Extension Manual on Production of Quality Catfish Seed

First Edition

TAAT Aquaculture Compact
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Guide for Users
This material has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to catfish breeders for profitable ventures. The content is in simple language for easy understanding. Learning objectives, activities and materials as well as facilitation methods are well highlighted. Other key component parts of each module are instruments for pre-and post-course evaluation. Output evaluation, outcome evaluation and feedback mechanism are provided for periodic improvement of the manual. The accomplishment of the learning objectives is based on activities properly scheduled and executed. Learning materials are packaged for different hatchery and nursery staff to acquaint them with necessary knowledge and skills for successful hatchery operation. The manual is only an instruction material. Therefore, trainer should run the session with necessary adjustments considering the knowledge and experience of the trainees. Training methodologies and technicality of each session are described in detail. These have been carefully planned to ensure active participation of the trainees in the training. Sticking to the methodologies will ensure the active participation of the trainees and expected outcomes of the session will be achieved. Training sessions are arranged in sequence. Necessary information will be discussed within fixed time in each session. If necessary, the trainer, in light of his/her own experience, can change or modify the session keeping main topic as it is. However, timely starting and ending the session is good for both trainers and trainees. Assessing the success of the training programme is important for both trainers and trainees. Therefore, learning of the trainees needs to be evaluated during and after the training. Instruments for evaluation assist in assessing how well the set targets have been met; while feedback enables assessment of overall progress leading to achievement of overall objectives.

Targeted Audience
These are mainly catfish breeders consisting of women (30%), Men (70%) and Youths inclusive (25%) according to the level of involvement along the aquaculture value chain. Any of these categories within the age bracket of 15-60 years are prospective learners.

One paragraph about FISH CRP and BP resource development. (Florine can add it and adjust for catfish) production.
Background
Technologies for African Agricultural Transformation (TAAT) is a framework developed by the African Development Bank as part of its current efforts to foster the development of agriculture on the continent. It aims to enhance the use of proven agricultural technologies among the stakeholders to foster the needed change through farm level productivity and value chain development. Aquaculture is one of the nine commodity compacts with proven technologies that have potentials for increased yield and benefits for up-scaling in 12 countries in Africa. These are: Benin, Burundi, Cameroon, Cote d’Ivoire, Democratic Republic of Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia. The TAAT Aquaculture Compact led by WorldFish has been training aquaculture Subject Matter Specialists (SMSs) and youth agripreneurs as facilitators under the capacity development and technology outreach.

The specific objectives of the Aquaculture Compact are: i) Creating an enabling environment for aquaculture technology adoption by the value chain actors; ii) Facilitate effective delivery of technologies to fish farmers and other actors along the aquaculture value chain; iii) Increase aquaculture production and productivity through the identification and dissemination of quality tilapia and catfish seed, production of low cost fish feed and value addition.

The African catfish, *Clarias gariepinus*, is a good candidate species for culture to boost fish production for both domestic and global markets. In Africa, this will contribute to human nutrition and food security. However, a major problem that has been an obstacle in realizing the full potential of catfish farming is scarcity of good quality fingerlings in hatcheries. Fish farmers often are forced to resort to collecting fish seed from the wild or purchasing poor quality seed from hatcheries. The essence of this manual is to expose extension workers to better practices in catfish fingerling production and facilitation techniques in disseminating the technology. This will enable them disseminate skills to catfish hatchery operators in their respective areas for increased production of quality fingerlings for the development of catfish farming.

The African catfish, *Clarias gariepinus* (also known as the mud catfish) is widespread in Africa and holds the potential for provision of cheap fish protein in the continent. Other catfish species that are good culture candidates are the red mud catfish, *Heterobranchus bidorsalis*, and the
Clarias - Heterobranchus hybrid (Hetero-Clarias). The hardy nature of the catfish in terms of its high tolerance to water stress and high utilization of supplementary feeds, make it a suitable candidate for culture promotion in Africa. Catfish also has a high market acceptance and allows value addition to varieties of products.

Rationale
The TAAT Aquaculture compact has noted the many challenges in the production of catfish by farmers in Africa. These include lack of access to quality fish seed; low skills of fish breeders in Better Management Practices (BMPs); high fry and fingerlings mortality and lack of knowledge on fish health management at the hatchery. The extension manual has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to catfish breeders to produce fast-growing and healthy fingerlings for profitable ventures.

Development Objectives
The development objectives of this material are:
   i. Enhanced productivity of catfish
   ii. Increased farmers’ income and,
   iii. Food (fish) security and improved nutrition.

Learning Objectives
At the end of this training, participants should:
   i. Have enhanced knowledge on broodstock selection, management and artificial breeding method.
   ii. Be exposed to BMPs in hatchery for increased productivity
   iii. Acquire entrepreneurial skills in business plan development for sustainable hatchery venture
   iv. Gain skills on how to share knowledge with other hatchery operators and fish farmers in their respective areas for increased catfish production.
MODULE 1
1.0. INTRODUCTION

1ai. Learning Outcomes/Learning Activity Bundle
For each learning outcome, prepare prompting questions that leads to participants’ sharing their experience about the intended contents at the end of the module (experiential learning).

1aii. Pre-Evaluation with Feedback
The purpose of pre-evaluation is to assess learner’s behavior (knowledge, skills and attitude) before they start learning. Prepare questions about the content that you intend to provide, and this could be open or close-ended questions. Ten simple questions should be raised on

Pre-evaluation questions
1. Which of the following is not a fish seed?
   (a) Broodstock (b) Fingerlings (c) fry (d) Juvenile

2. How mature should a broodfish be? at what age catfish mature and can be used as a brood fish
   (a) 4 months  (b) 7 months  (c) 9 months  (d) 12 months

3. Optimum temperature for what?? is
   (a) 1°C    (b) 80°C    (c) 11°C    (d) 25°C

4. pH of water for broodstock rearing should range between
   (a) 1-2    (b) 6.5-8.5  (c) 3.5-4.1  (d) 10.5-13.5

5. Which of the following is needed in high amount?
   (a) Ammonia (b) Nitrite (c) Dissolved Oxygen (d) Mercury

6. Which of the following reduces dissolved oxygen in water?
   (a) overcrowding due to high stocking density.
   (b) Crash of algal population.
   (c) Reduction in photosynthetic rate, because of cloudy weather
   (d) Heavy plankton bloom due to excess nutrient.

need to provide all the above option?

7. Broodstock should be fed 1% of body weight per day. True or False

8. What are the general sources of fish seed?

9. What will too much nutrients in the pond water likely cause?
10. What will be the likely response of fish in a water with too low dissolved oxygen?

1.1: Sources of Fish Seed
Availability of quality catfish fingerlings is a major challenge for fish farmers. This is partly due to non-adherence to BMPs for quality fingerlings production. Fish farming starts with stocking of fish seeds that are then grown to desired size or weight. Every farmer wants a breed that grows fast, reaches sexual maturity early and convert feed to flesh more efficiently. Fish seed consist of the following:

- Eggs and Spermatozoa (or fertilized egg)
- Hatchlings – Freshly hatched fish not older than 5 days
- Fry - Hatched fish not older than 6 weeks
- Fingerlings - Hatched fish not older than 8 weeks
- Juveniles - Hatched fish not older than 12 weeks
- Post Juveniles – Hatched fish not older than 15 weeks

Two major sources of fingerlings exist:

i). *Fingerlings from fish hatcheries*. Fingerlings can be obtained mainly through artificial propagation in the hatcheries. Advantages of these are:
- African catfish does not reproduce well in captivity, so artificial reproduction at the hatchery might be the only option
- Broodstock from hatcheries are already adapted to controlled breeding.
- They are genetically improved.
- Genetically improved fish through selection of desired traits in parent stock obtained from hatchery grow faster than those in the wild.
- They are fast growers.
- Scientific study of hybridization is enhanced through hatchery operations.

ii). *Fingerlings from the wild/natural water bodies*. The disadvantages of this are:
- Stunted growth is often common with stocks from the wild.
- They are not adapted to farming conditions. Could introduce pests and pathogens to farms.
1.1.1: Better Management Practices on Fish Seed Sourcing (may be this should come towards the end, once the seed is produced and available in the hatchery)

1. Fish seed should be collected from reputable farms in catfish breeding.
2. There is usually no adequate history on seed sourced from the wild, with uncertainty of fingerlings’ age and doubts on their genetic integrity and vigor.
3. More mature seed such as fingerlings or juvenile should be sourced as they have higher survival rate. Although these might be relatively more expensive than less mature seed, the reduction in mortality will more than compensate for the increased cost of seed. (less mortality).
4. The state of health of seed must be ascertained to prevent losses due to spread of diseases. State of health of fish seeds must be ascertained to ensure there are no abnormalities (deformities, lesions, movement and activities).

1.2: Identification of Male and Female Broodstock

The male and female of the African catfish can be easily recognized.

- Male broodstock can be identified by features in the urogenital area which includes a well pronounced genital (sexual) papilla which tapers to the tip, a nipple-like projection, elongated and located just behind the anus. Sexual papilla is usually red at the tip for sexually ready males (Plate 1).
- Female broodstock has a distinct genital papilla which is flat and more like a mound. The female broodstock also have urogenital septum which separate the genital opening from the urinary opening which gives a slit-like appearance. A sexually ready female has a swollen, usually reddish genital opening (Plate 1).
- A gentle press on the belly of the female fish towards the genital opening will release the ripe eggs indicating the readiness and viability of the female. A view from the top shows a female African catfish with both sides of the belly swollen as shown in Plate 1.
- Males need to be dissected to access the milt sac.
1.3: Better Management Practices in Broodstock Selection Process

1. Fish as offspring from the same parents or close relatives should not be interbred. It leads to inbreeding depression and reduces genetic diversity which in turn reduces the suitability of the stock. This situation can make it easier for entire stock to be wiped out when challenged by environmental or biological factors.

2. Broodstocks can be collected from fishponds or from natural waterbodies. Caution should be taken for wild stock. Selected broodstock from hatcheries are preferred since they have desired traits and better growth performance.

3. Fast growing fingerlings (‘shooters’ or ‘jumpers’) can be reared up to broodstock size in fishponds. At harvest, such breeders are selected and transferred to the holding unit or to a special brood fishpond.

4. Individual brood fish of 1.0–4 kg body weight and minimum of one year old is preferable. Older fish tend to have more matured eggs which increases hatchability.

5. Size and number of the male broodstocks depend on the number of females required for artificial propagation and number of artificial reproductions per year. The male broodstock should also be 1.0–4 kg body weight and minimum of one year old.

6. In some places wild brooders are captured and used for breeding during the breeding season. They aggregate in or towards shallow spawning grounds or dry season when they are relatively concentrated in their reduced natural habitats especially small pools and streams. However, it is not advisable to source for broodstock from the wild. But
if there are no certified hatcheries in the country to purchase from, catfish broodstock can be sourced from the wild.

7. Specific checks necessary on development of sexual organs before selection of broodstocks include genital papilla with red tip for males. The females have well distended and swollen abdomen (gravid), which when slightly pressed toward the genital papilla, will release ripe eggs.

8. General checks on fish well-being for selection of broodstock include non-existence of wounds on the fish body, absence of parasites and absence of deformity.

1.4: Better Management Practices for Broodstock Management

1. Rearing facility and stocking density: broodstock can be conditioned preferably in earthen pond of 2 m³ volume of water at stocking density of 3 kg-4 kg of fish per m³. Concrete or plastic tanks can also be used, but some fish breeders have observed that the female brooder absorb her eggs in such facilities.

2. The health of the broodfish should be assured by adequate feeding with brooders’ feed of 6-8 mm size (depending on the size of the fish) for a period of 8-10 weeks after fish has been used to spawn before being used again.

3. Separation of the male and the female fish into different holding facilities should be done for catfish to avoid fighting and wounding each other.

