SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

STATUS OF THE SMALL PELAGIC STOCKS IN GHANA (2015)

JUNE 2017

This publication is available electronically on the Coastal Resources Center's website at http://www.crc.uri.edu/projects_page/ghanasfmp/

For more information on the Ghana Sustainable Fisheries Management Project, contact:

USAID/Ghana Sustainable Fisheries Management Project

Coastal Resources Center

Graduate School of Oceanography

University of Rhode Island

220 South Ferry Rd.

Narragansett, RI 02882 USA

Tel: 401-874-6224 Fax: 401-874-6920 Email: info@crc.uri.edu

Citation: Lazar, N, Yankson K, Blay J., Ofori-Danson P., Markwei P., Agbogah K., Bannerman P., Sotor M., Yamoa K. K., Bilisini W. B. (2017) Status of the small pelagic stocks in Ghana (2015). Scientific and Technical Working Group of USAID/Ghana Sustainable Fisheries Management Project (SFMP). Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. GH2014_ACT093_CRC 28 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: Images of small pelagic fish species.

Detailed Partner Contact Information:

USAID/Ghana Sustainable Fisheries Management Project (SFMP)
10 Obodai St., Mempeasem, East Legon, Accra, Ghana

Telephone: +233 0302 542497 Fax: +233 0302 542498

Maurice Knight	Chief of Party maurice@crc.uri.edu
Kofi Agbogah	Senior Fisheries Advisor kagbogah@henmpoano.org
Nii Odenkey Abbey	Communications Officer nii.sfmp@crcuri.org
Bakari Nyari	Monitoring and Evaluation Specialist hardinyari.sfmp@crcuri.org
Brian Crawford	Project Manager, CRC brian@crc.uri.edu
Justice Odoi	USAID Administrative Officer Representative Jodoi@usaid.gov

Kofi.Agbogah
kagbogah@henmpoano.org
Stephen Kankam
skankam@henmpoano.org
Hen Mpoano
38 J. Cross Cole St. Windy Ridge
Takoradi, Ghana
233 312 020 701

Andre de Jager
adejager@snvworld.org
SNV Netherlands Development Organisation
#161, 10 Maseru Road,
E. Legon, Accra, Ghana
233 30 701 2440

Donkris Mevuta
Kyei Yamoah
info@fonghana.org
Friends of the Nation
Parks and Gardens
Adiembra-Sekondi, Ghana
233 312 046 180

Peter Owusu Donkor
Spatial Solutions
powusu-donkor@spatialdimension.net
#3 Third Nautical Close,
Nungua, Accra, Ghana
233 020 463 4488

Thomas Buck
tom@ssg-advisors.com
SSG Advisors
182 Main Street
Burlington, VT 05401
(802) 735-1162

Victoria C. Koomson
cewefia@gmail.com
CEWEFIA
B342 Bronyibima Estate
Elmina, Ghana
233 024 427 8377

Lydia Sasu
daawomen@daawomen.org
DAA
Darkuman Junction, Kaneshie Odokor Highway
Accra, Ghana
233 302 315894

Gifty Asmah
giftyasmah@Daasgift.org
Daasgift Quality Foundation
Headmaster residence, Sekondi College
Sekondi, Western Region, Ghana
233 243 326 178

For additional information on partner activities:

CRC/URI:	http://www.crc.uri.edu
CEWEFIA:	http://cewefia.weebly.com/
DAA:	http://womenthrive.org/development-action-association-daa
Daasgift:	https://www.facebook.com/pages/Daasgift-Quality-Foundation-FNGO/135372649846101
Friends of the Nation:	http://www.fonghana.org
Hen Mpoano:	http://www.henmpoano.org
SNV:	http://www.snvworld.org/en/countries/ghana
SSG Advisors:	http://ssg-advisors.com/
Spatial Solutions:	http://www.spatialsolutions.co/id1.html

ACRONYMS

CCM	Centre for Coastal Management
CECAF	Fishery Committee for the Eastern Central Atlantic
CEWEFIA	Central and Western Region Fishmongers Improvement Association
CRC	Coastal Resource Center
CSLP	Coastal Sustainable Landscape Project
DAA	Development Action Association
DFAS	Department of Fisheries and Aquatic Science
DMFS	Department of Marine Fisheries Sciences
DQF	Daasgift Quality Foundation
FAO	United Nations Food and Agriculture Organization
FC	Fisheries Commission
FtF	Feed the Future
GIFA	Ghana Inshore Fishermen's Association
GIS	Geographic Information System
GNCFC	Ghana National Canoe Fishermen's Council
HM	Hen Mpoano
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICFG	Integrated Coastal and Fisheries Governance
IEZ	Inshore Exclusion Zone
MESTI	Ministry of Environment Science and Technology
MOFAD	Ministry of Fisheries and Aquaculture Development
MSY	Maximum Sustainable Yield
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organizations
SFMP	Sustainable Fisheries Management Project
SMEs	Small and Medium Enterprises
SNV	Netherlands Development Organization
SSG	SSG Advisors
STWG	Scientific and Technical Working Group
UCC	University of Cape Coast
URI	University of Rhode Island
USAID	United States Agency for International Development
WARFP	West Africa Regional Fisheries Development Program

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

This document is aimed at providing the status of the small pelagic fish resources in Ghana, through consultation with the Scientific and Technical Working Group (STWG) of the USAID/Sustainable Fisheries Management Project (SFMP). The information contained in this document has been obtained from the Fisheries Scientific and Survey Division of the Fisheries Commission of Ghana and other available information. The report and assessment results were prepared by Najih Lazar, Senior Fisheries Advisor of SFMP and reviewed by an independent scientific panel and members of the STWG.

During the first year of the project, a Scientific and Technical Working Group was formed to prepare and deliberate on the status of the stock and provide management recommendations to the Fisheries Commission. Members of the STWG were selected from academia, government institutions and fishing industry representatives. Much effort was spent during the first year to gather catch and effort data and other biological and environmental data. However, although the information presented in this document is deemed the best available scientific information, the accuracy of consistency of data quality remains problematic. This is due to the lack of decentralized fisheries data collection system, adequate capcity and working conditions in the field of operation (landings sites).

The question whether small pelagic stocks in the Gulf of Guinea belong to the same population was not addressed in this document. A separate genetic study is ongoing to determine the integrity and boundaries of these population and final results are not yet available at the time of writing this report. It is assumed, for management purposes only, that the small pelagic stocks landed in Ghana are originated from the waters of Ghana and form a single stock.

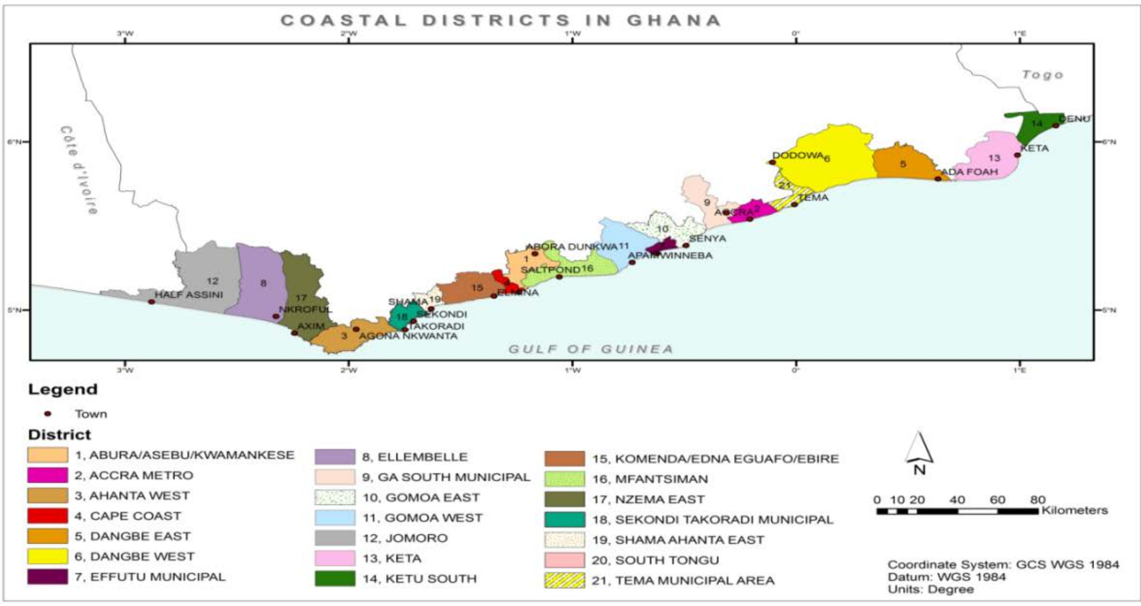
The assessment establishes a biological and management indicators/reference points for the purpose of monitoring the impact of fisheries management actions. They are based on the concept of the Maximum Sustainable Yield (MSY), measured with two indicators; 1) fishing/removal rate expressed in fishing mortality (F) which will achieve the MSY on a long term, known as F_{msy} and 2) the level of the living population at sea or biomass which will assure a continuous production of the MSY on a long term, known as B_{msy}.

<u>Members of the Scientific and Technical Working Group:</u>

- Professor Kobina Yankson – University of Cape Coast (Chair).
- Mrs Patricia Markwei – Private Citizen (Vice Chair).
- Mr. Kofi Abogah – Director of Hen Mpoano.
- Mr. Paul Bannerman – Deputy Director of Fisheries Scientific and Survey Division.
- Professor John Blay – University of Cape Coast.
- Mrs Wradi Bilisini.
- Professor Patrick Ofori-Danson, University of Ghana.
- Mr. Kojo Sortor, Inshore Fisherman (Elmina- Central Region).

