One Health & Development Initiative

AQUACULTURE FISH WELFARE TRAINING GUIDE

Best Practices to Improve Fish Welfare on Fish Farms in Nigeria

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TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

ALI	Aquatic Life Institute
AMR	Antimicrobial Resistance
AU-IBAR	African Union – Inter-African Bureau for Animal Resources
AWRA	Animal Welfare Research in Africa
CEA	Centre for Effective Altruism
CVON	Chief Veterinary Officer of Nigeria
DVPCS	Department of Veterinary and Pest Control Services
DVS	Department of Veterinary Services
EA	Effective Altruism
EU	European Union
FAO	Food and Agriculture Organization
FMARD	Federal Ministry of Agriculture and Rural Development
FW	Fish Welfare
FWI	Fish Welfare Initiative
GAWS	Global Animal Welfare Strategy
MDAs	Ministries, Department and Agencies
NAFDAC	National Agency for Food and Drug Administration and Control
NGO	Non-Governmental Organization
OHDI	One Health and Development Initiative
Q&A	Questions and Answers
SDGs	Sustainable Development Goals
TWGs	Technical Working Groups
VCN	Veterinary Council of Nigeria
WOAH	World Organization for Animal Health
WTO	World Trade Organization

PREFACE

FISH WELFARE IN NIGERIA AND AFRICA – OUR JOURNEY SO FAR

One Health and Development Initiative (OHDI) is a nonprofit organization based in Nigeria that works to address correlated issues of human, animal, and ecosystem health using the One Health approach. Farm animal welfare is one of the key contributors to One Health and in this work area, we seek to promote knowledge and build the capacity of farmers and other relevant stakeholders on implementing and integrating good animal welfare practices into existing animal agriculture and production settings.

Our intervention in aquaculture fish welfare was conceived in January 2022 upon our engagement with the Effective Altruism community where we acquired basic knowledge on fish welfare and engaged with various organizations who were implementing inspiring interventions, awareness and movement building in the cause area on other continents. We recognized that, in Africa, fish welfare is one of the most neglected in the farm animal welfare space and there were no interventions on the continent at the time, despite the billions of farm fish produced annually. For example, Nigeria, our pilot country, produces 52% of the total aquaculture fish in Sub-Saharan Africa and has the second largest aquaculture industry in Africa, after Egypt (Kaleem *et al.*, 2020). Nigeria is also the largest consumer of fish in Africa and among the largest fish consumers in the world with about 3.2 million metric tons of fish consumed annually (FAO, 2022; Adelesi, 2019). However, despite this large and rapidly growing aquaculture industry, little or nothing is said, known or practiced on fish welfare by farmers and other stakeholders. Instead, the focus is usually on improving fish productivity for higher gains on investments. This perpetuates factory farming systems where several dire welfare issues are rife with accompanying immense stress, pain and suffering for the billions of farm fish. This gap fuelled our determination to launch an intervention in this high-impact cause area in Africa by promoting knowledge and information on global best practices of fish welfare among local fish farmers and other aquaculture stakeholders and to build their capacity to implement good fish welfare practices in their operations.

Due to a lack of data on farm fish welfare in Nigeria, our journey began by conducting an extensive baseline research to understand the knowledge, attitude, and practices of fish farmers and stakeholders on fish/aquaculture Welfare in Nigeria (our pilot country) and determine the current state of fish welfare. This survey, supported by Animal Charity Evaluators (ACE), engaged over 1300 fish farmers, fish consumers, researchers, and administrators across the six geopolitical zones of the country. The full research report is currently being prepared for journal publication. Upon completion of the survey, research results were disseminated to national and global stakeholders, and this informed a series of subsequent discourses and engagement towards next-level interventions in awareness, training and capacity building for fish farmers and other stakeholders on fish welfare practices in Nigeria.

Following this, we received further support and resources from the EA Funds to pilot our proposed Fish Welfare intervention in Nigeria. To begin, we developed this Fish Welfare Training Guide – a document that establishes systematic and holistic guidance to educate fish farmers on the need for fish welfare, global best practices of fish welfare, and how to adapt these practices to local fish farm settings and fish species in the country. To pilot the training guide, we conducted an on-site training for 47 fish farmers and government staff (administrators) in State Departments of Fisheries - using the train-the-trainer approach. These 47 trainees were drawn from 7 states in Nigeria, and they currently serve as the pilot set of trainers to disseminate awareness and training of fish welfare to other fish farmer clusters within their respective cities and communities.

We appreciate the support and contribution of global fish welfare specialists/advocates who have carefully reviewed this training guide, provided their feedback, and validated the modules and content for deployment. We also value the feedback of fish farmers who engaged in our pilot training using the training guide and provided us with very useful feedback in refining and adapting the content and delivery of the training guide to fit local contexts.

WHO IS THIS TRAINING GUIDE FOR?

This training guide is for fish farmers and all who work with, contribute to, or support the work that fish farmers do. These include veterinarians, animal health and production practitioners, government administrators, policy makers and researchers in fisheries and aquaculture, fish welfare groups, advocates and affiliated organizations, certification bodies and export institutions, international organizations that support fish farmers, and private sector companies that purchase fish products. This inclusion of stakeholders is important to improve their knowledge of expected fish welfare standards and ensure that demand for fish welfare practices from fish farmers is sustained in their engagements.

While this training guide focuses on the Nigerian context and farm fish species in the country; subsequent versions will be developed and published for other countries in Africa and their respective diverse fish species. This would be done in collaboration with the animal and fish welfare stakeholders based in the country of interest.

WHAT NEXT?

Following the development of this training guide and the pilot training conducted, our organization will scale-up Fish Welfare interventions within and outside Nigeria that would include targeted media and community awareness, and the deployment of onsite and online fish welfare training of fish farmers and stakeholders using a train-the-trainer approach.

To support this, we have built an online course for Fish Welfare that will achieve the following:

- Expand the on-site training process and reach more farmers and stakeholders via digital platforms.
- Scale-up the fish welfare awareness and training to other African countries and other farm fish species on the continent.
- Enhance follow-up and continuous educational development and support for fish farmers and advocates that have been trained via in-person train-the-trainer programs; and
- Provide a medium for continuous peer support of farmers in integrating fish welfare practices on their farms and gaining the accompanying benefits.

Farmers and stakeholders in the fish farming industry are highly encouraged to undertake the Fish Welfare Course vis-à-vis utilizing the training manual.

In this regard, we look forward to mutually beneficial collaborations, technical and financial support of relevant organizations in Africa and beyond who are willing to join us to alleviate the pain and suffering of farmed fish on the continent and improve welfare standards. We are dedicated to the actualization of the cost-effective impact that can be achieved with partnership and collaboration to educate fish farmers/stakeholders and (potentially) improve the welfare of billions of fish in Africa.

You are welcome to join us to improve fish welfare in Africa.

Dr. Kikiope O. Oluwarore

Founder & Director, One Health and Development Initiative (OHDI)

MODULE 1 – OVERVIEW OF AQUACULTURE IN NIGERIA

This module explains the meaning of 'aquaculture' and summarizes the common types of aquaculture systems that are practiced in Nigeria

WHAT IS AQUACULTURE?

Aquaculture is the rearing of aquatic organisms (fish, shellfish, aquatic plants, and other aquatic flora and fauna etc.) in a controlled captive environment. For fish, it is commonly referred to as "fish farming". It is regarded as a key agricultural and food-producing sector throughout the world and often requires varying levels of farm management activities to increase yield such as daily husbandry, feeding, protection from predators, etc.

BRIEF OVERVIEW OF AQUACULTURE IN NIGERIA

Aquaculture fish production in Nigeria has increased by 12% annually over the past 35 years (in contrast to the global average of 8%), rising from just over 6,000 metric tons in 1980 to nearly 307,000 metric tons in 2016. Accounting for 52% of sub-Saharan Africa's total production of farmed fish, Nigeria is the biggest producer of fish for aquaculture in the region and second largest producer in all of Africa (after Egypt). Nigeria's fish farming mostly focuses on freshwater fish, with catfish species producing 64% of the nation's aquaculture in 2015 (WorldFish, 2018). 80% of Nigeria's aquaculture fish production comes from small-scale farmers engaged in brackish and freshwater cultivation, except for mariculture.

AQUACULTURE FISH PRODUCTION SYSTEMS IN NIGERIA

Fish are raised in a variety of water-holding structures including ponds, pens, hapas, tanks, cages, raceways, etc. (Orobator *et al.*, 2020), and these are utilized in a variety of production systems. Nigeria's main aquaculture fish production systems are extensive, semi-intensive, intensive, and integrated systems. These are explained in more detail below.

Extensive System

In the Nigerian extensive aquaculture fish system, fish are often reared in dug-out earthen ponds, pen enclosures, rice fields or small water bodies at minimal to moderate densities and farm inputs. This system is mostly used for freshwater staple-food fish species by small-scale farmers in many developing countries. Dietary nutrient supply can range from nothing to the regulated generation of living food organisms using fertilizers, supplementary or nutritionally full aquafeeds (Dawood and Koshio, 2016). Such systems can either be homestead ponds or water enclosures close to rivers and streams. Traditional fish farming methods have been used by artisanal fishermen and fishing communities in Nigeria's tide pools and floodplains for many years. These are often at subsistence levels which do not fit into the modern view of aquaculture and hardly make substantial contributions to the nation's economy. Reservoirs and impermeable ponds are widely used in extensive aquaculture systems and once stocked, the fish are left to the pond's natural carrying capacity. These systems are characterized by low inputs, low density stocking, no artificial feeding, no fertilizer, and low yield per unit area (Okwodu, 2016).

Picture 1.1 - Earthen Pond system; Source – One Health and Development Initiative

Semi-intensive System

In the semi-intensive system, fishes are stocked at a higher stocking density than in the extensive system and fed additional higher-quality feed to supplement the natural food supply. Its production costs are typically low, and its yield is higher than that of the extensive system, exceeding 10,000 kg/ha/year (Iruo *et al.*, 2018). The pond is often fertilized with organic and inorganic fertilizer, a small amount of supplemental feeding, and the yield is occasionally intermediate between those obtained from intensive and extensive culture. Most aquaculture ventures in the tropics - including Nigeria - are semi-intensive (Okwodu, 2016).

Picture 1. 2 - Cages in running water; This could be intensive or extensive depending on the type of feed and stocking density. Source – One Health and Development Initiative

Intensive System

The intensive fish culture system is one where fish are stocked at a high density and fed exclusively on a specially formulated nutritionally balanced diet to meet their nutrient requirements (Iruo *et al.*, 2018). Success in intensive aquaculture systems depends on factors such as water quality, stocking density, quality of feed (to some extent), the proliferation of bacteria in the system, and the interrelationship between the bacteria and fish species. Over 30,000 tons of various fresh and brackish water fish species are produced in Nigeria annually, comprising primarily of catfishes reared under intensive (commercial) and semi-intensive (artisanal) production systems (Erinsakin *et al.*, 2020). One major deterrent of intensive systems is the capital required as it is usually expensive for farmers to set up. It is also often the system with the most welfare issues due to its intensive factory farm settings. Some commonly used intensive culture systems in Nigeria are Recirculating Aquaculture System (RAS), concrete and earthen ponds, fish vats, tanks, and mobile ponds.

Picture 1.3 – An intensive fish farm with a concrete housing system. (Source – Darlington Omeh, 2013)

Integrated Aquaculture System

Broadly defined, integrated aquaculture farming is a concurrent or sequential culturing or breeding of two or more species of plants and animals using the same water source (Fregene, 2017). One type of system is aquaponics, in which fish and plants are grown together and the nutrient-rich water resulting from fish waste is used as fertilizer for the plants, thereby enriching the soil, instead of leaving the system (Ogah *et al.*, 2020). Another example is the Fish and Crop integration where crops (e.g., vegetables and arable crops like maize, rice, etc.) are cultivated alongside aquatic plants (like water spinach, water chestnut, and aquatic weeds including Pistia, duckweed, water hyacinth, and Azolla) in conjunction with fish farms.

Integrated aquaculture farming has been well promoted in Nigeria over the last few years and the main drivers of the promotion of this system are rising fish production costs, diversion from the use of chemical fertilizers, and the need for judicious use of farming space. For example, the West and Central African Council for Agricultural Research and Development (WECARD) and the University of Ibadan (UI) recently promoted the integration of fish and rice farming to help smallholder farmers improve their production, food security, and profits (Adewumi, 2015). The combination of crop production and animal husbandry has been advocated for as an environmentally sound farming system that provides an inexpensive source of protein for rural people, a higher farm income, increased output per small land area, and increases feed supply for livestock.

Picture 1.4 – Integrated Rice and Fish farming site in Nigeria. (Source – The Fish Site)

There is also integrated aquatic and terrestrial livestock farming in Nigeria. However, many of such systems are highly discouraged due to high health and welfare concerns. Some examples include:

- Integrated Fish and Poultry farming where fish are cultivated with poultry, sometimes using poultry litter. In this system, the poultry cage is built above the fishpond, so the poultry faeces drop directly into the fishpond. The fish are often fed very minimally and must depend on the poultry faeces for feeding and nutrition. This system has been highly discouraged and advocated against due to its many health, welfare and ethical implications on the fish and the humans who consume them (Adeyemi *et al.*, 2022). Therefore, it is no longer commonly practiced in Nigeria.
- Integrated Fish and Piggery farming is prevalent in southern and the middle belt of Nigeria. This is also fraught with health and welfare concerns and is highly discouraged due to the heightened risk of compromised water quality, poor hygiene and sanitation, cross infections, and presence of *Salmonella spp* and other bacteria residues in the final product, among other issues.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSIONS

❖ Introduce yourselves. Farmers to describe their fish farm (intensive, extensive, semi-intensive, culture system, species of fishes, number of fishes, location, successes, and challenges etc.). Others (non-farmers) should discuss why they are taking the course and what they seek to benefit?

❖ What is/are the most common fish farming system(s) practiced in your area? Why is this system common?

❖ Tell us which fish farming system you prefer the most and why. Share your personal experiences (if any) with your preferred fish farming system including the advantages and disadvantages.

❖ Have you practiced integrated aquaculture before? If yes, share details of the integrated fish farm system, your experience with it, and what you consider as advantages and disadvantages of the system.

MODULE 2: INTRODUCTION TO ANIMAL WELFARE

This module provides a basic introduction and overview of animal welfare, including information on the general animal welfare principles and rationale. We also introduce the 5 freedoms and domains of animal welfare and shared insights to general animal/fish welfare violations and practices. Lastly, we provide insights to provisional country-level legal frameworks in Nigeria on Animal Welfare.

OVERVIEW, HISTORY AND TRENDS OF ANIMAL WELFARE

Though previously marginalized, the field of animal welfare has continued to grow and advance over the last three decades and more due to the increasing recognition and appreciation of the link between animal sentience and animal well-being. Animal welfare used to focus mostly on health disposition, improved ways of detecting health issues, and animal management (Pinillos *et al.*, 2015). However, it has evolved to now include a better understanding of animals' social behaviours, cognitive abilities, and ability to feel and express pain and suffering (Mendl *et al.*, 2009; Broom, 2011).

The following provides chronological notable highlights of events in the evolution of animal welfare:

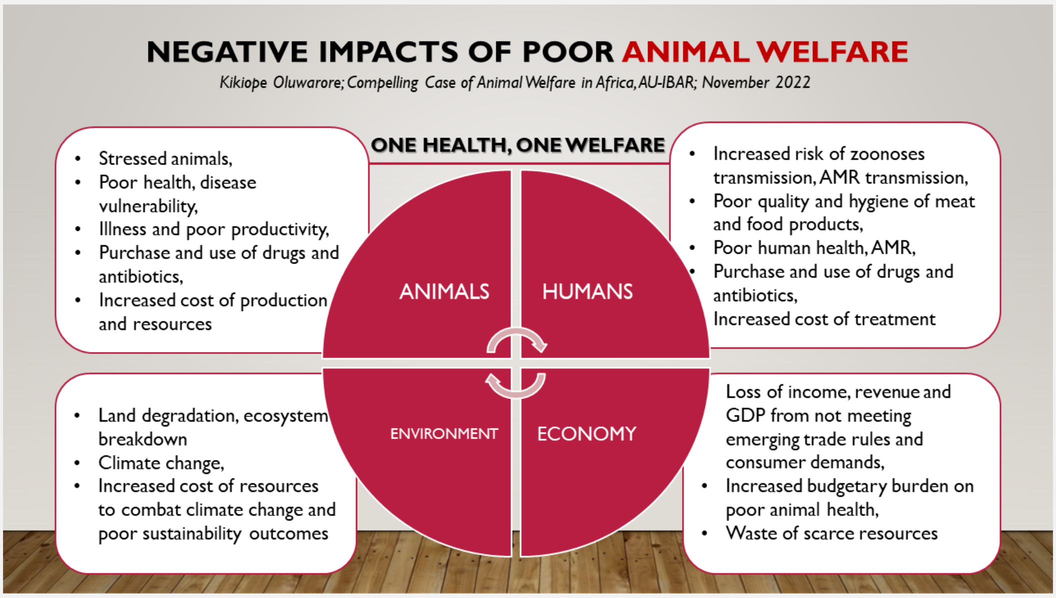
1) Ancient Civilizations (Prehistoric times - 600 BCE):
   - Early human societies had varying attitudes toward animals, ranging from reverence and protection to exploitation.
   - Some ancient civilizations, like the ancient Egyptians and Greeks, held certain animals in high regard and established laws to protect them.
2) Religious Influence (600 BCE - 1800 CE):
   - Religious texts, such as the Old Testament in Judaism and Hindu scriptures, promoted compassion and respect for animals.
   - Philosophers like Pythagoras and later Saint Francis of Assisi advocated for the ethical treatment of animals.
3) Animal Welfare Movement (1800s):
   - The Industrial Revolution brought increased urbanization and factory farming practices, leading to concerns about animal welfare.
   - Influential figures such as Richard Martin and William Wilberforce in Britain campaigned for the welfare of working animals and passed laws against animal cruelty.
4) Formation of Animal Welfare Societies (19th century):

- Animal welfare societies, such as the Royal Society for the Prevention of Cruelty to Animals (RSPCA) founded in 1824, emerged to promote animal welfare and enforce animal protection laws.