4. The following water qualities should be maintained (Table 1):

   • Physio-chemical parameters (water quality management):
   • Dissolved oxygen should not be less than 5mg/l
   • Optimum temperature is 25°C for qualitative and quantitative gonadal development.
   • pH should range between 6.5 and 8.5 (around neutral pH value)
### Table 1: Water Quality Parameters and Management

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Recommended Values</th>
<th>Possible Associated Cause</th>
<th>Possible Effects</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved oxygen</td>
<td>4mg/L (minimum)</td>
<td>• overcrowding due to high stocking density.</td>
<td>• Increased susceptibility to diseases.</td>
<td>• Feeding should be suspended for some time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Crash of algal population.</td>
<td>• Refusal to accept feed.</td>
<td>• Water should be flushed out.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduction in photosynthetic rate, because of cloudy weather</td>
<td>• Gasing for air at the pond surface.</td>
<td>• Replace with fresh water.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heavy plankton bloom due to excess nutrient.</td>
<td>• Crowding near water inflow source.</td>
<td>• Aerate the medium with aerators connected to air supply</td>
</tr>
<tr>
<td>Ammonia (NH₃)</td>
<td>0.05mg/L</td>
<td>• Pollution from sewage.</td>
<td>• Poor acceptance of feed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Over fertilization</td>
<td>• Mortalities occurring daily.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Accumulation of wastes at the pond bottom.</td>
<td>• Gasping for air.</td>
<td></td>
</tr>
<tr>
<td>Nitrite (NO₂)</td>
<td>0.30mg/L</td>
<td>•</td>
<td>• Brown patches on the gills known as brown blood disease.</td>
<td>• Avoid excessive stocking densities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Mortalities of fish due to lack of oxygen.</td>
<td></td>
</tr>
<tr>
<td>Turbidity or suspended clay</td>
<td>5mg/L for fry, 20</td>
<td>• Excessive mucus production on fish body.</td>
<td>• Poor growth.</td>
<td>• Addition of chloride ions e.g Sodium Chloride.</td>
</tr>
<tr>
<td>particles</td>
<td>mg/L for growing</td>
<td>• Gill damage.</td>
<td>• Mortalities.</td>
<td>• Flushing of the system.</td>
</tr>
<tr>
<td></td>
<td>fishes. Or 40cm in</td>
<td>• Limit growth of algae.</td>
<td></td>
<td>• Use adequate stocking density.</td>
</tr>
<tr>
<td></td>
<td>secchi disk.</td>
<td>• Solids may coat egg.</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
oxygen transfer is reduced, hatchability is consequently reduced in hatchery.

- Use of settling tanks.

5. The need to feed broodstock adequately cannot be over emphasized. This is because nutrition impacts gonadal development. Developing embryo and hatchlings depend on yolk sac, which formed in brood fish during embryo development, until feeding on live prey or artificial feeds begins. Because the yolk sac is the only source of food during the first days of the larvae, its quality and quantity are key indicators of successful feeding of the broodstock. Broodstock should be fed with a balanced compounded diet that satisfies the amino-acids, minerals and vitamins and all the other essential nutrient requirements of the fish at that life stage.

6. Broodfish should be fed with broodstock feed containing 40-42% crude protein and a daily ration of 1% of body weight (Table 2). The daily ration can be divided into 3-4 times and fed. Feeding must be stopped when fish stops showing interest to prevent overfeeding. It is better to consider it in number of fish (e.g. 1000 fish) because if considered in weight, the weight of the fish changes as they grow.

<table>
<thead>
<tr>
<th>Feed type</th>
<th>Feed size (mm)</th>
<th>Fish weight (g)</th>
<th>Feed quantity (Kg) per 1000 fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder</td>
<td>0.1-0.3</td>
<td>≤0.3</td>
<td>0.15</td>
</tr>
<tr>
<td>Micro particles</td>
<td>0.5</td>
<td>0.3-1.0</td>
<td>0.42</td>
</tr>
<tr>
<td>Crumble</td>
<td>0.7</td>
<td>1-3</td>
<td>1.2</td>
</tr>
<tr>
<td>Crumble</td>
<td>1</td>
<td>3-10</td>
<td>4.2</td>
</tr>
<tr>
<td>Mini pellet</td>
<td>1.8</td>
<td>10-15</td>
<td>4.0</td>
</tr>
<tr>
<td>Floating Pellet</td>
<td>2</td>
<td>15-40</td>
<td>22.5</td>
</tr>
<tr>
<td>Floating Pellet</td>
<td>3</td>
<td>40-150</td>
<td>91</td>
</tr>
<tr>
<td>Floating or sinking pellet</td>
<td>4</td>
<td>150-900</td>
<td>750</td>
</tr>
<tr>
<td>Floating or sinking pellet</td>
<td>5 or 6</td>
<td>900-1500</td>
<td>660</td>
</tr>
</tbody>
</table>
7. Non-ingested food and fecal deposits should be washed out daily by removing and replacing 20% of the water volume. Algal growth on the walls of the troughs should be removed once in every 6-8 weeks by scrubbing.

8. Health management and hygiene: hygiene is one of the most important factors determining the state of health of the broodstock and healthy sexual gametes which may affect offspring health.

9. Hatchery floor should be disinfected weekly and hatchery operator should also disinfect hands before and after cleaning with iodine solution 1-2%.

10. Facilitation methods to be used by facilitators include:
   i. Lecture with audio-visuals
   ii. Brainstorming on issues raised
   iii. Role plays on key issues
   iv. Group discussion and feedbacks in plenary

**1biii. Learning Materials**

Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content.

Sequential narration of module will be accomplished in simple non-technical form.

Facilitation methods to be used by facilitators include:
   i. Lecture with audio-visuals
   ii. Brainstorming on issues raised
   iii. Role plays on key issues
   iv. Group discussion and feedbacks in plenary

**1biv. Output Evaluation with Feedback**

1. Which of the following is a fish seed?
   (a) Papaya seed   (b) Fingerlings (c) Fry   (d) Juvey
2. **Why should broodstock be considered mature only when it has exceeded over a year of age?**

3. **What is the optimum temperature for good performance of catfish broodstock?**

4. **Water pH for broodstock rearing should be**
   - (a) highly acidic
   - (b) around neutral
   - (c) acidic
   - (d) highly alkaline

5. **Which of the following is not essential to good water quality?**
   - (b) phosphorus
   - (b) honey
   - (c) Dissolved Oxygen
   - (d) pH

6. **Which of the following reduces dissolved oxygen in water?**
   - (e) Overcrowding due to high stocking density.
   - (f) Crash of algal population.
   - (g) Reduction in photosynthetic rate, because of cloudy weather
   - (h) Heavy plankton bloom due to excess nutrient. Option for all the above??

11. **Why should broodstock be fed at 1% of body weight per day?**

12. **What are the advantages of sourcing fish seed from reputable farms over the wild?**

13. **What is too much nutrient in pond water likely to cause?**

14. **What will be the likely effect(s) of fish in a water with too high concentration of ammonia?**

**MODULE 2**

**2.0. HATCHERY OPERATION**

2ai. Learning outcome/Learning Activity Bundle

*For each learning outcome, prepare leading questions that leads to participants’ sharing their experience about the intended contents at the of the module (experiential learning).*

2aii. Pre-Evaluation with Feedback

*The purpose of pre-evaluation is to assess learners’ behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide, and this could be open or close-ended. Ten simple questions should be raised on Module 2 Pre-Evaluation with Feedback.*

1. **Which of the following process is correct in terms of order of activity?**
   - (a) Injection with pituitary-Striping-Laying of eggs in the incubating troughs.
   - (b) Injection with pituitary gland -Striping-Mixing the eggs and the milt (fertilization).
(c) Mixing the eggs and the milt (fertilization)-Injection with pituitary gland extract- Striping.
(d) Laying of eggs in the incubating troughs- Striping- Mixing the eggs and the milt (fertilization).

2. Which of the following is not needed during catfish breeding?
   (a) Incubating trough  (b) Cast net  (c) Saline water  (d) Pituitary gland extract

3. What is the colour of good eggs collected from a mature female catfish?
   (a) Red  (b) Black  (c) Golden brown  (d) White

4. How do you recognize the testes of a male catfish after opening it up?
   (a) By its round shape  (b) By its blood-red colour  (c) By its comb-like shape  (d) By its black colour

5. Fungi is more likely to grow on
   (a) broodstock  (b) dead eggs  (c) smoked fish

6. Depending on water temperature the incubated eggs will hatch in about
   (a) 20 to 36 hours  (b) 2 to 3 hours  (c) 2 to 3 days  (d) 40-71 hours

7. Depending on temperature, how long does it take between the time of injection and striping?

8. How do you recognize a gravid female catfish?

9. Why should the female fish be weighed before the process of hypophysation?

10. What is a fish hatchery?

2.1: Definitions and infrastructure Requirements

   i. 
   Hypophysation
   It is the technique of breeding the fish by administering pituitary gland extract injection, also known as artificial or induced breeding.

   ii. 
   Hatchery Definition
   A hatchery is a physical structure, indoor or outdoor that is built for fish reproduction process. Hatchery provides sanctuary for fish seed production and rearing before transfer to nursery ponds or sale. Broodstock meant for hatching are also often kept and maintained in hatcheries. The hatchery environment must be healthy to prevent/reduce infections, diseases and fish mortalities. Temperature and illumination are controlled or regulated in hatcheries. Hatchery
operations demand lots of care for success, especially within the first 2 weeks of hatching. Depending on the technical and managerial skills of the operator(s), hatchery can be a high profit or high-risk venture.

iii. Major Requirements/Infrastructure in Hatchery Operations

- Good and reliable water supply in quality and quantity
- Specified hatchery equipment and chemicals/drugs
- Good broodstocks (fertile and healthy).
- Knowledgeable and skillful operators
- Standard hatchery building with in-door units and out-door structures
- Efficient waste management for environmental health
- Understanding and compliance with bio-security issues
- Water storage tanks
- Hatching/incubating troughs
- Water filter to remove all mineral solids and debris from the water.
- Buckets to transport larvae
- Water testing kit.
- Rectangular or circular fry tanks.
- Fingerlings ponds.
- Pumping machine, aerators, syringes, and

  - hormone to induce egg maturity in the female broodstock

2.2: Injecting the Female Broodstock Fish

Final maturation followed by ovulation can be induced by injecting the fish with appropriate dose of hormone. The success of artificial propagation depends on the size of the female gonad and gonadal maturity. Steps are as follow:

i. When more than 10 females are to be injected, it is advisable to separate them into two separate groups of equal numbers and inject them with time interval of 30-60 minutes. This will allow the operator to have enough time to strip each fish.

ii. Selection of Gravid Broodfish: Weigh the female Broodfish and place her on a firm surface or the work table (Plate 2).
Plate 2: A Gravid Female on a weighing scale

iii. Preparation of Pituitary Hormone

Pituitary gland can be extracted from either male or other female fish (irrespective of the fish species) and stored in ethanol before being used to induce egg maturity in the selected female broodstock (Plate 3).

Procedures:

- The head should be cut, and the upper jaw separated from the lower jaw.
- Clean the palate with soft tissue paper or towel
- Open the palate with a surgical blade
- Open the ridge of bone gently
- The pituitary gland is a whitish tiny round tissue.
- Use a pair of tweezers to remove the pituitary and store in alcohol till use.

This pituitary gland can be dried in methylated spirit prior to use.
There are different hormones available that can be used to induce ovulation in gravid broodstock. Select hormones for induced egg maturation in the female broodstock. A natural hormone such as African catfish pituitary can be used. A synthetic hormone such as Ovaprim or Overtide can also be used (Plates 4). Prescription and dosage are usually given by manufacturer in accordance to the weight of the female fish.
v. For freshly removed pituitary a ratio of 1 kg:1kg for recipient: donor is recommended. If dried, preserved pituitary is to be used, a ratio of 1 kg:1.5 kg for recipient: donor (Plates 5-8).

vi. For synthetic hormones, 0.5 ml of the hormone is usually injected in a 1 kg female fish (Plate 9).

