

ESTIMATING GHANAIAN PURSE SEINE AND BAITBOAT CATCH DURING 2006-2013: INPUT DATA FOR 2015 BIGEYE STOCK ASSESSMENT

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SUMMARY

Ghanaian industrial tuna fisheries data covering the period 2006-2013 were analyzed following guidelines provided during the ICCAT preparatory meeting for the 2015 assessment of bigeye tuna (Thunnus obesus; BET). To account for differences in fishing strategy and quality of data sources available, the fleet was split between a component of large purse seiners and a component composed of baitboats and purse seiners that can collaborate at sea. First, the total Task I was derived from information on landings and logbooks for the first and second fleet components, respectively. Second, the monthly proportion of catch and spatial distribution on a 5°x5° grid were derived from logbook data with some necessary assumptions when data were missing. Third, species composition of the catch was estimated from the size samples collected onboard European purse seiners from fishing sets made on fish aggregating devices based on three processing areas. Bigeye represented about 15% in the 'offshore' area while its percentage in the catch was about 7-8% in areas closer to the shore during the same period. Size samples collected by MFRD during 2006-2013 showed that the distribution of bigeye caught by Ghanaian vessels differed from that of European purse seiners on FADs.

RÉSUMÉ

Les données de la pêcherie industrielle de thonidés du Ghana couvrant la période 2006-2013 ont été analysées en suivant les directives fournies au cours de la réunion ICCAT de préparation de l'évaluation du thon obèse de 2015 (Thunnus obesus; BET). Pour tenir compte des différences dans la stratégie de pêche et la qualité des sources de données disponibles, la flottille a été divisée entre une composante de grands senneurs et une composante composée de canneurs et de senneurs qui peuvent collaborer en mer. Tout d'abord, le total de la Tâche I a été obtenu des informations sur les débarquements et les carnets de pêche pour la première et la deuxième composantes des flottilles, respectivement. Deuxièmement, on a obtenu la proportion mensuelle des captures et de la distribution spatiale sur une grille de 5° x 5° des données des carnets de pêche, en formulant certains postulats lorsqu'il manquait des données. En troisième lieu, on a estimé la composition par espèce de la capture à partir des échantillons de taille recueillies à bord des senneurs européens dans le cadre d'opérations de pêche réalisées sur des dispositifs de concentration de poissons sur la base de trois zones de traitement. Le thon obèse représentait environ 15 % de la capture dans la zone « au large », tandis que son pourcentage dans les captures était d'environ 7-8 % dans les zones plus proches du rivage pendant la même période. Des échantillons de taille recueillis par MFRD entre 2006 et 2013 ont montré que la distribution du thon obèse capturé par des navires ghanéens différait de celle des senneurs européens opérant sous DCP.

RESUMEN

Se analizaron los datos de las pesquerías industriales de túnidos de Ghana que cubren el periodo 2006-2013 siguiendo las directrices proporcionadas durante la Reunión de preparación de datos de ICCAT para la evaluación de patudo de 2015 (Thunnus obesus, BET). Para tener en cuenta las diferencias en la estrategia de pesca y la calidad de las fuentes de datos disponibles, la flota se separó entre un componente de grandes cerqueros y un componente de cañeros y cerqueros que pueden colaborar en el mar. En primer lugar, la Tarea

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I total se derivó a partir de información sobre desembarques y cuadernos de pesca para el primer y segundo componente de la flota, respectivamente. En segundo lugar, la proporción mensual de la captura y la distribución espacial en una cuadrícula de 5°x5° se derivaron a partir de los datos de cuadernos de pesca con algunos supuestos necesarios cuando faltaban datos. En tercer lugar, la composición por especies de la captura se estimó a partir de las muestras de talla recopiladas a bordo de cerqueros europeos en lances realizados sobre dispositivos de concentración de peces basándose en tres áreas de procesamiento. El patudo representaba aproximadamente el 15% de la captura en la zona de alta mar, mientras que su porcentaje en la captura era de aproximadamente el 7-8% en zonas cercanas a la costa durante el mismo periodo. Las muestras de talla recogidas por el MFRD durante 2006-2013 mostraron que la distribución del patudo capturado por buques ghaneses difería de la de los cerqueros europeos sobre DCP.

KEYWORDS

Baitboat, Purse seining, FAD, Bigeye

1. Introduction

The preparatory meeting for the assessment of the bigeye tuna (*Thunnus obesus*; BET) stock of the Atlantic Ocean to be conducted in July 2015 defined some guidelines to process the Ghanaian fisheries data covering the period 2006-2014. The objective is to obtain Ghanaian Tasks I and II data that are required as inputs for the different stock assessment models to be used. In particular, the working group considered that (i) the Ghanaian fleet should be split into two components, (ii) vessel should be used as sampling unit, (iii) the total catch of the principal market tropical tunas should be based on the higher value between catch reported from landings and logbooks, (iv) the estimation of catch species composition should be derived from the species composition of the EU fleet fishing on fish aggregating devices (FADs), (v) the estimation of size composition of the catch for each species should be based on Ghanaian samples collected in Tema for a fleet component and from the samples obtained from the EU PS fleet fishing on FADs for the other component. As the data for the year 2014 are currently still being entered and checked by MFRD, the present analysis only covers the period 2006-2013.

