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SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

ASSESSING THE BIOLOGICAL EFFECTS OF THE FISHERIES CLOSED SEASON IMPLEMENTED FOR THE ARTISANAL AND SEMI-INDUSTRIAL FISHERIES IN GHANA, 2019

Ministry of Fisheries and Aquaculture Develoment (MOFAD)

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY | CRC COASTAL RESOURCES CENTER

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Cover photo: Fisheries officer from Apam entering data on smartphone with two fishermen.

Photo credit: Najih Lazar

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ACRONYMS

CPUE	Catch per Unit of Effort
FC	Fisheries Commission
FEU	Fisheries Enforcement Unit
FL	Fork Length
FSSD	Fisheries Scientific Survey Division
GHC	Ghana Cedis
GSI	Gonado-Somatique Index
MCS	Monitoring, Control and Surveillance
MOFAD	Ministry of Fisheries and Aquaculture Development
MRD	Marine Resources Division
NAFAG	National Fisheries Association of Ghana
ODK	Open Data Kit
SFMP	Sustainable Fisheries Management Project
SST	Sea Surface Temperature
STWG	Scientifique and Technical Working Group
TL	Total Length
USAID	United States Agency for International Development

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INTRODUCTION

The Ministry of Fisheries and Aquaculture Development (MOFAD) implemented a one-month fishing ban for artisanal and semi-industrial fisheries from May 15 to June 15, 2019 to protect the spawning brood stock of small pelagic species, mainly *Sardinella aurita*, *Sardinella maderensis*, *Engraulis encrasicolus* and *Scomber colias* and reduce fishing effort on these stocks. The fisheries closure covered all marine areas and coastal estuaries of Ghana's EEZ. This is the first ever closed season implemented for these two sub-sectors since the adoption of the National Fisheries Management Plan as a result of the recommendation made by the Science and Technical Working Group[1] (STWG) in 2015 (STWG 2015) . The first attempt to close the fishery for the artisanal fishery was announced in 2018 but failed due to short notice and unresolved conflicts between the fishing industry regarding the timing of the closure and its impact on culture festivals. The Minister then tabled this decision and formed a special committee to review and recommend an appropriate timing in 2019 and address biological, socio-economic and cultural impacts on the fishery, fishermen and their livelihoods.

The Committee held several public and technical consultation meetings to collect industry's and other stakeholders' input. A suite of options was discussed at the STWG meeting held in Accra on March 13-14, 2019. This final recommendation included inputs by members of the STWG, which include representatives from government (MOFAD, FC, MSC, Regional Directors), academia, NGOs, artisanal, semi-industrial, industrial, women processors and the National Association of Fisheries of Ghana (NAFAG). The final recommendation balanced cultural, socio-economic and biological needs of fishers while maximizing benefits for small pelagic stock rebuilding. It also took into consideration long-term planning to provide adequate notice to the fishing industry in order to prepare and manage their business aspects during the fishing season. The final recommendation was approved by the STWG to close the fisheries for all fleet at the same time (except tuna) from July 1 to 31, 2019. The recommendation was signed by STWG members and submitted to MOFAD for consideration. In response and after further consultation, MOFAD selected an alternative period for the closed season from May 15 to June 15, 2019. It was argued that this decision had already been reached through prior consultations with the National Fisheries Association of Ghana (NAFAG), which preferred this period over the July closure because it was outside of the bumper season (July-August) in order to ease the economic burden on artisanal fisherfolks.

Following this final and formal declaration by MOFAD, the Fisheries Scientific Survey Division of the Fisheries Commission (FC/FSSD) in coordination with the STWG and with the support of the USAID/Ghana Sustainable Fisheries Management Project (SFMP), undertook studies to assess the biological and socio-economic effects of the closed season as part of the management measure. This report provides the findings of the study on biological effects of the closed season implemented from May 15 to June 15, 2019. The data considered in this report are from May 1, 2019 to March 28, 2020. The time of the study was considered adequate for measuring the indirect biological effects of the closed season.

[1] The Science and Technical Working group is an ad-hoc committee facilitated by the USAID/Ghana Sustainable Fisheries Management Project consisting of scientists from the Fisheries Statistical Services Division of the Fisheries Commission, local universities, NGO representatives as well as several individuals representing fisheries stakeholder groups.

SPAWNING SEASON

Small pelagic species spawn year around with two major peaks, both coinciding with the major peak upwelling between July and September and the minor upwelling (December-February) (Quaatey et al. 1999, Osei, 2015). The month of August has been consistently the largest peak for spawning by small pelagic species, also known as the "bumper" season by local fishermen. During this time, fish aggregate and move in large schools close to shore to spawn. They become vulnerable to fishing gear as they feed on the sea surface rich with plankton and attract birds which make them visible targets for fishermen. This peak spawning period has been determined by several scientific studies (Bakun, 1978; Koratang 1989; Osei, 2015; Bernacsek, 1986) and confirmed by local fishermen (Castro et al., 2017). The report by the STWG reviewed and summarized the scientific evidence regarding the major peak spawning period of small pelagics, confirmed that the peak spawning occurred during the month of August, consistently over twenty years. The STWG report recommended to close the small pelagic fisheries for one month, for all fleet, during this peak spawning season for few years in order to rebuild these stocks (Lazar et al., 2016).

Although the spawning season is expected to peak during the month of August, there are some variabilities in the intensity of spawning due to environmental factors such as the positive influence of optimum sea surface temperature, high intensity of coastal upwelling and wind direction. In addition, scientific evidence shows that coastal precipitation of the July-August period is also correlated with and influenced by equatorial sea-surface temperature (SST) which results in a decrease or increase in rainfall when SSTs are abnormally cold or warm, respectively. The areas that are more subject to coastal and equatorial SSTs occurred around Cape Three Points, where the coastal upwelling exhibits its highest concentration. The large fluctuations in the abundance and recruitment of small pelagic species are influenced by these environmental factors, as well as their relatively short life cycle, and therefore make these stocks particularly difficult to manage.