Plate 6: Grind the pituitary to powder solution

Plate 7: Add Saline

Plate 8: Collect the solution and inject the female fish using a hypodermic Syringe
Plate 9: Ovatide, an example of a synthetic hormone can also be used

vii. Cover the fish’s head with a moist towel to reduce agitation and hold against the worktable to make it remain calm during the entire process of injection.

viii. Do not inject the fish on the lateral line, but just below the anterior part of the dorsal fin and above the lateral line by pointing the syringe towards the tail of the fish. Inject above the lateral line with the needle at an angle of 30-45 degrees to body of the fish. The hormone is injected within the fish muscles (Plate 10).

ix. The syringe should be carefully and gently withdrawn. Massage the injected spot with finger to allow even distribution of the hormone into the muscles.

x. Put the injected female broodstock in an isolated tank or bowl of water with enough water to cover half of the body. The fish should be left for about 10 to 12 hours before stripping.
2.3: BMP for Collection of Milt from Male Fish

i. Prepare saline water which is 0.9% salt. This can be prepared by weighing 9g of common salt in 1 liter of water. For best result, distilled water should be used.

ii. Bring out the injected female fish and sedate or kill the male to extract the comb-like testes one hour to two hours before the eggs of the female is ready. Usually only female fish is injected with hormone. Disect the abdomen of the male broodstock with a pair of siccors to expose the milt sac. Care should be take not to damage them. (Plates 11 and 12)
Plate 11: Dissection Male Broodstock for Extraction of Milt Sac for Fertilization

Plate 12: Careful Removal of the Milt Sac

iii. Move the intestine aside to allow ease removal of the testes. Clean the testes of blood smear using filter paper or tissue paper to avoid contact with water as this will inactivate the sperm cells (spermatozoa).
iv. Cut the testicles into bits to release the sperm. Cut or crush the white comb-like testes to release the milt.

v. Either use fresh sperm or add 9% saline water to the milt collected of not more than 2ml to 1 ml of milt.

*Note - The testes should always be removed before stripping of the eggs.*

### 2.4: Stripping the Female Broodstock

- **i.** Carefully bring the female fish out after 10-12 hours depending on temperature. The fish is ready for stripping if the eggs have started coming out of the fish already. This could be detected by sensing base of the tank for eggs. If the fingers crush some eggs at the base, this means eggs are coming out already (the eggs can be said to be running).

- **ii.** Wipe the body of the broodfish with a dry soft towel. Two people might be required during this operation using a wet towel to handle the fish at both the tail region and the head. One person holds the head with a towel while the other holds the tail (Plate 13).

- **iii.** Remove ripe eggs from abdomen by gently pressing several times from the anterior end until a high percentage of the eggs are collected into a dry bowl. Immediately stop pressing when blood is observed on the eggs.

- **iv.** Carefully collect eggs in a clean dry plastic or metallic bowl. It must be noted that ripe eggs are usually uniform in size with a dark spot on the center of the egg which is the nucleus (Plate 14).

- **v.** Weigh the stripped eggs; this makes it possible to estimate the expected fry number. African catfish contains approximately 600 eggs per gram, so the eggs can be weighed for estimation of expected fry number depending on egg hatchability. Alternatively, quantity of eggs can be estimated as 15-20% of the fish body weight.
2.5: Egg Fertilization and Incubation

- Spread the milt (collected milt) on the egg in plastic bowl (Plates 15-17).
- Immediately add saline solution (0.9%) to the mixture of the eggs and the milt in the bowl. This will enhance motility of the milt cells and fertilization of the eggs (Plate 18). This is because saline solution makes the milt last longer before they fertilize the eggs.
Plate 15: Milt extracted in a tube

Plate 16: Milt sac

Plate 17: Spreading of milt on eggs in a bowl for fertilization
Plate 18: Adding and mixing saline solution (0.9%) to the egg

- Saline water elongates the life span of the sperm cells and this makes it possible for all the eggs to receive active milt.
- Addition of fresh water reactivates and makes the sperm cells motile and initiates external fertilization process.
- Continue mixing to prevent eggs from sticking or clogging together (this should be done within 60 seconds). Mix the egg properly for one minute to increase the chances of all the eggs to be fertilized.
- After fertilization, it is expected that the fertilized eggs are incubated in an incubating unit provided.
- The eggs are evenly spread on the spawning mat of mesh size 1.2 by 1.2 mm inside an incubating trough (80-100 litres) prefilled with water and a constant water flow rate of about 1 to 3 litre/minute is allowed to flow through in the incubating unit (Plate 19).
a. Plate 19: Typical Incubation Trough with egg spread in the hatching tray

- Depending on water temperature (greater than 25°C) the eggs will hatch between 20 and 36 hours and the fry emerge.
- The hatching tray is removed after maximum of 36 hours to prevent fungi from attacking the fry since the unhatched eggs on the net will attract the growth of fungi.
- Incubation should be monitored at regular intervals to check overflow of water and subsequent loss of hatchlings.
- The outlet of the incubation system must be screened (mesh size) to prevent the fry from escaping or being washed away.

2bi. **Learning Activity**: Prepare learning activity that leads to discussion, remembering, memorizing, action on Module 2.

2bii. **Facilitation Methods**

Facilitation methods to be used by facilitators include:

v. **Lecture with audio-visuals**
vi. **Brainstorming on issues raised**

vii. **Role plays on key issues**

viii. **Group discussion and feed-backs in plenary**

2biii. **Learning Materials:** Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content

Sequential narration of module will be accomplished in simple non-technical form.

2biv. **Output Evaluation/with Feedback**

1. Estimate the number of eggs in 0.8 kg of eggs
   (a) 480,000 eggs  
   (b) 1,000,000 eggs  
   (c) 48,000,000 (d) 100,000

2. Estimate the number of eggs in a female fish weighing 6 kg
   (a) 540,000-720,000 eggs  
   (b) 1,000,000-1,200,000 eggs  
   (c) 48,000,000-50,000,000  
   (d) 50,000-100,000

3. Which of the following is needed during catfish breeding?
   (b) Incubating trough  
   (b) Cast net  
   (c) Glucose  
   (d) Cutlass

4. A well mature egg has a colour ranging from greenish to golden brown with a visible germinal disc like a dot. True or false?

5. Depending on water temperature of the incubated eggs, how long will it take to hatch?

6. Which of the following is wrong about fungi during breeding?
   (a) Fungi help hatchlings grow faster  
   (b) Presence of fungi has no effect on fry and eggs  
   (c) Fungi kill eggs  
   (d) Fungi serve as feed to hatchlings

7. Differentiate between a male and female catfish.

8. How do you recognize a gravid female catfish?

9. What is a fish hypophysation?

10. Why should the female fish be weighed before the process of hypophysation?
MODULE 3

3.0. BETTER MANAGEMENT PRACTICES (BMPs) IN HATCHERY

3ai. Learning Outcome/Learning Activity Bundle

For each learning outcome, prepare leading questions that lead to participants’ sharing their experience about the intended contents at the of the module (experiential learning).

3aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner’s behavior (knowledge, skills, and attitude) before they start learning.

Pre-Evaluation with Feedback

1. Biosecurity is important for the following reasons except
   (a) It minimizes the risk of project failure
   (b) Reduces viability and leads to eventual loss
   (c) Reduces the chance of disease outbreak
   (d) Reduces the chance of economic losses due to fish loss

2. Which of the following is not a facilitator of disease outbreak?
   (a) Disposure of fry and fingerlings to stress
   (b) Hygiene
   (c) Hatchery equipment
   (d) Visitors

3. Which of the following is not a Better Management Practice in waste disposal in a hatchery?
   (a) Proper treatment and discharge
   (b) Chlorinate and dechlorinate wastewater from sedimentation tanks before discharge.
   (c) Discharge water close to intake point or water source.
   (d) Bury or burn dead fish

4. Qualities of good fingerlings include except:
   (a) Uniformity of sizes; this will prevent early cannibalism
   (b) Vigorous activity and healthy look, i.e. very active and agile
Absence of deformities i.e. look healthy without wounds
(d) Number or quantity

5. Which of the following is not a disinfectant?
   (a) Oxytetracycline
   (b) Formalin
   (c) Chlorinated water
   (d) Potassium permanganate

6. Transportation of fingerlings is best when the weather is hot. True or false?

7. Why are hatchlings not fed for the first 3 days after they hatch?

8. Stress heightens the chance for opportunistic bacteria on fry. True or false?

9. How many times per day should a fry be fed?

10. What do the hatchlings feed on for the first 3 days?

3.1: Management of Hatchlings/Larvae and Fingerlings

i. Siphon the hatched larvae by removing the hatchlings into transportation buckets and transfer them into a different trough. Where there are dead eggs, siphon the larvae by stirring the water so that the dead eggs can come up since they are lighter than the larvae then siphon the larvae. Ensure that the water is oxygen saturated. Siphoning can be manual (mouth-siphoning) or mechanical (pressure tube operation).

ii. The larvae are transported to another tank and left undisturbed for three days. Do not allow flow-through which may disturb the water for this period. Do not feed during this period because the hatchlings/larvae are feeding on their yolk sac.

iii. Transfer the larvae after three days into the fry tanks (Plate 20). By this time, the fry have consumed their yolk sac. Feed them for 5 to 8 days with live food (cultured zooplankton) or other compounded feed for fry.

iv. Fry can be stocked at 50-65 fry per litre

v. Fry must be fed till satiation 6 times a day from 6:00am to 8:00pm. Water supply should be stopped during feeding. Once the fry are satiated and feeding is stopped, water supply must be resumed.
vi. Behavior of fry can be used to detect quantity of feed to be administered. Hungry fry will swim vigorously close to the surface while satiated. Fry gather in clusters on the bottom of the tank with considerably swollen belly.

Plate 20: Flow through Nursery Tank

3.2: Care of Hatchlings /Fingerlings

i. Catfish hatchlings are small and needle like with light green coloured globe yolk sac. At this stage feeding is not required until about three days after absorption of the yolk.

ii. It is required that the shell and unhatched eggs are removed by careful siphoning to prevent ammonia contamination in the water. This will predispose the hatchling to infection by bacteria and fungi.

iii. Aeration is very necessary as fry are very active and require a lot of oxygen. But if mechanical aeration is not affordable, constant water flow-through is very important for aeration, removal of faeces and uneaten food which can easily contaminate the water.

iv. Active feeding commences soon after absorption of yolk sac, at this time artemia or other fry feed available can be given to the fry for about 2 to 3 weeks.
v. This is followed by formulated branded feed of 40 to 45% crude protein until they reach fingerling stage of 6-8 weeks old.

vi. Fingerlings must be properly fed.

vii. Catfish can be carnivorous; it is therefore important for weekly or fortnight sorting to various sizes.

viii. Overstocking lead to high mortality due to higher amount of waste release and consequently higher rate of water pollution and degradation of water quality (Plate 21).

ix. Overfeeding must be avoided. This is one of the main causes of disease outbreak at this stage of development.

x. Minimize stress on fingerlings, opportunistic bacteria infect with ease when fish immunity is low due to stress from transfer.

xi. Health management of fingerlings must be assured. Prolonged exposure of excessive concentrations of toxic substances like CO₂ and NH₃ should be avoided. Preventive as well as curative methods should be promptly employed in managing the health of fingerlings.

Plate 21: Fingerlings in Rearing Trough

3.3: Biosecurity in Hatchery

Biosecurity in hatchery is the establishment and implementation of a system of procedures to prevent introduction of pathogens into fish from outside the farm or from another section within
the farm into the hatchery. Biosecurity involves all activities (sometimes simple and zero cost measures) put in place to prevent disease from occurring or spreading which cost less than treating or trying to control diseases.

Importance of biosecurity:

• It minimizes the risk of project failure
• It prevents high fish mortality
• Reduces the chance of disease outbreak
• Reduces the chance of economic losses due to fish loss
• Customers/ clients will no longer trust the quality of fry, fingerlings or juvenile without biosecurity.

Causes of Disease:

• Fry and fingerlings subjected to stress
• Poor quality feed
• Hatchery equipment
• Visitors (can bring in pathogens and contaminate the system).
• Broodstock
• Infected eggs
• Water source/ contamination

Biosecurity measures to be followed

1. Indiscriminate entrance into the facility increases chances of contamination and transfer of pathogens:
   • Control or restrict entrance of vehicles, visitors, staff, and other disease vectors to prevent transfer of infection.
   • Hand wash and footbath must be present at the entrance of the hatchery.
   • Wheels of vehicles should be disinfected to as they enter.
   • Regular change of disinfectant.

