ANAYSIS OF GHANAIAN INDUSTRIAL TUNA FISHERIES DATA: TOWARDS TASKS I AND II FOR 2006-2012

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SUMMARY

Ghanaian industrial tuna fisheries collected during 2006-2012 were analysed to define the main features of the available datasets and propose a framework for estimating the ICCAT tasks I and II. Data coverage and quality have greatly improved over the recent years as reflected by the increasing amount of logbooks collected, the decrease in the proportion of unknown type schools in the baitboat (BB) and purse seiner (PS) logbooks, the consistency between landings and logbook catches that were found to be very close to the total task I declared in 2012. For the first time in 2012, all logbooks for the PANOFI fleet became available and enabled to improve our understanding of the spatio-temporal patterns of this major component of the Ghanaian PS fleet, which represented about 50% of the total PS catch during 2006-2012. Regarding the difference in fishing grounds between the PANOFI purse seiners and the rest of the fleet, we propose to consider 3 distinct fleets for data processing: (i) baitboats, (ii) the PS PANOFI fleet (P-Fleet), and the other purse seiners (A-Fleet). Based on all data available, we first propose to increase the total task I of Ghanaian BB and PS for some years. Second, we make some assumptions to distribute the total catch between fleets and in time (months) and space (5°-squares of latitude and longitude). Third, we justify the use of size-samples collected from European purse seiner sets made on fish-aggregating devices (FADs) to estimate the size and species composition of Ghanaian BB and PS. We used a sampling scheme based on years and three spatial areas to estimate the species composition of the Ghanaian BB and PS. This sampling however results in some small numbers of samples for some strata which could bias the species composition. Based on the results of the processing, we propose a new Task I for Ghanaian tuna fisheries for 2006-2012. Perspectives of the work are presented, including some extensions of the tool T3+ currently in development which is devoted to the processing of BB and PS data and could strongly facilitate future analyses of Ghanaian fisheries data.

RÉSUMÉ

Les données des pêcheries industrielles de thonidés ghanéennes recueillies entre 2006 et 2012 ont été analysées afin de définir les principales caractéristiques des jeux de données disponibles et proposer un cadre d'estimation des données de Tâche I et II de l'ICCAT. La couverture et la qualité des données se sont nettement améliorées au cours de ces dernières années grâce au volume croissant des carnets de pêche recueillis, à la diminution de la proportion des types de bancs inconnus dans les carnets de pêche des canneurs (BB) et des senneurs (PS), à la cohérence entre les débarquements et les prises consignées dans les livres de bord qui se sont avérées très proches du total de la Tâche I déclaré en 2012. Pour la première fois en 2012, tous les carnets de pêche pour la flottille PANOFI ont été disponibles et ont permis d'améliorer notre compréhension des schémas spatio-temporels de cet élément important de la flottille de senneurs ghanéens, qui représentait environ 50% de la prise totale des senneurs entre 2006 et 2012. En ce qui concerne la différence de zones de pêche entre les senneurs de la flottille PANOFI et le reste de la flottille, nous proposons d'envisager trois flottilles distinctes aux fins du traitement des données : (i) canneurs, (ii) flottille de senneurs PANOFI (P-Fleet) et les autres senneurs (A-Fleet). Sur la base de toutes les données disponibles, nous proposons d'abord d'augmenter le total de la Tâche I des canneurs et senneurs ghanéens pour certaines années. Deuxièmement, nous formulons des postulats afin de distribuer la prise totale entre les flottilles et dans le temps (mois) et l'espace (carrés de 5º de

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latitude et longitude). Troisièmement, nous justifions l'emploi d'échantillons de taille prélevés pendant les opérations des senneurs européens réalisées sur des dispositifs de concentration du poisson (DCP) afin d'estimer la composition par espèce et par taille des prises des canneurs et des senneurs ghanéens. Nous avons utilisé un programme d'échantillonnage basé sur les années et trois zones spatiales afin d'estimer la composition des espèces des prises des canneurs et des senneurs ghanéens. Cet échantillonnage a toutefois été réalisé avec un nombre réduit d'échantillons pour certaines strates, ce qui pourrait fausser la composition des espèces. En fonction des résultats obtenus du traitement, nous proposons une nouvelle Tâche I pour les pêcheries de thonidés ghanéennes pour 2006-2012. Les perspectives des travaux sont présentées, y compris quelques extensions de l'outil T3+ en cours d'élaboration qui est dédié au traitement des données des canneurs et des senneurs et pourrait fortement faciliter les futures analyses des données des pêcheries ghanéennes.

RESUMEN

Se analizaron los datos de la pesquería industrial de túnidos de Ghana recopilados desde 2006 hasta 2012 para definir los rasgos principales de los conjuntos de datos disponibles y proponer un marco para estimar la Tarea I y la Tarea II de ICCAT. La cobertura y calidad de los datos ha mejorado en gran medida en años recientes, tal y como se evidencia en el mayor número de cuadernos de pesca recopilados, el descenso de la proporción de tipo de bancos desconocidos en los cuadernos de pesca de los cañeros (BB) y cerqueros (PS), la coherencia entre los desembarques y las capturas de los cuadernos de pesca, que recogen cantidades muy similares al total de Tarea I declarado en 2012. Por primera vez en 2012, todos los cuadernos de pesca para la flota PANOFI estuvieron disponibles y permitieron mejorar nuestra comprensión del patrón espacio-temporal de este importante componente de la flota de cerco de Ghana, que respondió de aproximadamente el 50% de la captura de cerco total durante 2006-2012. En cuanto a la diferencia en los caladeros entre los cerqueros de PANOFI y el resto de la flota, proponemos que se consideren tres flotas diferentes a efectos de procesamiento de los datos: (i) cerqueros, (ii) flota de cerqueros de PANOFI (flota P), y otros cerqueros (flota A). Basándose en los datos disponibles, proponemos en primer lugar un incremento del total de Tarea I de BB y PS de Ghana para algunos años. En segundo lugar, empleamos algunos supuestos para distribuir la captura total entre las flotas y en el tiempo (meses) y en el espacio (cuadrículas de 5º de latitud y longitud). En tercer lugar, justificamos la utilización de muestras de talla recogidas en lances de los cerqueros europeos realizados sobre dispositivos de concentración de peces (DCP) para estimar la composición por tallas y especies de BB y PS de Ghana. Utilizamos un programa de muestreo basado en los años y tres zonas espaciales para estimar la composición por especies de BB y PS de Ghana. Sin embargo, este muestreo tiene como resultado algunos números pequeños de muestras para algunos estratos lo que podría sesgar la composición por especies. Basándose en los resultados del procesamiento, proponemos una nueva Tarea I para las pesquerías de túnidos de Ghana para el periodo 206-2012. Se incluyen algunas perspectivas de trabajo como la ampliación de la herramienta T3+, que se está desarrollando actualmente y que sirve para procesar los datos BB y PS y podría facilitar en gran medida los análisis futuros de los datos de las pesquerías de Ghana.

KEYWORDS

Baitboat, Purse seining, FAD, bigeye, skipjack, yellowfin

1 Introduction

The monitoring of the Ghanaian industrial tuna fisheries has improved in the recent years through better data collection of purse seine (PS) and baitboat (BB) data. Fonteneau et al. (2013) made a comprehensive analysis of the Ghanaian fisheries data collected during 1996-2005 and identified gaps and caveats in the data to draw directions for the processing of data available for 2006-2012. Following a workshop conducted between MFRD and IRD in May 2013, a full AVDTH (v3.3) database compiling all available information on fisheries logbooks, landings (i.e. sale records), and size samples covering the period 2006-2012 was built. Damiano et al. (2013) showed that the sampling of tuna landings conducted in Ghana until July 2012 resulted in some bias in size-frequency histograms. Sampling operations have been modified since then to comply with the standard protocol used for the European purse seine and baitboat fisheries (Damiano et al. 2013). The present document aims to describe the steps and assumptions used to process the Ghanaian fisheries data and estimate the Tasks I and II for the period 2006-2012. First, a general description of the data is made to assess the overall data quality and point out some of the assumptions required for data processing. The steps for processing the Ghanaian fisheries data are then presented so as provide a framework to estimate the ICCAT tasks I and II.

