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SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

Post Harvest Processing Value Chain Literature Review Report

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Citation: Entee, S. (2015). Post Harvest Processing Value Chain Literature Review Report. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and SNV Netherlands Development Organization. GH2014_ACT022_SNV. 48 pp.

Authority/Disclaimer:

Prepared for USAID/Ghana under Cooperative Agreement (AID-641-A-15-00001) awarded on October 22, 2014 to the University of Rhode Island and entitled; the USAID/Ghana Sustainable Fisheries Management Project (SFMP).

Cover photo: Women smoking fish at New Takoradi (Credit: SNV Ghana)

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ACRONYMS

AOR	Administrative Officer Representative
ASSESS	Analytical Support Services and Evaluations for Sustainable Systems
CEMAG	Community Environmental Monitoring and Advocacy Group
CCLME	Canary Current Large Marine Ecosystem
CCM	Centre for Coastal Management
CDCS	Country Development Cooperation Strategy
CEWEFIA	Central and Western Region Fishmongers Improvement Association
COMFISH	Collaborative Management for a Sustainable Fisheries Future
CoP	Chief of Party
CPUE	Catch Per Unit Effort
CR	Central Region
CRC	Coastal Resources Center at the Graduate School of Oceanography, University of Rhode Island
CRCC	Central Regional Coordinating Council
CSLP	Coastal Sustainable Landscapes Project
CSO	Civil Society Organization
DA	District Authorities
DAA	Development Action Association
DAASGIFT	Daasgift Quality Foundation
DFAS	Department of Fisheries and Aquatic Sciences
DFID	*Department for International Development*
DO	Development Objective
EBM	Ecosystem-Based Management
EG	Economic Growth
EMMP	Environmental Mitigation and Monitoring Plan
ERF	Environmental Review Form
ETP	Endangered, Threatened and Protected
FAO	Food and Agricultural Organization of the United Nations
FASDEP	Food and Agriculture Sector Development Program
FASDP	Fisheries and Aquaculture Sector Development Program
FC	Fisheries Commission
FCWCGG	Fisheries Committee for the West central Gulf of Guinea
FEU	Fisheries Enforcement Unit
FHI	Family Health International
FoN	Friends of Nation
FtF	Feed the Future
HM	Hen Mpoano
GCLME	Guinea Current Large Marine Ecosystem
GIFA	Ghana Inshore Fishermen's Association
GIS	Geographic Information System
GIZ	Gesellschaft für Internationale Zusammenarbeit
GLM	Generalized Linear Models
GNAFF	Ghana National Association of Farmers and Fishermen
GNCFC	Ghana National Canoe Fishermen’s Council
GoG	Government of Ghana
GSA	Ghana Standards Authority
GSO	Graduate School of Oceanography, University of Rhode Island
ICFG	Integrated Coastal and Fisheries Governance
ICM	Integrated Coastal Management
ICT	Information, Communication Technology
IEE	Initial Environmental Examination
IR	Intermediate Results
IUCN	International Union for Conservation of Nature

IUU	Illegal Unreported Unregulated
JICA	Japan International Cooperation Agency
LEAP	Livelihood Enhancement Against Poverty
LOE	Level of Effort
LOGODEP	Local Government Development Program
LoP	Life of Project
MCS	Monitoring, Control and Surveillance
METASIP	Medium Term Agricultural Investment Program
METSS	Monitoring, Evaluation and Technical Support Services
MFRD	Marine Fisheries Research Division
MOFAD	Ministry of Fisheries and Aquaculture Development
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSME	Micro Small and Medium Enterprises
MSP	Marine Spatial Planning
M&E	Monitoring and Evaluation
NAFAG	National Fisheries Association of Ghana
NGO	Non-Governmental Organization
NC	National Committee
NRM	Natural Resources Management
PMEP	Performance Monitoring and Evaluation Plan
PMP	Performance Management Plan
PPP	Public Private Partnerships
RAVI	Rights and Voices Initiative
RCC	Regional Coordinating Council
RFA	Request for Application
RPA	Rapid Partnership Appraisal
SAMP	Special Area Management Plans
SFMP	Sustainable Fisheries Management Program
SMEs	Small and Medium Enterprises
SNV	Netherlands Development Organization
SS	Spatial Solutions
SSG	SSG Advisors
STEP	Sustainable, Transparent, Effective Partnerships
STWG	Scientific and Technical Working Group
UCAD	University Cheikh Anta Diop
UCC	University of Cape Coast
URI	University of Rhode Island
USAID	United States Agency for International Development
USG	United States Government
WA	West Africa
WARFP	West Africa Regional Fisheries Development Program
WASH	Water, Sanitation and Hygiene
WR	Western Region

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INTRODUCTION

The Sustainable Fisheries Management Project in Ghana is a United States Agency for International Development (USAID) funded project that seeks to "Rebuild targeted fish stocks through adoption of sustainable practices and exploitation levels." This project forges a campaign that builds a constituency for change that captures the support of high-level decision makers and politicians as well as grass roots anglers, fishmongers and processors.

The project is designed to improve fisheries management and strengthen governance to have positive impacts on fisheries resources and the people that depend on marine ecosystem goods and services. The SFMP will also compliment and coordinate closely with the two other sister projects in the USAID Coastal Program Portfolio: The Costal Sustainable Landscapes Project (CSLP) and the UCC Strengthening Project.

Fishing is an ancient practice dating back at least 40,000 years. Since the 16th century, fishing vessels have been able to cross-oceans in pursuit of fish and since the 19th century, it has been possible to use larger vessels and in some cases process the fish on board. Fish are normally caught in the wild. Techniques for catching fish include hand gathering, spearing, netting, angling, and trapping.

The fishing industry in Ghana supports the livelihood of about 10% of the total population. The importance of the fishing industry stems from the significant contribution of around 60% of the national protein supply and around 87 million USD exports in 2009. Fish and seafood account for 16% of total household spending on food (GSS, 2008).

The principal fish processing methods in Africa are smoking, salting, sun drying, and fermentation, grilling and frying. The predominant type of fishery product in any particular country is, however, closely related to the food habits and purchasing power of the population. Specific types of fishery products are best suited as the local staple food. Furthermore, due to the lack of a good transport infrastructure for the transportation of fresh fish to remote towns and villages, cured fish is the most convenient form in which fish can be sent to such areas. Many consumers in Africa prefer fish in the fresh state; however, a considerable proportion of the landed catch is preserved by artisanal methods.

This literature survey aims to document all the post harvesting processing of fish in Ghana and internationally.

HISTORY OF THE FISHING INDUSTRY

Fishing is an ancient practice that dates back at least to the Upper Paleolithic period, which began about 40,000 years ago. Isotopic analysis of the skeletal remains of Tianyuan man, a 40,000-year-old modern human from eastern Asia, has shown that he regularly consumed freshwater fish**.** (African Bone Tools Dispute, 2010)

Archaeological features such as shell middens, discarded fish bones and cave paintings show that sea foods were important for survival and consumed in significant quantities. During this period, most people lived a hunter-gatherer lifestyle and were of necessity, constantly on the move. However, where there are early examples of permanent settlements (though not necessarily permanently occupied) such as those at Lepenski Vir, they are usually associated with fishing as a major source of food. (Coastal Shell Middens and Agricultural Origins in Atlantic Europe)

Spearfishing with barbed poles (harpoons) was widespread in Palaeolithic times (Guthrie, Dale Guthrie (2005). Cosquer cave in Southern France contains cave art over 16,000 years old, including drawings of seals, which appear to have been harpooned. The Neolithic culture and technology spread worldwide between 4,000 and 8,000 years ago. With the new technologies of farming and pottery came basic forms of the main fishing methods that are still used today.

From 7500 to 3000 years ago, Native Americans of the California coast were known to engage in fishing with gorge hook and line tackle (King, 1991 pp 80-81). In addition, some tribes are known to have used plant toxins to induce torpor in stream fish to enable their capture (Rostlund 1952, pp 188-190).

Copper harpoons were known to the seafaring Harappans (Ray 2003, pg 93) well into antiquity (Allchin 1975 pg 106). Early hunters in India include the Mincopie people, aboriginal inhabitants of India's Andaman and Nicobar islands, who have used harpoons with long cords for fishing since early times (Edgerton, 2003 pg 74)

The ancient river Nile was full of fish; fresh and dried fish were a staple food for much of the population. The Egyptians invented various implements and methods for fishing and these are clearly illustrated in tomb scenes, drawings, and papyrus documents. Simple reed boats served for fishing. Woven nets, weir baskets made from willow branches, harpoons and hook and line (the hooks having a length of between eight millimetres and eighteen centimetres) were all being used. By the 12th dynasty, metal hooks with barbs were being used. As is fairly common today, the fish were clubbed to death after capture. Nile perch, catfish and eels were among the most important fish. Some representations hint at fishing being pursued as a pastime.

From ancient representations and literature, it is clear that fishing boats were typically small, lacking a mast or sail, and were only used close to the shore. There are numerous references to fishing in ancient literature; in most cases, however, the descriptions of nets and fishing-gear do not go into detail, and the equipment is described in general terms. An early example from the Bible in Job 41:7: Canst thou fill his skin with barbed irons? Or his head with fish spears? Traditional Chinese legends credit the art of fishing to Fu Xi.

OVERVIEW OF THE RECENT GLOBAL FISHING INDUSTRY

The global fisheries industry is generally described in terms of two distinct categories: capture and aquaculture. Capture includes inland and marine fisheries, with inland representing approximately 10% of total fish capture. Aquaculture includes inland and marine production, with approximately 60% arising from inland production.

The largest fish producer is China, accounting for almost a third of total global production from capture and aquaculture. China’s production has risen dramatically since the late 1980s in both capture and aquaculture. The most productive marine fishing areas are the Northwest and Southeast Pacific.

Capture fisheries and aquaculture supplied the world with about 110 million tonnes of food fish in 2006, providing an apparent per capita supply of 16.7 kg (live weight equivalent), which is among the highest on record. Of this total, aquaculture accounted for 47 percent. Outside China, per capita supply has shown a modest growth rate of about 0.5 percent per year since 1992 (following a decline from 1987), as growth in supply from aquaculture more than offset the effects of static capture fishery production and a rising population. In 2006, per capita food fish supply was estimated at 13.6 kg if data for China are excluded. Overall, fish provided more than 2.9 billion people with at least 15 percent of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9 percent in 1992 to a peak of 16.0 percent in 1996, declining to about 15.3 percent in 2005. Notwithstanding the relatively low fish consumption by weight in low-income food-deficit countries (LIFDCs) of 13.8 kg per capita in 2005, the contribution of fish to total animal protein intake was significant – at 18.5 percent – and is probably higher than indicated by official statistics in view of the under-recorded contribution of small- scale and subsistence fisheries.

China remains by far the largest producer, with reported fisheries production of 51.5 million tonnes in 2006 (17.1 and 34.4 million tonnes from capture fisheries and aquaculture, respectively), providing an estimated domestic food supply of 29.4 kg per capita as well as production for export and non-food purposes. However, there are continued indications that capture fisheries and aquaculture production statistics for China may be too high, as noted in previous issues of the State of World Fisheries and Aquaculture, and that this problem has existed since the early 1990s. Because of the importance of China and the uncertainty about its production statistics, as in previous issues of this report, China is generally discussed separately from the rest of the world. In 2008, China indicated that it was working to revise its fishery and aquaculture production statistics downwards based on the outcome of the National Agricultural Census of 2006, which included for the first time questions relating to fisheries and aquaculture, as well as fishery surveys. Revised statistics for a period of years are expected to be made available by 2009 and to be reflected subsequently in FAO statistics and in future issues of The State of World Fisheries and Aquaculture.

In 2008, China reported a downward revision of total fishery and aquaculture production for 2006 of more than 10 percent, corresponding to a reduction of more than 2 million tonnes in capture production and more than 3 million tonnes in aquaculture production. Preliminary estimates for 2007 based on reporting by some major fishing countries indicate that world fishery production excluding China is 96 million tonnes, representing approximately a 3 percent increase for capture production and a 7 percent increase for aquaculture production compared with 2006.