METHODOLOGY

Eight sampling sites were selected to represent the four coastal regions and with the highest landings in volume of small pelagics (Figure 1). In each landing site, an FC/FSSD enumerator and a zonal officer, both already in place by FC, were assigned biological sampling tasks following a training on biological sampling and use of mobile technologies, conducted by FC/FSSD with SFMP's support.

Biological data was collected using smartphones provided by FSSD on an application developed in KoBoToolbox[2] by SFMP for data entry and transmittal via internet. Each enumerator collected and uploaded the information weekly onto a cloud server database, maintained by FSSD coordinators who review and validate the data before uploading it to the master database.

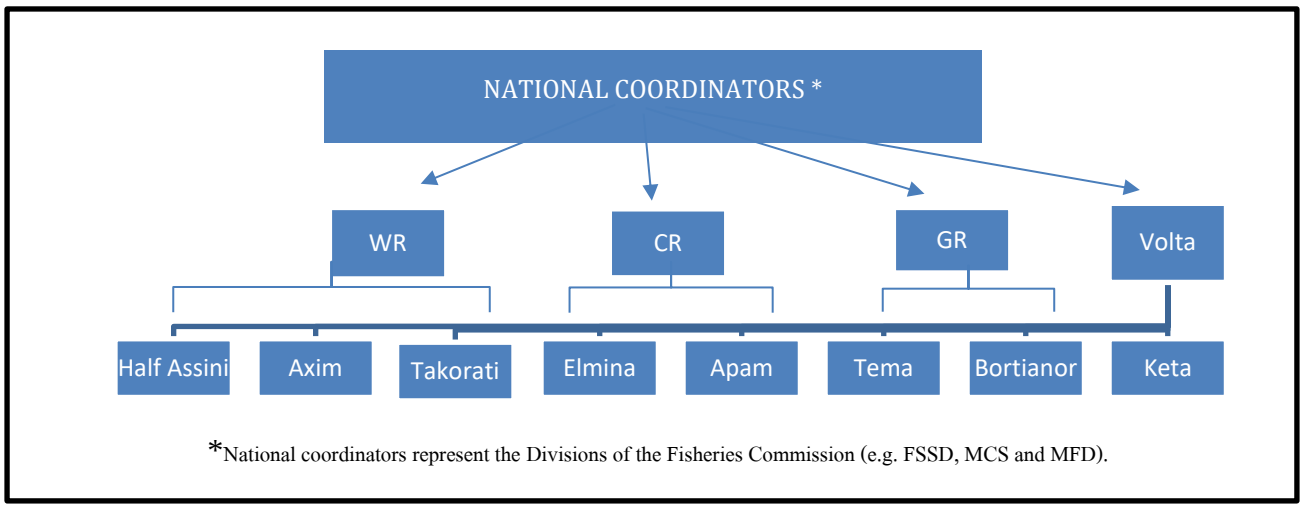

Figure 1 Sampling sites for biological monitoring of the closed season

In each coastal region, a zonal officer served as the regional coordinator to oversee and manage the data collection program in his/her region. The zonal officers operate under the direction of the national coordinators from FC-FSSD, FC-MSC and FC-MFD. The technical staff of SFMP assisted with the data management, analysis and report writing.

Biological monitoring was realized by monitoring key indicators through routine daily sampling of the size distribution of fish and the determination of the maturity stage and fecundity. A separate study relative to determining the fecundity (number and size of eggs) for the key species was conducted at the laboratories of the FSSD in collaboration with the University of Cape Coast.

Fish sampling occurred daily, except when there was no fishing due to bad weather or a fishing holiday. Two samples of 60-80 fish, representing the key small pelagic species were purchased directly from canoe or inshore vessels in each of the eight landings sites. Preference on purchases of samples was given in the following order of priority based on species availability:

1. *Sardinella aurita.*

[2] https://www.kobotoolbox.org/

2. *Sardinella maderensis.*
3. *Engraulis encrasicolus.*
4. *Scomber colias.*

In all cases, the enumerators were directed to focus on *Sardinella aurita* as the key species. Samples of this species were collected at least once per week. When samples were not available at the assigned landing site, the enumerator moved to search for fish at a nearby landing site. The enumerators collected other data associated with fishing operation, gear type, area fished, time spent at sea, total catch by species and prices.

For each sample, the enumerator measured each fish, determined the sex and the maturity stage. Enumerators were encouraged to engage fisherfolks to assist with the biological sampling as part of the participatory research agenda to learn together and foster buy-in about the results of this study. (Figure 2). Enumerators used biological sampling material and a Samsung smartphone for data entry provided by SFMP. An Android KoboToolbox application was developed by CRC and loaded in each smartphone to record data directly on the phone. At the end of the sampling day, a connection is made with the internet through the mobile phone network and newly collected data are sent to a cloud server.

Figure 2 Enumerators and fishermen working together to collect biological data for monitoring the effects of fisheries closed season 2019

Once per week, the coordinator connects with the server in the cloud and downloads the collected data of all landing sites. The following biological parameters were recorded directly on smartphones and transmitted to the database on the cloud server for validation and processing:

- Total weight of the sample (Kgs.).
- Fork length (FL) to the nearest ½ centimeter.
- Total length (TL) to the nearest ½ centimeter.
- Sex (Male or Female).
- Maturity stage (see maturity schedule in Table 1).
- Gonad weight (gr.).

The statistical design of this study was based on a *before*-and-*after* statistical design (Figure 3). This method is most useful in demonstrating the trends of key parameters and detect the significances of any differences between the before and after the treatment (closed season).

As implied, it is about comparing key biological parameters of small pelagic species before and after the seasonal closure. Ideally, the pre-closure data collection should have been initiated at least for one month prior to the closure to establish an adequate baseline situation. Unfortunately, the data collection began only one week before the start of the closed season due the late official declaration of the closed season by MOFAD. No sampling occurred during the closed season but resumed immediately when fisheries started fishing after the fishery opened again.

