CLIMATE-SMART SUSTAINABLE FISHING PRACTICES

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1. INTRODUCTION TO ARTISANAL AND INDUSTRIAL FISHERIES

1.0. INTRODUCTION

Nigeria has a coastline covering approximately 853 kilometers (km), a land area of 923,768 km^2, and 200 nautical miles of an exclusive economic zone (EEZ) from the Seme Border in Badagry, Lagos State to Ikang in Cross Rivers State. Nine of the 39 states are along the Atlantic Ocean's coastline. The Niger Delta covers a total area of 75,000 km2, 19 rivers with estuaries flowing into the Atlantic Ocean. These rivers are essential for breeding nurseries of most marine, estuary, and even freshwater species. In brief, Nigeria has enough fishery resources that could enhance increased fish production.

Fishing is an ancient occupation and a significant source of food for humanity. Nigeria's current fish production stands at about 0.8 million metric tons. The local demand for protein is 2.7 million tons annually. However, the sector contracted by 2.07 percent in the third quarter of 2020, lower than the 5.68 percent recorded for the second quarter of 2020.

Small-scale inshore fisheries are the backbone of socio-economic well-being in coastal communities worldwide, particularly in the tropics, where most countries with heavily fish-dependent populations are situated. It is a primary source of food and livelihood for some of society's most vulnerable groups, including low-income people and migrants.

1.1. ARTISINAL FISHERY

What is Artisanal Fishery?

The term "artisanal fishery" is used interchangeably with small-scale fishery. These terms describe fisheries that use relatively small production units with relatively low input, limited levels of technology, and small capital investment.

The definition of and terminology for artisanal fishers varies from country to country. Artisanal fisheries are most consistent with traditional fisheries, including anglers or fishers who use standard gears such as hook-and-line, bag nets, traps, lift nets, seine nets, barrier nets, and scoop nets. It involves family-scale fishing units operating from the coast to a depth of 20 meters.

For this study, we define artisanal fisheries as those that exhibit some or all of the following characteristics:

- Primarily geared toward household consumption, sale at the local level, or export in the case of high-value species, usually at low levels (primary and secondary) of economic activity.
- For fulfilling cultural or ceremonial purposes
- Non-mechanized or involve low technology and low capital investment
- Undertaken by the fisherperson and or family members only
- Conducted within inshore areas
- Minimally managed.

- **Small in Size-Big in Value**

Small-scale fishing is vital for the well-being of coastal communities. It contributes to:

- Poverty eradication
- Providing livelihoods - income for some of the poorest and most marginalized segments of society
- Informal employment
- Ensuring food security and nutritional needs of local communities

Artisanal fisheries remain vital at the community level, acting as social safety nets. Those in rural or remote locations rely on the catch from small-scale fishers for daily protein and micronutrient needs.

Professional Groups in Artisanal Fisheries

The professional groups include financiers of gear, canoes, and fishing trips, owners of gears and vessels, and the crew. We have the processors and small and large-scale traders in the post-captive phase. The crew consists of men and sometimes women fishers. The entire family can also decide to fish. Owners and crew often sell their part of the catch to a relative or their wives. Processors and traders mainly consist of women. Artisanal fisheries are frequently unregulated, under intense pressure from growing populations. The fishers try to catch whatever they can with the gear at their disposal.

1.2. INDUSTRIAL FISHERY

What is Industrial Fishery?

An industrial fishery may be defined as a fishery for non-food purposes. It generally refers to using refined or innovative technology, the level of investment, and the impact on a fishery. These fisheries, with a few exceptions in marine fisheries, use big boats worth millions of dollars and are often equipped with technology capable of giant catches. Boats may stay out on fishing trips anywhere from a few weeks to years and include both local and foreign fishing fleets.

What are the issues?

The most significant issues with industrialized fleets are over-fishing, habitat damage, and market and resource control unfavorable to small-scale fisheries and small coastal communities. Nevertheless, industrial fisheries are the primary sources of the seafood at major supermarkets. Many countries and organizations are working to make the fisheries more responsible and sustainable.

1.3. ACTIVITY

Participants should write down their suggestions and decisions.

2. FISHING GEARS AND FISHING TECHNOLOGY

2.0. INTRODUCTION

Fishery management requires a good knowledge of fishing gear. The efficiency of fishing gears varies based on their adaptability to specific conditions and the particular tasks they are designed for.

2.1. CLASSIFICATION OF FISHING GEAR AND FISHING METHODS

Passive Gears:

Hooks and lines,
maze gear,
pot gear,
lift nets and
traps.

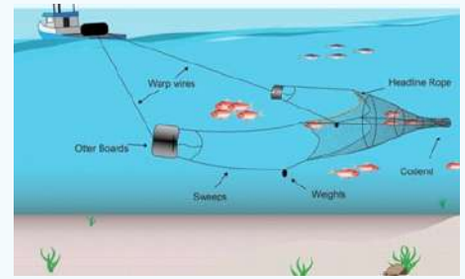
Hooks are employed in hook gear fisheries

Long lined hooks

Cylindrical Drum Traps

Lift Nets

Active Gears:



Trawling

Monofilament fishing net

Using camera and video technology

A fishing boat with an outboard engine

Most of the Nigerian waters are currently overfished. Upgrading the gear and making it more efficient increases the risk of further depleting the fish stocks. Even while introducing new fishing gear and methods for efficiency and increased productivity, it is crucial to monitor and protect aquatic resources adequately. Therefore, it is appropriate to establish and fund a functional monitoring/surveillance unit within the fisheries department.

3. MODERN FISHING METHODS

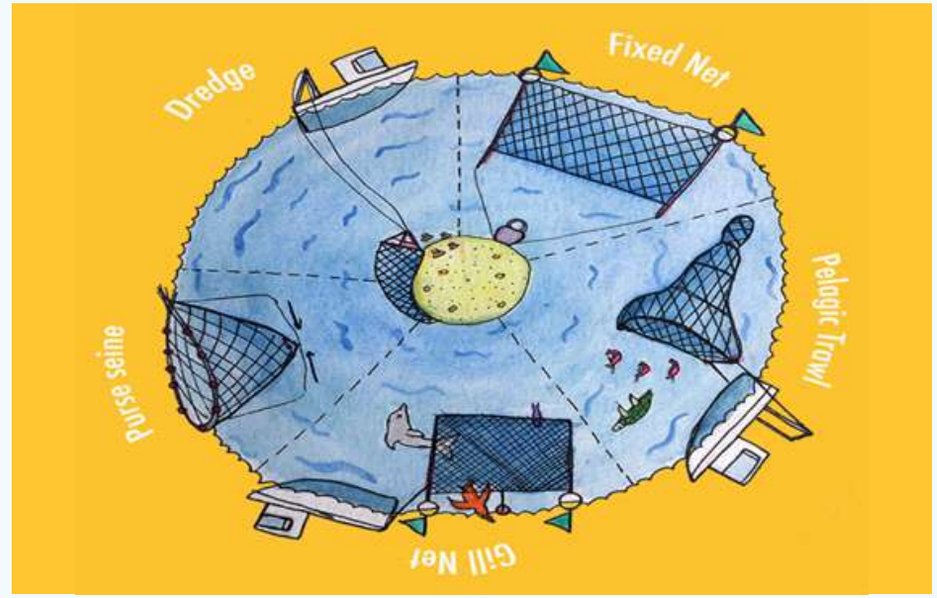
3.0. INTRODUCTION

Fish either come from the sea (wild caught) or are farmed (aquaculture). Approximately seventeen percent of animal protein consumed globally comes from seafood; this number can be much higher for coastal communities.