2. Materials

Following the guidelines of the preparatory meeting for the 2015 BET stock assessment, the Ghanaian fishery was split between a first component composed of the 6 PANOFI purse seiners (PANOFI) and a second component gathering the baitboats and non-PANOFI purse seiners (A-fleet).

2.1 Ghana AVDTH database for 2006-2013

The Ghanaian AVDTH database includes all logbooks, sale records by commercial category (i.e. species and weight category), and size-frequency samples collected by MFRD during 2006-2013, with few data available for 2007⁵. Data available for the period 2006-2012 are described elsewhere and differ on the margin with some results of (Chassot *et al.*, 2014) due to the exclusion of a Spanish PS, the BERMEOTARAK CUATRO, which was flying the Ghana flag during 2006-2008 but has been included in the associated flags of the European PS fishing fleet (SCRS/2014/080). A total of 153 fishing trips from 14 BB and 15 PS are recorded in the database for the year of landing 2013. The number of Ghanaian BB in operation did not change between 2012 and 2013 while the data reported to MFRD suggest that 1 vessel, the ADJOA AMISABA, could have left the Ghanaian PS fishery as no information was available for this boat in 2013. The numbers of BB and PS were consistent between the information collected from sale records (table MAREE) and logbooks (table ACTIVITE).

2.2 Additional information on PANOFI purse seiners landings

Ancillary information collected on the total annual landings of the PANOFI purse seiners was provided from PANOFI to MFRD for the period 2006-2012. In addition, information on total landings from the cargos VOLTA GLORY and VOLTA VICTORY unloading in Abidjan were reassigned to each PANOFI purse seiner through the well plans collected at port in 2013.

⁵ Depending on the availability of logbooks and sale records for 2007, it might be feasible to coordinate a “data rescue operation” to enter the data in the AVDTH database.

2.3 Ghana samples 2006-2014

A total of 2,187 size-frequency samples have been collected during the unloading of purse seiners, baitboats and cargos at the ports of Tema (Ghana), Abidjan (Côte d'Ivoire) and Walvis Bay (Namibia) during 2006-2014 (**Table 1**). Samples available during 2006-2014 are considered reliable for computing the size structure of the catch while only samples collected during 2013-2014 are considered suitable for estimating the species composition of the catch (Damiano *et al.*, 2014). Indeed, the median number of fishes by sample increased from about 250 during 2008-2012 to 537 in 2013 following the training of MFRD team with regards to the EU sampling protocol. It is noteworthy that the 112 samples available for 2014 are characterized by a small number of fish by sample, i.e. a median of 170 and a mean of 200. Information on the origin of the fishing sets sampled was derived from well plans available to MFRD although they might be biased in some case for purse seiners due to shifting of tuna between wells at sea. Each sample was assigned a sampling/processing area following the protocol in use for the processing of the European PS fishery data (Pallarés & Hallier 1997) (**Figure 1**).

Most of the samples collected during 2006-2014 come from the catches of baitboats and non-PANOFI purse seiners that compose the A-Fleet (**Table 1**). More than half million tunas have been measured by MFRD samplers over the period (**Table 7**), including more than 40,000 BET during 2006-2013 (**Tables 8 and 9**). Very few samples are available for the PANOFI purse seiners that mainly tranship their catch at port on cargos. In absence of relevant information for this component of the Ghanaian fleet and considering that PANOFI purse seiners mainly operate on FADs over the whole eastern Atlantic Ocean in the same fishing grounds as for the European PS fleet (Chassot *et al.*, 2014), we used the size samples available from the EU fleet to estimate the species and size composition of the PANOFI catch.

2.4 Samples collected from the European PS fishery

The current sampling protocol of the European purse seiners was established during the European project “Analyse du schéma d'échantillonnage multispécifique des thonidés tropicaux” (Pallarés and Hallier 1997). It is a simultaneous sampling to estimate both size and species composition of the catch. The current strata considered to represent homogenous species and size composition include fishing mode (i.e. FAD or free-swimming school FSC), quarter, and large spatial areas. FAD includes natural objects (e.g. logs, palm branches) and anthropogenic floating objects such as man-made bamboo rafts equipped with radio or satellite transmitters. The sampling is made during the unloading of the purse seiners at fishing ports and consists in a 2-step approach: (i) the wells are selected from among those containing homogeneous strata and (ii) fishes are randomly collected, within size category, from the wells and counted and/or measured following a specific protocol. The number of fish sampled by samples varies between 150 and 500. Samples combined with species-specific length-weight relationships are then used to estimate the size and species composition of the catch in each stratum. More than 5,000 samples have been collected during 2006-2013 from fishing sets made on FADs in the eastern Atlantic Ocean.