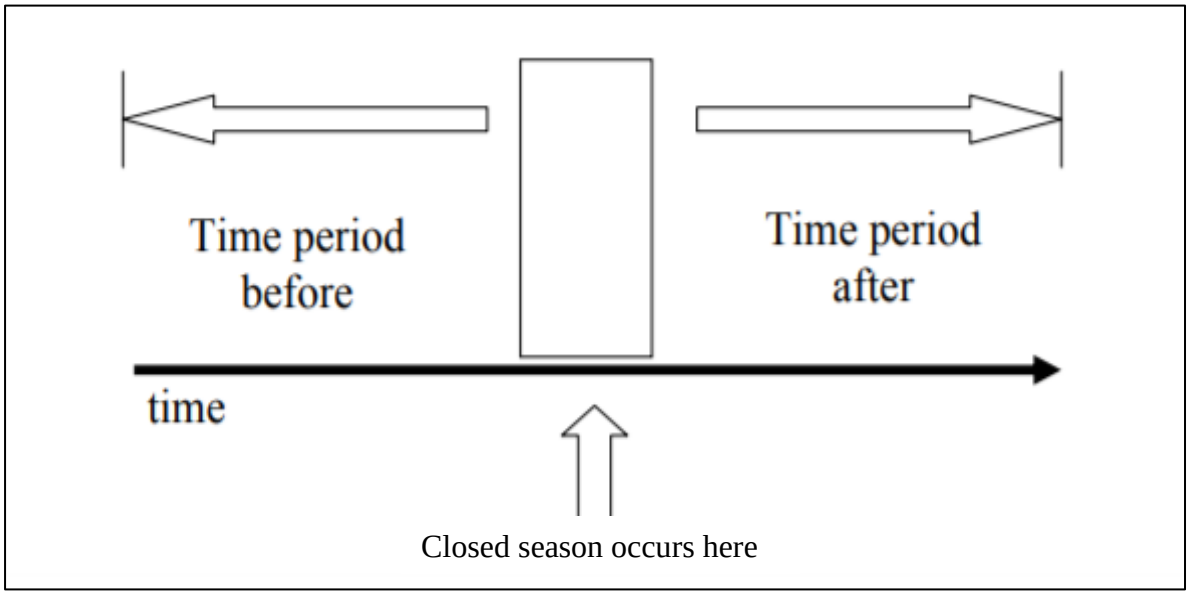

Figure 3 Before and after design diagram

Table 1 Description of the maturity stages applied to pelagic and demersal finfish species

Maturity Stage	State	Gonads Features
STAGE I	Immature	Ovary and testis about 1/3 of body cavity. Ovaries pinkish, translucent, testis whitish. Ova visible to naked eye
STAGE II	Maturing	Ovary and testis about 1/2 of body cavity. Ovaries pinkish, translucent, testis whitish, symmetrical. Ova NOT visible to naked eye
STAGE III	Ripening	Ovary and testis about 2/3 of body cavity. Ovary pinkish yellow color with granular appearance, testis whitish to creamy. No transparent of translucent ova visible.
STAGE IV	Ripe	Ovary and testis from 2/3 to full length of body cavity. Ovary orange-pink in color with conspicuous superficial blood vessels. Large transparent, ripe ova visible. Testis whitish-creamy, soft
STAGE V	Spent	Ovary and testis shrunken to about ½ length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent. Testis bloodshot and flabby.

A special study relative to fecundity (number of eggs produced by each mature female fish) was conducted in Tema by FSSD officers for key small pelagic species. This consisted of taking samples of 10-15 gravid females with advanced maturity stage with visible eggs, then measured as above with additional measurements at the laboratory as follows:

Laboratory work

- The fork and total length to the nearest ½ cm (FL, TL) and body weight (gr.) of each fish was measured.
- Gonadal stages of ovaries determined by macroscopic and microscopic examination.
- Gonads were weighed (gr.) for estimation of GSI[3].
- Ripe (mature) ovaries stored in Gilson's fluid and the eggs separated for determination fecundity using the sub-sampling technique.
- Eggs from five ripe ovaries of each species were counted under microscope.

Fisheries data collection

During the sampling period, the enumerator collected additional information regarding the fishing operation and the average daily market price of fish for all the four species; *Sardinella aurita,* Sardinella *maderensis, Engraulis encrasicolus and Scomber colias.* In addition, the enumerator collected information regarding the gear used during the fishing, the duration of the trip, area fished and the total catch by species. This information established the average Catch-Per-Unit of Effort (CPUE) and average price for before and after the closed season.

- Gear used (Ali-Poli-Watcha or purse seine).
- Set Nets or gillnets.
- Beach seine and others.

[3] The gonadosomatic index (GSI = (Gonad Weight/Weight of the Fish) x 100) describes the relative size of gonads will be used as indicator for the reproductive activity and to determine where the peak spawning occurs.

RESULTS

Compliance with the seasonal closure

The FC reported that fishermen complied with the closed season. Fishermen's reports also confirmed high compliance with the law during this closed season. With the support of USAID/Ghana SFMP, a communications campaign by MOFAD and the Fisheries Commission was launched immediately after the declaration through several media outlets which helped achieve this level of high voluntary compliance across all regions.

Participatory biological sampling

In each of the sampling sites, enumerators invited fishermen and women processors to participate in sampling and data measurements on a daily basis. This was an attempt to inform fishermen about the study and to engage them to add value to the data collection through their local knowledge and experience. The level of participation was significantly higher than expected, especially when they were asked their opinion about the biological aspects of the species collected and their knowledge about the fishery.

A total of 253 samples were taken and 13,819 individual fish were inspected and recorded. The frequency of samples taken by region, landing site, gear type and species are presented in Figures 4, 5, 6 and 7 below. Generally, the sampling frequency for each category was proportional to the total small pelagic landings. For example, about 40% of total samples were taken from the Western Region representing the equivalent of 40% total small pelagic landings from this region.