In its most basic terms, fishing is done using a net, a line, or a trap. The equipment can be mobile (active) or static (passive), depending on whether it is towed across the seabed or fixed. These commercial fishing methods are not occurring delicately either. Currently, at least 30% of large commercial fish stocks are classified as overexploited. This proportion is an improvement from past decades. For many regions of the world – notably less economically stable countries with small-scale fisheries – the sustainability status of fisheries and even the amount of fishing occurring is uncertain, as management remains mysterious or non-existent.

3.1. MODERN FISHING METHODS

The most common fishing methods are illustrated below. They are broken down into groups depending on how they impact the ocean habitats and ecosystem and how much bycatch occurs.



An illustrated guide to fishing methods

DREDGING:

A dredge is a metal framed basket with a bottom of connected iron rings or wire netting called a “chain belly.” The lower edge of the frame has a raking bar, with or without teeth, depending upon the species targeted. The (toothed) raking bar lifts the catch off the seabed and passes it back into the basket or bag. Depending on the size of the boat and the depth of water fished the number of “dredge bags” may be up to 10 per side.

Target species: Oysters, clams, mussels, conch, sea cucumbers, crab, and scallops.

FIXED (GILL) NET:

Gill netting is probably the oldest form of net fishing, having been in use for thousands of years. Fish that attempt to swim through the net get their gills caught in the mesh. Their heads pass through but not the rest of their body, so the fish becomes entangled as it attempts to back out of the net.

Target species: Monkfish, turbot, bass, crawfish, pollack, barracuda, spider crab, hake, cod, and red mullet.

PELAGIC TRAWL:

A method of towing a trawl at any point in the water column between the surface and seabed. Trawling is common worldwide due to its efficiency in capturing large numbers of fish. “Pelagic” means the trawling is done in the mid-zone of the ocean.

Target species: Sea bass, mackerel, redfish, herring, and pilchards.

DRIFT (GILL) NET:

Drift nets are gill nets left to drift with prevailing currents on the high seas.

Target species: A wide range of fish, including tuna, squid, and shark.

PURSE SEINE NET:

This is the general name given to encircling a school of fish with a large wall of net. The net is then drawn together underneath the fish (pursed) to surround them. Finally, the fish are scooped into the boat using “broilers.” It is a very efficient and aggressive fishing method aimed at capturing large, dense shoals of mobile fish.

Target species: Sardines, mackerel, anchovies, tuna, and herring.

LONGLINE: one of the most fuel-efficient catching methods, longlining is used to capture pelagic fishes (like tuna) and demersal (like flatfish). It involves setting out a length of line, possibly as much as 80-100 km long, to which shorter lengths of line, or “snoods,” with baited hooks are attached at intervals. The lines may be set vertically in the water column or horizontally along the bottom. The size of the fish and the species caught is based on hook size and the type of bait used.

Target species: swordfish, cod, and tuna.

NOTE: These fishing methods have high impacts on the ocean ecosystems. Their impact varies depending on where they're occurring, how intensively the area is fished, and how well the fishery is managed.

ACTIVITY

Participants should write down their suggestions and decisions.

4. CODE OF CONDUCT FOR RESPONSIBLE FISHERIES/TIDAL TABLE AND INTERPRETATION

4.0. Introduction

Fishing is a significant food source for humanity and provides employment and economic benefits to those practicing it. The wealth of aquatic resources was once assumed to be an unlimited gift of nature. It is now common knowledge that although fisheries resources are renewable, they are not infinite and need to be adequately managed. This will ensure that their contribution to the growing world's population's nutritional, economic, and social well-being is sustained.

4.1. Objectives of the Code

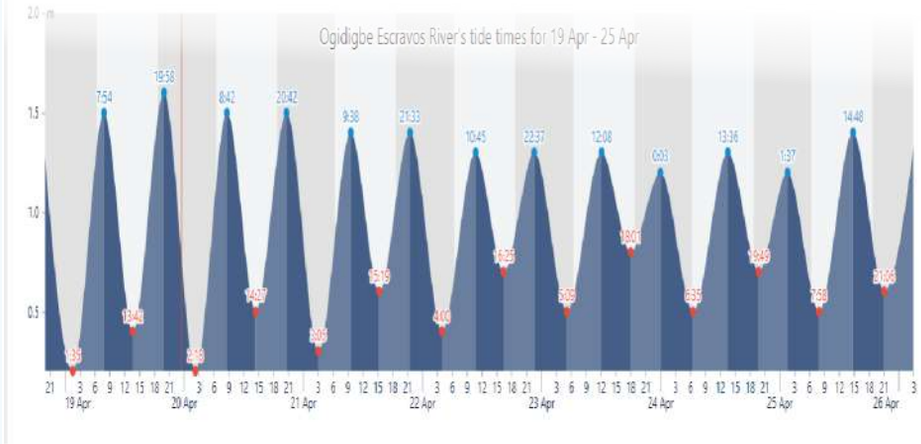
The code of conduct for responsible fisheries sets out principles and international standards of behavior for responsible practices in the fisheries sector. It recognizes the nutritional, economic, social, environmental, and cultural importance of fisheries and the interests of all those concerned with the fishery sector. The code considers the biological characteristics of the resources, their environment, and the interests of consumers and other users. Countries involved in fisheries, including Nigeria, are encouraged to apply the code and give effect to it.

4.1.1. Some Principles of the Code

1. States and users of living aquatic resources should conserve marine ecosystems. Fish responsibly.
2. Fisheries management should promote maintaining the quality, diversity, and availability of fishery resources in sufficient quantities for present and future generations.
3. Selective and environmentally safe fishing gear and practices should be further developed and applied.
4. The harvesting, handling, processing, and distribution of fish and fishery products should be carried out to maintain the nutritional value, quality, and safety of the products, reduce waste and minimize negative impacts on the environment.
5. All critical fisheries habitats in marine and freshwater ecosystems, such as wetlands, mangroves, lagoons, nursery and spawning areas, should be protected from destruction, degradation and pollution.
6. International trade in fish and fishery products should be conducted under the principles, rights, and obligations established in the World Trade Organization (WTO) Agreement and other relevant international agreements.
7. Recognizing the important contributions of artisanal and small-scale fisheries to employment, income, and food security, countries should appropriately protect the rights of fishers and fish workers, particularly those engaged in subsistence, small-scale and artisanal fisheries, to a secure and just livelihood.
8. States should consider aquaculture, including culture-based fisheries, as a means to promote diversification of income and diet.