5) Laboratory Animal Welfare (20th century):
   - Concerns grew regarding the use of animals in scientific experiments, leading to the establishment of regulations and guidelines for laboratory animal welfare.
   - Organizations like the American Society for the Prevention of Cruelty to Animals (ASPCA) and the Humane Society of the United States (HSUS) expanded their work to address animal experimentation.
6) Modern Animal Welfare Movement (Late 20th century - Present):
   - Animal welfare concerns expanded to various areas, including factory farming, animal entertainment, and wildlife conservation.
   - Animal welfare legislation and regulations are being enacted globally, focusing on issues such as animal transportation, humane slaughter, and the use of animals in entertainment.
   - Non-governmental organizations (NGOs) and grassroots movements are playing a significant role in advocating for animal welfare and raising awareness about animal cruelty.

However, despite these remarkable improvements in best practices globally, poor animal welfare practices are still prevalent and remain a challenge. This apparent neglect has been attributed to several reasons such as poor awareness, inadequate resources, poor policy frameworks, and socio-cultural influences [including traditional or religious biases], among other constraints.

On a more positive note, animal welfare is also receiving increasing recognition as an important contribution to an interconnected myriad of animal, human, environmental and ecosystem health (One Health), and sustainable development outcomes. This has led to the development of the on-going 'One Welfare' concept that encourages interdisciplinary partnership to improve animal and human welfare simultaneously and incorporate the environmental components of welfare (Marchant-Forde & Boyle, 2020).



Picture 2.1 - Oluwarore (2022), Compelling Case of Animal Welfare in Africa, AU-IBAR, Africa Conference for Animal Welfare, November 2022

For example, improved animal welfare practices can contribute to a reduction in animal diseases and zoonoses in humans (Madzingira 2017), reduces mortality, improves growth, increases feed efficiency and, all in all, improves production performance; foster human and animal bonds that improve human health and social wellbeing (Freisinger, 2021); and positively impact food safety and meat quality (Animal Welfare Institute, 2018). Furthermore, according to CIWF (2020), addressing welfare concerns such as housing and good management practices, have positive impacts on animal health, farms' environmental footprint, and economic and social performance. This recognition has stimulated concerted efforts by stakeholders at all levels to improve the welfare of animals, reduce their pain and suffering, and enhance their health and well-being.

THE 5 FREEDOMS OF ANIMAL WELFARE

In the quest for improved animal welfare, a major advancement is the development of the "Five Freedoms of Animal Welfare". This has contributed to the recognition, understanding and establishment of good animal welfare systems and practices. The Five Freedoms of Animals are globally validated basic guidelines and indicators used to determine the welfare status of animals, including fish. It has been touted by several in-country and international animal health and welfare organizations, including the World Organization for Animal Health (WOAH). The 'Five Freedoms' include freedom from thirst and hunger, freedom to display natural typical behaviour, freedom from discomfort, freedom from fright and despair as well as freedom from disease, pain, and injury (Mellor, 2016).

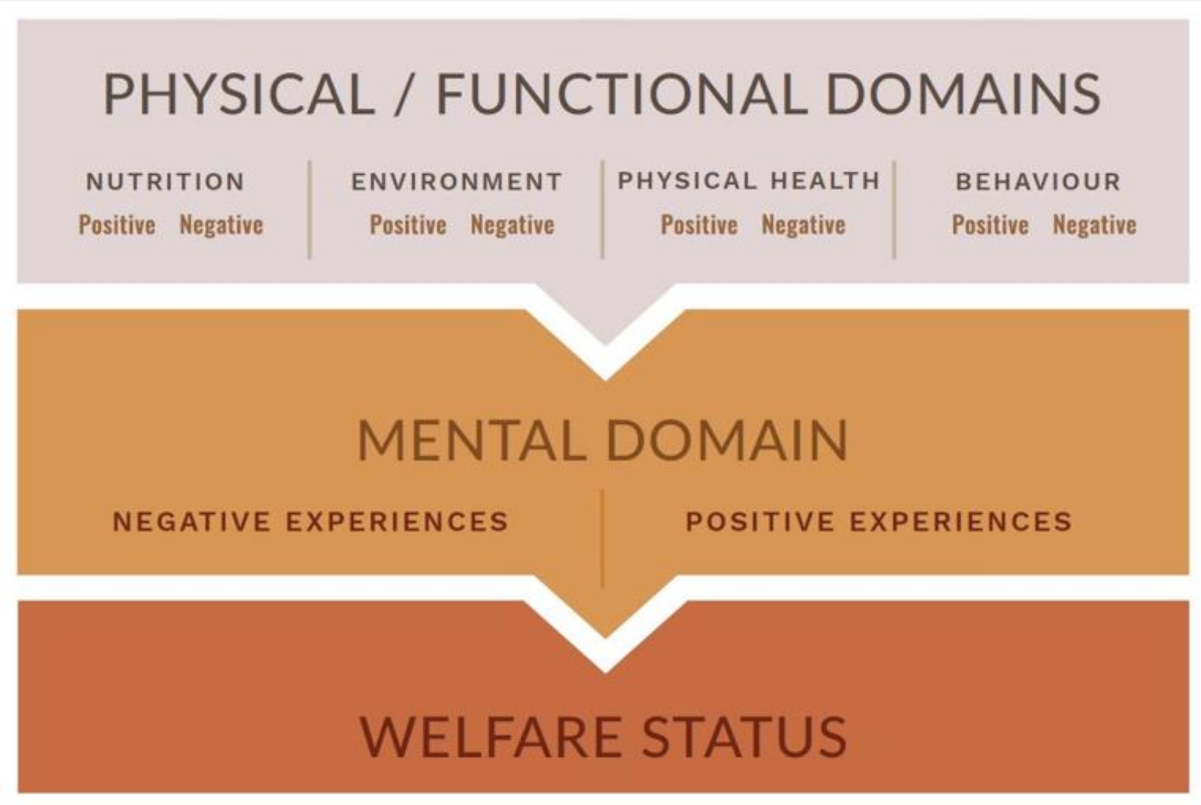
The following provide a detailed explanation of the Five Freedoms (which applies to fish):

1. Freedom from hunger and thirst – meaning the expected provision of adequate measures of food and water provided in timely, consistent, balanced, and nutritious rations devoid of contaminants and free of disease-causing organisms.
2. Freedom from discomfort – meaning the provision of a comfortable environment that involves a healthy, and good quality water ecosystem, and existence that is devoid of restrictions, unpleasant perceptions, and harsh environmental conditions (including but not limited to rainy, extreme cold or hot weather or water environment, noise, or fearful situations).
3. Freedom from pain, injury, and disease – meaning providing adequate care and environmental conditions that are devoid of (but not limited to) any form of infliction of painful or injurious experience, provision of standard fish management practice and biosecurity measures, prompt and quality veterinary care and treatment, and good antimicrobial stewardship.
4. Freedom to express normal and natural behaviour – This includes the provision of conditions that are not unduly restrictive in which the fish can move around (including swimming and other fish locomotion, vocalizing, feeding, and interacting with other fishes) within the considerable limits of a protected and safe environment, duplicating its natural settings or environment as much as possible and allowing the animals to express its natural instincts and behaviours.
5. Freedom from fear and distress – this includes considerate humane treatment of fish in a manner that does not induce fear, anxiety, distress, or other forms of psychological suffering to the animals.

It is important to note that while all Freedoms have their distinct roles, logically, they all feed into and impact each other in several ways. For example, an animal's "freedom from hunger and thirst" contributes to the satisfaction of the other four Freedoms.

THE 5 DOMAINS OF ANIMAL WELFARE

Though the Five Freedoms of Animal Welfare provide a strong basis for assessing animal welfare standards in animals, a more updated framework called the Five Domains of Animal Welfare has since been established. The five domains include Nutrition, Environment, Health, Behaviour, and Mental Domains. These domains are described as science-based best practice framework for assessing animal welfare and quality of life. The first four domains provide information about the animal's various experiences, which make up the fifth domain, the Mental Domain. It allows a distinction to be made between the physical and functional factors that affect an animal's welfare and the overall mental state of the animal arising from these factors. It also recognises that animals can experience feelings, ranging from negative to positive. In the last 20 years, this framework has been widely adopted by organizations globally as a tool for assessing the welfare impacts of farm animals, research procedures in animals, pest animal control methods and other interventions in animals' lives in many organizations.



Picture 2.2 - 5 Domains of Welfare. (Source - Zoo Aquarium, Australia)

RSPCA shares more details on the value of the Five Domains, explaining that to help ensure animals have a 'a good life', they must have the opportunity to have positive experiences including satisfaction and satiation. To enable this, those responsible for the care of animals need to provide them with environments that not only allow but encourage animals to express behaviours that are rewarding. Thus, the Five Domains provide a means of evaluating the welfare of an individual or group of animals in a particular situation, with a strong focus on mental well-being and positive experiences.

Comparing and integrating the 5 Freedoms and Domains

The Five Freedoms and Five Domains frameworks comparatively contain essentially the same five elements. However, the Five Domains explore the mental state of an animal in more detail and acknowledge that for every physical aspect that is affected, there may be an accompanying emotion or subjective experience that may also affect welfare. This is useful in terms of reinforcing the message that emotional needs are equally important as physical needs for animals. For example, Zoo Aquarium indicates that while they recognise the value of using the Five Freedoms for driving the prevention of negative welfare in animals, they also apply the Five Domains for animal welfare assessment to progress beyond preventing bad animal welfare to include actively promoting positive animal welfare.

Table 2.1 - Comparing Five Freedoms and Five Domains (Source – RSPCA)

Five Freedoms	Five Domains
1. From hunger and thirst	1. Nutrition
2. From discomfort	2. Environment
3. From pain, injury and disease	3. Health
4. To express normal behaviour	4. Behavioural interactions
5. From fear and distress	5. Mental state/experiences

KEY ANIMAL AND FISH WELFARE VIOLATIONS

In many countries, it is seen that several violations of the Five Freedoms of Animals occur to varying degrees. Although it may seem like the norm in many places (for example in Nigeria), animal abuse is getting less accepted across the world and animal welfare is highly regulated in many countries. Poor welfare practices common in fish and other animals are listed as follows:

- Inhumane transport causing discomfort such as overcrowding, exposure to uncomfortable weather or other environmental factors, and diminished water quality.

- Inhumane slaughter (painful, fearful, or distressing to animals) and inappropriate stunning and slaughter methods.
- Inhumane handling and mutilation practices especially without anaesthesia (such as eye-stalk ablation in female shrimp or the incision on the abdomen of the male to extract milt for artificial reproduction).
- Inhumane animal training for sports, entertainment, and catch and release of fish during angling for leisure.
- Factory farming including restrictive or confined housing.
- Lack of quality and timely intervention of veterinary care and treatment (including the use of untrained animal health practitioners)
- Antimicrobial misuse (from self-medication, poor quality veterinary services or unethical practice) or overuse (to compensate for poor animal welfare-induced immunosuppression).
- Administration of growth hormones, with resultant anatomical and physiological conditions that cause discomfort, pain, and poor health to the animal.
- Inadequate provision of food/water, excessive fasting periods or withdrawal of food and water for manipulative purposes.
- Prolonged periods of feed restriction for fish grading, transport, slaughter, and other farm management practices such as vaccination, which can cause stress, suffering and injuries such as dorsal fin damage.
- Exposing fish to harmful or strenuous conditions during research without proper ethical and welfare considerations.

LEGAL FRAMEWORKS FOR ANIMAL AND FISH WELFARE IN NIGERIA

According to the Animal Protection Index Reports of 2020 for Nigeria, although there is no independent law governing animal welfare in Nigeria.However, there are some provisions against it in other related laws. These include the:

1. The Criminal Code (1990) which addresses animal cruelty and the phrasing of the legal provision in this area seems to acknowledge that animals can suffer both physically and psychologically. It also includes protection for some groups of animals, such as those employed for draught purposes, for which overloading or overworking is illegal.
2. Animal Disease Law and Act of 1988 that empowers and provides the mandate for Veterinarians to work in their capacities. This law has been amended three times over the course of its existence. The most recent amendment is the Animal Disease (Control) Act (2022) which offers extra safeguards for farm animals, such as establishing a cap on the

number of animals that can be transported at once in order to guarantee adequate ventilation.

The Department of Veterinary and Pest Control Services (DVPCS) under the Federal Ministry of Agriculture and Rural Development (FMARD) oversees animal welfare. In the DVPCS, the Chief Veterinary Officer of Nigeria (CVON) who is the delegate for World Organization for Animal Health (WOAH) on Animal Health and Welfare, oversees the Ministry's national WOAH focal point and Division for animal welfare. To address the dearth of a comprehensive legal framework for animal welfare in Nigeria, local and international stakeholders have since been engaging the DVPCS and other relevant government MDAs and policymakers in the country. Now, a holistic and comprehensive Animal Welfare Law and Policy is currently being drafted and is awaiting stakeholders' validation. Generally, this policy is being established to align with the existing Global Animal Welfare Strategy (GAWS). However, while this has been in development since 2016, many of the improvements and revisions made have yet to be put into operation or enacted.

To support the operationalization of the policy, resource mobilization and stakeholder engagement is currently ongoing in the country by the DVPCS-FMARD. Also, an Animal Welfare Council with several related technical working groups (TWGs) have been established. These TWGs include:

- The Aquatic Animal TWG (which is responsible for addressing all issues of Fish and Aquaculture Welfare)
- Companion animals TWG
- Wildlife animals TWG
- Animals used in sports TWG.
- Livestock and Production Animals TWG
- Animals in transit TWG
- Animals in Research TWG
- Awareness and Advocacy TWG
- Ethics, and Policy TWG

For Fish Welfare, while there is no independent law governing this in Nigeria, the Inland Fisheries Act of 2010 provides regulations on the practice of aquaculture in the Nigerian inland waters and various culture systems. It is the regulatory document that addresses issues of fish farm set-up, artisanal fisheries, fish sales, permits to engage in fishing and fish businesses, prohibited fishing methods, exercise of powers vested in government officials, recreational fishing, offences, and their penalties.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSIONS

❖ Reflect on the topic of animal welfare generally. Were you aware of "animal welfare" before now? Did you consider it important in the management of animals? Have you ever thought about animal welfare in your daily activity? How do you think animal welfare can achieve better production outcomes or better food quality? Can you give an example you know where implementing animal welfare practices also improved human wellbeing and environmental health?

❖ Discuss general animal welfare practices and violations in Nigeria. Which of the animal welfare violations listed are common in Nigeria?

❖ What can be done to address and prevent poor animal welfare practices in Nigeria?

❖ Discuss your thoughts and feedback on the animal welfare legal framework in Nigeria. Is this enough? Are there gaps? Recommendations?

❖ What can be done to push for the establishment and implementation of the Animal Welfare Law (including fish welfare) in Nigeria? How can you support this?

MODULE 3: INTRODUCTION TO FISH WELFARE

This module provides an overview of farmed fish welfare, the 5 Pillars of Welfare in aquaculture, and the corresponding benefits of fish welfare practices.

WHAT IS FISH WELFARE?

Just like the definition for the welfare of animals, a fish (farmed or wild) is in a state of good welfare if it is in good health with all its biological systems working appropriately; can lead a natural life and meet its "behavioural needs" in the environment; is free of negative experiences (such as pain, fear, hunger, thirst, distress); has access to positive experiences (such as social companionship, other positive experiences: relational contentment, environmental compatibility, happy co-existence, and conducive environment); and can adapt to its environment.

THE 5 PILLARS OF ANIMAL WELFARE IN AQUACULTURE

To guide the understanding of Fish Welfare, the Aquatic Life Institute has established certain indicators which are specific to the welfare of fish and aquatic animals. They are referred to as the "5 Welfare Pillars of Fish" and they include environmental enrichment, feed composition, space requirements and stocking density, water quality, and stunning and slaughter.

[***Watch this 3-minute video for more information***]

Picture 3.1 – The Five Pillars of Fish Welfare [Source - Aquatic Life Institute (ALI]

BENEFITS OF IMPROVED AQUACULTURE FISH WELFARE

1) **Improved fish health** - When fish (or any other animals) are treated humanely, especially within the context of the five freedoms and domains of animal welfare, they stand a higher chance of being able to live a healthy, and optimally productive lives. This rationale is supported by Madzingira (2017), who states that "*Evidence that an animal has a good state of welfare includes having low levels of disease, displaying innate behavior, normal reproduction and living longer. Therefore, poor animal welfare can manifest as high mortality rates, poor reproduction, increased incidence of disease, body damage, behavior anomalies, heavy internal parasite load … and severe malnutrition*" – all of which are evidence of poor health, and invariably lead to poor productivity. The combination of pathogen presence and stressed fish leads to disease and parasite outbreaks and there is evidence that most disease outbreaks relate to or stem from poor welfare (Aslesen *et al.*, 2009; McClure *et al.*, 2005). On farms, disease can induce financial hardship, food shortages, and even industry failure for the farmer (Arthur & Subasinghe, 2002). Also, diseases and parasites frequently spread to wild populations, where they may endanger entire ecosystems (Naylor & Burke, 2005).