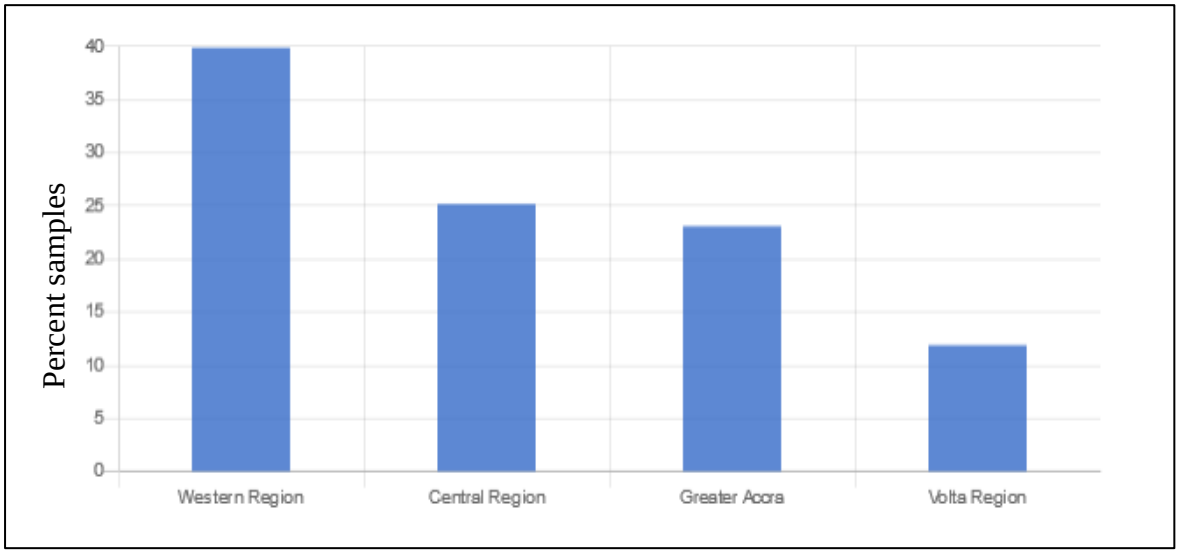

Figure 4 Samples taken by region

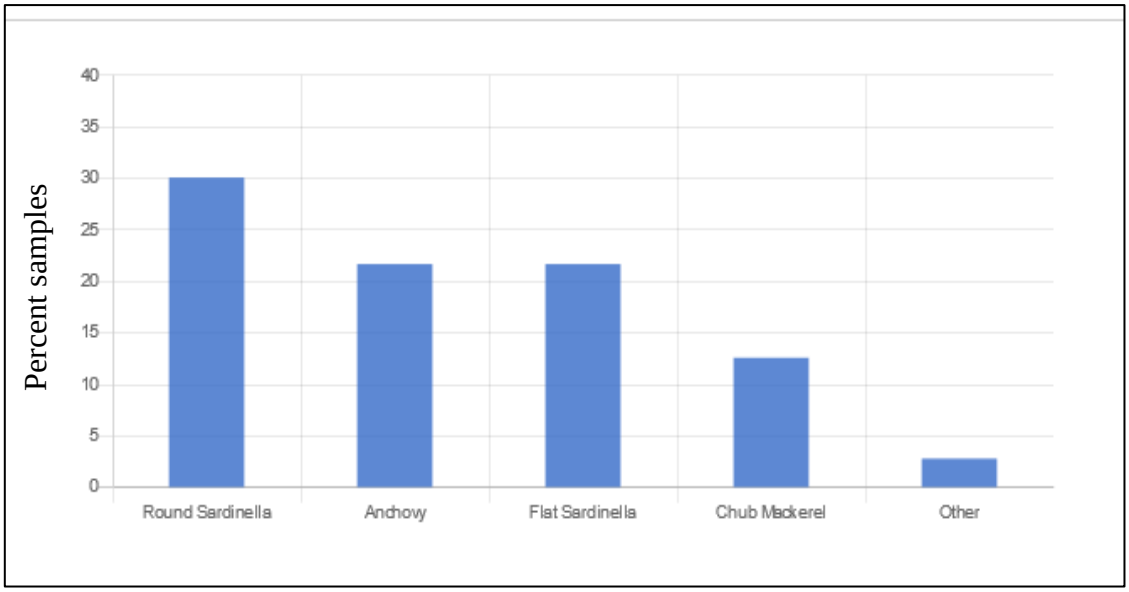

Figure 5 Samples taken by landing site

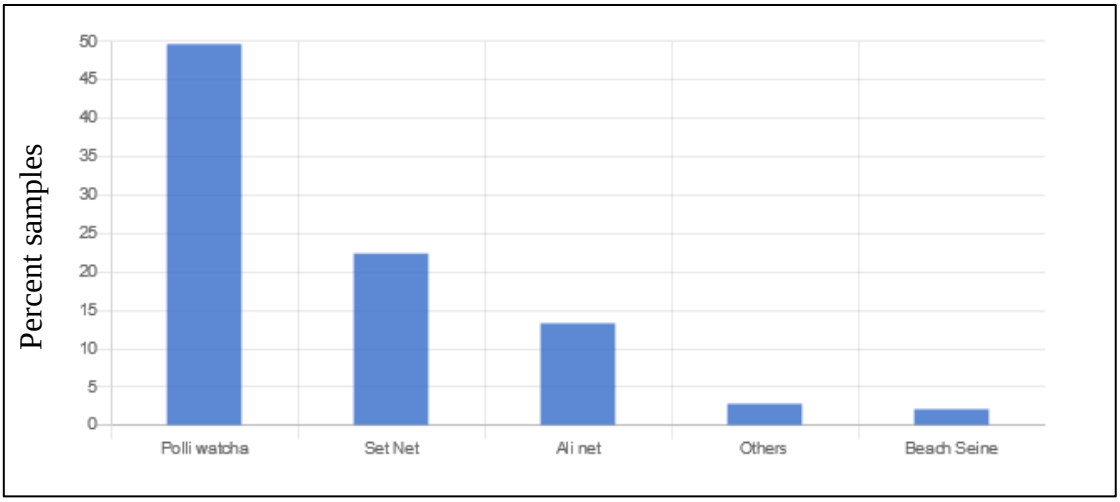

Figure 6 Samples taken by gear type

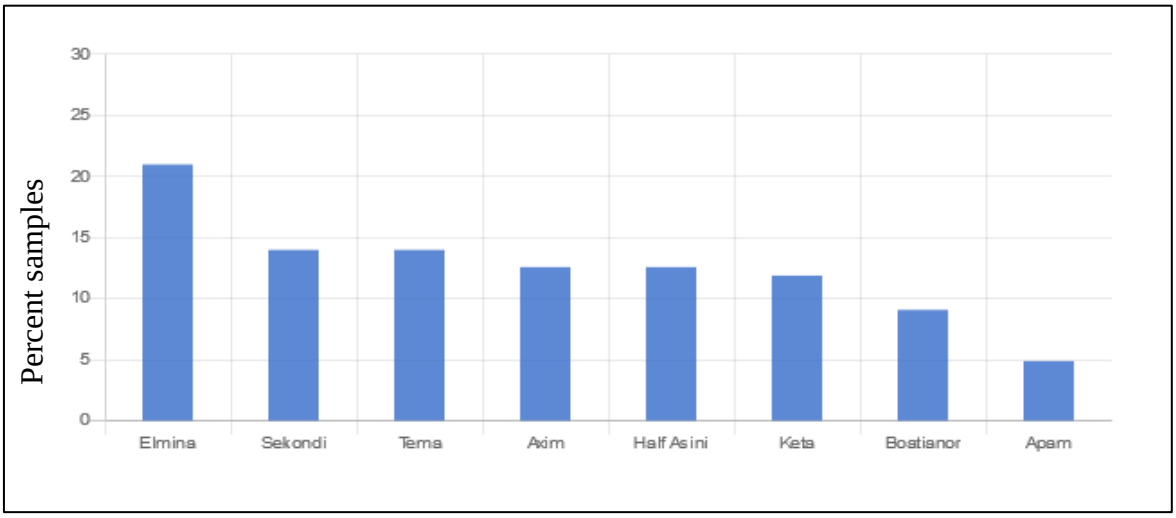

Figure 7 Samples taken by species

Changes in price and catch

Chub mackerel and anchovies were the dominant species of the total small pelagic landings (Table 2). The average price index increased by 12% for Sardinella and 23% for chub mackerel post closed season. The average price per pan of *Sardinella aurita* varied during the sampling period (Figure 8). It was at its lowest in the two weeks just before the closure and spiked to a high immediately afterwards, then dropped during August – Sept period which is the "bumper harvest" season when supply is most abundant. While the price post-closed season is much higher that then 2-week period prior to the closed season, we do not have enough time series data before the closed season (e.g. Jan – April) to be certain as to whether the 2-week period of sampling in May was reflective of the price several months prior to the closure. However, the average price per kg. of anchovies remained stable during the period before the closed season throughout the four months after the opening of the fishery.

Table 2 Catch, value and price per kg of the four main small pelagic species

Species	Kgs./Trip	Value/Trip (GHC)	Mean Price (GHC) per Kg.
Round Sardinella	348.05	690.34	1.87
Flat Sardinella	217.54	380.06	1.66
Anchovy	396.41	395.50	1.17
Chub Mackerel	2095.49	8482.58	4.05

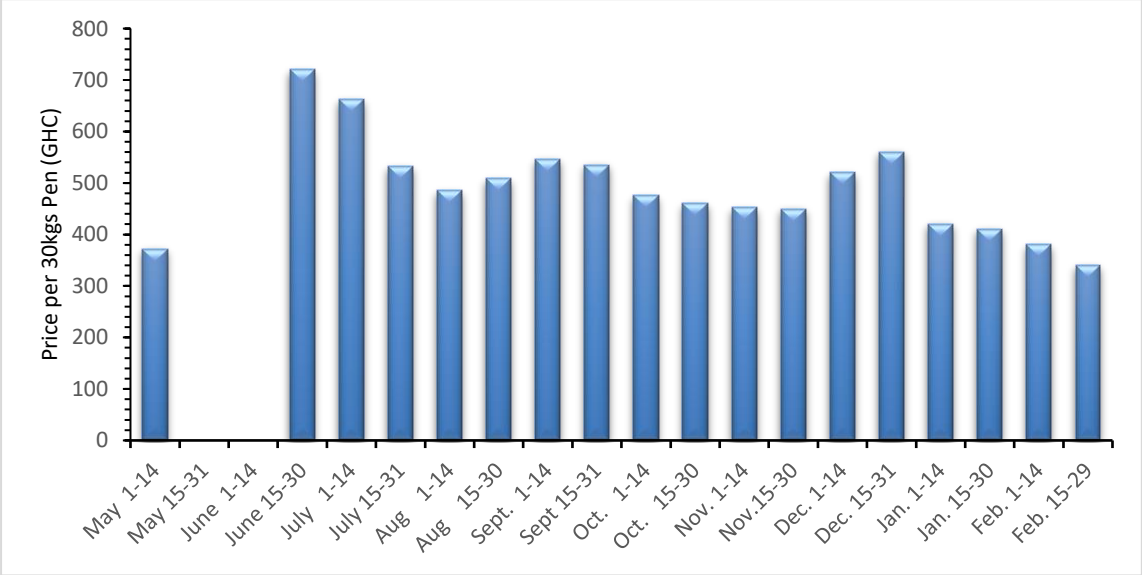

Figure 8 Average price of *Sardinella aurita* per pen[4] in Ghana cedis

Changes in gonad weight over time

The average gonadal weights for all species combined in grams for each ½ month from May 1 to February 29, 2020 showed that peak spawning occurred during the second half of July.

[4] Pen is an aluminum bowl used for holding fish. The average weight of a pen full of small pelagic fish is 30 kgs.