2 Data description

Following the workshop held in May 2013, corrections were made in the referential list of Ghanaian vessels (Chassot et al. 2013). The number of active BB was found to be consistent between landings and logbooks and decreased from 20 in 2006 to 14 in 2012 (**Table 1**). By contrast, information on the number of active PS differed between landings and logbooks and data availability improved over the years with logbooks and landings data becoming available in 2012 for 16 Ghanaian PS (**Table 1**). Little information was available in 2007 for both fishing gears. The annual number of days of activity per vessel recorded in the logbooks strongly varied between vessels for both fishing gears. The overall median value was 186 d y^{-1} and 174 d y^{-1} for BB and PS, respectively (**Figure 1**).

The information available in the Ghanaian vessel logbooks improved over 2006-2012 for both BB and PS. The cumulated catch declared in all vessel logbooks increased from a total of about 45,000 t in 2006 to almost 80,000 t in 2012 (**Figure 2**). In 2012, total catches and landings were at similar levels and close to the total Task I (**Table 4**). Meanwhile, the percentage of schools of indeterminate type decreased from 80% to 10% and from 25% to 5% for BB and PS, respectively (**Figure 3**). During 2010-2012, when the percentage of indeterminate schools was low (<13%), fish aggregating devices (FAD) sets represented 55% (SD = 8%) of all BB sets. By contrast, FAD-fishing largely predominated in the PS fishery, representing 85% of all sets during 2006-2012 (**Figure 3**). The success rates of PS sets on FADs and free-swimming schools (FSC) were found to be 98% and 85%, respectively. This would suggest that some null sets might not be recorded in the logbooks as the success rates on FAD and FSC sets for the European PS fishery are generally close to 95% and 70%, respectively (Delgado de Molina et al. 2013).

In 2012, logbook information became fully available for the PANOFI fleet (P-fleet) which was composed of 6 purse seiners: Frontier, Master, Volunteer, Discoverer, Pathfinder, and Forerunner. The cumulated catch of the P-fleet was more than 27,000 t in 2012, representing 50% of the catch of the Ghanaian PS fishery (**Table 2**). Little information from the logbooks was available for the P-fleet for the period 2006-2011.

Landing data indicated that the number of PANOFI vessels increased from 3 to 6 in 2010. The website of Silla (http://www.sla.co.kr/eng/E2_1_5.htm) indicates that the Discoverer and Forerunner entered in operation in September and November 2009, respectively. The P-fleet represented >50% of the total PS landings during 2010-2012 (**Table 3**). The total landings of the P-fleet recorded in 2008-2009 appeared small relative to the landings recorded during 2006-2007. Little information on the activity of the PANOFI vessels is however available for this fleet during 2006-2011 but landings at around 17,000 t y^{-1} are rather consistent with an annual catch of about 5,000-6,000 t for 3 purse seiners of length overall of 56-57 m.

The spatial distribution of the catch of the P-fleet derived from 2012 logbooks was found to differ with the rest of the PS fleet (A-fleet), extending more toward the western part of the eastern Atlantic Ocean in each quarter of the year (**Figures 4-5**).

3 Processing of the catch data

The processing of the fisheries catch is composed of 5 steps (**Figure 6**). First, the total catch for each fishing gear is estimated from the different data sources available, i.e. current ICCAT Task I, logbooks, and landings. The total catch is split between the PANOFI (P-Fleet) and other PS (A-Fleet) and the BB. Second, the total catch is distributed among months based on the monthly seasonality derived from logbook data on a yearly basis. Third, the monthly total catch is distributed in space according to information available in the logbooks and accounting for the difference in spatial distribution between the 3 fleets. Finally, size samples available from the European purse seine fleet are used to estimate the species and size composition of the catch during 2006-2012 based on a spatio-temporal stratification proposed by Fonteneau et al. (2013).

3.1 Total annual catch

The total catches derived from PS and BB logbook declarations and landings available in the Ghana database were found to exceed the current ICCAT Task I in some years (**Table 4**). Considering the maximum value of the 3 data sources available, **Table 4** gives a proposal of modification of the total Ghana Task I in 2006 and 2011-2012 for the BB and in 2006, 2008-2012 for the PS. The new total Task I would result in a substantial increase in the total catch for BB in 2011 (+51.9%) and in the PS for 2006 (+99.5%), 2008 (+91.6%) and 2009 (+36.5%). Note than landings are estimated for the year of unloading which differs a bit from the year of catch due to trips overlapping two years.

The total annual PS catch was then split between the P-Fleet and the A-Fleet. For 2009-2012, we assumed that the catches recorded in the logbooks of the A-Fleet were reliable (**Table 2**) and computed the total catch of the P-Fleet as the difference between the proposed total Task I and the catch of the A-Fleet (**Table 4**). For 2006 and 2008, the percentage of catch for each fleet was derived from their respective contribution to the total landings (**Table 3**). For 2007, the contribution of each fleet to the total PS catch was computed as the average percentage estimated from the landings in 2006 and 2008, i.e. when three PANOFI purse seiners were in activity. The final total catches of each PS fleet are given in **Table 5**.

3.2 Distribution of the total catch between months

The mean monthly seasonality appeared quite similar for both fishing gears with a peak in catch during September-October (**Figure 7**). The monthly seasonality in the catch of the P-Fleet and the A-fleet showed a relatively similar pattern over the year 2012[5], although the contribution of the first quarter to the catch appeared smaller for the P-Fleet than for the A-Fleet (**Figure 8**). The mean monthly seasonality in landings during 2008-2012 showed a similar pattern between the P-Fleet and A-Fleet (**Figure 9**). Consequently, we assumed that the P-Fleet and A-Fleet had a similar distribution of catch across months each year and used the monthly percentage of catch computed for the A-Fleet during 2006-2011 for the P-Fleet. The total catch was distributed between each month of each year based on the monthly percentage of catch derived from the logbooks (**Table 6**), except for 2007 as only about 11% of the catch was available in the logbooks for this year. The average monthly percentage of catch for 2006 and 2008-2012 was used for 2007.

3.3 Distribution of the total catch in space

The spatial distribution of the catch was computed on a quarterly basis for each fleet, i.e. the BB, the A-Fleet, and the P-Fleet. The percentage of catch of the BB and A-Fleet in each 5°-square of latitude and longitude was estimated for each quarter based on the logbooks for 2006 and 2008-2012. For 2007, the distribution was computed as the average of the years 2006 and 2008 for each fleet. For the P-Fleet, information on fishing grounds from the logbooks was almost exclusively available for 2012. Here, we assumed that the quarterly spatial distribution of the P-Fleet was stable over 2006-2012. This assumption was supported by the fact that the three PANOFI purse seiners already operating in 2006-2009 (i.e. Frontier, Master, and Volunteer) showed a quarterly distribution in 2012 very similar to the three other PANOFI vessels which arrived in 2010 in the fishery (Discoverer, Forerunner, Pathfinder) (**Figures. 4-5**).

[5] Unique year for which logbooks of the P-Fleet are considered to be fully available

3.4 Species composition of the catch

We assumed here that all catches of the three Ghanaian fleets during 2006-2012 can be described by a size and species composition characteristic of tuna schools associated with FADs. Indeed, FAD-sets largely predominated in the PS fleets over the period and represented 94% of the total sets in 2012 (**Figure 3a**). By contrast, information on school type available in the BB logbooks suggests that a significant part of sets might have been made on free-swimming schools, e.g. 35% of the sets of known type in 2012 (**Figure 3b**). However, the sharing of catch between BB and PS at-sea is known to be common practice in the Ghanaian fishery. Samples conducted at unloading of BB and PS in Abidjan during 2003-2004 showed there was no significant difference in the size-structure and species composition of the catch between gears (Fonteneau et al. 2013). Similarly, the size-structure of the landings showed similar distribution in 2006-2008 between BB and PS (Kell et al. 2011).