2. Water quality is the most import factor in ensuring fish health and should be managed:
   • Hatchery operators must ensure optimum physical and chemical conditions of water, using reliable instrument to take measurements so that fish is not unduly stressed and predisposed to opportunistic bacterial infection.
• Water used in production must be treated to kill pathogens, using chlorine, ozone, UV, ultrafiltration among others.

3. All hatchery equipment should be properly cleaned and disinfected after use and before any production cycle:
• Maintain a clean work environment and do not take hatchery equipment outside the facility or use them in other places.
• Disinfect all hatchery equipment regularly and dry them thoroughly.
• Flush sand filters and remove the sand to dry under the sun.
• Keep nets and other equipment away from the floor.

4. Quarantine incoming broodstock, juvenile or fingerling incoming from other farms. These could be a vector of disease into the facility. Prophylactic treatment is given to rid the fish of parasites and bacteria before introduction into hatchery facility:
• Prophylactic treatment in hatchery include medicated baths in formalin, oxytetracycline and potassium permanganate.
• Prophylactic treatment can be repeated three to four times within a week.
• It is good to allow flow-through when treatment is not ongoing.
• Fish can be fed when not undergoing treatment.
• Smooth inner surface in tanks allow easy and complete cleaning.
• During quarantine, fish should be closely monitored.
• Apart from quarantine treatment, broodstock should be given regular prophylactic treatment with or without Oxytetracycline at least once in a month.

5. Feeding is one of the most important daily routine which determines fish health, rate of growth and resistance to stress and diseases. It is therefore important to obtain quality pathogen-free feed from a reliable source:
• Keep feed in a cool dry place, away from rats and other animals which can contaminate the feed.
• Do not use fresh feed, except when it has been treated to remove pathogens. Commercial pelletized feeds are usually safe and with low risk.

6. Fish handling: too much handling can stress fish and make them susceptible to pathogen. Hence hatcheries must minimize handling of fish.
• Do not transfer fish more often than necessary and use anesthesia where necessary.
• Except when necessary, avoid removing fish from water or rough handling to minimize mucus loss.
• Avoid overstocking which puts more stress on available resources and consequently on the fish.

7. Improper waste disposal could turn back to affect the hatchery. Waste like dead animals and processing waste can be vectors for transmitting disease into hatchery.
• Proper treatment and discharge must be ensured to minimize the risk of disease within the hatchery or others in the vicinity.
• Release wastewater into sedimentation tanks. Chlorinate and dechlorinate wastewater from sedimentation tanks before discharge.
• Do not discharge water close to intake point to avoid water source contamination.
• Bury or burn dead fish to prevent spread of disease.

3.4: Qualities of Good Fingerlings
The viability of the seed highly depends on nutrition of the brood stock. Nutritional components in the diet, feed intake rate or the feeding period can affect spawning, egg and larval quality. Good quality may be determined by visual assessment or more technical assessment. Holding facility for fingerlings in the hatchery must be clean without foul smell

Qualities of good fingerlings include:
• Uniformity of sizes; this will prevent early cannibalism
• Vigorous activity and healthy look, i.e. very active and agile
• Absence of deformities i.e. look healthy without wounds
• Bright colour
• Accept at least 2mm extruded and compounded pellet feed
• Non-Occurrence of mortality at collection point
• No stomach protrusion or wounds on body. Hemorrhages, spots, cysts, presence of discoloured patches on body, gills and fins are signs of diseased fingerlings and such stock or pond must be avoided.
• Good growth and efficient Feed Conversion Ratio (FCR) may take a week or more to determine. The FCR is a measure of amount of flesh gained from a quantity of feed consumed. For fish of the same age a higher FCR means low efficiency of feed conversion
3.5. **Fingerlings Production**

1. Water quality is important for good hatching and larvae survival. If using borehole water, filter water to remove all heavy metals during hatching.
2. Syphon larvae into a clean environment after hatching and don’t disturb them for three days. No flow through for three days.
3. Grow larvae inside controlled environment for at least 5 days before putting them into earthen ponds. They will be big enough to eat up eggs of predators in the water.
4. Prepare ponds the day before stocking with fry to avoid predators in the pond. The fry are able to compete with the incoming predators and eat up their eggs and small insects. Use hydrated lime, 2000 kg/hectare for highly acidic soil or pond, 1200 kg/hectare for acidic soil or pond, 1000 kg/hectare for slightly acidic soil or pond, 400 kg/hectare for neutral soil or pond. Formalin or chlorine can also be used.
5. If using water from river, treat the water with formalin or potassium permanganate before stocking with fry to control diseases. Formalin can be applied again after 10 days. Mix the water with water from a pre-fertilized pond if necessary. No flow through is necessary.
6. Earthen ponds with concrete wall reduce the presence of predators by 50%. Use aerators in these ponds if over stocked.
7. Grade fingerlings after two weeks in the pond.
8. Hybrid fingerlings (Hetero-Clarias) have the best performance in terms of growth.
9. Big earthen ponds are more adaptable for fingerlings production than small earthen ponds.
10. The structure uses three industrial boreholes for its water supply. The borehole water is treated in tanks (main problem is water hardness and presence of bacteria) before sent into the indoor farm.
11. After hatching, the fry are grown to 1g in a concrete, plastic or Re-Circulatory Aquaculture System (RAS) tanks. They are transferred into concrete flow-through tanks outside till 50g, then transferred into out-door earthen ponds to grow till 500g and above after 3-4 months of rearing. Most of the juvenile in Nigeria are grown in earthen ponds.
3.6.  **Transportation of fingerling**

Transportation of fish can be a very stressful process for fish which may lead to losses by mortality or increased cost of production or eventual mortality due to diseases. Fingerlings usually come from hatcheries which are often located far away from the farm of destination. The seed therefore needs to be transported as economically as possible in a healthy condition and without or with minimal mortality.

If fingerlings are to be transferred from hatchery to another farm, then the following precautionary measures should be adhered to by fish breeders:

- Fish farmer should prepare pond before procurement of fingerlings
- Transport in airy vessels/vehicle and drain off the transport water on arrival and infuse container with recipient pond water
- Over long distances of 5-6 hours transport, refresh the water
- Avoid contact of vessel with petrol/chemicals during transport
- Avoid bad roads to prevent stress
- Transport at cool time to prevent heating up
- Add salt solution (5g/litre) to the transport container for 5-10 minutes as anti-stress.
- Gently lower container and allow fish swim to pond (acclimatization)
- Don’t feed fingerlings until after 3 hours of transfer to new pond.
- Handle fingerlings with care, they are tender

**Fish seed transportation:**

1. Fish seed should be preconditioned in hapa to reduce handling stress at point of transportation.
2. Fish seed should not be fed the day preceding the transportation, to allow the gut to be empty, hence, water pollution is reduced, and oxygen demand is kept at barest minimum
3. The period for which the seed should be conditioned depends on size of the seed, prevailing temperature and the duration of transport involved.
4. The fry needs to be conditioned for a minimum of 3 hours, early fingerlings (35-50 mm) for 6 hours, advanced fingerlings (80-100 mm) for 9 hours and juveniles (150 mm) for 12 hours.
5. Modern methods involve packing the fish in plastic bags filled with 1/3 water and 2/3 oxygen. The plastic bags are then kept in containers to prevent puncturing.
6. Before the fingerlings are packed give them a bath in a solution of potassium permanganate (2-3 ppm) or common salt (0.3%).

7. Check the plastic bags for any leakage and keep them in clean container with a lid to close it. Put cloth or used newspaper between the bags and the wall of the container and at the bottom to provide insulation from heat.

8. Fill the bags with water from the same source as the seed. However, if the water is rich in plankton or is turbid, avoid it and use clean agitated well water instead.

9. Tap water should not be used unless kept for 2-4 hours and well agitated to drive off the chlorine. Any water that is rich in iron and poor in oxygen should not be used.

10. Pack the seed either in the morning or evening to avoid increase in metabolic rate due to temperature.

11. The bag is filled with 6 liters of well-agitated clean water before the seed is put in.

12. Before the seed is put in the bags, it is first graded through a sieve to sort out the fry or fingerlings of uniform size.

13. At least three random samples of seed are taken using a perforated cup at the base. They are counted separately, and the average of the 3 samples taken. This gives the number of seed the cup can carry. This method saves time and reduces the stress fingerlings are exposed during counting.

14. Put the required number of seed into the bag. Twist the upper part of the bag to expel all the air above the water level.

15. Insert the tube from the oxygen cylinder into the bag. Oxygen is released by turning the key on the cylinder. Allow the bag to inflate.

16. When the bag is fully inflated, turn off the oxygen supply and remove the tube. Twist the top of the bag two or three times and it to prevent any leakage of oxygen. Tie it tightly with a fine cotton, jute or nylon rope.

17. This process needs to be done as fast as possible and the containers put in the vehicle for transportation to it destination.

18. The containers must be handled with care and kept in the shade during the day.

19. They should be transported during morning or evening, but if the distance to be covered is 4-6 hours or more, they should be transported at night.
Remember to check the fish during transport and keep them cool. When you transport fish to the destination, make sure the temperature in the bag has a chance to become the same as that in the pond, then release the fish gently into the pond.

3bi. Learning Activity: Prepare learning activity that leads to discussion, remembering, memorizing, action on Module 3.

3bii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raised
iii. Role plays on key issues
iv. Group discussion and feed-backs in plenary

3biii. Learning Materials: Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content.

Sequential narration of module will be accomplished in simple non-technical form.

3biv. Output Evaluation/with Feedback:

1. Prolonged exposure to excessive concentrations of one of the following is toxic or problematic for fingerlings
   (a) Carbon dioxide   (b) Oxygen   (c) Suspended solids   (d) all of the above

2. Facilitators of disease outbreak are all except one
   (a) Water source/ contamination
   (b) Infected eggs
   (c) Disinfection
   (d) Broodstock

3. Qualities of good fingerlings include the following except:
   (a) Vigorous activity and healthy look,
   (b) Absence of deformities
   (c) Lethargy
   (d) Number or quantity

4. Why is biosecurity important?
(a) Reduces the chance of disease outbreak
(b) Reduces fish immunity to pathogens
(c) Reduces efficiency of feed
(d) Exposes the fingerlings to toxins

5. Should equipment be shared between tanks? If equipment is shared, what should the farmer do not to break biosecurity?

6. Does a good feed efficiency translate to good feed conversion ratio (FCR)?

7. Why is feeding fresh feed to fish discouraged?

8. Fry should be fed with feed a minimum crude protein of what?

9. Give reasons why fish should not be fed the day preceding the transportation,

10. For how long should fish be prior to transportation?

**MODULE 4**

4.0. FISH HEALTH AND DISEASE MANAGEMENT

4ai. Learning Outcome/Learning Activity Bundle

*For each learning outcome, prepare leading questions that leads to participants’ sharing their experience about the intended contents at the of the module (experiential learning)*

4aii. Pre-Evaluation with Feedback

*The purpose of pre-evaluation is to assess learner’s behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide, this could be open or close-ended. Ten simple questions should be raised on Module 4.*

**Output Evaluation/with Feedback**

1. Which of the following is needed in fish seed pond water where phytoplankton are growing?
   
   (b) Carbon dioxide (b) Oxygen (c) None of the (d) All of the above

2. Sources of disease outbreak are all except one

   (e) Water source/ contamination

   (f) Infected eggs

   (g) Disinfection

   (h) Broodstock

3. Qualities of good fingerlings include the following except:
(e) Vigorous activity and healthy look,
(f) Absence of deformities
(g) Lethargy
(h) Number or quantity

4. Why is biosecurity important?
   (a) Reduces the chance of disease outbreak
   (b) Reduces fish immunity to pathogens
   (c) Reduces efficiency of feed
   (d) Exposes the fingerlings to toxins

5. Should equipment be shared between tanks? If equipment is shared, what should be done by the farmer in order not to break biosecurity?

