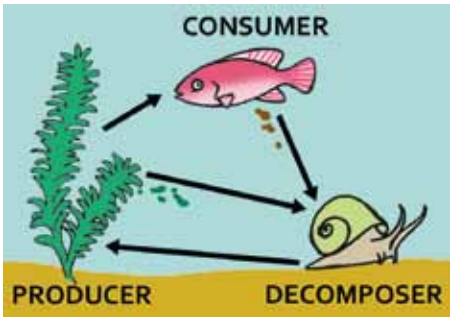
13. Close the discussion with the entire group by talking about the importance of a balanced ecosystem for aquaculture.

facilitators' notes

All ecosystems, whether on land or water-based, require three basic components: producers, consumers and decomposers. Producers, consumers, and decomposers must all remain in balance for the ecosystem to thrive. Too much of one of these will result in disaster. For example, if there are too many fish and not enough plants, the fish will starve or will suffocate from lack of oxygen. Therefore, it is important not to overcrowd the environment.

The producers are the plants, so named because they produce their own food and are the base of the food web. They also produce oxygen, essential for the consumers. After a few days of observing, it may be necessary to add more plants to provide food and oxygen if some of the fish begin to die.

Consumers are the animals and living organisms that feed off the producers, so named because they consume things in the environment. Consumers also contribute carbon dioxide and waste to the ecosystem.



Decomposers are the garbage cleaners of the ecosystem because they recycle the waste products. Decomposers include bacteria and worms. In a water system, snails and ghost shrimp are decomposers.

exercise 2

RESOURCE INVENTORY

OBJECTIVE:

Have participants think and discuss about their locally available resources.

TIME:

About 1 hour.

MATERIALS:

Flip charts, markers.

STEPS:

1. Ask participants to identify some of the natural resources they come across in the environment during their day-to-day activities and record all the responses on a flip chart.

2. Divide the participants into gender-balanced subgroups of 5–6 persons.

3. Ask each of the groups to make a map of water sources in the area. The map should have enough detail to show rivers and streams that may flow into it, trees, fields etc. Each group should also map other local resources that support fish farming (e.g. feed sources, fish markets, fish processing sites, transport facilities, financial services, extension services).

4. When the groups have finished, they should nominate one group member to present their map.

5. Participants should compare the different communities presented and discuss what the differences are and which resources for aquaculture are missing in the different communities.

6. Discuss with participants:

   - Is there any problem with these resources?
   - Are there any differences in quality among these resources?
   - What happens when the community does not take good care of these resources?

7. To conclude, summarize the discussion highlighting the constraints and advantages for aquaculture production in the area.

exercise 3

PLANNING OUR FISH PRODUCTION

OBJECTIVE:

Identify the type of aquaculture that will work best for the community and understand which factors are important for fish farming.

TIME:

2 hours.

MATERIALS:

Flip charts, markers.

STEPS:

1. Take the group to the nearest body of water.

2. Divide the participants into gender-balanced sub-groups of 5-6 persons.

3. Ask them to develop a step-by-step plan of what they have to do in order to farm fish, thinking about species selection, site selection, system preparation, feed selection, fertilization, harvesting methods, post-harvest storage etc.

4. Bring the participants back together and have them present their plans to the full group.

5. Conclude the session by asking the following questions:

   - Is it a good idea to make a plan? Why or why not?
   - What basic steps do we need to follow to make a plan?
   - Was it easy or difficult to make a plan in a group?
   - Did everyone participate in the discussion? Why or why not?

6. If available a local aquaculture producer can also be brought in to allow for a similar exercise related to the production of products.

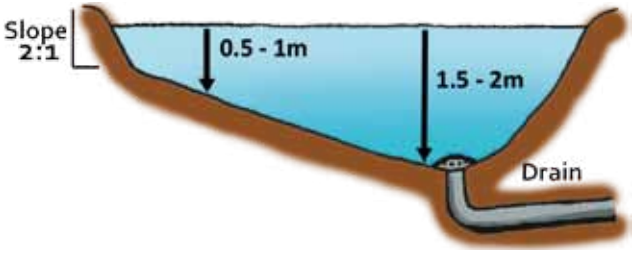
facilitators' notes

The two most common small-scale aquaculture systems are local pond fish farming and fish farming in open waters such as lakes, rivers, dams and reservoirs. Small-scale fish farming is mainly a secondary occupation for farmers, and ponds tend to be small (less than 1 000 m2) and without water drainage facilities.

POND CULTURE

Site selection: Site location depend on a number of factors including: the fish species to be farmed; soil quality, which affects water quality and productivity; an adequate supply of unpolluted water; land ownership; access to markets; fish feed and other inputs available to the farmer; and the capacity to retain water for more than 1 m for at least 6 months of the year. If possible, the pond should be located to take advantage of the effect of the wind on the surface of the pond to mix the water; although locations that are too windy can cause erosion. If the site is very windy, the long side of the pond should be at right angles to the prevailing wind. Hedges and trees can be used to protect the pond.

Pond size: Ideally, the fishpond should be 0.5–1 m at the shallow end and sloping to 1.5–2 m at the drain end. Drain valves or tilt-over standpipes should be incorporated into the design. It should be possible to drain the pond within three days. The edges of the pond should have a slope of 2:1 or 3:1 on all sides.



Pond facility management: There are many potential problems to be considered, including, for example, broken pond banks. To prevent this, pond walls should be checked on a regular basis. Grazing animals can damage the pond banks and should be kept away. An irregular water supply can also be an issue, providing too much water in the wet season and too little in the dry season. Predators are another threat to production, and the pond needs to be checked regularly for signs of snake and rat holes. In the pond, silting or a buildup of organic matter can be prevented by regular checks of the bottom of the pond and scooping out of silt when required. Mud on the bottom of the ponds can be agitated with a rope to release harmful gases. To avoid leakage, the pond inlet and outlet need to be checked on a regular basis. The fish itself has to be checked for diseases on a regular basis.

OPEN WATER FISH FARMING

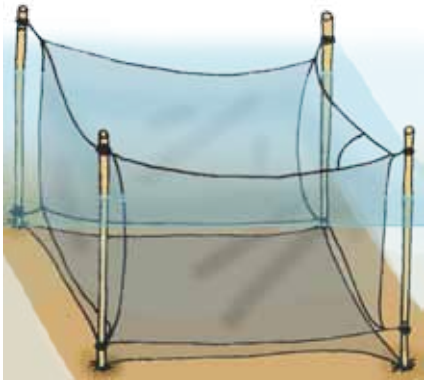
Cages or pens are used to separate an area of larger waterbodies for fish farming. The selected water source should be of good quality with low turbidity. Dams and reservoirs primarily exist to store water but as a secondary function these bodies of water can be stocked with fingerlings or fry and the fish can be harvested later by using nets. In river locations, a slow current is necessary and there should be little disturbance from water traffic.

There are several disadvantages to open-water fish farming that should be considered. These include that fish farmers have little control of the water, as they do not own the dam or reservoir. The risk from theft and vandalism is a serious problem in some places. It is more complicated to feed the fish or fertilize the water, creating a higher reliance on naturally occurring fish food. In larger waterbodies, there are likely to be more predators. A significant expansion of cage culture activities in some villages could have negative environmental impacts, leading, for example, to the local depletion of snails on which other animals depend (e.g. birds).