4.2. CLASS ACTIVITY

- Do you like the Code of Conduct for Responsible Fisheries?
- How does it affect your fishing business?
- What would you like to add to the General Principles of the Code of Conduct for Responsible Fisheries?
- Name one traditional knowledge in fishing that you learned from your family/community.



Compressed Tide Charts showing rising and falling tides for Escravos River from 19th April to 25th April 2022

Day	1st Tide	2nd Tide	3rd Tide	4th Tide	Fishing activity	Major fishing	Minor fishing	Moon phase	Water temp
19 Tue	1:35am ▼0.2 m	7:54am ▲1.5 m	1:42pm ▼0.4 m	7:58pm ▲1.6 m		8:35pm	8:14am 9:05pm		29 °C
20 Wed	2:18am ▼0.2 m	8:42am ▲1.5 m	2:27pm ▼0.5 m	8:42pm ▲1.5 m		9:06am 9:38pm	9:14am 10:08pm		29 °C
21 Thu	3:05am ▼0.3 m	9:38am ▲1.4 m	3:19pm ▼0.6 m	9:33pm ▲1.4 m		10:10am 10:42pm	10:15am 11:12pm		29 °C
22 Fri	4:00am ▼0.4 m	10:45am ▲1.3 m	4:25pm ▼0.7 m	10:37pm ▲1.3 m					29 °C
23 Sat	5:09am ▼0.5 m	12:08pm ▲1.3 m	6:01pm ▼0.8 m			5:46am 6:15pm	12:13am 12:20pm		29 °C
24 Sun	12:03am ▲1.2 m	6:35am ▼0.5 m	1:36pm ▲1.3 m	7:49pm ▼0.7 m		6:44am 7:09pm	1:10am 1:18pm		29 °C
25 Mon	1:37am ▲1.2 m	7:58am ▼0.5 m	2:48pm ▲1.4 m	9:06pm ▼0.6 m		7:36am	2:01am 2:11pm		29 °C

Compressed Tide Charts showing rising and falling tides for Escravos River from 19th April to 25th April 2022

4.3. TIDAL TABLE AND INTERPRETATION

4.3.0. Definitions

Tides are the alternate rising and falling of the sea, usually twice each lunar day at a particular place, due to the attraction of the moon and sun. A spring tide - popularly known as a "King Tide"- refers to the 'springing forth' of the tide during a new and full moon. While a neap tide - seven days after a spring tide - refers to moderate tides when the sun and moon are at right angles.

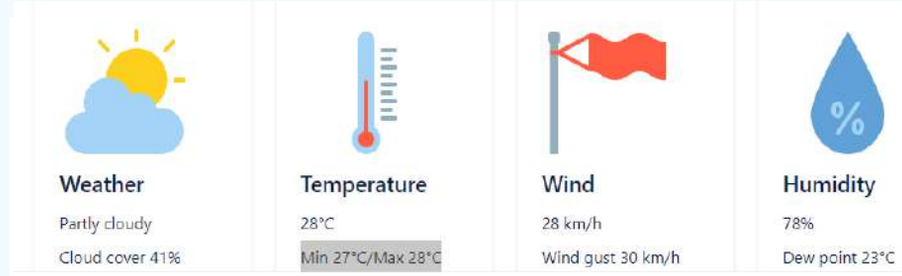
4.3.1. Tide Charts

The Nigerian Navy has the tide charts for all major rivers that funnel into the Atlantic Ocean. Tide charts can also be downloaded from a few dedicated websites. Examples of tide charts are shown below. Plate 18 shows that on a given day the lowest tide of 0.2 meters occurred at 1:35 am.

Table below presents the tide times for fishing in Escravos River, with much more information for a week. Fishers can use this chart to accurately predict the timing of the tides, when to go to the river for their fishing activity, and whether the fishing activity will yield a good catch or little.

4.3.2. Weather Forecast

Fishers can also click on the weather report for their current location. Plate 20 shows a pictorial weather forecast of the Ogidigbe Escravos River. It shows partly cloudy and partly sunny weather, hot temperature, wind speed of 28 km/hour, and humidity of 78%.



Weather Forecast for Escravos River

4.4. Website for Tide Charts and Tables

You can download information regarding the tides and weather information from either of these websites: www.tideschart.com **and** www.tides4fishing.com

5. IDENTIFICATION/CREATION OF MARINE PROTECTED AREAS

5.0. INTRODUCTION

Marine Protected Areas (MPAs) are protected areas of sea, ocean, estuaries, or the Great Lakes in the US. These marine areas can come in many forms ranging from wildlife refuges to research facilities. MPAs restrict human activity for a conservation purpose, typically to protect natural or cultural resources. Such marine resources are protected by local, state territorial, native regime, national or international authorities and differ substantially among and between nations. This variation includes different limitations on development, fishing practices, fishing seasons, and removing or disrupting marine life.

Creation and effective management of MPAs have lagged behind those of protected areas on land but are just as important. They are a vital part of broader programs to conserve the world's world'sworld's marine heritage and life support system and ensure that living marine resources can be sustained ecologically. The world urgently needs a comprehensive system of MPAs to conserve biodiversity and help rebuild the oceans' productivity.

MPAs can help achieve the three main objectives of living resource conservation as defined in the world conservation strategy (IUCN 1980):

1. To maintain essential ecological processes and life support systems
2. To preserve genetic diversity and
3. To ensure the sustainable utilization of species and ecosystems.

The criteria to identify potential marine protected areas may include typicalness (representativeness), naturalness, size, biological diversity, critical area, importance (including rarity), and sensitivity. Other practical criteria may also be applied, including location (adjacent to a terrestrial protected area), intrinsic appeal, and feasibility. Such measures are perpetually being re-invented and improved.

5.1. Ecological Criteria/Considerations

- Threatened or declining species and habitats/biotopes: This includes "rarity'' as information on declining species is often lacking.
- Important species and habitats/biotopes: This refers to global/proportional and regional importance, distribution and population numbers.
- Ecological significance: This includes dependency
- High natural biological diversity
- Representativeness
- Sensitivity
- Naturalness

5.2. PRACTICAL CRITERIA/CONSIDERATIONS

- Size (meaning the extent of the feature being considered – usually, the bigger, the better).
- Potential for restoration.
- Degree of acceptance.
- Potential for the success of management measures
- Potential damage to the area by human activities
- Scientific value

5.3. MANAGING MPAs

Managing MPAs, including environmental assessments and interpreting biological monitoring results, requires structure and information. Decisions to manage human activities and how these decisions were reached often need defending.