6. Mention two broad types of parasites?

7. Why is feeding fresh feed to fish discouraged?

8. What is a secondary infection?

9. Give reasons why fish should not be fed the day preceding the transportation,

10. How long should fish be starved before transportation?

4.1. Factors Affecting Fish Health

Fish health management is a term used in aquaculture to describe management practices that are designed to prevent fish infections and diseases, and to control diseases in cases of occurrences. Once fish get sick, it can be challenging to rescue them (Figure 1). Successful fish health management begins with prevention of disease rather than treatment. Prevention of fish disease is accomplished through good water quality management, nutrition, and sanitation.
Daily observation of fish behavior and feeding activity allows early detection of problems when they do occur so that a diagnosis can be made before majority of the population becomes sick. Treatment will be successful if it is implemented early following the occurrence of a disease while the fish stock is still in good shape.

Fish disease is significant to aquaculture because it leads to substantial economic loss due to effect of parasitic activities (Plate 22). Production costs are increased by fish disease outbreaks because of loss of fish (mortality), cost of treatment, and decreased growth during recovery. In nature we are less aware of fish disease problems because sick animals are quickly removed from the population by predators. In addition, fish are less crowded in natural systems than in captivity or culture system.
4.2. Types of Fish Diseases

Diseases can result in economic losses and reduction in market value of fish. There are two major categories of diseases: infectious and non-infectious diseases.

Infectious diseases are caused by pathogenic organisms present in the environment or carried by other fish species. They are contagious diseases, and treatment may be necessary to control the disease outbreak. Infectious diseases are broadly categorized as parasitic, bacterial, viral, or fungal diseases (Figure 2).

Non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic anomalies. They are not contagious and usually cannot be cured by medications.
Figure 2: Biotic Factors that Affects Fish Health

1. Infectious Diseases

i. Parasitic diseases of fish are frequently caused by small microscopic organisms called protozoa which live in the aquatic environment. There are several classes of protozoans which target the gills, gut, skin thereby causing irritation, weight loss, and even death in severe cases death. Most protozoan infections can be controlled by the use of standard fisheries chemicals such as copper sulfate, formalin, or potassium permanganate.

There are broadly two types of parasites:

- Ectoparasite: these are organisms that live on the skin of another organism called a host, from which they derive their food. This process in which they derive food and or protection is at the detriment of the host capable of costing its life. Examples of ectoparasites of the African catfish are *Ichthyophthirius multifiliis* (Ich or fish louse), Gyrodactylus and Trichodina.

- Endoparasite: these are organisms that live on the inside of another organism called a host, from which they derive their food. They exist in two forms: intercellular
parasites and intracellular parasites. Intercellular parasites are those that inhabit the spaces of the body of the host such as nematodes, tapeworms, and other helminthes. Helminthes live in the gut of their hosts. Intracellular parasites are endoparasites that live within the cell of the host such as protozoan.

ii. Bacterial diseases are often internal infections. Bacterial diseases can also be external, resulting in erosion of skin and ulceration. Columnaris is an example of an external bacterial infection which may be caused by rough handling. Bacterial opportunistic pathogens are microorganisms causing disease in hosts predisposed to environmental stressors or reduced immune function. Stress factors like hypoxia, abnormal pH, and high population density, high ammonia concentration etc. makes it possible for the opportunistic pathogens to thrive. Typically, fish infected with a bacterial disease will have hemorrhagic spots or ulcers along the body wall and around the eyes and mouth. They may also have an enlarged, fluid-filled abdomen, and protruding eyes. Most bacteria infection are seen when the fish immune has been compromised or when a parasitic infection has opened the way, this makes these bacteria in such cases to be secondary infection.

iii. Viral diseases are difficult to distinguish from bacterial diseases without special laboratory tests. They are difficult to diagnose and there are no specific medications available to cure viral infections of fish. Consultation with an aquaculture or fish health specialist is recommended if you suspect a bacterial or viral disease is killing your fish.

iv. Fungal spores exist freely in the aquatic environment, but only affect unhealthy fish. Healthy fish tend to be immune. When fish are infected with an external parasite, bacterial infection, or injured by handling, the fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cotton-like growth or may appear as brown matted areas when the fish are removed from the water. Formalin or potassium permanganate are effectively used to treat most fungal infections. Since fungi are usually a secondary problem it is important to diagnose the original problem and correct it as well.

2. Non-infectious diseases

These are broadly categorized as environmental, nutritional, or genetic. Environmental diseases are the most important in commercial aquaculture. These include low dissolved
oxygen, high ammonia, high nitrite, natural or man-made toxins in the aquatic environment. Proper techniques of managing water quality will enable producers to prevent most environmental diseases.

3. **Quick Signs observed when your Fish is Sick**

The most obvious sign that something is wrong within the culture system is the presence of dead or dying fish. This is because a careful observer would notice a change in the behaviour before mortalities begin (Table 3).

Quick signs are when:

- Fish stop feeding. Healthy fish should eat actively if fed at regularly scheduled times.
- The entire stock or a few may appear lethargic or sluggish.
- Fish observed hanging listlessly in shallow water, gasping at the surface, or rubbing against objects indicate something may be wrong. These behavioral abnormalities indicate that the fish are not feeling well or that something is irritating them.
- The presence of sores (ulcers or hemorrhages)
- Ragged fins
- Abnormal body shape (i.e., a distended abdomen or "dropsy" and exophthalmia or "popeye")

When these abnormalities are observed, the fish should be evaluated for parasitic or bacterial infections.

### Table 3: Characterization and Differentiation of Sick and Healthy Fish

<table>
<thead>
<tr>
<th>Fish condition</th>
<th>Healthy fish</th>
<th>Sick fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escape reflex (Determined in water)</td>
<td>Fish react to any external stimuli like sound or vibration</td>
<td>Lose ability to react to any stimuli and they are easily caught</td>
</tr>
<tr>
<td>Defensive reflex</td>
<td>Toss about and flab about when laid on a table</td>
<td>sluggish and remain motionless</td>
</tr>
</tbody>
</table>
Tail reflex | Show the caudal fin stretched in fan shape | Hang the caudal fin vertically downward.
Ocular reflex | Fish try hard to keep the eyeball in normal position. | Fish lose this reflex.

4.3 What to Do if Your Fish are Sick

If you suspect that fish are getting sick, the first thing to do is check the water quality. Low oxygen is a frequent cause of fish mortality in ponds, especially in the summer. High levels of ammonia are also commonly associated with disease outbreaks when fish are crowded in vats or tanks. In general, check dissolved oxygen, ammonia, nitrite, and pH, during a minimum water quality screen associated with a fish disease outbreak. The parameters of significance include total alkalinity, total hardness, nitrate (saltwater systems) and chlorine (if using city water).

Daily records are very important as it will be a reference point to trace what may have gone wrong and for general management. The record should include the dates fish were stocked, size of fish at stocking, source of fish, feeding rate, growth rate, daily mortality and water quality. Good records include also a description of behavioral and physical signs exhibited by sick fish, and results of water quality tests. These will provide a complete case history for easy diagnosis and information about management and prevention of future cases.

4.2 Some Common Catfish Disease observed in Fish

Most of these diseases do not infect catfish only; they also affect other species.

**Enteric Septicaemia of Catfish**

Enteric septicaemia of catfish, or Hole in the Head disease is caused by bacterium *Edwardsiella ictaluri*, which belongs to the family Enterobacteriaceae. A highly infectious bacteria disease, the Ictaluridea, Plotosidae, Claridea, Siluridae, Pangasiidae, Ariidae and ictalurids families of catfish are affected.

**Diagnosis and Control**

Infected fish often show lethargic swimming, abnormal behavior alternating listlessness and chaotic swimming, disorientation and swimming in spirals. A loss of appetite and
protruding the head from the water are also seen. Gross pathological signs in the chronic encephalitic form are:

- Swelling on top of the head, occasionally progressing to the erosion of connective tissue and exposure of the brain (a hole in the head).
- Granulomatous inflammation of the brain

Gross pathological signs in the acute Enteric septicaemia are:

- Pale gills
- Darkening of the skin (observed in species other than channel catfish).
- Multiple small white spots on the skin.
- Raised skin patches progressing to shallow ulcers on the flanks and head

- Hemorrhage at the base of the fins, around the mouth, and on the throat, operculum (gill cover) and abdomen
- Exophthalmos (popeye)
- Swollen abdomen (pot-belly)
- Ascites (fluid in the abdominal cavity)

**Columnaris**

Columnaris is caused by Flexibacter columnaris. Stress predisposes fish to this infection. Outbreaks generally result from temperature fluctuations, trauma from poor handling especially in younger fish, and poor water quality, crowding and poor nutrition increases severity of the disease.

**Diagnosis and Control**

Infected fish generally show lethargy, anorexia, weak swimming, and mortality. Raised white patches appear on the skin or fins and may later develop into ulcers. Certain antibiotics, copper sulfate, and potassium permanganate are reported to be effective for temporary treatment.

**Trichodina (parasitic disease put in the middle of bacterial disease discussion), bring it under parasitic**

Trichodina is a protozoan parasite that has severely affected production at many facilities. It can result in extremely high mortality rates, particularly in young fish. The parasites heavily infest the gill and body surfaces of infected fish.
**Diagnosis and Control**

Infected fish display flashing (swimming against floors of tanks to scrape parasites off), rapid breathing, weakness, and uncoordinated swimming. Since it attacks the gills, the gills are less efficient in absorbing oxygen, realizing carbon dioxide, excreting ammonia, and maintaining chemical balance between their body and the environment.

Trichodina can be temporarily controlled with copper sulfate and salt. Treated fish remain carriers even after treatment, and much like Streptococcus, it is nearly impossible to eliminate Trichodina from a system once it has been introduced. Any fish outdoor ponds or other farms should be carefully examined for Trichodina before letting them on your premises.

**Aeromonas**

Another bacterial disease that has significantly impacted production in farms is the disease Aeromonad septicemia ("Aeromonas"). This disease is caused by the bacteria *Aeromonas hydrophila*.

**Diagnosis and Control**

*Aeromonas* results in the clinical signs of generalized hemorrhagic septicemia such as lethargy, weakness and loss of appetite. Other signs are red discoloration at the anus and the base of the fins, hemorrhagic eyes, gills, internal organs, and muscle, blood tinged abdominal fluid, and swollen kidney, spleen, and liver. *Aeromonas* generally affects systems that have systemic poor water quality or over-crowding. *Aeromonas* temporarily responds to antibiotic therapy, but if a farm has *Aeromonas*, they really need to either change their source of fish seed or improve the farm’s husbandry. Always avoid getting fish from infected stocks at all costs.

### 4.6. Environmental and Nutritional Deficiencies

#### 4.6.1 Environmental Deficiencies

**Oxygen Depletion**

Oxygen depletion, or hypoxia, is a common effect of eutrophication in water. The direct effects of hypoxia include mortalities especially in fish that need high levels of dissolved oxygen. Low dissolved oxygen can result in high mortality of fish seeds and consequently serious financial consequences for commercial fish operations.
Signs of Pond Oxygen Depletion

Sometimes fish farmers may be confused on differentiating when catfish comes to the surface due to low dissolved oxygen and when its just normal swimming. When the water system is normal, the fish darts back and forth the surface, but when it is due to dissolved oxygen, they tend to be slow and seem to be in a hanging position. Although fish when fully fed, can show such behavior, this is therefore important for the farmer to distinguish fish hanging because they are fully fed and those hanging due to low dissolved oxygen.

- Fish gasping at the surface of a water are likely oxygen starved (Plate 23).
- Foul odours in poorly oxygenated ponds, decaying vegetation, excess fish waste, and other organic matter can emit distinct smells.

Plate 23: Catfish Gasping for air at the surface of the water

Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity.

Low phytoplankton density in ponds means less food and dissolved oxygen (DO) for the fish. On the other hand, too much (algal bloom) lead to minimized sunlight penetration causing algal deaths. Less phytoplankton and decomposing plankton also lead to less food and DO for the
fish. Good water quality therefore means water with the required plankton level. Visibility in a pond with the right plankton density should be about 30 cm (Plate 24).