Global capture fisheries production in 2006 was about 92 million tonnes, with an estimated first-sale value of US$91.2 billion, comprising about 82 million tonnes from marine waters and a record 10 million tonnes from inland waters. China, Peru and the United States of America remained the top producing countries. World capture fisheries production has been relatively stable in the past decade with the exception of marked fluctuations driven by catches of anchoveta – a species extremely susceptible to oceanographic conditions determined by the El Niño Southern Oscillation – in the Southeast Pacific. Fluctuations in other species and regions tend to compensate for each other to a large extent. China remains by far the global leader with more than 17 million tonnes in 2006. Asian countries accounted for 52 percent of the global capture production.

Overall catches in the Western Central Pacific and in the Western Indian Ocean continued to increase, whereas capture production decreased in both the Western and Eastern Central areas of the Atlantic Ocean. In the Eastern Indian Ocean, total catches in 2006 returned to growth after the decrease in 2005 caused by the destructive effects of the tsunami of December 2004.

Catches from inland waters, almost two-thirds of which were taken in Asia in 2006, have shown a slowly but steadily increasing trend since 1950, owing in part to stock enhancement practices and possibly to improved reporting.

Aquaculture continues to be the fastest growing animal food-producing sector and to outpace population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 6.9 percent. It is set to overtake capture fisheries as a source of food fish. From a production of less than 1 million tonnes per year in the early 1950s, production in 2006 was reported to be 51.7 million tonnes with a value of US$78.8 billion, representing an annual growth rate of nearly 7 percent. World aquaculture is heavily dominated by the Asia–Pacific region, which accounts for 89 percent of production in terms of quantity and 77 percent in terms of value. This dominance is mainly due to China's enormous production, which accounts for 67 percent of global production in terms of quantity and 49 percent of global value. China produces 77 percent of all carps (cyprinids) and 82 percent of the global supply of oysters (ostreids). The Asia–Pacific region accounts for 98 percent of carp, 95 percent of oyster production, and 88 percent of shrimps and prawns (penaeids). Norway and Chile are the world's two leading producers of cultured salmons (salmonids), accounting for 33 and 31 percent, respectively, of world production.

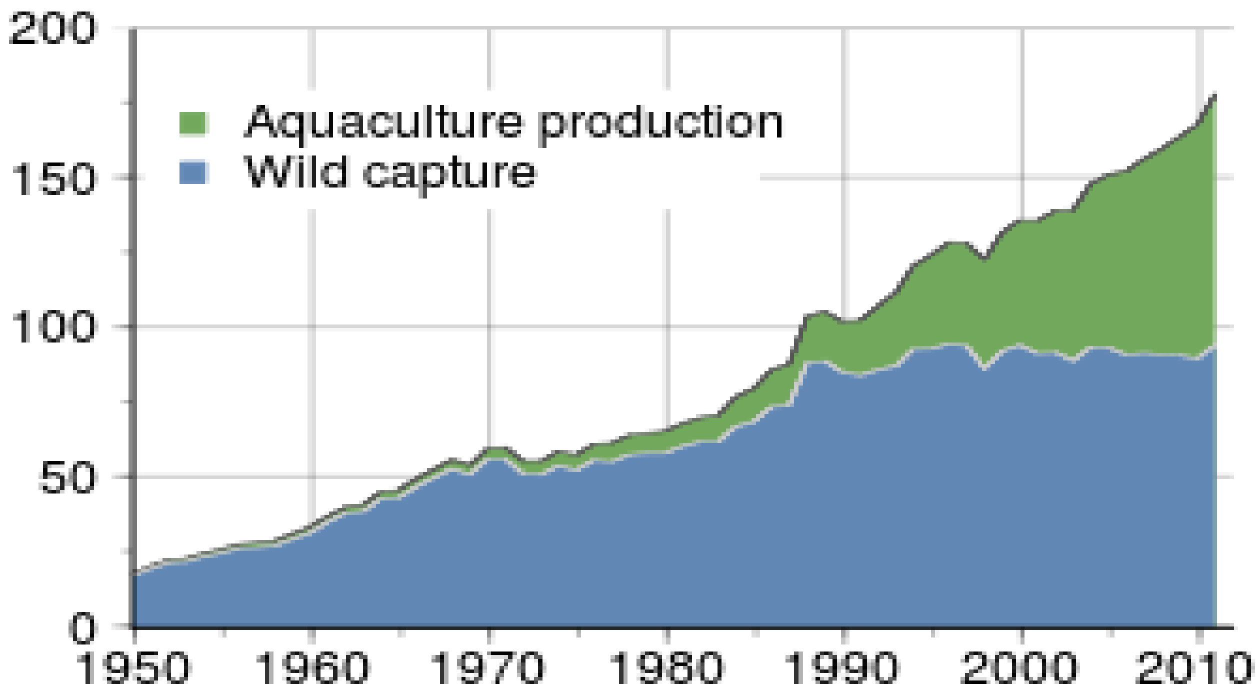

Figure 1 Total production

Aquatic plant production by aquaculture in 2006 was 15.1 million tonnes. The culture of aquatic plants has increased consistently, with an average annual growth rate of 8 percent since 1970. In 2006, it contributed 93 percent of the world's total supply of aquatic plants, or 15.1 million tonnes (US$7.2 billion), some 72 percent of which was produced by China. However, growth rates for aquaculture production are slowing, partly owing to public concerns about aquaculture practices and fish quality. Genetically modified organisms (GMOs) remain a controversial issue. In response to these concerns, integrated multitrophic aquaculture (which promotes economic and environmental sustainability) and organic aquaculture are on the rise.

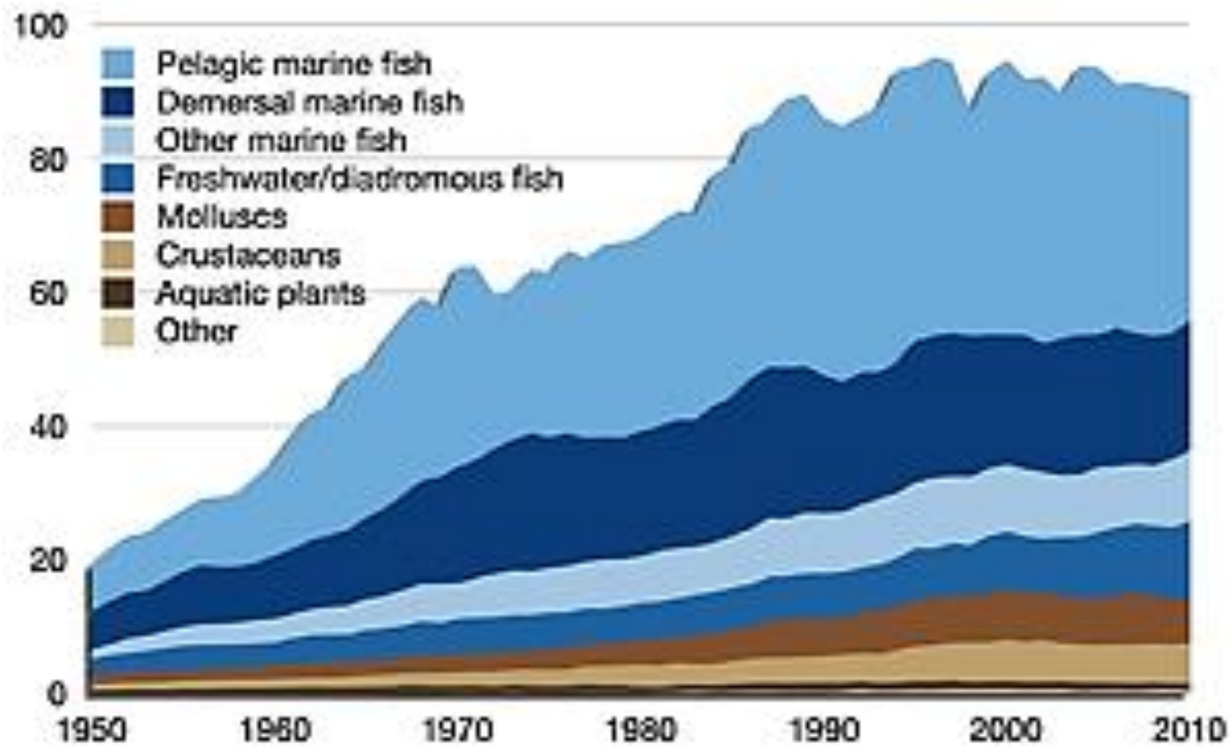

Figure 2 Wild fish capture

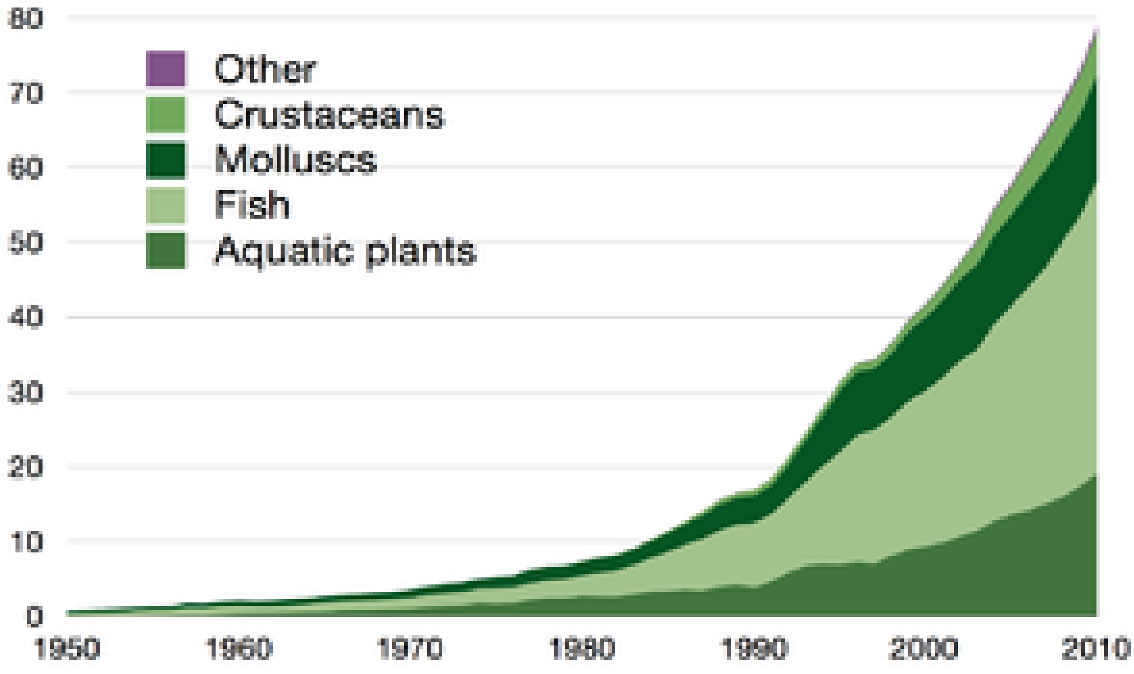

Figure 3 Aquaculture harvest

Importance of the Fisheries Industry

Fisheries and aquaculture, directly or indirectly, play an essential role in the livelihoods of millions of people around the world. In 2006, an estimated 43.5 million people were directly engaged, part time or full time, in primary production of fish either in capture from the wild or in aquaculture, and in a further 4 million people were engaged on an occasional basis (2.5 million of these in India).

Employment and Foreign Exchange

The fishing industry plays an important role in a country's economy. For example in Ghana, while accounting for 4 % of the country's GDP, it also provides employment opportunities to the nation's work force and is a major contributor to its foreign exchange. A large section of the impoverished people of the country is engaged in the fisheries sector. Over 150,000 fishers are said to be working in the fisheries, while over 500,000 people are engaged in related work such as the processing, distribution, and selling of fish

On the foreign income contributions, fish provides about 50% in the form of foreign income to the national economy of Ghana. In the year 2006, fish realized a foreign income of about $40,000,000 from the sale of about 10,000 tons of fish and fish products (Anon., 2008).