3. Methods

We follow the steps proposed by Chassot *et al.*, 2014 to process the Ghanaian fisheries data and consist in (i) estimating the annual total catch of the fleet, (ii) distributing the total catch in time (month) and (iii) space ($5^{\circ} \times 5^{\circ}$ statistical squares), (iv) estimating the species and size composition of the catch in large spatio-temporal strata, and (v) assigning the stratum-specific species and size composition to each month- 5×5 stratum. The main differences with previous analyses focusing on the processing of Ghanaian fisheries data (Fonteneau *et al.* 2013, Chassot *et al.*, 2015) include the definition of a fleet component that gathers different gears (BB and PS), a modification in the areas used for data processing, and the use of Ghanaian size samples for estimating the size composition of the catch.

3.1 Total Task I

Following the guidelines of the preparatory meeting for BET stock assessment, the annual total catch of the Ghanaian fishery was based on the higher value between catches reported in the logbooks and landings recorded at ports. Although data available from a cannery based in Ghana (Pioneer Food Cannery) and from the monitoring of landings on the local market (“faux-poisson”) of Abidjan (Côte d'Ivoire) suggested that the current annual total catch of Ghanaian PS and BB fisheries might be underestimated (Chassot *et al.*, 2015), the total TASK I estimated here was only based on the data collected by MFRD and recorded in the Ghana AVDTH database.

3.2 Monthly distribution of the catch

For the PANOFI fleet, the monthly proportion of total catch each year was dependent on the information available in the AVDTH database. Information on catch available from the logbooks during 2012-2013 represented well the total Task I and was used to derive the monthly proportion of catch. The average monthly proportion of catch observed in 2012-2013 was used to estimate the monthly proportion of catch during 2006-2011 although the fleet increased from 3 to 6 purse seiners in 2011-2012, which might have extended the fishing grounds between 2006-2010 and 2011-2013. For the A-Fleet, logbooks available represented more than 93% of the total TASK 1, with the exception of 2007 when very few information on fishing activities had been recorded. The average monthly proportion of catch in 2007 was computed as the average proportion of catch in the logbooks across the years 2006, 2008 and 2009.

3.3 Spatial distribution of the catch

The spatial distribution of the catch was first computed on a quarterly basis for each fleet component based on the information available from the logbooks. The spatial distribution of the catch was then assumed equal for the 3 months comprised within each quarter. For the PANOFI purse seiners, information from the logbooks was considered representative of the fishing grounds for 2012-2013. We assumed that the spatial distribution of the PANOFI fleet was constant over 2006-2011 and equal to the average quarterly distribution of the catch observed during 2012-2013. For the A-Fleet, the proportion of catch in each 5°-square of latitude and longitude was computed on a quarterly basis from the logbooks available for 2006 and 2008-2013. For 2007, the distribution of catch was assumed equal to that observed in 2006.

3.4 Species distribution of the catch

The preparatory meeting for BET assessment recommended estimating the species composition of the catch of the Ghanaian fleets based on the size-frequency samples collected from the EU fleet fishing on FADs. The choice of the strata for the processing was based here on the work of Fonteneau *et al.* (2014) and Chassot *et al.*, 2014. Multivariate statistical analyses of the species and size composition of the European PS catch are currently in progress but results were not available at the time of the present analysis. A major issue however is that very few samples (i.e., i.e. between 5 and 21 annually) are available in the coastal areas of Ghana and Côte d'Ivoire (ET area 1104) as the European purse seiners have not been fishing much in these areas during 2006-2013, while these areas are major fishing grounds for the Ghanaian fleets. A visual examination of the average species composition of the catch of the European FAD fishery during 2006-2013 suggested that the coastal area 1104 could be extended south to the Equator to increase the number of samples in each stratum to be considered for the processing. An average species composition derived from the samples collected from the European PS catch on FADs was then computed for each spatio-temporal stratum considered (**Figure 2**).

3.5 Size distribution of the catch

Size distributions of tropical tunas in the catch of the A-Fleet and P-Fleet were derived from the samples collected by MFRD and from the European PS FAD fishery, respectively. Average size frequency histograms were estimated on a quarterly basis in each spatial stratum and then assigned to each month of each quarter.

4. Results

4.1 Estimate of total Task I

For the PANOFI fleet, landings generally provide a better source of information on the total catch than logbook data, i.e. overall levels of landings are consistent with the number of PANOFI purse seiners with an annual catch by vessel around 5,000-6000 t during 2006-2013 (**Table 2**). Indirect information on PANOFI landings collected from cargos unloading in Abidjan in 2013 is consistent but lower than the annual catch derived from the logbooks, indicating a good monitoring of the PANOFI purse seiners activities in 2013.

For the A-Fleet composed of Ghanaian BB and non-PANOFI PS, the proposed total Task I is derived from logbook data during 2009-2013, as they exceed the total landings computed from the information collected through sale records to the canneries (**Table 3**). The total catch of the A-Fleet appears to be very small in 2013 with a 37% decrease relative to 2011-2012 despite a total number of vessels in operation that was very close (i.e. 23 vessels in 2013 vs. 24-25 in 2011-2012). Logbook records indicate a relative small number of active vessels

(8 boats) and associated fishing activities in the months of April and December 2013. Overall, the number of days at sea decreased by about 32% between 2012 and 2013 and the number of fishing sets decreased by about 28% in the mean time for both components of the A-Fleet (i.e. baitboats and purse seiners). It is noteworthy that the levels of successful sets on free-swimming schools (>95%) observed for the 2 fleets and for both BB and PS over 2006-2013 are way higher than for the European PS fleet (about 70%), which suggests some underreporting of null sets in the logbooks.

4.2 Temporal distribution of the catch

Fishing activities of the Ghanaian tuna fishery show a marked seasonal variability, with higher catches during the months of August-November for both components of the fleet. Information on the monthly catch of the PANOFI fleet considered reliable in 2012-2013 suggests higher seasonal variability than for the A-Fleet, with small catch during December-February during the period predominated by fishing on free-swimming schools for the European PS fleet. The monthly proportions of catch estimated for both components of the fleet are given in **Tables 4 and 5**.

4.3 Spatial distribution of the catch

Information available from the logbooks of the PANOFI purse seiners collected during 2012-2013 indicated that the fleet operated all along the equator from 30°W to 10°E, between 10°N and 10°S. Despite their large distribution, the PANOFI purse seiners frequently occurred in the coastal grounds along the coasts of Ghana and Côte d'Ivoire (**Figure 3a**). The A-Fleet appeared to be more concentrated in the Gulf of Guinea consistently with the smaller range of the BB component of the fleet (**Figure 3b**). Catches for this fleet predominated in the areas "Costal CIV-GHA" and "Cape Lopez" considered for the processing, representing 70% of the total catch of the A-Fleet during 2006-2013 (**Figure 2**).

4.4 Species composition

The overall pattern in species composition estimated from the FAD catch of the European PS fleet appears rather similar with SKJ predominating in the catch (60-70%), followed by YFT and BET that represent between 6% and 25% of the catch depending on the stratum (**Figure 4**). Frigate tuna (*Auxis thazard*) and bullet tuna (*Euthynnus alleteratus*) always represent less than 4% of the catch and appear to occur preferentially off the coasts of Ghana and Côte d'Ivoire and Cape Lopez, respectively. Albacore (*Thunnus alalunga*) is almost never caught in association with drifting objects. More specifically, the annual species composition was found to significantly differ between the 3 areas considered for data processing. In Cape Lopez, YFT represented on average 20% of the catch during 2006-2013 while it decreased to 16% along the coasts of Ghana-Côte d'Ivoire and to less than 13% in the remaining areas predominated by high seas. Conversely, BET represented about 15% in the 'offshore' area while its percentage in the catch was about 7-8% in areas closer to the shore during the same period. Annual changes were found to occur in the species composition of the European PS FAD-catch with the proportion of YFT in the catch constantly decreasing over time while SKJ proportion increased in the 3 areas.

The species composition declared in the logbooks of Ghanaian PANOFI purse seiners during 2012-2013 differs between the areas defined for data processing. The percentage of YFT in the catch is lower in the offshore areas (~10%) than in the coastal areas (20-24%) consistently with the spatial pattern observed in the samples. Nevertheless, the proportion of BET declared in Cape Lopez and CIV-GHA areas appears very small (~3.5%) as compared to that observed in the European FAD catch. A similar pattern is observed for the A-Fleet with a general higher proportion of YFT and smaller proportion of BET in the catch than observed in the European PS catch in the 3 areas. Such differences might be due to the misidentification of small BET which generally results in the under-reporting of this species in the landings, as observed worldwide for fisheries that catch small BET (Anon., 2010). The higher proportion of YFT is not due to the BB component of the A-Fleet which targets a significant part of free-swimming schools (Chassot *et al.*, 2014) as similar results were obtained when only considering fishing sets made on floating objects.

4.5 Size composition

The gathering of Ghanaian BB and non-PANOFI PS in a common fleet component appeared to be consistent with the size distribution of the catch. The relative size-frequency histograms in the catch aggregated across years in the 4 main areas considered for processing showed that BET displayed a very similar size composition between baitboats and non-PANOFI purse seiners (**Figure 5**). By contrast, size distributions observed for these

two components of the A-Fleet significantly differed from the size distribution of BET caught by European purse seiners on FADs that appeared to be switched toward smaller sizes, with a size mode around 42-44 cm fork length.

Table 6 provides a summary of the data sets used for each component of the Ghanaian industrial tuna fishing fleet, including some of the necessary assumptions for missing data (e.g 2007) and spatio-temporal resolutions considered in the processing.

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Table 1. Annual number of samples by processing area (ZET) for each component of the Ghanaian tuna industrial fishery. *c_zet*: Area code, *l_zet*: Area name.

<i>c_zet</i>	<i>l_zet</i>	<i>fleet</i>	2006	2008	2009	2010	2011	2012	2013	2014	Total
1102	Northwest Picolo	A-Fleet	1	2	0	0	8	5	6	36	58
1103	Southeast Picolo	A-Fleet	13	7	11	6	6	6	5	7	61
1104	Coastal	A-Fleet	26	131	124	233	192	104	64	0	874
1105	Cape Lopez	A-Fleet	13	29	47	18	29	7	1	2	146
1106	South Equator	A-Fleet	51	124	129	240	174	105	41	67	931
1102	Northwest Picolo	PANOFI	0	0	0	0	0	6	0	0	6
1103	Southeast Picolo	PANOFI	0	0	1	0	0	3	5	0	9
1104	Coastal	PANOFI	0	0	0	0	0	0	27	0	27
1105	Cape Lopez	PANOFI	0	0	0	0	0	10	0	0	10
1106	South Equator	PANOFI	1	1	3	0	0	25	35	0	65
			105	294	315	497	409	271	184	112	2187

Table 2. Annual total catch and landings of the PANOFI PS fleet as recorded in the Ghanaian fisheries database and proposal of total TASK I. Data does not include discards at sea and landings destined to the local markets of Tema and Abidjan.

<i>Year</i>	<i>Catch</i>	<i>Landings</i>	<i>Task I</i>
2006	659	25952	25952
2007	0	20457	20457
2008	505	16909	16909
2009	5444	17472	17472
2010	945	33153	33153
2011	1761	32397	32397
2012	27266	28721	28721
2013	29594	25640	29594

Table 3. Annual total catch and landings of the A-Fleet (BB and non-PANOFI PS) as recorded in the Ghanaian fisheries database and proposal of total TASK I. Data do not include discards at sea and landings destined to the local markets of Tema and Abidjan.

<i>Year</i>	<i>Catch</i>	<i>Landings</i>	<i>Task I</i>
2006	43843	46308	46308
2007	7500	0	47294
2008	40370	43487	43487
2009	63342	58070	63342
2010	57868	50119	57868
2011	52555	38182	52555
2012	52216	46608	52216
2013	33142	28644	33142

Table 4. Monthly proportion of the total catch of the PANOFI fleet during 2006-2013 (see method for details).

<i>Year</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>Mai</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>
2006	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2007	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2008	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2009	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2010	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2011	0.022	0.030	0.037	0.069	0.094	0.052	0.107	0.110	0.152	0.151	0.131	0.046
2012	0.043	0.051	0.009	0.058	0.128	0.053	0.082	0.096	0.151	0.139	0.145	0.046
2013	0.000	0.010	0.065	0.080	0.060	0.050	0.133	0.124	0.153	0.163	0.117	0.046

Table 5. Monthly proportion of the total catch of the A-fleet during 2006-2013 (see method for details).

<i>Year</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>Mai</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>
2006	0.056	0.069	0.064	0.039	0.124	0.055	0.047	0.091	0.180	0.183	0.073	0.019
2007	0.059	0.075	0.067	0.056	0.094	0.074	0.069	0.102	0.142	0.129	0.066	0.068
2008	0.078	0.052	0.065	0.059	0.072	0.061	0.070	0.120	0.139	0.120	0.065	0.099
2009	0.044	0.104	0.071	0.069	0.085	0.106	0.089	0.094	0.106	0.085	0.061	0.087
2010	0.089	0.100	0.097	0.072	0.086	0.059	0.041	0.098	0.093	0.094	0.079	0.092
2011	0.077	0.148	0.098	0.101	0.083	0.060	0.038	0.067	0.049	0.090	0.087	0.101
2012	0.099	0.056	0.092	0.058	0.064	0.070	0.086	0.082	0.127	0.076	0.120	0.070
2013	0.077	0.069	0.068	0.034	0.052	0.079	0.095	0.160	0.140	0.123	0.075	0.029

Table 6. Summary table of the processing steps used for estimating the monthly spatially aggregated catches of the Ghanaian tuna fisheries during 2006-2013. Sources of information and spatio-temporal resolutions are given for each data set.

	<i>P-Fleet</i>	<i>A-Fleet</i>
Gear	PS	PS & BB
Total catch	2006-2012: Landings 2013: Logbooks	2006,2008: Landings 2007: ICCAT declaration 2008-2013: Logbooks
Temporal distribution [month]	2006-2011: Logbooks 2012-2013 2012-2013: Logbooks	2006: Logbooks 2007: Logbooks 2006,2008-2009 2008-2013: Logbooks
Spatial distribution [quarter-5°x5°]	2006-2011: Logbooks 2012-2013 2012-2013: Logbooks	2006: Logbooks 2007: Logbooks 2006 2008-2013: Logbooks
Species composition [quarter-area]	European samples from PS-FAD 2006-2013	European samples from PS-FAD 2006-2013
Size composition [quarter-area]	European samples from PS-FAD 2006-2013	Ghanaian samples 2006-2013

Table 7. Annual number of fish sampled by EU sampling area (ZET) for each component of the Ghanaian tuna industrial fishery. *c_zet*: Area code, *l_zet*: Area name.

<i>c_zet</i>	<i>l_zet</i>	<i>fleet</i>	2006	2008	2009	2010	2011	2012	2013	2014	Total
1102	Northwest Picolo	A-Fleet	400	425	0	0	2247	1985	3010	4807	12875
1103	Southeast Picolo	A-Fleet	5200	1516	3000	1494	2543	1017	1400	781	16951
1104	Coastal	A-Fleet	10400	27806	28816	46782	46591	31650	24594	0	216639
1105	Cape Lopez	A-Fleet	5004	7128	9126	3521	7212	1453	502	514	34461
1106	South Equator	A-Fleet	20400	25755	31429	44533	38616	23432	13459	10662	208285
1102	Northwest Picolo	PANOFI	0	0	0	0	0	1562	0	0	1562
1103	Southeast Picolo	PANOFI	0	0	435	0	0	1208	746	0	2388
1104	Coastal	PANOFI	0	0	0	0	0	0	6530	0	6530
1105	Cape Lopez	PANOFI	0	0	0	0	0	1504	0	0	1504
1106	South Equator	PANOFI	400	500	1065	0	0	5025	7475	0	14465
			41804	63131	73871	96330	97208	68837	57716	16764	515661

Table 8. Annual number of bigeye tunas measured by area for the A-Fleet composed of the Ghanaian baitboats (BB) and non-PANOFI purse seiners (PS) during 2006-2013.

<i>Gear</i>	<i>Area</i>	2006	2008	2009	2010	2011	2012	2013
BB	1102	52	0	0	0	66	2	42
BB	1103	629	298	223	194	216	0	26
BB	1104	388	1753	1079	2234	982	443	415
BB	1105	336	662	711	96	81	28	29
BB	1106	2355	2827	3498	3892	774	312	116
PS	1102	0	64	0	0	77	1	0
PS	1103	135	126	514	106	41	104	76
PS	1104	306	451	289	980	215	100	85
PS	1105	192	168	653	402	298	52	0
PS	1106	881	1981	2678	3027	2229	713	1134
		5274	8330	9645	10931	4979	1755	1923

Table 9. Annual number of fishing trips (Ntrips) by Ghanaian baitboats and purse seiners during 2006-2013 and landing port as recorded in the MFRD database. Differences with **Table 8** from Chassot *et al.*, 2014 stem from not including the PS BERMEOTARAK CUATRO in the data set.

<i>Year</i>	<i>Port</i>	<i>Ntrips</i>
2006	TEMA	145
2007	TEMA	20
2008	ABIDJAN	15
2008	LAS PALMAS	1
2008	TEMA	164
2009	ABIDJAN	6
2009	TEMA	192
2009	WALVIS BAY	1
2010	ABIDJAN	9
2010	TEMA	207
2011	TEMA	199
2012	TEMA	220
2012	WALVIS BAY	10
2013	TEMA	153

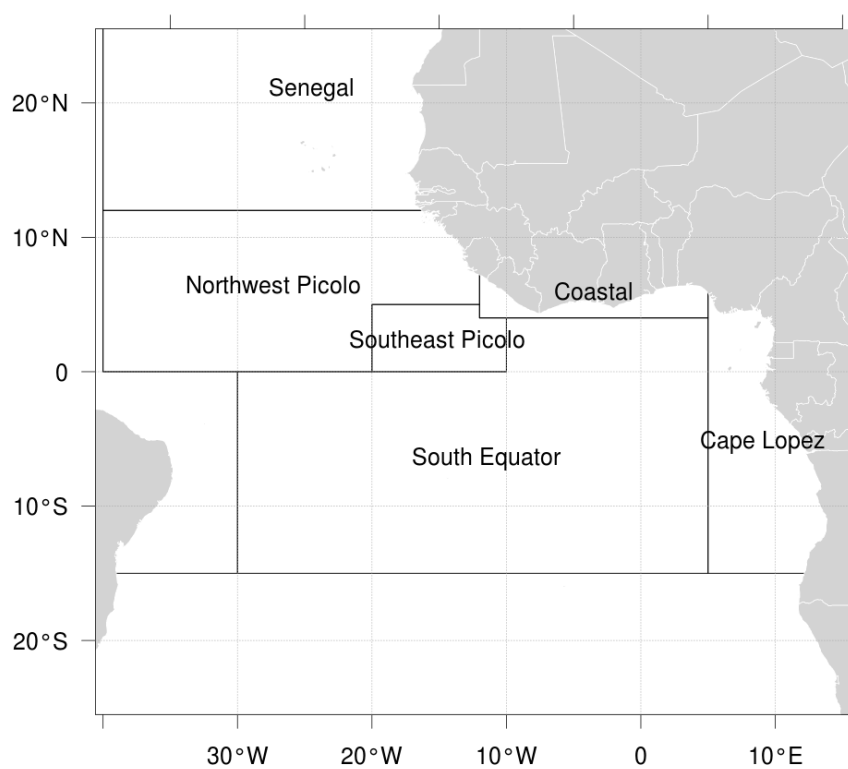


Figure 1. Map of the eastern Atlantic Ocean displaying the areas used for the processing of European PS and BB fisheries data.

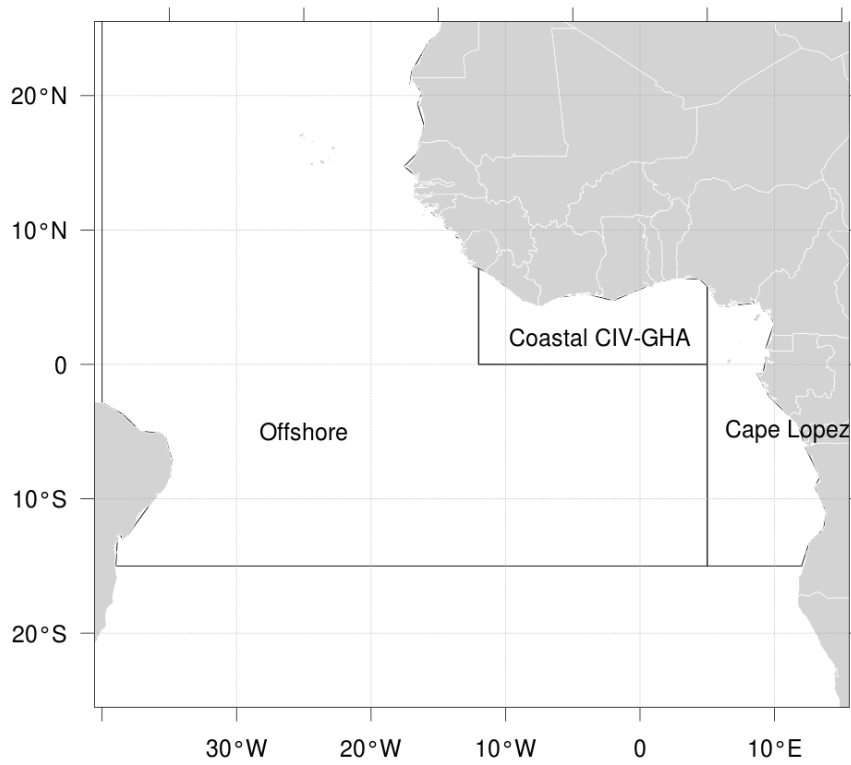


Figure 2. Map of the eastern Atlantic Ocean displaying the areas used for the processing of Ghanaian PS and BB fisheries data.

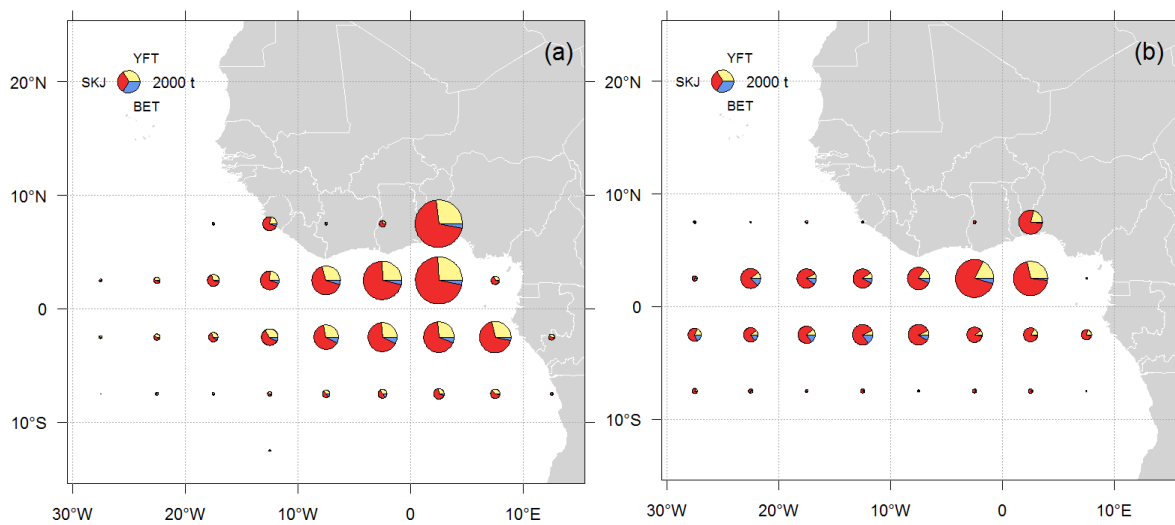


Figure 3. Average distribution of the catch of the Ghanaian PS and BB fisheries derived from logbook information (a) A-Fleet composed of baitboats and non-PANOFI purse seiners in 2006 and 2008-2013 (b) P-Fleet composed of the PANOFI purse seiners in 2012-2013.

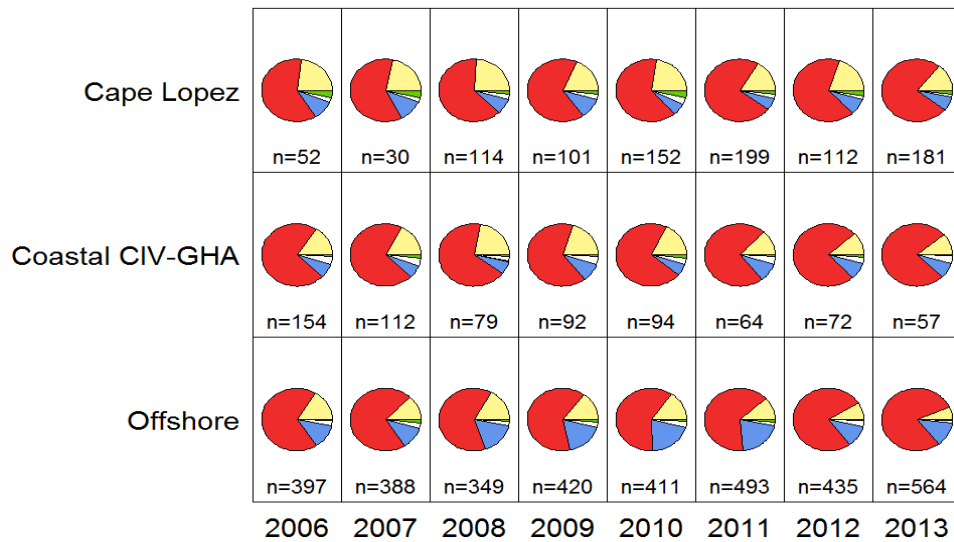


Figure 4. Annual species composition of the catch of European purse seiners fishing on FADs derived from size samples. red=SKJ; yellow=YFT; blue=BET, black=ALB; white=FRI; green=LTA. n represents the number of set samples.

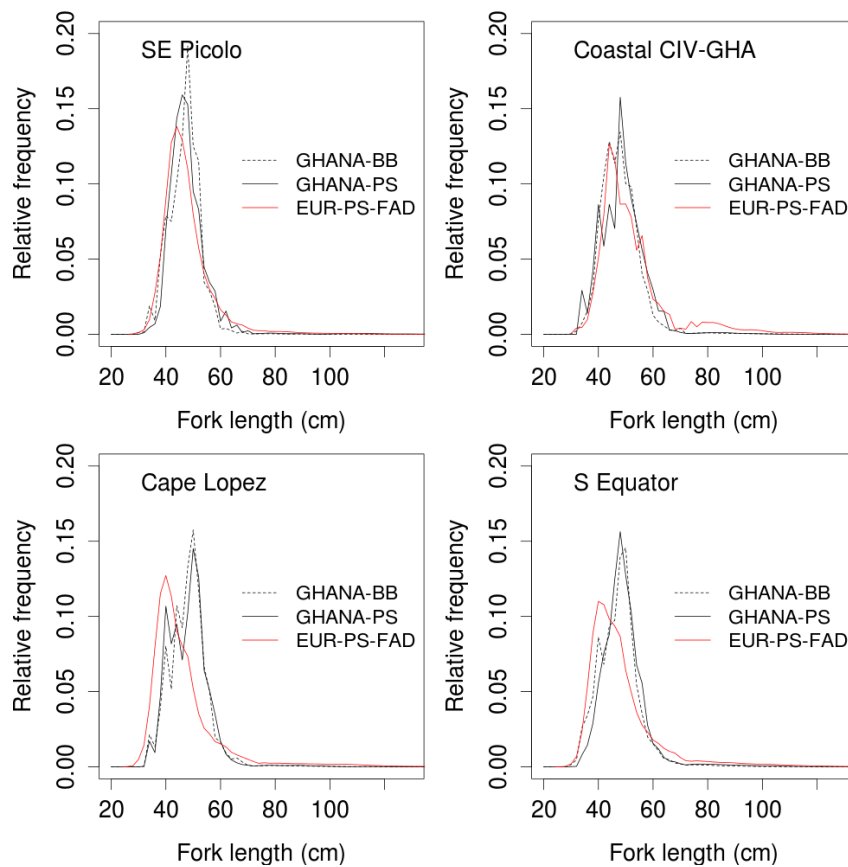


Figure 5. Relative size-frequency histograms for bigeye tunas caught by Ghanaian baitboats (GHANA-BB), non-PANOFI purse seiners (GHANA-PS) and European purse seiners fishing on FADs (EUR-PS-FAD) based on the samples collected during 2006-2013.