The peak spawning for *sardinella aurita* was observed in late July to early August, while the spawning peak for *Sardinella maderensis* was observed two weeks earlier, in early July while that of anchovies was observed in late August. These spawning events for all four species of small pelagics were very high during this period between July and August, which coincided with the peak upwelling event observed through satellite imageries from NOAA[5]. This is consistent with upwelling events and frequencies observed for the last twenty years, and as reported in the STWG report on closed season (STWG, 2016). No data were collected during the closed season, however the trajectory of the gonadal mean weight was low during May and June, suggesting that small pelagic species have not reached peak spawning during the closed season (Figure 9).

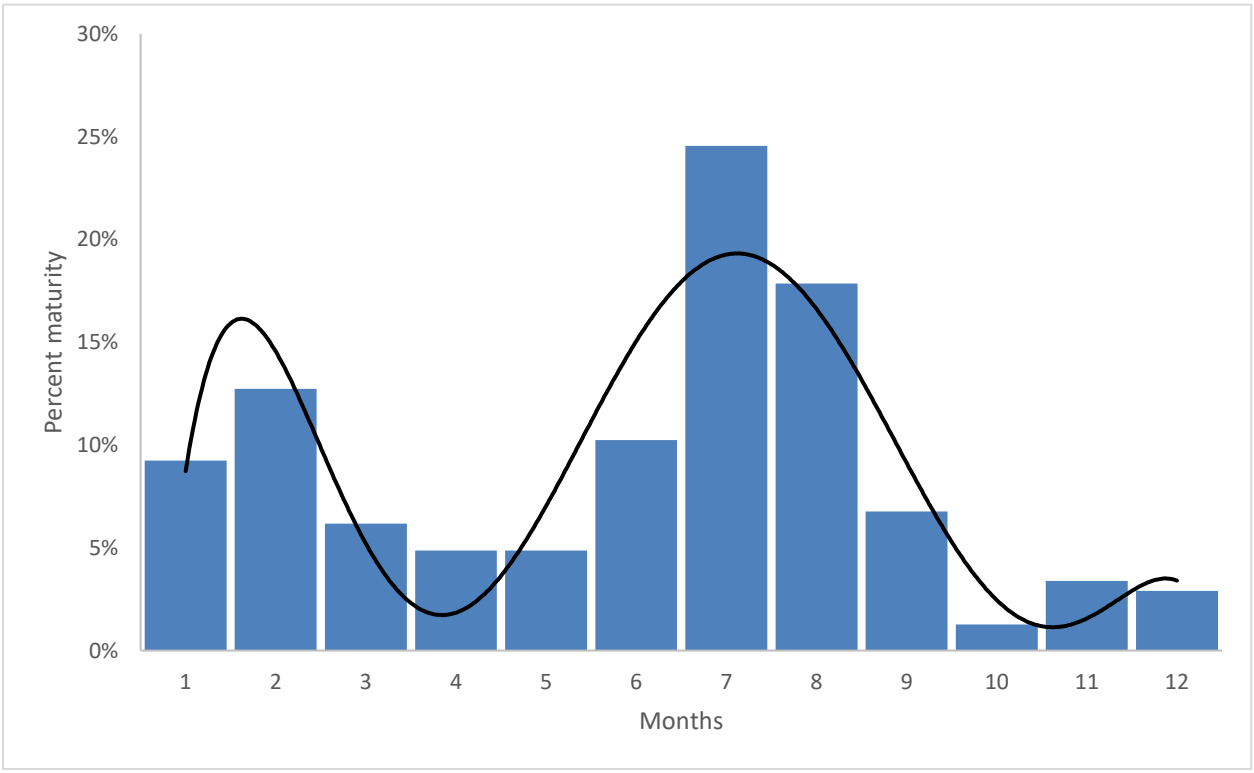

Figure 9 Percent maturity of *Sardinella aurita*, sexes combined, by month

Catch per unit of effort

The average catch per unit of effort (CPUE) of all small pelagic species combined varied from 100 kgs/trip to 700 kgs/trip during the period May 1, 2019 to February 29, 2020 (Fig. 10). The peak CPUE was during the first and second half of the month of August, which coincides with the peak upwelling and food availability for fish to aggregate and migrate from offshore to nearshore. The CPUE before closed season was about 100 kgs/trip, although low sample size did not provide a full contrast of the changes in CPUE before and after closed season. This seasonal variation of CPUE is consistent with fish availability and increased catchability during the mass migration of adult fish in coastal areas triggered by upwelling events and spawning behavior (Figure 10).