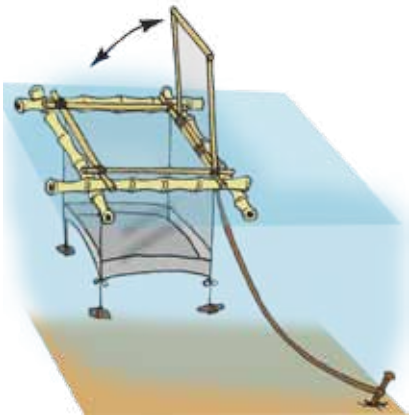
Fish cages: A cage is a simple means of restraining fish in one place, and it can be easily made using local materials. Cages are used within flowing or large bodies of water and can also be used in small pond fish culture to protect fingerlings in the initial stages of development. Small cages with a capacity of 1 m^3 are suitable for fingerling protection. Cage design must incorporate certain physical properties, including the ability to hold fish securely but also to be within the financial means of the cage operators. The cages currently used are small, measuring between 1 and 2 m^3, inexpensive and simple to construct. Bamboo poles can be used to form an outer frame that is covered in netting; inside is a "nursery" section for the younger, more delicate fish; and floats are added at the corners. Farmers use both fixed and floating cages. In general, fixed cages are installed in waters where the depth is relatively low and poles can be fixed into the river bed or substrate. Floating cages do not have this limitation and can be used in deep water. Floating cages tend to be easier to manage, but when selecting the type and design, the following points should be considered: input availability, risk of natural disasters, type of waterbody, water depth and current, and water retention period over one year.

CAGE MANAGEMENT

Fixed cages: Fixed cages are very easy to construct and only require a small amount of capital investment. The materials needed to make fixed cages are netting with an 8 mm mesh size, bamboo, rope, twine and sinker. Routine management is difficult for these cages, and storms, strong currents,



tidal surges and flooding may cause damage if precautionary measures are not taken. Fixed cages are difficult to move from one place to another during water fluctuation. A top cover is usually provided on cages to reduce the risk of fish escaping, especially in areas prone to flash floods where water levels rise very quickly. A small opening is kept at one edge or in the middle of the top covering for feeding purposes. A feeding platform made of fine mesh is placed on the bottom of each cage to minimize food loss. To fix the cage, four bamboo poles are fixed in the substrate and the four top and bottom corners of the cage are tied to the bamboo poles with nylon rope, allowing the cage netting to stretch. To minimize installation cost and to reduce daily management and labour, cages are sometimes fixed in rows with a narrow space between the adjacent cages.



Floating cages: The size of the cage is usually 1 m3. A top net is always used to minimize escapees because the cage is only a few centimetres above the water surface. The top of the cage is on hinges that can be opened to allow feeding, the checking of fish, the removal of waste and harvesting.

A layer of fine mesh net is placed along the bottom of the cage and 10 cm up each side to reduce food loss. However, where the water has a high turbidity, the use of fine mesh is not recommended as it clogs up the mesh and causes structural stress on the cage frame. In these areas, feeding trays should be used instead of fine mesh. Buoyancy is achieved by using four plastic floats (buoys) tied to the four horizontal frames, about 10 cm from the top of the cage. There are several advantages to using fixed cages. The cost per unit is very small and they are not damaged by storms. They are easy to construct and the water volume remains constant even with a fluctuation in the water level. Lastly, in tidal waterbodies, the effective cage depth is greater.

Cage maintenance: Maintenance includes: the cleaning of aquatic weeds nearby; removal of water hyacinth; cleaning of waste feed from cages; cleaning of deposited silts from cages; removal of dead fish; checking cage frames, floats, ties, anchors, feeding trays, etc.; cage shifting; considering the water level; checking water pollution; and guarding. The care of the net includes the removal of algae to ensure water exchange and the prevention and repair of holes. Profitability depends on proper attention to fish growth, and regular, adequate and quality feed is important. Feed can be of local origin, including aquatic weed or a mixture of rice bran, oil cakes, kitchen waste, chopped snails or cow dung. Fish health should be monitored regularly.

Fish types: The selection of suitable fish species for farming will depend on various biological and economic factors, such as market price, growth rate, ability to reproduce and available fish feed. Water temperature is also an important criterion in assessing which fish species is suitable. Common types of farmed fish are tilapia, Nile perch and catfish.

Feeding the fish: It is possible to feed fish on kitchen and agricultural waste, duck weed, oil cake, rice bran and snails, which will provide all the nutrition required. If available and not too costly, the diet may be supplemented with commercially available compound feeds.

FACTORS FOR COMMERCIAL SUCCESS

You should consider a variety of factors when venturing into aquaculture for commercial purposes. It is important to plan wisely and to do your homework. In addition to the available natural resources, evaluate other resources you have, including time, access to energy and financial resources. It is also crucial to assess the market of the region or community in which you want to sell your fish. Is there a demand for what you are going to produce? Can you make a profit? How are you going to sell your product?

exercise 1

WHAT SHOULD I PRODUCE AND WHO WILL BUY IT?

OBJECTIVES:

Identify local markets and their needs.

TIME:

3 hours.

MATERIALS:

Paper, pens, writing support, markers.

PREPARATION:

Before doing this exercise, meet with local fish traders to arrange for a group visit when they are not too busy. If there are many traders, contact several of them to distribute the group. It will also be beneficial to arrange a visit when customers will be purchasing product to capture their views as well. Based on the finding of the pre-exercise visit, decide the most appropriate size of the subgroups.

STEPS:

1. Introduce the task to the whole group. Working in subgroups, they will decide on two questions each for the consumer and the trader to better understand the market needs. Explain that the subgroups will have 15 minutes to complete this task.

2. Form smaller gender-balanced groups (adjust the size of the groups to the number of fish traders and customers, so as not to overwhelm the individuals) and provide them with paper and pen. These groups will work together throughout the exercise.

3. After 15 minutes, have a representative from each group present their questions to the class. Write the questions on the flipchart. Once completed, ask the participants if there are any more questions they would like to add. Use the questions in the Facilitator Notes to stimulate ideas within the groups.

4. Participants should use all the questions as a guide to engage in conversation with both the consumers and traders. Explain that a list of questions could make people uncomfortable and that it is better to have a casual conversation in which the questions are inserted. Participants should record the major points, but avoid writing the answers word for word as this can make the person being interviewed feel as if they are not being listened to. Participants should always be polite and thank everyone for their time.

5. Bring the participants to the prearranged location and give them an hour to meet with the traders and consumers. Agree on a meeting point.

6. When back, discuss what the participants learned. Based on their feedback, which product would they want to farm and why? Emphasize the importance of a market survey and explain how it is done and how it relates to the exercise the groups just participated in.

facilitators' notes

Participants should have an understanding of how to perform a market survey that allows understanding the conditions and the needs of a market. They can use this technique in their local communities but they can also use the survey questions as guides when speaking with other important players, such as exporters. Identifying a market is only part of the process; it is also important to make sure that any product chosen to be produced will be sustainable and profitable (for more, see module Post-harvest issues in fisheries and aquaculture). Participants will want to choose a product that is unique or in demand, rather than to produce one that is already being produced and meeting current demand. Shifts in the availability of certain fish species owing to climate change can open the door to new and profitable aquaculture endeavours.

SAMPLE QUESTIONS FOR MARKET SURVEY

For traders

- What are the most popular products?
- Are any of the popular products produced through aquaculture?
- What are the most expensive products? Do they sell well?
- Does the trader have a problem with obtaining a steady supply of certain products?
- Are there times of the year when certain products are more popular (e.g. festive seasons)?
- Is there a preference from the customer as to whether certain products are from aquaculture or wild caught?
- Are there any export markets for products from aquaculture?
- What products are imported for sale?

For consumers

- What is their preferred product to purchase?
- Do they know the difference between fish from capture fisheries and aquaculture fish?
- What is the biggest factor when deciding what to buy (price, taste, aquaculture vs. wild, etc.)?
- Are there any other fishery products they would like to see available?
- Are they able to find their favourite products at all times? Can they afford their favourite products at all times?
- Are there special items they would like to see available at certain times?

exercise 2

WHO WANTS TO BUY MY FISH?

OBJECTIVES:

Understand the dynamics of supply and demand in the local market.

TIME:

2 hours.

MATERIALS:

Paper, pens, writing support, markers, a local fish trader or local fish exporter (this session can include both or be done on two separate occasions with different individuals).

PREPARATION:

Make arrangements with a local fish trader or exporter in advance to inform about the purpose of the group visit and agree on a time for the visit.

STEPS:

1. Invite participants to imagine that they are going to start their own aquaculture operation. Before they make the initial investments, they have to look for local fish traders and exporters to identify local and international market needs.

2. Each participant should come up with two questions, which would help choosing the aquaculture species to obtain the greatest return on their investment.

3. Tell the participants to also consider laws and regulations related to selling and exporting fish, as this may be a significant cost factor in their production process. Inform the participants that a trader or exporter will be answering their questions.

4. Compile all questions on a writing support before the arrival of the guest to avoid asking the same question twice. Assign questions to each participant to engage them with the trader or exporter.

5. Begin the session by introducing your guest. Have him/her explain to the participants what his/her position is and ask to provide a brief overview of his/her job.

6. Open the floor so that participants can ask their questions. Encourage the trader or exporter to elaborate and ask questions back to the participants.

facilitators' notes

Fish traders and exporters have direct access to the consumer market; they know the drivers that affect demand and supply better than anybody in the value chain. These drivers can come from the consumers themselves. For example, increased consumer demand for certain wild species can contribute to increasing capture fisheries pressure on local stocks to satisfy this demand. This in return can reduce these stocks and there can be an increase in the demand for certain aquaculture products to substitute these capture fisheries products. There are also external drivers that can affect supply. For example, climate change may put limits on what species can be produced now and into the future; it is important to keep this in mind when thinking of products to produce.

WHAT ARE THE RISKS?

Aquaculture can be conducted in a wide range of environments from freshwater to marine water, in simple ponds or even in high-tech indoor recirculation systems. Each of these production systems has some specific risks. Certain risks may affect all production systems, for example, risks of disease outbreaks, equipment failure or natural hazards. Risks that may specifically affect aquaculture include water-quality degradation and competition with products from capture fisheries. The decrease in production from any risk results ultimately in an economic loss. In order to mitigate these risks, it is important to understand them. For example, preventive actions can be taken to minimize the risk of the outbreak of diseases. Risks cannot be eliminated but they may be reduced or managed. There are a number of options available to manage each potential risk; however, each option has associated costs and benefits, which should be understood in order to address them.

exercise 1

IDENTIFY RISKS

OBJECTIVE:
Identify the risks associated with aquaculture.

TIME:
1.5 hours.

MATERIALS:
Writing support, pens, index cards or a piece of paper.

STEPS:

1. Ask participants to discuss the types of aquaculture they are conducting or that occur in their community, and list them. Ensure that participants provide as much detail as possible: Does it occur in freshwater or saltwater? Which species are farmed (fish, shellfish, etc.)? Which method is used?

2. Hand out index cards to participants or ask them to fold a paper in half. Have participants write the possible risks associated with aquaculture production (these will become the risk cards for the game in the next exercise) and ask them to be as specific as possible. Only include one risk per card/paper and only write on one side.

3. Collect all cards.

4. Review the cards with the participant to see if there are any duplicates and remove them. Move on to exercise 2 (see facilitators' notes after exercise 2).

exercise 2

HOW TO MITIGATE RISKS

OBJECTIVE:
Work in teams to identify ways to mitigate risks.

TIME:
2 hours.

MATERIALS:
Risk cards (from previous exercise), blank game board (see below), dice, game pieces, timer.

STEPS:

1. Explain risk mitigation: Risk mitigation aims to reduce the probability that an event occurs as well as the possible negative consequences that can derive from it. For example a risk mitigation measure is the building of fences to reduce the likelihood that floods occur as well as to reduce the impact of floods (exposure).

2. Divide the participants into smaller gender-balanced teams.

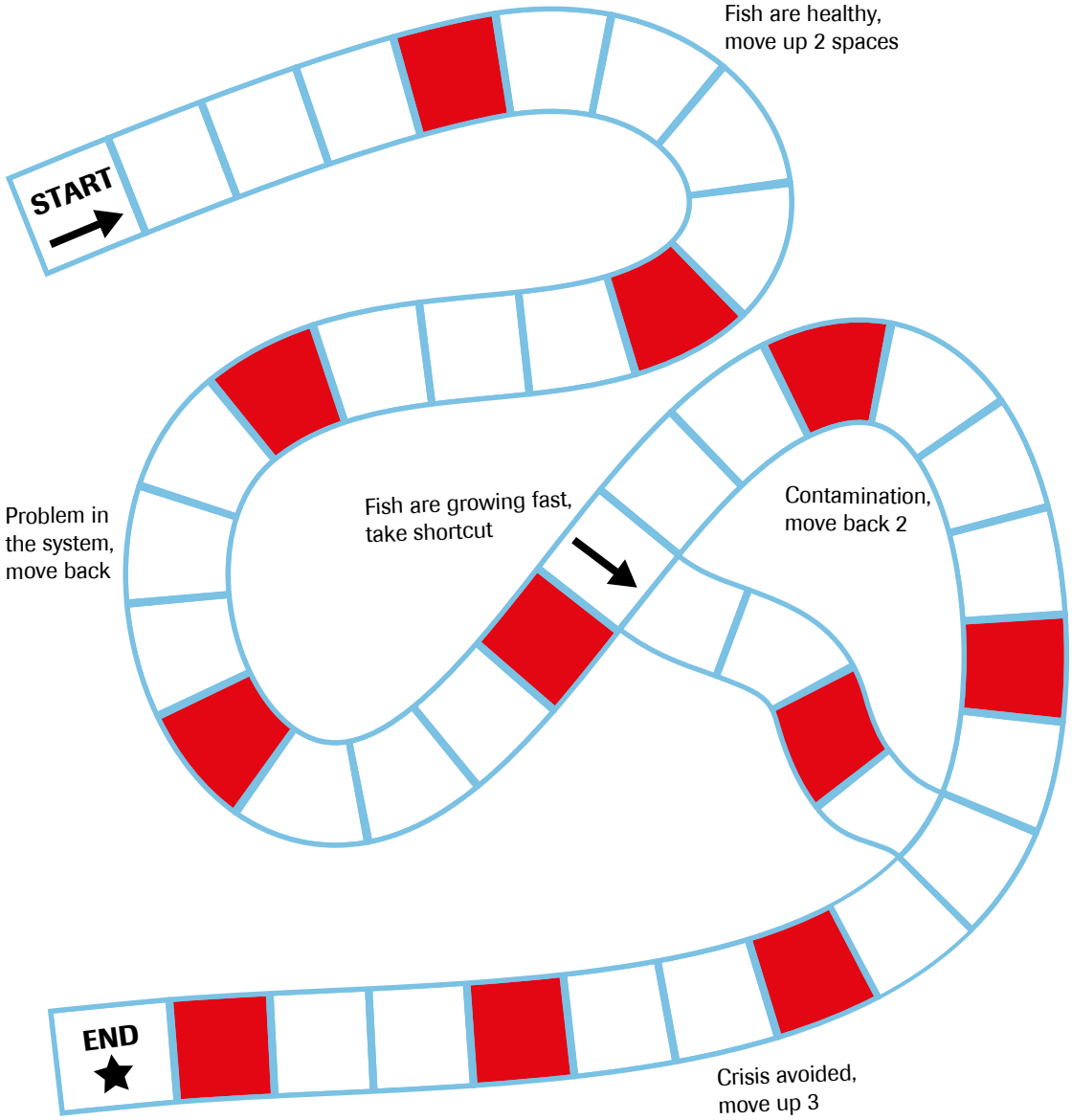
3. Each team will roll the dice in turns as they move around the game board. When they land on a red square, they pick up a risk card, read the risk aloud, and as a group discuss how they

can mitigate the risk. They have 1 minute to come up with an answer. If they come up with a solution, then they roll the dice again. If they cannot figure out a solution, they move back two spaces. If they cannot come up with a solution, the other teams have an opportunity to come up with a solution. If another team answers the question, they take over the turn and roll the dice. Along the way, there are additional squares that help teams advance or force them to move back.

4. The first group to reach the end wins.

5. Keep track during the game of the answers the teams come up with for ways to mitigate the risks. When the game is complete, as a group discuss the solutions and decide if they are the most appropriate and what other possible solutions there are to the different risks.

6. If not all risk cards have been played during the game go through the rest of the cards with the whole group and ask participants to come up with possible solutions for each risk.



facilitators' notes

Risk is defined as a combination of the likelihood of an undesired outcome occurring and the severity of the consequences. Risks can be broken down into different categories, including for example environmental, occupational, and those related to food safety and public health.

Environmental risks:

- Escapes: Escaped farmed fish that can interbreed with local stocks is considered a serious environmental threat. This occurs when farmed fish are being raised in net pens or cages in the wild. The introduced species may carry diseases or parasites that can significantly affect the native population. The introduced species may also out-compete the native stock for food and there may be inbreeding which potentially weakens the genetic fitness of the wild populations.
- Water pollution: Fish and feed wastes from aquaculture facilities, which contain large quantities of nutrients, can be potentially harmful to the environment when discharged untreated into coastal and ocean waters. Another form of pollution is the use of chemicals such as medical treatments, including antibiotics, when not disposed of appropriately or discharged into the environment.
- Climatic conditions and natural disasters: These can cause issues in aquaculture production. For example, flooding can cause physical damage to the production site, pathogens as well as predators can be introduced, or the cultured species may escape. Drought can also affect the facility by decreasing the amount of water available and thereby ultimately reducing the carrying capacity of the facility.

Occupational risks:

- Physical hazards that affect workers include mechanical injuries from the equipment. Other physical injuries include cuts, sprains, and fractures. These injuries can all be prevented by the use of the appropriate safety equipment.
- Workers are susceptible to bites from fish depending on the species raised or that they are exposed to in the facility, especially on outdoor fish farms. The use of appropriate protective gear can help prevent this.
- Chemicals are sometimes used in aquaculture facilities for a variety of reasons, thereby exposing workers to hazards that can cause a multitude of reactions. Fertilizers, pesticides, disinfectants and other laboratory chemicals can cause skin irritations as well as respiratory ailments or even worse problems. Proper use of equipment and hygiene can help prevent these reactions from occurring.

Food safety and public health:

- Diseases and parasites: Infectious diseases caused by bacteria, viruses and parasites are a major concern in aquaculture. One way to reduce the spread of diseases is by adhering to best practices in the handling and marketing of fish. Disease and parasite outbreaks on fish farms can be addressed with antibiotics and other chemicals in fish feed as well as using vaccinations for farmed fish, but it is preferable to prevent any disease outbreak as antibiotics and chemicals have potential negative environmental impacts as well as on the quality of the fish.

ORGANIZATIONAL STRUCTURES

A large proportion of aquaculture production today comes from small-scale operations. Small-scale fish farmers face many challenges, including having secure access to markets and the ability to purchase the necessary inputs for production. Often, small-scale producers also have limited access to knowledge about improved production technologies, progress in dealing with disease, etc. When working alone, these challenges can become a hindrance to running a profitable business. However, there are many ways for small-scale fish farmers to join forces and overcome these problems together.

exercise 1

ORGANIZATIONS

OBJECTIVE:

Illustrate how organizations can assist small-scale farmers to run a sustainable business.

TIME:

4 hours.

STEPS:

1. Divide the group into three gender-balanced groups. Each of them has to prepare a little play to be presented to the others. Suggested scenarios:

   - The price of fish feed has gone up. How can you afford to buy it from the only dealer that sells it?
   - There has been opposition to the expansion of your small-scale cage farm from the local non-governmental organization (NGO), which is worried about the environmental impact. How can you assure it that you are using best management practices?
   - The trader you usually sell to has just told you that the hygiene regulations are becoming stricter. What can you do?

2. Discuss the plays with the whole group to see if there are other options than the ones presented.

facilitators' notes

Increasing globalization and trade is leading to a change in supply chains in aquaculture. In some cases, large integrated production–distribution chains marginalize small-scale fish farmers. Powerful companies controlling the markets can impose prices and production requirements on small-scale producers who do not have a voice.

In particular for exports, the market demands a product that is safe, healthy, high quality and has been produced in an environmentally sustainable and ethical system. The presence of unfair working conditions and the use of child labour can exclude small-scale producers from benefiting from global value chains.

Organizations have been used in farming for centuries. Some benefits of collaboration for small-scale farmers include:

- bulk purchasing of production inputs such as feed at reduced costs;
- collective processing and marketing facilities and opportunities;
- effective management through sharing of best management practices;
- access to new information and extension services;
- easier access to certification for groups.

There are several models for aquaculture organizations: producer organizations, clusters or cooperatives, marketing organizations and community-based organizations with wider social objectives. Informal organizations often exist but they do not have legal rights and may face difficulties in obtaining loans, credit or technical assistance.

Associations are membership-based organizations that have easier access to services and benefits. Usually, they are not established for business activities but rather for non-profit purposes. In such cases, they cannot distribute profits to members, and members are liable for the association's debts.

Cooperatives are traditionally controlled and owned by their members, who have equal shares and voting rights. The main purpose of a cooperative is to provide competitively priced services to their members and to make a profit from the members' sales. The profits are then distributed to members. Common activities and services of organizations are:

- input supply: provide products to members at lowest possible price;
- production services: provide technical assistance and extension services and training;
- financial services: facilitate access to cash loans and credit;
- additional training: in addition to technical training, many provide training in literacy, numeracy, basic accounting and record-keeping;
- quality control: monitor and control the production process and quality of the final product, possibly leading to branding or certification;
- coordinating production: to take advantage of markets and needs of the buyers, they can act to coordinate the supply throughout the year;
- output marketing: analyze market information, identify opportunities and negotiate sales and contracts, collect, store and transport produce and pay members on time;
- trading and intermediation: can act as major intermediaries and negotiate contracts with buyers and purchase product from their members;
- processing: can process to add value;
- advocacy: promote and defend the rights of members and provide a voice that can be heard;
- community development: may take on projects such as donating money for local schools;
- environment and conservation activities: can help to offset negative impacts of aquaculture through activities such as replanting mangroves.

FOOD SAFETY AND HYGIENE

With the increase in seafood production through aquaculture, concern is growing the about the quality and safety of these farmed finfish and shellfish products. Safety concerns range from the threat of exposure to chemical contaminants and toxins that occur naturally in the environment to the improper use of chemicals during processing and handling. If proper food safety and hygiene measures are not respected, cross-contamination can occur along the supply chain (production, processing, storage, transport, consumption) and potentially cause larger public health issues. Therefore, the production of safe and healthy quality fish from aquaculture requires effective hygiene practices throughout the food chain, from growing the fish through to its consumption.

exercise 1

LEARNING HYGIENE PRACTICES

OBJECTIVES:

Raise awareness about the importance of food safety and hygiene and learn good practices.

TIME:

3 hours over several days.

MATERIALS:

Fresh food items (including fish), small piece of paper (big enough for the food item to fit on), paper and pens.

STEPS:

1. Break participants into small gender-balanced groups. Give each group a food item which was cut into two halves. Draw the participants' attention to the freshness of the product. Let the groups decide where to leave each half of the item for the remainder of the day/training (e.g. outside in the shade, on a shelf, in a sunny area).

2. Have participants write their names on a piece of paper together with what they think will happen to the item. Place the papers close to the food item.

3. On the next day, have participants explain what happened to their food item.

4. Have them monitor the food item throughout the following days, observing closely and at the end, report the results. Provide details on how the food looks, smells, if there are insects on the item, etc. Discuss the differences based on where the items were located, the temperature differences in those locations and how that made a difference (e.g. indoors versus outdoors), and any other observations participants made.

5. Lead discussion on the effects of bacteria, parasites and other microbial organisms on humans if they consume or even touch food that has been contaminated.

6. Based on the observations, ask participants to identify proper storage/cooling strategies for food items, especially fish.

facilitators' notes

It is important to remember that aquaculture is the production of fish for food, either for direct consumption or for trade. Therefore, when producing this food item, it is important to keep in mind that proper food safety and hygiene measure are essential. By not respecting these measures, the fish product can suffer and the consumer may end up sick in the long term.

Hazards can be microbiological such as bacteria, viruses and parasites. There are fungi in the air that can make food mouldy and make it rot. The fungi like warm, wet and light conditions so keep food cool and dry. Temperature is the most important factor affecting the rate of multiplication of micro-organisms and deterioration of food products especially fish. Therefore, icing, chilling or refrigeration is key to keeping fish fresh and safe. Hazards can also be chemical including heavy metals, biotoxins and histamines, and they can be physical such as hazards related to glass and metal fragments that enter the product during the production cycle.

When transporting fish products, an appropriate cool temperature should be maintained at all

times. If the product is frozen, then chilling equipment or ice should be provided. If the animal is alive, then the temperatures should be tolerable for that species.

Many processes designed to preserve food involve a number of food preservation methods. Below are some food preservation techniques to lengthen the shelf-life of perishable food items:

- **Drying**: Drying (air drying, sun drying, wind drying, or drying near an open fire) is the process of preserving food by removing water from it. Removing water prevents decay and the growth of microorganisms.
- **Freezing**: There are different methods of commercial freezing, but they are all based on two principles:
  – very low temperatures inhibit growth of micro-organisms and limit enzyme and chemical activity;
  – the formation of ice crystals draws available water from the food, also preventing growth of micro-organisms.
- **Pickling**: Pickling is the process of preserving food in an acid (usually vinegar).
- **Salting**: Salting is the process of preserving food with salt and drying it. This method draws out moisture that causes decay. Also, most bacteria fungi and other disease-causing organisms cannot survive in such a salty environment.
- **Smoking**: Smoking is achieved by exposing the food to smoke from burning plant materials such as wood.

exercise 2

HOW GERMS SPREAD

OBJECTIVE:
Understand how microbes spread through contact with objects or people.

TIME:

MATERIALS:
Flour, variety of objects, writing support, pens, water.

STEPS:

1. Divide the flour and objects into four sets.

2. Separate participants into four gender-balanced groups and give each group the flour and a set of objects.

3. Have one participant from each group thoroughly cover his/her hands with flour. Then have them go around touching the objects of their set.

4. Explain to the participants how, when surfaces are touched, the “germs” spread as can be seen by the flour spreading from object to object.

5. Rinse off the objects so that no flour remains.

6. Next, have a different participant from each group sprinkle flour on his/her hands and pretend to sneeze into the hands while standing over the set of objects (the goal is to disperse the flour onto the objects showing how germs are spread when sneezing – some flour should remain on the hands).

7. Then have these participants shake hands with someone else in their group and touch a couple of objects to transfer some of the “germs” onto those objects.

8. Finally, have another participant in the group put flour into his/her hand and pretend to sneeze again. This time, however, have them cover their face with their arm. Ask participants to notice what happened. They should note that much less flour and fewer “germs” made it out of the participant’s hand. This shows how properly covering when sneezing and coughing can help prevent the spread of germs.

9. Bring all the groups together. Have participants discuss ways to prevent cross-contamination when dealing with food items, and register key words on the writing support for all to see.

facilitators’ notes

When dealing with fish and fish products, people that come into contact with them either directly or indirectly should maintain an appropriate degree of personal cleanliness. Good hygiene practices should include washing hands, the wearing of appropriate protective clothing (e.g. goggles, gloves, masks) and the use of other proper equipment when handling food (e.g. hand washing sinks, footbaths). Training of staff in recommended practices is an important step to ensure food safety and hygiene. Some good practices are listed below:

- Wash your hands frequently, preferably with soap and warm water.
- Keep your nails short to avoid dirt accumulating under them.
- Stay home if you are sick (so you do not spread your disease to other people).
- Cover your nose and mouth when sneezing and coughing (or cough into your elbow).
- Wash your hands after coughing, sneezing or using tissues.
- Do not touch your eyes, nose or mouth (viruses can transfer from your hands and into the body).
- Do not share cups, glasses, dishes or cutlery.
- Clean and disinfect frequently touched surfaces at home, work or school, especially when someone is ill.
- Have plenty of sleep, be physically active, manage your stress, drink plenty of fluids, and eat nutritious food.

Also see the JFFLS Facilitator’s Guide Protection, specifically activity 2, the Wash Song on page 36.

HOW TO GROW FISH

There are numerous fish species cultured in the world. Fish are cultured in ponds, tanks and cages. Here, we concentrate on pond aquaculture, which is widely used all over the world. Freshwater pond aquaculture has changed a lot in recent years. The intended species to be grown in a pond is a primary consideration in determining the size of a pond. Site selection and available water supply are also factors to consider. Cage aquaculture can be also done in fish ponds if they are large and deep enough. Cage aquaculture is growing fish in a confined netted structure that allows easy access and harvesting by the fish farmer. Cages allow for protection from natural predators.

exercise 1

BUILDING AND USING A BAMBOO FRAME CAGE

OBJECTIVE:

Understand the effect of different stocking densities and species on growth.

TIME:

3 hours set up and continued maintenance during the following two months.

MATERIALS:

Twelve one-metre-long bamboo sticks (about 2 cm in diameter), fixed into the holes of the angles, one angle for each corner, giving a box shape and sinkers. This will produce a 1 m^3 bamboo cage (see Facilitator Notes).

STEPS:

1. Discuss with the participants the concept of cage aquaculture. Explain that cages are used as a form of farming within flowing or large bodies of water and that cages can also be used in small pond fish culture to protect fingerlings in the initial stages of development. Ask participants if any relatives or friends are currently doing cage aquaculture and discuss the responses.

2. Explore with the participants which materials are needed to build a cage, where to obtain them and what they cost. If they do not know, help them.

3. Divide the participants in four groups, give them the materials and explain the steps to construct the cage (see Facilitator Notes).

4. Catch about 20 juvenile fish of two local fish species, ideally cichlids and catfish.

5. Place 15 juveniles of one species of fish in one cage and 5 of the same species in another cage.

6. Place 12 juveniles of the other species in the third cage and 8 of the same species in the other cage. (Note: the number of the fish can vary but it should be an unequal distribution in order to demonstrate the effect of density).

7. Place the cages in a local pond, river or lake, and feed the fish on a daily basis by fertilizing the water. To fertilize the water, add compost, animal manure or plant materials so that there will be natural food for the fish to eat. Make sure that you are feeding the fish based on the number of animals in the cage.

8. Assign a group member to check the cage every day to assess the mortality of the stock and remove any dead fish. Each group member should take a turn at this for a two-week period if possible. Multiple turns may be required. Remove any debris caught on the cage or any fouling by plants and detritus that has built up.

9. Discuss with the participants the need for daily maintenance of the cages. Will they be able to do all the work themselves or will they need to hire someone? Will the cost outweigh their profits?

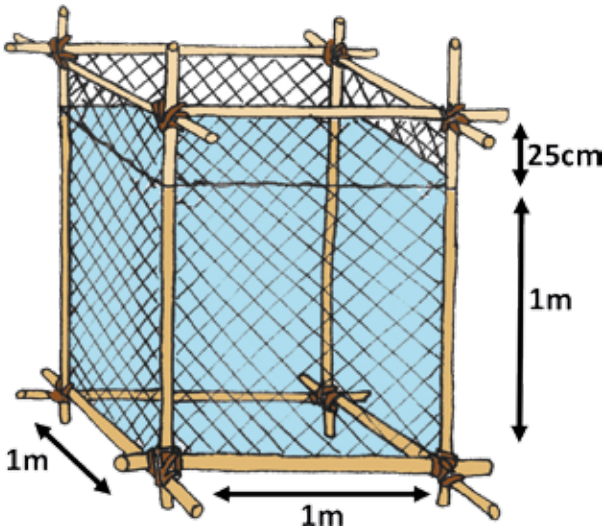
10. After two months, discuss the results with the group: Are the cages of each group performing differently? Does the stocking density make a difference in terms of productivity and survival rate of the cage?

facilitators' notes

Fish cages offer an efficient way to feed and harvest fish. Fish cages also offer cover to protect fish from predators. Once a day, you can easily pour feed in, inspect the cages and check for mortality. Fish should be pulled periodically from the cage and inspected to see how they are growing and if there are any health issues. At harvest time, the cage can be pulled to shore where you can wade in and net the fish. In order to be financially viable, the revenue should be higher than the costs of the initial investment for materials and labour. However, there is a minimum number of fish needed to make growing fish financially viable.

Bamboo or wooden trap

The cage can be small or large depending on the number of fish that you want to raise. However, when you first begin, start by building a small cage. You will need fewer materials and it will be easier to take care of. You can begin with a cage of about 1 m^3 (1 m × 1 m × 1 m) of space for the fish.



Cut 12 one-metre-long bamboo sticks (about 2 cm in diameter). Make a hole in each end of the sticks large enough to allow another stick to fit into in it. Put the sticks into one another and secure with some twine. You will now have a box shape.

Cover the frame with 8 mm fish netting and secure it with twine by wrapping it through the netting and around the frame until all openings are covered. If you cannot obtain fish netting, you can use either plastic mesh or woven material made from split bamboo or wooden strips. The openings in the material that you use to cover a cage must be small enough to keep the smaller fish from getting out. However, if the openings are too small, they may become filled with dirt.

Attach a rope and a buoy if you want it to be a floating cage. If you would like it to a fixed cage, add sinkers to the bottom corners of the cage.

exercise 2

FEEDING OUR FISH

OBJECTIVE:

Become aware of different feeding behaviour of fish.

TIME:

1 hour.

MATERIALS:

Pictures with mouth types of fish (see below), fresh fish, fishing line, clothes peg, soft edible fruit and hard bread, scissors, writing support, pens.

STEPS:

1. Inform the participants that this exercise will help them understand the importance of learning about the fish they will stock in their ponds, which will help them determine the most appropriate feed.

2. Begin the exercise by reviewing the fish mouth types on the pictures (terminal, subterminal, up-pointing, specialized – see facilitators' notes). Explain that fish mouths have developed to adjust to specialized lifestyles. The size of fish mouths can give a clue to its feeding habits, especially when considered with the type and placement of teeth.

3. Divide the participants into pairs, ideally a male and a female.

4. Observe the fresh fish. Based on the introductory discussion and the observations invite participants to think of the different ways fish feed and where their mouthparts are located.

5. Gather one set of materials for each group (fishing line, clothes peg, edible fruit or bread, and scissors).

6. Tie the fishing line to the clothes peg. Clip the food onto the clothes peg and then hang the line and the clothes peg at various heights from an overhead structure (light, tree branch, etc.). Have one group member try to eat the food from the clothes peg without using their hands.

7. Now have the other member of the group try the exercise, reminding them that they cannot use their hands.

8. Discuss what type of feeder we as humans are (terminal, subterminal, up-pointing, specialized).

9. What kind of feed would be best for the fish you think you would like to raise in aquaculture (household edible waste, floating or sinking pellet, live feeds, or microalgae)?

facilitators' notes

Fish have a wide variety of mouth types. Some species have terminal mouths. Fish that catch their food directly in front of them as they are swimming through the water have a terminal mouth (Figure 1). Bottom-feeding fish have downward-pointing or subterminal mouths (Figure 2). Fish that tend to swim on the surface and capture their food there have up-pointing or superior mouths (Figure 3). Fish that are flat, like the ray, and feed directly off the ocean floor have a mouth on their belly, or ventral side. This kind of mouth is called an inferior mouth and makes it easy to scoop fish and invertebrates from the ocean floor. This can be considered a specialized mouth (Figure 4). Other fish have highly specialized mouths. Each of these mouth types has evolved to accommodate efficient feeding on prey items.

Figure 1.
Nile perch and pipefish with terminal mouth.

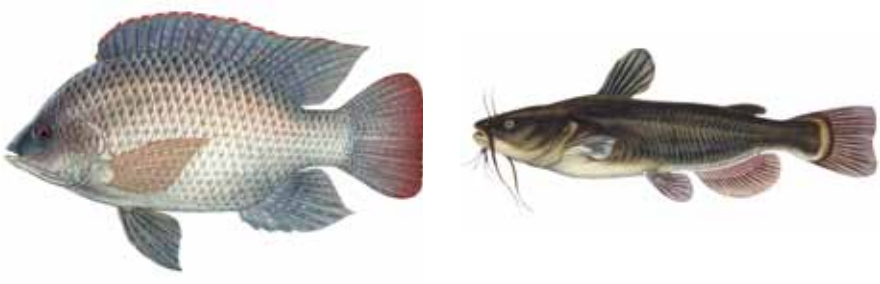


Figure 2.
Tilapia and catfish with sub-terminal mouth.

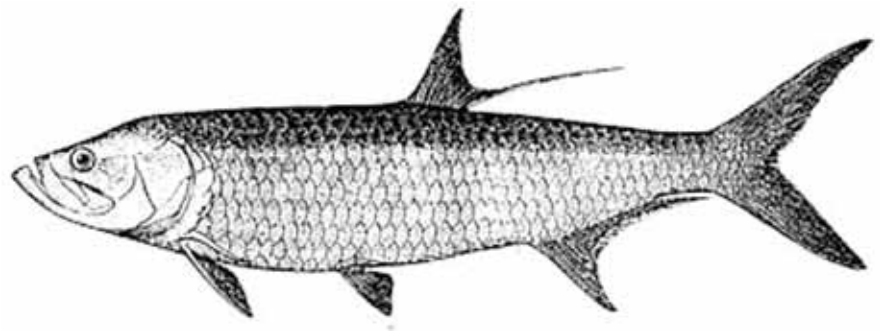


Figure 3.
Tarpon with up-pointing mouth.

Figure 4.
Seahorse and ray with specialized mouth.

exercise 3

HOW TO GROW FISH IN A POND – GETTING STARTED

OBJECTIVE:

Identify key factors in the pond site selection and management and understand selection criteria for species for the pond.

TIME:

3 hours.

MATERIALS:

Paper, pens, clay and soil and sand samples, containers, water.

PREPARATION:

Invite a local fish farmer to the class. Brief the person about the objective and format of the lesson. Ask the participants to collect and examine samples of clay and other soil textures from a nearby area that could be used for a pond. Together with the fish farmer, identify a nearby area suitable for pond construction that can be visited by the class.

STEPS:

1. Have a local fish farmer who has a pond come into the classroom. Let him/her explain to the participants about the species of fish he/she is raising, if/what type of cages are being used and the location of the pond.

2. Have the speaker ask how participants imagine the construction of a pond in as much detail as possible (e.g. materials, equipment, size).

3. Develop a list that summarizes the details and equipment that the participants name. This will provide an opportunity for participants to explore how ponds should be designed, constructed and used in aquaculture. Ask the fish farmer to comment on the list.

4. Discuss the characteristics of an excavated pond (the most common one used in small-scale aquaculture) and what site characteristics should be considered in its construction.

5. Have the fish farmer explain that the soil that will form the pond's main structure must be of soil that will hold water. Seepage can result in large losses of water and create the additional expense of pumping more water to the pond. Locations should have soil that will restrict the entry of contaminated groundwater.

6. Ask participants to compare the soil and clay samples they brought. Explain that the fine texture of clay allows it to hold water.

7. Ask participants to wet the clay with some water in the containers and to mould it into a small vase or container that will hold water temporarily. Demonstrate that sand will not do this.

8. If possible, make a visit with the fish farmer to a nearby area that could be used for a pond. Break the group into teams of 5–6 participants. While at the site, discuss that a site should be investigated to determine whether it is subject to flooding by rivers during seasons of heavy rainfall. Ask participants to name some grasses that are locally suited for erosion control.

9. Return to the classroom. Review the fact that careful planning is needed before the construction of a pond. Ask participants to sketch the layout of their pond operation, taking into consideration the area just visited.

10. Disease is another big problem in fish ponds. Discuss the types of disease that can occur in ponds, and then ask participants and the fish farmer to explain how diseases could be transferred.

11. Discuss with the participants and the fish farmer what species can be grown easily, and have participants make a list of ones that they can think of. Examples are tilapia, shrimp, catfish, milkfish and carp.

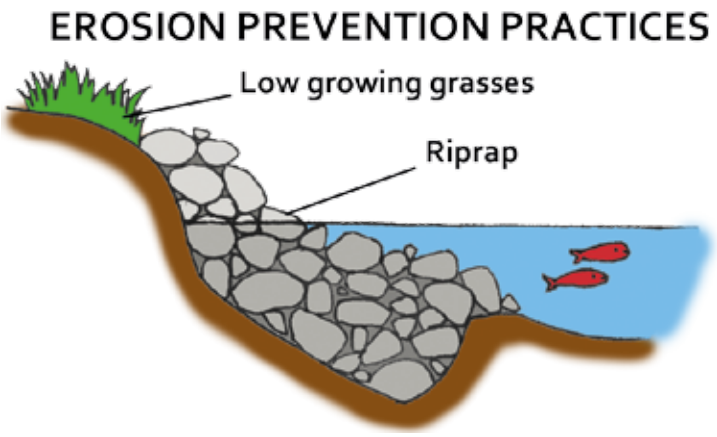
12. Feeding is another factor to be considered. It is important that the farmer is able to make sure the feed is available in a form the fish can eat. Most farmers use commercially prepared feed formulated to meet the nutritional needs of the species being cultured, but many leftovers from the household can also be used. Obtain information from the fish farmer on this.

13. Have a closing question-and-answer session with the fish farmer to allow the participants to gather information about topics not discussed.

facilitators' notes

Clay soil particles are very small and hold water. Percolation is the term used to describe the movement of water through soil, and soils high in sand do not hold water well. Soil at the pond site should have a clay content of at least 20 percent. If available, soil survey maps or textural classifications can be used in assessing site suitability.

Erosion prevention practices should always be used around ponds. Bare earth should be seeded with low growing grasses, and riprap can be used around the perimeter of the pond. Riprap is the use of bags of rocks to prevent drainage and erosion.



Debris should always be removed from the pond site. The decay of trees and debris ties up oxygen the fish need to grow.

Over-flooding can result in the loss of a fish crop. Flooding also contaminates the water left in the pond once the flood has subsided. Climate change increases these risks, as do natural disasters.

Frequency of feeding is important with some species. Some species grow better if fed two or three times a day. The amount to feed varies with the species of fish, stocking density and size of fish. A general rule is to feed no more than will be eaten in a few minutes. A 10-minute time frame is often used as a guide. Another rule of thumb is the amount fed should be no greater than 3 percent of the live weight of the fish. You can demonstrate how to calculate the amount to feed using the general rule of 3 percent (example: 1 000 kg live weight, 3 percent = 30 kg).

POTENTIAL IMPACTS ON THE ENVIRONMENT

Aquaculture systems can have significant environmental impacts. The degree of these impacts depends on the size of the facility, the species, type of feed being used, location, etc. Impacts can include pollution from fish feed as well as waste, escapes from the aquaculture sites, habitat modification from the aquaculture structure, and disease and parasite outbreaks and the resulting use of antibiotics or other chemicals. It is important to understand these impacts because preparation is key to help alleviate their impact and plan for the future.

exercise 1

WHAT'S WRONG WITH THIS PICTURE?

OBJECTIVES:

Increase awareness about the environmental impacts of aquaculture and potential methods to reduce these.

TIME:

1.5 hours.

MATERIALS:

Aquaculture system poster (or handouts, see below figures 1 -3 for examples), paper, pens, writing support.

STEPS:

1. Break the class into small gender balanced groups of 5-6 participants.

2. Give each group a handout, a writing support and pen. Be sure to cover up cover up descriptions with pieces of paper or tape. When one of these problems is identified the paper can be removed.

3. Inform the participants that each group should review the handout and write down the problems shown in it.

4. After they have identified the problems in the handout, ask them to think of any problems that are not shown in the pictures. They can write these down too.

5. Ask one member from each group to present the problems that the group identified.

6. Write down the problems on a large writing support for the whole class to see.

7. For the second part of the exercise, assign a problem to each group until there are no more problems left (if there is a small number of groups more than one problem can be assigned).

8. Inform the groups they will have 25 minutes to discuss their assigned problems and come up with possible solutions.

9. Each group will present their solutions and ask for feedback from the rest of the class.

10. Add the suggested solutions to the writing support for the whole class to see.

11. When the exercise is complete you will have a list of problems and possible solutions..

12. Ask them to discuss the following question: Is there any local issues related to the problems and solution that have been discussed before? Or are there any other problems existing in the community which have not been mentioned? And if so, what possible solutions could help to overcome these problems?

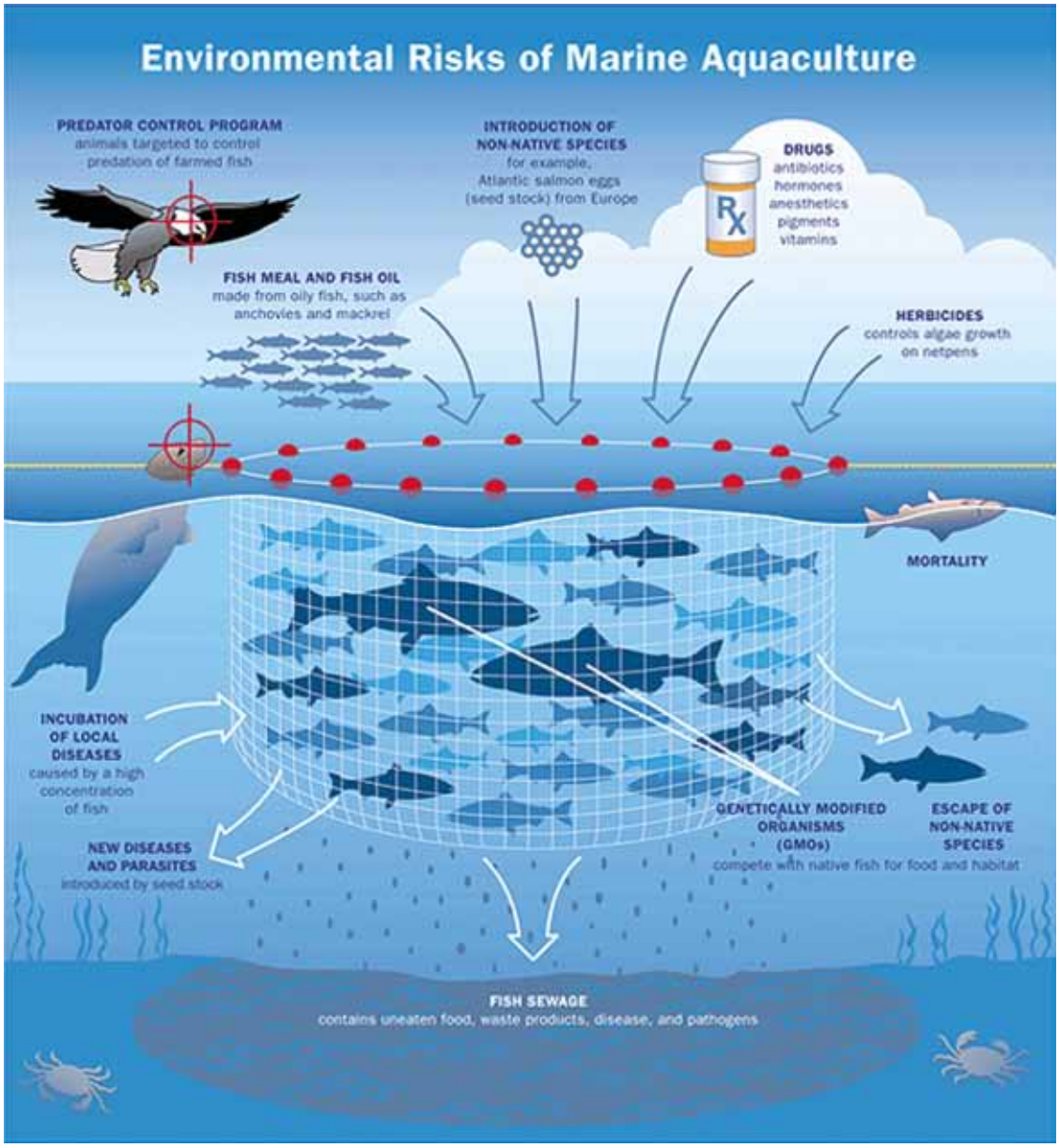


Figure 5: Source: www.motherjones.com/environment/2006/03/aquaculture-environmental-impact

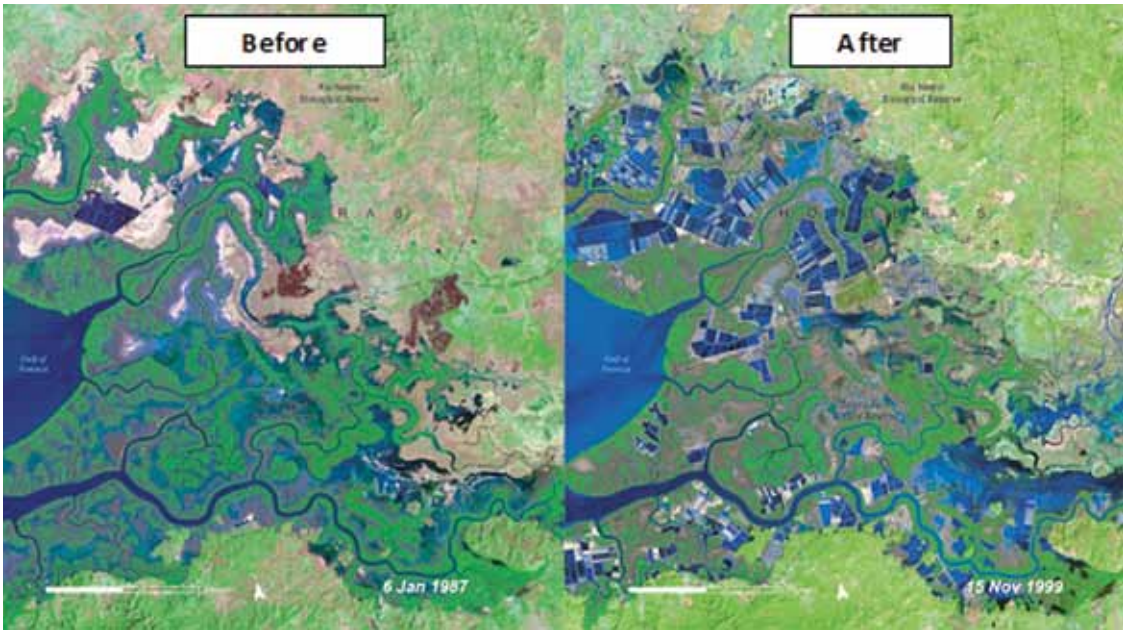


Figure 6: Source: UNEP, 2005. One planet, many people

Figure 7: Source: http://en.wikipedia.org/wiki/Mariculture

facilitators' notes

Figure 5 shows a variety of the risks deriving from open water aquaculture.

- Fish sewage or feed waste results in pollution and can change the nutrient composition and other quality aspects of the water.
- Escapees: farmed fish may escape and out-compete the wild population, interbreed and introduce disease to the wild population.
- Farmed fish may be treated with antibiotics and other chemicals that are then introduced into the environment, or herbicides are used to control algae growth of cages.
- The aquaculture structure may cause habitat modification or damage to the environment, especially in very susceptible areas such as mangrove forests.

Figure 6 shows aerial photographs of the Gulf of Fonseca, Honduras, before and after the introduction of shrimp aquaculture. The rapid growth of shrimp aquaculture has had serious impacts on the environment as well as on the local communities in the area. The results include the cutting of mangroves and the use of wild shrimp post-larvae for the farm production. This had led to a decline in biodiversity, water quality, natural protective barrier to storms and hurricanes, as well as a decline in the artisanal fishing industry. In the second image, the blue rectangles are the lagoons for industrial shrimp production that were once mangrove forest.

Figure 7: The image on the left shows an aquaculture site with dense growing conditions, which can cause quality loss owing to dense concentrations of fish, and physical loss due to mortality from disease or lack of oxygen. On the right, the picture illustrates mangrove destruction, which reduces natural biodiversity, removes important shrimp breeding grounds and increases the vulnerability to climate change and natural disaster impacts.

Recognizing possible environmental impacts will help design systems that work with the environment and not against it. Preventing degradation of the local environment will help sustain ecosystem biodiversity that will benefit both the environment and the community. Learning how to identify disease at an early stage will reduce transmission to the farmed population as well as wild populations Taking measures to prevent escapement will help ensure that no invasive species are introduced and that the wild genetic population is maintained.

While increasing the availability of fish, aquaculture can also compete with the products of local fishers and threaten traditional livelihoods. Prices and demand for fish products may change if new species are introduced in markets. Aquaculture production may also create competition over productive resources, in particular with regard to access to and use of water (both marine and freshwater). This is particularly important in view of potential impacts of climate change, which may reduce the availability of water in some areas.

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