The fishing industry provides employment for many rural and urban people in Ghana. It has been estimated that about ten per cent of the population is involved in the fishing industry from both urban and rural areas and women are key players in post-harvest activities. The sector is also important from a gender perspective. Men are involved in fish harvesting, undertaking the main fishing activities in the artisanal, semi-industrial and the industrial sectors while women are the key players in on-shore post-harvest activities, undertaking fish processing and storage and trade activities

Many are also engaged in the frozen fish distribution trade as well as marketing fish within and outside the country. It is estimated that a total of 500,000 fishermen, fish processors, traders and boat builders are employed in the Fisheries Sector. These people, together with their dependents, account for about 10 per cent of the population (Afful, 1993; Anon, 1995; Quartey et al., 1997). A canoe census conducted for the marine fisheries in 2001 estimated the number of artisanal fishermen at 120,000 (Bannerman et. al., 2001).

Fisheries provide direct employment to about 2.2 million people in the country of Ghana, and it is currently contributing 4.4% to the Gross Domestic Product of Ghana and is more than the contribution of cocoa, which is supposed to be the main traditional contributor to the GDP of Ghana (Anon., 2008). In the last three decades, employment in the primary fisheries and aquaculture sector has grown faster than the world's population and employment in traditional agriculture. Eighty - six percent of fishers and fish farmers worldwide live in Asia, with China having the greatest numbers (8.1 million fishers and 4.5 million fish farmers). In 2006, other countries with a significant number of fishers and fish farmers were India, Indonesia, the Philippines and Vietnam. Most fishers and fish farmers are small-scale, artisanal fishers, operating on coastal and inland fishery resources. Currently, fleet-size reduction programmes in China and other countries, aimed at tackling overfishing are reducing the number of full-time and part-time fishers. Globally, the number of people engaged in capture fisheries declined by 12 percent in the period 2001–06. On the other hand, in recent decades, major increases in the total number have come from the development of aquaculture activities.

In 2006, the estimated number of fish farmers was nearly 9 million people, with 94 percent operating in Asia. For each person employed in the primary sector, it has been estimated that there could be four employed in the secondary sector (including fish processing, marketing and service industries), indicating employment of about 170 million in the whole industry. Taking account of dependents, about 520 million people could be dependent on the sector, or nearly 8 percent of the world population. Employment in fishing and aquaculture has grown rapidly over the past few decades, increasing more than threefold from 13 million people in 1970 to over 41 million in 2004. 2002 figures for employment in fisheries and aquaculture are 38 million full-time equivalents, increasing slightly from 2001 figures. Asia has the highest numbers of workers in fishing and aquaculture, with China accounting for almost one-third of total world employment. Trends in employment are showing a decline in the workers in capture fisheries, particularly in the most important fishing countries, with corresponding increases in aquaculture employment. Overall, there has been a 2.6% increase per year between 1990 and 2002.

75% of the total number of fisheries workers is in marine and inland capture fishing, while the remaining 25% are employed in aquaculture. The global distribution of fishery workers is as follows: Asia (87% of total); Africa (7%), Europe, North and Central America and South America (approximately 2% each) and Oceania (0.2%). China has almost one-third of the total workers in fisheries, equating to 12.3 million people. Reductions in employees in China and a number of other nations are starting to be seen, however, as part of fleet-reduction programmes that aim to reduce overfishing. Increased productivity, as a result of technical improvements, has also contributed to reductions in employment in capture fishing. Employment in aquaculture has increased approximately 8% per year since 1990, although a levelling off is starting to occur in the developed countries.

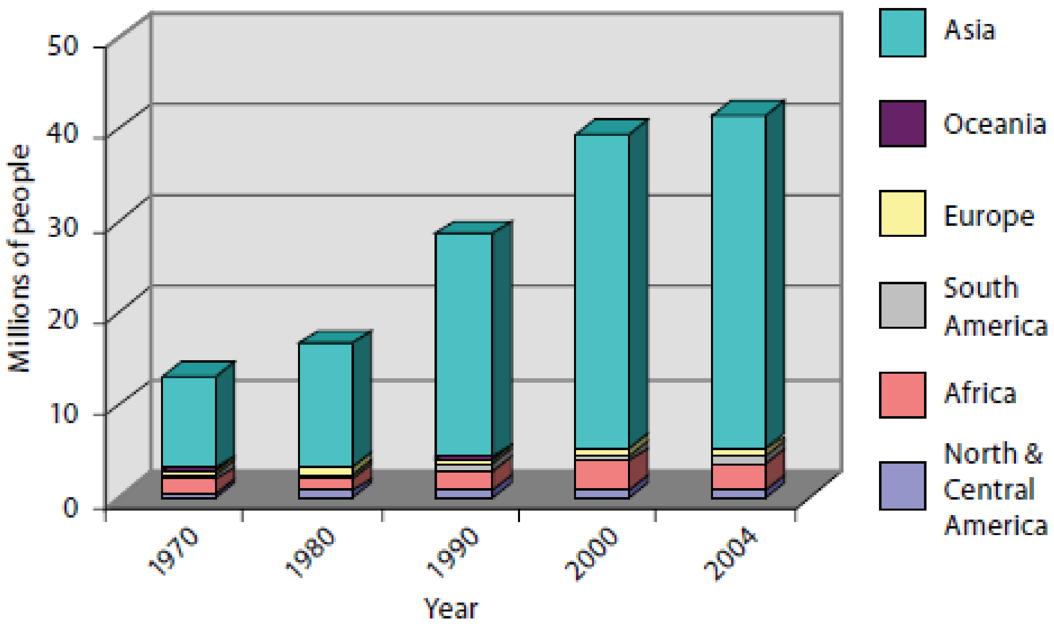

Figure 4 Employment in fisheries and aquaculture. Data for 1970, 1980 and 1990 are from FAO (1999), while data from 2000 and 2004 are from FAO (2006), and therefore may not be perfectly comparable.

Food Security, Nutrition and Health

Several literatures have spelt out Food Security, nutrition and health as some of the importance of the fishing industry in the world especially in the African Continent.

Even when consumed in small quantities, fish often comprises a nutritionally important part of many people's diets in developing countries. It is a vital source of protein and micronutrients, and improves the quality of protein in largely vegetable and starch-based diets by providing essential amino acids. FAO (2006) has estimated that fish accounts for approximately 20 percent of animal protein consumption in LIFDCs. In some coastal and island countries (including Bangladesh, Indonesia, Senegal, and Sri Lanka),

It provides, over 50 percent of animal protein, and reaches 62 percent in Gambia and 63 percent in Sierra Leone and Ghana. It is a particularly important component of the diets of the poor, as it is often the most affordable form of animal protein.

Fish is also rich in iron, zinc, magnesium, phosphorous, calcium, vitamin A and vitamin C, and marine fish is a good source of iodine. Many of these vital nutrients are found only in small amounts, if at all, in staple foods such as maize, rice and cassava which make up the bulk of people's diets in developing countries. Fish are an indispensable source of these nutrients for many people, and small low-value fish, which are largely consumed by the rural poor, provide more minerals than the same quantity of meat or large fish, as they are consumed whole, with the bones intact. Fish also contain fatty acids, which are essential for the development of the brain and body, and are particularly crucial for the diets of babies, children, and pregnant and lactating women (World Fish Center 2005a).

Consumption of omega-3 fatty acids during pregnancy reduces the risk of low birth weight, which is a key factor in both maternal and child mortality. These acids are also critical for the neurological development of infants, and are found almost exclusively in fish, making the consumption of fish during lactation and pregnancy especially important.

The nutritional benefits of fish consumption are also particularly important for people living with HIV/AIDS. Proper nutrition is essential for the effectiveness of anti-retroviral drugs, and fish has also been shown to contain combinations of nutrients, which reduce susceptibility to secondary diseases.

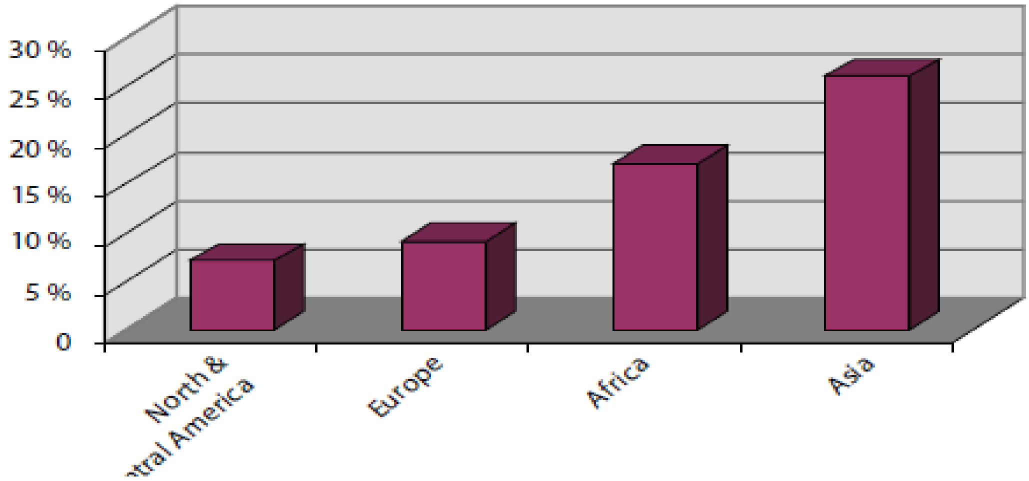

Figure 5 Fish as percent of animal protein in the various continents

Source: Delgado et al, 2003

Common Species of Fish Harvested

Fisheries are harvested for their value (commercial, recreational or subsistence). They can be saltwater or freshwater, wild or farmed. Examples are the salmon fishery of Alaska, the cod fishery off the Lofoten islands, the tuna fishery of the Eastern Pacific, or the shrimp farm fisheries in China. Capture fisheries can be broadly classified as industrial scale, small-scale or artisanal, and recreational.

Close to 90% of the world's fishery catches come from oceans and seas, as opposed to inland waters. These marine catches have remained relatively stable since the mid-nineties (between 80 and 86 million tonnes). Most marine fisheries are based near the coast. This is not only because harvesting from relatively shallow waters is easier than in the open ocean, but also because fish are much more abundant near the coastal shelf, due to the abundance of nutrients available there from coastal upwelling and land runoff. However, productive wild fisheries also exist in open oceans, particularly by seamounts, and inland in lakes and rivers.

Most fisheries are wild fisheries, but farmed fisheries are increasing. Farming can occur in coastal areas, such as with oyster farms, but more typically occur inland, in lakes, ponds, tanks and other enclosures.

GHANA FISHERIES INDUSTRY

Ghana's marine coastline of 550 kilometres stretches from Aflao in the East to Half Assini in the West. Ghana's freshwater sources especially the Volta also stretches from the Upper East region towards the south and enters the sea at Ada in the Greater Accra Region. (Bank of Ghana, 2008)

In Ghana, the average per capita fish consumption is said to be around 20 - 25kg, which is higher than the world average of 13kg. Importantly, as much as 60 per cent of animal protein in the Ghanaian diet country-wide is thought to be from fish, which accounts for 22.4 per cent of household food expenditures. (FAO, 2004)

The fishery sector in Ghana includes marine and inland fisheries. The marine fishery constitutes over 80% of the total fish landing, including inshore and offshore fisheries. The inshore fisheries mainly consist of small-scale artisanal canoes fishing contributed about 70% of the marine fish supplies in Ghana between the periods 2000-2006.

Year	Marine	Inland	Total Fish Landing
1997	395,889	76,200	**472,039**
1998	376,361	76,300	**452,661**
1999	332,641	89,400	**422,041**
2000	379,793	87,500	**467,293**
2001	365,741	88,000	**453,741**
2002	290,008	88,000	**378,008**
2003	331,412	82,450	**413,862**
2004	352,405	82,450	**434,855**
2005	322,789	82,654	**405,443**
2006	323,617	83,168	**406,784**

Table 1 Total marine production of fish from 1997 to 2006 in Ghana

Ghana has been a regional fishing nation with a long tradition of a very active fishing industry dating back to as early as the 1700s and 1800s when Fante fishermen embarked on ocean fishing along the coast of Ghana. Bounded on the south by the Gulf of Guinea, Ghana has a 550-kilometre coastline and a total continental shelf area of about 24,300 square kilometres to support a vibrant marine fishing industry. Ghana also has a system of rivers, lagoons and lakes that form the basis of an inland fisheries industry. Indeed, Fantes are reported to have been fishing in the coastal waters of Benin Republic and Cote d'Ivoire since the early 1900s (Atta-Mills et al, 2004).

The former Department of Fisheries built fishponds in the northern part of the country in 1953, post which fish farming came into existence. Built to operate as hatcheries along with complementing the country's demand for fish, it was also a way to generate employment opportunities for people. Communities that lived near reservoirs were taught fishing skills. After Ghana gained independence in 1957, the government launched various irrigation schemes and policies to develop fishponds to promote this sector. Majority of Ghana's fish farmers operate on a small scale, deploying extensive practices for fish farming. Based on marine as well as inland water resources, aquaculture and coastal lagoons, Ghana's fisheries constitute 5 % of the GDP. Almost 75 % of the local produce of fish in Ghana is consumed, as the per capita fish consumption is 25 kg every year. Though relatively new, fish farming is spreading in the country, with fish being the most important non-tradition commodity.

There are a wide variety of fishes available in Ghana's waters. These include, the anchovy, cassava fish, chub mackerel, flat sardinella, largehead hairtail, meagre fish, moonfish, red pandora, red snapper, round sardinella, skipjack, and yellowfin. In general however, these can be classified into pelagic (coastal) and demersal (deep sea) fish species. Pelagic fish species are those fishes that are characteristically mobile and migratory and live in open waters of the sea. Some commercially important species include round sardinella, flat sardinella, skipjack, yellow fin, bumper and chub mackerel. On the other hand, demersal fish species are commonly found near and just beneath the sea bed. The major demersal fish species common in Ghanaian waters are the lujanidae (snappers), serranidae (groupers), and polynemidae (threadfins)

The largest found and exported species in Ghana include anchovy, chub mackerel and round as well as flat sardinella, all of which contribute to almost 70 % of the total marine produce within the country. Lake Volta is a stable and consistent contributor, accounting for almost 16 % of Ghana's national output. Ghana's fish exports comprise of frozen fish, tuna, dried or smoked fish and cuttlefish, and they are usually exported to European Union countries. The largest tuna resources in Ghana are the Yellow fin. There are three sectors in the fishing industry of Ghana.

The fishing industry in Ghana started as an artisanal fishery with very simple and inefficient gears and methods operating close to coastal waters, lagoons, estuaries and rivers.

GLOBAL CATEGORIES IN THE FISHING INDUSTRY

The fisheries sector comprises two main categories: capture (inland and marine fishing), and aquaculture

Capture Fisheries

The top ten nations for capture fisheries (inland and marine) have remained the same since 1992. Together, they accounted for approximately 60% of the total world trade in 2002, with China and Peru dominating. In order of productive, the top ten countries are China, Peru, United States, Indonesia, Japan, Chile, India, Russian Federation, Thailand and Norway.

The top ten marine capture species are anchoveta, Alaska pollock, skipjack tuna, capelin, Atlantic herring, Japanese anchovy, Chilean jack mackerel, blue whiting, chub mackerel, and large head hair tail.

The types of fisheries in Ghana can be classified into seven categories namely marine, artisanal, inshore, industrial, lagoon, and inland fisheries. However, the data available from the Fisheries Commission does not explicitly include lagoon fisheries. The marine fisheries are essentially dominated by artisanal agents who provided an average of 71% of the total fish catch over the period 2000-2010. This result was followed by tuna fisheries (21%), other industrial fisheries (2.8%).

The operators in inshore fishery used locally built motorised wooden vessels or small steel vessels measuring between 9 m and 12 m long, which operated both as trawlers and purse seines (MoFI, 2006). The vessels operated from Tema and Takoradi (where there were deepwater ports), the old Sekondi fishing habour and the Bosotonneswi-Sam Fishing harbour in Sekondi. The fleet exploited both pelagic and demersal fish species and competed with the traditional canoes. In 2009, there were 226 operational boats which were generally fitted with 30-90hp diesel engines. They fished during the upwelling seasons using purse seines mainly in the inshore waters between 30-50m depth where they competed with the canoe fleet. The semi-industrial fleets produce about 2 per cent of the total marine catch.
The inshore fishery output by purse seine vessels from 2000-2010 is presented in table 5, where some of the caught species were round sardinella, flat sardinella, chub mackerel, scad mackerel and others. The highest fish catch was in 2003 (11,891.84 tonnes) where as the lowest was in the year 2002(4,974.3 tonnes)

Table 2 Inshore fishery output by purse seine vessels (tonnes)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Round sardinella	3177.99	3208.81	3449.14	8323.44	3585.03	2599.616	4326.38	4712.45	2888.73	7262.2	5792.79
Flat sardinella	34.97	529.79	80.91	158.34	49.33	77.687	2644.04	2320.054	128.21	273.79	565.96
Chub mackerel	3630.21	971.81	891.06	1999.56	1307.71	2023.968	1335.01	1176.626	1265.65	2088.49	1177.49
Scad mackerel	5.14	119.46	149.93	14.49	13.43	29.236	71.29	190.259	62.34	71.01	59.51
Others	368.21	381.89	403.26	1396.01	532.16	1987.79	5.49	388.38	899.84	1147.85	933.7
Sub-total	**7216.52**	**5211.76**	**4974.3**	**11891.84**	**5487.66**	**6718.297**	**8382.21**	**8787.764**	**5244.77**	**10843.34**	**8529.445**

Source: Fisheries Commission of Ghana

In the case of inshore fishery output by trawlers, the highest catch was in 2003 with 13,318.69 tonnes, whereas the lowest catch was in 2008 having 6140.25 tonnes of different fish species. The main catch consists of species like sole, cassava fish, red fishes, cuttlefish burrito and small pelagic.

Table 3 Inshore fishery output by trawlers (tonnes)

TRAWLERS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SEA BREAMS	27.47	266.29	70.8	34.48	7.162	5.89	1.5	0.148	0.1	0.49	0
CASSAVA FISH	255.03	425.76	524.48	234.43	182.18	138.6	295.09	225.03	206.9	273.46	317.03
BURRITO	0	632.08	679.38	354.76	196.32	274.08	446.61	326.741	169.05	245.09	264.98
TRIGGER FISH	0	2.23	3.02	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
RED MULLET	450.35	56.89	40.21	4.98	0.18	0.04	0	0	n.a.	n.a.	n.a.
FLYING GURNARD	0.12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
CUTTLEFISH	63.15			72.23	20.34	19.79	29.22	1.124	0.35	8.411	1.852
OTHERS	655.42	3828.39	1492.36	726	437.51	434.58	722.54	667.88	519.08	682.99	710
SUB-TOTAL	1451.54	2393.78	2810.25	1426.85	843.69	872.985	1494.96	1220.923	895.48	1204.402	1293.86
TOTAL INSHORE	**8668.06**	**7605.54**	**7784.55**	**13318.69**	**6331.35**	**7591.282**	**9877.17**	**10008.687**	**6140.25**	**12047.742**	**9823.305**

Source: Fisheries Commission of Ghana

Inland fisheries cover fish production from Lake Volta, aquaculture, dams, other lakes and lagoons. However, fishery statistics are collected only from Lake Volta and aquaculture. Stocking of water bodies by fish began in the late 1940s in connection with the construction of community water supplies in Northern Ghana. Many small water bodies have been constructed in other parts of the country for the same purpose. Apart from the north, such dug-outs were common in the Volta Region.

Stocking remains a Fisheries Commission activity in the north and also in the Volta Region; however, operations have been hindered by the lack of mobility and availability of fingerlings. The Volta Lake is the largest source of inland fish and according to Braimah (1995), it supports about 140 species of fish and provides about 85% of the inland fish catch. The total production from the two sectors reached its peak in 2000 and its lowest production was in 2002.

Table 4 Fish Production (metric tonnes)

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total inland fish production	76000	89000	88000	88000	88000	75450	79000	76630	74331
Total marine fish production	376000	333000	380000	366000	290000	331412	352405	322790	315530
Total production	**452000**	**422000**	**468000**	**454000**	**378000**	**406862**	**431405**	**399420**	**389861**

Source: Fisheries Commission of Ghana

Aquaculture is essentially not a marine activity in Ghana, and production is mainly concentrated on tilapia and catfish. The government of Ghana is implementing an Aquaculture Sector Development Plan with set production targets. Tilapia is the major species and constitutes over 80% of aquaculture production. The catfishes (Clarias sp, Heterobranchus sp) and Heterotis niloticus account for the remaining 20%. While fish production from aquaculture has been growing steadily, its contribution to the national economy has not been fully researched thus; its importance is not fully recognised.

Aquaculture Fisheries

Production from aquaculture grew 6.1% between 2000 and 2002, with a volume of 51.4 million tonnes, and value of US$60 billion. Asia accounted for 91.2% of the production volume and 82% of value, with production and volume from China representing 71% and 54.7% respectively.

Aquaculture contribution to global supplies of fish, crustaceans and molluscs has grown from 3.9% of total production by weight in 1970 to 29.9% in 2002. The aquaculture sector is the fastest growing sector that all other animal food-producing sectors, growing at an average rate of 8.9% since 1970, compared to 1.2% for capture fisheries and 2.8% for land-based farmed meat production.

The majority (57.7%) of aquaculture production for fish food is from freshwater, with 90.7% of production in 2002 coming from the developing countries. Growth has continued in all continents except for Europe, which has remained relatively static during the 2000-2002 period. China continues to have the highest growth in aquaculture in both freshwater and marine, with approximately 11% increase in both, since 1970, compared to approximately 6% in both types for the rest of the world. Production growth in other developing countries is also higher than that in the developed countries; the annual growth in the developing countries (including China) between 1970 and 2002 being 10.4%, compared with 4% for the developed countries.

The highest production from aquaculture in 2002 was in the following species groups (in order): freshwater fish, molluscs, and aquatic plants; highest value comes from freshwater fish, crustaceans, molluscs and aquatic plants. This indicates that crustaceans have the highest value/volume ratio.

The top ten species collectively accounted for 92.5% of total aquaculture production of fish, crustaceans and molluscs. These species are (by volume): carps and other cyprinids; oysters; miscellaneous marine molluscs; clams, cockles, arkshells; salmons, trouts, smelts; tilapias and other cichlids; mussels; miscellaneous marine molluscs; shrimps, prawns; scallops, pectens. The individual species with the largest production was the Pacific cupped oyster; three species of carp represented.

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Fish farming is relatively new to Ghanaian but its practice is becoming widespread in many parts of the country. Fish are cultured semi-intensively in earthen ponds either as monoculture of tilapia or polyculture of tilapia and catfish. Cage culture in ponds has recently been introduced and is being practised on one commercial fish farm. Pen culture with tilapia, recently introduced in the Keta lagoon, has been very successful.

Shrimp/prawn farming has not caught on in Ghana even though research has shown that there is a great potential for commercial farming of the local shrimp species, Penaeus notialis and P.kerathurus

The Government has taken some measures to accelerate the development of fish farming in Ghana. A crawler dozer has been acquired for the Ashanti Fish Farmers Association (FFA); to be paid for on hire purchase and a modern hatchery has been established near Kumasi to provide good quality fish fingerlings to fish farmers.

Table 5 Fish farm data (2008)

	No. of fish farmers	**No. of ponds**	**No. of functional ponds**	**Total surface area (ha)**
Ashanti	304	746	746	118.71
Brong Ahafo	333	761	761	138.63
Central	253	633	610	39.91
Eastern	107	311	311	20.35
Greater Accra	64	233	207	39.5
Volta	143	308	254	67.35
Western	1650	2550	2550	59.1
Upper East	15	25	25	7.52

Source: Fisheries Commission

FISH HARVESTING IN GHANA

Fish are harvested by commercial fishing and aquaculture. According to the Food and Agriculture Organization (FAO), the world harvest in 2005 consisted of 93.3 million tonnes captured by commercial fishing in wild fisheries, plus 48.1 million tonnes produced by fish farms. In addition, 1.3 million tons of aquatic plants (seaweed etc.) were captured in wild fisheries and 14.8 million tons were produced by aquaculture. The number of individual fish caught in the wild has been estimated at 0.97 - 2.7 trillion per year (not counting fish farms or marine invertebrate

The activities in the marine sector range from artisanal canoe operations through inshore to industrial operations. Both pelagic and demersal fishery resources are exploited. Marine fisheries in Ghana are affected by a seasonal upwelling that occurs in Ghanaian coastal waters. These are the fishing seasons in Ghanaian waters as the fish becomes more available for exploitation by the fishers during the upwelling seasons.

Fishing Seasons in Ghana

In Ghana, there exist two major marine fishing seasons in Ghana. These are the:

1. Major upwelling (Bumper) season 2. Minor upwelling (Lean) season

Major upwelling (Bumper) season

The major upwelling or bumper season lasts approximately three months in the year. During upwelling periods (December/January – February and July – September) biological activity increases in the sea that result in increased production of fish food and abundance of most marine fishers. The major upwelling season begins when the sea surface temperatures fall below 25^{0}C -17.5^{0}C.

Minor upwelling (Lean) season

The minor upwelling or lean season occurs for approximately three weeks in January or February or rarely in December or March. During the minor upwelling season, sea surface temperatures fluctuate between 27.5^{0}C -26^{0}C.

HANDLING OF FISH AFTER HARVESTING

When fish are captured or harvested for commercial purposes, they need some pre-processing so they can be delivered to the next part of the marketing chain in a fresh and undamaged condition. This means, for example, that fish caught by a fishing vessel need handling so they can be stored safely until the boat lands the fish on shore. Typical handling processes are:

- transferring the catch from the fishing gear (such as a trawl, net or fishing line) to the fishing vessel
- holding the catch before further handling
- sorting and grading
- bleeding, gutting and washing
- chilling
- storing the chilled fish
- unloading, or landing the fish when the fishing vessel returns to port

The number and order in which these operations are undertaken varies with the fish species and the type of fishing gear used to catch it, as well as how large the fishing vessel is and how long it is at sea, and the nature of the market it is supplying. Catch processing operations can be manual or automated. The equipment and procedures in modern industrial fisheries are designed to reduce the rough handling of fish, heavy manual lifting and unsuitable working positions, which might result in injuries.

The intrinsic and extrinsic qualities of fish vary considerably depending upon the location of the fishing ground, species, water quality and harvesting techniques. The primary objective of any handling method is to preserve the quality of the fish by bringing down the temperature near to $0^{0\ C}$ as quickly as possible. The factors such as delay in handling and chilling the catch, poor temperature control in the fish hold, damage from rough handling, poor standards of gutting, bleeding and washing the fish and mechanical damage due to the overfilling of the containers have a deleterious effect on the quality of fish and result in reduction of shelf life and loss of weight.

Immediately after catching, the fish start to spoil in one way or the other. However, the rate of spoilage is different depending on ambient conditions, fishing technology, fishing equipment, species of fish, catching season and handling and preservation activities (Hobbs 1982). Using low temperature with ice is a popular method for fresh fish preservation. The chilling temperature of nearly 0°C can maintain freshness quality for a long time. When the temperature decreases the bacterial, growth is slower, the reaction rate of enzymes is also decreased and the rigor mortis time can be extended. If the shelf life of some fish products stored at 0°C is known, the shelf life at different temperatures can be calculated by a certain formula. Example, if the fish can maintain quality for six days at 0°C the shelf life at 5°C will be 2.7 days or if another fish can maintain quality for 10 days at 0°C the shelf life at 15°C will be only 1.6 day.

Fish chilling should be carried out quickly and the fish raw material should not be exposed to sunshine or wind. Sunshine and wind can speed up not only autolytic and bacterial spoilage but also the oxidation process especially in fatty fish species. Fish handling and preservation can be carried out on board of the fishing vessel or on land.

The first pre-processing stages for whole fish include some stages e.g. bleeding, gutting, icing and freezing. Some fish species can be bled and gutted on board, but this work can take much time and some fish species are only primarily washed and put into boxes or tubs with ice and stored in the hold of the vessel (Kelman 1992).

There are a lot of enzymes in the fish intestine, which can be activated strongly when the fish dies. Fish intestines contain many enzymes catalysing autolysis and spoilage in fish. Fish intestines also contain many undesirable micro-organisms, which can contaminate the fish flesh. Removing intestine can eliminate these undesirable enzymes and micro-organisms. Thus, it is preferred to bleed and gut the fish, before chilling and storing. However, after gutting the inside of the belly area is exposed to air, which can lead to oxidation and discolouration of the fish. Therefore, some fat fish species are not always gutted before chilling especially the small sized fish, as gutting them takes too long time. For the lean fish species, gutting is usually carried out because this can retain the quality for extended time periods. The chilled sea water (CSW) that includes ice and seawater can chill the fish raw material very fast.

However if the fish is kept in water for a long time some colour pigments from the skin as well as some soluble and nutrition substances can be released and loaded into the environment. Using CSW can also create sensory changes in the fish e.g. higher salt content after chilling and storing. The chilled water (CW) is also often used for chilling fish and this does not affect to the fish salt degree (Huss 1994). Different types of ice can be used for chilling fish like liquid ice, flake- ice, tube ice, and block ice. Block ice should be grinded before use. Liquid ice has the highest cooling rate, the second is flake ice but grinded block ice is the slowest. Liquid ice has uniform particle size and large surface squares which means better heat transfer. Following Huss (1994), the crushed block ice and the tube ice is suitable for the chilled sea water (CSW) system. The rate of chilling is important. For some big fish species (e.g. ocean tuna) chilling is carried out by gutting and putting ice into the belly of fish to increase the chilling rate.

Many literatures have spelt out some steps involved in handling of fish after harvesting. In Vietnam, for example the following processes are involved in the handling of fish after harvesting.

Boarding

Tackles are used for transferring the catch from the gear to vessel or hauling in the trawl. Then the net bottom is opened and the fish can fall down into a steel container below.

Holding

This stage is carried out especially when the volume of fish caught is quite big. The fish is put into a tank with chilled seawater (CSW) that includes ice and seawater slurry or refrigerated seawater (RSW). This stage is very important because it lowers the fish temperature rapidly and limits the activities of enzymes and bacteria. Depending on conditions, the sorting stage can be carried out after or right before this stage. The fish can be boarded by the tackle or using the pump to transfer the fish into the tank with CSW or RSW. This work is carried out by machine in order to save time and worker labour. The suitable tools can be used for transferring fish into the tank with care to avoid mechanical damage. In Iceland, this work is carried out very fast. The fish is poured from the net into the big hold and then the fish is transferred by conveyer to the sorting stage

Sorting

The fish is sorted quickly by hand parallel to the processing stage. This work is carried out below the deck with a conveyor belt. The by-catch is sold in an auction market on shore.

Bleeding and gutting

In order to the make the fish fillet maintain a good appearance, the fish has to be bled. Blood stains are regarded as defects, as the fillet should be white. Gutting removes the fish intestines limiting access of most spoilage bacteria. However, for small fish like pelagic species, the bleeding and gutting stage is not carried out. However, for some lean fish, gutting always is carried out. Then the CSW system is used to decrease fish temperature quickly.

Washing

After bleeding and gutting the fish is transferred to the washing stage. This stage cleans blood and viscera residues. The washing stage is carried out in a tub with ice and seawater. It is carried out quickly in order to avoid losing the nutrition substances.

Chilling

The fish is cooled down by liquid ice, therefore the fish temperature decreases very fast. This stage is short, about 30 minutes. The liquid ice has a lot of advantages to flake ice including high regular size, larger square surface and the ability to fill the entire tub/box and cover the fish. The disadvantage of liquid ice affects the taste of the fish a little bit because it is made by sea water it can make the fish salted. The liquid ice is also relatively expensive.

Storing

The fish is iced and arranged in layers in insulated tubs with tube ice for storing. The tubs are stacked in the hold and are easy to lift by crane when landing. A label is attached to each tub for traceability at further stages of the process.

POST HARVESTING PROCESSING OF FISH

There are large variations across countries and regions of the world in the amount of total fish supply for human consumption, reflecting different eating habits and traditions, availability of fish and other foods, prices, socio-economic levels, and seasons. Of the 107 million tonnes available for human consumption in 2005, consumption was lowest in Africa (7.6 million tonnes, with 8.3 kg per capita), while Asia accounted for two-thirds of total consumption, of which 36.9 million tonnes were consumed outside China (13.9kg per capita), with 33.6 million tonnes in China alone (26.1 kg per capita). The corresponding per capita consumption figures for Oceania, North America, Europe, Central America and the Caribbean, and South America were 24.5, 24.1, 20.8, 9.5 and 8.4 kg, respectively. (FAO Fisheries, 2014)

Fish caught from the ocean needs to be processed promptly because of enzymatic and microbial processes which deteriorate the quality of the dead fish. Fish begins to spoil within 12-20 hours after being caught and brings unpleasant taste, smell and texture depending upon the size and type of the fish species, reducing consumer acceptability for that particular fish species, and if the fish is not eaten fresh as soon as it is caught, it needs to be processed for future use or store frozen to help prevent post-harvest losses (Obodai et al., 2009).

The term fish processing refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer. Although the term refers specifically to fish, in practice it is extended to cover any aquatic organisms harvested for commercial purposes, whether caught in wild fisheries or harvested from aquaculture or fish farming.

Larger fish processing companies often operate their own fishing fleets or farming operations. The products of the fish industry are usually sold to grocery chains or to intermediaries. Fish are highly perishable. A central concern of fish processing is to prevent fish from deteriorating, and this remains an underlying concern during other processing operations.

Fish processing can be subdivided into fish handling, which is the preliminary processing of raw fish, and the manufacture of fish products. Another natural subdivision is into primary processing involved in the filleting and freezing of fresh fish for onward distribution to fresh fish retail and catering outlets, and the secondary processing that produces chilled, frozen and canned products for the retail and catering trades.

Fish is an extremely perishable food. For example, most fish become inedible within twelve hours at tropical temperatures. Spoilage begins as soon as the fish dies, and processing should therefore be done quickly to prevent the growth of spoilage bacteria. Fish is a low acid food and is therefore very susceptible to the growth of food poisoning bacteria. This is another reason why it should be processed quickly. Some methods of preservation cause changes to the flavour and texture of the fish which result in a range of different products. These include:

Cooking (for example, boiling or frying)
Lowering the moisture content (by salting, smoking and drying collectively known as curing)
Lowering the pH (by fermentation)

Lowering the temperature with the use of ice or refrigeration also preserves the fish, but causes no noticeable changes to the texture and flavour

The principal fish processing methods in Africa are smoking, salting, sun drying, and fermentation, grilling and frying. The predominant type of fishery product in any particular country is, however, closely related to the food habits and purchasing power of the population. Specific types of fishery products are best suited as the local staple food. Furthermore, due to the lack of a good transport infrastructure for the transportation of fresh fish to remote towns and villages, cured fish is the most convenient form in which fish can be sent to such areas. . Many consumers in Africa prefer fish in the fresh state, however, a considerable proportion of the landed catch is preserved by artisanal methods.

In West Africa, hot smoking is the main method of fish processing. However, salting, fermentation and sun-drying are also important fish processing methods. It is estimated that nearly 70 percent of the total fish supply in West Africa is marketed in the smoked or dried form. In the Sudan, on the other hand, nearly 70 percent of the total fish landings is consumed fresh; the rest is cured either by salting, fermentation or sun-drying. Very little of the local fish supply is smoked, except in southern Sudan where smoked and very dry fermented fishery products are very popular among the local community.

Several methods could be used to process fish. In Ghana and the African continent in general, fish is processed mainly for the following reasons:

- To prolong its shelf life,
- To improve taste, i.e. to enhance flavour and increase utilisation in soups and sauces,
- To increase income, i.e. to reduce waste in times of bumper catches and to store against the lean season,
- Better nutrition, i.e. to increase protein availability to all people throughout the year,
- Improved marketing, i.e. to make it easier to pack, transport and market.

Fish Smoking in Ghana and Internationally

According to Brownell et al., (1983), among the numerous reasons why fish is smoked include; to increase the shelf life of the fish; to enhance the flavour of the fish in soups and sauces; to reduce waste in times of abundant harvest; to preserve the fish for future use; to increase the protein intake among the people; and to make packaging easy for transportation to urban market centres.

According to Sirra, (2000) one of the methods for fish processing is the application of smoke during fish smoking. There are chemicals in fuel wood, which improves flavour, increases the utilization of the fish and promotes its shelf life; then again, the fuel wood used in smoking creates heat and fire, which dries the fish.

Smoked fish processing is the main economic activity for the people living in and around the coastal areas and also along the river banks of Ghana. The main employment for these people is to process and preserve the fish for marketing. The smoked fish business is dominated by women whose economic activities in the fish processing sector has become more important considering the low levels of income of many women in Ghana (Koranteng, 1993).

The smoked fish sector has also become an alternative means of employment for the girls who could not enrolled in formal education, or learn a trade, these girls and many others enter into the smoked fish sector either to assist parents or husbands, or for their own upkeep (Brownell et al.,1983).

Internationally, the most common types of smoked fish in the US are salmon, mackerel, whitefish and trout, although other smoked fish is also available regionally or from many ethnic stores. Salmon, mackerel and herring are universally available both hot-smoked and cold-smoked, while most other fish is traditionally preserved by only one of the smoking methods.

Fish can either be cold or hot smoked. Only salmon, tuna, and sable are permitted by law to be cold smoked. All other fish, including whitefish, trout, whiting, mackerel, bluefish, sturgeon, marlin, chubs, ciscoes, and wahoo are hot smoked. Salmon and tuna are also hot smoked. Cold smoking is a drying and smoking process where the heat does not exceed 85°F and the whole process takes up to 20 hours. Hot smoking is a cooking and drying process where the fish must reach at least 145°F or above for at least 30 minutes.

A common name for cold-smoked salmon is *lox*, of which many different types are available, usually identified by point of origin (e.g., from Scotland, Norway, Holland, the Pacific, and Nova Scotia, Canada—the latter usually identified as *Nova lox* or just *Nova*). Traditionally, *lox* designates brined rather than smoked salmon, but the linguistic boundary between the two types of products has become blurred. *Gravad lax* or gravlax remains the only type that is unmistakably *not* smoked fish. However, commercial labels still identify most smoked products as "smoked salmon" rather than "lox".

Most other smoked fish in the US is hot-smoked, although cold-smoked mackerel is always available in East-European delis, along with cold-smoked sturgeon, sea bass, halibut or turbot and many other varieties. Jewish delis often sell, in addition to lox, hot-smoked whitefish, mackerel, trout, and sablefish (also sometimes referred to as black cod in its fresh state). Along the Mississippi River, hot-smoked locally caught sturgeon is also available. Traditionally, in the US, cold-smoked fish, other than salmon, is considered "raw" and thus unsafe to consume without cooking. For this reason, in the US, cold-smoked fish is largely confined to specialty and ethnic shops.

In the Netherlands, commonly available varieties include both hot- and cold-smoked mackerel, herring and Baltic sprats. Hot-smoked eel is a specialty in the Northern provinces, but is a popular deli item throughout the country.

Smoked fish is a prominent item in Russian cuisine, Ashkenazi Jewish Cuisine, and Scandinavian cuisine, as well as several Eastern and Central European cuisines and the Pacific Northwest cuisine.

English, Scottish, and Canadian cuisine incorporate a variety of strongly brined, smoked herring that used to be known as "red herring". With the increased use of the idiomatic expression "red herring", references to the smoked fish product in this manner declined. A more common contemporary name for it is kippers, or kippered herring. Kippered herring traditionally undergoes further processing (soaking and cooking) before consumption. Arbroath Smokies (haddock) and Traditional Grimsby smoked fish (haddock and cod) have both received Protected Geographical Indication status from the European Commission, which restricts use of the name to fish that is processed using specific methods within a defined geographical area.

- Preparation of fish for smoking

Except for larger fishes such as grouper, tuna, and snapper, the gills guts and scales are normally not removed before smoking. The larger fishes are normally cut into steaks or fillets but medium and small fish are smoked whole. The fishes are washed in clean fresh or salt water and carefully arranged on trays. Sometimes they are left for about an hour to dry in the sun before smoking. The trays are filled with fish and then stacked on top of each other in the chamber of the oven.

Plate 1 Cleaning of fish for smoking

Plate 2 Laying of fish on trays for smoking

- Fish smoking process

The smoking process can take between one hour to two days depending on factors such as the type of fish (species, thickness, the way it is cut), the purpose for its use and the length of time it would be stored. The fish are turned and the orientations of the trays changed two to four times during smoking cycle. The upper trays are placed closer to the fire while the lower ones are moved higher. Sometimes the trays are turned 180^{0} on the oven.

Any kind of fish can be smoked. There are three main methods of smoking:

(a) Smoking and roasting;
(b) Hot smoking;
(c) Long smoking.

(a) Smoking and Roasting

This is a simple method of preservation, for consumption either directly after curing or within twelve hours. Re-smoking and roasting can keep the product in good condition for a further twelve hours. Fresh unsalted fish is put over a wood or coconut husk fire. This should be kept very small and the fish turned over every five minutes. In about half an hour the fish is ready for consumption or, if it is the intention to keep it for a while, it should be put in an aerated container.

Fish can be preserved in this way even in open fishing boats, but the smoking has to be done in a tin or a half-drum.

Salted fish can also be smoked by this method, but this is used mostly for immediate consumption or in order to bring the produce in smoked form to a nearby market.

(b) Hot Smoking

The hot smoking system can be used for immediate consumption or to keep the fish for a maximum of 48 hours. Small fish can be salted first for half an hour. After salting, they are put on iron spits and dried in a windy place or in the sun for another half hour.

Several smoking kilns can be used for hot smoking including the oil drum. With an oil drum kiln, the top of the drum is cut out and holes are made 8 inches below the rim to place spits.

Near the bottom, a rectangular opening is made to control the fire. This opening should be closed with a small door or piece of steel plate. A fire of hardwood or coconut husks is made in the stove, and once it is well started it is regulated so as to give no flames. The fish are then placed over the spits. During the smoking operations the top of the drum must be covered with a sack or with palm fronds laid as close together as possible; the fire control opening should also be closed. The fire must be watched from time to time. The fish will be ready in about one hour. An indication that they are done will be found in the golden yellow colour of the skin. For big fish, l to 2 feet long, the best method is to split them in halves, to the right and left of the backbone. Each half fish is fixed between two flat bamboo slats or sticks. These halves are then rested head down on racks built four feet above ground. A number of split fish can be lined up next to each other. A fire of hardwood or coconut husks, or several separate fires, is then lit under the rack. The number of fires depends on the quantity of fish one has to smoke. There should be a slow fire for about half an hour followed by a brisk one for one hour. A small fire is then kept going for six hours (just smoking).

After this treatment, the fish is ready for transport and will keep in good condition for two to three days under tropical conditions. This method is used in particular in the Celebes for skipjack and other tunas.

(c) Long Smoking

If fish must be kept in good condition for a long time, for instance, two or three months or even longer, it can be done by smoking, provided the fish is not oily. For this purpose, a small closed shed made of palm leaves or other local material can be used. The dimensions of the shed depend, of course, on the quantities of fish to be smoked, but the height should in no case be less than six feet. In this shed, racks are built to hang the fish from or to lay them upon. Hanging the fish on spits is the best method, but they can also be laid on loosely-woven matting. One can start hanging fish three feet from the bottom up to the roof.

The preservation of fish is effected by smoke only in this method, and it is best to use coconut husks which should burn very slowly so that the fish is dry smoked after 48 hours. After such a treatment, the flesh is dried throughout.

If it is necessary to transport these fish to other islands, they should be packed in small packages wrapped in dry leaves and reinforced with bamboo or sticks.

Table 6 Forms of smoked fish processing available in the Nzema East district of Ghana (Anon., 2007)

Types of Processes	**Shelf life**	**Duration in smoked**	**Moisture content (%)**
Wet hot smoked	About 3 days	About 2 hours	40-50%
Dry hot smoked	About 9 month	About 18 hours	10 – 15%

Table 7: The three stages of smoked fish processing (Anon., 2007)

1st Stage: The cooking stage	**2nd Stage:** The drying stage	**3rd Stage:** The Smoking stage
The fish is cooked at a temperature of 63°C. Here enough heat is produced to cook the fish for preservation and makes it safe for consumption.	Here the fire produces heat that is enough to dry the fish at this stage of smoked fish processing.	The fuel wood used in smoking the fish produces a smoke which has a number of compounds that kill the bacteria on the fish. The smoke also builds the colour of the fish which starts developing between the temperatures of 54.4ºC and 60ºC The fuel wood also helps to preserve the fish by giving it a longer shelf life.

According to Jong et al., (1992) to avoid the growth of food poisoning bacteria, smoked fish must not be consumed immediately it is smoked but rather, allow the heat to settle at the temperature of 2ºC and this temperature must constantly be maintained until the fish is finally consumed. In the Nzema East District, the smoked fish is immediately packed for marketing the moment it is brought off from the fire because of lack of humidity in the storage facility, and also the level of smoke could reduce the moisture content of the fish to lower the possible growth of fungal. The hot smoked fish are often sent to the market in ventilated baskets which have been pre-packaged in brown paper because according to the smoked fish processors in the study area, brown papers do not easily generate heat nor pose a health risk.

Plate 3 Smoked fish ready for eating in Ghana

Plate 4 Mechanized smoked fish in a developed country

Plate 5 A smoking fish site in a developed country

Fish Salting in Ghana and Internationally

Salting is the preservation of food with dry edible salt. It is related to pickling (preparing food with brine, i.e. salty water), and is one of the oldest methods of preserving food. Salt inhibits the growth of microorganisms by drawing water out of microbial cells through osmosis. Concentrations of salt up to 20% are required to kill most species of unwanted bacteria. Salting is used because most bacteria, fungi and other potentially pathogenic organisms cannot survive in a highly salty environment, due to the hypertonic nature of salt. Any living cell in such an environment will become dehydrated through osmosis and die or become temporarily inactivated. The absorption of salt during fish curing results in the removal of water from the flesh to a level that impedes microbial growth and enzymatic activities. When high levels of salt are used in fish fermentation, the primary objective is to select the halophilic micro-organisms which will affect a controlled degradative process on the organic compounds in the fish muscle to bring out the desired flavours in the product.

In the coastal countries of Côte d'Ivoire, the Gambia, Ghana and Senegal, where solar salt produced by the natural evaporation of seawater is readily available and inexpensive, fermented fish is heavily salted.

The use of salt in fish processing may either be by dry salting (krenching) or wet salting. In dry salting, the granular salt is applied directly to the fish either in the gills, on the surface or, in the case of split fish, in the belly. The exudate from the fish may be allowed to drain away or be retained. In the latter case, the fish becomes immersed in the exudate and this is often referred to as "pickling".

In wet salting, the fish is immersed in brine for up to two days or dipped for a few hours. It was observed that some processors who cure fish with brine sometimes reuse the salt solution a number of times. This may be a potential source of bacterial contamination to fresh batches of fish

The water activity, a_w, in a fish is defined as the ratio of the water vapors pressure in the flesh of the fish to the vapor pressure of pure water at the same temperature and pressure. It ranges between 0 and 1, and is a parameter that measures how available the water is in the flesh of the fish. Available water is necessary for the microbial and enzymatic reactions involved in spoilage. Traditionally, techniques such as drying, salting and smoking have been used, and have been used for thousands of years. In more recent times, freeze-drying, water binding humectants, and fully automated equipment with temperature and humidity control have been added. Often a combination of these techniques is used.

After gutting and washing the fish is iced and kept in chilled store at sea and on shore to preserve raw material quality. In processing, it is washed, headed, split or filleted, trimmed and brined in large plastic tubs. After 1-2 days the split fish or fillets are dry-salted into large clean plastic tubs by arranging the fish in layers with ample salt in between. Only clean salt of food-grade quality is used.

Fish is left in the tubs for 8 to 14 days at controlled temperature for salt curing. At the end of this period it is fully and evenly salted (18 -20% salt) and some of its proteins have denatured, giving the fish a white, opaque appearance. Salt fish is termed 'tender cure' at this stage. Processing may also be continued for a few days at controlled temperature and sometimes salt fish is stacked to give a stronger tasting and a little drier product, in line with the older tradition. Each salt fish is graded by quality, including size, and packed according to customer specifications. Split salt fish is often dried further in the marketing countries and to a small extent also in Iceland.

Most food poisoning bacteria cannot live in salty conditions and a concentration of 6-10 per cent salt in the fish tissue will prevent their activity. The product is preserved by salting and will have a longer shelf-life. However, a group of micro-organisms known as 'halophilic bacteria' are salt-loving and will spoil the salted fish even at a concentration of 6-10 per cent. Further removal of the water by drying is needed to inhibit these bacteria.

During salting or brining two processes, take place simultaneously:

- Water moves from the fish into the solution outside
- Salt moves from the solution outside into the flesh of the fish.

Salting requires minimal equipment, but the method used is important. Salt can be applied in many different ways. Traditional methods involve rubbing salt into the flesh of the fish or making alternate layers of fish and salt (recommended levels of salt usage are 30-40 per cent of the prepared weight of the fish). There is often the problem, however, that the concentration of salt in the flesh is not sufficient to preserve the fish, as it has not been uniformly applied. A better technique is brining. This involves immersing the fish into a pre-prepared solution of salt (36 per cent salt). The advantage is that the salt concentration can be more easily controlled, and salt penetration is more uniform. Brining is usually used in conjunction with drying.

Ultimately, the effectiveness of salting for preservation depends upon:

- Uniform salt concentration in the fish flesh
- Concentration of salt, and time taken for salting
- Whether or not salting is combined with other preservation methods such as drying

Many different kinds of salt, some being better than others are used for fish curing. However, in islands or in outlying places there is often no choice, and whatever is available in the way of salt has to be used, whether it is bought in a shop, prepared on the spot, or extracted from earth containing salt.

A distinction must be made between the two chief techniques of salting: wet salting and dry salting.

Wet Salting:

This is the cheaper, since it requires lesser amounts of salt. The principle is to keep the fish for a long time in brine. The equipment needed consists of a watertight container, which can be a tin, drum, canoe, barrel, etc. To make the brine, one takes four parts of clean water (sea or fresh water) and one part of salt. If the salt is coarse, it has to be ground or pounded first. It is then dissolved into the water by stirring with a piece of wood. To be good, the brine must float a fish.

The next step depends on what kind of fish one wants to salt. It is best first to cut off the head and gut and clean the fish, though small fish can also be salted whole. Large fish must be cut open, and it is preferable to take out the backbone. Fish with a heavy armour of scales must be scaled. In places where the flesh is thick, slashes must be made so that the salted brine can penetrate the flesh. Very large fish should be cut in thin fillets.

After the fish has been prepared according to its size, it must be cleaned and put in the brine. A plank or matting is laid over it and weighted with rocks so that the fish is entirely covered with brine.

This salted fish can be kept for a long time in a dark or at least a shady place.

The remaining brine can be used three times, but water and salt must be added every time until a fish can again float on the liquid. In any case, fresh brine is always best.

Dry Salting:

In this method the fish is salted but the juices, slime and brine are allowed to flow away. Dry salting can be done in an old canoe, or on mats, leaves, boxes, etc. In any case, the brine formed by the fish juices and the salt must be allowed to run away. For two parts of fish, one needs one part of salt.

Layers of fish must be separated by layers of salt. It is a valuable method when one has no containers. This method is used to salt down flying fish in open fishing boats while at sea, and the fish in this case are kept whole.

Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in fresh water before use.

Plate 6 Fish in a salt crust

Plate 7 Fish being salted, Maura Angke, Jakarta, Indonesia.

Plate 8 Salted dried fish sold on a Hong Kong street

Fish Drying in Ghana and Internationally

Sun drying is an important step in the traditional method of fish processing in many African countries. With the exception of Fessiekh, Mindeshi and Terkeen in the Sudan, as well as certain types of wet fermented fish in Ghana, most fermented fishery products in Africa are sundried to reduce the water activity and therefore slow down or stop the growth of the micro-organisms responsible for fermentation or spoilage. Drying is normally combined with salting to reduce the moisture content sufficiently to ensure a longer shelf-life. Products with high moisture content (above 35 percent) are susceptible to attack by blowflies especially if the salt level in the product is low. This results in the development of maggots in some fermented fishery products during storage. At low moisture content (below 15 percent), the product is brittle and prone to fragmentation and attack by insects such as dermestes

The heat of the sun and movement of air remove moisture that causes the fish to dry. In order to prevent spoilage, the moisture content needs to be reduced to 25 per cent or less. The percentage will depend on the oiliness of the fish and whether it has been salted.

Traditionally, whole small fish or split large fish are spread in the sun on the ground, or on mats, nets, roofs, or on raised racks. Sun-Drying does not allow very much control over drying times, and it also exposes the fish to attack by insects or vermin and allows contamination by sand and dirt. Such techniques are totally dependent upon the weather conditions. The ideal is dry weather with low humidity and clear skies.

A lot of research has been conducted on other forms of drying for improved results. One of these improved methods of drying is the use of solar driers which may be any of the following: solar tent drier, solar cabinet drier, solar dome drier and solar drier with a separate collecting and drying chamber.

These driers have been found to be efficient by achieving higher drying temperatures and reduced humidities. They also increase drying rates, producing lower moisture content in the final product and highly improved quality. It is possible to attain temperatures as high as 45°C inside solar driers and it has been suggested that this relatively high temperature offers some protection against attack by blowflies, beetles and other vermin. Additionally, solar driers also offer some protection against adverse weather conditions, for instance wet seasons.

Although solar driers have been successful at the experimental level, artisanal fish processors have not found them useful because of the large capital investment required for their construction. Other constraints have been the lack of robustness in most solar driers, the fairly low capacity and the technology needed for their construction which often makes them unattractive to artisanal fish processors. Furthermore, some processors have found the quality of products from solar driers different to that of traditional driers and often unacceptable to consumers.

For some time to come, these improved driers will not be favoured by the artisanal fish processors in developing countries due to the constraints mentioned above

Alternatives to Sun-Drying involve the use of solar or artificial dryers. There has been a great deal of research on the development of solar dryers as an improved method of drying fish. This has shown that by achieving increased drying temperatures and reduced humidities, solar dryers can increase drying rates and produce a lower moisture content in the final products, with improvements in fish quality compared with the traditional sun-drying techniques

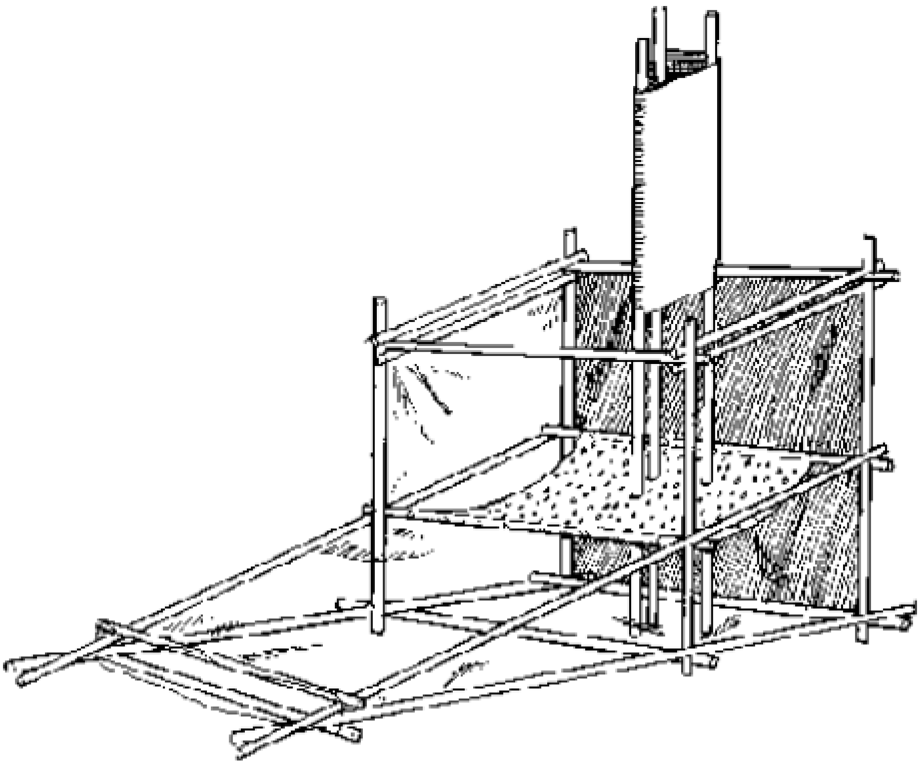

Figure 6 illustrates a solar tent dryer. This was first developed in Bangladesh, but there are now numerous variations in different parts of the world. It is probably one of the simplest designs.

Very small and thin fish can be dried straight away in the sun if they are brought in early enough in the morning. If these conditions are not fulfilled the fish must be put for one night in brine, or dry salted. They can then be dried the next morning. If it happens to be raining the next day, it is necessary to wait until the weather has cleared up, which could take from a few hours to a couple of days. In this latter case it will be necessary to wash the salt away from the fish by soaking it in fresh or sea water for a couple of hours before drying it; this depends again on the tastes of the consumers and on the purpose for which the fish is cured.

Small fish are mostly sun dried on mats, or suspended. When it rains the fish must be kept dry by covering or transferring them under shelter. If fishes are laid on mats or other material to dry, it is best to turn them over every two hours so that they will dry quickly and not becomes maggoty. In the case of large fish, hanging is better if they are merely split.

Dry salted fish can also be dried, but they should first be cleaned in water.

Normally the fish will be dried after three days. If a great quantity of fish has been dried and is to be kept for some time, the best way is to pile it up in a dark place, off the ground and preferably on wooden boards. It should then be covered with a sack or mat.

After a fortnight the fish should again be laid in the sun for one or two hours and then put away as before

These are only indications of the main principles of fish drying; variations are possible.

- Salted Sun Drying

The salted sun-dried fish preservation business has the potential of creating jobs, improve food security, create incomes and enhance nutrition during the lean fishing season, if the processing technology is improved (Abila, 1997).

Salted sun-dried fish preservation suffers severe post-harvest losses during the rainy seasons. Another eminent post-harvest loss is the numerous spoilage of the product due to fat and protein degradation from hydrolysis and proteolysis, making the whole product low quality with poor marketing (Dampha et al., 1995).

Table 8 Stages of salted sun-dried fish processing (Bille et al., 2006)

Stages	Methods	Details
1.	Chilling	Fish are preserved immediately after being caught from the ocean at -4°C before the process of salted sun-dried begins.
2.	Preparation	Fish are washed to clear of dirt and other unwanted materials on the fresh fish.
3.	Brining	Fish is soaked in about 2% salt water solutions for 15 minutes of more.
4.	Dripping	Fish are taken out from brining but put in a basket to allow the salt solution to drip out.

5.	Drying	Fish are spread on either coconut/palm branches or raffia/rubber mat for racking in the sun for several days.
6.	Storing	Fish are taken from being dried in the sun for several days and kept in the store house.
7.	Packaging	Fish are being packed in the baskets for sales at the salt sun-drier fish market.

The way in which the salted sun-dried fish is dried anywhere in the sun including the beaches, rocks, grass, or sand during the preservation processes contributes in making the salted sun-dried fish harmful for human consumption with lots of dirt and strange materials not meant for human consumption Anon.,(1998). Another reason why many fish processors do not undertake salted sun-dried fish processing is as a result of the seven stages painstaking processing methods as described in the above.

Plate 9 Fish drying processing on a rack

Fermentation of Fish Processing in Ghana and Internationally

African countries require food processing technologies that will meet the challenges of peculiar food security problems in the continent. Such technologies should be low-cost to be affordable by the poor sectors of the community and should be able to address the problems of food spoilage and food borne diseases, which are prevalent in the continent. Fermentation is one of the important food processing technologies that meet these challenges. According to Parkouda et al fermentation is generally carried out to bring diversity into the kind of foods and beverage available; make otherwise inedible foods products edible; enhance the nutritional value; decrease toxicity; preserve food; decrease cooking time and energy requirements.

The fermentation methods are indigenous to African cultures and have been used in many of these countries for centuries. Of course, these methods were artisanal in nature and obviously developed at home and improvements were based on the observations of actors. The activities are carried out mostly by illiterate women as the major actors; in general, there is little interest in knowing the role of microorganisms and the physical and chemical changes that occur in the products. What is recognized are changes in colour, odour and taste that result from modifications of the process or variation in ingredients. Among the various fermented food processed in Africa, the fermented fish products are one of the oldest and most widespread used as condiments or main sources of protein of animal origin throughout the world.

According to Beddows, salted, fermented and sun dried fish is generally known as “fermented fish” since the processing methods usually involved salting, fermentation and drying. This combination of such processes is needed in tropical regions mainly because of climate and the extreme perishability of fresh fish. Indeed, a key factor limiting fish utilization is its extreme perishability due especially to bacterial and autolytic spoilage, which usually occurs at the same time, after the death, during processing and sometimes during storage, and both contribute to normal spoilage processes.

As reported by Adams et al, fish flesh offers to micro-organisms conditions of good nutrient availability coupled with a moderate pH and high water activity. In tropical regions, these conditions coupled with a high ambient temperature and unsanitary conditions cause fish spoilage within 12 hours. The fermentation was also found to be an important method for fish preservation particularly because poor quality fish or unpopular species of fish are usually processed in this way. For this reason, fermentation helps to salvage fish, which would otherwise have been thrown away. Campbell-Platt defines fermented foods as foods, which have been subjected to the action of micro-organisms so that desirable biochemical changes cause significant modification of the food. In tropical regions, the ambient conditions (high temperature, high humidity) provide ideal conditions for fermentation. Left alone, most foodstuffs will ferment naturally, some with desirable results and others with less desirable and even poisonous end-products. In this respect, the traditional fermentation of fish is qualified as natural or spontaneous fermentation.

According to Gram and Huss, the fermentation of fish is brought about by autolytic enzymes from fish and microorganisms in the presence of salt. Various workers have reported the use of salt in fresh fish preservation as selective microbial agent. Fermentation is also a low cost method of fish preservation using artisanal equipment, which is readily available, easy to fabricate and repair. Therefore, processors do not need a large capital outlay to start operations. Rudimentary equipment such as basket, old barrels, earthenware pots, old nets, locally made drying racks, mats, sack jute/ poly sacks and cans are the major items used. Generally, these items are locally available and affordable. Consequently, a large number of people are engaged in fish processing by fermentation because of a ready domestic market and high demand for such product mainly at national and sub-regional levels, and sometimes at international level; therefore, there is a flourishing export potential. With the exception of fisher men who provided fresh fish to processors, in most West Africa countries, females are the sole actors involved in the processing and the commercialization of fermented fish products. However, in Central African countries such as Chad and Sudan, the processors are also males. For most of processors, this activity constitutes their main source of income. According to Essuman more income is derived from fish fermentation than from smoking or drying in most African countries. This means that there is a potential for higher market value for superior quality fermented fish products. A higher market value for superior quality fermented fish products will improve the economic situation of the processors who adopt improved technologies for fermented fish processing; in addition, the public will consume a healthy product**.** The present review examines the traditional processing methods in use in different regions of Africa and the quality of various products in both microbiological and physicochemical aspects as well. The constraints limiting the promotion of fermented fish products in Africa were also raised.

Fish Fermentation Processing Methods

In most African countries, the traditional fermentation of fish is carried out in artisanal way and the processing methods seem to be the same from one country to another with however a slight variants. Three basic methods were identified for fish fermentation in Africa: fermentation with salting and drying, fermentation with drying without salting and fermentation with salting but without drying. The fermented fish products in Africa are habitually whole or cut in pieces, and are not a paste or sauce like in Southeast Asian countries. Different local names are attributed to fermented fish products such as Lanhouin in Benin and in Togo, Momone, Koobi, Kako and Ewule in Ghana, Guedj in Gambia, Tambadiang, Yet and Guedj in in Uganda, Gyagawere, Adjonfa and Adjuevan in Ivory Coast, and Salanga in Chad. The endogenous knowledge on processing methods of some major fermented fish products including Lanhouin, Momone, Guedj, and other are discussed in the following sections; Senegal, Djege and Jalan in Mali, Fessiekh, Kejeick, Terkeen and Mindeshi in Sudan, Dagaa

Fish Fermentation Processing in Ghana

The Momone is a Lanhouin-like fermented fish product from Ghana. It is also widely used for its flavor enhancing properties. The processing of Momone is similar to Lanhouin one (figure-1**a**); it is usually carried out to salvage large quantities of fish which would otherwise have been discarded due to poor quality. The main species of fish used to process Momone include: catfish, barracuda, sea bream, threadfin (*Galeoides decadactylus*), Cassava croaker (*Pseudotolithus senegalensis*) barracuda (*Sphyraena* spp), jack mackerel (*Caranx hippos*), Scad mackerel (*Caranx rhoneus*) and kingfish/Spanish mackerel (*Scomberomorus tritor*). For Momone processing, the whole fish may be used or cut into smaller pieces or split dorsally.

The dressed fish is thoroughly washed and left overnight before salting or salted immediately after washing and allowed to ferment for 3 to 8 days after which the fish is dried on the ground, grass, nets, stones or raised platforms for 1 to 3 days. The salt ratio generally used range between 15-40 % by fish weight. A second salting with ¾ of salt weight used in the first salting is applied when the fermentation is proceeded more than three days. Other Ghanaian fermented fish products such as Koobi and Ewurefua are different from Momone by the duration of fermentation, which is 2 to 3 days for Koobi. In addition, the main fish used to process Koobi is *Tilapia*. ‘Ewurefua’ is a product obtained from the fermentation of fish in tanks containing saturated brine from previous salting; the duration of fermentation varied from 12 to 24 hours but this method can lead to cross contamination of the product due to the reuse of brine.

Fish Fermentation Process in Senegal and Gambia

Guedj is a Senegalese and Gambian traditional fermented fish product, used as flavoring agent and very appreciated by the local populations because of its exceptional flavor and taste. For Guedj processing, the raw fish is often dressed, salted and allowed to ferment for about 2 to 3 days, followed by the drying step during which, the salted and fermented fish is put on raised platforms for about 3 to 5 days. In another procedure, the raw fish is left overnight to ferment before salting for 12-24 hours and drying.

Canning processing of fish internationally

Canning is a modern technological advancement in food processing. Canning improves shelf life enabling storage of the canned product for several years. The canning process involves hermetically sealing the product in a container, heat sterilizing the sealed product and cooling to room temperature for storage (Emokpae, 1979).

Fish may be easily damaged during handling. Therefore, most operations involving handling in the canning industry, such as filing of containers are manually carried out. Certain services like the addition of brine; edible oil and sauces are metered into containers mechanically. The usual pre-canning operations include heading, gutting, cleaning and cutting to sizes, addition of oils, sauces salt or brine, and cooling. The pre-canning operations ensure that the fish are easier to handle once the products are less fragile. Excess moisture are removed from the fish during the processing operations. The removal of excess water ensures that shrinkage due to water exuding from the fish is reduced inside the can during the final heat treatment stage. This may be the factor responsible for the tight packing given to sardines in cans (Eyo, 1999). During canning process, heat is normally transferred through the fish by conduction. This is a very slow process, which could result in uneven cooking of the fish. Using heat transfer by convection, shorter time is required to heat the can and produce even cooling of the fish. This is achieved by surrounding the can in fluid. Heat transfer involves the use of rotary retort. The movement of the headspace bubble during rotation forces an increase in the liquid movement within the can. This consequently causes an increase in convection heat transfer. Even cooking of the product within the can is assured. The headspace also allows for the expansion of the content during heating. An ideal headspace is achieved by sealing can under pressure. If air is present in the headspace, oxidation of the content may occur. The lid is attached in two double seaming operations using solder and a plastic sealing compound on the inside of can. The operation using the rotator retort is referred to as heat sterilization (Ito, 2005).

The application of heat sterilization calls for an understanding of the effect of heat on fish tissue. The fish to be canned must be in the prime condition. It must be free from any form of spoilage. During heat treatment, water exudes from the fish. This may cause problem in non-fatty fish. If the fish is fatty or oily, the oil may act as physical barrier to water exuding from the fish. The latter enable canned oily fish retain their succulence through heat process. The heat treatment given to canned food is generally that, which gives complete protection from spoilage organisms (Okonta and Ekelemu, 2005).

Fish spoilage, particularly canned fish have to be protected against *Bacillus mophilus* and *Clostridium botilium*. This is achieved by the use of condensed steam under pressure in a sterilizer. When the cans are sealed in the network, steam is admitted and the temperature of the retort is allowed to rise to 1000C. This temperature is maintained for sufficient time to allow all air be flushed from the retort. The drain and steam exit are shut while allowing steam into the retort. Air entering the retort with the steam can escape. Temperature range of 115 to 1200C is attained. The pressure and temperature are both automatically controlled soon after the required steam has been admitted (Olokor, 1997).

In cooling the cans, chlorinated water is used. The pressure in the retort is initially maintained by admitting compressed air into the retort. Loss in pressure can cause distortion and damage to cans. Chlorinated cooling water is then admitted to the retort. At this stage, the internal sealant is still molten and the vacuum created in the scan may cause suction of drops of chlorinated water into the can. If the water has no residual chlorine, this may be the source of bacteria responsible for food poisoning. The residual chlorine level generally does not exceed

20 mg/L. As the cooling continues, the pressure is reduced till normal atmospheric temperature is attained. The cans are mechanically removed to the can drier to prevent contamination. The cans are labeled, and parked into cartons (Opara and Al-Jufiaili, 2006).

Canning is an expensive venture. Therefore, a number of factors would have to be considered when setting up a canner. The market for the canned products must exist. The consideration for export market for canned products is generally based on the product line. For example, fish such as tuna are highly priced.

Therefore, it makes sense to export these lines. The species of fish desired must be in limitless supply. Since fresh fish is preferred in the case of small sized fish, canning industries should be sited not too far from ports/ harbours. Disposal of waste is therefore an important factor considered. For sardines, such waste constitutes 50% enough and suitable labour and management staff (Oyelese, 2006).

Since fish and fish products are perishable. It is essential that products be rendered safe and bacteriological stable by the use of heat. This heat process must be limited so as to change the flavor and texture as little as possible (Tawari, 2006).

Plate 10 Fish ready to be canned

Plate 11 Canned fish

GENDER ROLES IN POST HARVESTING OF FISH PROCESSING

Throughout Africa, gender roles are associated with various aspects of post-harvest fish handling and processing. This division differs from one geographical region to another.

In West Africa for instance, women dominate on-shore handling and processing of fish. In Chad, Côte d'Ivoire, the Gambia, Ghana and Senegal, salting, fermentation, sun drying and smoking are women's occupations. Some women also own fishing boats, but lease them to men for fishing while they process or market the catch. Many women also buy fresh or frozen fish for processing. Women fish processors occasionally hire young men to assist in dressing fresh fish especially during the peak periods of processing.

In Burundi, the Sudan and Uganda, fish processing is dominated by men. In Uganda for instance, a survey of fish processing activities revealed that in one district 82.6 percent of men were involved in fish frying, whilst 78 percent of men were involved in salting, fermentation and sun drying. In recent times, however, the number of women engaged in fish processing in Uganda has increased. In the Sudan, women are not only involved in fish processing but some have their own canoes and are actually involved in fishing as well as the processing of fermented fishery products.

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