[5] https://www.nhc.noaa.gov/satellite.php

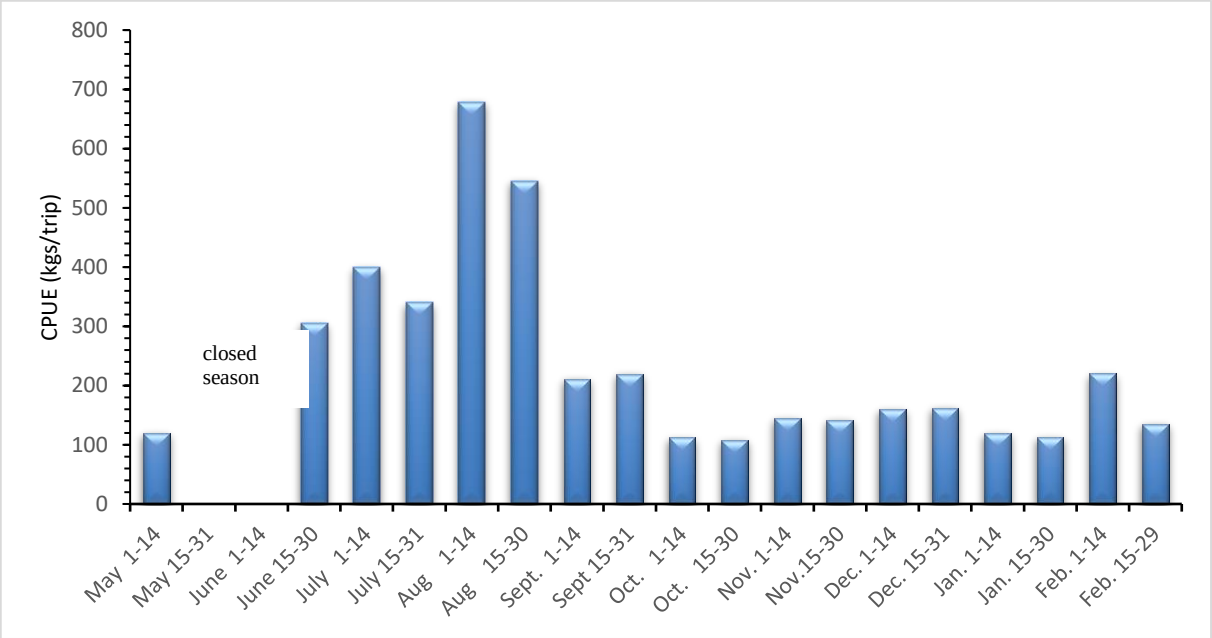

Figure 10 Catch Per Unit of Effort by canoes of small pelagics by 1/2 month period from May 1, 2019 to February 29, 2020

Size structure

Length frequencies of *Sardinella aurita* showed a multi-modal distribution during the period from June to September. This represent the presence of multiple year classes including a large portion of juvenile fish born during spawning season. During this period the epicenter of fish population of the small pelagics is nearshore and available to all various gears of the artisanal fisheries. The average length of the catch is on average below the legal minimum size (18 cm) with the exception of the catch during the months of August and September.