5.4. SAFETY SIGNS AND SYMBOLS

Since there are many pipelines in the waterways, warning signs like the ones shown below, indicate their appropriate location along the pipeline route. The characters are in high visibility. Colors (yellow or red) are located at different intervals along the pipeline right-of-way. These are extremely important as they can help avoid net damage.

Mandatory Signs On Water Ways (Source: Dr. A.F. Yakubu)

CONCLUSION

MPAs in their various forms are worthwhile only if a regime of managing human activities protects biodiversity. Some parts of the world already have a high density of MPAs, often needing more management to protect them and the marine

environment outside of them. While MPAs have a role in the suite of measures to protect the marine environment, it seems most important to advocate and pursue an overall 'duty of care' for our oceans and seas and to do it now rather than continue just talking while biodiversity is being conspicuously damaged.

ACTIVITY

Participants should write down their suggestions and decisions.

6. MANAGEMENT CONCEPTS FOR SMALL-SCALE FISHERIES

6.1. What are Small-Scale Fisheries?

Artisanal or small-scale fisheries:

- Are traditional fisheries that involve fishing households as opposed to commercial companies.
- Require relatively small amounts of capital and effort.
- Use small fishing vessels, if any.
- Make short fishing trips close to shore.
- Produce mainly for local consumption.
- Can be for subsistence or commercial purposes.

6.2. Management Approaches

The goals of management are:

- To prevent biological and commercial extinction,
- To optimize the benefits derived from the fishery over an indefinite period
- To use resources sustainably

However, for decades, fishery management has focused on avoiding commercial extinction and optimizing benefits through ecosystem health and ecological integrity.

6.3. Ecosystem Health

It refers to a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization that has evolved naturally. So long as a healthy state can be determined or inferred, management should strive to generate and maintain such a state in a given ecosystem.

Inherent to this management strategy would be specific goals for the ecosystem, including a description of "unhealthy" conditions to be avoided.

6.4. Ecological Integrity

It refers to the maintenance of ecosystem structure and function. Biodiversity is a good measure of structure and allows for more specific indicators, such as the percentage of long-lived and high-value species, such as groupers, in the catch. Function refers to ecosystem processes such as production, energy flow, and nutrient cycling.

Many fishery managers use fish yields to indicate ecological integrity or ecosystem health: if fish yields decline sharply, this is usually a good indication that something is wrong.

6.5. Constraints Affecting Effective Management of Small-Scale Fisheries

Marginalization of small-scale fishers

The low level of organization of small-scale fishers in the Niger Delta has hindered their participation in fisheries governance. In instances where small-scale fisher associations exist, they are often manipulated by the fishing industry, elite groups in the community, and the authorities and fail to represent the interest of the fishers.

Gender inequity

Women remain marginalized within the small-scale fishing sector in terms of their fishing-related activities and their role in decision-making processes. Also, traditional beliefs prevent women from entering the industry as fish harvesters in many areas where certain taboos exist.

Overexploitation, resource conflicts, and environmental degradation

Over-exploitation of fish resources occurs in Niger Delta on a grand scale, verified by the constant fall in yearly catch records in many fishing communities, where some fish species have even disappeared recently. The need for more transparency in many African fisheries policies, including the allocation of licenses to industrial fishers, has resulted in overexploitation in many countries.Foreign fishing vessels (mainly from Europe and Asia) ply African coastal waters. These vessels often conflict with small-scale fishers, harvesting illegally in areas reserved for small-scale fishers and damaging their nets.

Resource limitations

The limited fishing range of small-scale fisheries confines their area of operation to a narrow strip of the sea, often at most a few kilometers from the coast. The occurrence and migration of fish into this area also determine the resource available to the fishery.

Conflicts with large-scale fisheries

Not only is the resource base of the small-scale fishery limited by its fishing range and biological productivity, but often it has to compete with other fisheries using more advanced technology.

The resource available to a coastal fishery is regularly exploited in offshore waters. Large-scale fisheries operating offshore may thus reduce the fish available to small-scale fishermen.

Inadequate data and high interest rates on loans

High-interest rates on investment loans have prevented prospective investors in the marine fisheries industry from taking loans from commercial, merchant, development, and even microfinance banks.

Lack of relevant data and information on fishing vessels, catch landings, and fish stock biomass, especially in developing countries, including Nigeria, also hinders investment from a business perspective. Inland finfish aquaculture was put at 313.2 thousand tons of marine. Coastal aquaculture of finfish and other aquatic animals and plants was unavailable.

Pollution of aquatic environments

Pollution of the aquatic environments is a significant threat to marine fish populations worldwide. The problem of invasion of exotic fish species is linked to ballast water from ships.

Climate Change

The most fundamental impact of climate change on fish is an increase in global temperature. Global warming is responsible for the unprecedented warming of the oceans.

6.6. Impacts of Climate Change on Fish Production and Fishing Communities

Impact on Fish Production

Climate change impacts several significant creatures, including plankton, which comprise the base of the marine food chain. Global fish production is changing in terms of distribution, productivity, and species composition, which has complex and interconnected effects on the oceans, estuaries, mangroves, and seagrass beds that serve as fish habitats and breeding zones.

Although there is a drop in fisheries due to climate change, overfishing is also a contributing factor. By making a fishing population more susceptible to environmental changes, overfishing exacerbates the effects of climate change.

Overfished species are more vulnerable to the impacts of climate change. Fish from overfished populations are smaller, older, and have less genetic variety than fish from other people. They become more vulnerable due to environmental stressors, such as those brought on by climate change.

Impact on Fishing Communities

Countries that depend on fisheries and coastal populations are particularly vulnerable to climate change because it reduces the number of fish they can catch, which has a detrimental influence on their ability to support themselves. Due to flooding and escalating waves brought on by rising sea levels, fishing settlements are rendered inaccessible.

Adaptive Strategies of Fisher Folks to Climate Change

Some fisherfolks in the coastal communities cope by eating less preferred food due to inadequate finances during seasons of low catch and low economic returns on fishing. Fishers devise measures to effectively deal with their predicament before returns on fish catch increase.

Institutional and management responses, strengthening and diversifying people's livelihoods, risk mitigation, and resilience assistance are all necessary to enable adaptations.

The most fundamental impact of climate change on fish is an increase in global temperature. Global warming is responsible for the unprecedented warming of the oceans.

6.7. Strategies for Effective Fisheries Management

Involvement of small-scale fishers

Small-scale fishers from various communities should participate in fisheries governance and management and developing national legislation.

Human-Rights-Based Approach Instead of an Economic Approach

Fishers become more effective and motivated fishery managers. Government should not privatize aquatic ecosystems through policy mechanisms such as transferable fishing quotas or other systems promoting private property rights.