Consequently, the size-samples collected from the European purse seine fishery during 2006-2012 from fishing sets made on FAD-associated schools were selected for estimating the species composition of the Ghanaian catch. We relied on the spatial stratification proposed by Fonteneau et al. (2013) which consists of 3 areas: (i) the coastal areas along Ivory Coast (CIV) and Ghana (GHA), (ii) the Cape Lopez area, and (iii) the offshore area (**Figure 10**). Adopting this stratification however resulted in the availability of a small amount of samples in the coastal areas of CIV and GHA, i.e. <10 for some years.

An average species composition derived from the samples collected from the European PS catch on FADs was computed for each spatial stratum on a yearly basis as the quarterly stratification currently in use for the European PS resulted in very high variability in species composition across strata and several strata without any sample. The yearly species composition of the FAD catch was found to be rather stable in offshore areas with about 67% SKJ, 14% YFT, and 15% BET (**Figure 11**). The yearly species composition of the catch in the Cape Lopez area was also rather stable over time, with the same magnitude of SKJ (66%) but more YFT (21%) and less BET (6%), as compared to the offshore area. By contrast, the species composition in the coastal areas of Ivory Coast and Ghana showed a strong interannual variability which might be due to the small sample size (**Figure 11**).

The species composition derived from the samples was assigned to the catch of the BB and PS according to the year and area of origin of the catch (see section 3.3). Annual catches by species and fleet are given in **Figures 12-14**.

4 Perspectives

4.1 Data processing

The processing of the catch data to estimate the Task I must be considered as preliminary as several points need to be elucidated. First, the proposal of total task I derived from the available data sources should be agreed by the SCRS. Second, the assumptions used to reallocate the catch across space and time (i.e. months) should be discussed and alternative scenarios might be considered. Third, the current spatio-temporal stratification suggested by Fonteneau et al. (2013) results in a lack of representativeness of the samples in some strata and calls for further analysis to define a better sampling scheme. These 3 major points should be analysed so as to agree upon a final method to estimate the spatio-temporal composition of the catch and eventually derive the Ghanaian tasks I and II over 2006-2012. Finally, a complementary analysis has to be conducted to estimate the nominal fishing effort for both purse seiners and baitboats over the period of interest.

4.2 Towards an integrated tool for processing Ghanaian fisheries data: T3+

Monitoring the Ghanaian BB and PP fisheries requires good data collection in the first place. The AVDTH software currently in use by MFRD and also employed for the European tropical tuna fisheries of the Atlantic and Indian Ocean provides a robust tool that combines a data entry application coupled with a MS ACCESS database. Several tools associated with AVDTH (Akado, Anapo, Babys, Acarto) enable to control the data quality and visualise the raw data collected. Data processing represents the second step to estimate the ICCAT tasks I and II from logbooks, landing, and sampling data. The software T3+ has been recently developed as a server application dedicated to the processing of BB and PS fisheries data (Cauquil 2012). T3+ enables (i) data importation from AVDTH databases, (ii) data processing through SQL/JAVA codes (e.g. length-weight conversions, raising) through successive steps, and (iii) production of data outputs for ICCAT. T3+ could be

deployed on an ICCAT server so as (i) to avoid the installation of the tool on a specific machine and thus maintain a unique centralised database with controlled access, (ii) to host and mutualise size-samples collected from different fisheries of the Atlantic for data processing, and (iii) to ensure that historical assumptions and methods used to process the data are transparent and repeatable as they are stored in the database through specific configurations.

All intermediate results are stored in tables and can be currently accessed through SQL, R, PHP, etc. T3+ is still in development and future work could include the development of (i) a tool dedicated to the selection of the samples through a list of spatial layers and the possibility to construct its own spatial strata (e.g. Mapserver and Openlayers), (ii) libraries of SQL queries described and directly included in the database in the form of views, and (iii) an interface to easily extract the data processed (e.g. Model Data Sharing Tool currently developed at IRD). Procedure of data export could finally be developed in collaboration with ICCAT to comply with the standard referentials of the ICCAT databases.

Acknowledgments

This paper is a contribution to the ICCAT-MFRD-IRD project aimed at strengthening the Ghanaian industrial purse seine fishery monitoring in the Gulf of Guinea. We are grateful to Alain and Viveca Fonteneau for their dedication to the improvement of Ghanaian fisheries data. Muchas gracias to Alicia Delgado de Molina (IEO) for providing size-samples from Spanish and associated flags purse seiners. Daniel Gaertner and Pierre Chavance initiated the collaboration between IRD and MFRD and supervised the project. We are grateful to J Barde and N Billet for fruitful discussions on data access and web services.

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Table 1. Number of Ghanaian active fishing vessels as recorded in the landings (Ntrip) and logbooks (Nactivity) during 2006-2012.

YearC	*GearGrp*	*Ntrip*	*Nactivity*
2006	BB	20	19
2007	BB	2	6
2008	BB	19	19
2009	BB	19	19
2010	BB	20	19
2011	BB	15	15
2012	BB	14	14
2006	PS	10	7
2007	PS	2	3
2008	PS	9	7
2009	PS	12	12
2010	PS	16	12
2011	PS	16	12
2012	PS	16	16

Table 2. Total catch (t) declared in the logbooks for the PANOFI and other Ghanaian PS during 2006-2012.

Year	*P-Fleet*	*A-Fleet*	*ALL*
2006	659	13749	14408
2007	0	4361	4361
2008	505	18040	18545
2009	5444	35533	40977
2010	945	35833	36778
2011	1761	27629	29390
2012	27266	26786	54052

Table 3. Total landings (t) recorded for the PANOFI and other Ghanaian PS during 2006-2012. Information on PANOFI landings was not fully included in AVDTH database and provided through an alternative data source.

Year	*PANOFI*	*OTHERS*	*ALL*
2006	25952	19348	45300
2007	20457	0	20457
2008	16909	21714	38623
2009	17472	30786	48258
2010	33153	28386	61539
2011	32397	21608	54005
2012	28721	23796	52517

Table 4. Total nominal catch of the Ghanaian baitboats (BB) and purse seiners (PS) from the current ICCAT Task I, the cumulated catches declared in the logbooks, and the cumulated landings recorded at unloading. Proposal = maximum value of total catch proposed, Change = % change between current ICCAT and proposed total catch, Source = Origin of the proposed total task I.

YearC	*GearGrp*	*ICCAT*	*Catches*	*Landings*	*Proposal*	*Change*	*Source*
2006	BB	28972	31062	28972	31062	+7.2%	Logbooks
2007	BB	25501.63	3139	NA	25502	0	ICCAT
2008	BB	43932.36	22330	25259	43932	0	ICCAT
2009	BB	31125.74	27809	27284	31126	0	ICCAT
2010	BB	23884.75	22035	21733	23885	0	ICCAT
2011	BB	16410	24926	16574	24926	+51.9%	Logbooks
2012	BB	22864.3	23938	22812	23938	+4.7%	Logbooks
2006	PS	22703	14408	45300	45300	+99.5%	Landings
2007	PS	42249.38	4361	20457	42249	0	ICCAT
2008	PS	20162.22	18545	38623	38623	+91.6%	Landings
2009	PS	35344.26	40977	48258	48258	+36.5%	Landings
2010	PS	56335.37	36778	61539	61539	+9.2%	Landings
2011	PS	53394.5	29390	54005	54005	+1.1%	Landings
2012	PS	52465	54052	52517	54052	+3%	Logbooks

Table 5. Distribution of the new total task I for purse seiners between the P-fleet and the A-fleet. FP = Faux-Poisson landed in Abidjan.

Year	P-Fleet	A-Fleet	Task I	FP
2006	25952	19348	45300	7087
2007	20457	21792	42249	8211
2008	16909	21714	38623	9807
2009	17472	30786	48258	10552
2010	33153	28386	61539	12363
2011	32397	21608	54005	NA
2012	28721	23796	54052	10274

Table 6. Monthly percentage of catch derived from logbook data during 2006-2012. The percentage in 2007 was computed as the mean value from 2006 and 2008-2012.