2) **Improved quality of life -** The concept of animal welfare is embedded in the provision of optimal environments for animals where they are free to express their natural behaviors without restriction, fear, or pain. In recent years, the evidence and scientific knowledge of the mental complexity of animals has become increasingly proven and generally accepted. It is stated that poor animal welfare negatively affects the animal's sentience and mental state, and impacts their ability to express their natural behaviors, leading to a poor quality of life (Nicks and Vandenheede, 2014). This poor quality of life stems from the psychological stress and suffering they experience, which may then further undermine their immune system and hence their physical health (Nicks and Vandenheede, 2014). Therefore, the establishment of these welfare-enhanced environments and living conditions improves the quality of animals' lives as living, sentient beings.

3) **Meeting emerging trade and consumer demands** - As the world continues to evolve, people are increasingly caring about animal welfare, where their products originate from, and what kind of industry their purchase promotes (Conte, 2014; Lai *et al.*, 2018; Buller *et al.*, 2018). Poor welfare systems for fish and other animal products are now being rejected by

members of the public, government institutions, and consumers. Animal welfare standards are being entrenched as part of the several measures used in determining an acceptable sustainable animal health and management system (Broom, 2008), and guide trade standards. Consumers, institutions [WTO, WOAH), and government policies are now demanding food items from farms and companies that are welfare certified. For example, global markets such as the European Union have introduced minimum standards for welfare and humane treatment (Buller *et al.*, 2018). Additionally, with animal welfare gaining attention in political agendas, the EU is currently reviewing its animal welfare legislation including stunning and slaughter for farmed fish. Therefore, the integration of welfare (alongside animal health and food safety standards) in marketing and trade of animal products has driven a change in the actions and behaviors of farmers and associated companies to implement and improve fish welfare standards and get certified. This has become a concern in export trade where there are higher chances of acceptability of fish and fish products that are welfare certified. With more products than ever, consumers can now choose between animal protein and new alternatives. Therefore, the only way farmers can remain viable in this increasingly competitive and dynamic market is by offering high-quality, welfare-oriented, and certified healthy products or choosing an alternative means of sustainable livelihood. Exporting to these countries requires welfare to be a core part of production and introducing higher welfare standards demonstrates that companies are responding to consumer demands and evolving government policies. It also demonstrates a commitment to growth and product quality.

4) **Improved productivity and sustainable livelihoods** - increased welfare can improve productivity and potentially profit, and it is an element that mitigates adverse impacts on the environment, climate, and sustainable livelihoods. There is evidence that higher welfare standards in production settings and improved efficiency are closely correlated, and it often reflects good fish health, productivity and return on investment for the farmers. Some of this is detailed by Fish Welfare Initiative (FWI) which discuss the following evidence:

❖ Some studies show that farmers who integrate welfare on their farms note less aggression, reduced fin damage, improved growth rates, and improved feed conversion ratios (Stewart *et al.*, 2012; Schneider *et al.*, 2012).

❖ One study found that the introduction of aerators to enhance water quality increases survival rates by roughly 43%, led to increased fish production, and boosted farm profits (Qayyum *et al.*, 2005).

- ❖ Appropriate transport and handling further reduce stress and mortality rates (FAO, 2008).
- ❖ Keeping suffering and stress affiliated with slaughter to a minimum is reported to ensure not only animal welfare but also high product quality (Holmyard, 2017).
- ❖ Welfare-oriented products are also appreciated by customers who are willing to pay extra for welfare-friendly options (Lai *et al.*, 2018; BENEFISH, 2010). By improving welfare, farmers not only improve their efficiency, but can also sell their products for a premium price and increase their revenue.

5) **Food Quality and Safety** - Also, as detailed by FWI, fish raised and slaughtered with adherence to welfare and health guidelines may be tastier and healthier to eat, and it guarantees high product quality (Poli, 2009). Stress before and during slaughter not only affects them but also leads to reduced quality. Fish products can contain bacteria, viruses, biotoxins, and parasites, all of which occur more frequently under poor welfare situations or practices, and prolonged stress can increase bacterial growth post-slaughter (EFSA, 2008; EFSA, 2009). On the other hand, reducing stress during cultivation and slaughter safeguards fish welfare and increases fillet quality. For example, effective stunning methods reduce harmful post-mortem processes. As a result, high fish welfare ensures humane treatment, improving food quality and safety.

6) **Sustains a healthy ecosystem and environment** - As detailed by FWI, improved fish welfare reduces harmful wastewater generation which, when untreated, can degrade the environment and disrupt ecosystems (Adams, 2019). Such wastewater significantly contributes to eutrophication, causing algal blooms and ocean dead zones (Global Aquaculture Alliance, 2019). Aquaculture waste also often contains antimicrobials, leading to health problems if ingested by humans. Therefore, improved fish welfare can reduce harmful wastewater generation through the following ways:

- ➢ By using appropriate feeding systems which reduce aggression, improve feed conversion ratios (FCRs), and leave less feed suspended in the water (Gan *et al.*, 2013).
- ➢ By using appropriate stocking densities and less crowding which further enhance feeding efficiency, reduce aggression, frequency of wounds and cannibalism, and lead to better feed conversion ratios (Santos *et al.*, 2010).

- Less stressed fish have better immune functions (McClure *et al.*, 2005), decreasing the need for antimicrobials. Consequently, fewer antimicrobials end up in the surrounding environment.
- Animal welfare provisions can prevent escapes from the farms into the local ecosystems. The escape of non-native fish from aquaculture farms causes competition for food and potential displacement of native fish, which could lead to deleterious consequences for wild fish populations and the local environment.

7) **Contribution to Sustainable Development** - As adapted from FWI, fish welfare is also an integral part of sustainable development and it contributes to the achievement of the Sustainable Development Goals (SDGs). This is also echoed by a 2023 report from the Aquatic Life Institute on the Benefits of Aquatic Animal Welfare for Sustainable Development Goals. SDGs also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity (UNDP, 2023). The 17 SDGs are integrated—they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability (UNDP, 2023). Fish welfare implementation contributes to the following Sustainable Development Goals (SDGs):

   - **Goal 1- No Poverty:** Aquaculture and fisheries currently provide livelihoods for 250 million people worldwide and employment for millions more. By improving fish welfare, farmers increase fish health and, thus, create a more ethical and profitable basis for their income.
   - **Goal 2 - Zero Hunger:** Aquaculture significantly contributes both to global nutrition and basic income. This is particularly important in developing countries, most of whom still rely heavily on it as sources of protein and livelihoods.
   - **Goal 3 - Good Health and Well-Being:** Fish is currently the primary protein source for millions of people, especially in developing countries. Higher welfare decreases the risk of contamination and zoonotic infections during production and processing. Generally, fish are less stressed, have fewer disease incidence, and less need for the use of antimicrobials - all of which ultimately ensures food safety. Higher animal welfare in fisheries can also support food security for coastal communities that rely on small-scale fisheries as a main source of nutrition.
   - **Goal 6 - Clean Water and Sanitation:** Aquaculture wastewater can contain toxic residue from fish feed and antimicrobials. Increasing fish

welfare improves feed uptake, and less feed ends up in the wastewater. Higher welfare standards also decrease disease susceptibility and reduce the need for antimicrobials that diffuse into the wastewater.

- **Goal 12 - Responsible Consumption and Production:** Higher welfare on fish farms reduces our ecological footprint and waste production by improving the way we farm fish, and it also ensures that we are abiding by ethical and responsible standards.
- **Goal 14 - Life Below Water:** More efficient production reduces the burden of overfishing, conserves aquatic animals and allows aquatic systems to maintain their natural balance. Reduced waste generation (e.g., ammonia) from mariculture farms prevents events that threaten aquatic life such as harmful algae blooms. Additionally, higher fish welfare decreases disease and parasite transmission between wild and farmed fish.
- **Goal 17 - Partnerships for the Goals** Work on fish welfare involves local and international stakeholders from various sectors, including academia, research, policy advocacy, and industry. By working to improve fish welfare, we can collaborate and promote sustainability, economic stability, food safety and security, and more humane treatment of farmed animals.

8) **The right thing for fish.** As adapted from FWI, "*aquaculture is the fastest-growing food sector worldwide, and already today over 50% of seafood comes from farm cultures (Ritchie & Roser, 2021). On these farms, between 73 and 180 billion fish are reared at any given time (Fishcount, 2019). In the future, aquaculture will likely expand much further and produce most of the seafood consumed. Nevertheless, many fish reared in aquaculture continue to suffer greatly. Welfare issues include diseases, crowding, improper handling, poor water quality, and the inability to display natural behavior (e.g., Animal Charity Evaluators, 2020, Fish Welfare Initiative, 2019). Consequently, in most aquaculture farms, fish are exposed to constant stress and mortality rates are high (Ashley, 2007). This suffering is unacceptable because fish are sentient beings capable of feeling pain as much as terrestrially farmed animals (e.g., Brown, 2014; Braithwaite, 2010; Riberolles, 2020; Babb, 2020). Even when there is no legal requirement, we have a moral obligation to provide them with a life worth living. To this end, humane rearing, appropriate transport, and slaughter methods that minimize suffering are essential.*"

INTRODUCTION TO FISH WELFARE PRACTICES

In most fish farm systems - whether extensive or intensive - fish are captured, confined and may not be able to live like they do in their natural habitats. However, intervention or adaptations can be made to their environment and management practices that would provide a positive environment where they can express their species-specific behavioural needs and preferences. Also, welfare standards should prevent the most harmful practices and not infringe on the health and well-being of fish. This would usually include implementing the appropriate pond designs (shape and size); making appropriate choice of fish species farmed (whether *Clarias, Tilapia, Heterotis*), stocking density (number of fish per space area), feeding regime (unlike in the wild where fish can grow normally feeding on natural nutrients); water quality managements, and disease prevention, treatment, control and management. This will be discussed in full in subsequent modules.

Also, to measurably improve welfare, aquatic animal welfare standards should be specific to species, life stages, and holding environments. It is important to note that there are different types of fish species that are commonly cultivated in Nigeria, and these include:

- *African catfish species [most farmed] (Clarias gariepinus, Clarias anguilaris, Heterobranchus longifilis, Heterobranchus bidorsalis)*
- *African bony tongue (Heterotis niloticus)*
- *Tilapia (Sarotherodon niloticus, Oreochromis niloticu)*
- *Pangasius (Pangasius bocourti)*
- *Silver catfish (Chrysichthys nigrodigitatus)*
- *Common carp (Cyprinus carpio)*
- *Moon fish (Citharinus citharius)*
- *Tarpon (Megalops atlanticus)*

Though there are species-specific considerations and contexts to cater for, general welfare practices can be implemented across fish species. From the inception of fish production systems to growing, production, handling, slaughter, and processing, fish welfare practices should be implemented. Details on specific fish welfare practices for different stages of aquaculture production and management are discussed in subsequent modules.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- What new knowledge have you gained from this lecture on fish welfare today?
- Drawing experience from your own fish farm (or working with fish farmers), discuss how you plan to adapt and utilize your knowledge of the "Five Pillars of Animal Welfare in Aquaculture."
- Among all the benefits listed, what are the top 3 benefits that you look forward to getting when you implement fish welfare? Why?

This module provides guidance on the selection and evaluation of suitable sites for fish farms, provides detailed information on the various types of growing systems and their respective welfare concerns, and explains best practices for stocking density.

Before you start a fish farm, you must plan properly and consider various factors that will affect the health and welfare of your fish - all of which will have a considerable impact on their productivity, and on your investment returns. It is generally recommended to first establish certain strategic planning and operational standards and protocols for your fish farm. These may include a business plan, emergency plan, biosecurity plan, stocking density protocol and other practices that can be well adopted by anyone who works on the farm. You should also have a list of required materials/tools to prevent or tackle specific situations, human resources to hire and clearly established job functions for staff such as farm managers, veterinarians etc.

Among these arrays of planning, a major process to undertake is making a good decision on the environment in which your fish will be housed and grown. This majorly impacts on the health, welfare, and productivity of your fish. Key factors to consider include site selection, rearing systems, and stocking density, and they are explained below.

SITE SELECTION

Planning where your fish will be housed must start with the siting (location) of your fish farm. Where will it be situated? What are the environmental conditions and how will they potentially affect it? These and more have been categorized below and they include the following:

Location and structure of growing facilities: Ideally, farms should not be located near industrial areas, commercial arable farms, areas prone to flooding, high tidal water, strong currents, or noise. The precautions are to prevent runoff of pollutants such as industrial wastes, effluents, fertilizers, agricultural/sewage wastes into the pond water as these reduce water quality. Poor water quality will cause stress, disease and suffering to the fish which may result in morbidity and mortality. Chemicals may also weaken and cause structural damage to infrastructure of the culture facility. Flooding and strong currents may cause damage and breakdown to the culture facilities or total loss if washed away. In addition, extreme weather events observed because of climate change should also be factored into decision making regarding the structural integrity of the proposed farm. Furthermore, noise pollution can startle the fish unnecessarily leading to stress and negatively affect both male and female brooders and their breeding processes.

Environmental Impact Assessment (EIA) must be conducted as part of site selection to ensure minimal negative impacts. Initial cleaning and sanitation of the environment (ideally) should be carried out before siting the system. Safeguards for extreme low and high temperatures must be provided or production cycles can be tailored to favourable weather conditions to avoid unnecessary stress factors to the fish. When the temperature is too low, the fish will become very sluggish in movement, will not feed, and may eventually die. Extreme hot temperatures (as may be experienced in the northern regions of Nigeria or during the dry harmattan seasons) will also lead to massive mortalities.

Construction of culture facilities or growing systems should follow stipulated standards to avoid damage to facilities, and environmental problems. All construction permits must be obtained, and hydrology of the area studied and approved before any construction work proceeds.

Other factors to consider in selecting an optimal fish farm site include:

- **Accessibility to the farm**,
- **Constant availability of water**,
- **Good water quality**,
- **Access to medications and veterinary care**,
- **Appropriate layout and topography of the fish farm**, **and**
- **Acceptability of the project by the neighbouring communities**.

REARING SYSTEMS

A rearing system (sometimes referred to as growing or culture systems) for fish farms is a facility which contains, grows, or holds fish for later harvest, processing, sale, or to release for conservation purposes.

Fish growing or culture facilities commonly used in Nigeria include earthen ponds, concrete flow-through tanks, intensive recirculatory system, recirculatory systems, mobile fishpond systems (which may consist of fiberglass tanks, wood tanks lined with carpet or lino, polyethene tanks, and plastic tanks), Hapas, Raceways, and Pens. Also, in all growing systems, the intended specific activity should be considered - whether hatchery, nursery, grow-out, brood stock bank, holding or transfer tanks - as these might come with varying welfare and management needs and practices.

General considerations for improved welfare in a fish culture System:

- A key welfare practice is that while fish remain in captivity, they are allowed to grow in an environment that is similar to their natural ecosystem as much as possible. This enhances their ability to express their natural behavior and gives them a comfortable environment to reside in. Therefore, providing environmental enrichment of the rearing space will simulate the natural environment of these aquatic animals and improve their welfare.
- The rearing systems should be constructed in a way that prevents damage to skin, fins, and other parts of their body etc.
- The rearing system should allow an easy, effective removal of fecal content, avoiding disturbance of the fish as much as possible.
- The rearing system should be able to protect the fish from predators and prevent the escape of farmed fish.
- The rearing system should prevent noise such as the ones from pumps, construction noise and other machines as this can be a disturbing factor to farmed fish.
- The rearing system should ensure appropriate illumination of the tanks.
- The rearing system should minimize external disturbances such as external visitors.
- They should have proper protocols for disease prevention, disinfection and cleaning, site biosecurity, control of disturbance, etc.
- They should have emergency plans in case of adverse climate events, fires, floods, and other potential catastrophic events.
- Farmers should ensure that their staff members are regularly trained and kept informed on updated protocols and best practices established for their fish farms.

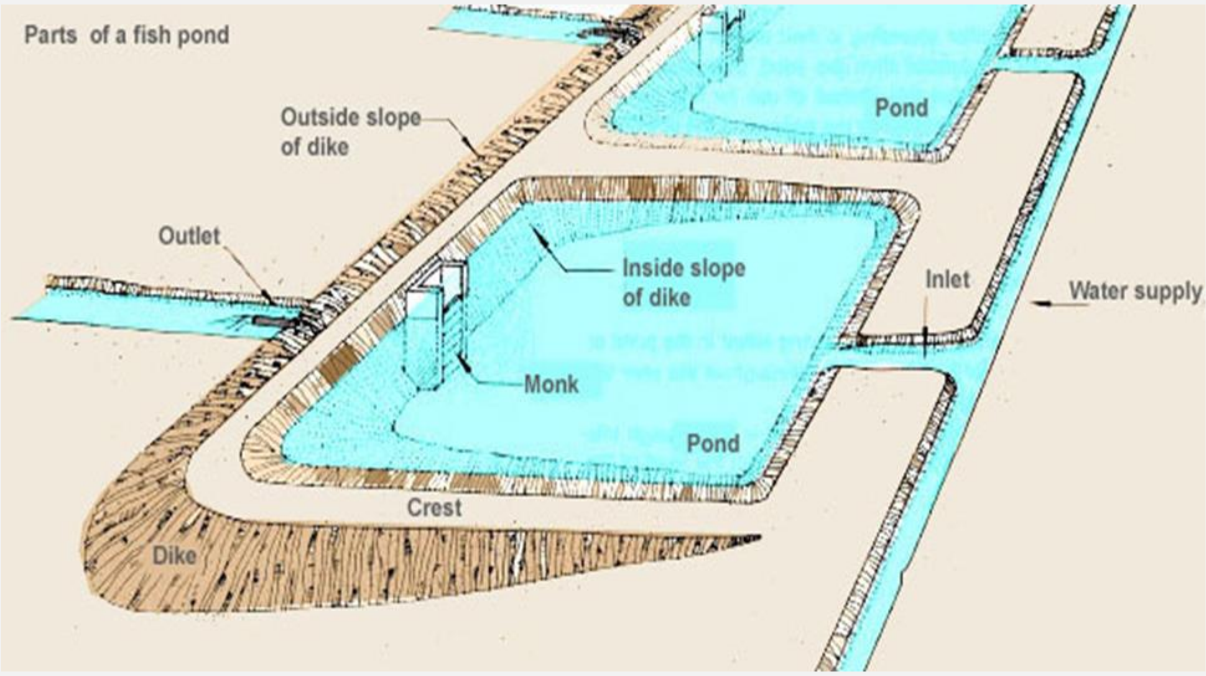
Common Growing facilities and Welfare Considerations

Some common growing facilities and their welfare considerations and issues are discussed in detail below.