1. OVERVIEW OF THE MARINE FISHERIES SECTOR IN GHANA

The marine fisheries sector in Ghana plays an important role in its contribution to the GDP, employment, livelihood strategies, food security and poverty reduction. This sector is composed of four main fishing subsectors: 1) Artisanal fisheries, 2) Inshore fisheries, 3) Industrial Trawl fisheries and 4) Tuna or large pelagic fisheries. Within the continental shelf, fishing is carried out by an important artisanal sub-sector operating from about 186 fishing villages and 292 landing beaches along within 26 coastal metropolitan, municipal and district assemblies in the four regions of Ghana (Figure. 1). The artisanal fisheries subsector is the most important with respect to landed weight of fish, contributing about 67% of the total annual landings of the marine fishery and employs about 107,518 fishermen and 4,241 fish processors (Dovlo *et al*. 2016, Asare *et al.* 2015). The subsector is composed of multiplicity and high numbers of gears operated from a variety of sizes of dug-out canoes, powered by outboard motors with engines up to 40 hp. The artisanal and inshore fisheries operate largely but not restricted to the Inshore Exclusion Zone (IEZ 12 miles/30 m depth). However



industrial trawling is prohibited ti fish within the IEZ.

Figure 1 Map of coastline of Ghana with coastal districts

(Source: Fisheries Commission, 2011)

The 2016 frame survey estimated 11,583 active fishing canoes in the artisanal fisheries in Ghana. The artisanal fishery is open access with numbers fluctuating from 11,000 to 13,000 in the last 10 years due to migration and new entry, exit and regional migrations. However, inshore fisheries operate under annual licensing requirements administered by the Fisheries Commission (FC). The registered and licensed number is 113 in 2016, while the number of the industrial trawlers reached 90 in 2016. The trawl fleet is largely operated by Chinese under joint venture arrangements. The tuna fleet operating in Ghana is 24 industrial vessels. They are licensed by the FC and managed by the International Commission for the Conservation of Atlantic Tunas, ICCAT, and operate offshore by large foreign vessels (Table 1).

Table 1 Fleet exploiting marine resources in Ghana

Fleet	Vessel type	Target species	Gear	Number
Artisanal	Canoe up to 20 m	Small pelagic species Demersal species Some large pelagics	Purse seines Gillnets Hook and line	11,583
Inshore	Small inboard boat (10-37 m)	Small pelagics Demersal species	Purse seine Trawl	113
Industrial trawl	Large steel vessel (Chinese made)	Demersal species	Trawls	90
Tuna		Large pelagics	Purse seine Pole and line	24

(Source: Fisheries Commission, 2016)

There is a gender division of labor in the organization of artisanal fishing in the country. Men naturally undertake fish harvesting while women are key in the post harvest activities including processing, storage and trade. While nearly 110,000 fishers are directly engaged in marine fisheries, it is estimated countrywide that between 1.5 million and 2 million people in households are also engaged in the indirect benefits of the artisanal marine subsector (Bank of Ghana, 2008; Mensah et al., 2006).

Fishermen involved in the artisanal subsector are relatively older (+50 yrs) in rural fishing communities and younger in metropolitan communities (20-30 yrs). The education level is relatively low. About 50% of fishermen have no formal education. Those who attended school have up to basic education level, that is, school up to junior high school level (Asare, *et al.* 2015).

Fishermen migrate from communities to communities following migrating fish (small pelagics and sharks). This migration take many forms, from short term movements over modest distances within the country to long distances across borders to Benin, Togo, Cote d'Ivoire, Liberia and as far north as Senegal. There is a seasonal pattern of fishermen's migration; often between July and December when small pelagics are migrating inshore and eastward.

Ghana is a net importer of fish as its national landings declined over the past 10 years and population growth increased. It is undoubtedly that this gap will continue to remain wide for the coming years as fish stocks can no longer meet local market demands. Fishing sector generates about $1.3 billion in total revenues in 2016, representing 1.03% of the national GDP. This showed a declining trend from 2.7% in 2008 years as a result of increased exploitation and sales from offshore oil fields and decline in total landings (Figure 2).

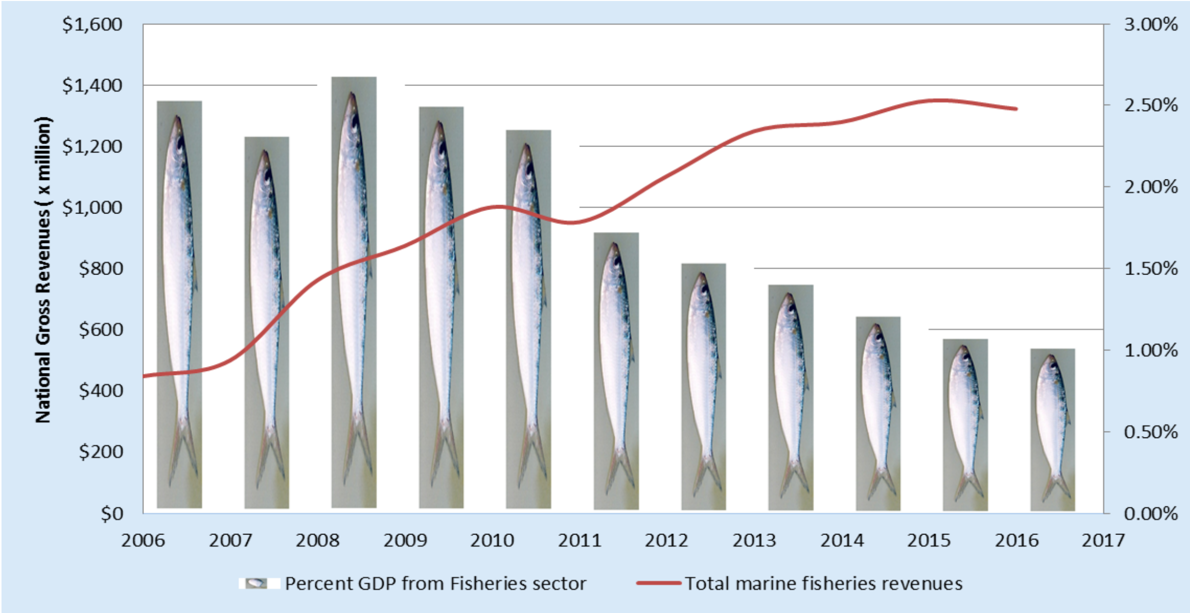


Figure 2 National marine fisheries revenues and percent GDP (2006-2017).

2. SMALL PELAGIC FISH STOCKS

The waters of Ghana and its neighboring countries are rich in "small pelagics": species like sardinella, anchovies and mackerel that swim in large schools in the upper water layers. They are called "small pelagics" to distinguish them from tuna, swordfish and other "large pelagics". The abundance of small pelagics in Ghana waters is related to the high plankton production in this area, which in turn is caused by upwelling of nutrient-rich water.

The small pelagic fish stocks are composed of round sardinella (*Sardinella aurita),* flat sardinella *Sardinella maderensis,* anchovies (*Engraulis encrasicolus) and* mackerel (*Scomber colias).* The four species represent more than 80% of the total small pelagic fish stocks. They have common biological and ecological traits and are processed and consumed dried or smoked.

Round Sardinella (Sardinella aurita)

The Round sardinella *Sardinella aurita* (Valenciennes, 1847) belongs to the family clupeidae and forms an important fishery in many parts of the world. It is a small pelagic species that inhabits warm waters. They can be found in tropical and subtropical waters of the western and eastern Atlantic Ocean, the Pacific Ocean and the Mediterranean Sea. Its eggs and larvae can be fully represented in the plankton during the spawning periods.

The Round sardinella is a subtropical and thermophilic pelagic species distributed between 47°N - 40° S and 98° W - 43° E (Mustać and Sinovčić, 2012). The greatest catches are made in the western Atlantic Ocean off the Venezuelan and southern Brazilian coast with annual production figures of 200,000 metric tonnes (Longhurst and Pauly, 1987; FAO , 1992) and off West Africa in Senegal-Mauritania, Ivory Coast-Ghana and Congo-Angola waters where annual catches are up to 650, 000 metric tonnes (Fréon, 1988; Marchal, 1991).

The spawning of *S. aurita* is synchronized with the occurrence of the major upwelling and maximum production of plankton. The modal length size of the *S. aurita* in Côte d'Ivoire was between 15cm and 18 cm in the sixties and seventies. In the 1980s, this modal size increased to 18 cm and 24 cm. In Ghana, a similar increase in length was observed between the early 1960s (14 cm -17 cm) and the 1980s (17cm - 21 cm). The length at first maturity of the S. *aurita* in Côte d'Ivoire seems to have increased from 15 cm in the 1960s and 1970s to 18 cm – 19 cm in the end of 1980s.

S. aurita spawns during the minor and major upwelling seasons. S. *aurita* carries out major spawning during the major upwelling (July - September) and minor sporadic spawning during the minor upwelling (Mensah and Koranteng, 1988). It is able to spawn in any favorable condition and consequently there are two possible recruitments per year. The length at sexual maturity is between 15-15 cm with a corresponding weight of 31 gr (Osei, 2015). A female of S. *aurita* is able to hatch between 50,000 and 200,000 eggs per year (Conand, 1977). Few numbers of females can thus give rise to a high population if the environment conditions are good for the larvae produced. The environment is variable and can induce strong mortality as well. Anang (1976) and Houghton and Mensah (1978) showed that the highest concentrations of phytoplankton, zooplankton and *S. aurita* occur during the major upwelling (July-September). *S. aurita* larvae and the general zooplankton feed on phytoplankton while the juveniles and adult feed on zooplankton.

S. aurita migrates from offshore areas of Ghana in depths below the thermocline (50-90 m) during the peak upwelling season (June – September). Large schools of fish aggregate to the surface and occupy nearshore areas in the western region then move gradually throughout the coastal zones of Ghana (Figure 3). By end of September and after spawning, *S. aurita* migrate back to offshore areas and deeper waters in the form of less organized schools and rest in these areas for few months before retunting to inshore areas as minor upwelling manifest during December- February (Figure 3).

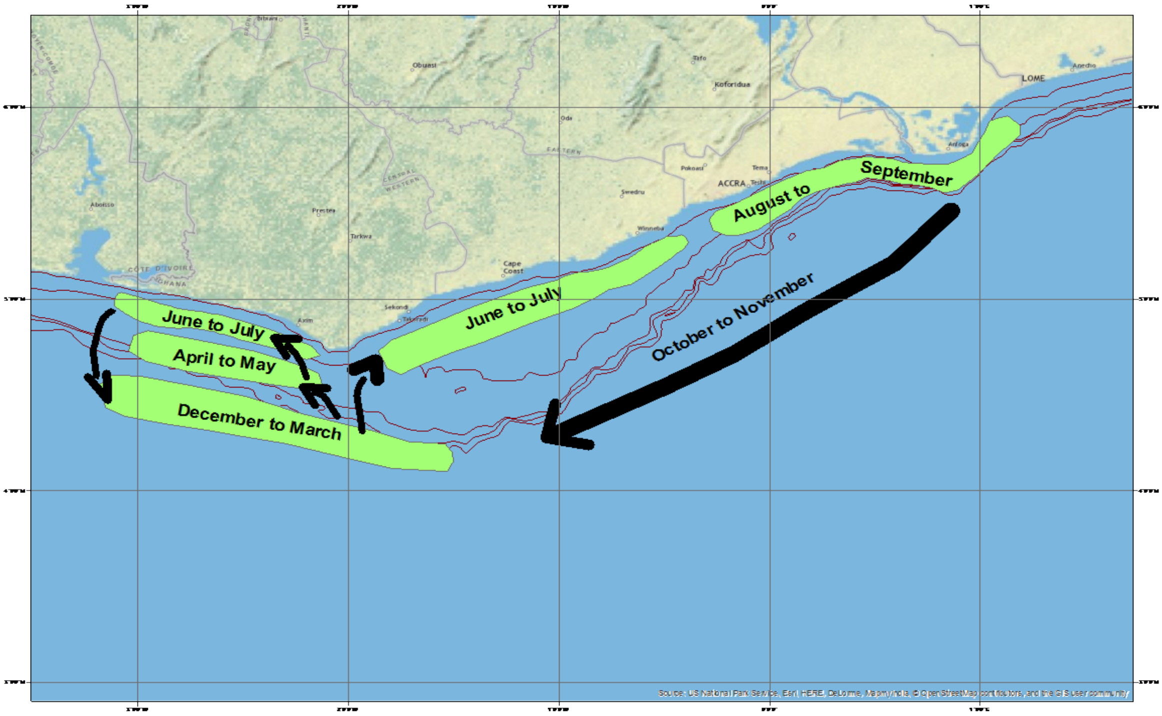


Figure 3 Representation of the migration route of Sardinella aurita in Ghana

Flat Sardinella (Sardinella maderensis)

The flat sardinella *Sardinella maderensis* (R.T. Lowe, 1838) occupies a more restricted area than the round sardinella, as it is found in the eastern Atlantic, from Gibraltar to Angola. The flat sardinella is tolerant of low salinities in estuaries, migrate in small schools and prefers waters of 24° C, at surface or at bottom down to 50 m.

S. maderensis is a less migratory species than *S. aurita*. This species, therefore, is more likely to constitute local populations that stay within the same area throughout the year. The boundaries between these local populations, however, are not clear and the existing sampling data are inadequate to differentiate between local populations. The migration occur during the peak upwelling (June-August) and starts from the western region into the costal shores from the Central region to the Volta. Two nurseries of *S. maderensis* were identified in Ghana around Cape Three Points in the central region and around Keta laggon in the Volta (Figure 4).

The feeding diet of *S. maderensis* is similar to that of *S. aurita*, composed of copepods and fish larvea (Medina-Gaertner, 1985). The length at fisrt maturity was determined at 15.5 cm TL for both sexes with a corrsponding average weight of 30 gr. (Osei, 2015).

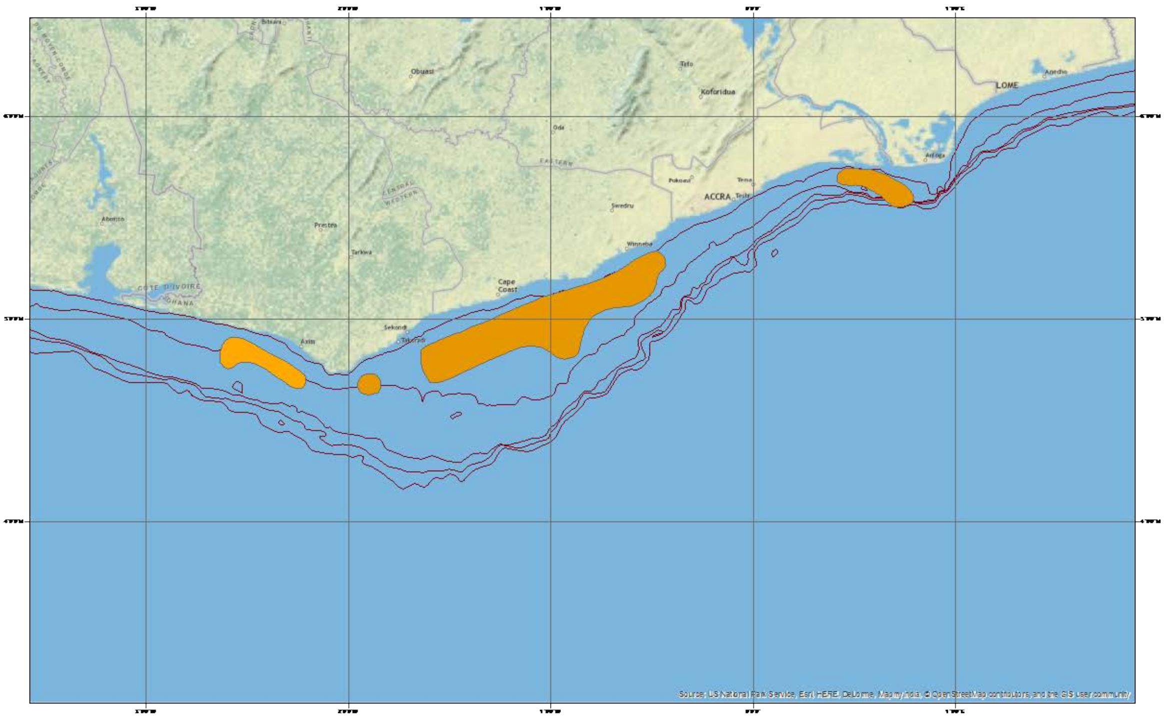


Figure 4 Distribution of *Sardinella maderensis* in April 2016 (R/V Dr. Fritdjof Nansen survey)

The maximum observed length was 27 cm for *S. aurita* and 28 cm for *S. maderensi*. Both species grow at fairly fast rate and reach sexual maturity in 1.5 years of its life span. The maximum age is about 6 years for *S. aurita* and 5 years for *S. maderensis*.

Table 2 Estimate of growth parameters of S. aurita and S. maderensis

	S. aurita	*S. maderensis*
L_{max}	27.9 cm	28.2 cm
L_∞	28.70 cm	29.53 cm
K	0.51 yr^{-1}	0.6 yr^{-1}
t_{max}	5.88 yr	5.0 yr
t_o	- 1.97 yr	- 1.65 yr

Source: Osei, 2015.

Anchovies (Engraulis encrasicolus)

Engraulis encrasicolus (Linnaeus, 1958) called European anchovie, is one of the second most abundant smallpelagic species in Ghana. They contribute on average about 25% of the total landings.

It is mainly a pelagic species forming large schools, but has been recorded down to 40 m depth off West Africa and descending in winter to 100 to 150 m depth in the Mediterranean. It is a euryhaline species, tolerating salinities of 5 to 41°/oo and in some areas entering lagoons, estuaries or lakes, especially in the warmer months during the spawning season. *E. encrasicolus* feeds on planktonic organisms, especially calanoid copepods, cirrepede and mollusk larvae, and fish eggs and larvae.

The length at first maturity of these fish is around 5.7 cm FL (Koratang, 1986). Spawning occurs over an extended period from April to November with peaks usually in June through August. Eggs are ellipsoidal to oval, floating in the upper 50 m, hatching in 24 to 65 hours.

The distribution range is from Morocco to as far south as Angola and St. Helena. The southern limit at the Angola/Namibia border is arbitrary since there is perhaps no distributional break between these populations and those of the Southern African anchovy (recognized as <u>*E. capensis*</u>). Attempts to split the European anchovy into races and even subspecies have not been wholly successful.

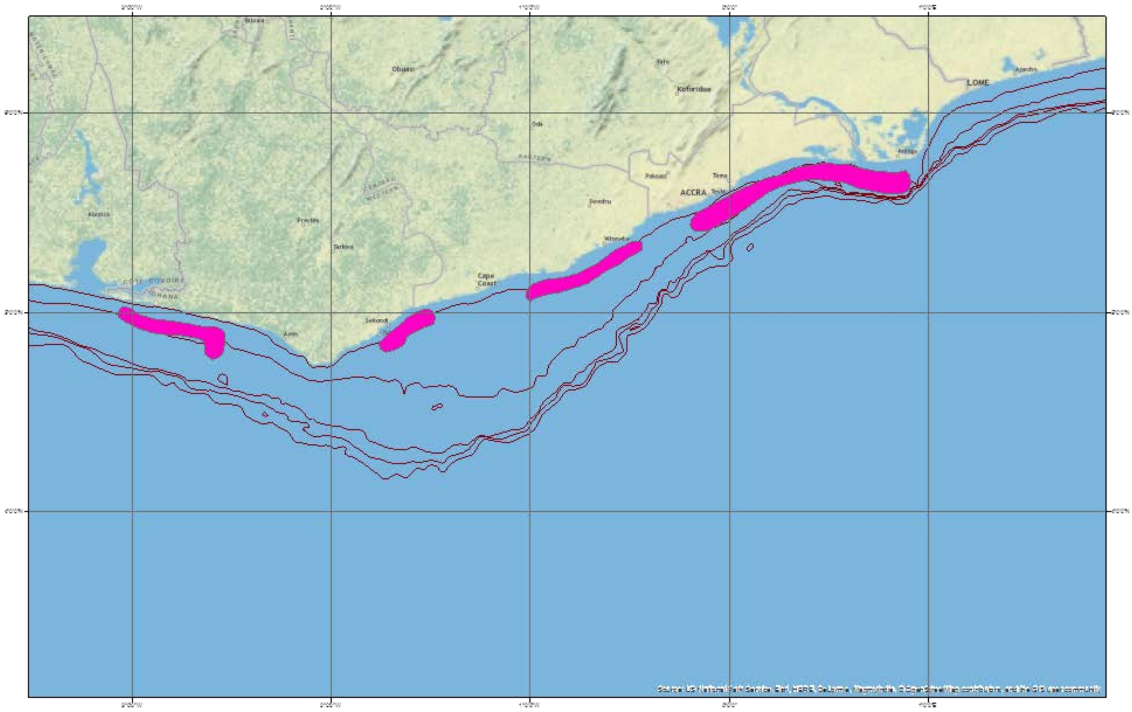


Figure 5 Distribution of anchovies *Engraulis encrasicolus* in April 2016 (R/V Dr. Fridjoft Nansen survey)

Mackerel (scomber colias)

The species shares the same family with tunas and bonitos, namely, family Scombridae. It is a cosmopolitan species inhabiting temperate and subtropical waters of the Atlantic, Indian and Pacific Oceans and adjacent seas. In the Eastern Atlantic, it is distributed from the Mediterranean and Black Seas, Madeira, the Canary Islands and from 10 ^{0} to 16 ^{0} S in the Gulf of Guinea. It is also found around the Cape of Good Hope.

A primarily coastal pelagic species, to a lesser extent epipelagie or mesopelagic over the Continental slope, occurring from the surface to about 250 or 300 m depth. Seasonal migrations increase southwards with summer temperatures and overwinter and spawning during cold temperatures. It migrates in size-specific schools. It is common to notice mackerel moves in multispecies in the Northeastern Pacific with Pacific bonito (*Sarda* *chiliensis*), jack mackerel (*Trachurus symmetricus*), and Pacific sardine (*Sardinops sagax*). The maximum size observed is about 50 cm fork length while the common size present in landings is around 30 cm.

Spawning between chub mackerel typically occurs at temperatures of 59 to 68°F. Spawning occurs in several batches of about 250 to 300 eggs per 9 of fish with the total number of eggs per female ranging from approximately 100 000 to 400 000. Although maturation of chub mackerel has never been thoroughly documented, data shows that spawning can happen from March through October, but spawning mostly happens from April through August. Sometimes in females, ripe translucent eggs appear simultaneously with unripe ova in early stages of development; this is also seen with the Atlantic mackerel as well.

Spawning most often occurs at water temperatures of 15° to 20°C, which results in different spawning seasons by regions, for example: off Peru, from January through May and in September; off northeastern Japan, from April to August with a peak in May, but initiating in March further south; off California and Baja California, from March through October with peaks between April and August.

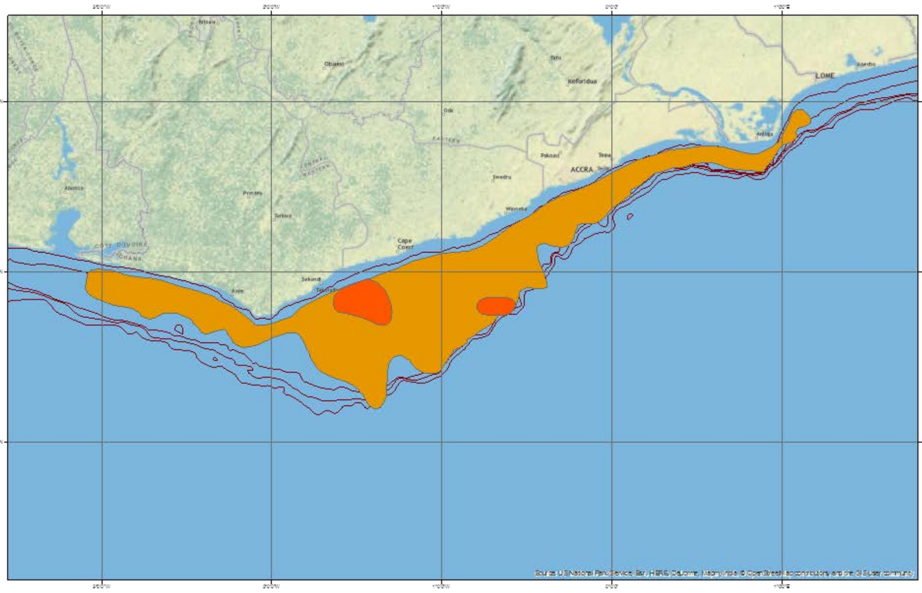


Figure 6 Distribution of anchovies *Engraulis encrasicolus* in April 2016 (R/V Dr. Fridjoft Nansen survey)

3. STOCK UNIT DEFINITION

Small pelagic species caught in southern CECAF region from Guinea to Angola are not known to have distinct biological differentiation of more than one stock. However, for management purposes and in the absence of information on stock identification, the FAO/CECAF scientific Working Group considers the existence of four stocks of small pelagics in the southern CECAF area. Northern zone (Guinea-Bissau, Guinea, Sierra Leone and Liberia), Western zone (Côte d'Ivoire, Togo, Ghana, Togo and Benin), Central zone (Nigeria and Cameroon) and Southern zone (Gabon, the Democratic Republic of the Congo, the Congo and Angola) areas (Figure 7). This is an assumption based on management needs and in the absence of information to match the biological boundaries of these two species with management strategies.

However, and from a stock assessment perspective, this is a fundamental problem in fisheries management where numerous fisheries have failed to maintain sustainability principally due to mis-specified stock structure. The SFMP is working together with research institutions from West African countries to delineate the stock structure of *S. aurita* and *S. maderensis*. For the purpose of this assessment, we assume that the stock of the southern western zone (Côte d'Ivoire, Togo, Ghana, Togo and Benin) can be characterized by an assessment of the data from Ghana, which representmore than 80% of the total biomass (R/V Fridjoft Nansen 2007, 2016).

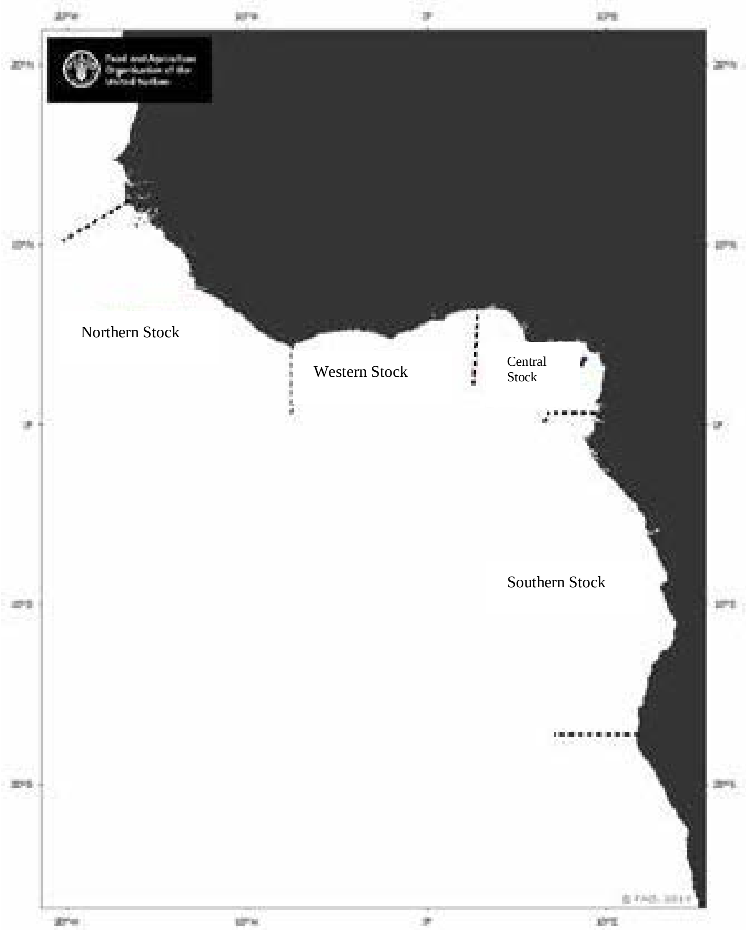


Figure 7 Stock identification of small pelagics in the south CECAF area.

4. DATA SOURCES

Landings and effort

The artisanal purse seine and beach seines are the main fishing gear used in exploiting the small pelagic resources. There are two types of artisanal purse seine gear, and the difference is in the mesh size. The purse seine with a 25 mm mesh is locally called "*watsa*" while the one with a10 mm mesh is called "*poli*". The beach seine has a mesh size of 10 mm and is operated from the beach, mainly along estuaries. The artisanal gear is operated from canoes ranging between 10 to 20 meters. There are over 3000 artisanal purse seine canoes and 900 beach seine canoes operating along the entire coast.

The inshore fleets are locally built wooden vessels fitted with inboard engines of up to 400 hp and have lengths ranging between 8 and 37 metres. These vessels are multipurpose and are used for both purse seining and bottom trawling. They operate as purse seiners during the upwelling periods and switch to bottom trawling for the rest of the year. They tend to fish in the same coastal waters as the artisanal fleet during the upwelling seasons. There are about 230 inshore vessels operating from 7 landing centres.

Table 3 and Figure 8 show the landing and effort trends of small pelagic species in Ghana from 1990 to 2014. Data was provided by the FC Fisheries Scientific and Survey Division. Fishing effort is measured by the number of purse seine vessels active in the fishery. However, the nominal effort used in the model assessment was not calibrated through time to account for the changes in catchability as a result of increased net and boat sizes and reduction in mesh sizes. The assumption of contstant catchability will be addressed in subsequent analyses when the survey to build hirtorical perspectives of these changes overtime.

Commercial landings of small pelagic species peaked in 1996 to 250,000 metric tons (Figure 8). Landings declined continuously to reach the lowest level in 2013 recorded during this time series. Commercial landings averaged 135,000 metric tons annually during this period. The total small pelagic species realized in 2014 represented 24% of the average landings from 1980 to 2014, and only 12% of the maximum landings realized in 1996. The small pelagic landings dominated the total marine production in Ghana for over 2.5 decades, however, in recent years the contribution of small pelagic landings reached the lowest level in the time series at about 20% of the total marine landings. Monthly landings of *Sardinella aurita* also reflect a dramatic decline, with a consistent peak in August which corresponds to the peak of the spawning season (Figure 9). This representation looks similar to deteriorating health conditions of a dying patient, as fishermen and managers once said. As sardinella began de decline in late 1990s, anchovies dominated the catch in the small pelagic species since 2011 at an average of about 42% of the total catch.

Landings of mackerel have followed similarly the trends of sardinella. The highest catch was realized in 1998 and 2000, then declined to low levels since 2002.

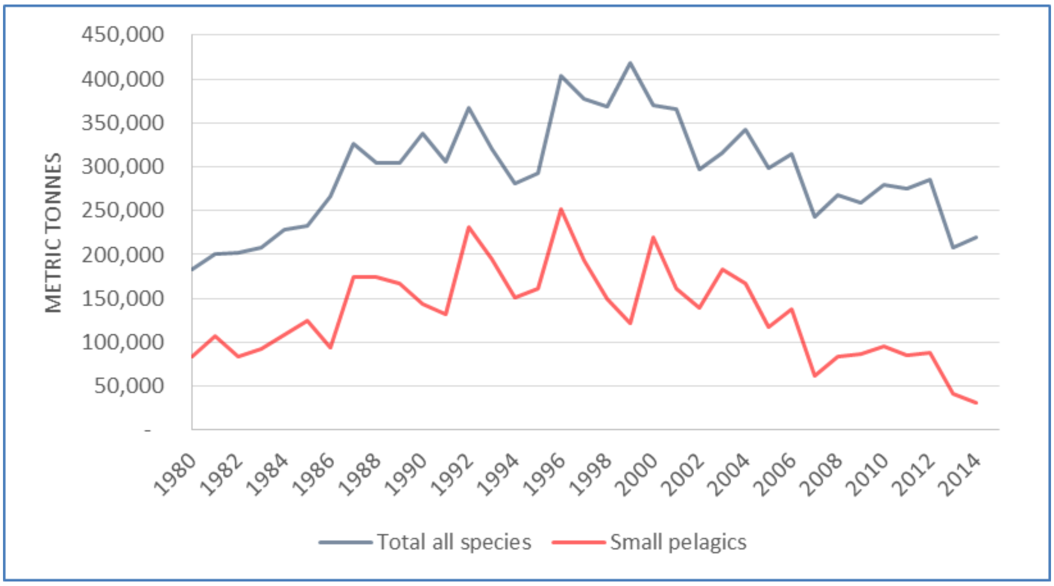


Figure 8 Landings of small pelagic species in Ghana (1980-2014)

The rapid declining trends of small pelagic landings in Ghana, varying from about 250,000 mt in mid-1990s to 44,180 mt in 2014, do immediately suggest that there is a serious overfishing situation in Ghana's small pelagic fisheries. However the total (all species combined) landings seem to be steady but this is masked by a rise in number of species caught by exploring new grounds while the average size of decreases (fishing for juveniles. The presence of smaller sizes in the catch is noticeable in almost every landings site due to the use of smaller mesh sizes.

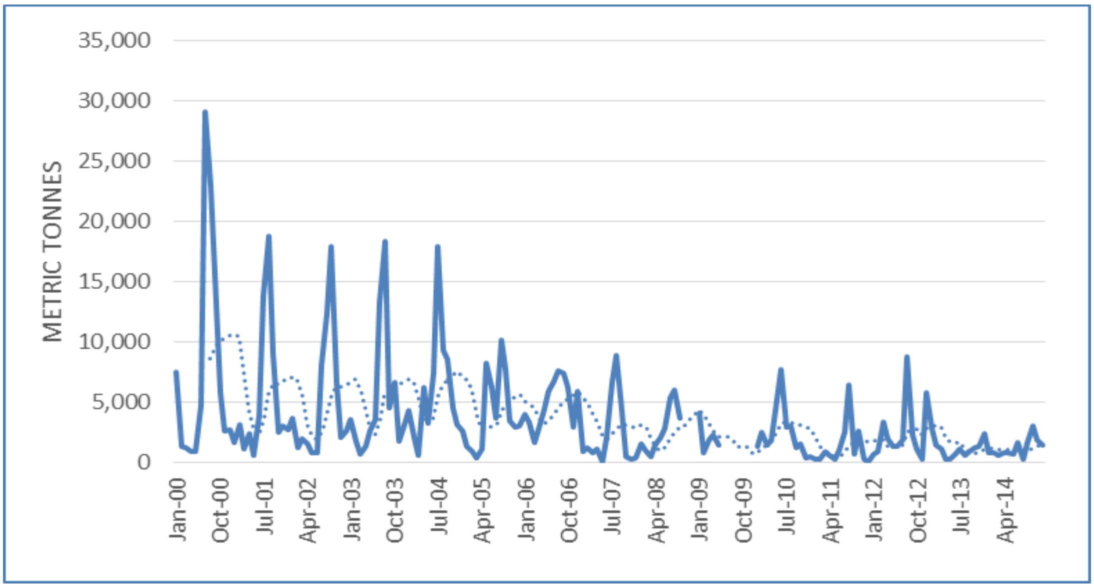


Figure 9 Monthly landings of small pelagic species in Ghana (1980-2014)

A five year average landings of small pelagics during the period from 1980 to 2014 showed similar downward trends with an average -40% decline since 2000. There was a slight increase in mackerel landings in the last five years. On average of 79,349 recorded during the period 2000-2005 for *S. aurita* and reached the lowest levels during the period of 2010-2014 at an average of 20,476 tonnes. Similar trends were realized for *S. maderensis* at 10,983 tonnes during the period 200-2005 to reach the lowest level during the period 2010-2014 at an average of 3,248 tonnes. For anchovies, the five year average during the period 2000-2005 reached average landings of 61,415 tonnes but also declined sharply to an average of 15,442 tonnes during the most recent period between 2010 and 2014.

The artisanal fishery in Ghana is free and open to all Ghanains. With the exception of a voluntary canoe registration program managed by the FC, fishermen can build unrestricted sizes of canoes and fishing gear, equipe it with necessary outboard engines and fish without catch limits in any open waters of Ghana's EEZ, with the exception of a 500 meter radius around the oil rigs. This situation created a condition for rapid expansion of fishing effort beyond sustainable levels. It also provided a competitive conditions to race for the few fish left as the Catch-Per-Unit of Effort (CPUE) continued to decline and profitability shrunk significantly. The number of purse seines opearetd to target small pelagic species also increased by almost 3 fold since 1980 from 1,146 to 3,085 nets in 2014 (Figure 10). This increase in numbers was also coupled with increase in net dimensions from 275 m to 800 m in length and from 25 to 55 m in depth during this period (pers. Comm). The average zero catch (vessel spending more than 20 hours searching for fish and returning with no catch) increased in recent years. Fisheremen showed that about one quarter of the effort in Tema returns to the harbor without catch daily since 2010 (personal communication).

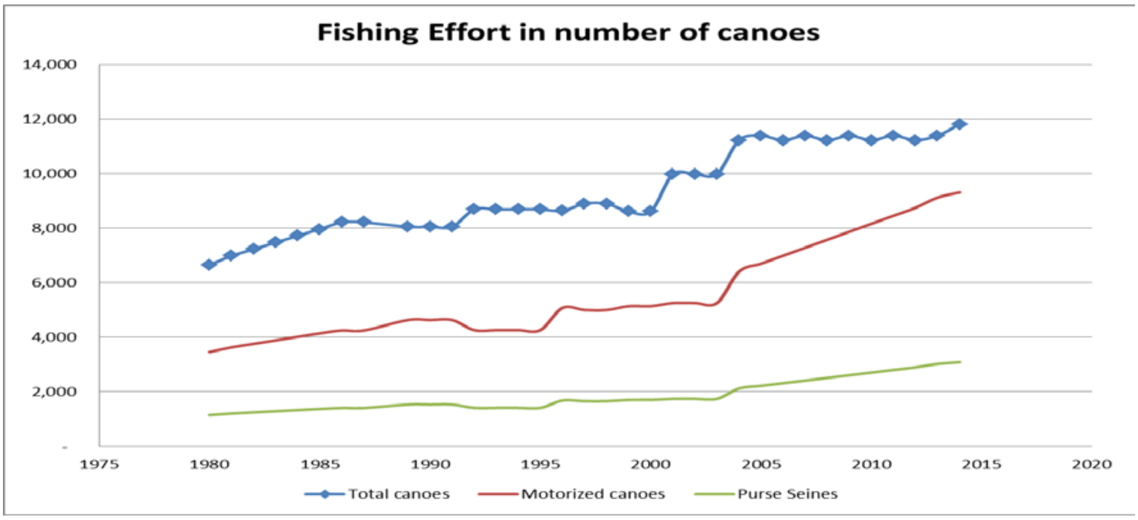


Figure 10 Fishing effort represented in number of canoes and purse seine nets (1980-2014)

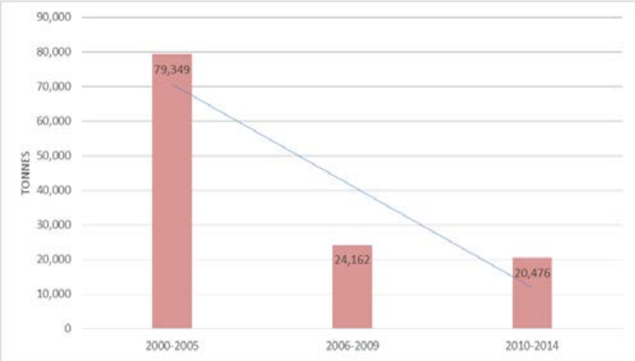


Figure 14 Five-year average landings of *S. aurita*

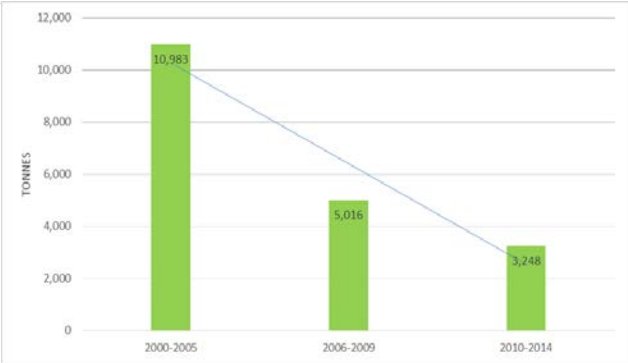


Figure 14 Five-year average landings of *S.maderensis*

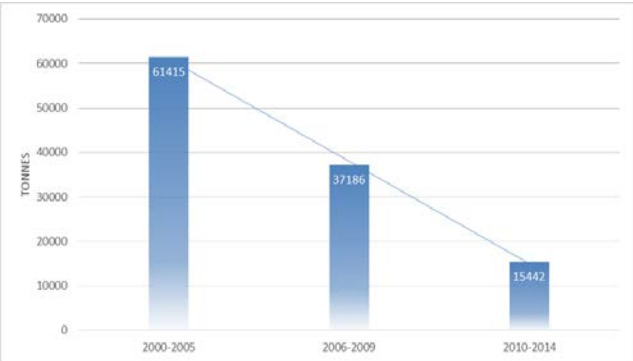


Figure 14 Five-year average landings of *E. encrasicolus*

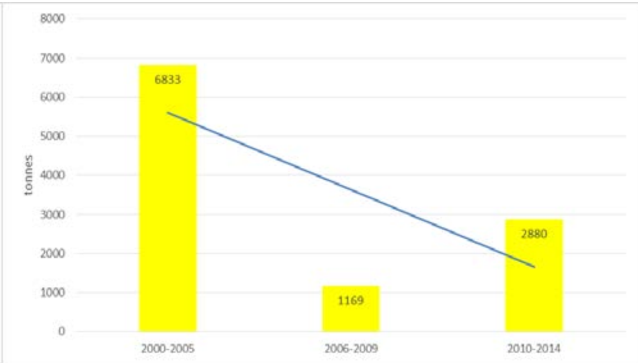


Figure 14 Five-year average landings of *S.colia*

5. SEASONAL LANDINGS OF SMALL PELAGICS

Landings of small pelagics follow a seasonal trend influenced by the two periods of upwellings; a major upwelling between June and September and a minor upwelling in December to February. The upwellling is influenced by the Guinea current (part of the Canary Current), which flows from Guinea-Bissau in the north of the sub-region to Angola in the South. Landing values during the major upwelling are always higher than those in the minor upwelling (Figure 15). The CPUEs are equally important during major upwelling periods (Figure 16). However the price-per-pan often reach its lowest value due to the lack of storage and processing capacity. The peak of landing seems to be consistent during the period between 2000 and 2014. About 40% of total annual landings occur in only two month in the year (July and August). It is worth nothing that thses extreme variations of CPUEs influenced by environmental conditions present a challenge on the use of CPUE as a reliable index of abundance.

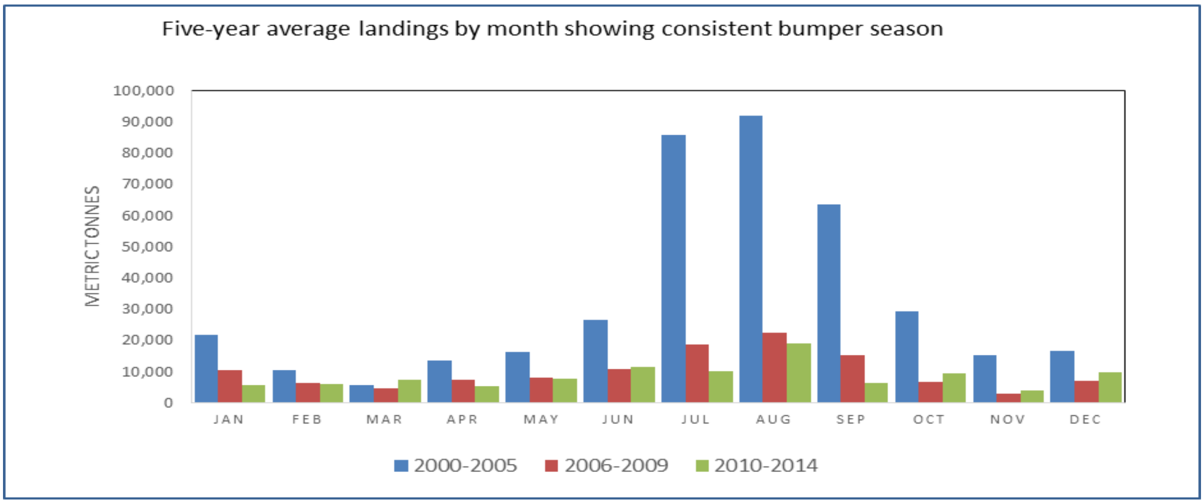


Figure 15 Monthly landings of small pelagics in Ghana (five-year average 1980-2014)

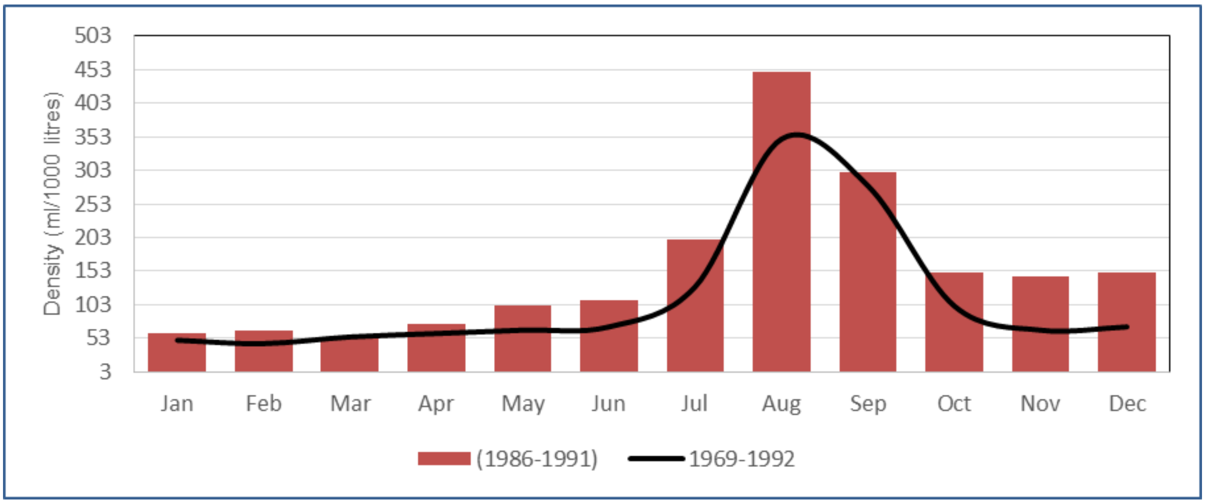


Figure 16 Monthly landings of small pelagics in Ghana (five-year average 1980-2014)

6. ACOUSTIC SURVEYS

Independent measure of abundance of small pelagic resources is measured by specialized research sureys conducted by the R/V Fridjoft Nansen. They are conducted using scientific echo sounders (type SIMRAD ER60) equipped with keel-mounted transducers. Acoustic data are looged and processed using an echo-integrator which converts the sounder signals into biomass. When signals suggest mixed species, a sample of fish using mid-water pelagic trawl is taken to determine species composition. In addition, length frequencies are taken to determine species-specific lsize composition. The total biomass in each area is obtained by summing the biomass of each length group. The number and biomass per length group in each concentration are then added up to obtain totals for each region forloowing a modeling framework.

Table 3 Acoustic biomass estimates of main pelagic groups (tonnes) from surveys with R/V "Dr. Fridtjof Nansen" off Côte d'Ivoire, Ghana in 1981, 1989, 1999, 2000, 2002, 2004, 2005 and 2006

Survey Year	Survey period	Côte d'Ivoire	Ghana	Total
1981	June	39,000	40,000	79,000
1989	12.10 – 20.10	6,000	41,000	47,000
1999	19.4 – 8.5	42,000	40,000	87,000
2000	29.8 – 15. 9	111,000	56,500	175,700
2002	16.7 – 9.8	34,000	73,000	108,500
2004	16.5 – 9.6	68,000	68,000	157,800
2005	4.5 – 27.5	37,000	54,000	94,800
2006	19.5 - 5.6	62,000	57,000	121,000
2007	6.6 – 11.6	1,000	20,000	21,000
2016	01.04 – 20.04	Not covered	25,000	

Source: EAF-NANSEN Project

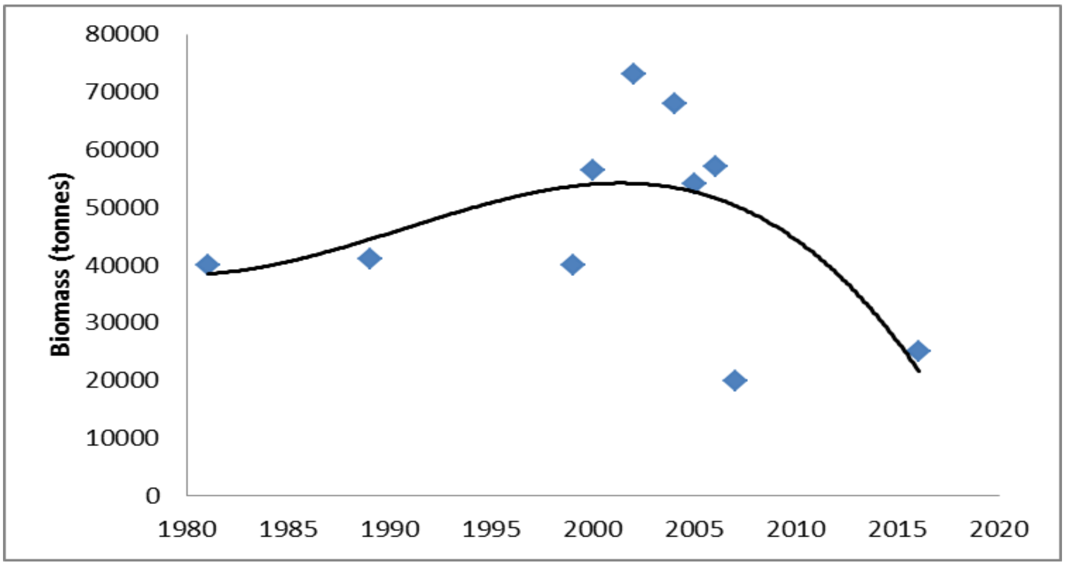


Figure 17 Trends of acoustic surveyestimates of abundance by research surveys R/V Dr. Fridtjof Nansen

7. STOCK ASSESSMENT MODEL

A surplus production model was fit to observed landings and effort data of small pelagics (sardinella, anchovies and mackerel). The landings of the thre major small pelagic species represent a strong indicator for the status of all small pelagic species. The effort is represented by the number of canoes without calibration and no auxiliary estimates of abundance using acoustic surveys. The model is a mass balance approach in which stock biomass each year is the biomass the year before plus new production minus the catch removed. New production is the net difference between additions from growth and recruitment and mortality losses. The stock growth is assumed to follow the familiar logistic curve.

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - C_t + \in$$

Where:

t = year

B_{t+1} = population biomass of next year (t+1)

B_t = population biomass of this year (t)

r = intrinsic rate of increase in biomass

e = lognormal process error

The (*r*) parameter is a measure of population growth rate at very low abundance when density dependent factors are inoperative. The term in parenthesis is the density dependent feedback mechanism that reduces stock growth when abundance is high.

To connect the catch rates of biomass (*B*) via a catchability coefficient (propotion of the total stock taken by one unit of effort) represented by (*q*). The relationship between the catchability q and the CPUE is:

$$\overline{CPUE} = \frac{Catch}{Effort} = qB$$

Where:

q = catchability coefficient

CPUE = Catch-Per-Unit of Effort

B = Biomass

The model is then fit iteratively by minimizing the sum of square residulals between observed CPUE and predicted CPUE in the form of:

$$\sum (\, CPUE - \overline{CPUE}\,)^2$$

Where *CPUE*, representing an Index of abundance (I), is the observed rate from which to substract the predicted or expected *CPUE* from the model.

The management quantities for sustainable fisheries can be derived from the logistic model parameters as follows:

$$MSY = \frac{rK}{4}$$

$$F_{msy} = \frac{r}{2}$$

$$B_{msy} = \frac{K}{2}$$

Maximum sustainable yield (MSY) is the maximum yield that a stock can deliver year after year over the long term. It is a function of both carrying capacity and stock productivity. In order to produce MSY, a stock needs to be at a biomass level equal to one-half carrying capacity (B_{msy}) and be subject to a fishery removal rate no greater than F_{msy}. The latter is equal to one-half the maximum rate of stock growth. A fishing mortality rate that approaches the maximum rate of stock growth will lead to stock collapse (F_{coll}).

8. RESULTS

The model performed well and provided a reasonable level of precision (CV=0.15). Estimated biomass of total small pelagic species in Ghana declined sharply following the trends of landings. Recent levels have reached the lowest level over the period between 1980 and 2014. Biomass in 2014 was estimated at 182,726 tonnes. This represents about 50% of the biomass needed to maintain sustainable exploitation of the stock. The rebuilding target B_{msy} was estimated at 310,476 tonnes. The terminal relative biomass (B_{2014}), expressed in a ratio of current biomass divided by B_{msy}, was estimated at 0.52.

This observation is based on trends of CPUEs from 1980-2014 which, although not calibrated, seems to corroborate the trend of independent measure of abundance by the acoustic surveys. These data may be interpreted to show that Ghana's fisheries are in worse condition than suggested in previous reports, with a possibly much more serious threat to food security than currently anticipated. This situation is supported by observed time at-sea for small canoes, which increased from 1 day in early 2000 to 4-6 days in 2014 (pers. Comm), coupled with declining average size in landings of several species followed by shrinking mesh sizes of trawls and purse seines (prevailing mesh size in TEMA is less than 1 inch). In addition, recorded increased bycatch and incidental catch on marine mammals, is widely seen in major fishing harbors.

Fishing mortality increased from F=0.6 in 1980 to F=1.4 in mid-1990s following the trends of effort increase. As the biomass declined below B_{msy} in 1997, so did fishing mortality due to low availability of fish. This is always presented in small pelagic fisheries as the search time for fish becomes high making the cost of fishing trips prohibitive. The standard fishing guidelines are to fish small pelagics at low fishing mortality when abundance is high to maintain abundance as long as possible while stopping fishing entirely when stocks reach a collapsed state.

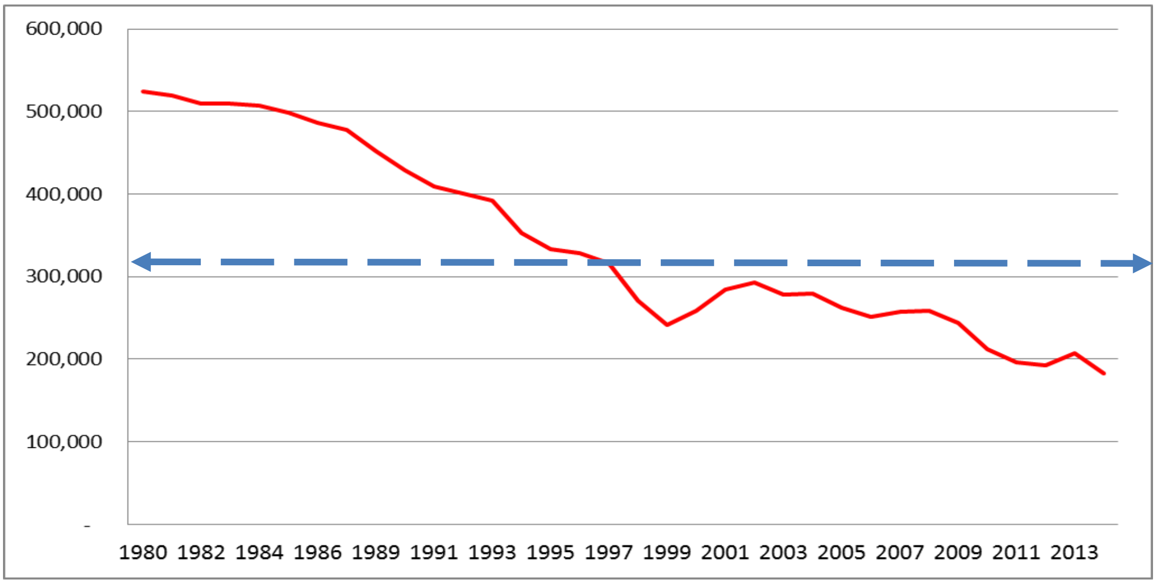


Figure 18 Trends of biomass of small pelagic stocks in Ghana (1980 – 2014)

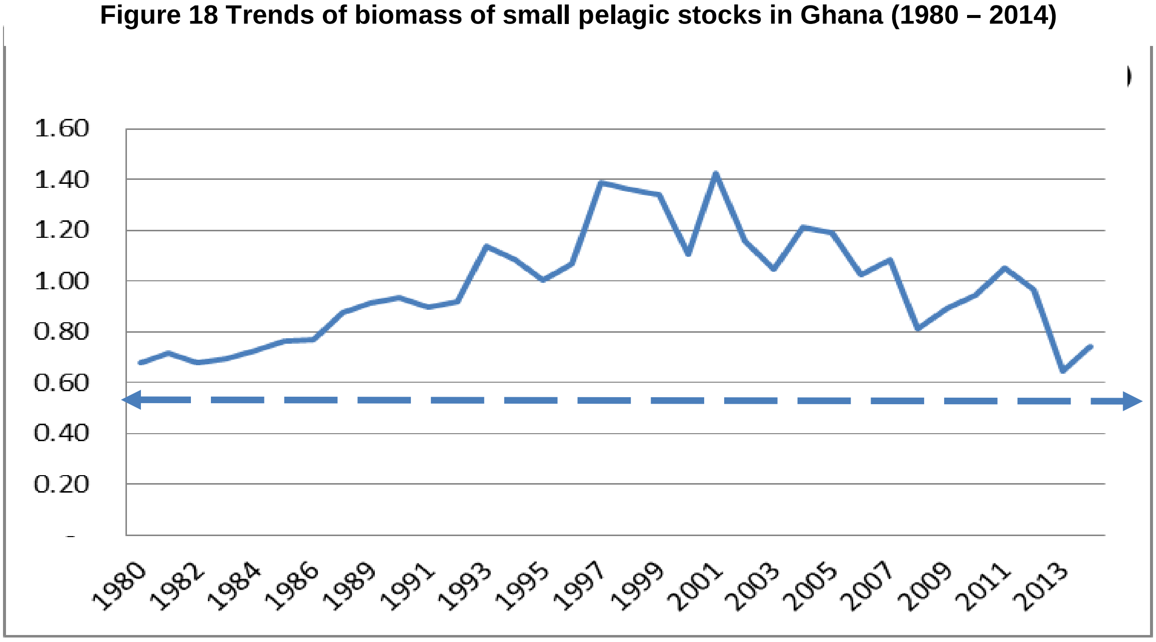


Figure 19 Trends of fishing mortality for small pelagic stocks in Ghana (1980 – 2014)

The estimates of small pelagic stocks are extremely low despite declining fishing mortality. The ecological resilience of the stock to rebound in the absence of continuous fishing pressure remain unknown. However, changes in species composition and the dominance of anchovies is instructive, as in other situations where the anchovy stock always expanded when the clupeid stocks are very low. However the anchovy stocks typically do not reach the same high volume as the clupeids.

Table 4 Model estimates of management reference points

Biological reference points		
Bmsy	310,476 tonnes	
F_{msy}	0.40	
B_{2014}	182,726 tonnes	
F_{2014}	0.74	

The current fishing effort seems to be well beyond the level of sustainability for the small pelagic stocks. In the absence of effort control measures, stocks will continue to decline with diminishing economic returns leading to further deterioration of social conditions. The Fisheries Commission began addressing this situation with the support of the World Bank by registering small artisanal canoes. The semi-industrial and the industrial fishing vessels have been subject to an annual registration and licensing requirements. Furthermore, it is expected that the canoe registration will be followed by a program of licensing and ultimately an implementation of effort control program in the artisanal fishery.

The small pelagic fish stocks in Ghana are considered severely overfished an overfishing continues to occur. Fishing mortality has gradually increased in the past 25 years and remains beyond the sustainable capacity level F_{msy}. The stock is at its lowest level of biomass in almost 3 decades.

It is common for small pelagic species (forage species) to be more prone to rapid collapse than are those for other types of marine fishes due in part to their rank in the food web and their response to environmental conditions. These fish occupy a very special position in food webs, ensuring energy transfer between species lower and higher levels, while forming narrow range of species richness. The collapse of the pelagic stocks have a domino effect on both higher and lower trophic species. This is referred to as the “wasp-waists” to characterize the central role of the small pelagic species as they assure an important ecological balance of lower and upper trophic levels (Lazar, 2012).

REFERENCES

Anang, E. R. 1976. Seasonal Changes in the Phytoplankton Population in the Coastal Waters of Ghana. *M.Sc. Dissertation*, Botany Department, University of Ghana.

Asare C, Nortey D.D.N., Lazar N, Kankam S and Agbogah K. (2015). Results of the Field Survey on the Small Pelagic Fisheries. The USAID/Ghana Sustainable Fisheries Management Project (SFMP), Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and Hen Mpoano, Windy Ridge – Takoradi. GH2014_ACT020_HM 57 pp.Bank of Ghana. September 2008. The fishing sub-sector and Ghana's economy. BOG Research Department.

Conand, C. 1977. Contributions à l'étude du cycle sexuel et de la fécondité de la sardinelle ronde, Sardinella aurita: pêche sardinière sardinière dakaroise en 1975 et premier semestre 1976. Cah. ORSTOM, Sér. Océanogr., Vol. XV (4): 301-312.

Dyck, A.J. and U.R. Sumaila. 2010. Economic impact of ocean fish populations in the global fishery. Journal of Bioeconomics. DOI: 10.1007/s10818-010-9088-3

Essington, T. E.; Moriarty, P.E.; Froehlich, H. E.; Hodgson, E. E.; Koehn, L. E.; Oken, K. L.; Siple, M. C.; Stawitz, C. C. Fishing amplifies forage fish population collapses .PNAS 2015. 112 (21) 6648-6652, doi:10.1073/pnas.1422020112

FAO. 1992. Fishery Statistics. FAO Yearbook. Fish.Stat. Catches Land., Rome, Vol.74.

FAO. 2012. Fisheries Committee for the Eastern Central Atlantic. Twentieth session. Main Outcomes of the Sixth Session of the Scientific Subcommittee. Rabat Morocco 14-16 March 2012. FAO 16 pp.

FAO/CECAF. 2009. Working Group on the Assessment of Small Pelagic Fish – Subgroup South Accra, Ghana, 19–28 October 2009. Report of the Working Group / Rapport du Groupe de travail FAO/COPACE sur l'évaluation des petits poissons pélagiques – Sous-groupe Sud Accra, Ghana, 19-28 octobre 2009.

Fisheries Commission. 2011.

Fisheries Commission. 2016.

Fréon. 1988. Réponses et adaptations des stocks de clupéidés d'Afrique de l'Ouest à variabilité du milieu et de l'exploitation: analyse et réflexion à partir de l'exemple du Sénégal(Responses and adaptations of clupeid stocks West Africa to the environmental variability and exploitation: an analysis and reflection from the example of Senegal). Ph.D.Thesis, Aix Marseille University, ORSTOM Editions, Paris, 287 pp.

Houghton, R. W. and M. A. Mensah. 1978. Physical Aspects and Biological Consequences of Ghanaian Coastal Upwelling 167-180pp *In* Boje, R. and M. Tomczak (Eds.) Upwelling Ecosystems, Springer-VerlagBerlin Heidelberg

Koranteng K.A. 1986. Size at first maturity of the anchovy (*Engraulis encrasicolus*) in Ghanaian waters and suggestions for appropriate mesh size in its fishery. FISHBYTE CEOS contribution No 19.

Lazar N. 2012. Small pelagics in upwelling systems: A wasp-waist interaction is West Africa. Climate change conference – Dakar 2012.

Longhurst, A.R. & D. Pauly. 1987. Ecology of Tropical Oceans. Academic Press, San Diego, 407 pp.

Lowe, R.T., 1838. A synopsis of the fishes of Madeira; with the principal synonyms, Portuguese names, and characters of the new genera and species. Trans. Zool. Soc. Lond. 2:173-200.

Binet D., E. Marchal, O. Pezennec, 1991. Sardinella aurita de Côte d'Ivoire et du Ghana. Fluctuations halieutiques et changements climatiques. Zn: P. Cury, @. Roy (ed.) Pêcheries ouest-africaines. Variabilité, instabilité et changement. Orstom. Paris. 320-342

Mensah MA, Koranteng KA.1988. A review of the oceanography and fisheries resources in the coastal waters of Ghana, 1981 – 1986. Fisheries Research and Utilisation Branch, Fisheries Department, Tema, p 35.

Mensah, M. A., Koranteng, K. A., Bortey, A., & Yeboah, D. A. (2006). The State of World Fisheries from a Fishworker Perspective: The Ghanaian Situation. SAMUDRA Monograph, Chennai: International Collective in Support of Fishworkers (ICSF), 88

Mustać, B. and Sinovčić, G. 2012. Inshore *versus* offshore length distribution of round sardinella (*Sardinella aurita)* in the middle eastern Adriatic Sea, Acta Adriat., 53(3): 341 - 351, 2012.

Nye, J.A., J.S. Link, J.A. Hare, and W.J. Overholtz. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast US continental shelf. Marine Ecology Progress Series 393:111-129.

Osei, I. (2015) Aspects of the biology of Sardinella aurita and Sardinella maderensis (Clupeidae) in the coastal waters of the central region, Ghana. MPhil Thesis, University of Cape Coast, Ghana. Pinsky, M. L., Worm, B., Fogarty, M. J., Sarmiento, J. L. & Levin, S. A. 2013. Marine taxa track local climate velocities. Science 341, 1239–1242 (2013).

Weatherdon, L., Rogers, A., Sumaila, R., Magnan, A., Cheung, W.W.L. 2015. The Oceans 2015 Initiative, Part II: An up-dated understanding of the observed and projected impacts of ocean warming and acidification on marine and coastal socioeconomic ac-tivities/sectors, Studies N°03/15, IDDRI, Paris, France. 46 pp.