YearC	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	BB	4.3	6.6	4.8	4.0	12.8	4.5	4.2	9.7	20.8	21.3	6.2	0.9
2007	BB	6.5	8.0	7.8	6.7	8.3	7.7	6.2	9.2	12.1	12.1	8.5	6.9
2008	BB	4.5	3.3	7.3	5.8	7.1	4.1	6.9	15.9	13.7	11.7	7.9	11.7
2009	BB	5.8	9.6	6.5	5.4	6.3	17.4	8.0	9.0	8.6	9.8	6.5	7.0
2010	BB	8.9	9.2	9.5	7.1	8.7	6.6	3.8	8.4	10.8	10.1	8.1	8.7
2011	BB	4.3	13.8	9.7	11.1	9.1	7.6	4.1	3.9	5.2	10.8	10.8	9.7
2012	BB	11.4	5.5	8.8	6.9	6.1	5.8	9.9	8.5	13.5	8.8	11.5	3.3
2006	PS	12.3	9.2	10.0	7.1	10.2	6.9	5.1	6.8	10.0	9.8	8.8	3.8
2007	PS	8.9	9.6	8.3	7.0	8.7	6.2	6.5	9.0	10.3	9.6	8.3	7.5
2008	PS	11.5	7.4	5.4	6.0	7.1	8.3	6.9	6.9	13.6	14.2	5.2	7.5
2009	PS	4.2	9.6	6.5	8.1	9.3	5.7	11.4	12.1	11.9	7.5	5.0	8.7
2010	PS	8.7	10.2	12.2	7.0	8.3	5.3	4.1	10.4	8.2	8.7	7.6	9.3
2011	PS	10.2	15.6	10.2	8.6	7.2	4.3	3.4	8.6	4.3	7.2	9.5	10.9
2012	PS	6.7	5.5	5.4	5.5	9.9	6.9	8.1	9.1	13.9	10.5	13.8	4.8

Table 7. Annual catch by gear, fleet, and species for the Ghanaian fisheries derived from the data processing.

YearC	Flag	Gear	Fleet	YFT	SKJ	BET	ALB	AUX	EUT	Total
2006	Ghana	BB	GHA	5501	20767	3435	0	1093	266	31062
2007	Ghana	BB	GHA	4302	17500	2142	1	835	722	25503
2008	Ghana	BB	GHA	10236	27741	4363	5	1020	568	43932
2009	Ghana	BB	GHA	6935	18807	3532	3	1067	782	31126
2010	Ghana	BB	GHA	4287	15778	2315	3	987	515	23885
2011	Ghana	BB	GHA	3453	18009	2242	0	795	324	24823
2012	Ghana	BB	GHA	3312	17865	1120	0	510	761	23568
2006	Ghana	PS	A-Fleet	3458	12835	2174	0	736	144	19347
2007	Ghana	PS	A-Fleet	3805	13877	1670	1	652	540	20544
2008	Ghana	PS	A-Fleet	4774	13703	2494	3	490	250	21714
2009	Ghana	PS	A-Fleet	5711	19245	4325	5	962	538	30786
2010	Ghana	PS	A-Fleet	4663	18160	4051	6	1045	461	28386
2011	Ghana	PS	A-Fleet	2546	14094	3603	0	506	233	20982
2012	Ghana	PS	A-Fleet	2729	17882	2098	0	628	458	23794
2006	Ghana	PS	P-Fleet	4515	17337	2962	0	983	154	25952
2007	Ghana	PS	P-Fleet	2905	14376	2034	2	674	468	20459
2008	Ghana	PS	P-Fleet	3642	10647	2071	3	371	176	16909
2009	Ghana	PS	P-Fleet	3387	10728	2553	3	509	292	17472
2010	Ghana	PS	P-Fleet	5121	21368	4932	8	1245	479	33153
2011	Ghana	PS	P-Fleet	3854	22121	5218	0	870	334	32397
2012	Ghana	PS	P-Fleet	3072	21537	2865	0	796	448	28718

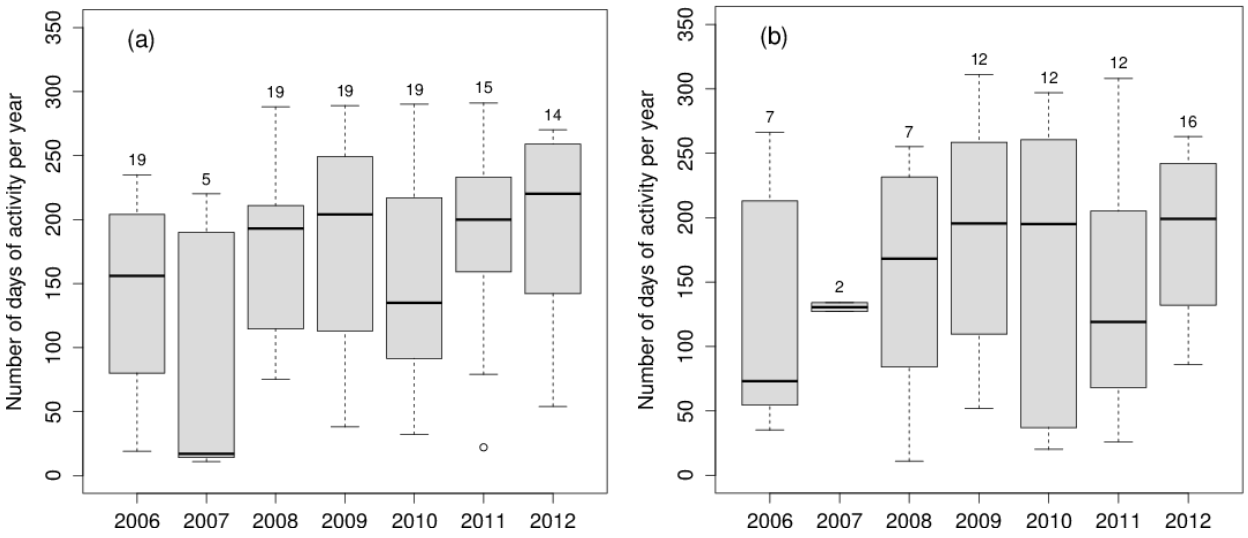

Figure 1. Number of days of activity with catch per vessel as recorded in the logbooks during 2006-2012 for (a) baitboats and (b) purse seiners. Number above the boxplot indicates the number of vessels for which data is available.

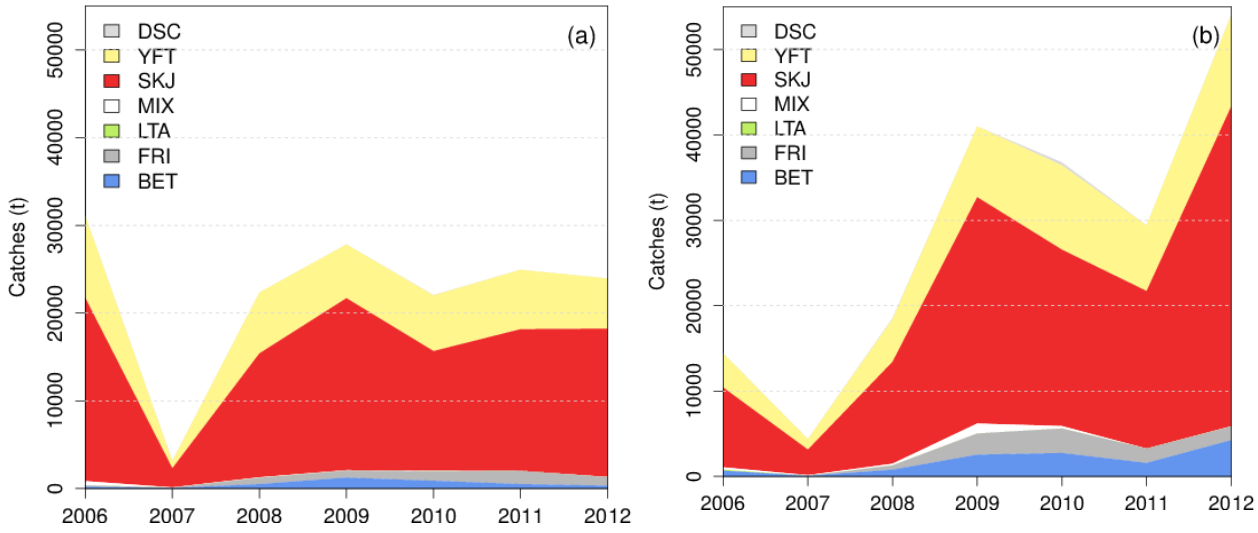

Figure 2. Annual cumulated catch by species as recorded in the logbooks during 2006-2012 for (a) baitboats and (b) purse seiners.

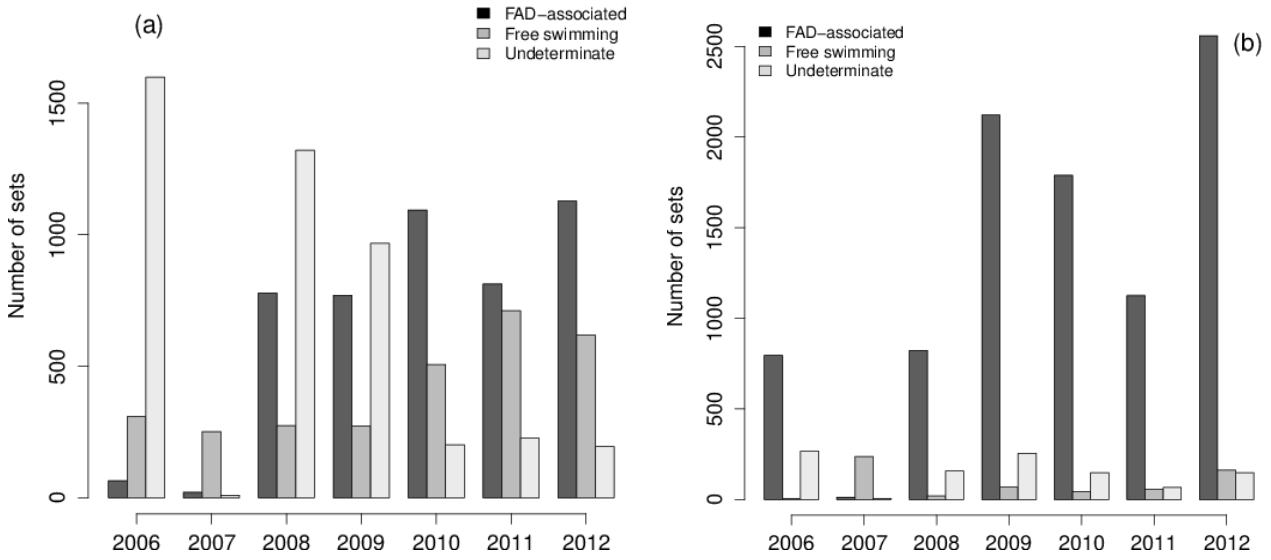

Figure 3. Annual number of fishing sets by fishing mode derived from logbooks of (a) baitboats and (b) purse seiners.

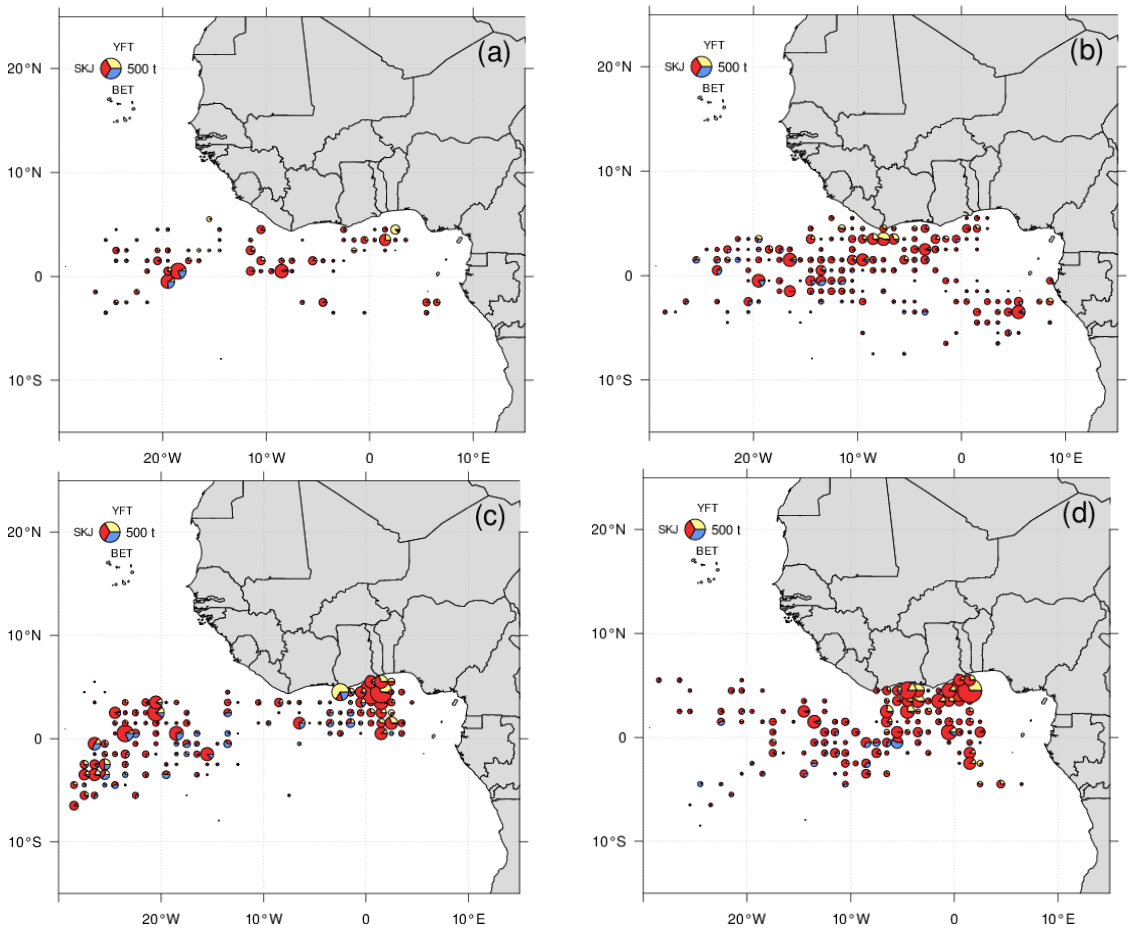

Figure 4. Quarterly spatial distribution of the catch of principal market tunas for the P-fleet (PANOFI) in 2012: (a) Jan-Mar, (b) Apr-Jun, (c) Jul-Sep, (d) Oct-Dec

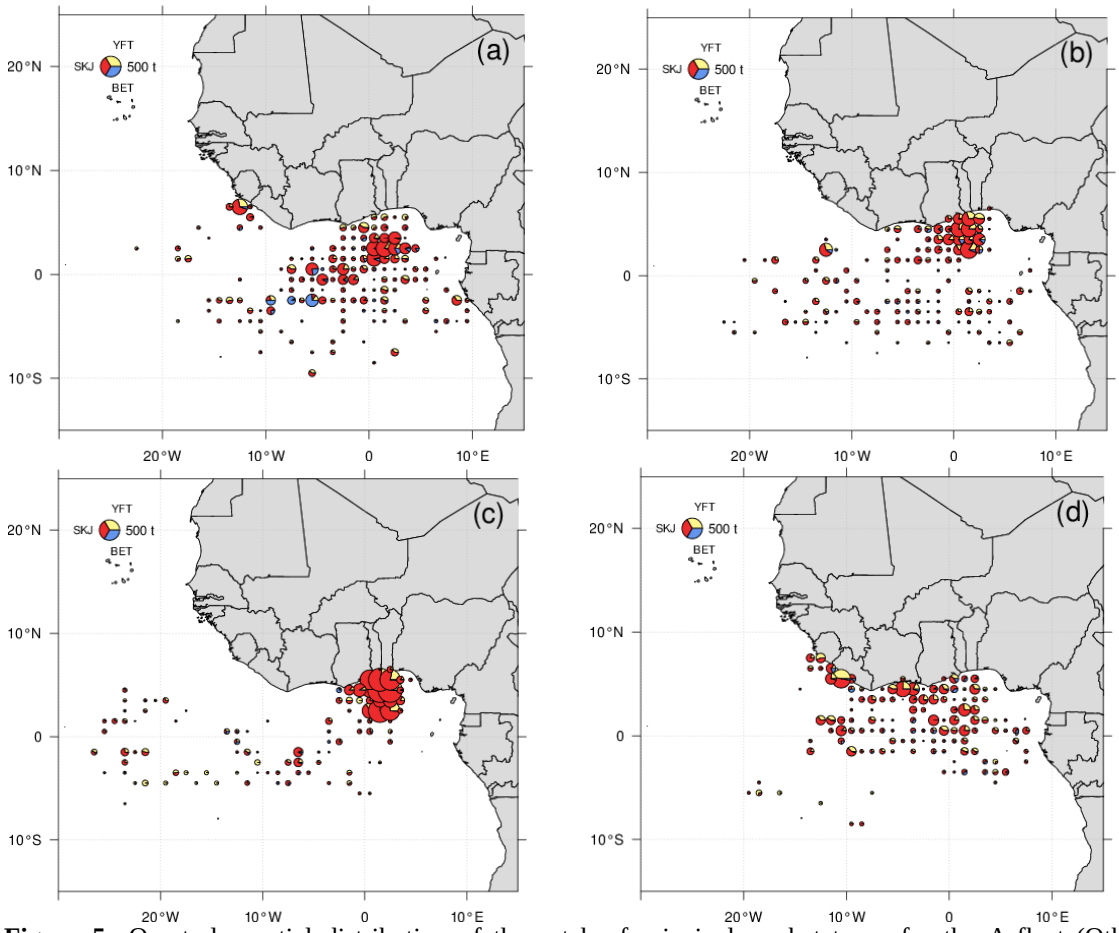

Figure 5. Quarterly spatial distribution of the catch of principal market tunas for the A-fleet (Others than PANOFI) in 2012: (a) Jan-Mar, (b) Apr-Jun, (c) Jul-Sep, (d) Oct-Dec.

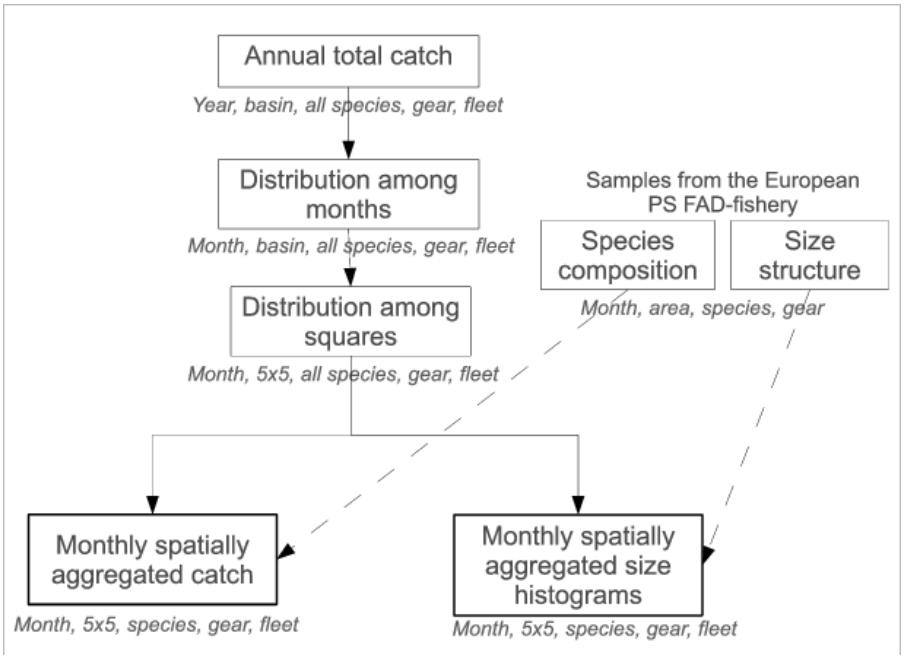

Figure 6. Steps of the processing of Ghanaian industrial tuna fisheries data. The temporal, spatial, and technical resolution is given for each step

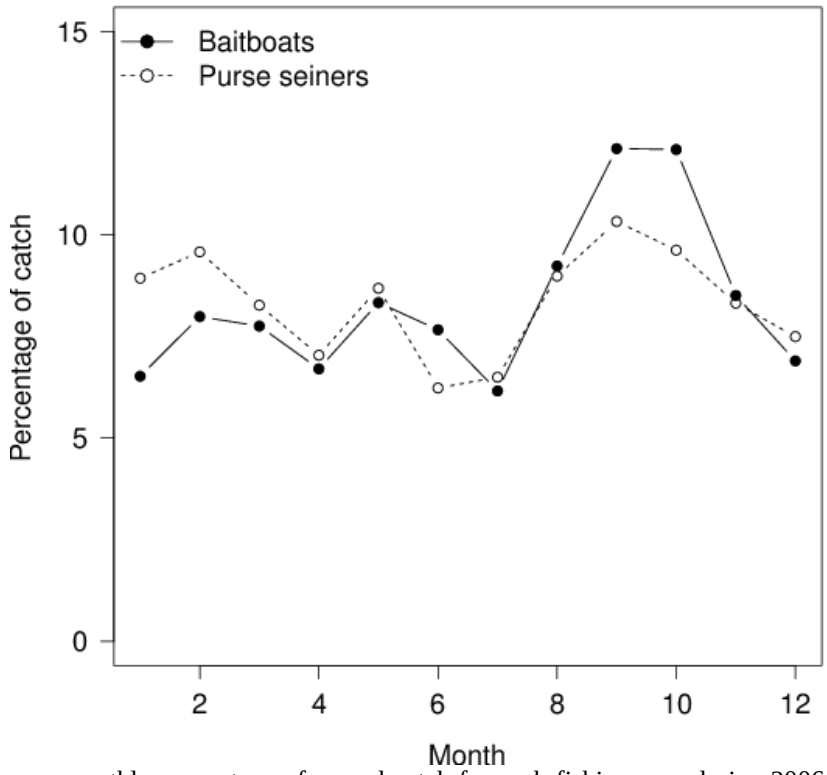

Figure 7. Average monthly percentage of annual catch for each fishing gear during 2006-2012. The year 2007 was not included as the logbooks represented about 11% of the total Task I for this year.

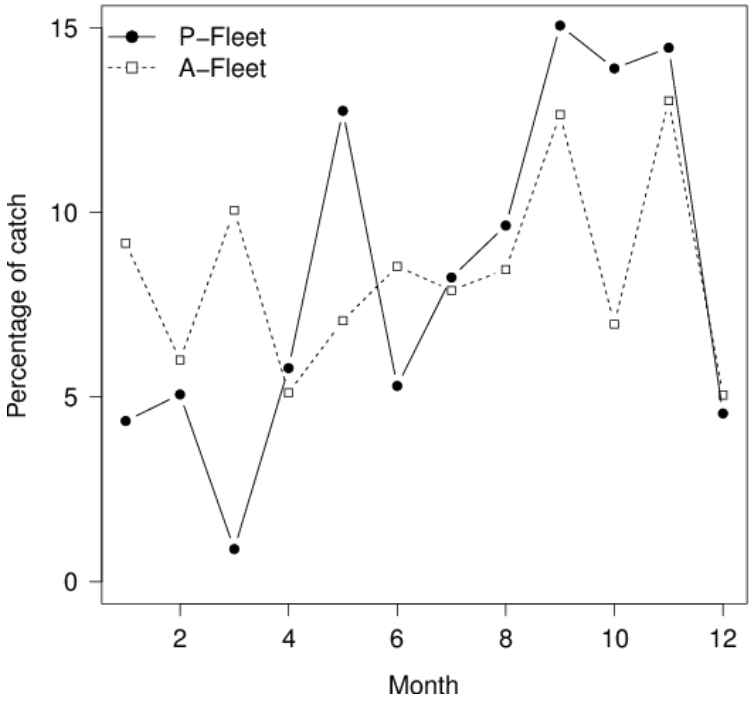

Figure 8. Monthly percentage of annual catch in 2012 for the PANOFI vessels (P-Fleet) and the rest of the Ghanaian PS fleet (A-Fleet)

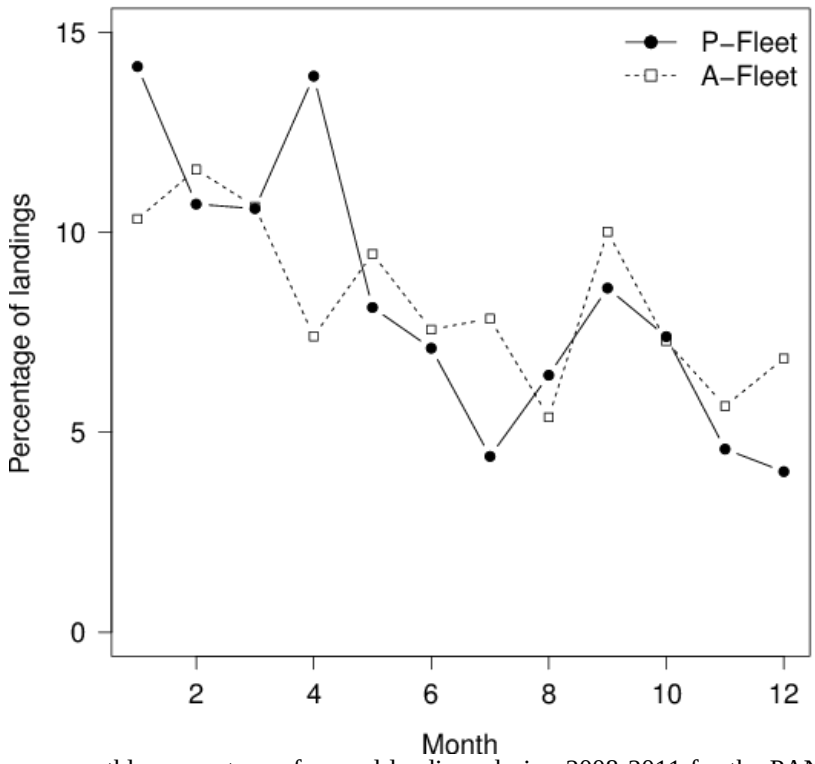

Figure 9. Average monthly percentage of annual landings during 2008-2011 for the PANOFI vessels (P-Fleet) and the rest of the Ghanaian PS fleet (A-Fleet).

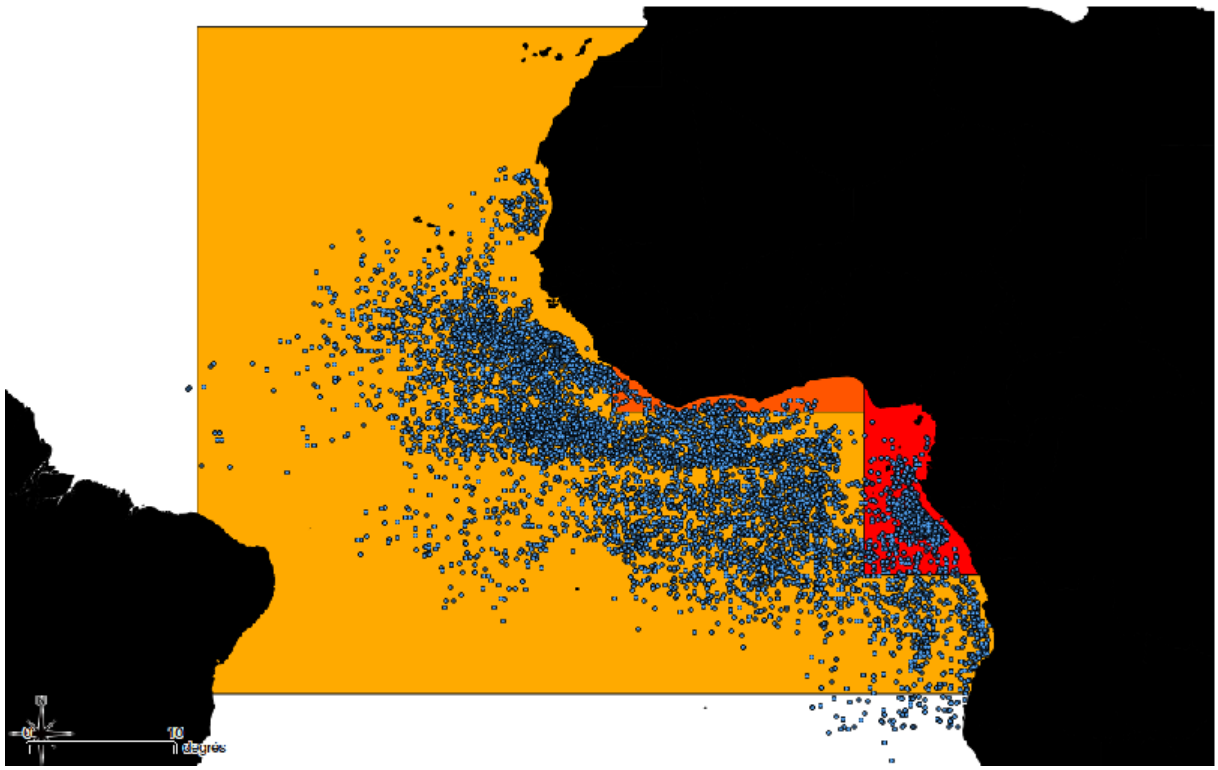

Figure 10. Location of the size-frequency samples (blue points) collected from the European purse seine fishery during 2006-2012. The 3 stratification areas are indicated with colors: (i) Coasts of Ivory coast and Ghana (dark orange), (ii) Cape Lopez area (red), and (iii) offshore area (light orange).

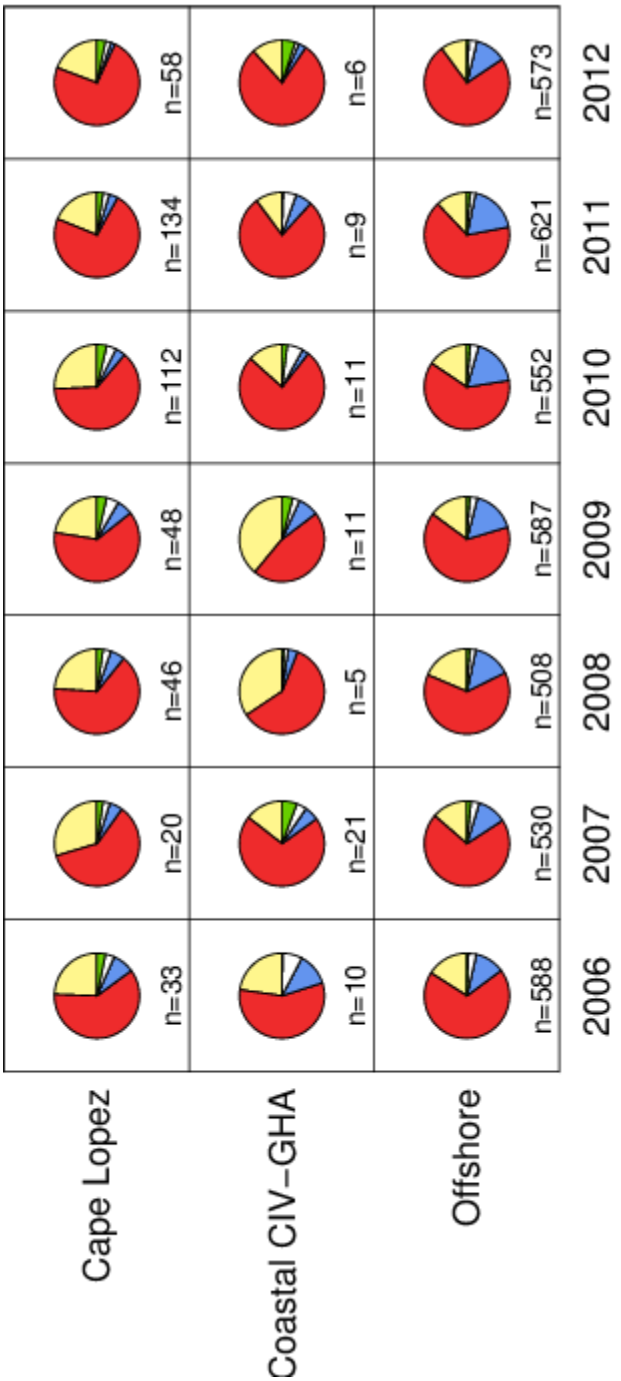

Figure 11. Annual species composition by spatial stratum derived from the size-samples of the European purse seine fishery on FAD-associated schools during 2006-2012. red = *Katsuwonus pelamis*, yellow=*Thunnus albacares*, blue = *Thunnus obesus*, green = *Euthynnus* spp., white = *Auxis* spp., black = *Thunnus alalunga*

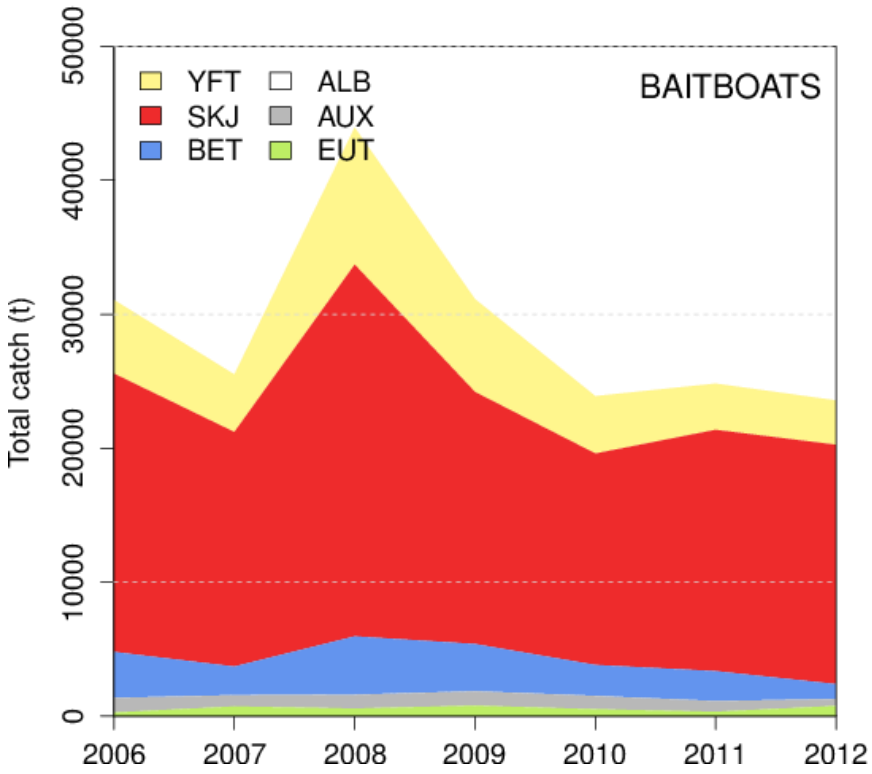

Figure 12. Annual cumulated catch (t) by species of the Ghanaian baiboats during 2006-2012 as derived from the data processing.

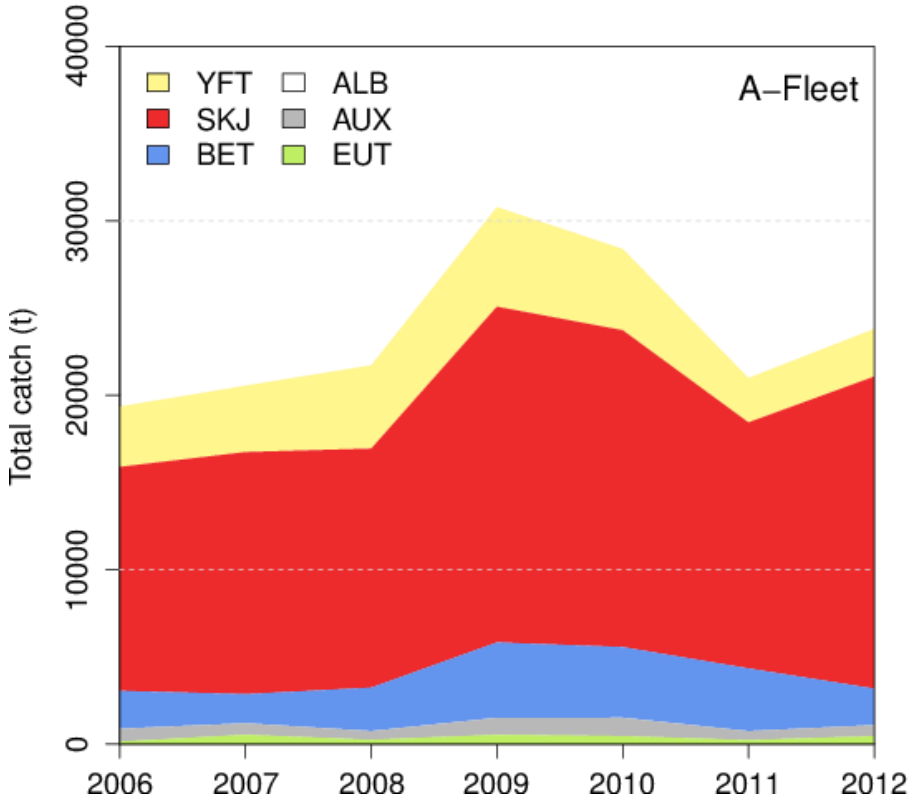

Figure 13. Annual cumulated catch (t) by species of the Ghanaian A-Fleet of purse seiners during 2006-2012 as derived from the data processing

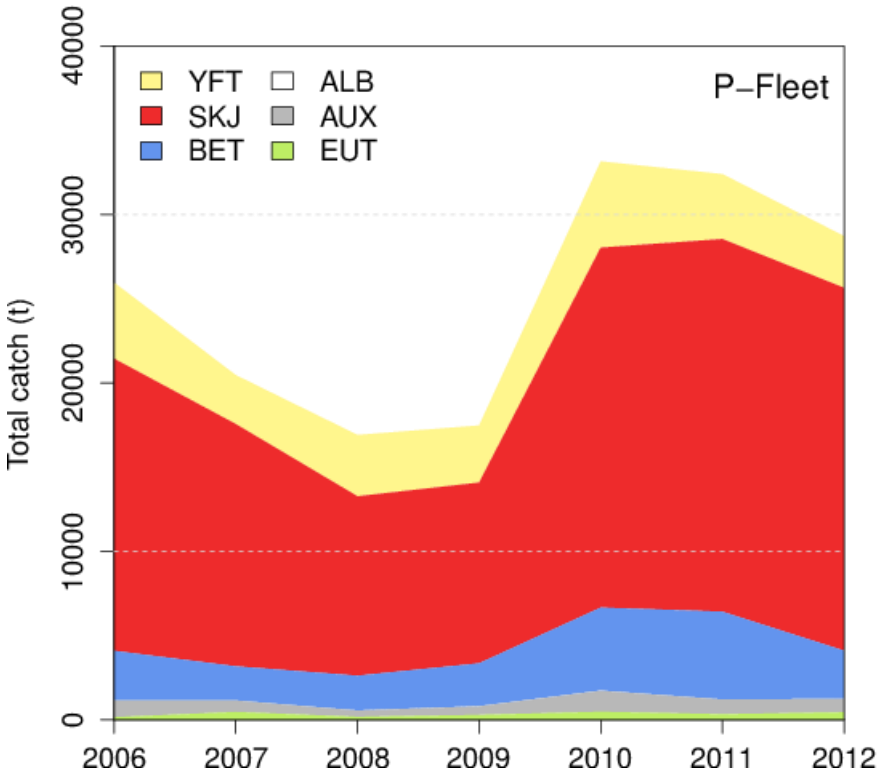

Figure 14. Annual cumulated catch (t) by species of the Ghanaian P-Fleet of purse seiners during 2006-2012 as derived from the data processing.