EARTHEN PONDS

Marywil (2022) describes an earthen pond as an artificial dam, reservoir, or lake constructed to house different fish species in order to retain some natural aquatic environment features. It is constructed manually or mechanically in a carefully selected site with enough clay soil for high water retention.

Picture 4.1 - Dug-out earthen ponds used for housing fish in their clusters (Source – nobowa.com)



Picture 4.2 – Schematic representation of Earthen Ponds. (Source – FAO)

To use an earthen pond, the following welfare considerations, protocols, and activities must be undertaken:

- Proper soil and water analysis must be carried out to determine suitability of location, vegetation, and topography.
- Locations with clay or loam-based soil containing more than 65% clay and pH between 6.5 to 8.5 is preferable. Sites with sandy soil should be avoided due to the porous nature that may cause percolation or seepage of water, infiltration of wastewater from the surrounding into the ponds. Soil with heavy metal deposits must also be avoided.
- The pond must be structured in such a way that it will not cause flooding or obstruct water drainage flow patterns in flood plains or wetlands, or cause erosion.
- Low lying ponds should be screened with appropriate non-toxic material to prevent fish loss during flooding as well as entry of wild fish and other predators.
- There must be adequate and continuous supply of good quality water, especially in areas prone to drought.
- Water sources must be free from iron as this affects fish gills and oxygen intake, causing stress, poor reproductive ability, and stunting.
- Measures to cope with predators (snakes, rodents, and birds) should be in place and this may include the use of screens, scare-crow, and keeping the environment clean.

Common welfare issues with fish grown in earthen ponds.

- Sorting the fish along the growing cycle will be difficult. The common practices of sorting and cropping fish often lead to them being brought out of water for a considerable length of time and may cause stress to them. While some fishes can stay out of water longer than others (e.g., catfish compared to tilapia), it should not be encouraged.
- The throwing of fish into ponds is also a grave issue of animal welfare as it temporarily disorientates them before they regain their balance.
- Cannibalism and predation are often common within the earthen pond environment, especially in polyculture. Generally, growing of carnivorous fish with other fish species with the intent of using these others to feed and grow the former is a grave and unapproved rearing method.
- Earthen ponds are highly vulnerable to environmental pollution and other hazards. There is a high probability of lower sanitation which increases the risk of disease transmission from humans to the fish and vice versa.
- Some farmers try to manipulate soil quality and provide enrichment in ponds. However, caution must be exercised to prevent wrong application and overdosing. This will negatively impact water quality (growing environment) and fish welfare. There have been reported cases of fish skin bleaching and mass mortality in growing ponds during soil enrichment, and accidental introduction of pathogens through the application of organic fertilizers. Such pollutants also have One Health implication that may impact both aquatic and land animals, including humans.

CONCRETE TANKS

Concrete ponds are often made from concrete blocks or reinforced slabs. A mixture of sand, cement and gravel are used to prevent cracks and leakages. Therefore, water flows through the pond in and out through drains. The water may be treated for use in crop farming and vegetable production or may be released into natural water bodies. Concrete tanks must be well designed with a complete drainage and overflow system. Also, the tank must be cured (treated with salt) before use to avoid water pollution with chemicals from the cement as this will lower the pH and make the water acidic. They can be of varying sizes and shapes. Ideally, the tanks should not be smaller than 2m x 3m and a depth of 1.2m-1.5m is desirable to cool the water. The shape could be rectangular, square, circular and is determined by several factors such as expected production, length of production period, sanitation regime, and fish behavioural swimming pattern.

Picture 4.3: Concrete tanks constructed to house fish; Source – Business Compiler

Picture 4.4: Concrete tanks built in an enclosed housing space to house fish; Source – Everlush.ng

Common welfare Issues with fish grown in concrete tanks.

- High fluctuation of temperature (temperature shock) may happen if adequate volume and consistent availability of good quality water is not guaranteed. This situation would greatly stress the fish and would often lead to mortality, if not addressed on time.

- This system is easily prone to built-up water pollution and fish mortality if daily good management practices are not strictly adhered to.
- Faulty inlet, outlet and drainage system or leakages may lead to massive fish mortality borne out of issues such as lower water levels, temperature fluctuation, oxygen depletion, etc.

MOBILE FISHPOND SYSTEMS

Mobile fishponds may be easily moved around (as indicated) or placed in a stationary position depending on need. They may be made up of fiberglass, wood lined with carpet or linoleum (fish vat), polyethene, and plastic tanks**.** These systems are also designed with inflow and outlets with a variety of designs and level of sophistication. Ideally, these must be installed under some form of shade or cover from the heat and direct sunlight.

Fiberglass tanks are usually circular and require a special cleaning methodology. Some use aerators to ensure enough oxygen concentration or have installed sprinklers (showers) at the inlet. Other mobile pond systems are not as durable. For example, wood tanks are particularly prone to wood rot which may lead to leakage, water loss and pollution.

Picture 4.5: Plastic tank pond set-up rear fish. (Source – Everlush.ng)

Picture 4.6: Tarpaulin Pond set-up to house fish with tarpaulin material placed in a dug-out earthen space; Source – Everlush.ng

Picture 4.7: Tarpaulin Fishpond set-up; (Source – Aqua4nations.com)

Common welfare issues with fish grown in mobile fishpond systems.

- Increased risk of algae excess buildup on the rearing system's walls which may affect water quality.
- Possibility of an accidental introduction of food items and wastes which will cause pollution and reduce water quality.
- High risk of water temperature fluctuations that may stress fish.

RECIRCULATORY AQUACULTURE SYSTEM (RAS)

A water recirculating system is an automated system of aeration of the fish growing water, efficient removal of particulate matter, biological filtration to remove ammonia and nitrite, and buffering of the pH. It consists of fish tanks, sedimentation tanks, chemical and biological filter systems, aeration systems (ozone generator), and pathogen control systems. Water is re-circulated to minimize water replacement, maintain water quality conditions, and compensate for an insufficient water supply. The key to this system is water quality. Farmers achieve high biomass stocking intensity by maintaining good water quality, and that requires skilled, educated farmers. High emphasis needs to be placed on cleaning of intake water, good water flow inside the tank, optimised sludge removal and, thorough water treatment inside the RAS.

Picture 4.7: Small-scale Backyard RAS Fish Pond set-up; (Source –Hydroponics Nigeria)

Picture 4.8: RAS Fishpond set-up; (Source – Africaninfoblog)

Issues of fish welfare with water recirculatory system

- It is a highly intensive system that is not often welfare friendly. It consists of high stocking density which restricts fish movement and behavior and causes stress.
- The capital-intensive maintenance of the system may not be sustainable, and any slight disruption may create immense stress on the fish.
- Sourcing and availability of high-quality feed required may be difficult.
- Disruption to continuous electric power supply will lead to ammonia build up in the system and fish blood leading to stress, pain, and in extreme cases, death.
- System breakdown will create stress on the fish and may lead to high mortalities.
- Its complex nature requires skilled personnel to manage it.

CAGES AND PENS

A cage is a net enclosure usually suspended in a water body anchored on the natural waterbed kept buoyant by floats and used for farmed fish. A pen is a shallow water enclosure for the rearing of fish in an open water body and often sits on the floor of the water body. These should be constructed not to obstruct navigation on water as the regular movement of the cages and pens to allow passage to other users of the water bodies will cause extreme stress to the fish which may affect the rate of feeding and their health. The cage and pen should not be constructed on waterways that are used for navigation. Cages can be installed in deeper waters (>4m) whereas pens should be in shallow waters (1-2m). Also, the materials used must be durable to withstand severe weather conditions and prevent the inflow of debris while allowing for the free flow out of the system excess feed that will pollute water. Often, farmed fish rely on natural live foods within the environment augmented with artificial feed when the stocking densities are high, which is a common practice with such systems.

Picture 4.9: Fish Cage set-up; (Source – Everlush.ng)

Issues of fish welfare with cages and pens

- The system is vulnerable to environmental pollution from the surrounding water body. Also, other environmental hazards and predators will stress the fishes.
- Use of poor-quality material may create tears and openings for other unintended stray fish species, predators or aquatic animals' access to the cages and pens, and these could hurt farmed fish, introduce extraneous pathogens, and diseases to farmed fish, and vice versa.
- Conflicts in the use of waterways and upstream activities could lead to disruption of maintenance activities, and disturbances to the fishes in cages and pens.

STOCKING DENSITY

Stocking density (kg fish/m³) describes the biomass of fish per unit of water in the rearing system. Optimal stocking densities is based on several factors such as type of fish species, life stages, growing systems, water flow rates and can also depend on the environmental conditions. It is also one of the main characteristics that determine whether a fish farm is extensive or intensive.

It can have a major impact on fish welfare, as it influences water quality, growth, stress status and social interactions – such as aggression among the fish. For example, if you manage to maintain high water quality, that means you can increase the biomass or stocking density. However, if you don't maintain high water quality, you will need to lower stocking density else, this will lead to stress, and in extreme cases, death of fish.

For species like rainbow trout, other salmonids, tilapia and catfish, successful rearing is generally possible at densities in which all fish of the rearing unit form a community. Such fish species thrive best in groups and may develop dominant and aggressive behaviour if there is too high or too low stocking densities, or if there is one gender only.

Because of this, deciding stocking densities on a fish farm is not a simple discussion to have, even though farmers usually prefer higher stocking densities as they assume this would automatically increase their production capacity. However, from research and experience, stocking density should be carefully considered and should always be backed up by research and welfare guidelines.

How to measure Stocking density

To find the current stocking density of an **already stocked** growing system, one needs to have the following preliminary information:

1) The volume of water in the growing system,
2) The volume of the growing system, and
3) The number and weight of the fish stocked.

To calculate stocking density, the simple formula is:

$\frac{Total\ number\ or\ weight/biomass\ of\ fish\ stocked}{Volume\ of\ water\ in\ the\ growing\ system}$ = either Biomass/volume or number/ volume.

Using biomass is preferable because it captures the growth current state of the fish better than mere numbers. For instance, 10 fish weighing 500g each will occupy more space than 10 fish weighing 100 g each, thus using numbers without a regard for the growth stage can be misleading.

So, with this formula, it is assumed that in a pond with total volume of 10,000 litres of water carrying 6,000 litres of water with 1,500 fish weighing 400g each,

Total biomass= 400g x 1500 = 600,000g (600kg)

Stocking density will be= $\frac{600{,}000}{6{,}000}$ =100g of fish per litre of water

Therefore, the stocking density of that growing system will be 100g of fish per litre (going by weight/biomass of fish) of water or ¼ fish per litre (going by number of fish).

Before embarking on fish farming, the stocking density for the desired species (established by research and guidance) must be known and strictly adhered to. Furthermore, the feeding habits and natural behaviours of the species in question must be known and factored into the stocking density computations as this will enhance productivity and welfare.

Recommended stocking densities

Information on optimal stocking density for different fish species is not novel as the optimum stocking densities for the commonly cultured fish species in Nigeria (Catfish, Tilapia and Carp) have already been established by research.

Examples of species-specific and growing system-specific recommendations for optimum stocking densities as evidenced by research include the following:

- Kareem *et al.* (2023) provides the stocking density of *Clarias gariepinus* as 250 fish/m^2 for intensive earthen ponds.
- Oke and Goosen (2019) provides the stocking density of *Clarias gariepinus* as 7 fish/m^{-2} for extensive earthen ponds.
- Nouman *et al.* (2021) provides the stocking density of *Oreochromis niloticus* in cages to be 120 fish/m^3.
- Ahmed *et al.* (2002) provides the stocking density of *Cyprinius carpio* to be higher at 25 fish/m^2 in cage culture.

As mentioned earlier, every system has a carrying capacity, and different fish species have their specific optimal stocking densities. Therefore, fish farms should not be overstocked as this has a negative impact on their health and welfare. For example, the optimal stocking density of larval catfish is 100 per square meter. After 5 weeks, 35–40 fingerlings per square meter can be harvested, each weighing 2–3 grams. Increasing this stocking density does not increase the production and while lower stocking densities will result in less fingerlings per square meter, the harvested fingerlings will be bigger in size. (FAO)

Table 4.1 below provides recommendations for stocking densities of catfish, tilapia, and carps.

Table 4.1 - Recommended stocking densities of catfish, tilapia, and carps.

SPECIES	**STOCKING DENSITY**	**REFERENCE**
Clarias gariepinus (Catfish)	7 fish m^{-2} (Floating Cages)	(Nouman *et al.*, 2021)
	120 fish/m^3 (Concrete Tanks)	(Kareem *et al.*, 2013)
	100- 150 fry/L (Indoor Aquaria)	(Ajani *et al.*, 2015)
	250 fish/m^3 (Indoor Aquarium Tanks)	(Wiyoto *et al.*, 2023)
Oreochromis niloticus (Tilapia)	3 fish/m^3 (Extensive earthen ponds)	(Abou *et al.*, 2007)
	400-500 fish/m^3 (RAS)	(Gullian-Klanian and Arámburu-Adame, 2013)
	10-15 kg fish/m^3 (Indoor Aquarium Tanks)	(Al-Harbi and Sidduqui, 2000)
	160 fry/m^3 (Concrete Pond)	(Towers, 2014)
Cyprinus Carpio (Carp)	2470 fishes/ha (Earthern Pond)	(Hossain *et al.*, 2020)
	0.7 fish/m^2 (Earthen Pond)	(Taher and Al-Dubakel, 2020)
	15 kg m^{-3} (Concrete ponds)	(Lu *et al.*, 2022)
	0.5 Common Carp m-(^{2}) (Eathern pond)	(Ahir, 2022)
	0.4 fish/L (Concrete tanks)	(Jha and Barat, 2005)

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- ❖ Discuss each of your current growing systems for your fish farms. What problems are you facing in your farm now?
- ❖ Did you do any analysis or evaluation of your farm sites before you decided? Tell us your findings and why you decided on your current system.
- ❖ Based on what has been learned so far, how do you intend to improve the growing system and site of your farm to align with good fish welfare practices?
- ❖ Discuss your current stocking density (if you know them).
- ❖ Did you consider stocking density before starting your fish farm? How do you determine the optimal stocking density for it?
- ❖ Based on what has been learned so far, what challenges have you been experiencing, and how do you intend to improve your fish farm stocking density going forward?

MODULE 5: WATER QUALITY AND FISH WELFARE

This module discusses the impact of water quality on fish welfare and how to monitor this important factor to ensure the health and welfare of fish.

INTRODUCTION TO WATER QUALITY

Fish are in intimate contact with water. Thus, water quality is arguably one of the most critical factors for fish welfare and needs to be closely monitored. Poor water quality or rapid changes of its parameters can lead to both acute and chronic health and welfare problems for fish. Each species has its specific requirements for water quality. Under all circumstances, it must be kept at optimal levels.

Water quality parameters include temperature, conductivity, pH, oxygen concentration, nitrogenous compounds such as ammonia, nitrite, and nitrate concentration, hydrogen sulphide and more. Also, the water flow rate is a critical determinant of its quality as it provides fresh oxygen supply and dilutes and disperses metabolic waste. At a high flow rate, certain rearing systems may tolerate much higher stocking densities than at a low flow one.

Flow speed and direction within a tank should be arranged in a way that all water is exchanged regularly to avoid "dead" unexchanged zones, thus preventing areas with low oxygen content and/or increasing ammonia and/or hydrogen sulphide concentration due to unwanted sedimentation of faeces and uneaten feed. Modern fish farming often relies on technical equipment to keep water quality at optimal levels. Malfunctions of such equipment may rapidly cause serious deteriorations in water quality, especially in intensive production systems. Hence, monitoring and alarm systems are necessary to detect and report rapid changes, allowing for responsive actions to address them.

CONSIDERATIONS FOR OPTIMAL FISH HEALTH AND WELFARE

Water quality is one of the most important factors contributing to fish health and their entire existence is dependent on the water environment they live in. This makes fish very sensitive to pollution and poor water quality issues. On the other hand, they will flourish and be in good health in a good water environment that is optimal for them. To ensure good water quality for optimal fish health and welfare, the following must be taken into consideration:

- **Source of water and type**: Source of water for any growing system should be natural water or close as much as possible in quality and consistency of what is determined as optimum for the fish species. It should also be devoid of chemicals, pollutants, and infectious organisms.
- **Water budget and storage**: This needs to be calculated, monitored, and replenished regularly. Adequate provisions should be made prior to any production activity. As much as possible, acute shortage of water must be avoided because it may lead to water pollution and decrease in oxygen concentration. This will immediately induce stress, affect fish welfare and health – and in extreme cases, cause death.
- **Water monitoring and analysis** should be carried out regularly for key water parameters and indicators to determine water quality before usage. This must be continuously, at least once daily, and at consistent intervals. It is also important to have a record for keeping track of all the historical measurements. The water quality parameters to be monitored include:
    - ❖ **Physical parameters** - temperature, pH, dissolved oxygen, salinity, ammonia, nitrite, hydrogen sulphide, alkalinity, hardness, turbidity, and suspended solids.
    - ❖ **Organic chemical contaminants** – veterinary drugs, antibiotics, hydrocarbon-based chemicals, and other pollutants.
    - ❖ **Biochemical hazards** – toxins
    - ❖ **Biological contaminants** – pathogens such as bacteria and viruses

LIFE STAGE AND SPECIES-SPECIFIC CONSIDERATIONS

Water quality requirements vary for different species of fish and even for the different stages of their life cycles. The following table presents general water quality parameter required for farmed catfish, tilapia and carp.

Table 5.1- Water quality parameters for catfish, tilapia, and carp

Parameters	**Catfish**	**Tilapia**	**Carp**
Temperature	26°C-32°C (Kashimudddin *et al.*,2021)	20.2 - 31,7°C (Leonard and Skov,2022)	28 and 34 °C (Veluchamy *et al.*,2022)
Dissolved Oxygen (DO)	2.91 and 4.85 mg/L(Boyd and Hanson,2010)	5 and 7 mg/L(Abd El Hack *et al.*,2022)	0.5-20 mg/L(Homoki *et al.*,2021)

pH	6,5-8,5(Fathurrahman *et al.*,2020)	6-8.5(El-sherif *et al.*,2009)	7-8.0(Heydarnejad ,2012)
Ammonia	0.34mg/L(Edward *et al.*,2010)	0.14mg/l (Benli *et al.*,2011)	0.24 ± 0.06 mg L–1,(Heydarnejad, 2012)
Nitrite	1.19 mg.L-1 (2% of LC50-96h) (de Limal *et al.*,2011)	0-7 mg/L (Amazon Web Services)	0.18 ± 0.02 mg L–1(Heydarnejad, 2012)
Nitrate	400 ppm nitrate (Agricultural Marketing Resource Center)	5-500 ppm(Sallenave ,2016)	Below 80ppm (Sacramento Koi)
Alkalinity	4.56mg/L (Baldisserotto and Rossato,2007)	1.6 to 9.3 mg/L (Colt and Kroeger,2013)	7.8 ± 0.9 mg L–1(Heydarnejad,,2012)
Water hardness	25-50 mg CaCO3 L-1(Copatti *et al.*,2011)	401.33 mg/l to 634.00 mg/l (Choudhary and Sharma,2018)	300-500 mg/l CaCO 3 (Rach *et al.*,2010)
Turbidity	Below 88(Jayadi,2022)	200 mg/L(Ardjosoediro and Ramnarine,2002)	25-100 mg/l FAO

CATFISH WELFARE AND WATER QUALITY

Catfish are the most common of farm fish species in Nigeria, and they can often withstand greater environmental fluctuations. This is due to the presence of their false lungs (arborescents) which help them to breathe in air, unlike most other fish species that depend solely on their lungs. Catfish are said to be hardy, but if they are out of water, they undergo high stress which negatively impacts their welfare. Therefore, their hardiness should not be an excuse to ignore welfare practices and they must be kept in optimal water quality conditions.

HOW TO MEASURE AND CORRECT WATER QUALITY PARAMETERS

Measuring water quality is essential for maintaining a healthy aquatic environment. Farmers can use various testing kits, electronic meters, or send samples to a water quality laboratory for more comprehensive analysis. For use of test kits and meters, follow the instructions provided on the kit for accurate measurements.

Solutions for Out-of-Range Parameters

When any of the water quality parameters fall outside the desired range, farmers need to take appropriate actions immediately to correct the issue. On a general note, after removal of the agent causing the water parameter imbalance, partial/full water replacement with water of desirable parameter can salvage most parameters, this needs to be done in such a way that minimises stress/shock to the fish. In addition, here are some parameter-specific measures to correct out-of-range water quality parameters:

- Temperature: If the temperature is too high or too low, consider using a heater or a chiller to adjust the water temperature to the desired range for the specific species you are caring for.
- pH: To adjust pH, use pH buffers or pH adjusters. For example, adding sodium bicarbonate (baking soda) can raise pH, while adding phosphoric acid can lower it. Improvised pH buffers like ground crustacean and mollusc shells can also be applied to moderate the pH.
- Ammonia, Nitrite, Nitrate: High levels of ammonia and nitrite can be toxic to aquatic organisms. Perform partial water changes to dilute these compounds. Beneficial bacteria in biological filtration systems can also help convert ammonia and nitrite to less harmful nitrate. Regularly monitor these parameters and ensure proper filtration.
- Dissolved Oxygen: Low oxygen levels can lead to stress and health issues for fish. Increase aeration and water movement to improve dissolved oxygen levels. Address sources of oxygen depletion, such as excessive organic matter decomposition or overstocking.
- Total Dissolved Solids and Salinity: High TDS or salinity can indicate excessive mineral content. Regular water changes can help reduce TDS, and for saltwater systems, use purified water or a reverse osmosis unit to maintain appropriate salinity levels.
- Alkalinity and Hardness: Maintain stable alkalinity and hardness levels to prevent pH fluctuations. You can use alkaline buffers to adjust alkalinity, and crushed coral or calcium supplements can increase hardness.

- ❖ Turbidity: Turbid water can be a sign of sediment or organic matter. Address the source of the turbidity and use mechanical filtration to clear the water.

To reiterate, it is beneficial to always refer to species-specific water quality guidelines and adjust water parameters gradually to avoid stressing the aquatic organisms. Regular monitoring of water quality is essential to prevent issues before they become severe. **If you encounter persistent problems or are unsure about the appropriate solutions, consult with an experienced veterinarian, aquaculturist, or aquatic biologist for personalized guidance**.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- ❖ Discuss your previous knowledge and experience with good and bad water quality.
- ❖ Have you been monitoring water quality? If yes, how?
- ❖ Based on what you have learned so far, what issues have you experienced with water quality and how do you intend to improve the water quality on your farm to align with good fish welfare practice?
- ❖ How can you better measure water quality on your farm? What parameters are most important to you?

This module provides general welfare considerations and guideline in feeding of fish including best practices, feed composition and feed quality.

GENERAL BEST PRACTICES FOR FEEDING

Feeding is generally an important part of the fish life cycle and is a constant activity in fish farms management. However, to ensure optimal fish welfare and health, the following general best practices must be implemented:

- Strive for the most optimal feeding times and feed quantities and avoid starvation periods exceeding 72 hours.
- Fish must always be provided with sufficient and adequate amounts of feed. This includes avoiding underfeeding or overfeeding them. Insufficient feed adversely impacts their growth, productivity, and welfare while providing too much can cause poor water quality, which in turn will affect health and welfare.
- Avoid giving feed in unavailable forms, such as excessively large pellets.
- Avoid feeding in a location where smaller fishes are outcompeted, as these can result in poor health and welfare of the affected ones. It is important to grade fish by size in any of your species to achieve a homogenous group and to avoid competition for the smaller fish.
- Also, provide feed formulations in appropriate amounts that are available to all fishes in the farm.
- Ideally, vary the locations periodically where feed is administered within the enclosure, to provide mental stimulation for fish, simulate their natural environment, and avoid overcrowding in feed locations.
- Where possible, farmers can implement systems where animals and their feed are co-produced.

COMPOSITION AND QUALITY OF FEED INGREDIENTS

All ingredients used for fish feed must be of high quality devoid of any form of contaminants and should have good taste and smell. Feed must be nutritionally balanced in terms of the protein content, carbohydrate, fats and oils, and mineral contents. ***Hormones - especially growth hormones-treated feeds should NOT be fed to fishes.***

For catfish, recommendations for high quality feed consists of about 40-45% protein and it must be highly digestible with an ideal feed conversion ratio of 1:2. Also, fish feed should preferably be in pelleted floating form, and it is important to match the size of the pellet to the fish mouth - indicating that pellet sizes should keep increasing following fish growth.

FISH FEED AND SPECIFIC WELFARE CONSIDERATIONS

Use of Animals for Fish feed: As sentient beings, a key animal and fish welfare consideration is that the number of animals used for feeding in the supply chain should be minimized to reduce their suffering, and limit the reduction and elimination of terrestrial, aquatic and insect animal ingredients. Wild-caught fish and animal species that are smaller in size and have a larger individual-to-weight ratio, such as insects and krill, should not be used as feed. To this end, producers where possible must move toward the use of alternative feed products which have the following characteristics:

1) Have higher feed efficiency ratios that also maintain good nutrition and health,
2) Substitute carnivorous farmed species with herbivorous extractive species.

Use of chicken offal or maggot for Fish Feed: Feeding fish with chicken offal or maggots is highly discouraged or should be subjected to further treatment to destroy potential pathogens before being fed to fish. Apart from being visually unethical for consumption by the fish and the end-consumers (humans and other animals), it has a high risk of transmitting zoonotic infections with dire health consequences. In future advocacy for country-level and Africa-wide animal and fish welfare regulations, recommendations to ban this practice will be promoted.

Feeding rates: The recommended daily rate for fish feeding is 2-5% of fish body weight. In reality, especially in catfish farming, the fish must be fed to satiation with the last feeding schedule preferably done at 10PM. This practice will limit the risk of cannibalism and predation in most fish farms in Nigeria as there are hardly any farms with automatic feeders that can ensure continuous feeding until the next day. Factors affecting food consumption rate include fish health, water temperature, pH, oxygen contents, feed quality in terms of taste, size and palatability, method of feeding, etc. These factors should be monitored at regular intervals, and a log should be kept allowing for evaluations and taking corrective measures if needed.

Feed storage: Feeds must be appropriately stored to prevent exposure to moisture, heat from direct sunlight, mold, and other contamination which may lead to degradation of their ingredients and impact their overall quality and or composition. They must also be stored appropriately to avoid contact with rodents, insects, birds and other animals or parasites.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

❖ Discuss your previous knowledge and experience with good and bad feed. How do you differentiate between good and bad feed for your fish?

❖ Based on what you have learned, what experiences have you had in the past with sourcing for feed for your fish?

❖ How do you intend to improve the feeding on your farm to align with good fish welfare standards?

❖ What local alternatives do we have to poor unethical feeding practices such as:

  a) Use of smaller animals for fish feed,
  b) Use of hormones,
  c) Use of chicken offal and maggots, and
  d) Use of insects?

❖ How can we innovate on alternative feeding that meet optimal welfare standards for fish production?

HANDLING AND FISH WELFARE

The capture and handling of fish on a farm is unavoidable due to the need to carry out various procedures (e.g., vaccination, grading, tagging, and slaughter) throughout the production cycle. It is also needed to move fish between facilities, and these include transferring them within the rearing system, transporting them between farms for marketing and slaughter.

Welfare Considerations in Fish Handling

Fish are very sensitive to handling and the removal of fish from water elicits a maximal emergency stress response. Therefore, animal welfare groups and organizations advise that handling should be kept at an absolute minimum, and removal of fish from water should only be carried out when absolutely necessary, for no longer than 15 seconds, unless anaesthetised (Humane Slaughter Association, 2005). Building on this, it is important for the aquaculture industry to continually develop less stressful ways of carrying out on-farm procedures that would involve fish capture, handling, and transportation.

Fish sensitivity to handling is particularly dependent on temperature. At high temperatures, they are usually more sensitive, and handling should be avoided. The same applies to very low temperatures, and below zero, where fish should not be handled at all.

Poor handling may cause injuries to eyes, fins, and muscle, as well as scale loss. It also damages the skin's protective mucous coating, which serves as the primary line of defence against pathogens, thus increasing the vulnerability of fish to disease. Furthermore, all equipment used for handling must be in a good hygienic condition and, if possible, have a plain surface structure to avoid fish injury.

TRANSPORTATION AND FISH WELFARE

Transport of live fish is a multi-step operation consisting of preliminary capture and preparation of animals and transport facilities, harvest of the fish, loading, conveyance – including maintaining water quality – and unloading at the delivery location. These procedures can induce large stress responses from which the fish will take a long time to recover. For example, salmon smolts take more than 48 hours for their levels of cortisol to return to pre-transport levels (Iversen *et al*, 1998). Also, according to Fish Count (2019), it is reported that fish have a stress physiology which is directly comparable to that of mammals and birds. Stressful stimuli in this manner have been shown to produce a wide variety of effects on transported fish such as metabolic hormonal and behavioural alterations. They further report that immunosuppressive effects and osmoregulatory problems can activate latent disease organisms and are the major cause of death when fish are handled and transported. Furthermore, for some species, the initial loading of fish into the container is the most stressful component of transport.

Welfare Considerations in Fish Transportation

Methods and Equipment Used: Various methods are used in the capture and movement of fish within farms, ranging from the use of small nets for individual animals to large nets for larger fish collection. Special fish pumps or pipes are also used for fish movement between ponds or to other tanks for treatment. Each of these methods, however, have their associated limitations. For example, the use of nets can easily cause abrasions, damage and loss of scales, and poorly designed pumping systems can also cause fish injury, as they can often be dropped onto hard surfaces at the point of exit from the pipe.

The present popular mode of transportation of catfish in Nigeria include using modified jerry cans which are often conveyed in buses, sometimes in vehicles emitting smoke with carbon dioxide or ammonia. The fish may be transported for long distances of up to 6-12 hours and are often starved to avoid polluting the water. However, ***these methods are completely unacceptable and totally against the principles of fish welfare***. The process is extremely stressful for fish and may negatively affect their survival rates.

Ideal transport systems should include the following:

- Transported in specially designated vehicles with insulated holding tanks, monitoring apparatus and for very short journeys.

Picture 7.1 – Insulated holding tanks

- Fish seeds should be transported in gassed polyethene bags placed in Styrofoam boxes to minimize movement shocks during transportation. Before transportation, the receiving tanks must be prepared with high quality oxygenated water which will serve as temporary holding tanks. These fish seeds will be observed for about a week to ensure that there are no accompanying parasites/pathogens. After the quarantine period, they can be transferred to receiving and more permanent holding tanks for onward growth.

Picture 7.2 - Photo credit – Mrs. Bukola Adetayo (A fish farmer)

Conditions during transport: Fish transportation exposes fish to a range of stressful stimuli and poor conditions, including overcrowding, inadequate water quality, limited oxygen, and accumulation of carbon dioxide and ammonia. Stress can occur at different stages of transport such as during:

- Pre-transport treatment (e.g., draining of ponds, pre-transport starvation to clear the gut).
- Loading (e.g., netting the fish); and
- The journey (e.g., inadequately maintained water quality leading to low oxygen levels and build up of CO_2 and excretory products).

These can cause irreparable damage to the fish and even death. Whilst stress can be reduced by using anaesthesia or sedation, these are not licensed and acceptable for use in farmed fish. For these reasons, welfare advocates remain opposed to live fish transportation over long distances, instead recommending transport to be kept to an absolute minimum.

Also, the changes in temperature to which fish are exposed during transport are highlighted as a major welfare problem (Fish Count, 2019). Lowering the temperature under which fish are transported may increase the stocking density that they can tolerate, since lower temperature slows the metabolism (reducing oxygen requirements), but abrupt temperature changes are stressful. On a final note, the WOAH has published general welfare guidelines for fish transportation which are very useful for fish farmers, researchers, and other stakeholders.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- How do you currently handle your farmed fish? Please mention all handling methods you use.
- As a fish farmer, have you received training on handling Operational Welfare Indicators (OWIs)? If so, please briefly explain who provided it, when it happened, and some examples of how you apply it to your daily routine.
- Based on previous experiences, what is your knowledge of fish transportation? Please mention all transportation methods used.
- As a fish farmer, have you received training on transportation OWIs? If so, please briefly explain who provided it, when it happened, and some examples of how you applied it before and after live fish transportation.
- Is the person responsible for live fish transportation trained for that purpose? Does this person know how to act in frequently encountered situations and emergencies during transportation?
- How do you intend to improve the handling and transportation of your farmed fish to align both with good welfare standards? Are there challenges (e.g., economic costs, operational on-farm procedures) preventing you from implementing them?
- How can local innovations in transportation be employed to meet optimal fish welfare standards?

OVERVIEW OF HUMANE FISH SLAUGHTER

At least 124 billion fish are reared and slaughtered each year for human consumption (Mood *et al.,* 2023). In line with animal welfare standards, slaughter should be humane and not cause unnecessary pain or suffering for the fish. Humane fish slaughter often involves the **stunning** which means an intentionally induced process that render fish immediately unconscious and insensible to pain, a condition that must persist until they are dead (Holmyard, 2017; European Union Regulations, 2009). It provides benefits to the slaughter process of fish by making fish easy to handle and causing less injuries to the flesh. Though various systems have recently been developed to achieve humane stunning and slaughter, inhumane fish slaughter is still predominant especially in Nigeria in both commercial and non-commercial fish farms, markets, and private homes. Also, many catfish farmed in Nigeria are sold live before slaughter and they often suffer prolonged transport without food and sometimes water, while contending with asphyxia, temperature shock, excessive handling, and ineffective stunning. This exposes multi-millions of farmed fish to substantial suffering and pain, and it is a major impediment to achieving export-certified fish products into many countries, including the United States and Europe.

Guidelines on fish welfare during stunning and slaughter are offered by WOAH's Aquatic Animal Health Code, and all member states are expected to adapt it for their own slaughter guidelines. In response to this, some relatively humane slaughter methods have been developed. While many acclaimed humane methods are yet to be perfect, this is evidence of growth and evolution of completely inhumane methods which are outrightly unacceptable, and, in some places, banned. Generally accepted slaughter methods include those that utilize electrical stunning, since it allows for a rapid process and is evidenced to have minimal physical and biological effects on the fish.

Furthermore, it is highly recommended that stunning and slaughter of fish must be conducted by staff that have the technical capacity, training, and knowledge to utilize slaughter equipment, can recognize when effective stunning has taken place, and know how and when to re-stun, if necessary. They should receive periodic re-training, upskilling and evaluation of their stunning and slaughter methods, and keep records of these activities in the farm. This is especially important because fish slaughter equipment and methods are still evolving as fish welfare and industry professionals continue to make efforts to ensure a seamless and painless slaughter process.

BENEFITS OF HUMANE SLAUGHTER OF FISH

Carrying out humane slaughter of fish comes with several benefits for the fish, the farmer, and the consumers. These are elucidated below:

- Humane slaughter methods improve meat quality and reduce the risk of spoilage (Fish Count, 2019). It reduces the appearance of soft flesh, gaping, bruising and scale loss, and improves shelf-life when compared to the traditional less humane slaughter methods (Holmyard, 2017). For example, fish slaughtered with more humane methods will often have firmer, translucent fillets with brighter colour, and the onset and severity of rigor is delayed when compared to the conventional less humane slaughter methods (Humane Slaughter Association, 2019).
- Reducing stress at slaughter through humane slaughter methods is also likely to improve eating quality and taste for the consumer (Fish Count, 2019).
- Implementing humane slaughter processes increases the ethical value of the fish product, which can potentially add economic value. Ethical consumers are usually willing to pay extra for more humanely produced and slaughtered fish (Fish Count, 2019).
- Practicing humane methods of slaughter improves compliance with existing local and global food processing and safety standards which invariably improve the market value of the product.

PRE-SLAUGHTER WELFARE CONSIDERATIONS

Humane Slaughter Association provides recommendations for pre-slaughter welfare considerations which is detailed as follows:

Purging: Purging (also known as fasting) is the act of withdrawing feed from farmed fish prior to slaughter to enable their guts to empty their contents. It reduces the risk of fish being contaminated during processing and maintains the quality and hygiene of final products. The recommended time range for purging is 24 to 48 hours to completely empty fish guts while minimizing adverse welfare effects. It is also important to note that the minimum duration of fasting needed to achieve gut clearance may vary depending on water temperature. The higher the water temperature, the less time is needed.

Crowding: This is a common husbandry practice in aquaculture, where farmers reduce the water level or increase fish stocking density. It is usually done during harvesting, as a pre-slaughter procedure. However, it exposes fish to a rapidly increasing density, and as a result, oxygen availability and general water quality can decrease quickly. Its adverse effects can be lessened by slowly reducing densities and providing additional oxygen. Also, overall, crowding should be carried out gradually in steps (rather than crowding all fish all at once) and fish should not be crowded for more than two hours.

Crowding can cause suffering and stress for the fish but, with correct management and careful handling, it is possible to keep stressors to a minimum. For these reasons there must always be at least one member of the slaughter team monitoring the crowd pen. It is important that this person who is solely responsible for the welfare of the fish, can recognise problems and knows what action to take to resolve them.

Where possible, a crowd pen should be set up so that fish can swim against the tide towards the inlet pipe and preferably into a shaded area. Taking advantage of the natural behaviour of the fish in this way will encourage movement with minimal stress.

Dewatering: This is the phase from the crowding to the stunning/slaughter point when the fish are briefly out of water. Most stunning and slaughter methods involve removing fish from the water alive and conscious, which stresses the fish since they are out of their natural environment. To reduce the amount of times fish are exposed to air, they should be removed from water, or dewatered, as close to the stunning point as possible. The dewatering process should be designed to move fish gently and promptly to the stunner in the correct orientation. Humane dewatering processes may include using aquatic anaesthetics to sedate fish immediately prior to their removal from the water, use of pumps used to move fish from the crowd pen, and the use of braille nets.

COMMON FISH SLAUGHTER METHODS

Air Asphyxiation: It is the oldest slaughter method for fish where they are removed from the water and allowed to die through asphyxiation. It is considered inhumane because it can take the fish over an hour to die. Nile Tilapia and African Sharptooth catfish fall within the category of fish that are quite resistant to hypoxia and take a long time to die. This is especially true for African catfish because they can breathe atmospheric air to some extent, which means they take even longer to die. Also, the rate at which the oxygen is depleted is dependent upon ambient temperature and the rate of fish activity. For example, at 20 °C, rainbow trout experience brain death in about 2.6 minutes and cease moving in 11.5 minutes. At 14 °C, the same processes require 3 and 28 minutes, respectively. Since the body temperatures of fish vary according to ambient temperature, reducing the temperature of their bodies typically prolongs the time to anoxia and, therefore, the time to insensibility, lengthening the period of distress. Also, fish that evolved from low-oxygen environments take longer to die, while at higher temperatures, fish lose consciousness more quickly. Another major drawback of the asphyxiation method is that meat quality and shelf-life are diminished.

Head Strike and Stunning: Also known as manual percussion, this is one of the traditional methods for fish stunning and slaughter. In this method, fish are removed from the water and given a sharp blow to the head. If the blow is strong, the animal is slaughtered. If the blow is weak, the animal is stunned. Worse still is cracking of the skull with a heavy instrument or hitting the skull on a hard surface. After the blow is engaged, the fish usually bleed. Percussive stunning – a recommended stunning method – involves a forceful and accurate blow to the head with a blunt instrument. The force required will depend on the size of the fish. The blow should be aimed just above the eyes to impact on the brain. The effectiveness of the stun should be checked, and another blow applied if the fish is not unconscious.

The main disadvantages are the unethically violent nature of the method and often stressful handling of the fish before the slaughter or stunning process. In this case, fish undergo pain and rigor, thereby affecting their flesh and taste even after the processing. Also, there are high failure rates in some fish (such as catfish) and they may remain conscious or retain body movement and sensibilities despite such head strikes.

Spiking: Another crude traditional method is Spiking, and this involves a sharp spike (such as an ice pick or a sharpened screwdriver) inserted through the head of the fish directly into the brain. The procedure can be applied more accurately in large fish due to the larger size of their brains. In smaller fish, the brain may be difficult to locate and destroy. If it is not destroyed, the fish undergo stress, and some undesirable meat quality changes may result. For best results, the spike should be placed in a position to penetrate it and then pushed quickly and firmly into the skull. The impact of the spike should produce immediate unconsciousness. The spike should then be moved from side to side to destroy the brain. The main disadvantage here is also the unethically violent nature of the method. It is important to note that manual spiking requires a lot of precision and expertise to be efficient. Therefore, if you must choose between manual percussion (striking) and manual spiking, manual percussion is probably easier to implement effectively because it requires less precision.

Live Chilling: Live chilling is considered by the aquaculture industry since it has advantages of sustained carcass quality, as reducing muscle temperature close to 0 °C helps delay enzymatic and microbial spoilage processes. It also increases the time for onset of rigor mortis and the resolution of rigor. Another advantage is that the water can be drained, and the fish placed in an iced container with their temperature lowered. Also, the method immobilizes the fish so they can be more easily handled. However, some believe the method is unacceptable since it prolongs the period of consciousness and does not reduce the animals' ability to feel discomfort. Because chilling slows metabolic rate and oxygen needs, it may prolong the duration until death in some instances, with some cold adapted species taking more than an hour to die.

In Nigeria, farmers may use basic crude methods by pouring ice blocks on the fish directly, but this leads to a slow and painful death by causing systemic shock to the fish.

Exsanguination (Bleeding to death): This is the process whereby an animal bleeds to death. Fish are cut in highly vascular body regions, and the process is stressful and painful ***unless the animals are first rendered unconscious***. One advantage for the industry is that bleeding prevents the fish muscles from turning an unpleasant red color and acquiring a bloody odor. The main disadvantage is that if stunning is not done before bleeding according to behavioral and neural criteria, fish may remain conscious for 15 minutes or more between the times when major blood vessels have been cut and when they lose consciousness.

Bleeding can be accomplished by three major processes – cutting the gills, removing the gills or severing the caudal artery. Alternatively, the heart can be pierced or the blood vessels in the tail severed. The animals die from anoxia, and any struggling, which can range from four to 15 minutes, serves to hasten death. However, some species may live longer – for example, eel brains may continue to process information for 13–30 minutes after being decapitated.

Additionally, bleeding can be achieved with decapitation and while not encouraged due to the unethically violent nature, it provides the most profuse bleeding and the shortest time before loss of consciousness.

Use of Anaesthesia: An advantage of using anaesthesia is that, once fish are anesthetized, death can be accomplished more easily by other slaughter methods. Another major advantage is that the fish do not undergo stress, which helps to maintain post-harvest quality. However, the use of anaesthetics has a major concern that some of their compounds may be absorbed into the animal flesh and leave residual chemical traces in the muscle tissues which would be consumed by humans and animals. Also, some species may show adverse reactions for a short time to anaesthetics because they appear to be irritating. The efficacy of this method may vary depending on dosage and on species. For example, African Sharptooth Catfish appear to be very resistant to Aqui-S i.e., they have shown to become paralysed while still being conscious at doses which are known to be lethal to salmonids. For many species, there is still a lot of uncertainties as to whether chemical anaesthesia actually results in a loss of consciousness or whether it only makes fish paralyse. For this reason, it is considered that chemical anaesthesia could potentially be humane but that there is too much uncertainty to recommend it.

Nevertheless, different countries have different regulations when it comes to pre-slaughter chemical anaesthesia for fish destined for human consumption. Some countries allow it without any withholding period or maximum residue concentration, and some countries have standards on both of those aspects. All these points back to the uncertainties associated with the use of anesthesia.

Carbon dioxide narcosis: This slaughter method involves dissolving carbon dioxide in the water prior to introduction of the fish. After that, they react violently while their blood rapidly absorbs the gas. The fish may acquire bruises from hitting each other or the sides of the container. The time required to become anesthetized can vary from less than 4 to more than 100 minutes, and fish may be removed once movement stops, typically after 2-3 minutes. However, there is concern that fish may be rendered immobile by the carbon dioxide before completely losing consciousness and may be bled or eviscerated while still sensible. Also, adding a lot of carbon dioxide in water lowers the pH, making the water very acidic, which causes distress to fish.

Some countries have used nitrous oxide ("laughing gas") as opposed to carbon dioxide, since it does not cause the strong activity seen in fish immersed in carbon dioxide-saturated water. Nevertheless, the fish recover quickly when removed from contact with the gas.

Electrical Stunning: Stunning by use of electricity is known as electronarcosis, whereas killing by electricity is known as electrocution. Electrical shock using either alternating or direct current has received substantial interest in recent years. Electric stunning is reversible, as normal brain function is disrupted for a short period only. Hence, electronarcosis must be immediately followed by bleeding. Electrocution destroys brain function and, therefore, renders the animal unconscious while stopping the breathing reflex from functioning. For electrical stunning to be effective, proper current and stun duration must be maintained. Also, water factors such as conductivity and temperature must be properly managed.

This method has gained substantial support due to concerns for the ethical treatment of animals and their immobilization (used in other slaughter methods) which needs mechanical or hand processing. It also prevents stress and struggling prior to slaughter, which helps to maintain quality.

A potential risk of electrical stunning methods is inflicting pre-stun electrical shocks (which is, electrical shocks that fish will consciously endure without losing consciousness). Pre-stun shocks can happen for the following reasons:

1) The electrical parameters are not adequate.
2) The way the electrical shock is applied is not adequate, because:
    a) The current is applied on a part of the fish body far away from its brain e.g., its tail.
    b) The current loses its strength because of the resistance of fish bodies if it is applied in such a way that it has to go through the bodies of some fish before reaching other fish.
    c) When performed in water, the electrical parameters are not suited to the water conductivity,
    d) When performed in water, the way the current is applied makes it so that the resulting electrical field is not homogeneous.

Although, electrical stunning is among the most humane available methods, not all electrical stunning methods are good. Acceptable electrical stunning methods include:

- In-water pipeline electrical stunning
- Head-to-body dry/semi-dry electrical stunning
- In-water batch electrical stunning

Unacceptable electrical stunning methods include:

- Batch electrical stunning in an electrical tank without any water
- Prod electrical stunning with or without any water

Recent advances in electrical equipment design have made substantial improvements in preventing or minimizing undesirable physical and biological effects in treated fish. However, use of electronarcosis and electrocution remains a challenge in many developing nations due to its expensive set-up and inconsistent supply of electricity in many of these countries.

Other stunning and slaughter methods include **Salting** to slaughter fish which is also considered an inhumane method, as it exposes the fish to pain and suffering because death is not immediate; **use of ammonia baths**; **shooting**

which is often done for large fish; **using a pneumatic accurate gun** which can deliver the required velocity for effective stunning.

Generally, the WOAH Aquatic Animal Health Code particularly considers air asphyxiation, ice bath, CO_2 narcosis, and exsanguination ***without stunning***, as inhumane. Overall research continues in the search for the most humane slaughter methods for farmed fish and fundamental technical issues still need to be resolved for some species.

OVERVIEW OF SLAUGHTER PROCESSES IN NIGERIA

In Nigeria, commercial processing of live catfish often involves hitting the head with a strong club and bleeding the fish to death by cutting one of the gills. This does not cause immediate loss of consciousness, and the pain and distress are likely lasting several minutes. African catfish have been shown to remain conscious more than 10 minutes after cutting, while some fish take even longer for loss of consciousness and death. It is important to note that prior to gill-cutting, the fish may have experienced removal from water for some time, crowding in bowls and baskets, and rough handling by the handler. Note also that cutting only one of the gills, and not both, will result in a slower bleed-out and a slower death, prolonging the distress further.

GENERAL GUIDANCE FOR HUMANE SLAUGHTER METHODS FOR FISH

Generally, humane methods of fish slaughter are ones that cause an instant death or render fish instantly insensible to pain until dead. This can be possible for both manual or automated processes and it often requires fish to be stunned (rendered instantaneously insensible) before being slaughtered. The fishes should also remain in water until immediately prior to the stunning process. Generally humane methods of fish slaughter include:

- Percussive and electrical stunning machines,
- Percussive stunning with a club,
- Spiking the brain, and
- Spiking combined with food-grade fish sedatives (licensed for use in some countries).

To achieve optimal humane slaughter, these methods can be combined as stunning and slaughter. They must also be properly designed for the target species and effectively carried out. Certain systems must be put in place, and these include:

1) a well-organized operating cycle that can reduce to an absolute minimum the duration and intensity of stress,
2) incorporation of fish stunning to induce unconsciousness of the fish.
3) the need for well-trained personnel who can recognize signs of re-consciousness in the fish species after stunning.

Additional general considerations for humane slaughter as detailed below:

- It is important to note that, when possible, it is better to use manual pneumatic guns rather than fully manual methods. While pneumatic guns have been developed for salmonids, other pneumatic guns originally designed for small mammals or poultry can also be used.
- Manual percussive stunning requires less precision to be effective than brain spiking. Therefore, unless operators have specific skills to correctly implement brain spiking, percussive stunning is preferable if you must choose between the two.

In conclusion, for most commercially important fish species, technologies are now available that allow humane slaughter. It is the responsibility of farmers to apply or adapt manual or automated technologies for fish stunning and slaughter to avoid distress and pain for the fish during the procedures.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

❖ Do you slaughter your fish? If yes, what procedure do you currently use?

❖ Based on what you have learned so far, what mistakes have you made with fish slaughter? Mention which of the slaughter methods you have used.

❖ How do you intend to improve the slaughter of your fish to align with good welfare standards?

❖ How can local innovations be adapted to meet optimal welfare standards?

WHAT IS ENVIRONMENTAL ENRICHMENT?

Environmental Enrichment (EE) involves enhancing an animal's living environment to promote species-specific behaviours, mental stimulation, and overall well-being. In the context of fish, it refers to creating conditions that mimic their natural habitats and encourage natural behaviours. It can include adding structures or modifying rearing units to create a more natural or complex environment that resembles the fish's natural habitat. It may also include any intentional augmentation of complexity to the surroundings of the animal, such as buildings made of plants and pebbles, music, unusual foods, and the introduction of various fish species. Furthermore, it may include mimicking colours and introducing varied conditions like dark hiding spots and cooler water areas for them to choose from (Leone and Estévez, 2008; Näslund & Johnsson, 2014). This is particularly relevant in captive settings such as aquaculture farms and public aquariums (Zhang *et al.*, 2020a).

The challenge is figuring out the kind and quantity of environmental enrichment that fish prefer, and this can be aided by knowledge of their sensory abilities. To get started, we must ensure that each potentially enriching material is pertinent to the biology and preferences of the species. For instance, some fish may prefer hiding, while others may prefer swimming against the flow of the water (Zhang *et al.*, 2020a).

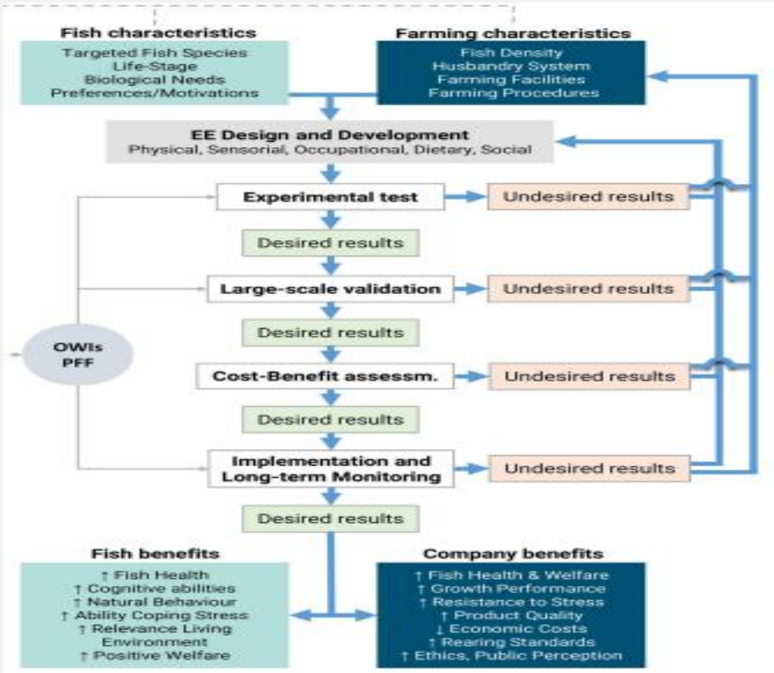


Figure 1: Schematic for the decision-making process in Environmental Enrichment; OWIs: Operational Welfare Indicators; PFF: Precision Fish Farming; (Source: Arechavala-Lopez *et al.*, 2021)

TYPES OF ENVIRONMENTAL ENRICHMENT

Näslund & Johnsson (2014) outlined commonly recognized spheres of enrichment that can be incorporated into farm enclosures for aquatic animals. Producers should strive to achieve enrichment inclusion in each of these areas where possible.

Social enrichment – This is when animals experience the correct amount and type of contact with other fish or animal species. This includes sufficient access for social species and sufficient distance for mutually aggressive or cannibalistic species.

Occupational enrichment – This includes physical and psychological stimulation that allows for the expression of behaviours that promote psychological well-being. This can involve play, interactive feeding opportunities, and sufficient room to swim freely.

Physical/structural enrichment – This includes modification of housing environments to include structural complexity, shelter, and visual stimulation. This can include adding silt, sand, or other incubation substrates to the floor which allows animals to burrow.

Sensory enrichment - It aims at stimulating the fish's senses through the use of different stimuli such as light, sound, or odour (Arechavala-Lopez *et al.*, 2019) which is a diversity of visual, auditory, olfactory, tactile, and taste stimuli.

Dietary enrichment- It involves providing a varied and balanced diet to meet the fish's nutritional needs and promote overall health and well-being. The use of feed is enhanced with appropriate nutrients, the amount and variety of food available, feeding frequency, and/or delivery system.

These different types of environmental enrichment can have positive effects on fish physiology, health, and survival, ultimately improving their welfare.

BENEFITS OF ENVIRONMENTAL ENRICHMENT

Environmental enrichment (EE) has been shown to have several benefits for fish welfare, if applied correctly. These are explained as follows:

- It improves post-stocking survival, and foraging efficiency, reduces fin damage, and promotes social cohesion in fish farms (Rosburg *et al.*, 2019; Huysman *et al.*, 2019).
- It can improve various aspects of fish biology, including aggression, stress, energy expenditure, injury, and disease susceptibility (Arechavala-Lopez *et al.*, 2019; Zhang *et al.*, 2020b).

- It can have positive effects on fish physiology, health, survival, and general welfare.
- It improves the physiological state and behaviour of fish, serving as an indicator of their well-being (Oliveira *et al.*, 2022). This is because it provides new sensorial and motor stimulation to help meet their behavioural, physiological, morphological, and psychological needs, whilst reducing stress and frequency of abnormal behaviours (Arechavala-Lopez *et al.*, 2021).
- It also increases spatial use of the tank, and enhances growth rate in fish (Zhang et al., 2020a).
- Environmental enrichment enhances the fish's surroundings to avoid negative welfare (like stereotypical behavior and chronic stress) and encourage positive welfare (natural behaviour display and positive emotions).
- Some examples from scientific and evidence-based resources show the impacts and benefits of environmental enrichment. These include:
    - Adding structural environmental enrichment to rearing environments has proven positive in reducing aggression, interactions with net pens, and fin erosion in juvenile seabream (Zhang *et al.*, 2021).
    - Intraspecies aggression in fish can be reduced with increased levels of physical enrichment (Zhang *et al.*, 2020b).
    - Occupational enrichment, such as providing opportunities for fish to engage in natural behaviours can help fish cope with acute stressors (Arechavala-Lopez *et al.*, 2019).

Overall, Environmental Enrichment has the potential to improve fish welfare in aquaculture by enhancing their well-being, reducing stress, and promoting natural behaviours. It often requires aqua-ecosystem and biodiversity management, as well as the use and application of local and traditional knowledge (Schweiz *et al.*, 2015; Aubin *et al.*, 2017).

SPECIE RECOMMENDATIONS FOR ENVIRONMENTAL ENRICHMENT

Catfish

Generally, key recommendations for the environmental enrichment of catfish include provision of shelter structures and floating pond covers, use of dark tank coloration, and provision of feed in dry crumbles at the fingerling stage, with night feed preferred at the adult stage. As adapted from the Aquatic Life Institute (ALI), key recommendations for environmental enrichment of Catfish have been explained in Table 1 below.

Table 9.1: Environmental Enrichment Recommendation for Catfish Species

African sharp-tooth catfish (*Clarias gariepinus*)		
Enrichment Category	**Juvenile**	**Adult**
Enclosure Coloration	For higher survival and better growth in fry, provide black tanks (FishEthoBase)	Not enough information is available currently. Therefore, we default to the species' "natural" conditions at this stage.
Substrate Provision	For the most natural solution, provide vegetation or mud banks (FishEthoBase)	For the most natural solution, provide mud, shale, sand, and vegetation (FishEthoBase)
Lighting	To accommodate preference in fry and for lower stress in juveniles, provide ≤15 lux. For juveniles, 24-hour photoperiod is stressful, stress decreases and growth increases with decreasing photoperiod. Natural photoperiod is 9-15 hours. (FishEthoBase)	For lower aggression under light intensities of 0.002-1.4 μmoles/m2/s, provide blue light. Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. (FishEthoBase)
Water Augmentation	For better growth in fry, provide shallower than deeper tanks (14.5 diameter-to-depth ratio or 0.1 m2 x 0.03 m depth) (FishEthoBase)	Provide variations in the direction and the velocity of the water inlet, depending on the life stage. Depth: Provide at least 2-4 m, ideally up to 10 m or more, bearing in mind the planned stocking density (FishEthoBase)
Structures	For better growth in juveniles, install bamboo poles in ponds which probably enable periphyton growth which serves as additional food (FishEthoBase)	African catfish cultured in a coupled aquaponic system with basil showed a reduction of injuries and agonistic behaviour when coupled with high plant density compared with low plant density and control conditions (no plants).
Shelter	Shelter structures reduced juvenile cannibalism (Hecht and Appelbaum, 1988; Hossain et al., 1998) Enrichment with shelters probably increases the value for fry, but this may cause attacks and chases to establish territories. (FishEthoBase) Must be carefully monitored.	For the most natural solution, provide vegetation or mud banks; alternatively, provide artificial shelters inside the system or outside (e.g., black plastic shade material, black nylon shade cloth netting, aluminium roof plates. (FishEthoBase)

Feeding System	Juveniles under hand-feeding regimes were more active than self-feeding regimes and showed higher activity during the morning compared to the afternoon.	Night-feeding enhanced growth and lowered feed conversion ratio compared to day-feeding (Boerrigter et al., 2016). Install a belt feeder and provide the majority of feed during the night (FishEthoBase)

Tilapia Fish

Environmental enrichment strategies for Tilapia fish species have been studied to improve their behaviour and welfare in captivity. Studies have shown that structural environmental enrichment such as the use of plant-fiber ropes or physical structures can enhance cognition, exploratory behavior, and brain physiological functions in Tilapia fish (Torrezani *et al.*, 2013). Enriched environments have shown the reduction of aggression and increased hierarchical behavior in Tilapia fish (Arechavala-Lopez *et al.*, 2020). As adapted from the Aquatic Life Institute (ALI), key recommendations for environmental enrichment of Tilapia fish have been elucidated in Table 2 below.

Table 9.2: Environmental Enrichment Recommendation for Tilapia Fish Species

Nile tilapia (*Oreochromis niloticus*)		
Enrichment Category	**Juvenile**	**Adult**
Enclosure Coloration	Not enough information is available at this time. Therefore, we default to the species' "natural" conditions at this stage.	Maia & Volpato (2016) showed that it takes at least 10 days of testing to find the colour preference for Nile tilapia, and that green and blue are the most preferred colours by the species.
Substrate Provision	Enrichment with e.g. river pebbles and plastic kelp models probably increases the value for juveniles, but this may cause more intense fights to establish territories (FishEthoBase). Must be closely monitored.	Males choose to make their nests in sand substrate when compared to other substrates such as stones. Individuals presented equal frequency of total attacks whether they were being kept with or without substrates, but fewer highly intense attacks were observed in animals kept with the substrate. For the most natural solution, provide sand and mud; alternatively, provide

		gravel. Bamboo poles also increase growth (FishEthoBase).
Lighting	Increased light intensity (280-1390 lx) reduces aggressive interactions between pairs of juvenile males. Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. (FishEthoBase)	Blue light reduces stress by preventing the confinement-induced cortisol response (Volpato & Barreto, 2001) Natural photoperiod is 9-15 hours. Provide access to natural (or at least simulated) photoperiod and daylight. Avoid 1,400 lux, as it increases aggression compared to 280 lux. (FishEthoBase)
Water Augmentation	Depth: Provide at least 2-6 m, ideally up to 20 m, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to life stage and status. (FishEthoBase)	Depth: Provide at least 2-6 m, ideally up to 20 m, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to life stage and status. (FishEthoBase)
Structures	An enriched environment increases resource value which in turn prompts more intense fights (FishEthoBase)	Fish cultured in environments enriched with artificial water hyacinth and shelter presented higher latency to trigger confrontations, and the confrontations were less intense in the section with enrichment items (Neto & Giaquinto, 2020).
Shelter	An enriched environment increases resource value which in turn prompts more intense fights (FishEthoBase)	For the most natural solution, provide roots or submerged branches, bushes, or trees; alternatively, provide artificial shelters inside the system (e.g. artificial reef) (FishEthoBase)
Feeding System	Make sure to provide sufficient feed from ca 4-8 days after hatching. Self-feeders could prevent stressful food competition (FishEthoBase)	Tryptophan-supplemented food was found to reduce confrontations (Neto & Giaquinto, 2020) Install a self-feeder and make sure all Nile tilapia adapt to it. (FishEthoBase) Provide sand and mud and bamboo poles so that individuals may search for food. (FishEthoBase)

Carp Fish

Environmental enrichment recommendations for carp fish species include expanding the range of bred fish, considering the available feed base and biotechnics level (Servetnik, 2022). The traditional set of fish recommended for polyculture in north-western regions includes planktophages (peled), benthophages (chir, pyjian, carp), predators (pike perch, pike, trout), phytoplankton, zooplanktophages (white amur and motley carp), herbivorous fish (white cupid), Chudsky whitefish, muksun, and hybrids of peled with chir for nectobentos (Williams *et al.*, 2009). Multi-colored gravel substrate, cobbles and plants can be provided in the hatchery environment (Murtaza et al., 2020). As adapted from the Aquatic Life Institute (ALI), key recommendations for environmental enrichment of Carp fish have been elucidated in Table 3 below.

Table 9.3: Environmental Enrichment Recommendation for Carp Fish Species

Common carp (*Cyprinus carpio*)		
Enrichment Category	**Juvenile**	**Adult**
Enclosure Coloration	For lower stress and higher growth, avoid red and black tanks (FishEthoBase)	For lower stress and higher growth, avoid red and black tanks (FishEthoBase)
Substrate Provision	For the most natural solution, provide sand, mud, gravel, and submerged vegetation (FishEthoBase).	For the most natural solution, provide sand, mud, gravel, and submerged vegetation (FishEthoBase).
Lighting	Natural photoperiod is 7-17 hours. Provide access to natural (or at least simulated) photoperiod and daylight (FishEthoBase). For lower stress and higher weight in juveniles, prefer 200 over 80 lux (FishEthoBase)	Natural photoperiod is 7-17 hours. Provide access to natural (or at least simulated) photoperiod and daylight (FishEthoBase). Allow Common carp a resting period at night or in the dark (FishEthoBase).
Water Augmentation	Depth range: in the wild, found at 0-1.3 m, adults up to 25 m. Provide at least 1.5 m, ideally up to 5 m or more, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to their life stage (FishEthoBase).	Depth range: in the wild, found at 0-1.3 m, adults up to 25 m. Provide at least 1.5 m, ideally up to 5 m or more, bearing in mind the planned stocking density. Individuals should be able to choose swimming depths according to their life stage (FishEthoBase).

Structures	Cover: Avoid complete cover for differences in the daily rhythms (FishEthoBase).	Cover: Avoid completely covers concerning differences in the daily rhythms (FishEthoBase).
Shelter	Juveniles used plants as shelters (FishEthoBase).	For the most natural solution, provide vegetation; alternatively, provide artificial shelters inside the system or outside (FishEthoBase).
Feeding System	Food competition: Make sure to provide sufficient feed from ca 1-7 days after hatching. To improve stress tolerance, enrich feed for fry with 4% fructo-oligosaccharides (FishEthoBase).	The most natural solution is to provide food at 1) varying intervals or 2) constant intervals but day as well as night, while making sure not to disturb the resting part of the population. Alternatively – and for lower stress and higher growth – install a self-feeder and make sure all Common carp adapt to it.

In conclusion, environmental enrichment is a powerful tool for enhancing fish welfare by providing opportunities for species-specific behaviours, mental stimulation, and improved overall health. Recognizing the importance of environmental enrichment in captive settings can contribute to the ethical treatment of fish and the sustainability of aquaculture practices. Regular research and collaboration between scientists, aquaculturists, and conservationists will continue to advance our understanding of effective enrichment strategies.

Q&A SESSION

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If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- ❖ Have you heard about or tried "Environmental Enrichment" before now? What was your experience like? What enrichments do you (or someone you know) currently use?
- ❖ Based on your current knowledge, how do you intend to improve the environmental enrichment of your fish to align with good welfare standards?
- ❖ How can local innovations and traditional knowledge in the environment be employed to meet optimal welfare standards?

ANIMAL HEALTH AND WELFARE

Animal welfare is defined as a state of the animal, the treatment it receives from animal care, animal husbandry, humane treatment, and how an animal is coping with the conditions in which they live (Animal Welfare Institute, 2018). Animal Health can be defined as the absence of disease and the normal functioning of an organism and normal behaviour (Ducrot *et al.*, 2011). From the above definitions, it is evident that the concepts of animal 'health' and 'welfare' are different but very much linked to each other. For example, an animal in a good state of welfare is considered healthy, comfortable, well nourished, safe, able to express innate behaviour, and is not suffering from unpleasant states such as pain, fear, and distress.

The main difference is that animal health largely focuses on the occurrence, impact and treatment of diseases, infections and sub-optimal health conditions, while welfare incorporates the sentience and mental complexity of animals which includes their ability to feel emotions, have needs, be conscious and their ability to adapt to domestication without negatively impacting their freedom of expression of natural behaviours (Nicks and Vadenheede, 2014). Though varying in approach to well-being, they mutually impact each other and are both integral to the overall optimal well-being and livelihood of animals. Good animal welfare especially for farmed animals encompasses disease prevention, appropriate shelter, management, nutrition, humane handling and humane slaughter (Animal Welfare Institute, 2018). Therefore, the idea of welfare remains an important element in addition to traditional animal health concerns (Nicks and Vadenheede, 2014).

BIOSECURITY FOR FISH HEALTH AND WELFARE

Biosecurity is a set of practices to minimize the introduction, establishment and spread of pathogens. It entails a set of consistent and systemized practices that minimize the risk of introducing an infectious disease and/or spreading it to the animals within or outside a farm or facility. It also reduces the risk of diseased animals or infectious agents leaving a facility and spreading to other sites and to other susceptible species (Yanong and Erlacher-Reid, 2012). These practices also reduce stress to the animals, thus making them less susceptible to disease, and improving their overall welfare and wellbeing.

According to Yanong and Erlacher-Reid (2012), the major goals of biosecurity are:

- Effective animal management through acquiring healthy fish stocks and optimizing their health and immunity through good husbandry.
- Management of pathogens by preventing, reducing, or eliminating pathogens
- Management of people by educating, training, and managing movement of staff and visitors

The ease with which a specific pathogen can enter a fish farm, spread from one system to another, and cause disease depends on many factors. These include the fish species, their immune status, their condition (with reference to welfare and well-being), and life stage. It also depends on environmental factors such as the water quality and chemistry, characteristics of the pathogen such as biology and life cycle, presence of potential disease hosts or reservoirs, and survival on inanimate objects or fomites. Finally, it depends on the workers' skills, understanding, husbandry practices and compliance with biosecurity principles and protocols (Yanong and Erlacher-Reid, 2012)

Many disease agents (live or dead, animate or inanimate) may come in contact with fish or their pond water on farms and have the potential to carry and spread diseases. Farmers need to be prepared to establish biosecurity measures against such agents. These agents include:

1) Fomite (inanimate objects): which may be nets, buckets, siphons, footwear, clothing, vehicles, haulers, containers, etc.
2) Vectors (living creatures): which may be new livestock, predatory birds, pets, and people.
3) Direct contact between fish: with dead or dying fish, or other aquatic animal, contaminated feed and water sources: on-site sources, water reuse, transportation sources (Sahu *et al.*, 2020)

Benefits of Biosecurity on Fish Farms

As noted by Aarattuthodiyil and Wise (2017), it can be simply stated that biosecurity offers protection from exposure to diseases, and is the most cost-efficient and effective means of disease control available. Generally, implementing biosecurity measures will contribute to achieving the following goals:

❖ Reduce the risk of disease transmission and minimize the spread of the disease within the same farm or from one farm to another.
❖ Promote aquatic animal health.

❖ Prevent new diseases in ponds.
❖ Protect human health (zoonoses, food safety) (Sahu *et al.*, 2020)
❖ Reduce stress and improve fish welfare and well-being.

Lack of a biosecurity plan in the face of a disease outbreak could result in fish morbidity/mortality, increased cost of treatment and diagnosis – all of which lead to poor fish welfare, reduced quality and value of products, damaged market reputation, and fish facility closure.

The consequences of infectious disease outbreaks can be catastrophic, especially in intensive farming systems like recirculating systems and hatcheries, due to the inherent expensive nature and operational intensity. These intensive aquaculture practices create bigger disease risks for the producers, and it is risky to ignore biosecurity. A single disease outbreak has the potential to put a farmer out of business and in huge financial debt. Therefore, since aquaculture operations will always have to deal with pathogens, it is a sensible approach to adopt biosecurity practices, as disease prevention is better than cure Aarattuthodiyil and Wise (2017).

Also with the international nature of trades in today's world, farmers who can demonstrate the establishment and integration of documented biosecurity measures and systems on their farm are more readily accepted in international trade markets (Aarattuthodiyil and Wise, 2017)

Common biosecurity measures and practices

Bera *et al.* (2018) and Ernst *et al.* (2017) share a comprehensive list of good biosecurity measures and practices to be adopted by fish farmers. These include the following:

❖ Providing clean pathogen-free water source at all times for land-based fish farms
❖ Restricting movement of fish from other farms or one farm to the other, specially from those of poorer health
❖ Limiting visits to the fish farm or access to a farm site i.e., by setting up gates and fences
❖ Fixing clear signs to direct traffic within and outside the farm where necessary
❖ Establishing and implementing strict sanitary measures such as defining sanitary units, cleaning and disinfection for people entering the farm, using protective and disinfected clothing, foot dips and hand hygiene
❖ Restricting movement of tools and culture organisms

- Fish stock health should be maintained by keeping stock stress to minimum level and maintaining optimum water quality.
- Minimize the pest and disease risk associated with stock movements onto, within and off your farm by maintaining appropriate quarantine procedure during stock movement.
- Minimize the risks of pests and disease entry associated with incoming water through proper treatment.
- Preventing the entry and spread of pest and disease by assessing all equipment, vessels and vehicles entering the farm through proper biosecurity procedures like disinfection of equipment, controlled use etc.
- Records should be kept of the workers and visitors, and all the workers should be trained on biosecurity standards.
- Food-borne disease organisms can be minimized by proper handling and storage.
- Implementing pest control management by controlling or eradicating predators, wildlife, scavengers, and other organisms from farm areas.
- Wastewater and solid waste should be treated appropriately before disposal.
- Maintain record for all aspects of biosecurity plan (staff training, workers and visitor's log, inspection, and maintenance of farm infrastructure).
- Regular monitoring, surveillance and audit of the biosecurity measures should be implemented throughout the farm.
- Development and implementation of an appropriate biosecurity management plan (Bera *et al*., 2018; Ernst *et al*., 2017)

FISH DISEASES AND IMPACTS

Disease outbreaks are a key menace in aquaculture, capable of causing huge economic losses to the farms from increased mortality, decreased growth and productivity, and higher production costs. Due to its catastrophic impacts on aquaculture, FAO (2020) regarded it as one of the major obstacles to the growth and development of sustainable aquaculture. The major barriers to effective prevention and control of diseases in fish farms include poor aquaculture disease management training, inadequate effective drugs within the reach of the farmers, high cost of quality feeds, high cost of drugs and treatment, and poor financial support. These indicate the need for fish farmers and managers to be well trained in aquaculture disease management, reduce the occurrence of disease outbreaks, and increase their farms' economic performance.

Numerous infectious diseases are significant to global aquaculture, and they are often caused by viruses, bacteria, parasites, fungi, or pests (Cascarano *et al.*, 2021). They have the capacity to spread through the movement of infected host species, have devastating effects on aquaculture productivity, and pose greater challenges for aquaculture development (Subasinghe *et al.*, 2009). Fish diseases undermine sustainable development goals, especially in developing nations, by lowering income earnings, causing job losses, endangering food availability, and posing a threat to nutrition and food security (World Bank, 2014). Because aquaculture in developing nations is typically small-scale and rural, the vast majority of infections go undetected, untreated, and unregistered, placing a heavy burden on populations trying to overcome poverty (Mukaila *et al*, 2023).

Diseases of fish and other animals may be from infectious organisms such as bacteria, virus, fungi, parasites, and protozoa, or may be from miscellaneous non-Infectious origins.

Common bacterial diseases of farmed fish include:

- Red Pest characterized by bloody streaks on the body, fins, and/or tail which may lead to ulceration and possibly fin and tail rot in extreme cases.
- Mycobacteriosis caused by the bacterium *Mycobacterium piscium* and characterized by emaciation, hollow belly, and possibly sores. The main cause is usually overcrowding or high stocking density in unkept conditions.
- Dropsy caused by *Aeromonas* and characterized by bloating of the body, and protruding scales. It affects the kidneys, causing fluid accumulation from renal failure.
- Tail Rot & Fin Rot caused by *Aeromonas* and characterized by disintegrating fins that may be reduced to stumps, exposed fin rays, blood on edges of fins, reddened areas at the base of fins, and skin ulcers with grey or red margins, cloudy eyes. If the tank conditions are not good, an infection can be caused by a simple injury to the fins/tail.
- Ulcer caused by bacteria, *Haemophilus* sp and characterized by loss of appetite and slow body movements.

Common fungal diseases of farmed fish include:

- Mouth Fungus caused by the bacterium *Chondrococcus columnaris* and characterized by white cottony patches around the mouth. It may be fatal due to the production of toxins and the inability to eat.
- *Ichthyosporidium* is a fungus, but it manifests itself internally, primarily attacking the liver and kidneys, but may spread everywhere else.

Symptoms include sluggishness, loss of balance, hollow belly, external cysts, and sores.

- Saprolegnia causes tufts of dirty, cotton-like growth on the skin and can cover large areas of the fish. These fungal attacks always follow some other health problems like parasitic attacks, injury, or bacterial infection. Eventually, if left untreated, the fungus will continue to eat away on the fish until it finally dies.

Common Parasitic Diseases of Fishes include the following:

- Argulosis caused by *Argulus* (Fish louse) which is a flattened mite-like crustacean that attaches itself to the body of the fish. They irritate the host fish which scrapes itself against objects, may have clamped fins, become restless, and may show inflamed areas where the lice have been.
- Velvet or Rust is a highly contagious and fatal disease characterized by yellow to light brown "dust" on the body, clamped fins, and respiratory distress (breathing hard).
- Anchor Worms (Lernaea) are crustaceans whose young are free-swimming and burrow into the skin, go into the muscles and develop for several months before showing, releasing eggs and dying. The holes left behind are ugly and may become infected. The fish scrapes itself against objects, and whitish-green threads may hang out of the fish's skin with an inflamed area at the point of attachment.
- Erasmus is a parasite like the anchor worm but is smaller and attacks the gills instead of the skin. Also, the fish scrapes itself against objects, and whitish-green threads hang out of the fish's gills.
- Fluke infestations also cause the fish to scrape itself against objects, causing the skin to be reddened. In some cases, mucus covers the gills or body, and the gills or fins may be eaten away.
- Nematoda are threadworms hanging from the anus which infect just about anywhere in the body but only show themselves when they hang out of the anus. A heavy infestation causes hollow bellies.
- Leeches are external parasites visible on the fish's skin, which affix themselves to the body, fins, or gills of the fish. Usually, they appear as heart-shaped worms attached to the fish.

Common Protozoan Diseases in Fishes

- Costia is a rare protozoan disease that causes a milky cloudiness of the skin.
- Hexamita is an intestinal flagellated protozoa that attacks the lower intestine and is characterized by the loss of appetite.

- Ich is a protozoan called *Ichthyophthirious multifiliis* and it is also known as white spot disease. It causes salt-like specks on the body fins, excessive slime, breathing problems, clamped fins, and loss of appetite.
- Neon Tetra disease is caused by the sporozoa *Plistophora hyphessobryconis*. It causes muscle degeneration leading to abnormal swimming movements.
- Glugea and Hnneguya are sporozoans which form nodular large cysts on the fish's body and release spores. The fish bloat up, with tumor-like protrusions, and eventually die.
- Whirling Disease caused by *Myxosoma cerebralis* causes blackening of the tail and deformity of the anal region.
- Knot Disease caused by protozoa, *Myxobolus exiguous* and Bio-Disease caused by protozoa *Myxobolus pfcifferi* with symptoms such as large boils of varying sizes appearing in several parts of the body.
- Myxosporidisis caused by infection of *Myxosorida*. Cysts appear on the body, internal tissues, and organs. Infected fish becomes weak and scales may become perforated, and fall off.

Viral diseases in Fish

- Lymphocystis is a virus which affects the cells of the fish and causes nodular white swellings (cauliflower) on fins or bodies. It can be infectious but is usually not fatal.
- Tumors can be caused by a virus or cancer, but most tumors are genetic. The genetic tumors may be caused by too much hybridization, common amongst professional breeders. It is important to note that practically all tumors are untreatable, and if the fish is in distress, it should be culled and slaughtered.

General treatment options

For many diseases treatment may vary and include disinfecting of the fish tank, and treatment with antibiotics, metronidazole, copper or malachite green, acriflavine (trypaflavine), para-chloro-meta-xylenol, thiabendazole, Trichlorofon, potassium permanganate, common salt solution, quinine hydrochloride, quinine sulphate, or quicklime – all in the right dosage. In other cases, the best thing to do is to cull, slaughter or destroy the infected fish. If unkempt conditions or overcrowding is the suspected cause, it is required to take necessary measures.

It is important to note the following when treatment interventions are being applied to disease conditions in fish:

1) Antibiotics may disturb biological filtration in the tank. Therefore, it is also recommended to monitor either ammonia and nitrite levels of water or use an ammonia remover to be sure that the level of ammonia does not exceed the desired limit.
2) With larger fish and light infestations, parasites such as lice can be picked off with a pair of forceps.
3) Some chemicals used for treatments may pose risks to fish and even human health. Therefore, ensure that they are used in the right dosages and ensure to wear protective clothing and gloves.

Miscellaneous non-infectious health issues may be caused by

- Congenital abnormalities which usually occur when professional breeders are trying to acquire certain strains in breeds.
- Physical Injuries
- Constipation which is mostly caused by diet.
- Poor nutrition (Okhueleigbe, 2021)

Disease Reporting

Availability of data on diseases in both public and private facilities is in the public interest and important to monitor welfare of animals. All farms must record and retain records of disease, treatments, transport, mortality rates, and causes of mortality for all animals in their care and must use these records actively to further improve conditions within their production.

As a precaution, you should report any suspected serious disease or unusual mortality even if you haven't identified the infectious disease.

ANTIMICROBIAL RESISTANCE

Antimicrobial resistance (AMR) is the ability of bacteria, viruses, fungi, and parasites to resist the activity of medications (antimicrobials) designed to kill or inhibit them. These medications include antibiotics, antifungals, antiparasitic drugs, and antivirals. This resistance allows pathogens to survive and grow in the presence of antimicrobials. This leads to increased treatment period and costs, increased risk of disease spread, severe infections, and increased mortality in terrestrial animals, aquatic species, and humans (Towers, 2014; WHO, 2021).

Although AMR develops naturally over time, antimicrobial misuse and overuse in humans and animals remains a major predisposing factor (Cabello, 2006; Chowdury *et al*, 2022). This inappropriate use is linked to lack of AMR and antimicrobial stewardship awareness and lack of diagnostic capacity (mostly in low- and middle-income countries (LMICs). This affects proper identification of causative pathogens in diseased animals and antimicrobial prescriptions (Henriksson *et al*., 2018; Adekanye *et al*., 2020).

Another contributing factor is the use of antibiotics as prophylactics in disease prevention – especially in intensive factory farm settings in aquaculture production (Cabello, 2006). Furthermore, intensive aquaculture, poor animal welfare practices, poor biosecurity can increase the risk of infection in fishes and consequently increase antibiotic use (Cabello, 2006).

Antibiotics are typically administered to fishes through feeds, in baths, or via injections (Chowdury *et al*., 2022). These methods can lead to the accumulation of antibiotic residues in the fishes and their aquatic ecosystems. If the proper withdrawal periods are not observed after the administration of antibiotics, consumers of such fishes will ingest antibiotic residues at suboptimal doses and this can facilitate AMR development and other health risks (Heuer *et al*., 2009; Sapkota *et al*., 2008). Furthermore, these residues and resistant bacteria can be transferred between the aquatic and terrestrial animals through the environment and waterways (Goldburg & Naylor, 2005; Naylor & Burke, 2005; Chowdury et al, 2022).

How does AMR spread from animals to humans?

Resistant bacteria can spread from animals to humans through the following routes:

- via contamination of food animals or animal products e.g., from poor antimicrobial stewardship (misuse or overuse)
- occupational exposure for farm workers and fish keepers, abattoir workers, veterinary surgeons, and health workers.
- environmental transfer can also occur upon contamination with resistant bacteria, resistance genes (which can be transferred from resistant pathogens to non-resistant ones), antibiotic residues, and
- recreational activities including fishing and swimming (Towers, 2014).

Impact of AMR

Antimicrobials are essential in intensive animal agriculture and aquaculture. Antibiotics including oxytetracycline, amoxicillin, and sulphadiazine-trimethoprim are used extensively in aquaculture to treat or prevent fish diseases, thus maximizing productivity (Chowdury *et al*., 2022). However, misuse and over-use leads to AMR which causes treatment failure and affects aquaculture fish production and welfare (Schar *et al*., 2020).

Furthermore, antimicrobial misuse in aquaculture results in wide contamination of the environment with antimicrobial residues via water distribution systems (Schar *et al.*, 2020). These residues can affect the environment's microbiome and, consequently, its regulatory and supporting activities in ecosystems (Sarmah *et al.*, 2006; Larsson *et al.*, 2018). Also, aquaculture systems with high antimicrobial use may serve as reservoirs for antimicrobial resistance genes, hence facilitating AMR development in animals and humans (Schar *et al.*, 2020). We should also consider that authorized antibiotics for aquaculture species are scarce globally, hence, their efficacies should be maintained.

COMBATING AMR

How can aquaculture farmers contribute to AMR prevention and control while addressing the increasing demand for seafood animals without compromising food safety, environmental health, human health, and animal health and welfare?

The FAO action plan on AMR 2016–2020 recommends prudent use of antimicrobials and effective biosecurity practices (FAO). The main recommendations include:

1. Prudent and responsible use of antimicrobials to preserve their efficacies.
2. Provision of clean, safe, and disease-free aquatic systems to prevent infectious disease incidence and reduce antimicrobial use.
3. Proper routine monitoring of resistance during disease outbreaks.
4. Proper animal welfare standards should be adopted and maintained as they ensure better immune systems in animals, thus preventing infections, minimizing outbreaks, and reducing antimicrobial use.
5. Routine removal of antibiotic residues in water via appropriate adsorption techniques, filtration, biological methods, sedimentation, and flocculation (Homem & Santos, 2011).
6. Vaccination of aquatic food animals for infectious disease prevention. For example, oral fish vaccines are effective against many aquatic diseases (Newaj-Fyzul & Austin, 2015).
7. Probiotics should also be considered in infection prevention and control. For example, probiotics are potential alternatives in controlling pathogens such as *Vibrio harveyi*, a major health threat in aquaculture (Chabrillon *et al.*, 2005).
8. Immunostimulants can also be considered for use. Example is β-1,3 glucans which is reportedly effective alternatives against various aquatic diseases like vibriosis, enteric redmouth, aeromonadiasis, pasteurellosis, and Hitra disease (Ngamkala *et al.*, 2010).

9. Broad-host range phages can also be considered to treat bacterial infections. For example, due to the unavailability of appropriate vaccines, phages were used in salmonids to prevent rainbow trout fry syndrome (RTFS) caused by *Flavobacterium psychrophilum* (Castillo *et al.*, 2012).
10. Traditional medicinal plants can also be explored as antimicrobial alternatives. Examples include seaweeds, extracts of mango, peppermint, turmeric, jasmine, and neem which are promising alternatives to treat bacterial infections by aeromonads and vibrios in aquatic animals (Newaj-Fyzul & Austin, 2015).

In conclusion, to combat and reduce the incidence and prevalence of AMR, farmers should implement, with government support, good animal health practices, and biosecurity to prevent the occurrence and/or spread of infectious diseases. Through this, losses caused by infectious diseases can be avoided, less antimicrobials are used and AMR development is prevented (WOAH 2023). Also, proper antimicrobial use according to prescription should be adopted to maintain the efficacies of antimicrobials.

Furthermore, withdrawal periods set by governing agencies in Nigeria such as the NAFDAC and VCN should be strictly observed before aquatic food animals are harvested and sold. This will ensure that antimicrobial residues are not present in the food animals or their products before consumption.

Q&A SESSION

In a facilitator-led training session, fish welfare trainers/facilitators should provide opportunities for trainees to ask questions and engage in discourses on the module, while the facilitator provides answers.

If reading the training manual in a personal capacity, you can share your questions in the following ways to receive answers and further support, where necessary:

- Send your questions to contact@animalwelfarecourses.com or info@onehealthdev.org.
- Share your questions on the Discussion Forum on the online training platform for Fish Welfare.

DISCUSSION POINTS

- ❖ Do you have any biosecurity protocols or systems on your farm?
- ❖ Have you experienced any disease outbreaks on your fish farm before? If you have, share your experience on how you discovered the onset of disease (e.g., what were the signs), if and how you diagnosed the cause of disease, and what you did to treat the disease and combat the spread.
- ❖ Do you engage qualified professional(s) to provide diagnostic and treatment services for your fish farm? If you don't, why? What are the alternative options you employ?
- ❖ Discuss your current use of antibiotics. Do you consider it currently as antimicrobial stewardship or misuse?
- ❖ Do you have a record keeping system for your fish health, disease reports and antibiotic use?

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