Gender Equity

The critical role played by women within fisheries must be recognized and empowered

Adaptive Management

It is a relatively new approach in resource management science. All fishery management systems learn from their successes and failures. Adaptive management goes one step further and relies on systematic feedback learning.

Record Keeping

Record keeping is an essential tool in Fisheries Management. It is helpful in the monitoring and evaluation of skills and technology transfer. Fishers should be encouraged to keep records of their different activities.

Types of Records to Keep

Input:

Variable expenses or input vary with the level of production. These variables include information on the boats, nets, traps, baits, fuel, and labor.

Catch Records

Provides information on the number of fish caught, size, date, species (fish type), and average and total weight in grams.

Date	Species	Area	Number	Weight	Length	Size

Sales Record

This is a record for the sales of the fish.

Date	Species	Area	Number	Weight	Length	Size

ACTIVITY

Participants should write down their suggestions and decisions.

7. INTRODUCTION TO MARICULTURE

7.0. Introduction

Mariculture can be defined as rearing fish and other aquatic organisms in marine waters by manipulating the environment to increase production beyond natural limits. It focuses on producing quality fin and shell fishes found in the creeks, lagoons, estuaries, and seas through rational rearing.

7.1. Potential for Brackish Water

Fish Farming in the Niger Delta

The region has a long natural coastline and an extensive network of inland river systems. These and other factors indicate that Niger Delta has a remarkable potential for brackish/ marine water aquaculture development.

A typical brackish water fish farm

Niger Delta Environment

Oyster farming

A mariculture farme

7.2. Procedures for Mariculture

1. Fish Production Facilities

The facilities for mariculture are many and varied and could be any of the following:

- Earthen ponds
- Cast concrete tanks
- Cages
- Concrete/block tanks
- Plastic tanks
- Fiber glass tanks

2. Production Process & Requirements

- Water: The source of water for mariculture could be from the sea, estuaries, and the adjoining creeks
- Species: Select brackish water/marine species for culture
- Stocking: is the process of introducing the fish into the rearing enclosures, while the stocking rate is the number of fish per area (m^2) of the pond or volume (m^3) of water.

3. Culture Techniques

a. Monoculture: Monoculture is the cultivation of one fish species in a pond. Monoculture of high-value, market-oriented fish species in intensive systems is standard practice.

b. Polyculture: It involves rearing different fish species together in the same pond at a given time. It allows for better utilization of available natural food produced in a pond.

4. Fish Transportation

Transportation involves transferring fish to sites and other distances for rearing. Adverse reactions under poor transporting conditions include:

- Rapid deterioration of water quality
- Increase metabolic rate
- Increase production of feces/mucus
- Weakened fish.
- High mortality
- Financial loss

Hence, fish must be transported correctly in aquaculture to reduce these effects.

Methods of fish transportation

There are two methods

I. Enclosed System: It involves the use of oxygen bags

ii. Semi-enclosed System: It involves using open container half filled with water to transport fish. It can be done using anesthetics such as MS 222, metomidate, eugenol, and clove seed extract.

Factors to consider before transporting fish

- Do not feed before and during transportation to reduce metabolic wastes so that their excrement and uneaten food do not foul the water.
- Avoid overcrowding of live fish; this can lead to stress and suffocation.
- Avoid carrying weak, sick, or injured fish. They may die and foul the water.
- Transport fish in cool weather, preferably very early in the morning or late in the evening.
- Maintain sufficient oxygen in the transport water throughout the journey
- To prevent mass mortality, avoid sudden transfer or dumping of fish from one different water environment to another without proper acclimatization.

5. Management Practices

- **Feed and Feeding Regime:** Fish is fed with fish feeds that come in different pellet sizes depending on the age/size of the fish. Fish and fingerlings are fed with micro pellets or mash (< 1mm). We have 2mm, 3mm, 4mm, and 6mm for grow-out production.
- **Growth Monitoring:** Monitor the fish's growth of fish monthly. Bring it out of the pond with a net. Measure the total length in centimeters (cm) and the weight in grams (g) of a few in the ponds.
- **Harvesting and Sales:** The fish are harvested within four to six months of culture when they have attained an average weight of 1 kilogram. The harvested fish could be sold live, smoked, or frozen to market dealers.

7.3. Business Opportunities in Mariculture

These business opportunities include but are not limited to:

- **Fingerling Supply:** Fishermen can harvest fingerlings and sub-adults of fish for rearing in aquaculture.
- **Table fish production:** Marine fish is in great demand in Nigeria.
- **Fish feed production:** Production of local fish feed is one of the possible business opportunities in the aquaculture industry recommended to upcoming entrepreneurs.
- **Fish meal production:** Thrash from artisanal fisheries could be processed into fish meals and used to produce fish feed.
- **Marketing of fish and fishery products:** Marketing fish and fishery products is a critical aspect of the fisheries and aquaculture value chain. Fish can be marketed in fresh and processed forms.

ACTIVITY

Participants should write down their suggestions and decisions.

8. IMPORTANT MARINE/BRACKISH WATER FISH SPECIES, SELECTION AND FISH SEED SOURCES

8.0. Introduction

The choice of species to culture is vital for the success of any aquaculture venture. Specific criteria are developed to select the species, shell or fin fish most suitable for commercial culture in marine/brackish water fish farms. The species must have a high market value, acceptability of artificial feed, tolerance to culture conditions in a pond, and, most importantly, regular availability of seeds from the wild for culture. Seed availability is the most critical factor as brackish water species propagation techniques in this part of the world are still embryonic. Many fin and shellfish species are abundant in brackish water zones of the Niger Delta.

8.1. Factors that Determine Types of Species to be Cultured

- Cultural environment - fresh, brackish, or marine environment
- Culture systems being practiced by the farmers
- Purpose of production
- Scale of production
- Economic value
- Availability of fish seed
- Environmental conditions

8.1.1. Characteristics of Culturable Species

- Fast growth
- Ability to convert artificial feed to carcass weight
- Acceptability of artificial feed
- Resistant to disease and pathogens
- It must be hardy with a high ability to withstand stress
- It must be easy to produce
- It must have the high consumer preference
- It must have a good market value
- Tolerance to environmental changes
- Palatable with high nutritional value
- Compatibility with other cultivable species
- Easy to breed and rear the seed
- Non-predacious

8.2. Fish Seed Sources

They are majorly from two sources:

- The natural environment (wild)
- Artificial propagation (hatchery)

8.2.1. Types of Fish Seed

- Fry
- Fingerlings
- Post Fingerlings
- Juveniles
- Sub Adults

8.3. Some Culturable Fin and Shell Species Found in the Niger Delta

Black jaw tilapia (*Sarotherodon melanotheron*)

Guinean tilapia *(Coptodon guineensis*)

Red snapper *(Lutjanus goreensis)*

Atlantic tarpon *(Megalops atlanticus*)

Grey mullets (*Mugil cephalus)*

West African lady fish (*Elops lacerta)*

Silver catfish (*Chrysichthys nigrodigitatus)*

Bloody cockle (*Senilia (Anadara) senilis)*

Mangrove oyster (*Crassostrea gasar)*

Periwinkle (*Tympanotonus fuscatus)*

Whelk (*Thais coronate)*

Giant Tiger Shrimp (*Penaeus monodon*)

9. OCEAN HEALTH AND HUMAN HEALTH

9.0. Introduction

The ocean covers over 71% of the earth's surface. It is crucial not only for environmental health but also for human health. The environment's health is critical for human health; the seas and the oceans are not different. The ocean has faced unprecedented challenges due to human actions. Repairing the human-influenced damage done to it will not only benefit the environment but also benefit humans.