Plate 24: Monitoring Pond Turbidity

**Fish production can be greatly affected by excessively low or high pH**

Extreme pH values can kill your fish. Growth of natural food organisms may also be greatly reduced. The critical pH values vary according to the fish species, the size of individual fish and other environmental conditions.

Purpose of measuring the level of unionized ammonia is to manage pond pH:

- Above 8.5 at sunrise, you can use acid fertilizers.
- Below 6.5 (at sunrise), use lime and alkaline fertilizers

4.4.2 Diseases Due to Nutrient Deficiency or Irregularities

(a) Dietary Essential Amino Acid (EAA) deficiency and Toxicity

Poor feed formulation due to the use of disproportionate amounts of feed proteins with natural specific deficiencies of Dietary Essential Amino Acid (EAA) deficiencies may arise from excessive heat treatment of feed proteins during feed manufacture. Nutritional pathologies also arise from the consumption of feed proteins containing toxic amino acids. Some feed proteins
contain toxic amino acids which have impacts negatively on fish growth and efficiency. It may lead to eventual fish death. There are toxicity symptoms of scoliosis, deformed opercula, scale deformities, scale loss, and spongiosis of epidermal cells. These occurs when dietary content of leucine is over 13.4%. Some general symptoms of protein deficiency are dorsal or caudal fin erosion, cataract, decreased carcass lipid content and renal calcinosis.

(b) Dietary Essential Fatty Acid Deficiency and Toxicity

When fish is fed with feed deficient in EFA, they tend to display reduced growth and poor feed efficiency. This can be due to poor feed formulation or from the use of live food organisms that are deficient in EFA. Dietary excess of EFA may exert a negative effect on fish growth and feed efficiency. Cyclopropenoic can be toxic to fish. It is a toxic fatty acid found in the lipid fraction of cottonseed products. This toxic FA can reduce growth rate, result in extreme liver damage, it increases glycogen deposition and decrease protein content, and a decrease in activity of several key enzymes.

(c) Hypervitaminosis and hypovitaminosis

Hypervitaminosis in fish is a condition that occurs when the fish has accumulated too much vitamin in their body. It is caused by fat-soluble vitamins because they are stored in the fish body longer than the water-soluble vitamins. Under certain conditions it is so high that it results in a toxic condition. Such fat-soluble vitamins are Vitamin D and A. Most recorded cases of hypervitaminosis in fish occurred under experimental conditions and are hardly found to occur under normal catfish culture conditions.

Hypovitaminosis on the other hand, is vitamin deficiency which may be caused by inadequacies in nutrients, malabsorption of nutrient from feed, presence of dietary anti-vitamin factors, dietary antibiotic addition or effects of pharmacological agents, and abnormalities of vitamin metabolism or utilization in the metabolic pathways, feed processing and storage. Fish with vitamin deficiency can have symptoms such as scoliosis, lordosis, reduced growth/wound repair, internal/external haemorrhage, caudal fin erosion, exophthalmia, anaemia and reduced egg hatchability.

(d) Dietary essential mineral deficiency and Toxicity

Minerals can either be macro minerals (minerals needed in large quantities) or microminerals (minerals needed in minute quantities but are equally very important in diet). Deficiency in
minerals can lead to problems in physiological functions within the fish. Some symptoms of deficiency of minerals in fish are skeletal deformity, abnormal calcification of bones, cranial deformity, reduced growth, poor feed efficiency, bone demineralization, low carcass ash, Calcium and Phosphorus, anaemia, anorexia, sluggishness and muscle flaccidity. Toxicity of minerals in fish are usually associated with the use of unconventional dietary feed ingredients which may have heavy metal contaminants. Some of such contaminants include copper, lead, cadmium, mercury, arsenic and lead.

4bi. Learning Activity: Prepare learning activity that leads to discussion, remembering, memorizing, action on Module 4.

4bii. Facilitation Methods:
Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
   i. Brainstorming on issues raise
   ii. Role plays on key issues
   iii. Group discussion and feed backs in plenary

4biii. Learning Materials: Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content.
Sequential narration of module will be accomplished in simple non-technical form.

4biv. Output Evaluation with Feedback
1. Which of the following is not an internal factor that affect fish health?
   (a) Cleaning    (b) Geology    (c) water exchange    (d) maintenance

2. Which of the following is not a type of disease?
   (a) Fungi    (b) Symbiosis    (c) bacteriophage    (d) Virus

3. Which of the following is not a sign of sickness in fish?
   (a) Voracious feeding
   (b) Gasping at the surface
   (c) Abnormal body confirmation
   (d) The entire stock or a few may appear lethargic.

4. Are parasites primary or secondary problems?
5. What would you recommend to a fish farmer with a pH problem reading above 9 in the morning?
6. What is/are the effect(s) of diseases in fish?
7. What is the remedy for water pH below 6.5?
8. Is the statement below right or wrong?
   Some fish diseases are infectious while others are not infectious.
9. Which of the following is not an external factor that affect fish health?
   (a) Geology   (b) Sewage   (c) Soil   (d) Virus
10. Potassium permanganate can be used to control water turbidity. True or false?

There should be more clear demarcation between module 3 and 4. In module 3 also you touch up some biosecurity aspects. Module 4—should only focus on describing key parasitic, bacterial and other diseases in catfish hatcheries (from broodstock ---- to fingerlings??)

MODULE 5
5.0. BUSINESS PLAN
5ai. Learning Outcome/Learning Activity Bundle
For each learning outcome, prepare leading questions that leads to participants’ sharing their experience about the intended contents at the of the module (experiential learning).
5aii. Pre-Evaluation with Feedback
The purpose of pre-evaluation is to assess learner’s behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide, this could be open or close-ended. Ten simple questions should be raised on Module 5

Pre-evaluation questions
1. What is capital?
2. What is a loan?
3. What is a grant?
4. Why is it important to have/prepare a business plan?
5. What is a brand?
6. What are market demographics?
7. What is competition?
8. What is market segmentation?
9. What is profit?
10. What is a business profile?

5.1. Purpose of Business Plan
A business plan is a step by step blueprint of how you will operate your business. It provides direction for every decision made. Primarily, a business plan has two main purposes. First, it is used to run a company/business with a clear and more consistent vision. Second, it is required to facilitate access to funding such as loans and grants for business.
A business plan is used to manage an organization/business by stating the goals, how they will be achieved and when. The plan will also summarize details of the business and why it exists. It serves as a point of reference to partners, investors, employees and management to assess progress regarding its objectives.

5.2. Business Profile
A business profile is a list of basic details about a company which emphasize the strength of the company to prospective clients and customers. It is a form of résumé for the company. A business profile tells about a company’s values, objectives, services, and products and current status.
A simple business profile format includes:

- Business Name
- Head Office Address
- Phone Number
- Website Address
- Company Status
- Contact Information of the Person in Charge (name, phone, email address)

5.3. Organization and Products
Business organization details include:

- Date of registration and commencement of business
- Main areas of activity of business
- Main product lines
- Main services
• Principal customers in industries and across geographical boundaries
• Business capacity in terms of:
  - Human resources - Business organization and number of employees
  - Financial - Financial circumstances of business (Optional)
  - Technical - Company capacity for project in terms of staff qualifications/certification.
  - References to success stories in a similar project.

5.4. Description of Management Team

The management team is the group of individuals that organize the business strategy and ensure business objectives are met. They operate at the higher level of an organization and are responsible for day-to-day managing of other teams or individuals. The description of a management team should help third parties to recognize what sets the business apart.

5.5. Market Analysis

Market analysis is a qualitative and quantitative assessment of a market’s attractiveness and its dynamics such as market size (volume and value), buying patterns or preferences of customers, degree of competition, economic environment including demand and supply forces, and various customer segments. Market analysis helps to gain an insight or understanding of potential customers and competitors and is therefore useful in identifying a niche for the business or in developing a marketing strategy. The process involves the following:

1. Demographics and Segmentation: Market demographic segmentation is the division of the market according to age, race, gender, family size, religion, ethnicity, education and income. They provide direct information on market size, target market and market need. The first step in the process of market analysis is measuring the market size. Market size refers to the maximum total number of sales or customers your business has or the total potential number of customer or sales in a given year. Measurement of market size can take two approaches - volume and value. Volume deals with the number of customers while value is the estimated monetary worth of the proposed business. The number of customers available to buy fish in an area can be compared with the value they attach to fish in that area.

If in an area, 100 small catfish farms (potential customers) are willing and capable of buying catfish fingerlings at the price of ₦15 per fingerling, while in another area, 2
small catfish farms (potential customers) are willing and capable of buying catfish fingerlings at the price of ₦30 per fingerlings. It may be better to establish in the first area where there is a larger volume. Though smaller value and with higher competition, there seem to be a chance of a more stable and accessible market.

2. Target Market: is the group of potential customers a company wants to sell its products or services. No one can effectively target everyone; therefore, it is wise to target a niche market which enables small businesses to compete with large established ones.

3. Market Need Assessment: involves knowing why customers buy the product. If customers buy catfish fingerlings because they grow fast, it may differ from if they bought catfish fingerlings because of the price, health, resistance to diseases or other factors.

4. Identify competitors’ strength and weaknesses, which your company could use to better position itself in the market. Competition between companies selling similar products and services are daily occurrence in business. A quick way to do the market analysis is to compare your competitors with your business using a simple table containing some important drivers of demand (Table 4). Differentiation can be made by size of seed and discount offered. This will give a reasonable view of businesses you are competing with and will enable you find your competitors’ weaknesses which your company could use to better position itself in the market.

**Table 4: Hypothetical Competitors’ Analysis**

<table>
<thead>
<tr>
<th>Company</th>
<th>1st competitor (Sales of fingerlings)</th>
<th>2nd competitor (Sales of Juvenile)</th>
<th>3rd competitor (Sales of Heteroclarias fingerlings)</th>
<th>My company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>₦ 100,000</td>
<td>₦ 150,000</td>
<td>₦ 700,000</td>
<td>₦120,000 (first year target)</td>
</tr>
<tr>
<td>Employees No.</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Size</td>
<td>1farm sales</td>
<td>1 farm</td>
<td>1farm</td>
<td>1farm</td>
</tr>
<tr>
<td>Price</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Average</td>
</tr>
<tr>
<td>Quality</td>
<td>Average</td>
<td>Low</td>
<td>Low</td>
<td>Superior</td>
</tr>
<tr>
<td>Delivery</td>
<td>Free</td>
<td>No</td>
<td>₦1,000</td>
<td>Discounted</td>
</tr>
</tbody>
</table>
5. Barriers to Entry: barrier to entry are obstacles or hindrances that make it difficult for a new company to enter an existing given market. Analysis of barriers will answer two main questions:
   i. What prevents new entrants from coming in and taking off a good percentage of your customers?
   ii. What makes you think you will be able to break the barriers and successfully enter the market?

There are many barriers to entry. Some of the barriers to fish seed production business are:

- Investment: fish seed production is capital intensive, and this is a barrier to many who would have entered the industry.
- Location/Geographical: the inability to secure a good or suitable location for fish seed production and other factors that determines a successful enterprise
- Brand loyalty: consumers’ attachment to existing fish seed producers or their products
- Brand cost: a huge marketing cost is needed to receive certain level of recognition
- Economies of scale: existing fish seed producers benefiting from lower average cost due to scale (size) of production. Inputs can be acquired in bulk, hence lowering the cost of production appreciably.
- Being ‘the first mover’: some companies earn a strong position because they are the first to enter and dominate a market.
- Regulations: these are rules and guidelines made by governing bodies to control the way something is done, or the way people behave. A fish seed producer is expected to comply to these regulations that may affect production activities. These regulations vary from one country to another.