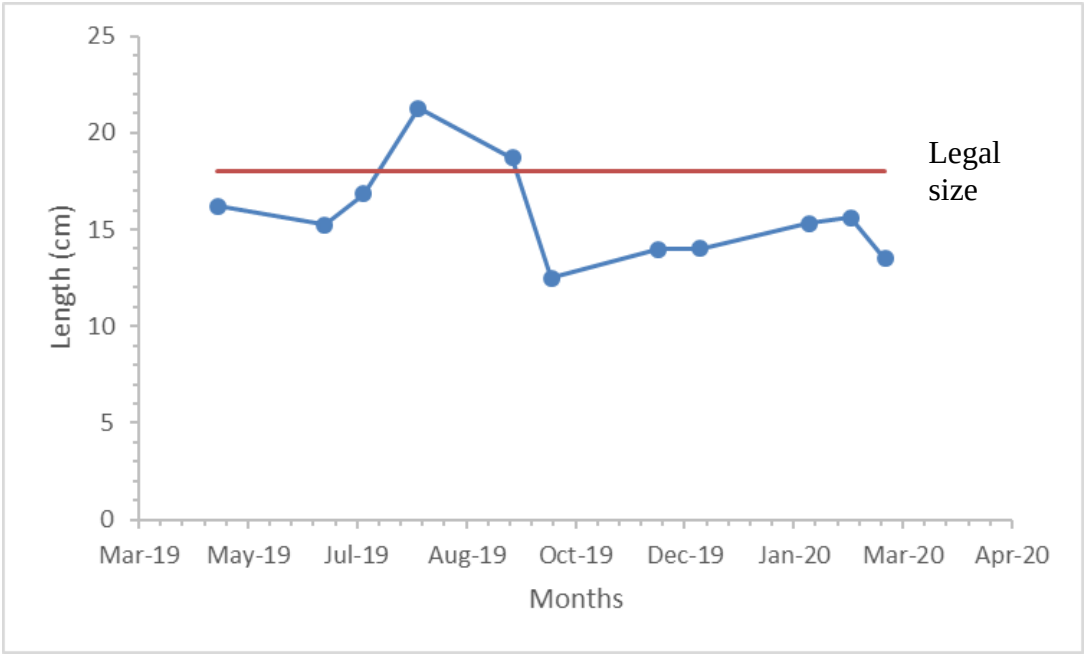

Figure 11 Mean length of Sardinella aurita, May 1, 2019 to March, 2020

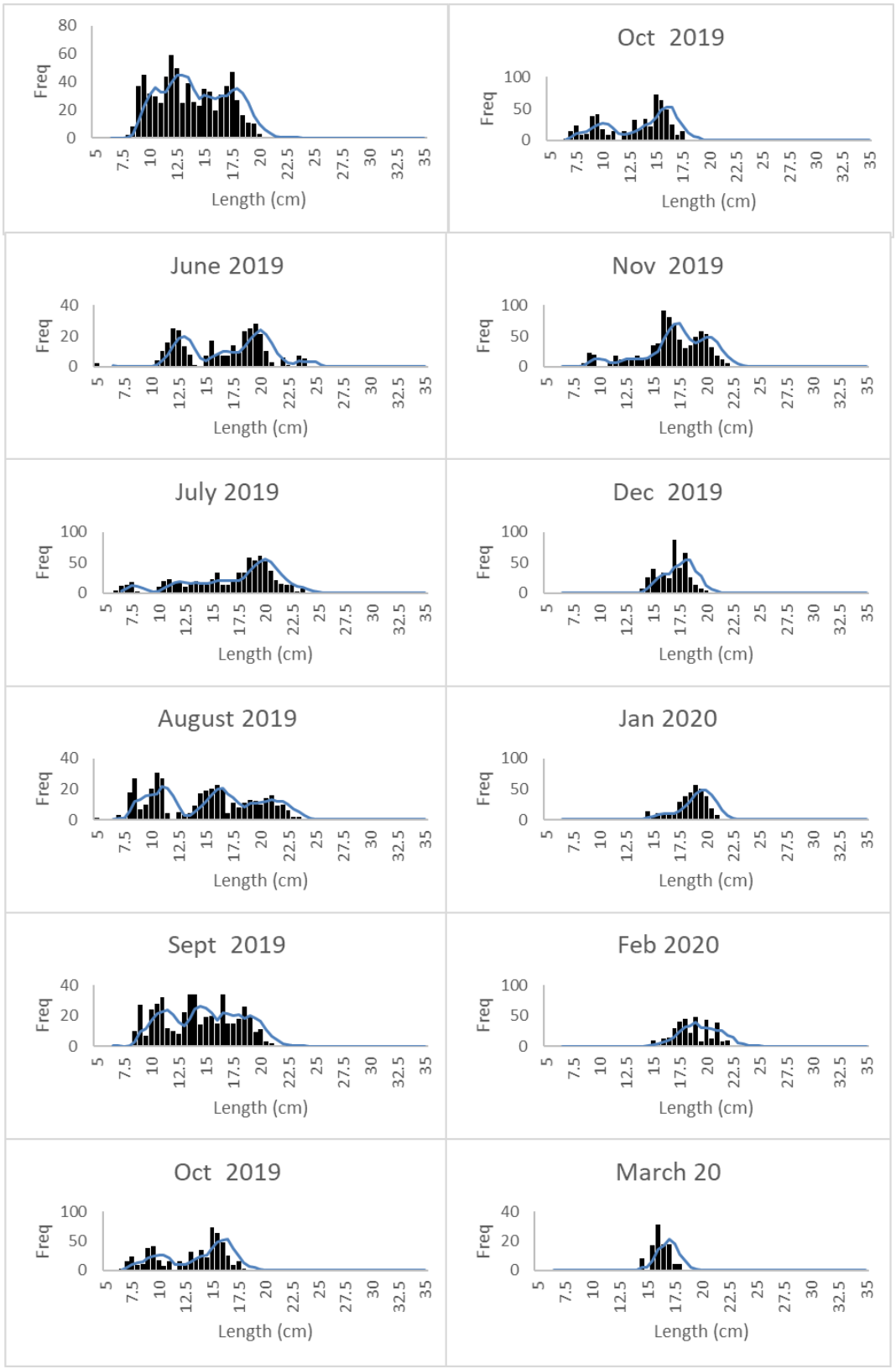

Figure 12 Length frequencies of fish samples of *Sardinella aurita* collected from the artisanal fisheries between May 2019 and March 2020

CONCLUSIONS

The biological assessment of the closed season for the canoe and semi-industrial sectors showed that the closed season timed during the period from May 15 to June 15, 2019 did not coincide with the peak spawning period. This was evidenced by the average maturity and gonad weight being low during the closed season and at a peak in the August period. The period of lowest spawning occurred from May through June, and in October. The closed season (May 15 to June 15) had the lowest level of spawning and therefore the least preferred period for biological benefits consideration. Therefore, the 2019 closure did not produce the desired effects which were to maximize the reproductive potential of small pelagic species during their peak spawning period. It should be noted however, that the closure for the industrial trawlers during August and September was timed with peak spawning, and as trawlers now account for significant but difficult to quantify level of small pelagic landings via “saiko”, probably had some level of beneficial impact on these stocks. The high voluntary compliance and the overwhelming support by fishermen and women processors for a closed season was a good sign for adjusting future seasonal closures for the canoe and trawler fleet within the periods of the peak spawning.

RECOMMENDATIONS

The results of the biological monitoring suggest that seasonal closures for the small pelagic fishery should be timed during the peak spawning period between early July through August, with the optimum period being the month of August. Bearing in mind the importance of cultural celebrations in fishing communities occurring in early August, a seasonal closure before and/or after the cultural celebration is acceptable.

The STWG maintains its original recommendation to close the fishery for small pelagic fisheries during the month of July to early August for all fleets with the exception of tuna fisheries. This closure will provide high spawning potential and should contribute greatly to the rebuilding efforts of depleted fish stocks.

Actual dates should be negotiated by the Fisheries Commission and representatives of the various fisheries and professional organization (GNCFC, GIFA and NAPFTA and NAFAG), STWG and other stakeholders. It is recommended that the industrial trawler closure be maintained annually for the months of August and September.

Adequate public notice should be given to fisherfolk prior to the 2021 closure, at least six months or longer in advance so that fishermen can adapt and plan their businesses for the closed season. The closure for all fleets should be made annual and predictable during the same period each year.

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ANNEX 1: SURVEY FORM

Biological Monitoring

FORM 1: BIOLOGICAL STUDIES

Enumerator

NAME OF ENUMERATOR *	ENUMERATOR'S MOBILE NUMBER *

Location

REGION *	SITE *
0 Greater Accra	0 Terna
0 Central Region	0 Boatianor
0 Western Region	0 Elmina
0 Volta Region	0 Apam
	0 Half Asini
	0 Sekondi
	0 Keta
	0 Axim

GPS

LOCATION

latitude (x.y °)

longitude (x.y °)

altitude (m)

accuracy (m)

CANOE INFORMATION

FISHING GEAR TYPE	CANOE REGISTRATION NUMBER *	WHAT WAS THE TRIP DURATIC OIFNOTKNOWN
0 Polli watcha 0 Beach Seine 0 Set Net 0 Ali net 0 Others		

Catch in kilograms

TOTAL CATCH ROUND SARDINELLA (KG)	TOTAL CATCH FLAT SARDIN ELLA (KG)	TOTAL CATCH ANCHOVY (KG)	TOTAL CATCH MACKERAL (KG)

Price in Ghana GHS

AVERAGE DAILY PRICE ROUND SARDINELLA	AVERAGE DAILY PRICE FLAT SARDIN ELLA	AVERAGE DAILY PRICE ANCHOVY	AVERAGE DAILY PRICE MACKERAL

Subsample taken for biological measurements

SELECT SPECIES FOR LENGTH WEIGHT MEASUREMENTS	WHAT IS THE TOTAL WEIGHT OF THE SAMPLE TAKEN FOR BIOLOGICAL MEASUREMENTS? (KG)
0 Round Sardinella 0 Flat Sardinella 0 Anchovy 0 Chub Mackerel 0 Other	

Repeat for each fish measured

» **Fish data**

FORK LENGTH (CM) *	TOTAL LENGTH (CM) *	INDIVIDUAL WEIGHT (GR) *	SEX 0 Male 0 Female