9.1. Benefits of the Ocean

There are a lot of things the ocean does for humans and the planet.

- **The air we breathe:** The ocean produces over half of the world's oxygen. It also absorbs 50x more carbon dioxide than our atmosphere.
- **Climate regulation:** The ocean transports heat from the equator to the poles and regulates climate and weather patterns.
- **Recreation:** Recreational fishing vessels are not for fishing alone but for fun and amusement.
- **Food:** It provides more than just seafood to billions of people. It is a source of table salt.
- **Pharmaceuticals (medicine):** Many medicinal products come from the ocean. Omega-3 fatty acids, good for the health and extracted from marine organisms, play a role in medical treatment. Supplements that help fight cancer, arthritis, and Alzheimer's disease are obtained from the sea/ocean. One of the biggest surprises in using animal models has come from the nerve cells of the squid. This animal's nerves are enormous (about 1000 times larger than vertebrates'). These studies have opened the door to medical breakthroughs in diagnosing and treating nerve disorders.
- Marine products are used as research tools.
- Blue spaces help improve people's physical and mental health.
- **Economic benefits:** These involve goods, services, ocean department businesses, and employment
- The ocean serves as a means of transportation.
- **Tourism:** Beach tourism is one of the earliest forms of modern tourism and a staple of the tourism industry.

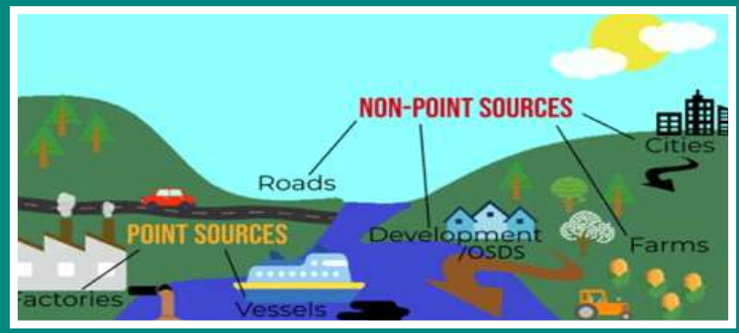
These are just a few examples of how the Ocean contributes to the health and well-being of thousands of men, women, and children worldwide.

9.2. Water Pollution

9.2.1. What are the causes of water pollution?

Water is uniquely vulnerable to pollution. It is a “universal solvent” as it dissolves more substances than any other liquid on Earth; hence it is easily polluted. Toxic substances from farms, towns, and factories readily dissolve and mix in water, causing pollution. Water pollution is a widespread problem that is jeopardizing human health. Unsafe water kills more people yearly than war and all other forms of violence combined.

Squid



Point and non- point sources of water pollution

Oil spill in Gbaramatu kingdom

· **Suspended Matter**

Some contaminants do not dissolve in water because their molecules are too large to be mixed with the water molecules. These substances are called particulate matter and can often be identified as a source of water pollution. Biodegradable materials are usually suspended in water and can induce problems by increasing the number of anaerobic microorganisms and are harmful to the survival and growth of aquatic species.

·· **Plastic pollution**

Ninety-five percent of waste in the ocean is plastic. This plastic is damaging to all the species in the sea. Turtles and fish choke on the plastic or get tangled up in the waste which enters the sea. Between 1.15 and 2.41 million tons of plastic enter the ocean yearly.

Plastic pollution in a riverine community

· **Microplastic**

Microplastics have been discovered in the digestive tracts of fish, beer, human breast milk, and other food items. They can cause oxidative stress, inflammatory reactions, and

· **Industrial and Agricultural Waste**

Industrial and agricultural practices involve using various chemicals that can run off into the water. Metals and solvents from industries can pollute lakes and rivers. These are toxic to various aquatic species and may slow their growth, make them infertile, or even cause death. Runoffs of pesticides cause water pollution and poison marine life. Humans and animals that eat these infected fish become exposed to poisoning.

· **Sewage and Waste Water**

Used water is wastewater. It comes from our sinks, showers, and toilets from commercial, industrial, and agricultural activities. The term also includes stormwater runoff, when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways. Over 80 percent of the world's wastewater flows into the environment without treatment.

· **Microbial Pollution**

There are many microorganisms in water. Over 2 billion people worldwide lack access to toilets and latrines—about 673 million defecate in public. Improperly treated waste containing microbes can adversely affect ocean and human health.

· **Ocean Acidification**

It is the lowering of the pH in the ocean over time. Over the last 200 years, carbon emissions have risen considerably, and the pH of the surface waters in the sea has fallen by 0.1 pH. It may not sound like a tremendous amount, but a 30% increase in acidity damages calcifying organisms such as corals, clams, and oysters.

British Poet W.H. Auden once noted, "Thousands have lived without love, not one without water." Yet, while we all know water is crucial for life, we still trash it.

9.2.3. What are the Effects of Water Pollution?

On human health

Water pollution makes us ill and can kill us. Our coastal communities are disproportionately at risk because homes are often closest to the most polluted areas. Diseases spread by unsafe water include diarrhea, cholera, dysentery, hepatitis A, and typhoid. Chemical pollutants can cause cancer, hormone disruption, and alter brain function. Swimming can also pose a risk.

On the environment

Water pollution causes algal bloom in a lake or marine environment, reducing oxygen levels in the water. This shortage of oxygen, known as eutrophication, suffocates plants. In some instances, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles.

9.2.4. What can you do to prevent water pollution?

Your actions

- There are some simple ways you can limit or prevent water contamination.
- You need to know the unique qualities of water in your vicinity. Where does stormwater or wastewater flow into? Discover where your actions will have the most impact.
- Reduce the use of plastics. Reuse or recycle plastic when you can.
- Properly dispose of non-biodegradable items to keep them from going down the drain.
- Maintain vehicles so they don't leak oil, antifreeze, or coolant.
- Avoid applying pesticides and herbicides.
- Don't flush your old medications. Dispose of them in the trash to prevent them from entering local waterways.
- Stop illegal refining of petroleum products (bunkering).
- Ensure we have a marine pollution control program.
- Make sustainable choices regarding food and drinks.
- Take reusable bottles and containers for food to the beach rather than buying plastic.