5.6. Financial Analysis

Financial analysis is the evaluation of the viability, stability and profitability to justify investing into the business or project. It can be used to build a long-term plan to draw business activities. There are countless methods of financial analysis. In this module we shall use Cost-Benefits Analysis (CBA), Profit Margin and Return on Investment (ROI) using Nigerian example of catfish seed production as shown in Tables 5 and 6 for financial analysis.

i. Cost-Benefits Analysis (CBA): is a process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles. The model is built by identifying the
benefits of an action as well as the associated costs and subtracting the costs from benefits. This is often used in capital budgeting to analyze the overall value of money for undertaking a new project. The CBA produces a ratio: Benefit-Cost Ratio (BCR) which is an indicator that shows the relationship between the relative costs and benefits of a proposed project. It can be expressed in monetary or qualitative terms.

*The Cost-Benefit Analysis Process*

A detailed or exhaustive list of all the costs and benefits associated with the project will be made. The costs involved in a CBA might include the following:

- Direct costs including direct labour involved on the farm, equipment and machineries, seed cost, feed cost and all form of farm inputs.
- Indirect costs are electricity, overhead costs from management, rent, utilities.

If a project has a BCR greater than 1.0, mean that benefits outweigh costs. This implies that the business is feasible and worth investing in. For example, a BCR of 1.20 means that for every dollar spent in costs there is a financial gain of US$20 cents more.

Net Present Value (NPV) is the difference in the sums of discounted benefits and discounted costs. A positive NPV means the project is feasible while a negative one means the project is not worth investing in and the business should not be considered.

*The rule guiding the use of NPV or CBR:*

1. If separate, unrelated projects is being assessed, and the budget for funding the projects is not limited, use NPV or BCR.
2. If separate, unrelated projects is being assessed, and the budget for funding the projects is limited, the projects can be ranked with BCR. NPV should not be used

For small to mid-level capital expenditures, businesses which have short to intermediate time to completion, an in-depth cost-benefit analysis may be dependable for a sensible decision making. For very large businesses with a long-term time horizon, a cost-benefit analysis allows for calculation of the present value of money through discounting. The BCR is computed as a ratio of discounted benefit stream divided by discounted stream of costs. Inflation is accounted for by deflating prices using price indices.
ii. **Profit Margin**: is the amount by which revenue from sales exceeds cost in a business. There are four levels of profit margins.

Profit Margin = \( \frac{\text{Net Profit}}{\text{Revenue}} \)

These are gross profit margin, operating profit margin, pre-tax profit margin, and net profit margin. A company takes in sales revenue, which pays direct costs of the products or services. The cost of the product or service is subtracted from sales revenue. What’s left is gross margin. Advertising, the indirect cost is also subtracted. What is left is operating margin. Interest on debt and any unusual charges or inflows unrelated to the company’s main business are subtracted with pre-tax margin left over. Taxes are paid, leaving the net margin, also known as net income, which is the very bottom line. The Profit Margin:

- Measures the degree to which a company or a business activity makes money, by dividing income by revenues.
- Expressed as a percentage; indicates how much profit has been generated for each dollar of sale.
- Most significant and commonly used is net profit margin, a company’s bottom line after all other expenses, including taxes and other costs have been removed from revenue.
- Used by creditors, investors, and businesses as indicators of a company’s financial health, management's skill, and growth potential.

iii. **Return on Investment (ROI)**: is a financial metric of profitability that is used extensively to measure the profit or gain an investment can realize. The ROI is a simple ratio of the gain
from an investment relative to its cost. It is as useful in evaluating the potential return from a stand-alone investment. It can also be used to compare returns from several investments.

The ROI can be positive or negative. A positive ROI figure means that net returns are good because total returns exceed total costs. On the other hand, negative ROI figure means that the investment produces a loss because total costs exceed total returns. To compute ROI with greater accuracy, total returns and total costs should be considered. It is better to express ROI as percentage because it is easier to comprehend and make deductions from.

**Steps in calculating ROI**

- Compute all costs and all income
- Sum all the costs to generate total cost of production
- Sum all income to generate total income
- To calculate net income, subtract total cost of production from the total income (total income - total cost of production)
- To calculate ROI, divide net income by total cost of production and multiplied 100 (net income/total cost of production x 100),

- Knowledge of the factors to be considered in cost computing is important to prevent omissions.

**Table 6: Return on Investment Analysis of Catfish Fingerlings Production in Nigeria**

<table>
<thead>
<tr>
<th>Feed</th>
<th>Fish (g)</th>
<th>Fish biomass per cycle (kg)</th>
<th>Feed quantity per fish (g)</th>
<th>Feed required for 1000 fish (kg)</th>
<th>Lag (kg)</th>
<th>price/kg (N)</th>
<th>price for 1 kg (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>10.0</td>
<td>0.86</td>
<td>18.4</td>
<td>15.4</td>
<td>0.6</td>
<td>0.7</td>
<td>2.3</td>
</tr>
<tr>
<td>3.5</td>
<td>2.4</td>
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</tr>
</tbody>
</table>

5.7. **Sourcing for Capital/Grant**

A capital-intensive project or business-like catfish seed production is usually difficult to start. This is a barrier to entry. Hence ways of overcoming this challenge must be considered.
If business owners do not have the funds to start or improve an existing business, the other available options are seeking for a grant or getting a loan.

There are many ways to secure the funds required to complete a project:

1. Personal fundraising: the first investor in a business should be you. This can be in form of cash, in-kind or with collateral on assets. This signifies to potential investors that you have a long-term commitment for the project you are embarking on.

2. Partnerships: this is an agreement between two or more parties to advance their mutual interest (sharing management and profits). The partners may be individuals, Non-Governmental Organizations, businesses and Community-Based Organizations.
   - Check if there are other organizations, either not-for-profit or commercial, that could partner with you in sharing the capital costs of the project.
   - Depending on agreement and arrangement, they may join in management (sharing or dividing responsibilities) or they may be passive.
   - It is advantageous when the partners are trained and equipped in different fields because it increases the chance of success.

3. Government or public funding: depends on the country and agricultural policies. There may be grants and subsidies by government for low interest loans expected to boost agricultural production. It will be good to check lists of available grants or loans by government either online or at governmental offices in charge of such funding.

5bi. Learning Activity: Prepare learning activity that leads to discussion, remembering, memorizing and action in Module 5.

5bii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raise
iii. Role plays on key issues
iv. Group discussion and feed backs in plenary

5biii. Learning Materials: Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content.

Sequential narration of module will be accomplished in simple non-technical form.
5biv. Output Evaluation with Feedback: (Prepare evaluation questions based on the content/s you covered; either open- or close-ended). Then prepare answers for learners to check their performance. Ten questions with answers should be prepared based on content of this Module.

Output Evaluation with Feedback

1. Differentiate between loan and grant
2. Is competition an advantage to fish feed business?
3. What are advantages of branding?
4. Identify barriers to entry.
5. What is the safest form of sourcing fund?
6. Enumerate challenges of personal fund sourcing?
7. What is the advantage of partnership funding?
8. List the disadvantages of partnership funding
9. Direct costs include the following except
   (a) Seeds cost (b) Equipment and machineries (c) Feed cost (d) Rent
10. Indirect costs include except
    (a) Seed cost (b) Overhead costs from management (c) Electricity (d) Rent
6.0 PRACTICAL EXPERIENCES FROM CATFISH BREEDERS IN NIGERIA

6.1. FISH BREEDER A

The fish breeder embarks on exclusive catfish breeding producing 7.5 million catfish fingerlings per year using tarpaulin hatching troughs, fibre incubation tanks and circular fry tanks.

6.1.1. Infrastructure

- A borehole with 4 tanks of 5,000 liters capacity for the hatchery
- One hatchery building with 5 hatching troughs (about 20 cm deep) made of tarpaulin with an aluminum sheet below to transmit heat from a gas stove. Two water filters to remove all mineral solids and debris from the water. Buckets to transport the larvae and a small water testing kit.
- Forty 2 m³ fiber incubation tanks.
- Ten 30 m³ circular fry tanks.
- Eighteen 700 m² - 1,000m² fingerlings ponds.
- Several big diesel water pumps to pump water from the river into the ponds.

6.1.2. Procedures

- Treat borehole water in tanks to raise the pH from 6.5 to between 7.5 and 8. Eggs clog together in pH below 7.5. Soda ash is used to raise the pH (28 tablespoons in 5,000 liters). When eggs clog together, only the outer eggs are oxygenated and hatch. A pH of 7.5 maintain the eggs as loose individuals and produces a higher hatchability.
- Make sure the two filters are working to remove the rest of the debris from the water. Eggs stick on any debris and hatchability is low.
- Usually strip about 20 females (42kg) to have between 4kg (cold season) and 7kg (adequate warm season) of eggs. When 4kg of eggs are used, expect about 300,000 fingerlings and 600,000 for 7kg of eggs.
- Set the gas stove to an adequate flame to maintain the temperature in the hatching troughs.
- Remove the hatching tray into different hatching troughs (to continue hatching if necessary) after 24-36 hours

- Siphon the hatched larvae into transportation buckets. Stir the water for the dead eggs to come up since they are lighter than the larvae, then siphoned the larvae.

- The larvae are transported to the incubation tanks for three days. Do not allow water flow-through and do not disturb the water for the three days.

- The water used in these tanks is pumped from the river into a buffer pond and pumped into the larvae incubation tanks.

- Transfer the larvae after three days into the fry tanks. Feed them for 5 to 8 days. These fry tanks of 30 m$^3$ each is constructed in a circular form with the outlet in the middle. The tanks slopes from the outside into the outlet; 0.8 m at the perimeter to 1m in the center. A small collection point for fry is constructed at the exit.

- Transfer fry into earthen ponds. The ponds are prepared by turning the soil in the ponds using hoes. A gutter is created in the middle of the pond to the exit for easy collection of fingerlings.

- Ponds are prepared and treated with 5 liters of formalin mixed in 150-300 ml of water sprinkled all over each pond. The ponds are filled with water a day before bringing the fry. Water is pumped directly from the river into each pond. Tetracycline antibiotic of 5mg/5ml can be added to 1kg of fry feed as preventive measure, in accordance with the local regulations. If water is treated with potassium permanganate, no antibiotic should be added. Water from a previously fertilized pond (using Potassium fertilizer mixed with poultry or pig manure) is introduced as inoculation into the pond for fast growth of planktons. The ponds are covered with net to avoid predators.

- The fry are introduced into the pond the next morning to avoid the presence of predators. Ponds are opened after two weeks for grading. No exchange of water is necessary during this period. At 8 weeks old, the fry are big enough to eat eggs of most predators and colonize the ponds.

- Stock 100,000 fingerlings in each pond of 150 x100m$^3$.

- Best performance is hybrid, crossing male *Heterobranchus* sp. with female *Clarias gariepinus* of one male with as many as 20 females.
6.1.4 Marketing

- The fish breeder sells fingerlings between 1.5g to 5g. 1.5g to 3g sold at ₦10 for *Clarias species* and ₦15 in Nigeria for *Hetero-Clarias hybrid*; 5g sold at ₦20 for *Clarias species* and ₦25 for *Hetero-Clarias hybrid*.
- No publicity is used. The quality of fingerlings produced is the only marketing strategy adopted by the fish breeder. All batches of 300 to 600 thousand fingerlings produced per cycle are sold before they reach 60 days.

6.2.1 FISH BREEDER B

This fish breeder produces over 3 million fingerlings a year with production cycles spread across the year using earthen ponds with concrete walls.

6.2.1. Infrastructure

- Fry grow-out station.
- Uses earthen ponds with concrete walls to grow fry. Concrete walls solve some predator problems. Concrete walls also help to stabilize the water temperature. Cover the ponds with one finger mesh size cover nets. Each pond of 100ft x 25ft produces 300 thousand fingerlings. Each pond has 6 aerators of 45W because of the high stocking density he is using. A big hole is at the exit of each pond for the collection of fingerlings.