Your voice

Speaking out is one of the most effective ways to stand up for our waters. Tell the Federal/State/local government and legislators to support water protection. Our waterways serve every one of us; we should all have a say in how they're protected. Let them know pollutants are closing down coastal areas, destroying marine life, and making people seriously sick.

Moral imperatives

Depleting a nation's fishery resources represents a moral failure by society to maintain the natural environment and its productivity. It compromises food security, threatens vulnerable communities in particular, and reduces the livelihood opportunities of future generations. The contamination by pollution of an otherwise highly healthy food source, reducing food safety and threatening human health, is a moral failure.

10. INTRODUCTION TO SHELL FISH FARMING

10.0. Introduction

Niger Delta has rich aquatic ecosystems. Different culturable fin and shellfish species of economic value exist in these water bodies.

10.1. Classification of Marine Shellfish

Marine shellfish species are invertebrates, i.e., they do not have backbone or vertebrae. They have shells or hard calcareous outer body covering, e.g., crustaceans such as crabs, shrimps, prawns, and mollusks such as aquatic snails, periwinkles, whelks, clams, and cockles.

One group of shellfish that have no outer calcareous shell but possesses an inner shell is the cephalopods. Members of this group include squids and octopuses.

10.2. Where do shellfish live?

Shellfish live in marine, brackish, and freshwater environments. Most are edible, and quite a number are of commercial importance.

10.3. Why farm shellfish?

Shellfish are farmed for many reasons, especially for food - being a rich protein source - and medicines. Shellfish farming also provides jobs and income.

Other reasons for farming shellfish are:

- To reduce poverty
- To ensure food security
- For recreational benefits
- Oils
- For conserving and reducing pressure on wild stock. Shellfish production from the wild/natural habitat is reducing due to overfishing and environmental pollution.
- Shellfish are used as bio-indicators of polluted sites.
- The hard shells of some shellfish are used as construction material for paved and unpaved roads, walkways, houses, etc.
- Shells of shellfish, particularly mollusks, are rich in calcium. Calcium is an ingredient in feed fish and other farm animal feed.
- In the cosmetic and pharmaceutical industry, calcium powder is a valuable resource in the production of creams, beauty products, and a variety of cosmetics.

10.4. Culture enclosures and ponds for farming shellfish

Shellfish can be grown in tidal ponds, river ponds or open sea cages, and surface tanks. Hatchery for shellfish seed production can use surface tanks such as glass reinforced plastic (or fiberglass tank), concrete or plastic tanks. It is necessary to get a good quantity of and quality water supply to the ponds. Natural sources are good but must be free from pollutants.

A floating raft is used to set up mussel and oyster culture in a river or sea

Modified oyster cage farm in tidal ponds at the Nigerian Institute for Oceanography and Marine Research (NIOMR), Buguma, Rivers State

Circular concrete tank for shrimp hatchery at NIOMR, Badore, Lagos State

10. 5. Mangrove Oyster culture

The mangrove oyster (*crassostrea gasar*) is a conspicuous inhabitant of the mangrove ecosystem. Harvesting of mangrove wood for fuel and pollution from oil refining activities threaten the survival of the mangrove oyster. Hence, recent research has focused on the culture of the mangrove oyster. Selecting a suitable site free from pollution, rich in phytoplankton, with good water quality characteristics, and high spatial is essential to successful oyster farming.

Culture technique

The off-bottom culture method in trays/cages is used to grow oysters to table size. Spats or juvenile oysters can be obtained directly from an oyster hatchery, mangrove stilts, or oyster pond, where stringed old oyster shells are hung up in the water column to collect seed or spat naturally.

The desirable salinity range for oyster farming is 5-21 parts per thousand (ppt). The farm should have a good water flow which should be rich in phytoplankton, the natural food of the oyster. To exclude major predators like crabs and whelks, use Netlon material to produce the cages. Easy to handle and clean tray size is 60 cm x 50 cm x 15 cm. The ideal stocking density is 500 spats per tray.

Materials needed for preparing oyster cage for culture

- Netlon material
- Twine
- Scissors for cutting
- Bamboo/wooden poles/plastic pvc pipes
- Racks
- Artificial spat collectors
- Brackish water pond or creek

10.6 Cockle Farming

(Senilia (Anadara) senilis)

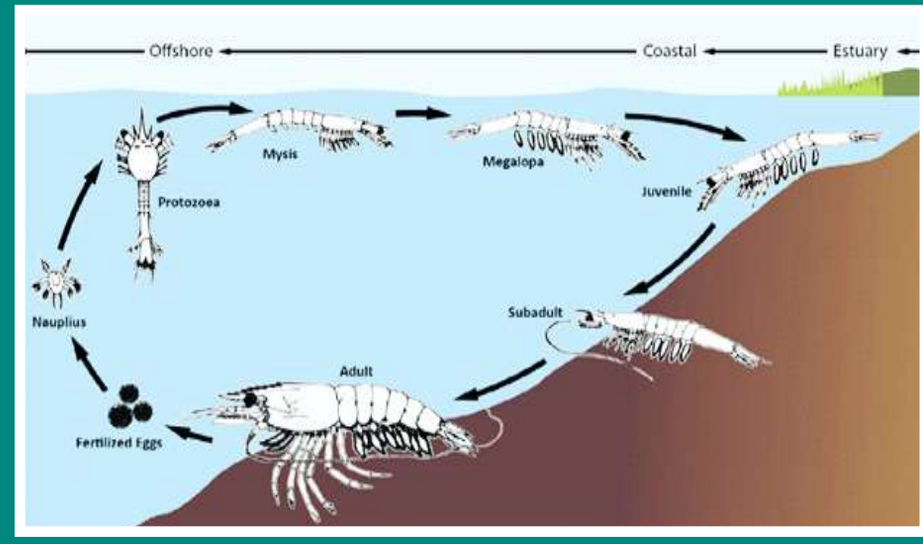
Cockle farming in the intertidal Andoni mudflats is an age-long practice. Cockles live in the mud just below the surface, but they are planktonic in the early stages of their life cycle. Ninety percent of people involved in harvesting and transplanting cockle seed are women and youth.

Blood Cockle, *Senilia Senilis*

10.7. Marine Shrimp Farming

Black tiger shrimp (penaeus monodon) is an invasive species. It invaded the West African coastal space for the first time in 1999. The life cycle spans from the sea bed to the ocean, where the adults release their eggs and sperm for fertilization. Fertilized eggs hatch into larvae which undergo different stages of metamorphosis from nauplius to protozoa to mysis, which look like tiny shrimp. At this stage, the shrimp begins a deliberate migration into the creeks, where they grow into post larvae and juveniles. They feed and grow as they become sub-adults.

Black Tiger Shrimp
(*Penaeus Monodon*)



Life cycle of Black Tger Shrimp (*Penaeus Monodon*)

10.8 Summary of Water Quality Requirements and Stocking Density

- Sea water for hatchery [30 to33 ppt]
- Brackish water for grow-out [15 to 25 ppt]
- Dissolved oxygen >4 mg/l
- Slightly alkaline pH 7.5 to 8.5
- Alkalinity 120 – 150 mg/l
- Water depth 1-to-1.5-meter depth
- Transparency 50 – 60 cm reduces as production progresses
- Water exchange – recirculation or flow through
- Stocking density 10 – 25 post larvae/m^2

11. FISH PROCESSING AND PRESERVATION

11.0. Introduction

Fresh fish spoils very quickly after capture. Temperature influences deterioration: the higher the temperature, the faster the spoilage rate. Fish production can significantly increase by emphasizing adequate processing and preservation procedures. Consumers naturally demand and pay more for good quality fresh fish. It is, therefore, important to maintain the quality of the fish through effective processing and preservation procedures.

11.1. Pre-preservation Procedures

- **Gutting:** Soon after harvesting, it is essential to gut the fish. Gutting involves cutting the fish open with a knife at the abdomen and removing the internal organs and gills.
- **Scale removal:** Detach scales from scaly fish with a sharp knife or scale remover. Wear appropriate protective gloves, aprons, and caps.
- **Washing:** Wash the fish thoroughly with clean running water
- **Cutting:** Preserve fish whole, or cut in neat chunks/fillets using a sharp knife. Cutting large fish before processing shortens the processing time as it exposes a larger surface area of the fish.

11.2. How To Increase Shelf Life Through Preservation

Fish quality is preserved through many techniques, thus increasing their shelf life. These methods prevent or reduce the metabolic changes that lead to spoilage. They include: chilling, freezing, salting, and fermentation.

- **Chilling:** Chilling is placing fish in ice to reduce its temperature. This process maintains the fish's freshness from harvest until it reaches the consumer. Different types of ice exist - ice blocks, ice cubes, ice chips, ice flakes, crushed ice, etc. Put the ice and fish in alternate layers in fish/ice boxes, chests, or bins.

- **Freezing:** It is the best method for preserving fresh fish. Keep fish frozen below 0^0C in cooling compartments such as refrigerators, deep freezers, or cold rooms. Fish frozen at a fast rate to avoid changes in their texture or taste can last for more than three months.

Conventional Ice Versus Functional Ice

Fish Preserved in Ice

Conventional ice is produced by freezing water till it is solid. Functional Ice (FICE) is made by adding food-grade materials, e.g., citric acid, to the water before freezing it. Conventional Ice thaws faster than FICE at room temperature. FICE melts slowly and can last up to 48 hours in the ice chest, which ensures fish remains fresh and of good quality for longer. It is more cost-effective to use FICE than conventional ice.

- **Salting:** Salting preserves fish by extracting water from fish tissue through osmosis. It inhibits spoilage by bacteria, enzymes, and chemicals in the fish. Salt also inhibits spoilage by dehydrating the bacterial cells. There are three methods of salting:

1. **Dry or kench salting:** Rub granular salt all over the fish. In kench salting, we rub granular salt on the surface of the split fish, and stack with a sprinkling of salt between each layer. Allow the liquid (pickle) that forms to drain away.

2. **Wet or pickle:** After kench salting, place fish in containers that retain the liquid. This liquid which is the pickling agent, helps in preserving the fish.
3. **Brine salting:** Immerse fish in a salt solution for up to one hour.

11.3. Fish Processing

Fish processing is the act of changing the natural form of fish. Usually, there is a change in its texture, taste, and physical appearance to retain its quality by arresting or stopping deterioration and extending its shelf life. Fish processing methods include smoking, frying, canning, curing, producing fillets, and minced fish products.

- **Fish Smoking:** Smoking fish involves heating it using fire/heat from wood, charcoal, gas, or electricity. Smoking is a common and efficient traditional method of preserving fish over long periods. Smoked fish do not necessarily require electricity for processing or storage.

To smoke fish using a smoker:

1. Preheat the kiln (Fig.5) to 100 °C
2. Place the prepared fish in the kiln
3. Smoke the fish using charcoal for 2 to 3 hours at this hot temperature
4. At this time, the fish is cooked but not dry
5. Step down the heat to 50 – 60 °C
6. Smoke at this moderate temperature continuously for one to three days, depending on the size of the fish.

Fish smoking kilns at Bayelsa Aquaculture Village

7. Large fatty fish take a longer time to get well-dried than small, less fatty fish.

In addition, to reduce the inclusion of cancer-causing materials known as polycyclic aromatic hydrocarbons (PAH), e.g., benzo alpha pyrene, into the fish, it is preferable to use charcoal instead of wood as the fuel for smoking. Also, well-designed and fabricated kilns that filter out hazardous smoke could be used instead of the open fire, popularly known as an 'altar.'

- **Fish Canning:** Fish canning involves heat treatment of fish in sealed containers made of tin plates, aluminum cans, or glass until the product is thoroughly sterilized. Canned fish species include mackerel, sardines, tuna, croaker, tilapia, and African catfish.

Fish are canned in various flavors, the most common being fish in oil or fish in tomato sauce. Canned fish makes fish available for the inhabitants of cities, villages, and even very remote locations, war-torn zones, and are handy protein meals in refugee or internally displaced person camps.

Innovation in Fish Processing (Value Addition)

Many innovative ways of processing fish exist and are based on traditional recipes or new creations. New products can be developed by adding value to raw fish. These innovative products can create new market opportunities and guarantee other income streams, particularly for youths.

ABOUT PIND

PIND is a non-profit organization that promotes peace and equitable economic growth in the Niger Delta region through strategic partnerships and collaborations.

Since 2010, with our partners, we have been contributing to strengthening and stabilizing the region by

- reducing conflict and fostering peace & stability,
- reducing poverty,
- facilitating alternative clean energy solutions for remote coastal communities that are off the national grid,
- enabling youth employment,
- supporting gender equality and social inclusion for women, youth, and people with disabilities,
- empowering local civil society organizations,
- and influencing governments policies, programs & practices that significantly benefit the poor and marginalized.

Our vision is to foster a strong legacy of sustainable peace and development among communities in the Niger Delta. Hence, we implement collaborative market-based, community-owned programs to mitigate conflicts and boost economic opportunities for local businesses, ensuring that economic progress occurs in a systemic, inclusive, and sustainable manner.

Our projects span all nine Niger Delta states: **Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers**, focusing on the underserved and hard-to-reach coastal communities of the region.

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