6.2.2. Procedures

- Procedure for hatching is the same as with Fish Breeder A (6.1.2). After hatching, all the larvae are siphoned and transferred into clean tanks for three days. No flow through is used in these tanks and water is not disturbed. Fry are fed with decapsulated artemia in flow through tanks for 5 days after absorption of yoke sacs. No flow through should occur during the feeding episode otherwise all the decapsulated artemia will be drained out of the system.
- Ponds are treated with hydrated lime the day before stocking. The lime is washed off in the morning, the pond is netted, fresh water brought in (pumps water from the river in addition to what comes out naturally from the ground), and stock the ponds with fry in the evening. The fry is fed around the walls for the first week because all fry come to the walls at this time. Spread feed to the center during the second week. Treat water with
formalin before stocking (50cl for each pond of 100ft x 25ft). He uses 25cl 10 days after stocking to control all diseases. Malachite green (4g) can be added to 1l of formalin for better results. Grade fingerlings after two weeks.

- For better performance of broodstock, always stock the males separate from the females. Stocking broodstock in the same pond causes the males to release sperms and females to absorb eggs.

6.2.3 Marketing

- The farm has 20 concrete tanks of 1-2m³ for holding fingerlings for sale.

- Fingerlings and juveniles are sold at the rate of ₦10 to ₦35.

- The farm produces only *Hetero-Clarias* hybrid with traits of faster growth, more resistant to infection and disease? and better feed conversion ratio.

7.0 CONCLUSION

Catfish farming is becoming increasingly popular in Africa. The provision of high-quality catfish fingerlings and adoption of BMP in fish farming on the continent, can substantially contribute to solving fish protein crisis thereby leading to improved nutrition.
## KEY TERMS

<table>
<thead>
<tr>
<th>Terms</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae</td>
<td>These are photosynthetic organisms that possess photosynthetic pigments such as chlorophyll. However, they lack true roots, stems and leaves characteristic of vascular plants.</td>
</tr>
<tr>
<td>Artificial Breeding</td>
<td>Refers to a process in which some stimulants, hormones or pituitary extracts are injected in the brood fishes, which do not spawn in the closed water bodies causing the fishes to spawn.</td>
</tr>
<tr>
<td>Better Management Practices (BMPs)</td>
<td>Any program, procedural technique, method-of-operations, skills, measurement or device that maximizes health and well-being of cultured species, minimizes environmental effects, and promotes an efficient and economic aquaculture operation.</td>
</tr>
<tr>
<td>Biosecurity</td>
<td>A strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) that analyse and manage risks in the sectors of food safety, animal/fish life and health, and plant life and health, including associated environmental risk.</td>
</tr>
<tr>
<td>Broodstock/Breeders</td>
<td>Broodstock or broodfish, are a group of mature individuals used in aquaculture for breeding purposes.</td>
</tr>
<tr>
<td>Cost-Benefits Analysis (CBA)</td>
<td>A process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles</td>
</tr>
<tr>
<td>Cost-Benefit Ratio (CBR)</td>
<td>An indicator that shows the relationship between the relative costs and benefits of a proposed project.</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>The amount of gaseous oxygen ((O_2)) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement, or as a waste product of plant photosynthesis. Dissolved oxygen levels that drop below 5.0 mg/L cause stress to aquatic life.</td>
</tr>
<tr>
<td><strong>Feed Conversion Ratio (FCR)</strong></td>
<td>Amount of feed required to grow a kilogram of fish; e.g., if two kilograms of feed is required to grow one kilogram of fish, the FCR would be two. This means that when a feed has a low FCR, it takes less feed to produce one kilogram of fish than it would if the FCR was higher. The lower the FCR, the better the feed performance and vice versa.</td>
</tr>
<tr>
<td><strong>Fertilization</strong></td>
<td>The fusion of haploid gametes, egg and sperm, to form the diploid zygote. During spawning season, the male fish seek out the nests of fish eggs that the female has laid. When they find one, they swim over the nest, and fertilize them with their semen. This allows conception to take place, and immediately the fish eggs start to become fish.</td>
</tr>
<tr>
<td><strong>Fingerlings</strong></td>
<td>Fish eggs hatched into larvae develop into the size of fingers called fingerlings. Usually they are not older than 8 weeks</td>
</tr>
<tr>
<td><strong>Fry</strong></td>
<td>Freshly hatched fish not older than 4 weeks</td>
</tr>
<tr>
<td><strong>Fungi</strong></td>
<td>A group of living organisms which are classified in their own kingdom. This means they are not animals, plants, or bacteria. Unlike bacteria, which have simple cells, fungi have complex cells like animals and plants.</td>
</tr>
<tr>
<td><strong>Genital Papilla</strong></td>
<td>A small, fleshy tube behind the anus in some fishes, from which the sperm or eggs are released</td>
</tr>
<tr>
<td><strong>Gonad</strong></td>
<td>A gonad, sex gland, or reproductive gland is a mixed gland that produces the gametes (sex cells) and sex hormones of an organism. In the female fish the reproductive cells are the egg cells, and in the male fish the reproductive cells are the sperm.</td>
</tr>
<tr>
<td><strong>Gonadal Maturity</strong></td>
<td>Both male and female fish gonads undergo marked cyclic morphological and histological changes before reaching full maturity and becoming ripe. This is called maturation of the gonads</td>
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<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Gravid</td>
<td>When fish are full of eggs which are laid and fertilized externally.</td>
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<tr>
<td>Hatchery</td>
<td>A physical structure, indoor or outdoor that is built for fish reproduction process. Hatchery provides sanctuary for fish seed production and rearing before transfer to nursery ponds or sold off.</td>
</tr>
<tr>
<td>Hatchlings/Larvae</td>
<td>Freshly hatched fish not older than 5 days. Fish larvae eat smaller plankton, while fish eggs carry their own food supply. Both eggs and larvae are eaten by larger animals.</td>
</tr>
<tr>
<td>Hormone</td>
<td>A regulatory (chemical) substance produced in an organism and transported in tissue fluids such as blood or sap to stimulate specific cells or tissues into action. Hormones may be natural e.g. African catfish pituitary or synthetic e.g. Ovaprim</td>
</tr>
<tr>
<td>Hybridization</td>
<td>The mating of genetically differentiated fish species either as individuals or groups and may involve crossing individuals within a species (also known as line crossing or strain crossing) or crossing individuals between separate species.</td>
</tr>
<tr>
<td>Hypodermic Syringe</td>
<td>Hypodermic means 'beneath the skin') consist of a hollow needle attached to a syringe. They pierce the skin and inject substances into the bloodstream. They are also used to extract liquid such as blood from the body.</td>
</tr>
<tr>
<td>Hypophyzation</td>
<td>The technique of breeding fish by administering pituitary gland extract by injection. It is also known as induced breeding.</td>
</tr>
<tr>
<td>Incubation of fish eggs</td>
<td>The maintenance of fertilized fish eggs in a body of water or in fish-breeding (incubation) apparatus until the fry hatch. The fertilized eggs are incubated in a body of water (non-plant method) or in fish-breeding plants (plant method).</td>
</tr>
<tr>
<td>Incubation Trough</td>
<td>Containers used for hatching fish eggs in the hatchery.</td>
</tr>
<tr>
<td><strong>Juveniles</strong></td>
<td>Hatched fish not older than 12 weeks; typically, between 25 and 50 mm long</td>
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<tr>
<td><strong>Milt</strong></td>
<td>The semen or sperm of a male fish.</td>
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<tr>
<td><strong>Milt Sac</strong></td>
<td>Sperm Sac or testis</td>
</tr>
<tr>
<td><strong>Optimum Temperature</strong></td>
<td>The temperature at which a procedure is best carried out, such as the culture of a given organism or the action of an enzyme.</td>
</tr>
<tr>
<td><strong>Ovulation</strong></td>
<td>The release of eggs from the ovary;</td>
</tr>
<tr>
<td><strong>Parasites</strong></td>
<td>These are disease causing organism in fisheries</td>
</tr>
<tr>
<td><strong>Pathogens</strong></td>
<td>Pathogens are infectious agents that cause fish disease. Pathogens are always present in an aquaculture system, but not always at sufficient levels to cause a disease. (good)</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>Power or potential of hydrogen ranging from 1(highly acidic) to 14 (highly alkaline)</td>
</tr>
<tr>
<td><strong>Physico-Chemical Parameters</strong></td>
<td>This consist of parameters such as water temperature, pH, dissolved oxygen, conductivity, salinity, secchi disc depth, nitrate, nitrite, sulfate, chloride, total hardness, calcium, magnesium etc. which are measures of water quality.</td>
</tr>
<tr>
<td><strong>Pituitary Gland</strong></td>
<td>The major endocrine gland, a pea-sized body attached to the base of the brain that is important in controlling growth and development and the functioning of the other endocrine glands.</td>
</tr>
<tr>
<td><strong>Post Juveniles</strong></td>
<td>Hatched fish not older than 15 weeks; also known as sub-adult</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td>Total fish biomass in a production system</td>
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<tr>
<td><strong>Profit Margin</strong></td>
<td>Amount by which sales revenue exceeds costs in a business</td>
</tr>
<tr>
<td><strong>Prophylactic Treatment</strong></td>
<td>A prophylactic is a medication, or a treatment designed and used to prevent a disease from occurring.</td>
</tr>
<tr>
<td><strong>Quarantine</strong></td>
<td>A state, period, or place of isolation in which fish that have arrived from elsewhere or been exposed to infectious or contagious disease are placed.</td>
</tr>
<tr>
<td><strong>Return on Investment (ROI)</strong></td>
<td>A performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. Calculate ROI: benefit (or return) of an investment is divided by cost of the investment.</td>
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<tr>
<td><strong>Saline Solution</strong></td>
<td>A mixture of salt and water. Normal saline solution contains 0.9 percent sodium chloride (salt), which is similar to the sodium concentration in blood and tears. Saline solution is usually called normal saline.</td>
</tr>
<tr>
<td><strong>Shooters’ or ‘Jumpers’</strong></td>
<td>Fish seed which usually grow at geometric rates while others grow at arithmetic rates. They constitute between 18-22% of freshly hatched fish population.</td>
</tr>
<tr>
<td><strong>Siphoning</strong></td>
<td>Draw off or convey water by means of a tube in hatchery operation; this can be done manually (mouth-siphoning) or mechanically (pressure tube operation).</td>
</tr>
<tr>
<td><strong>Spawning</strong></td>
<td>The deposition of eggs and sperm so that they can unite.</td>
</tr>
<tr>
<td><strong>Spermatozoa</strong></td>
<td>The mature motile male sex cell of an animal, by which the ovum is fertilized, typically having a compact head and one or more long flagella for swimming.</td>
</tr>
<tr>
<td><strong>Stock</strong></td>
<td>Fish stocks are subpopulations of a particular species of fish</td>
</tr>
<tr>
<td><strong>Stocking Density</strong></td>
<td>The number of fish that are kept on a given unit of area. In a monoculture pond, the stocking rate is the same as the stocking density because there is only one kind of fish.</td>
</tr>
<tr>
<td><strong>Stripping</strong></td>
<td>The process of applying moderate pressure on the flank of the spawner which results in the release of fish egg. Distilled water is then added to the mixture of eggs and milt.</td>
</tr>
<tr>
<td><strong>Stunted Growth</strong></td>
<td>Reduced growth rate; they constitute between 18-22% of freshly hatched fish population; these should be sorted out.</td>
</tr>
<tr>
<td><strong>Water Quality Management</strong></td>
<td>This includes the systematic collection of physical, chemical and biological information, and the analysis, interpretation and reporting of those measurements in comparison with the expected for maximum fish yield in aquaculture.</td>
</tr>
</tbody>
</table>
Wild/Natural Water Bodies | Naturally occurring waterbodies such as rivers, streams, lakes, lagoons, etc.  
---|---
Zooplankton | Microscopic animal organisms drifting in oceans, seas, and bodies of fresh water.

**BIBLIOGRAPHY (SOURCES)**


Ruth Francis-Floyd, *Introduction to Fish Health Management* Department of Large Animal Clinical Sciences (College of Veterinary Medicine) and Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

ADDITIONAL RESOURCES-FURTHER READING

https://www.sciencedirect.com/science/article/pii/B9780323025980501397
For more information please contact:
WorldFish Nigeria Office, c/o International institute of tropical Agriculture (IITA)
AfricaRice Building IITA HA, Ibadan Nigeria
Telephone: +2348033476184 Email:

Partners: