NEW TASK2 (CATCH & EFFORT, CATCH AT SIZE) STATISTICS ESTIMATED IN 2013 FOR THE GHANAIAN FLEET DURING THE 1996-2005 PERIOD

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SUMMARY

This paper describes the data, method and hypothesis proposed to estimate an optimal TASK2 (catch & effort and catch at size statistics) for the Ghanaian fleet during the 1996-2005 period. It makes a review of the various results, pending questions and problems in the data available and in the sampling process. These uncertainties are discussed and an optimal data processing scheme is proposed. Various types of stratification and of statistical hypothesis are compared. A base case optimal data processing and its results are proposed by this study. This new data processing basically uses the log books and size samples done on the Ghanaian fleet but also the species composition of FAD catches sampled in the EU PS fleet. The adult BET and YFT that are always caught by EU PS, but most often missing in the Ghanaian samples until 2007 have been added to Ghanaian samples. This paper also discusses the changes in TASK1 & TASK2 (C/E & CAS) due to this new data processing. A preliminary data processing has been also done for the 2006-2010 data and its results are proposed for discussion.

RÉSUMÉ

Ce document décrit les données, les méthodes et les hypothèses proposées pour estimer la Tâche II de manière optimale (statistiques de prise et d'effort et de prise par taille) de la flottille ghanéenne pour la période 1996-2005. Il passe en revue les différents résultats, les questions restées en suspens et les problèmes entourant les données disponibles et survenus lors du processus d'échantillonnage. Ces incertitudes sont abordées et un système optimal de traitement des données est proposé. Plusieurs types d'hypothèses statistiques et de stratification sont comparés. Un système optimal de traitement des données du scénario de référence et ses résultats sont proposés dans la présente étude. Ce nouveau système de traitement des données utilise principalement les carnets de pêche et les échantillons de tailles provenant de la flottille ghanéenne ainsi que la composition par espèce des prises échantillonnées réalisées sous DCP par la flottille de senneurs de l'Union européenne. Les spécimens adultes de thon obèse et d'albacore qui sont toujours capturés par les senneurs de l'Union européenne, mais dont la plupart font souvent défaut dans les échantillons ghanéens jusqu'en 2007, ont été ajoutés aux échantillons ghanéens. Le présent document se penche également sur les changements de la Tâche I et de la Tâche II (prise/effort et prise par taille) découlant de ce nouveau système de traitement des données. Un traitement provisoire des données de 2006-2010 a également été réalisé et ses résultats sont soumis à la discussion.

RESUMEN

En el documento se describen datos, métodos e hipótesis propuestos para mejorar las estimaciones de Tarea II (estadísticas de captura y esfuerzo y de captura por talla) para la flota ghanesa durante el periodo 1996-2005. Se realiza una revisión de los diferentes resultados, cuestiones pendientes y problemas en los datos disponibles y en el proceso de muestreo. Se debaten estas incertidumbres y se propone un esquema de procesamiento de datos óptimo. Se comparan varios tipos de hipótesis estadísticas y de estratificación. En este estudio se proponen un sistema procesamiento de datos óptimo del caso base y sus resultados. Este nuevo sistema de procesamiento de datos utiliza básicamente los cuadernos de pesca y las muestras de talla recogidas en la flota de Ghana, pero también la composición por especies de las capturas con DCP muestreadas en la flota de cerco de la UE. El patudo y el rabil adulto que está siempre presente en las capturas de cerco de la UE, y que está a menudo ausente en las muestras de Ghana hasta 2007, se añadieron a las muestras de Ghana. En el documento se

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debaten también los cambios en Tarea I y Tarea II (captura y esfuerzo y captura por talla) debidos a este nuevo sistema de procesamiento de los datos. Se llevó a cabo también un procesamiento de datos preliminar para el periodo 2006-2010 y sus resultados se presentan para debate.

KEYWORDS

Ghana, tuna, statistics, species composition, tuna sizes

1 Introduction: main goals of this work

This work is a follow up of the work done by the ICCAT WG in 2011 and subsequent work done by scientists (Ghanaian & EU) following this 2011 meeting. Its goal is to build a set of methods and hypothesis allowing to estimate optimal TASK1 and TASK 2 (catch & effort and catch at size statistics) for the Ghanaian fleet during the 1996-2005 period. The goal of this work is to create realistic TASK2 series for the Ghanaian fleet that can be used in future ICCAT stock assessments of YFT, SKJ and BET. This work first makes a review of the various pending questions and problems in the data available and in the sampling process since the 2011 WG, and it proposes potential new methods allowing to estimate this TASK2 using a combination of Ghanaian and EU PS statistical data. The 2013 WG will have a full opportunity to examine and discuss these results and hypothesis, and if necessary, to estimate the results of alternate data processing that could be done during the 2013 WG based on alternative hypothesis. This work will be solely targeting the catches and catches by size of the 3 major tuna species, YFT, SKJ and BET, and it will not try to estimate the quantities and sizes of small tunas landed by Ghanaian vessels, because these secondary species are poorly followed and very difficult to estimate, when these data have never been used by SRCS to do stock assessment analysis.

2 Some basic results, facts and questions on Ghanaian statistics and fisheries

2.1 Overview

The WG organized in 2011 by ICCAT on the Ghanaian statistics made a comprehensive analysis of the data analysis and statistical questions that should be used & took into consideration in the creation of the realistic TASK2 (C/E & sizes). The 2011 WG was not in position to estimate such realistic TASK2 because of several serious problems that were identified but without a clear solution during this 2011 WG.

The first year of this statistical series, the year 1996, has been already estimated by the 2011 WG, but because of the wide uncertainties in the statistics of this important year (a catch of 37.000 t.), its C/E & CAS statistic have been again estimated following the new working hypothesis used for this period. The WG will have the choice to choose the 2011 or 2013 results as being the best ones that should be used for this year 1996 in its future stock assessments.

2.2 Species composition

The 2011 WG for instance showed that the species composition presently estimated for Ghanaian catches was widely questionable, for instance always showing very low proportion of skipjack, a result in total contradiction with many observations done on the Ghanaian catches in Abidjan and at the MW-Brands cannery and on the species composition always observed on the FAD catches of EU PS.

This structural heterogeneity of species composition is well summarized by figures 1 and 2 (from the 2011 WG).

A very important factor that was noted during the 2011 WG was that **the species composition of Ghanaian catches (TASK1 & CAS) was totally and solely conditioned by the species composition of the Ghanaian samples (in weight):** the percentage of each species in the catch being calculated by the ICCAT secretariat, but without any stratification by size category or by time and area strata or gear. More importantly, this species composition was assuming a constant perfect randomness in the multispecies sampling done in Tema. Thus the present species composition of Ghanaian catches is totally conditioned:

- by the often quite low rate of Ghanaian size sampling
- by the full randomness of the fish selection sampling: each sampled fish should have the same probability to be sampled or counted by scientists, independently of its species and its size or of the unloading process (without pre-selection of sampled tunas by samplers)
- by the inadequate data processing of this non stratified species composition.

These unsolved major questions related to the species composition of Ghanaian landings had hampered the 2011 WG to estimate a realistic species composition. Subsequently, various new sampling experiments have been done in 2012 by EU and Ghanaian scientists to at least control the validity & randomness of the Ghanaian sampling.

The main conclusion of these experiments (Damiano et al July 2012) was that there was a structural bias in the selection and randomness of the tuna measured and counted in the Ghanaian sampling process, this bias producing an underestimation of SKJ catches. It should also be noted that this non randomness of the Ghanaian size sampling was already well identified and analysed by Alain Hervé 2003 in his report to ICCAT. However, it has been noted that Ghanaian samplers are very efficient to identify the small BET, even at small sizes and frozen. It remains unknown at which date this full efficiency has been reached by the Tema samplers?

However, when the SKJ sampling bias has been accepted, it is now very interesting to estimate the ratio of BET quantities vs (YFT+BET), i.e. the % of BET in the catches of **"major tunas without stripes"**. This parameter has been estimated from the various sources of sampling and for various fleets (Ghana & EU PS, Ghanaian BB & PS), see **Figure 3.**

Keeping in mind that small BET was already well identified in the EU PS catch sampling since 1980, this figure would indicate that the increasing percentage of BET in Ghanaian samples was probably due to two factors: (1) a real increase in BET percentage in the catches (as shown in the EU PS samples) and (2) to an increased capacity of Ghanaian samplers to identify small BET. This figure would also indicate often a lower percentage of BET in the Ghanaian samples than in the EU PS catches, probably due to their more coastal fishing zones (where BET is less abundant, see **Table 6**).

Furthermore, there is also an additional clear bias in the lack of very large YFT & BET in the Ghanaian samples of the purse seine catches , during many years (cf paragraph 2.4).

As a consequence, it has been decided that all the new data processing of the 1996-2005 period should be done using 3 alternate hypotheses:

1) Using the **hypothesis H1** that the real species composition of Ghanaian catches was identical to the EU PS FAD catches (but stratified by time and area) and (2) that Ghanaian PS also have been catching large YFT & large BET, as EU PS on FADs. This hypothesis that Ghanaian & EU purse seiners fishing of FADs in the same strata are catching tuna schools with identical species and size composition may still be questionable[5], but we have no other alternative to estimate this basic statistical parameter. The size distribution of the Ghana sampling will be conserved for all tunas measured at size <1 meter, but the species composition of these catches will be driven by EU PS on FADs, and large fishes will be added in the Ghana samples when they are missing.

2) Using an alternate **hypothesis H2**, assuming that the % of SKJ caught by Ghanaian vessels was identical to the % of SKJ on FAD schools (stratified by time and areas, but that the proportion of BET sampled by scientists on the Ghanaian catches of YFT+BET was unbiased and representative of the true proportion of the 2 species in the landings of BB and PS (this rule being applied after adding the big BET & YFT to the catches of each gear, big fishes that are assumed to be missing from the Tema samples, see paragraph 2-4, using the same procedure as in the working hypothesis 1). In this hypothesis 2, the species composition of Ghanaian will be assumed to be identical all year round and everywhere, due to the high rate of samples that are poorly documented, but keeping a 2 gears stratification between for BB & for PS (see paragraph 2-8)

[5] Species composition of FAD sets may for instance be conditioned by setting times, as the early morning sets (the majority of EU FAD sets) could produce a catch showing different species composition than FAD sets done in the afternoon, due to the differential behaviour of each tuna species.

3) Using a **third hypothesis H3**, assuming that the percentage of SKJ caught by Ghanaian vessels was correctly identified identical in the Ghanaian log books, when the relative quantities of BET and YFT are estimated as in H2, the justification for this hypothesis H3 being examined in paragraph 4.8.

2.3 FAD and free school catches

The 2011 WG also discussed the free schools and FAD catches in the Ghana fishery: it is well known, based on the EU PS catches, that FAD and free school catches are most often producing widely different species and size composition (free school catches show a majority of large YFT). The information available on the Ghanaian landings would indicate that most/all Ghanaian catches during the 1996-2005 period were caught showing the typical profile of FAD catches. This conclusion is well based on the absence in the samples of pure YFT (large size), that are widely dominant in the free school fishery in the Gulf of Guinea (**Figure 4**). The rarity of free schools sets could also be easily identified in the log books: when set by set data are well recorded in the log books, all the sets with pure large YFT that have been typically done on free swimming schools are easy to identify. Only 20 of these sets of pure YFT that can be estimated as being free schools sets, can be identified in the 2006-2010 Ghanaian log books. This rarity of free school fishing could possibly be explained by the difficulty for the Korean skippers to catch these highly mobile schools of pure large YFT. However, it should be kept in mind for the future data processing of Ghanaian statistics that free school catches may have been increasing in recent Ghanaian landings due to a commercial pressure by the MW BRANDS cannery (large YFT being more frequently noticed in the recent catches of their PS). This tendency should be well analyzed in the recent log books of PS belonging to the PIONEER cannery.

2.4 Catches of large YFT & large BET by the Ghanaian fleet?

The analysis of Ghanaian size data by the 2011 WG has shown that catches of large YFT and of large BET over 1 meter are most often/always absent from all the Ghanaian size sampling in Tema. On the opposite, they have been most often sampled in the EU PS landings of FAD associated catches, and on the 5308 samples done on the EU PS FAD catches during the 1996-2005 period, 59% of these samples had at least 1 large YFT or more in these samples: these large tunas are caught in small numbers, but they are typical of FAD catches caught by PS, and they are significant in weight. These large YFT have been also frequently noticed in the sampling of Ghanaian landings in Abidjan and they have also been frequently registered at the MW Brands during recent years. They are also well sampled in the Ghanaian size samples done since 2009, but not in the scientific samplings of the period 1996-2005. This lack of large tunas in the historical sampling was probably due to a bias in the sampling process done in Tema until 2007: the 2011 WG identified this bias as being due to the fact that these large tunas were measured in predorsal length or LD2 (as in the EU PS landings), but that these data have not been computerized or not converted to fork length (it would appear now that these LD1 size samples have been lost).

In this context, we have to assume that small numbers of large YFT and large BET have also been caught by Ghanaian fisheries during this 1996-2005 period, for instance in a proportion similar to the EU FAD fishery. During the years 1996-2005, these catches of large tunas will be estimated from the EU PS FAD catches on an average yearly scale, and not quarterly, taking into account that there is a marked inter annual variability of the percentages of these large YFT, but no visible seasonality in these catches, see following **Figure 7**.

This addition of large tunas in the Ghanaian size samples is important, because adding small percentages of these large YFT (about 1.4 % in numbers) in the CAS widely reduces the catches of small individuals, in proportion to the significant weight of these large individuals.

2.5. Abidjan sampling of Ghana vessels in 2001-2004

Sampling of Ghanaian landings done in Abidjan during the 2002-2004 periods: most of the Ghanaian vessels landed in Abidjan during this period, due to an economical crisis in Ghana. During this period many of the landings have been well followed (log books and species/size sampling) by IRD/CRO scientists, and these data have been fully validated in the AVDTH data base. The rates of log books collected on these Ghanaian landings in Abidjan were higher than the log book coverage in Tema. This independent data set also covers the beginning of the P-fleet in July 2003, and it offers a valuable independent data set: in term of species and size composition, this random sampling of the Ghanaian catches was identical to the sampling of the EU fleet.

As an example, this quite intensive sampling, done under the EU PS rules of random sampling, would indicate that PS catches contains significant % of large YFT and large BET > 1 meter, these large tunas being more rarely sampled in the BB catches (see **Figure 8** and **Table 1**).

This Abidjan sampling would indicate that the percentages of large tunas were variable in 2003 & 2004, and that pole and line vessels have been also landing large tunas, but in a much lower proportion compared to PS.

Furthermore, it should be noted that the size sampling of the Ghanaian fleet done in Abidjan in 2001-2004 has been quite intensive, allowing to sample 45.100 tunas. The size composition of these ABJ samples appear to be quite similar to the EU PS FAD catches during this period, and quite different from the Tema multispecies sampling (see **Figure 10**).

2.6 Size sampling available during the period and its potential use in the estimation of quarterly CAS

It was noted during the 2011 Ghana WG that a quite good level of size sampling have been done on the 3 species landed by Ghanaian vessels (mainly in Tema, secondarily in Abidjan) during the 1996-2005 period. The total number of tunas sampled each year by gear and species are shown by **Table 2**.

In the estimation of Ghanaian CAS, the following recommendation by the 2011 WG that, *"Due to the observed seasonal variations in size frequency, it is important to calculate catch at size at the quarter level, at least, whenever possible"*, should be kept in mind and accepted in the processing of the 1996-2005 data because quarterly sizes sampled during the period are clearly showing for YFT & BET (but not for SKJ) the typical seasonality of size caught, see **Figure 11**, that was analyzed by the 2011 WG during recent years (after 2005).

The extrapolation of sampled sizes has been made in order to estimate the quarterly CAS of each species. The following working hypothesis has been used in the present data processing:

(1) Large YFT and large BET are first added in the PS samples (as described before)

(2) All the quarterly samples by gear of the 1996-2005 period are extrapolated, to the quarterly catches by 5° squares, by species, the area stratification with 3 strata being used in this calculation.

(3) Sizes of faux poissons landed in Abidjan estimated by the Abidjan sampling have been added to these CAS.

However, it can be noticed that the numbers of available samples are quite small during some quarters (cf **Table 4**), and that it may be better to extrapolate the average profiles of quarterly sizes sampled during the entire average period 1996-2005.

2.7 Spanish purse seiners fishing under Ghanaian flag: S-fleet

The total yearly catches and average fishing zones of this fleet during the period are given in the following **Figure 12** and **Table 3.**

The available task2 data of these 2 vessels (C/E & CAS) have been already processed by EU scientists and already submitted to the ICCAT secretariat for the 1996-2005 period. These vessels are showing a fishing more or less similar to the EU fishing mode, in a very large fishing zone, and not as in the Ghanaian fishing mode (conditioned by the Korean skippers of Ghanaian vessels). This point is also well shown by the high percentage 33% of free schools catches observed in this segment of the fleet.

As a consequence, the data processing of these vessels has been done using the EU T3 software and data base (and its strata substitution with other EU PS data), and independently of the main Ghana/Korean segment of the fleet. A pending question: it is not clear if these catches should be added to the Ghana TASK1 or if they are already included in the data submitted by Ghana to the ICCAT.

2.8 Small tunas sold as "Faux poissons" in Abidjan

These quantities of the 3 species of major tunas have been well estimated by CRO & EU scientists, and they have been already submitted to the 2011 Ghana WG. These tunas must be incorporated in the new TASK2 (catches and sizes), but the time and area strata of these catches cannot be estimated.

A pending question: it is not clear if these catches should be added to the Ghana TASK1 or if they are already included in the data submitted by Ghana to the ICCAT.

For simplicity reasons, they will be simply added to the total catches. These cryptic catches of major tunas are quite moderate during the processed period (an average total catch of only 1550 tons), but they are much more important during the 2006-2010 period (an average catch of 5 500 tons).

2.9 Pole and line and purse seine stratification?

The Ghana 2011 WG made a recommendation that BB & PS catches and sizes should preferably be pooled without using the traditional stratification between these 2 gears statistics, primarily because of the limited data set available.

"For the third period (1997-2010), Ghanaian catches increased to represent nearly 20% of total catches of Atlantic tropical tuna. Because of the cooperative fishing activities and sharing of catches among Ghanaian purse seine (non-PS_Other) and baitboat vessels, these must be treated during this period as if they were a single gear".

This sharing/exchange of tunas between BB and PS was already well described by Bannerman & Bard 2002 & by Alain Hervé in their report to the ICCAT Secretariat.

However it should be kept in mind that most BB and PS fisheries tend to show during the studied period a widely distinct size selectivity for large size YFT & BET: large YFT and large BET being easily caught by PS, and very rarely by BB, & especially BB that are not equipped to catch large tunas (as in Dakar and in Canary Islands). This conclusion has been well confirmed by various size sampling, for instance the unbiased Abidjan sampling in 2001-2004, showing for Ghanaian purse seiners **32%** of YFT catches in weight larger than 1 meter, and only **6 %** of large YFT for baitboats (**Figure 8**). This heterogeneity of tuna sizes landed by the 2 gears during this period is a strong proof that the exchange of tunas between these 2 gears was quite limited, as otherwise, size distribution of tunas landed by the 2 gears should have been identical.

Furthermore, most multispecies size sampling done on Ghanaian BB & PS are often showing during the 1995-2005 period a distinct species composition of the 2 gears, for instance lower rates of BET in the BB samples (see **Figure 14 a & b**). This lower rate of BET should be considered as being potentially realistic, as BET was very well identified by Ghanaian samplers during recent years. This lower rate of BET could also be exaggerated by differences in fishing zones (being a logical consequence of their more coastal fishing zones with a lower % of BET), this point being well handled by the geographical strata. A selectivity/behavioural bias, each species potentially showing a variable catchability to the shallow live bait, could also explain the lower rate of BET in often observed for BB.

In this context, the use of a combined gear BB+PS during the period 1996-2005 may introduce a bias in the estimation on the sizes & species caught by Ghanaian vessels. This problem would disappear when the BB are simply working as freezers for the PS fleet (and not as fishing vessels; in this hypothesis, all landing from Ghanaian BB & PS should show very similar or identical sizes and species composition (on the opposite, this homogeneity of the PS & BB landings, sizes and species composition, will not be visible during recent years for instance in the 2011 samples).

As a consequence, it could be concluded that stratification between BB & PS should preferably be kept in the data processing during this period 1996-2005. Furthermore, the increasing percentages of the PS catches in the Ghana landings during the 1996-2005 period, see **Figure 13**, could introduce some unexpected bias in the results, if the 2 gears are not randomly sampled in proportion of their catches[6] and later combined in the data processing. Consequently, this 2 gears hypothesis has been kept as a base case in the present data processing but an additional data processing combining the 2 gears will also done as an alternate method.

However, it should be noticed that these differences in species and in size composition of BB & PS tend to disappear during recent years, for instance during the 2008-2011 period, and during the 2006-2012 period the working hypothesis of combined gear would probably be the only hypothesis to consider in the data processing.

[6] For instance when the P-Fleet fleet of purse seiners is not sampled

2.10 1996-2005: a period of very low of log book coverage:

The yearly coverage of the log book data by 1° squares & month (ratio of log book catches and of total catches) and the percentage of catches sampled for their sizes is given by **Figure 16.** The average coverage of these log books is much lower than 10 %, rates, increasing sharply in 2003 & in 2004 (because of log books collected in Abidjan), in 2006, and after 2008.

It should be concluded that the very low average level of log books coverage, lower than 10% during most years, does not allow doing realistic extrapolations of the monthly task2 catch & effort by 1° or 5° squares, month or quarter. Furthermore, this low coverage is unevenly distributed over time: some months/quarters do not have any log books. Consequently, it has been concluded that the best & only way to estimate a realistic task 2 during this period would be working under a strata substitution hypothesis with recent years (as during the previous period 1973-1995): for instance assuming that the C/E quarterly pattern of catches by 1° was observed each year during the 1996-2005 period were identical to the fishery pattern observed during recent years, for instance during the average period 2006-2010.

2.11 A basic stratification between P-fleet & A-fleet

The Ghana 2011 WG has shown that the Ghana fleet should preferably be stratified in these 2 fleets that are showing widely different fishing zones, catch rates and percentages of well filled log books: (1)PANOFI or P-Fleet& (2) the rest of the Ghanaian fleet or A-Fleet. The P-fleet has been showing during the studied period a very low coverage of its log book and seldom landings of its purse seiners in Tema, the opposite for A-fleet with a quite good log book coverage and frequent landing/sampling in Tema during recent years. The P-fleet started its activities in 2003, and its has been quite well sampled in Abidjan in 2003 and 2004 during its 2 first year of activity (log books and size/species composition).

The yearly ratio of P-fleet log books available /P-Fleet declared catches is shown by the following **Figure 17** (also taking note that during various quarter of some years, there are few or no P-fleet log books available during the 2004-2008 period, see **Figure 18**).

The quarterly fishing zones of these 2 fleets are given by 1° squares in **Annex 1**.

Because of the low coverage of log books data of the P-fleet, and because there are no log books available during several quarters of this period (see annex 1), the C/E and CAS of this fleet will be estimated by strata substitution based on the average pattern of catch and effort during its period 2006-2010 of improved sampling. However, because of the time heterogeneity in the P-fleet log book coverage, and because of its low rate of coverage , see **Figures 17, 18 & 19**, a constant quarterly catch has been assumed for each year (at 25% of the yearly catches) for the P fleet. Its fishing zones exploited during each quarter have been assumed to be identical, based on their yearly average fishing zones during the period 2003-2010. This quite questionable statistical rule has been chosen taking into account the weakness of log book data of the P-Fleet and because of the apparent lack of seasonality in its fishing zones, well shown by the quarterly catches identified in the available log books of this fleet, see **Figure 20.**

The log books of the A-Fleet, BB & PS, have been better sampled by scientists during recent years 2006-2010 (see **Figure 16**). Their C/E data of the 1996-2005 period will be processed without strata substitution with the P-fleet, but basically doing for this A-fleet a strata substitution with the average quarterly catch and effort pattern well observed during the 2006-2010 period: assuming that the C/E by time and area strata of the A-Fleet was identical to the C/E scheme observed during this period. This seasonal pattern of quarterly fishing zones of the Ghanaian A-fleet is shown by **Figure 21**.

3 Data and methods

3.1 Basic data available and used in this work.

Seven sources of information and data bases have been used at various degrees in this work:

1) Catch and effort during the 1996-2010 period: catch and effort data corresponding to the sampled fraction of the Ghanaian fleet, by 1° and month, submitted to the ICCAT by Ghana in 2011. C/E data of 2006 and 2008-2010 have been entered in the AVDTH software and processed by the TT Ghana 2011 WG

2) Size data: unraised size samples submitted to ICCAT by Ghana in 2011 (1972-2010) and size data of the Ghanaian landings done in Abidjan during the 2001-2004 period.

3) Catch and effort and size data sampled on Ghanaian vessels in Abidjan during the 2001-2004 period (entered in the AVDTH IRD data base)

These two sets of size sampling have been cumulated by species and quarter, and the **Table 4** summarizes the numbers of tunas sampled for size in the data base.
It can be noted that the quarterly sizes by species by gear of this sample is quite consistent over time, most quarters being quite well sampled, especially taking into account the fact that these fishes are predominantly caught in a limited ranges of small size fishes.

1) Gure Campolibre & Bermeo Tarak 4, later called S-Fleet (2 vessels owned by Spanish owners & fishing under Ghana flag): detailed C/E and size data have been provided to ICCAT by IEO Spanish scientists & processed by EU scientists during the 1996-2005 period

2) Data on the yearly landings and sampling of Ghanaian "faux poissons" landed from Ghanaian vessels on the local market in Abidjan, provided by IRD/CRO to the ICCAT.

3) Monthly & yearly catches declared by Ghana for its P-fleet since 2003.

4) EU purse seiners: 2 sets of data were available and used in this study: (1) all the detailed sampling data ("SPECIES" file: by sample, by fishing mode, with the exact fishing date and position) and (2): the processed extrapolated size samples of the same fleet, extrapolated to the best catch at size of each species (by quarter and by 5°-month), after the ad hoc strata substitutions done by the IRD T3 software..

This work will be using the report of the 2011 ICCAT WG on Ghanaian statistics, and the 2012 reports by the EU scientists following there sampling experiment in Tema.

3.2 TASK 1 Used in the analysis

The present work will be done in the hypothesis that the total yearly catches of tropical tunas declared by Ghana to ICCAT for the 1996-2005 period were basically correct, but not their species composition. However the total catch during the year 2004[7] has been increased to a total of 77 807 tons instead of the 49 435 tons declared, as this last value was clearly too low, and inconsistent with the total catches declared for BB (39 558 tons) and for the P-fleet PS (20 305 tons). A total catch of 17 944 tons has been estimated for this year 2004 for the A-Fleet PS (the average of its 2003 and 2005 catches).(cf **Table 5**)

This work will use the table of total catches declared by the P-fleet as being a correct equivalent to the total catch of this fleet. These total catches of the P-Fleet are assumed to be a component already included in the total TASKI Ghanaian catches.

This work will also incorporate the yearly amounts and estimated quarterly catch at size of the small size tunas sold as "Faux Poissons" in the Abidjan local market, as they have been estimated by the CRO sampling scheme and provided to the Ghana 2011 WG. These catches will be added to the 2 fleets as an additional catch, but without explicit fleet, and without gear. The species composition and quarterly sizes of these "faux poissons" landings during the 1996-2005 period are based on the average species composition and sizes that have been sampled & estimated in Abidjan during the 2007-2010 period (strata substitution). Two working hypothesis will be used in the data processing: (1) quantities of "faux poissons" are already included in the TASKI and (2) quantities of "faux poissons" are not included in the TASK1 and they should be added to it.

A revised TASK1 will be estimated after this data processing, keeping the present levels of total catches, but estimating a corrected species composition of these landings.

Furthermore, the yearly total catches of the 2 main fishing gears used by Ghana to target tropical tunas, BB & PS, will be kept in most calculations (but not for faux poissons), because of the apparent differences in sizes and in the species composition of tunas catches landed by each gear. These yearly total catches of each gear declared by Ghana and used to stratify the catch of the A Fleet are given in **Table 7.**

[7] The same statistical problem will also be faced for the year 2006

This data processing will not envisage the serious questions concerning the uncertainties in the levels of TASKI declared by Ghana: there are serious reasons to consider that this TASKI has been possibly underestimated during some recent years (Ann ICCAT 2011). These statistical questions are for instance quite clear concerning the P-Fleet data, a fleet that has been very poorly followed by scientists. However this TASKI question is highly complex, at a statistical level for scientists and at a political level, and it will not be included as a scope of this technical paper.

3.3 Data processing

3.3.1Geographical strata

Due to the quite low coverage of the Ghanaian log books and sample sizes during the 1996-2005 period, a 3 areas stratification (Figure 24) has been used in the proposed data processing, these 3 areas being derived from the EU FAD sampling areas shown by **Figure 23**. The yearly species composition of EU PS FAD catches in each of these 3 Ghanaian areas is shown by **Figure 25.**

- Area 1: coastal zone off Liberia, Cote d'Ivoire and Ghana: an important fishing zone for the Ghanaian tuna fleet, & an area often showing in the FAD catches by the EU PS a peculiar species composition with a higher % of YFT (but unfortunately with few samples available).
- Area 2: coastal zone off Cape Lopez, an area fished seasonally by EU PS between June and October, and also showing peculiar types of size and species composition, but at a lower degree.
- Area 3: all the other offshore fishing zones, that are assumed to be homogeneous in their species composition and sizes caught. This strong hypothesis may not 100% valid, but it appears that the size and species composition of FAD catches tend to be quite homogeneous in the offshore areas, a conclusion based on the average composition observed by 5° for the EU PS catches on FADs. However, based on the fact that the EU PS have major fishing zones north of 5°N, when the Ghanaian fleets have been very seldom fishing north of 5°N during the period (see **Figure 32**), the **species composition of EU PS FAD catches** will be calculated in the offshore areas, but **only south of 5°N.**

Table 6 provides the same basic information that will be conditioning the species composition of Ghanaian catches in the H1 and H2 hypothesis.

These species composition percentages can also be compared to the species composition sampled in Abidjan during the period 2001-2004, these catches being predominantly sampled in area 3, but also from unknown geographical position, see **Table 7.**

It should be noticed that when this SKJ percentage was similar to the levels in the EU PS FAD fishery, percentages of BET tend to be quite low, much lower than in the offshore main fishing area, but at the lower levels observed in the coastal areas of Cape Lopez & Ghana-CI.

The yearly species composition of the EU PS FAD catches in each of these 3 areas is also well summarized by the % of SKJ in the following **Figure 26**. These species percentages by area will be conditioning the species composition of the Ghanaian catches in the H1 and H2 species composition hypothesis, in proportion in the Ghanaian catches taken in these coastal areas.

This **Figure 26a** shows the lower % of SKJ observed each year in the 2 coastal areas (higher % of YFT), a fact already noted by the 2011 Ghana WG. This figure also shows that the % of SKJ in the today Ghanaian TASKI is most often well under the percentage of SKJ observed in all areas for the EU PS FAD catches. However, it appears that the coastal area off Ghana & CI has been seldom fished by the EU PS, and then that small numbers of size/species samples are available in this area. These low and variable sampling rates are a potential cause explaining the large year to year variability of the species composition of the catches estimated in the Ghana-CI area.

3.3.2 Gear stratification

Based under the conclusion of paragraph 2.9, the creation of the TASK2 for the 1996-2005 period has been done assuming a A-fleet stratified in BB & PS. Large YFT and BET have been added to the Ghanaian CAS (A & P fleets) solely in the PS samples and PS catches. It was concluded that this stratification may be interesting during the 1996-2005 period because of the visible heterogeneities in the tuna catches landed by the 2 gears, even if the

tuna catches of the two gears are significantly and increasingly mixed (when this stratification should not be kept during the subsequent period 2005-2012).

3.3.3 Time strata

Quarter have been used in all data processing: assuming an homogeneous size and species composition within each quarter, but all the C/E results are provided on a 1° scale.

3.3.4 Catch & effort data used for the period 1996-2005

It could have been envisaged to extrapolate the log book data collected in Tema and in Abidjan to the total catches (TASKI) declared to ICCAT by Ghana. However, this method cannot be used because of the very low rates of log book coverage during all years, including during their best sampling period in Abidjan (2002-2004). This very poor level of the log book coverage is well summarized by figure 15 and by the quarterly fishing maps of the 2 Ghanaian fleets (**Annex 1**).

In this context, a constant quarterly fishing pattern of catches by time & area strata estimated during the 2006-2010 period has been used, using a strata substitution, to estimate the fishing strata of the various fleets. These quarterly patterns of time & area catches will be extrapolated yearly to the TASKI of each fleet (**Table 5**)

3.3.5 Free schools and FAD stratification

This data processing has not been stratified by fishing mode, but it is most often assumed that all the Ghanaian catches were caught on FAD associated schools.

3.3.6 Tunas size categories

When size categories of tuna caught are playing an important role in the EU PS data processing (estimating the species composition in each size category based on detailed log books information), the available data during this period do not allow to use this parameter in the data processing. However, it should be kept in mind that the species composition estimated from the EU PS catches that has been used to adjust the Ghanaian species composition is making of full use of these size categories.

3.3.7 Catches of large YFT and of large BET over 100 cm (about 20 kg)

Based on the 2011 WG analysis, it has been assumed that the lack/rarity of large YFT and large BET in the Ghanaian samples during the studied period was due to a sampling bias. The quantities of these large tunas have been estimated from the percentage and sizes of large YFT and of large BET estimated in the EU PS FAD catches (by time & area strata). These large tunas have been added to the Ghanaian samples in their ad hoc percentages, allowing to estimate more realistic profile of size composition of the Ghanaian catches. The yearly catch at size of these large YFT and large BET caught by EU PS on FADs have been added to the Ghanaian Tema samples in their proportion observed in the EU PS FAD samples. These proportions are given by **Table 8** (percentage of total catches in numbers).

These yearly amounts of large YFT & BET tunas have been added to the Ghanaian samples of PS and not to the BB samples, assuming that these catches of large tunas were very rare for the Ghanaian BB.

3.3.8 A three fleets stratification: P-fleet, A-fleet and S-fleet

- Catch and effort of the P-fleet (active since June 2003) during the 2003-2005 period has been assumed to be identical to the C/E quarterly pattern of its 5° catches observed during the 2009-2010 average period. These catches have been extrapolated each year to the yearly total catches declared by the P-fleet (**Table 5**). The species composition has been estimated (on the 1° scale catches) from the EU PS FAD species composition in the 3 areas, and the catch at size of these estimated catches have been estimated based on their size sampling in Abidjan during the years 2003 and 2004.

- Catch and effort of the other Ghanaian (active during the period 1996-2005) has been assumed to be identical to the average 2006-2010 C/E scheme (without 2007 data, as the log book coverage during this year is considered to be insufficient). The catches of this period have been extrapolated each year to the yearly total catches estimated for each fleet (**Table 5**) and the species composition has been estimated (on

the 1° scale catches) from the EU PS FAD species composition in the 3 areas. Catch at size of these estimated catches have been estimated based on their size sampling during the years 1996-2005. This calculation has been done primarily combining PS & BB, as recommended by the 2011 WG, but also stratified by gear (BB & the 2 fleets of PS).

- The TASK2 (C/E and CAS) of the S-fleet has been processed independently by the EU T3 software (and in conjunction with the EU data & software, cf Pianet et al 2000, this S-fleet being a statistical component of the EU fleet).

3.3.9 Species composition

The new data processing has been done on 2 different hypothesis:

1) In the **1st hypothesis so called H1**: all Ghanaian catches by 1° squares were extrapolated by time and area strata assuming the yearly species composition estimated by EU scientists for the EU PS catches on FADs, using their fully stratified ad hoc TT software (Pianet et al 2000). This average species composition by area estimated during the period 1996-2005 is given at a yearly scale table 9 and shown by figure 25. All species corrections have been corrected on a quarterly and 3 areas basis, but simply assuming a constant species composition in each area; the same species composition is applied by area to both P-fleet & A-Fleet.

(2) In the **2nd hypothesis so called H2:** the species composition of the Ghanaian catches during the period 1996-2005 was estimated also using the Ghanaian multispecies sampling and now assuming (a) that the proportion of SKJ catches was identical to the % of SKJ observed in the EU PS FAD fishery (but only south of 5°N), and (2) that the proportion between YFT and BET in the Ghanaian samples was unbiased (see paragraph 2.2) and representative of the percentages of these 2 species in the Ghanaian catches. This data processing has been done on a quarterly basis (assuming each quarter a constant % of each species), and separately for BB and for PS (as the species composition of the 2 gears is often quite distinct, due to their differential selectivity between species), but without geographical stratification (assuming that the Ghanaian sampling have been done + or – in proportion to the Ghanaian catches by time & area strata).

The analysis of the proportion of BET & YFT estimated in the EU PS & Ghanaian samples during recent years has also be done in order to better evaluate its potential validity and use. The main result of this analysis is shown by **Figure 26b** where the % of BET in the YFT+BET samples are plotted by decreasing weight, for the samples taken on the 3 fleets: Ghanaian BB & PS samples and EU PS FAD samples.

This figure is based on a quite large number of samples: EU PS FAD, 5240 samples (average amount of BET 41%), Ghana BB 814 samples (average = 30% BET) and Ghana PS, 643 samples (average = 34% BET). It shows a rather striking & surprising quasi linear declining trend of BET percentages in the EU PS FAD samples, at least for the 80% of samples showing the higher rates of BET. It should also be noted that the EU & Ghanaian samples are showing quite similar patterns of levels & trends in BET %, when the Ghanaian BB & PS samples are showing some differences: BB samples often showing lower percentage of BET. These differences in BET proportions are probably due to geographical effects, BET being less abundant in coastal waters where Ghanaian fleets are very active.

3.3.10 Catches of the S-Fleet

These yearly quantities of Ghanaian/Spanish tunas landed yearly are given in **Table 5** The TASK1 & TASK2 of this peculiar segment of the Ghanaian fleet has been estimated by the EU scientists, using their TT software and when necessary doing *ad hoc* strata substitutions with the EU PS data base. For simplicity reasons in the final data processing, these minor catches and CAS estimated externally have been simply added to the Ghanaian TASK1 & TASK2 estimated by the ad hoc methods described in this paper. This simplified hypothesis could of course be changed.

3.3.11 "Faux Poissons" landed in the local market of Abidjan.

The total yearly amount of these Ghanaian tunas have been estimated by scientists, but not their exact species composition nor their sizes (sampled only since 2007). These yearly quantities of Ghanaian tunas landed yearly in the faux poisons market of Abidjan are given in **Table 5.** The new data processing proposed will assume that the species composition and sizes of each species landed in the "*Faux Poissons"* market had a typical quarterly

profile of the average sizes sampled during the 2007-2010 period. These average sizes that are typical of the *faux poissons* Abidjan market are shown **Figure 27**.

For simplicity reasons, the total catches and CAS by species that have been estimated by this ad hoc strata substitution will be simply added to the basic TASK1 & TASK2 data estimated for the Ghanaian fleet, taking note that these levels of catches are quite minor ones during the period 1956-2005: an average total catch of only **1760** tons, then only 2.7 % of Ghanaian TASKI during this period.

3.3.12 Summary of the recommended data processing

The data processing that has been recommended and used during this period 1996-2005 is summarized by the flowchart **Figure 28.**

4 Results

4.1 Species composition

The new species composition of the Ghanaian fishery during the 1996-2005 period obtained by the Species Composition 1st Hypothesis and a 2 gears stratification is shown by **Table 9** and by **Figure 29**, in comparison of the previous one.

This figure shows that the species composition estimated in the 2 hypothesis H1 & H2 are very similar, but both being very different from the species composition previously assumed in the today ICCAT TASKI.

The main changes in the levels of catches by species estimated in these H1 & H2 hypothesis can be noticed as following:

- Systematic decline of YFT and showing during the period a significant average decline of 25%. Similar rates of decline are estimated in the H1 & H2 species composition hypothesis: 23 & 21 %.

- Frequent decline of BET landings but not every years, and showing during the period a significant average decline of 18% (H1) and 22 % (H2), but stable or increasing catches have been estimated during some years, for instance in 2002 & in 2004. These increases in the BET catches are due to the higher rates of BET that have been sampled on a large number of samples in Abidjan during this period (and they are probably realistic?)

- Systematic increase of SKJ landings (except in 1997?), and showing during the period an average increase of 28% .

The yearly catches by species estimated in the 2nd hypothesis of species composition H2 are given in the following **Table 10.**

It appears that when the average catches by species estimated in the 2 hypothesis H1 & H2 are very similar (**Tables 9** and **10),** the between years variability of catches by species estimated in the 2 hypothesis H1 & H2 are quite high in some years, for instance BET catches estimated by the 2 method fluctuating between 1 & 2 in 2002 and in 2004.

The results obtained in the H3 species composition are showing very similar results in the average catches of each species during the 1996-2005 period, taking note that the yearly catches estimated each year in this hypothesis are sometimes quite different for the estimated catches by species in H1 and H2. These results are given in the following table 11 and shown by **Figure 30**.

4.2 Fishing zones

The average fishing zones of the 2 Ghanaian fleets, P&A, have been estimated by 1° squares , & they are shown (by species) on figure 31 and 32. These Ghanaian fishing zones are also compared with the EU PS fishing zones on FADs (**Figure 33**).

These figures are showing the differential fishing zones observed for the two fleets, and the relative weight of each fishing zone, at least much better than the traditional CATDIS fishing maps done by the ICCAT secretariat and their artificial excessive catches in the two 5° squares off Ghana. The average quarterly fishing zones estimated now for the Ghanaian fleet during this period 1996-2005 are shown by figure 35, in comparison with the EU PS FAD fishing zones during the same period (**Figure 36**).

The average fishing zones that have been estimated for the Ghanaian fleet during the period 1996-2005 (based on the 2006-2010 fishing zones) can be compared with the average geographical locations of catches that have been recorded in the too rare log books by 1° squares. This result is shown by **Figure 34.**

The comparison of **Figure 32** y **34** would indicate that the fishing zones that have been estimated by strata substitution with recent years are quite consistent with the log book data of the 1996-2005 period. However, it should be noted that the log book catches 1996-2005 in the area of Cape Lopez are much lower than the catches estimated by strata substitution in this area, and that they may be overestimated.

It should be noted that this fishing pattern of Ghanaian vessels is showing fishing patterns that are quite different from the EU PS fishing patterns, for instance showing:

- Much more important catches in the coastal areas off Ghana and Ivory Coast

- Very low seasonality of most of its fishing zones (keeping in mind that this conclusion is totally driven from the 2006-2010 log books used to estimate the 1996-2005 fishing patterns).

- For instance, noting the fishing activity all year round off Cap Lopez, when on the opposite the EU PS fishery is always seasonal, see the following maps, **Figure 36.**

- The very low catches of the Ghanaian fleet at latitude north of 5° N in the central western Atlantic (the opposite for the UE PS FAD fishery).

4.3 Catch at size by species.

The average catch at size of the 3 species estimated in the H1 hypothesis of species composition are shown (in weight, by 2 cm class) as histograms by **Figure 37**. These figures are based on the new species composition, and they incorporate the Faux Poissons landings and the amount of additional large YFT and BET that have been estimated from the EU PS FAD catches and added to Ghanaian BB and PS in proportion of their yearly catches by gear.

These three figures are showing:

(1) An increase in the new CAS estimated for SKJ due to increased SKJ catches, and also larger numbers of very small SKJ due to the catches of *"faux poissons"*.

(2) Significant weight of large YFT and large BET are now caught by the Ghanaian fleet.

(3) A marked decline in the numbers of small YFT and of small BET caught by the Ghanaian fleet, due to the decline of total catches of the 2 species and to the increased catches of large tunas.

The CAS caught by each gear BB & PS are also interesting to compare, for instance the CAS of YFT estimated in the H1 hypothesis, see **Figure 38.**

In this estimated CAS, a small percentage of YFT were caught by PS at size over 1 m during the average period 1996-2005 (only 4.2%), but these sizes caught correspond to a large percentage: 39% in weight. However, it should be kept in mind that these large size YFT have been mainly estimated from the EU FAD samples. On the opposite, catch at size of BB & PS estimated for BET and SKJ are very similar for small fishes.

The average CAS by species during the 1996-2005 period estimated in the H3 hypothesis are shown in weight, for the 3 species by **Figure 39**, in comparison with CAS previously assumed by SCRS.

These average CAS by species estimated in the H1, H2 & H3 species composition hypothesis are very similar,, being nearly identical at the level of their 10 years average (simply because total catches by species are very similar, and because the same samples are extrapolated to these same average levels of catches).

4.4 Average weight of Ghanaian catches

The new CAS presently estimated allows to estimate the yearly average weights caught yearly by BB & by PS (including large YFT & BET added from EU PS and *faux poissons* CAS). This basic result is given by **Table 12.**

4.5 PS & BB apparent heterogeneity

The proposed data processing stratified between BB & PS allows to compare the CAS & species composition estimated for each of the 2 gears, this results being of peculiar interest for the H2 hypothesis. In the H1 hypothesis, the species composition of the 2 gears is identical by time & area strata, both gears being conditioned by the EU PS sampling. As a result, this PS/BB stratification has no visible consequences in the H1 hypothesis.

However, in the H2 hypothesis where the species composition of each gear is widely conditioned by their sampling, some differences are introduced by the hypothesis H2 in the species composition of each gear. This is for instance the case for the amount of BET caught by BB and by PS that are showing each year distinct changes of their species composition in H1 & H2, see **Figure 40**.

The average species composition of BB & PS appears to be quite distinct during the period, less SKJ and more YFT caught by BB, this estimated difference being similar in the 2 working hypothesis H1 & H2, see **Table 13**.

4.6 YEAR 1996: TASKI &TASK2 estimated by the 2011 WG & in 2013

As this year has been estimated by the 2 ICCAT WGs in 2011 and in 2013, there is a potential choice now to use one or the other series for future stock assessment of tropical tunas. The species composition of Ghanaian catches during this year 1996, estimated by the 2011 WG and now are shown by **Table 13.**

It can be noticed that the new data processing has been keeping similar level of SKJ catches (+7%), but producing more significant changes of BET estimated catches (+21%) and of YFT catches (-25%).

Furthermore, the fishing zones estimated in these 2 series appear to be quite distinct: the 1996 fishing zones estimated in 2011 being substituted with previous years data (average period 1982-1986, then a quite historical period), when the present fishing zones are estimated based on the 2006-2010 log books (**Figures 41a & 41b**).

Fishing zones presently estimated are quite similar, but larger than in 2011, for instance reaching now 25°W and only 10°W before). It is impossible, based on statistical evidence, to firmly conclude what are the best & more realistic statistical series for this "frontier year" 1996. However, based on the 3 following facts that:

(1) the 2011 data processing was based on strata substitution with a remote historical period 1982-1988;

(2) that the species composition is now much more realistic than in 2011; and

(3) that the 1996 fishery that was already active on FADs (Bannerman & Bard 2002)developed on FADs should preferably be compared to the today fishery, then it should be recommended to use the 1996 TASKI & TASK2 data set estimated now, instead of the previously estimated 2011 series.

4.7 Fishing efforts in the proposed C/E series

The proposed statistical C/E series contain fishing efforts, but it should be kept in mind that these fishing efforts have been obtained by strata substitution from the recent period. As a consequence, these fishing efforts have very little or no scientific value and they should never be used in any stock assessment work (the same comment being also valid for the previous two periods of Ghanaian statistics that were also based on strata substitution with other fleets (1^{st} period) or other period (2^{nd} period).

4.8 A-Fleet catch by species estimated in the 2 gears & in the 1 gear stratification

An alternate data processing of the A-Fleet data done without taking into account the fishing gear has been done, allowing to estimate total catches and CAS by species, and to compare these catches with the previously estimated catches by species and gear (keeping in mind that SKJ catches that are driven by EU PS FAD catches are unchanged by hypothesis). These total catches by species are given on **Table 15** and **Figure 42** is showing the total catches of BET that have been estimated in these 1 & 2 gears stratifications.

This table and figure are showing that the species composition of the fleet A catches are very similar in the 2 methods, the worse difference between the 2 results being observed in 2004 with an increase of 950 t. (about 10%) of the BET catches in the 1 gear hypothesis.

The levels of CAS are changed in proportion of these changes in total catches of YFT & BET, but also at a minor degree.

These comparative results would tend to the conclusion that the combined gears stratification could also be used in the data processing, as it was recommended by the 2011 WG, and without introducing major changes in the results. However, it should be kept in mind that the differential selectivities between PS & BB, and the potential catches of large YFT in FAD and in free schools by purse seiners, an important factor in the data analysis, stock assessment and management, would be lost from the Ghanaian statistics if this combined gear method is used in the Ghanaian data processing.

4.9 Catches by species: before & after correction

It is also interesting to compare the species composition of Ghanaian catches before its correction of species composition and after the present data processing. This comparison is summarized by **Figure 43** showing the percentages of SKJ and of BET in the original Ghanaian log books and after the H2 hypothesis data processing.

This figure shows a paradoxical fact that the Ghanaian log books contains proportions of SKJ that are very similar to the amount of SKJ estimated in the H2 hypothesis (base on EU PS FAD sampling): only showing an average decrease from 62.7% to 61.8% (when the TASKI level presently estimated by ICCAT secretariat was much lower at only 50.6%). The H3 species composition hypothesis was based on this result that the amount of SKJ estimated by Ghanaian in the log books are very similar to the amounts of SKJ estimated on FAD from the EU PS sampling, and that subsequently these amounts of SKJ could be well used in the data processing of the Ghanaian TASK2.

On the opposite, the percentages of BET are widely underestimated in the log books (4.7%) and they have been multiplied by a factor of 3 to reach their presently estimated average level of 13.8% of total catches (also producing equivalent declines of the YFT catches).

5 Data processing of the 2006-2012 TASK2: first results & prospects

5.1 General considerations

Major improvement in the 2006-2012 Ghanaian data should be noticed:

1) Better data: more size samples with good species identification (unfortunately still biased in terms of species composition until July 2012) & much more log books, reaching a 100% coverage. All species composition of the 2006-July 2012 period should be corrected, one way or another.
2) Including a quite good statistics on the PANOFI fleet.
3) Better potential validation of the all basic data for all years entered under the AVDTH framework and using its validation routines (AKADO & other)
4) Much better sampling of "*Faux poissons*" in Abidjan: now with a good species and size composition during this period!
5) Useful validation of scientific data by the data given to ICCAT (via ISSF) by the PIONEER cannery. This commercial data set that is covering large quantities of processed tunas (close to 40.000t yearly) is very powerful to allow independent data cross validations of the landing data in Tema, as it contains the landed total catches of several vessels (especially the PIONEER PS), including some P Fleet catches, and with a quite good size and species composition of these landings: at least for catches of SKJ and large YFT that are very well identified in these data.
6) Good sampling of large tunas starting in 2009, keeping in mind that large YFT and BET should be added to the samples of previous years.

The data processing of this period will be done using widely different methods: as the log book and size sampling coverage are quite good for the A-Fleet during this period, at least during some years, this data processing will simply be done based on the extrapolation of log book and sampling data (with only few small scale strata substitutions routinely handled by the TTGhana software), However, the A-Fleet during the year 2007 will also need to be estimated by strata substitution with neighbouring years, at least to a great extent, because of the weakness of its log book data available in 2007 (an average coverage of only 16%).

On the opposite, the data processing of the P-fleet will require during the 2006-2009 period large scale strata substitutions, similar to the one used for the 2003-2005 period. Furthermore, the analysis of the heterogeneity between sizes and species landed during this recent period 2006-2012 tend to show an homogeneity of BB & PS landings (same percentages of large YFT & large BET sampled on the BB & PS landing in 2011, probably the result of frequent exchanges of catches between the 2 gears), and consequently, the data processing should solely be conducted during this period without stratification between PS and BB. The H3 hypothesis would appear to be the best one to estimate and to correct the species composition during this period. Total catches in 2006 should also be corrected, because the total of BB & of P fleet catches is larger than the TASKI declared by Ghana. These 2006 catches have been tentatively increased to a level of 71,600 t (instead of the today 51,300 t), assuming an average level of the A-fleet PS catches.

5.2 Experimental tentative data processing of the 2006-2010 period

A tentative 1st data processing of this period 2006-2010 has been done also in the H3 hypothesis of species composition and combining all the PS & BB data in a combined gear: estimating the percentages of SKJ from the Ghanaian log books, and later estimating the percentages of YFT and BET from the multispecies sampling of Ghanaian landings. It has been assumed in this data processing that large YFT and large BET have been well sampled since 2006 (the alternate hypothesis and the addition of some large tunas from the EU PS FAD fishery should also be envisaged in future data processing).

5.3 Results

The corrected species composition obtained by this preliminary data processing is given in the following **Table 16.** These preliminary analysis and their first results are solely indicative. The rates of SKJ catches obtained after this data processing appear to be slightly higher than during previous years

5.4 Pending questions in the data processing

However this data processing will also be facing **new and/or increasing statistical questions** during this recent period 2006-2012:

1) Increasing uncertainties on the Ghanaian TASK1 due to possible underestimated catches, as shown by log book entries of the A Fleet that are sometimes higher than its TASKI. Also Kebe 2011 report suggesting this potential underestimated TASKI.
2) Bias in the samples of large YFT and large BET in Tema? There is a need to compare the detailed data of individual landings of these large tunas, estimated from scientific sampling and from the Pioneer cannery (as these large tunas are perfectly well identified by the cannery).
3) Serious questions on the increasing PANOFI fleet and of its activities: a good log book coverage in 2010, but no coverage or a very low coverage during the years 2006-2008. This should lead to an absolute re-estimation of the TASK2 of this fleet using strata substitution with recent years, & not extrapolating log books. Many pending statistical questions will remain on this major & efficient fleet, due to its at sea transhipments during the period under study and the lack of control of its log books and landings by Ghanaian scientists.
4) A change in the Ghanaian catch pattern: more free schools caught during recent years, for instance by the MW BRANDS PS fleet? A need to explore recent Ghanaian log books, searching if these typical free schools sets are now occurring? A need to create soon a free schools component in the data processing ?
5) A need to do, starting in 2011/2012, a full data processing of the BELIZE flags PS in the Ghanaian data processing and data base? Similar to the EU NEI PS.

6) Serious questions remains on some components of the species composition in the PIONEER cannery: quantities of BET estimated by the cannery appear to be widely underestimated and the BET quantities should necessarily be estimated based on scientific multispecies sampling.

7) C/E data for the S-Fleet have been collected & well processed by EU scientists, but since 2006 it would appear that this data set has not yet been submitted to the ICCAT secretariat due to administrative constraints in the circulation of TASK2 data. This 2006-2009 data set of the S-Fleet should be recovered and incorporated in the future Ghanaian TASK2

6 Conclusion

The presently estimated Ghanaian TASK1 & TASK2 cannot be considered, & by far, as being an ideal data set based on good log books and large unbiased samples covering the various Ghanaian fleets. This data processing has no choice, but to rely mainly on a wide range of hypothesis and strata substitutions. Its basic goal was simply to provide more ***realistic working files of Catch & effort and Catch at size*** that can be used in future SCRS stock assessment works and other analysis on tropical tunas: based at least on a realistic species composition, realistic time and area fishing zones and realistic catch at size off the 3 species.

This more realistic species composition is also of great importance for the Ghanaian TASK1 series. These proposed new series of TASK1 & 2 are probably much better than the Ghanaian TASK1 & 2 available today to ICCAT scientists, as the ICCAT series available until 2012 were clearly widely unrealistic (1) in their species composition (not enough SKJ & too much BET & YFT!), (2) in their fishing zones artificially concentrated in the 5° square off Ghana, and (3) their catch at size by species (with too many small YFT & BET, and not enough big fishes). All these series of proposed TASK1 & 2 are the ones that are considered to be the best ones today, based on the data and data processing hypothesis that have been considered as being the most convenient ones. A positive factor in this work was that all these methods and hypothesis have been providing TASK1 and TASK2 series that are very similar between them, and always very different from the non corrected Ghanaian data presently available.

Some of the rules proposed for this 1996-2005 period should also be used in the planned data processing of the 2006-2012 period, keeping in mind that some of the same sampling bias have been in place until 2012, but with the positive factors that the Ghanaian log books and sampling coverage and their data validation, have been widely improved since 2006, probably allowing to do a full data processing & with few strata substitutions, at least for the A fleet.

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Table 1. Average percentages of large YFT and of large BET >1 m observed, in numbers, in the random samples of the Ghanaian fleet landing in Abidjan in 2003 & 2004 (16300 tunas measured)

Gear	Year	YFT	BET
BB	**2003**	**2,64**	**2,31**
BB	**2004**	**0,97**	**0,16**
	Average	**1,81**	**1,23**
PS	**2003**	**8,27**	**1,95**
PS	**2004**	**6,67**	**3,70**
	Average	**7,47**	**2,83**

Table 2. Yearly numbers of tunas sampled on the Ghanaian landings, by gear and by species.

Gear	Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
PS	YFT	982	4 538	5 602	2 804	2 792	3 425	7 176	10 030	5 623	1 662	44 634
PS	SKJ	2 320	7 986	17 998	5 214	4 224	3 836	13 011	40 156	34 238	3 266	132 248
PS	BET	692	2 764	3 442	2 076	1 098	770	2 692	6 405	9 645	1 070	30 654
BB	YFT	13 214	15 104	10 600	8 458	5 316	6 684	16 197	11 334	5 648	4 944	97 498
BB	SKJ	30 596	37 860	20 996	15 810	9 594	15 320	50 868	28 812	16 279	10 188	236 323
BB	BET	6 156	9 868	8 370	4 588	828	3 494	6 168	6 161	5 212	2 798	53 643
All	YFT	14 196	19 642	16 202	11 262	8 108	10 109	23 373	21 364	11 271	6 606	142 132
All	SKJ	32 916	45 846	38 994	21 024	13 818	19 156	63 879	68 968	50 516	13 454	368 571
All	BET	6 848	12 632	11 812	6 664	1 926	4 264	8 859	12 565	14 857	3 868	84 296

Table 3. Yearly catches and average % of free schools catches of the S-Fleet purse seiners during the studied period.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Catches	**2027**	**3142**	**3756**	**2160**	**2927**	**0**	**510**	**3085**	**3853**	**2608**
% Free schools	**44**	**18**	**7**	**56**	**70**		**8**	**39**	**25**	**32**

Table 4. Number of tuna sampled by gear during each quarter of the 1996-2005 period (T3TABCOGHANA9605.XLS)

Year	Quarter	PS	BB	Total
1996	1	484	7 818	8 302
1996	2	330	4 828	5 158
1996	3	557	4 246	4 803
1996	4	626	8 091	8 717
1997	1	920	6 823	7 743
1997	2	1 188	7 783	8 971
1997	3	2 886	7 145	10 031
1997	4	2 650	9 665	12 315
1998	1	3 975	6 668	10 643
1998	2	4 547	4 739	9 286
1998	3	2 341	4 093	6 434
1998	4	2 658	4 483	7 141
1999	1	2 041	6 683	8 724
1999	1	2 041	6 683	8 724
1999	2	1 710	4 830	6 540
1999	2	1 710	4 830	6 540
1999	3	1 189	1 803	2 992
1999	3	1 189	1 803	2 992
1999	4	107	1 112	1 219
1999	4	107	1 112	1 219
2000	1	1 098	1 882	2 980
2000	2	834	2 050	2 884
2000	3	471	1 183	1 654
2000	4	1 654	2 754	4 408
2001	1	939	1 701	2 640
2001	2	567	2 535	3 102
2001	3	1 211	4 322	5 533
2001	4	1 298	4 192	5 490
2002	**1**	**3 915**	**16 672**	**20 587**
2002	**2**	**3 513**	**13 446**	**16 959**
2002	**3**	**3 704**	**4 748**	**8 452**
2002	**4**	**307**	**1 751**	**2 058**
2003	1	3 755	4 177	7 932
2003	2	6 022	8 811	14 833
2003	3	8 451	3 720	12 171
2003	4	10 068	6 445	16 513
2004	**1**	**428**	**1 556**	**1 984**
2004	**2**	**3 390**	**7 786**	**11 176**
2004	**3**	**17 357**	**1 934**	**19 291**
2004	**4**	**3 578**	**2 294**	**5 872**
2005	1	1 000	1 996	2 996
2005	2	599	2 388	2 987
2005	3	600	2 389	2 989
2005	4	800	2 192	2 992

Table 5. Yearly total catches of the various components of the Ghanaian fisheries identified and used in the present data processing

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
BB	28 551	36 941	43 245	47 026	32 105	56 241	25 848	27 602	39 558	35 766
PS PANOFI	0	0	0	0	0	0	0	7 175	20 305	26 258
PS Non PANOFI	8 576	14 660	21 962	36 220	20 439	31 833	35 428	21 833	**17 944**	14 055
total TASKI	37 127	51 601	65 207	83 246	52 544	88 074	61 276	56 610	77 807	76 079
"Faux poissons" tunas	884	1 540	236	684	2 126	182	0	2 948	3 237	5 759
Spanish/Ghanian PS	0	0	0	0	2 027	3 142	3 756	2 160	2 927	0

Table 6. Average yearly species composition of FAD catches in the EU PS FAD fishery, in the 3 areas presently used

Area	Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average
Ghana-CI	YFT	25,8	59,1	20,4	43,8	41,7	48,2	23,9	37,9	33,6	13,9	**34,8**
	SKJ	59,4	34,6	66,9	51,4	54,3	49,0	63,7	56,8	59,0	77,1	**57,2**
	BET	14,8	6,4	12,7	4,8	4,0	2,8	12,5	5,3	7,5	9,1	**8,0**
CapeLopez	YFT	37,1	41,9	40,3	33,6	34,5	34,3	38,9	27,8	26,9	22,2	**33,7**
	SKJ	45,9	44,6	48,4	58,8	57,5	56,0	54,3	63,6	66,2	71,1	**56,6**
	BET	17,0	13,5	11,3	7,7	8,1	9,7	6,7	8,6	6,9	6,8	**9,6**
Offshore	YFT	13,7	14,0	17,7	12,1	14,4	13,0	12,9	13,9	13,1	14,7	**13,9**
	SKJ	66,1	65,4	60,9	65,1	66,9	63,2	64,5	65,1	73,5	73,2	**66,4**
	BET	20,2	20,6	21,4	22,8	18,7	23,8	22,6	21,0	13,5	12,1	**19,7**
Total	YFT	26,1	38,7	26,0	29,9	30,3	32,1	26,0	26,7	24,7	16,8	**27,7**
	SKJ	56,7	47,2	58,1	57,8	59,6	57,5	60,4	62,1	66,0	73,7	**59,9**
	BET	17,2	14,1	15,9	12,3	10,1	10,4	13,6	11,1	9,3	9,4	**12,3**

Table 7. Average yearly species composition of Ghanaian catches sampled in Abidjan during the 2001-2004 period (expressed in % caught by species).

	2001	2002	2003	2004	Average
YFT	39	54	28	10	33
SKJ	55	43	65	73	59
BET	6	3	7	17	8

Table 8. Percent in numbers of large YFT and large BET >1m. in the EU PS FAD catch at size (in per thousands of the total CAS on FADs).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
% Big YF	**14,0**	**10,3**	**5,8**	**3,9**	**4,3**	**3,4**	**5,7**	**3,4**	**5,0**	**3,5**	**5,8**	**2,7**	**4,0**	**3,1**	**3,0**
% Big BE	**1,8**	**1,5**	**0,9**	**2,3**	**0,7**	**1,9**	**0,9**	**1,6**	**1,2**	**1,0**	**1,2**	**1,3**	**0,9**	**1,0**	**1,0**

Table 9. Species composition of the Ghanaian fishery: before and proposed, based on the species composition of EU PS on FADs (H1).

year	YFT	SKJ	BET	Total	*%SKJ*	YFT	SKJ	BET	Total	*%SKJ*
1996	11 720	19 602	5 805	37 127	*52,8*	7904	22635	6589	37128	*61,0*
1997	15 437	26 336	9 828	51 601	*51,0*	17664	26498	7438	51601	*51,4*
1998	17 656	34 182	13 369	65 207	*52,4*	13992	40125	11090	65207	*61,5*
1999	25 268	40 215	17 763	83 246	*48,3*	21139	49691	12417	83246	*59,7*
2000	17 662	28 973	5 909	52 544	*55,1*	13826	32266	6452	52544	*61,4*
2001	33 545	42 488	12 041	88 074	*48,2*	24802	50404	12867	88073	*57,2*
2002	23 673	30 498	7 105	61 276	*49,8*	11843	38642	10787	61272	*63,1*
2003	18 457	24 596	13 557	56 610	*43,4*	12912	35226	8473	56610	*62,2*
2004	15 053	25 726	14 900	55 679	*46,2*	15834	53310	8663	77807	*68,5*
2005	17 492	44 671	13 916	76 079	*58,7*	11559	56257	8263	76079	*73,9*
Average	***19 596***	***31 729***	***11 419***	***62 744***	***50,6***	***15 148***	***40 505***	***9 304***	***64 957***	***62,0***

Table 10. Species composition of the Ghanaian fishery: before and proposed, based on a species composition H2 combining EU PS on FADs and Tema multispecies samples.

	YFT	SKJ	BET	Total
1996	9 236	22 638	5 264	37 138
1997	14 921	26 502	10 189	51 612
1998	14 094	40 127	10 995	65 216
1999	22 672	49 694	10 890	83 255
2000	14 661	32 270	5 623	52 553
2001	26 328	50 407	11 348	88 083
2002	17 387	38 645	5 250	61 282
2003	13 585	35 232	7 810	56 628
2004	11 048	53 316	13 460	77 824
2005	11 750	56 262	8 083	76 095
Average	**15 568**	**40 509**	**8 891**	**64 969**

Table 11. Species composition of the Ghanaian fishery: before and proposed, based on a species composition H3, based on Ghanaian log books (SKJ) and multispecies Ghanaian samples (BET & YFT).

Year	YFT	SKJ	BET	Total
1996	8 182	24 205	4 751	37 138
1997	15 080	26 364	10 165	51 609
1998	13 222	41 840	10 155	65 216
1999	20 815	52 024	10 416	83 255
2000	12 304	34 980	5 269	52 553
2001	23 392	55 475	9 214	88 081
2002	18 100	37 570	5 611	61 280
2003	15 002	32 977	8 646	56 624
2004	14 044	46 030	17 744	77 817
2005	13 019	54 209	8 860	76 089
Average	**15 316**	**40 567**	**9 083**	**64 966**

Table 12. Yearly average weights (kg) of YFT, SKJ and BET caught yearly by Ghanaian vessels in the H1 species composition.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
YFT	**7,1**	**6,2**	**5,2**	**3,6**	**3,8**	**3,7**	**4,3**	**3,2**	**3,6**	**3,7**
SKJ	**2,1**	**2,3**	**2,2**	**2,0**	**2,2**	**2,0**	**2,3**	**2,0**	**1,9**	**2,2**
BET	**3,1**	**3,6**	**3,5**	**3,6**	**3,1**	**3,5**	**3,6**	**3,7**	**3,2**	**3,1**

Table 13. Average species composition of BB & PS estimated in H1 & H2 (in %).

	YFT	SKJ	BET
PS H1	19,6	64,6	15,9
PS H2	22,2	64,6	13,2
BB H1	26,1	60,7	13,2
BB H2	25,3	60,7	14,0

Table 14. Ghanaian catch by species of the fishing year 1996 estimated in 2011 and now H3.

	YFT	SKJ	BET	Total
1996 WG 2011	**10 506**	**21 184**	**5 438**	**37 128**
1996 H3	**7 908**	**22 638**	**6 592**	**37 137**
Change %	**-24,7**	**6,9**	**21,2**	

Table 15. Yearly total catches by species estimated for the A fleet based on a 1 or a 2 gears stratification.

Year	YFT	SKJ	BET	Total	**YFT**	**SKJ**	**BET**	**Total**
1996	9 423	22 637	5 074	37 135	**9 236**	**22 638**	**5 264**	**37 138**
1997	15 202	26 500	9 905	51 608	**14 921**	**26 502**	**10 189**	**51 612**
1998	14 352	40 127	10 734	65 214	**14 094**	**40 127**	**10 995**	**65 216**
1999	22 784	49 692	10 775	83 252	**22 672**	**49 694**	**10 890**	**83 255**
2000	14 622	32 268	5 660	52 550	**14 661**	**32 270**	**5 623**	**52 553**
2001	25 957	50 405	11 716	88 079	**26 328**	**50 407**	**11 348**	**88 083**
2002	17 854	38 644	4 780	61 278	**17 387**	**38 645**	**5 250**	**61 282**
2003	11 832	30 586	7 022	49 440	**11 949**	**30 588**	**6 909**	**49 445**
2004	7 911	38 543	11 053	57 507	**8 865**	**38 544**	**10 102**	**57 511**
2005	7 703	36 993	5 131	49 827	**7 669**	**36 994**	**5 168**	**49 831**

Table 16. Total catches by species estimated for the 2006-2010 period (faux thons being added to TASKI).

	YFT	***SKJ***	***BET***	***Total***	***%SKJ***	***% SKJ TASKI***
2006	16 747	46 592	12 893	76 232	61,1	58,9
2007	11 435	48 873	8 606	68 913	70,9	54,6
2008	14 986	44 818	7 456	67 261	66,6	61,4
2009	13 405	52 133	6 367	71 905	72,5	55,5
2010	22 336	60 623	7 907	90 867	66,7	73,6
Average	***15 782***	***50 608***	***8 646***	***75 035***	***67,6***	***60,8***

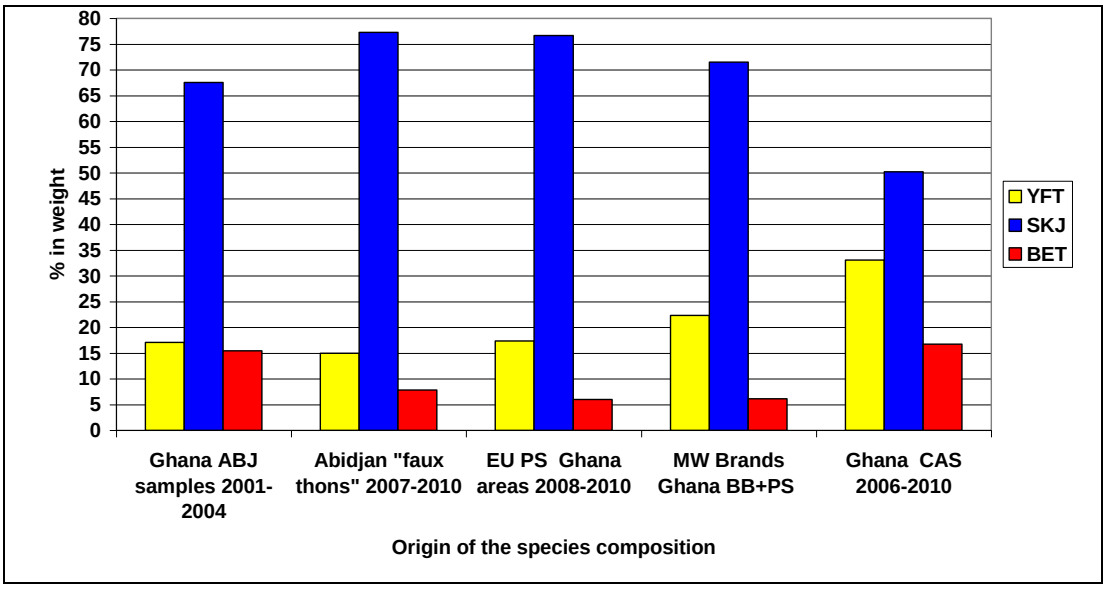

Figure 1. Comparative overview of the average species composition of various segment of fleets or of sampling schemes

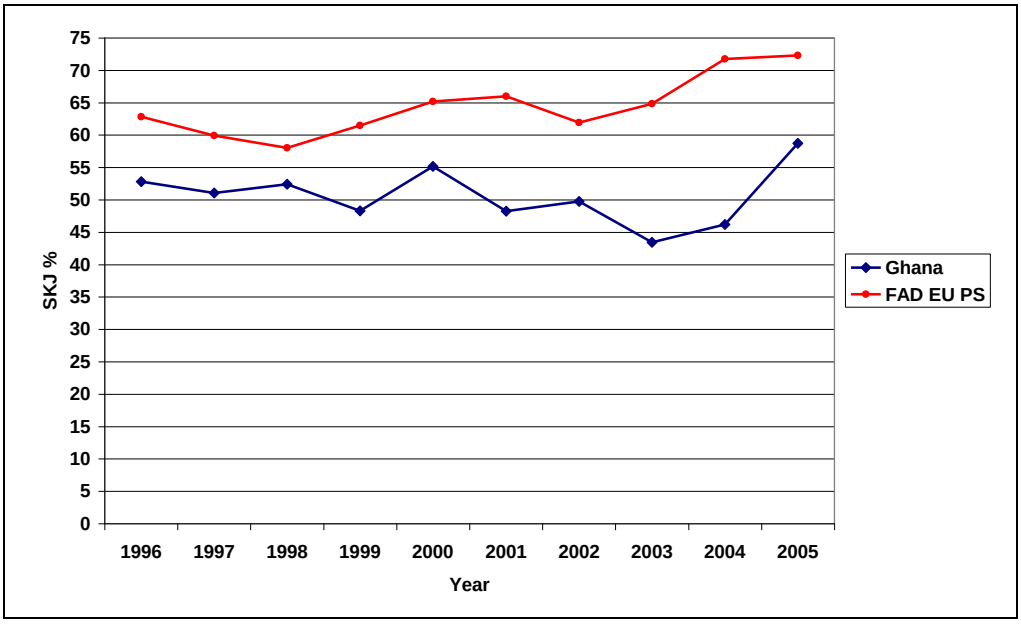

Figure 2. Percentage of SKJ in the sampled Ghanaian landings and in the EU PS FAD total catches

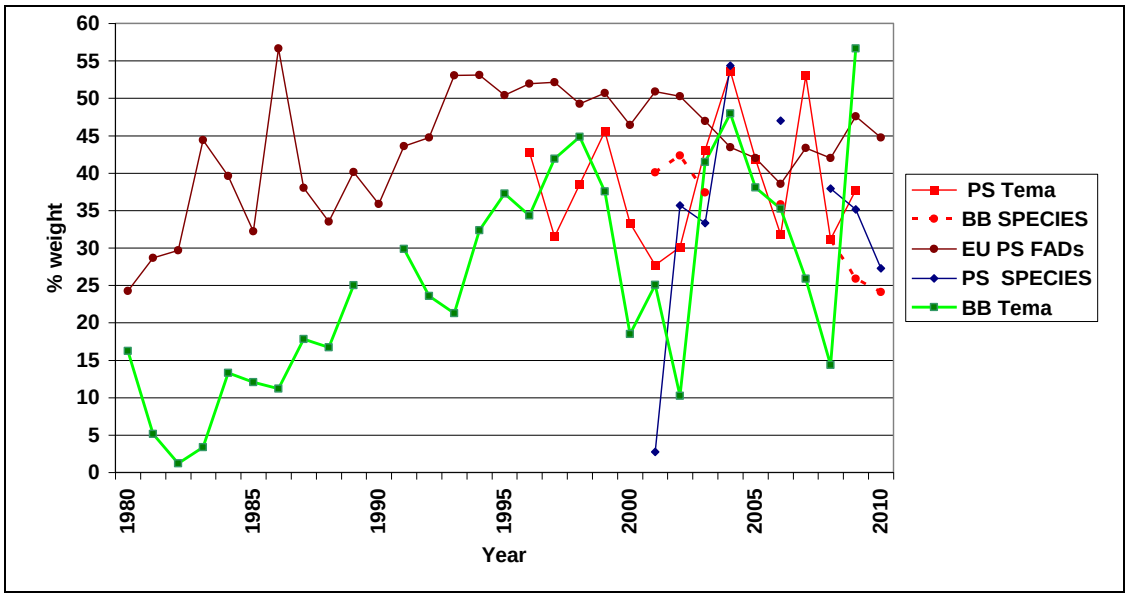

Figure 3. Yearly percentage of BET in the sampled catches of various Ghanaian fleets and from various data processing sources.

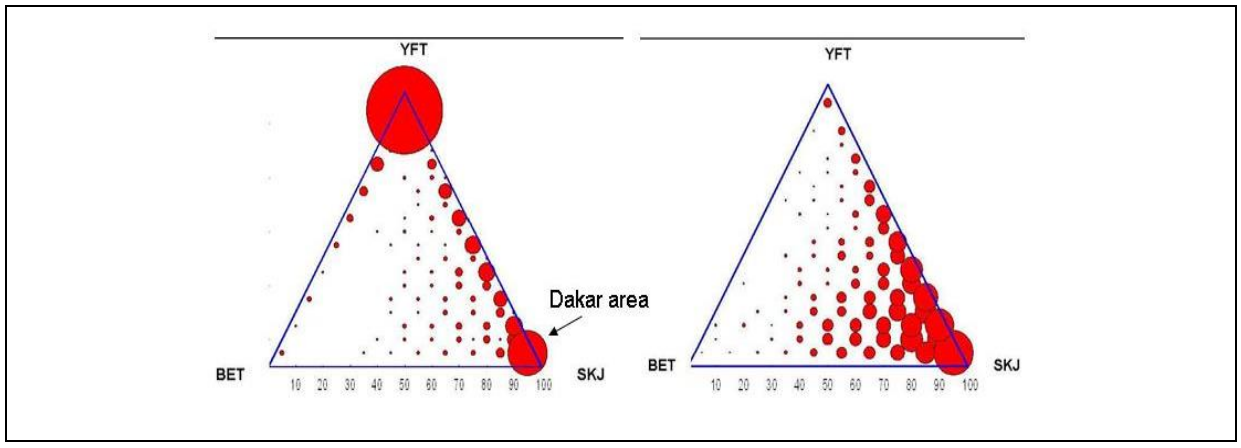

Figure 4. Observed species composition of the free (left) and FAD (right) schools set in the Atlantic on EU PS (shown by Definetti plots. the area of each circle is proportional to the frequency of the observed species composition and to the % (in weight) of each species in all sampled sets).

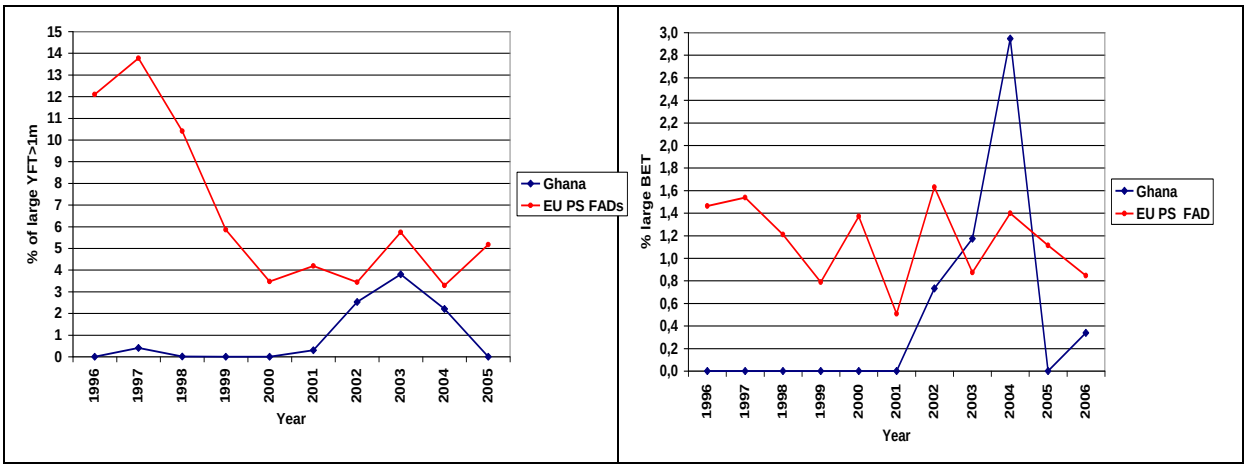

Figure 5. Yearly percentages of large YFT over 1 meter in the nominal Ghanaian samples and in the extrapolated EU PS FAD samples (NB: 2002-2004 samples dominated by Abidjan CRO sampling).

Figure 6. Yearly percentages of large BET over 1 meter in the nominal Ghanaian samples and in the extrapolated EU PS FAD samples (2002-2004 samples dominated by Abidjan CRO sampling)

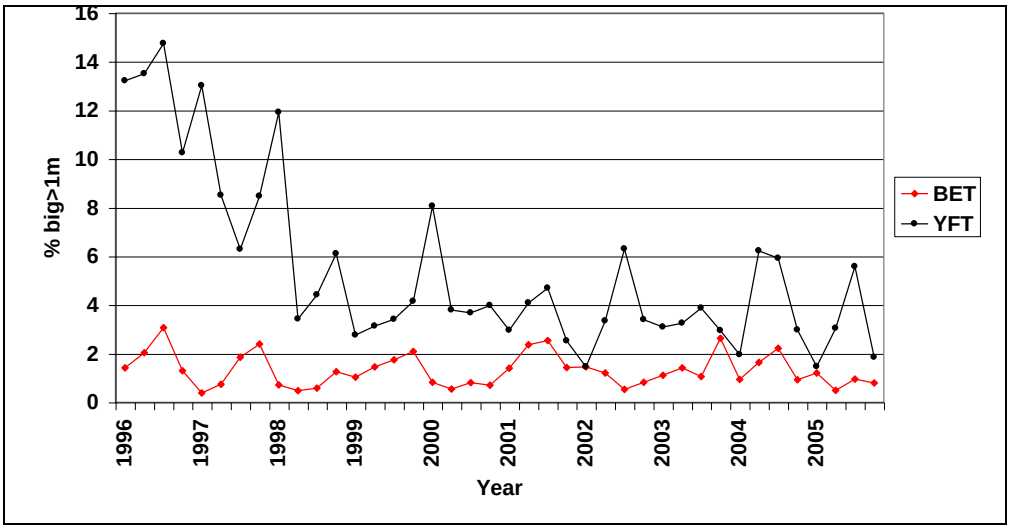

Figure 7. Quarterly percentages of large YFT & BET over 1 m caught by the EU PS on FADs during the studied period.

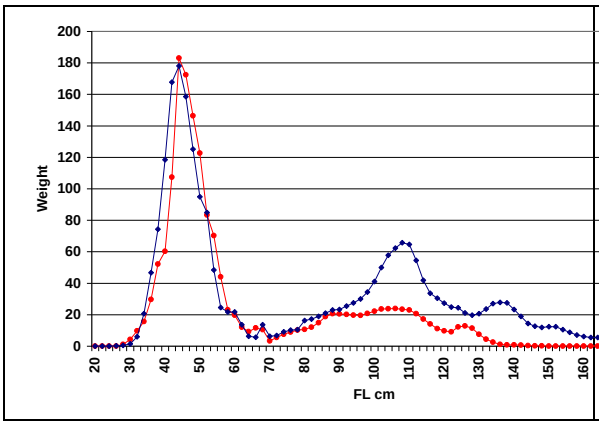

Figure 8. Ghanaian YFT samples (weight) made on PS & on BB in Abidjan in 2003-2004

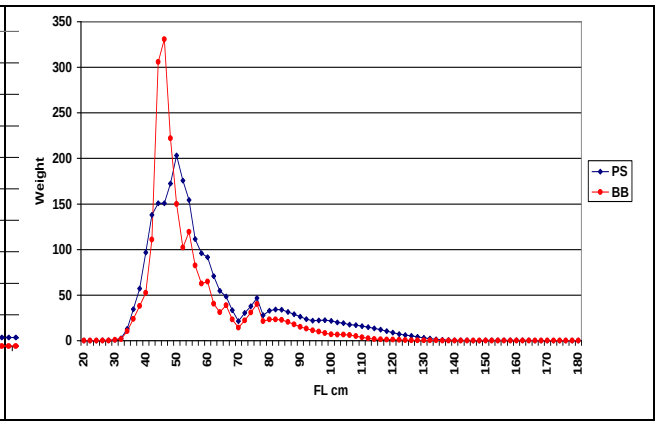

Figure 9. Ghanaian BET samples (weight) made on PS & on BB in Abidjan in 2003-2004

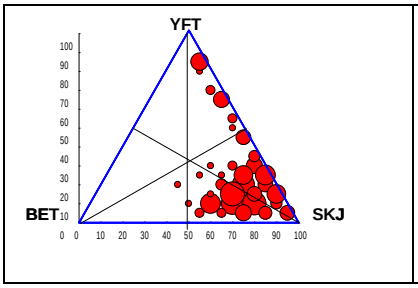

Figure 10a. Species composition of Ghanaian ABJ samples 2003-2004.

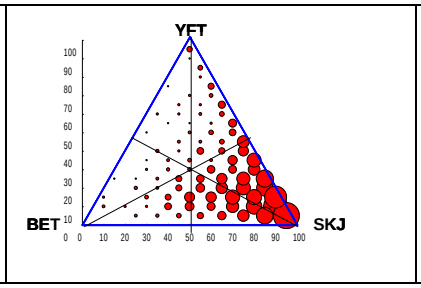

Figure 10b. Species composition of EU FAD PS samples 2006-2010.

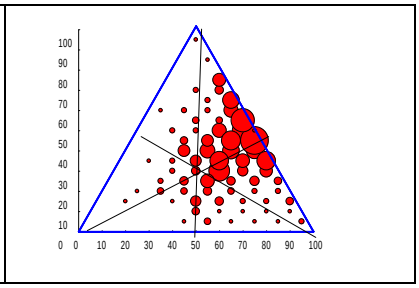

Figure 10c. Species composition of Tema samples 2006-2010.

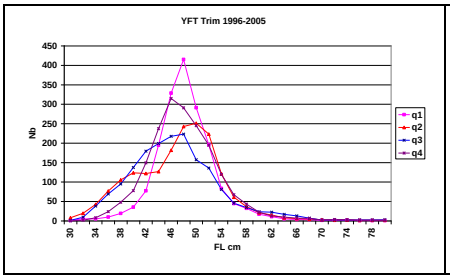

Figure 11a. Average quarterly size distribution of the sampled YFT caught by Ghanaian vessels during the 1996-2005 period.

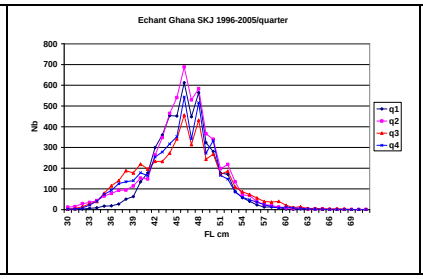

Figure 11b. Average quarterly size distribution of the sampled SKJ caught by Ghanaian vessels during the 1996-2005 period.

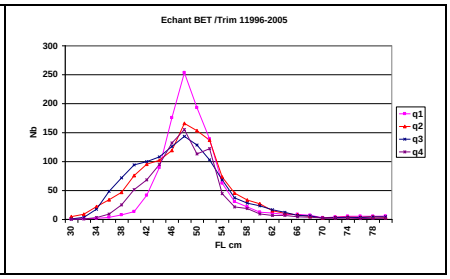

Figure 11c. Average quarterly size distribution of the sampled BET caught by Ghanaian vessels during the 1996-2005 period

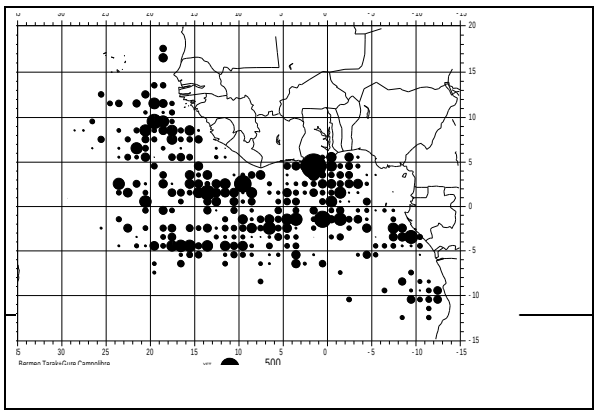

Figure 12. Average fishing zones of the S-fleet PS during the 1996-2005 period.

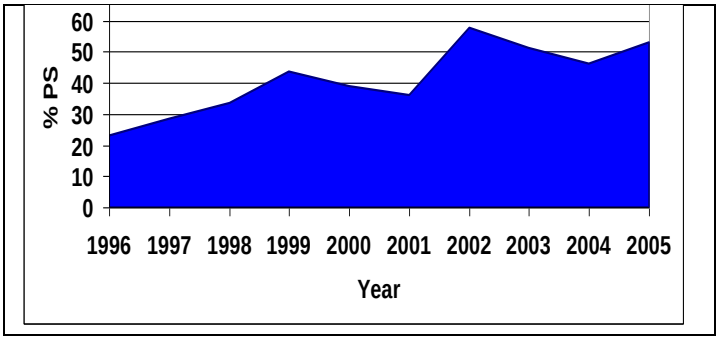

Figure 13. Yearly percentage of PS catches in the total Ghanaian landing (2004 PS catches corrected).

Figure 14a. Percentage of BET in the YFT+BET catches of BB & of PS sampled in Tema.

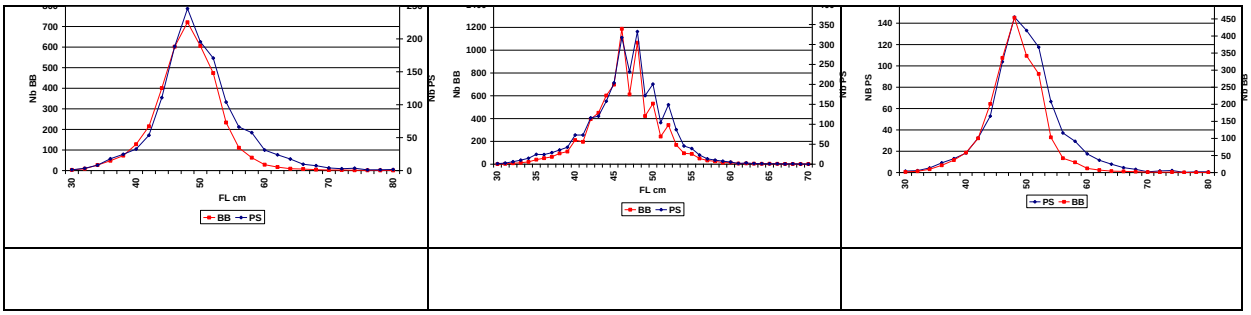

Figure 15a. average sizes of the small YFT sampled on Ghanaian BB and PS landings (1996-2005).

Figure 15b. idem SKJ.

Figure 15c. idem BET.

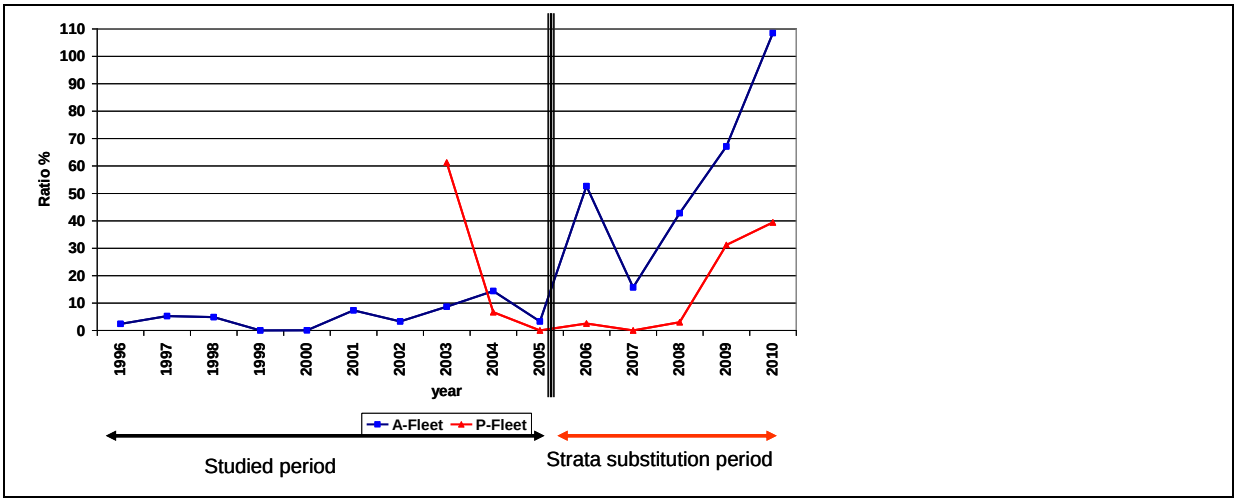

Figure 16. Yearly percentage of catches covered by log books for the P-Fleet and for the A-fleet during the 1996-2010 period.

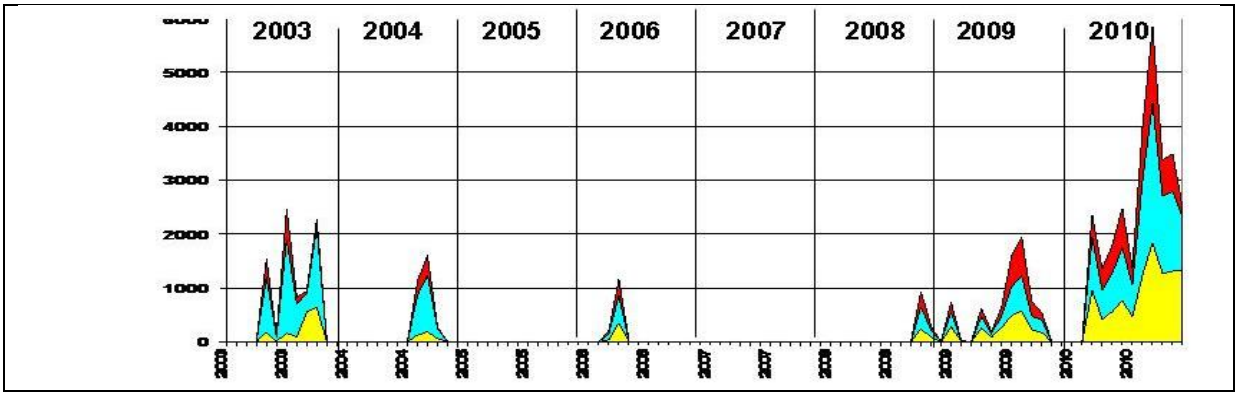

Figure 17. Monthly amount of tunas covered by the P-Fleet log books during the 2003-2010 period.

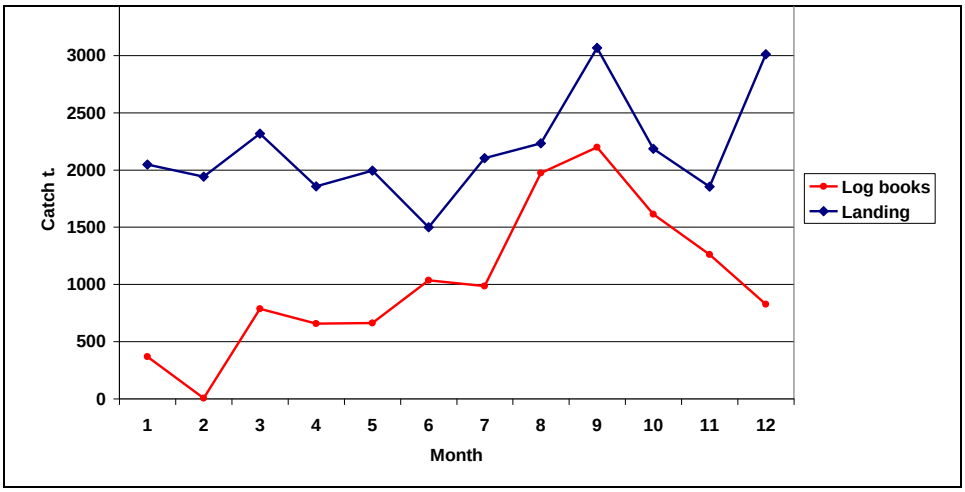

Figure 18. Average monthly catches recorded in the P-Fleet log books during the 2006-2010 period, and average monthly total catches declared by the P-fleet during the same period.

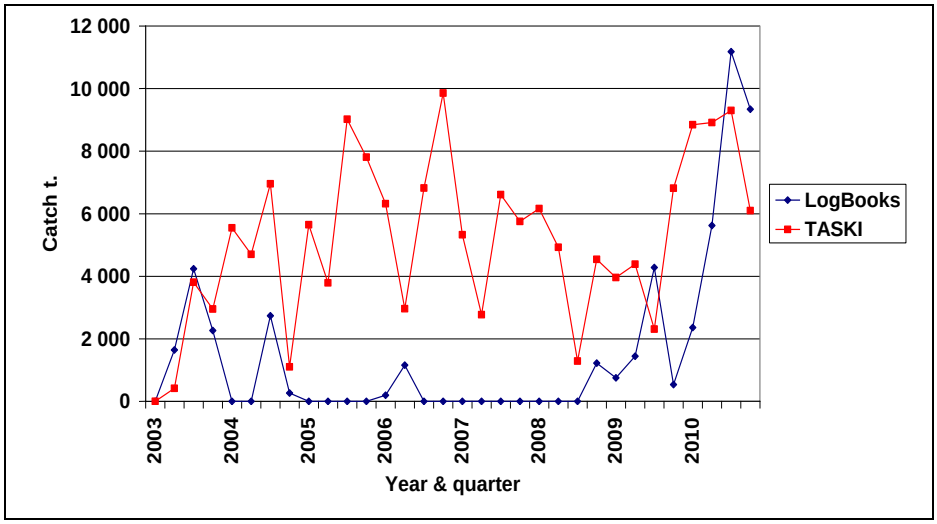

Figure 19. P-Fleet quarterly total catches: declared and covered by log books.

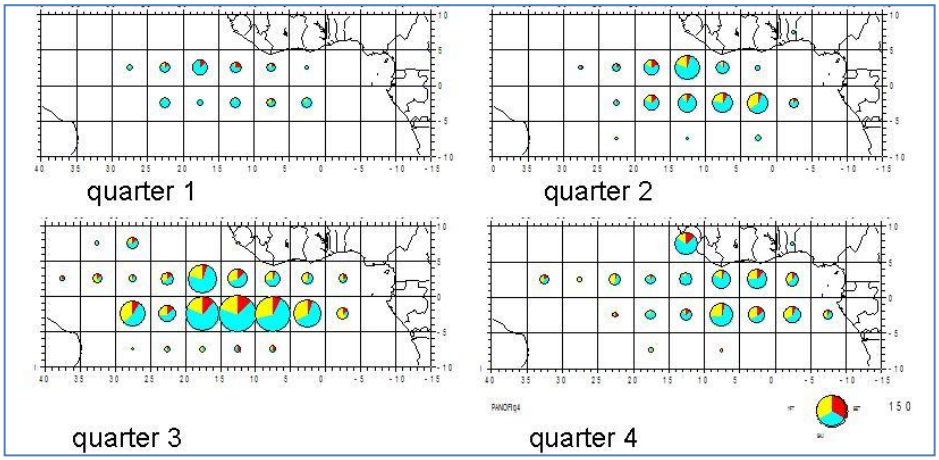

Figure 20. Average quarterly catches by species and by 5° squares, of the P-fleet during the 2003-2010 period based on its log books *(the variability of quarterly catches being due to the heterogeneity in the sampling rates of log books)*

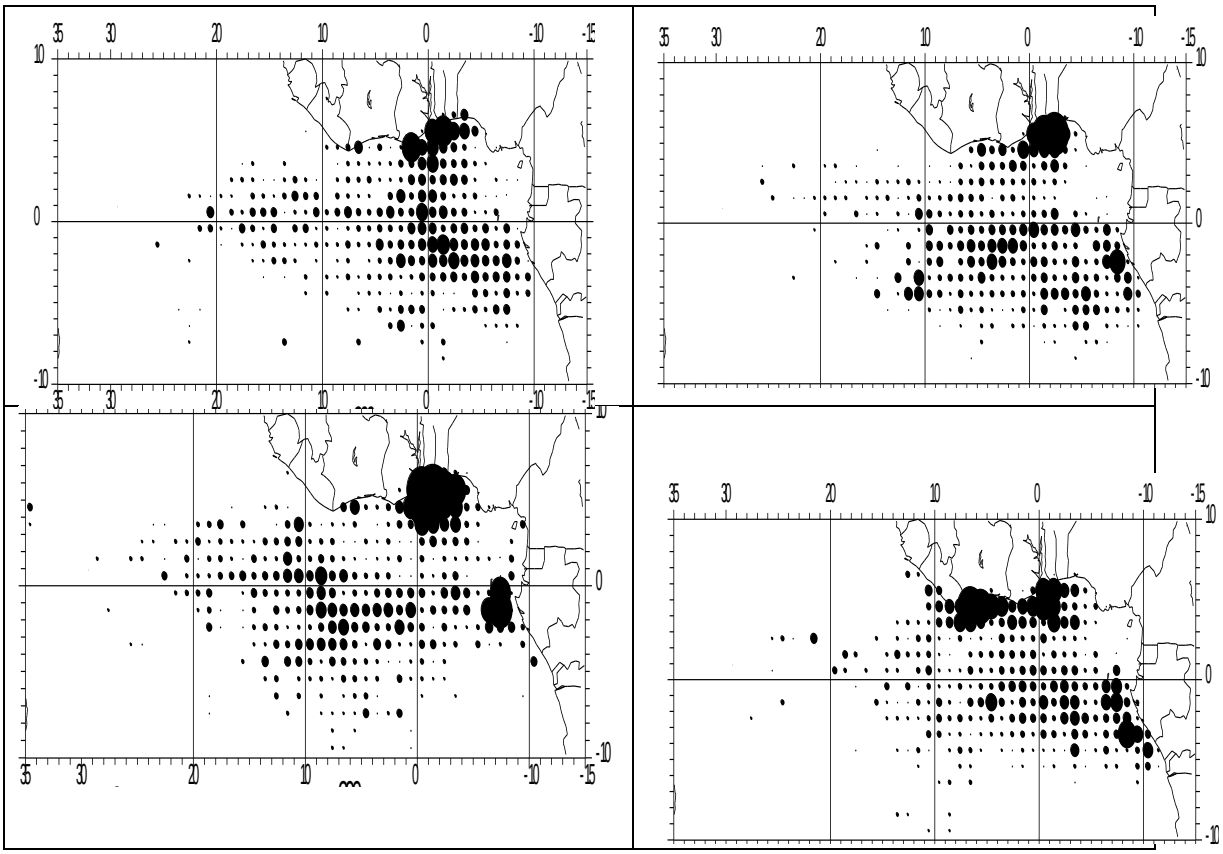

Figure 21. quarterly catches by 1° square of the A-fleet during the period 2006-2010 (upper panel: q1 left & q2 right, lower panel q3 left & q4 right)

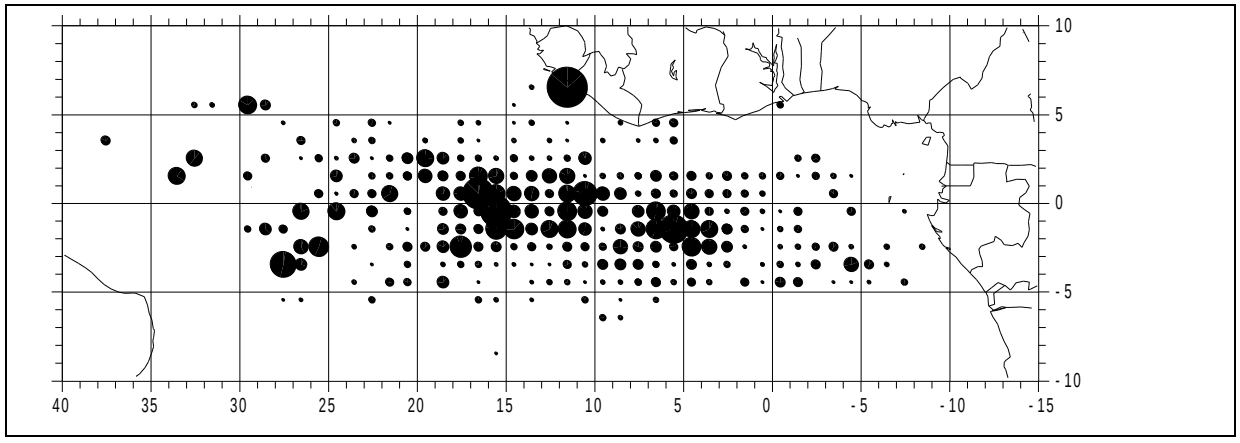

Figure 22. Average catches by 1° of the sampled P-Fleet log books during the 2006-2010 period used to estimate the fishing zones of this fleet

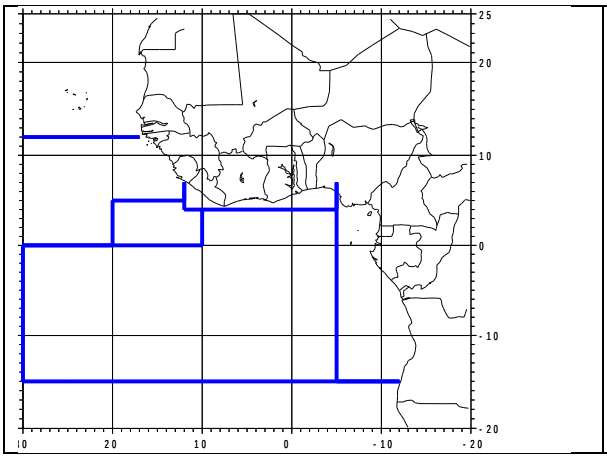

Figure 23. Statistical areas used since 1998 in the statistical analysis of **EU PS on FADs**

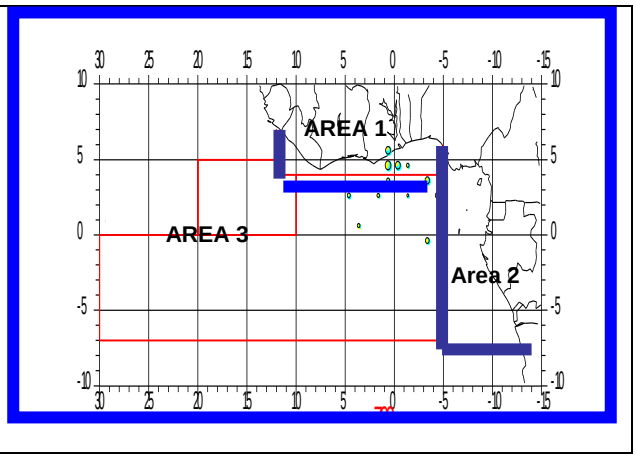

Figure 24. Geographical strata proposed for the Ghana TASK2 data processing 1996-2005

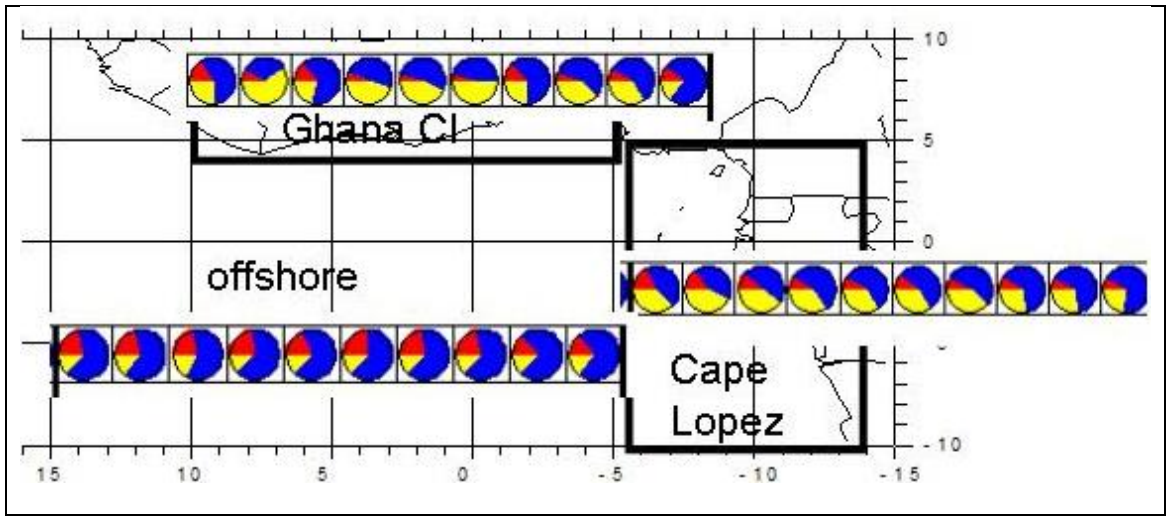

Figure 25. Average yearly species composition by area observed the EU PS catches on FADs during the studied period 1996-2005

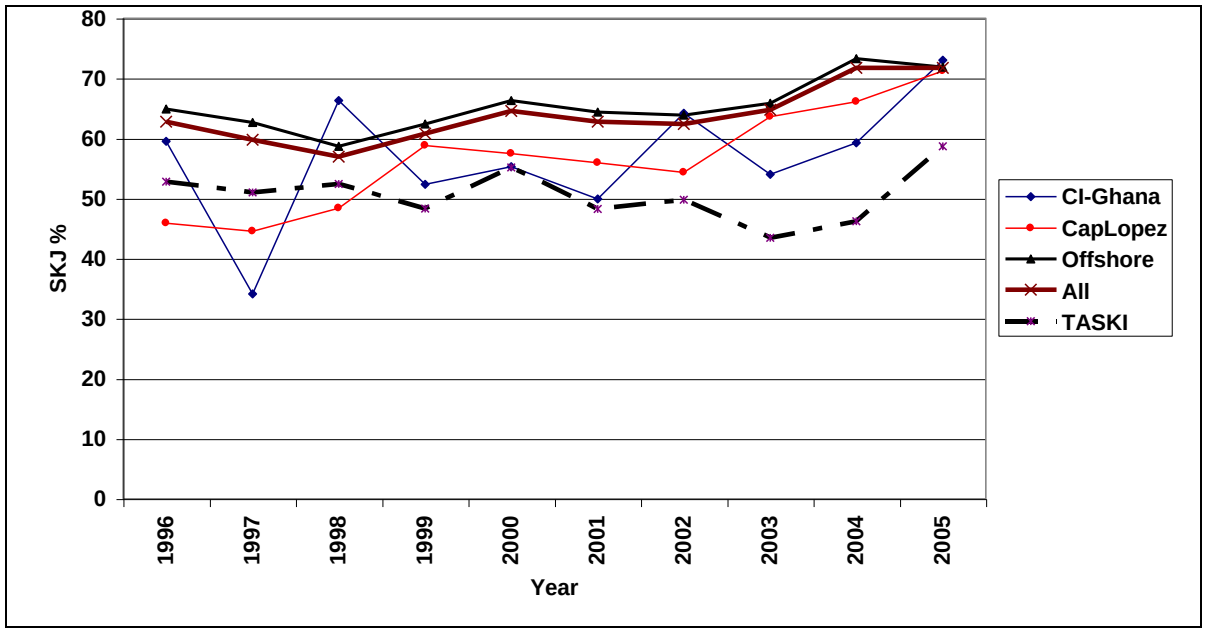

Figure 26a. Percentage of SKJ in the EU PS FAD catches in the 3 areas used in the Ghanaian data processing of the 1996-2005 period (compared to the % of SKJ in the Ghanaian TASK1)

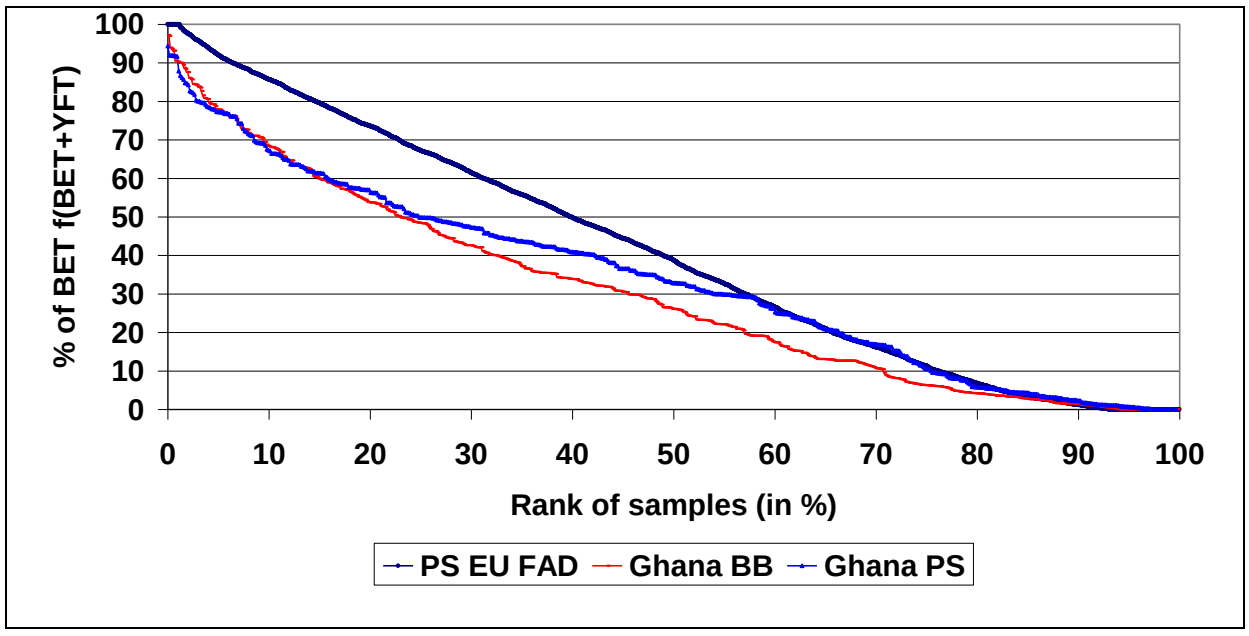

Figure 26b. Percentage of BET f (BET+YFT) in the size samples on Ghanaian BB &PS & on EU PS FAD, sorted by decreasing % of BET (2001-2010 period)

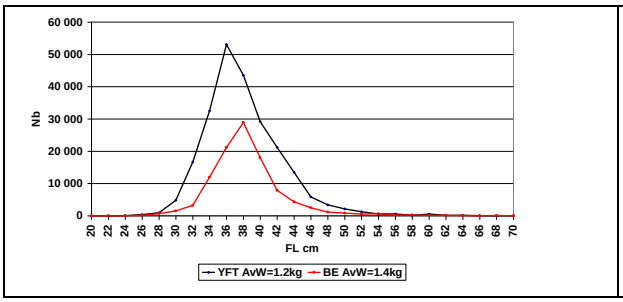

Figure 27 a. CAS of Ghanaian YFT and BET sampled in the Faux poisons market, 1996-2005

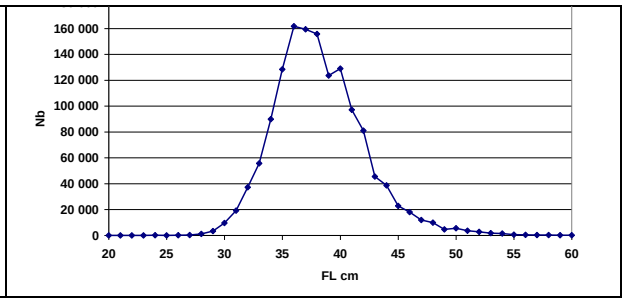

Figure 27 b. CAS of Ghanaian SKJ sampled in the Faux poisons market, 1996-2005 (av. Weight = 1.1 kg)

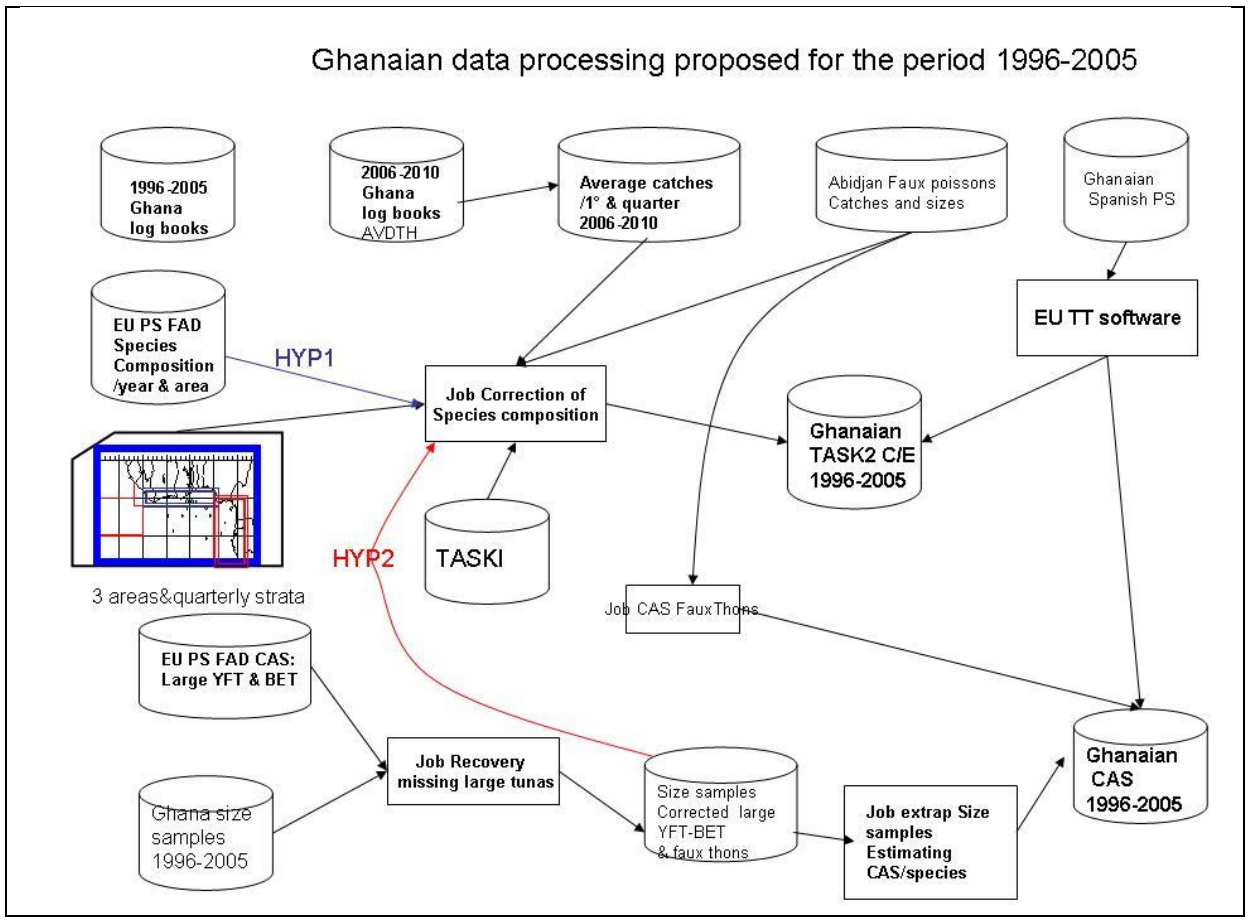

Figure 28. Flowchart of the data processing of the TASKI 2 Ghanaian data, catch & effort and catch at size, done during the period 1996-2005

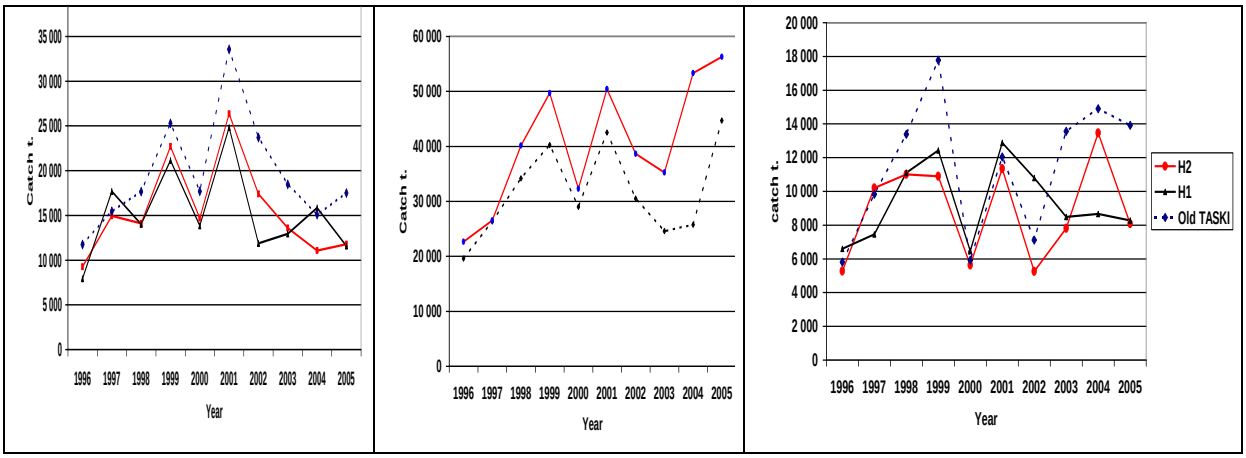

Figure 29a. Yearly catches of YFT: before (dotted line) and after the proposed revision (H1 & H2)

Figure 29b. Yearly catches of SKJ: before and after the proposed revision H1 & H2

Figure 29c. Yearly catches of BET: before and after the proposed revision H1 & H2

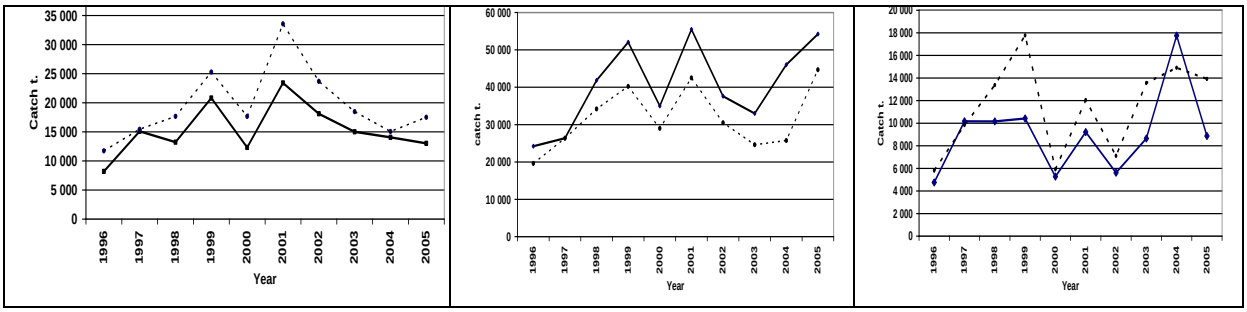

Figure 30a. Yearly catches of YFT, before (dotted line) and after the proposed revision in the H3 species composition hypothesis

Figure 30b. Yearly catches of SKJ, before (dotted line) and after the proposed revision in the H3 species composition hypothesis

Figure 30c. Yearly catches of BET, before (dotted line) and after the proposed revision in the H3 hypothesis

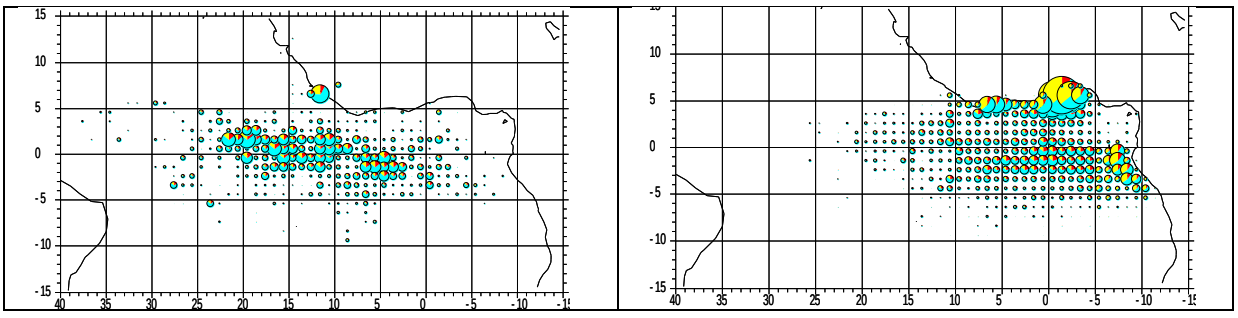

Figure 31a. Average catches by 1° square of the P-fleet during the 2003-2006 period

Figure 31b. Average catches by 1° square of the A-fleet during the 1996-2006 period

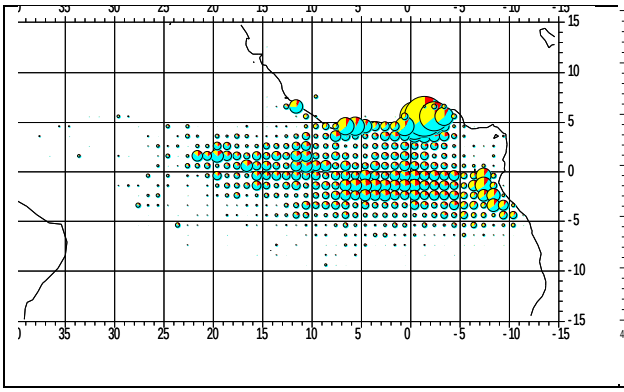

Figure 32. Average catches by 1° areas of the Ghanaian fleets during the period 1996-2005

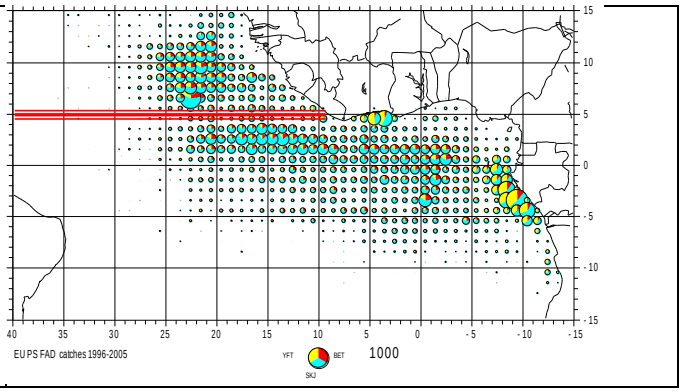

Figure 33. Average catches by 1° areas of the EU PS fleet on FADs during the period 1996-2005

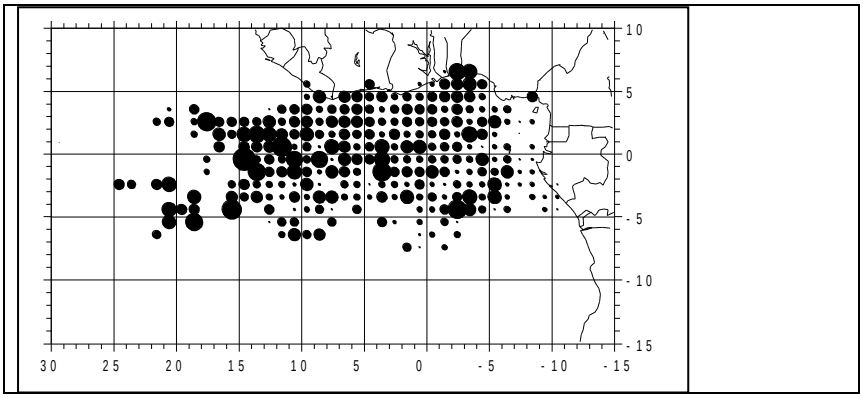

Figure 34. Average catches by 1° square of the available log book data, all Ghanaian fleet, during the period 1996-2005.

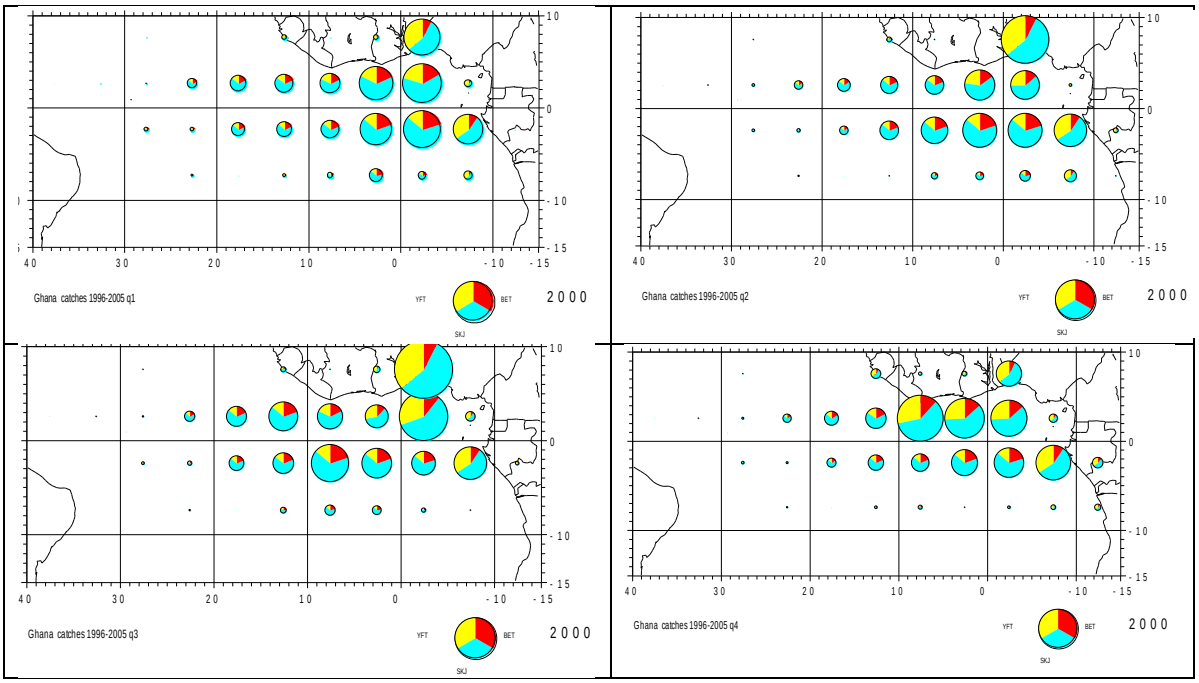

Figure 35. Average quarterly catches by 5° areas of the Ghanaian fleet during the 1996-2005 period

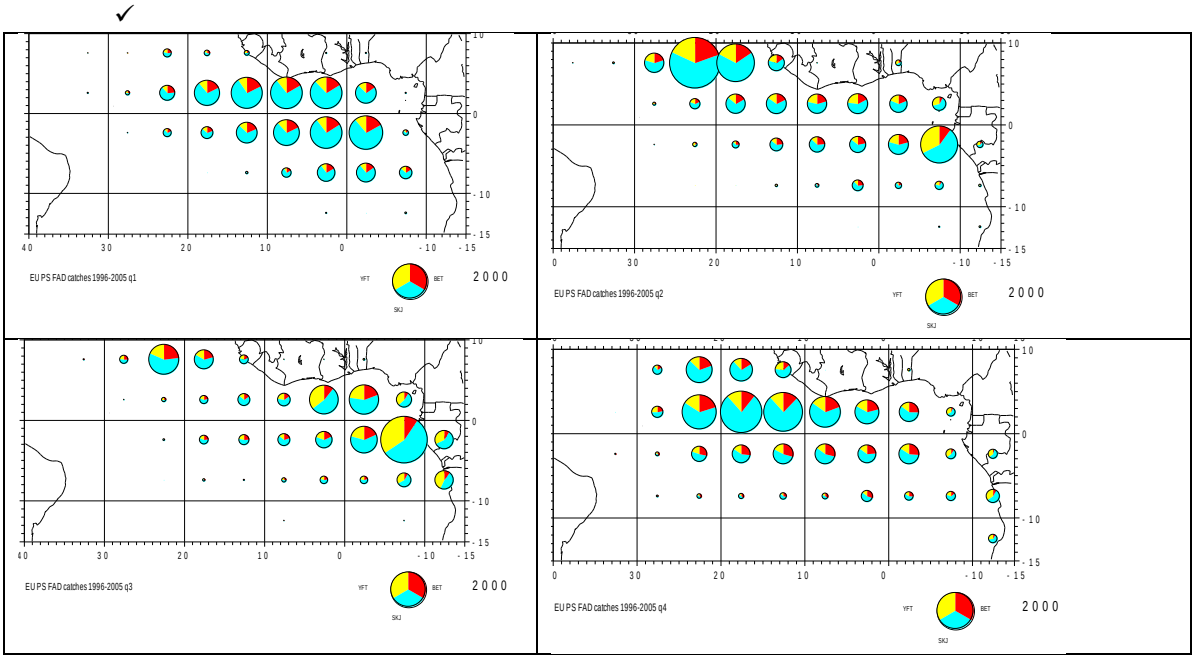

Figure 36. Average quarterly catches by 5° areas of the EU PS FAD fishery during the 1996-2005 period

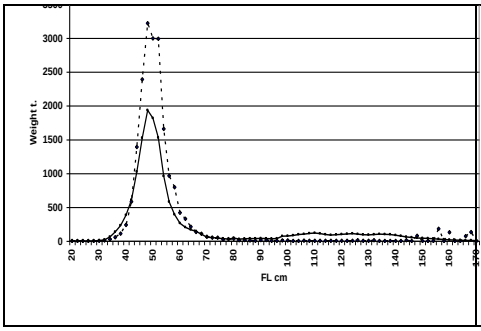

Figure 37a. Average catch at size of YFT, in weight, estimated before and in the H2 hypothesis

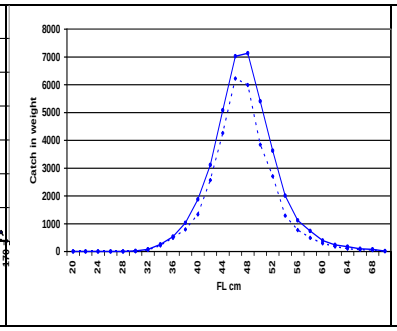

Figure 37b . Average catch at size of YFT, in weight, estimated before and in the H2 hypothesis

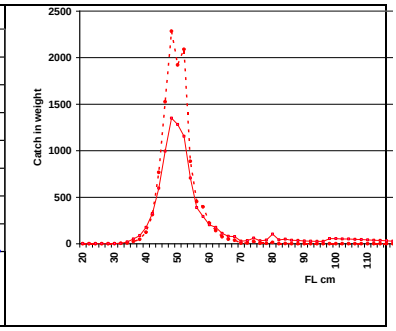

Figure 37c. Average catch at size of BET, in weight, estimated before and in the H2 hypothesis

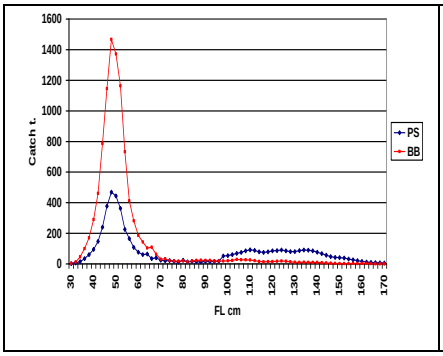

Figure 38a; Average CAS of YFT by Ghanaian BB & PS, 1996-2005; estimated in the H1 hypothesis (and ICCAT CAS) (bilanechantghana7310CAS.xls

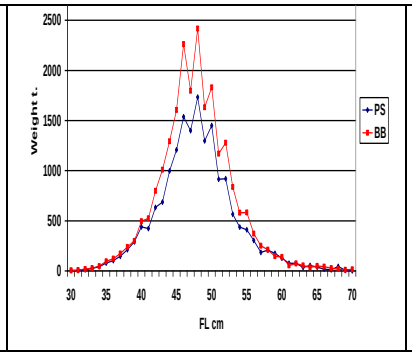

Figure 38b. Idem SKJ

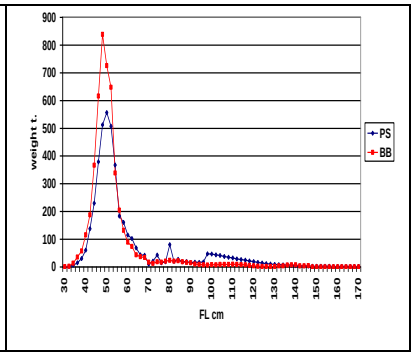

Figure 38c. Idem BET

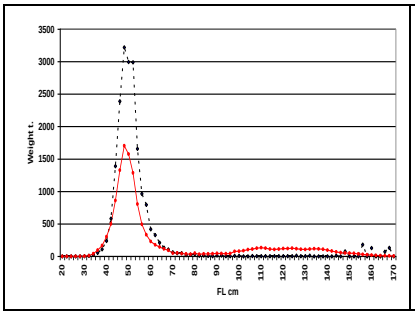

Figure 39a. Average CAS of YFT by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS, dotted line))

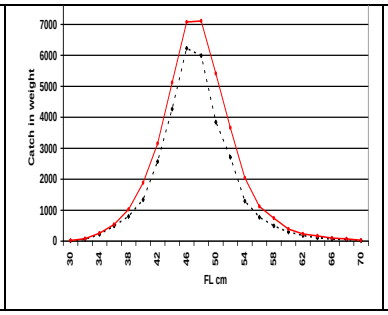

Figure 39b. Average CAS of SKJ by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS)

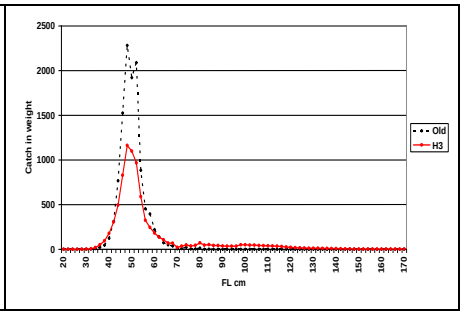

Figure 39c. Average CAS of BET by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS)

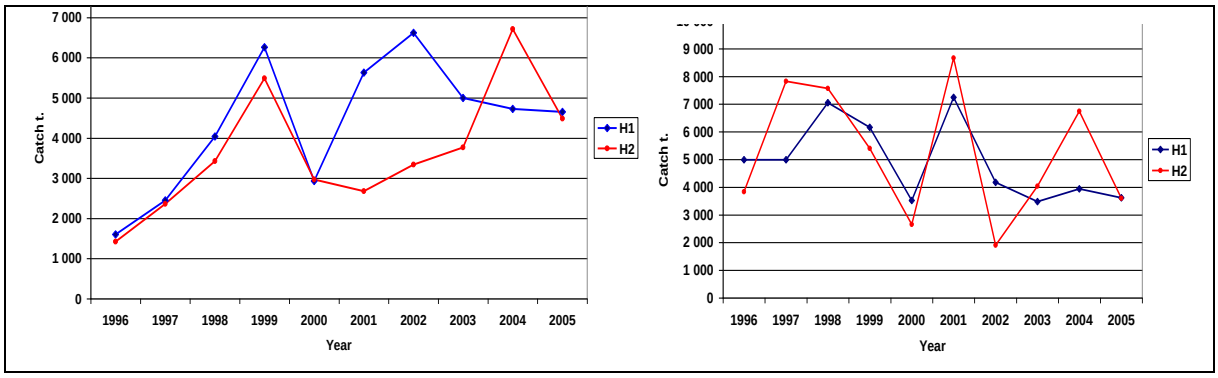

Figure 40. Yearly catches of BET by PS (left) and by BB (right) estimated in the 2 species composition H1 & H2

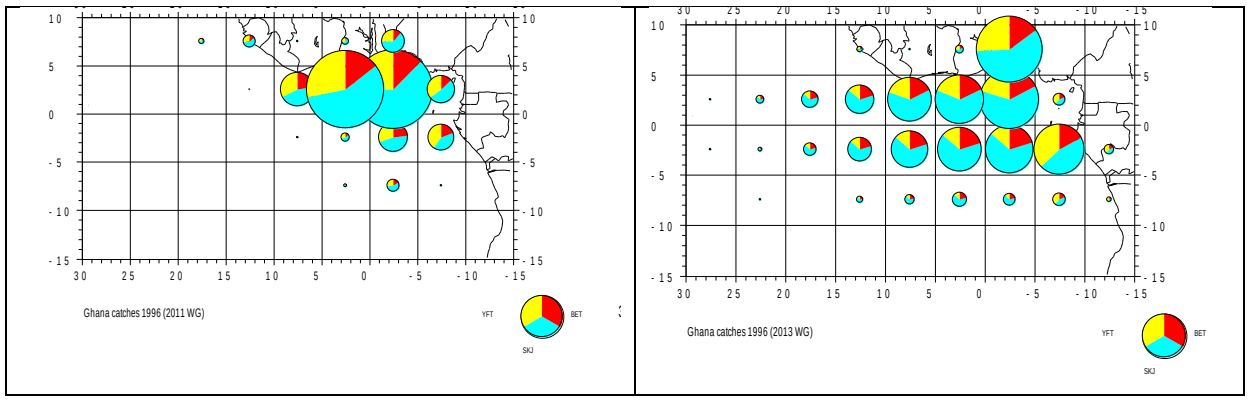

Figure 41a. Fishing map of the year 1996 estimated by the 2011 WG (scale=3000t.)

Figure 41b. Fishing map of the year 1996 estimated now

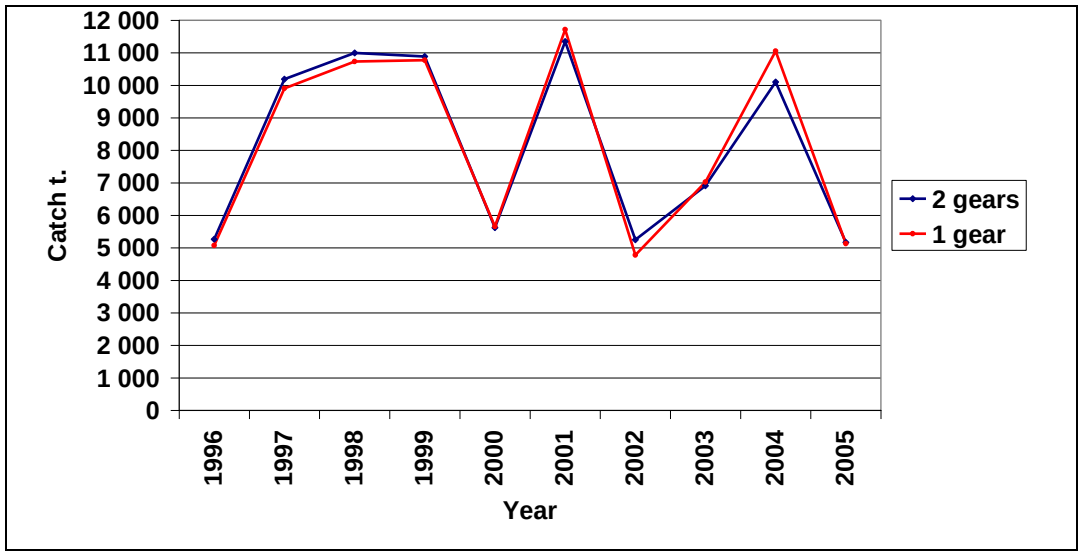

Figure 42. Yearly BET catches by species estimated for the A fleet based on a 1 and a 2 gears stratification during the studied period.

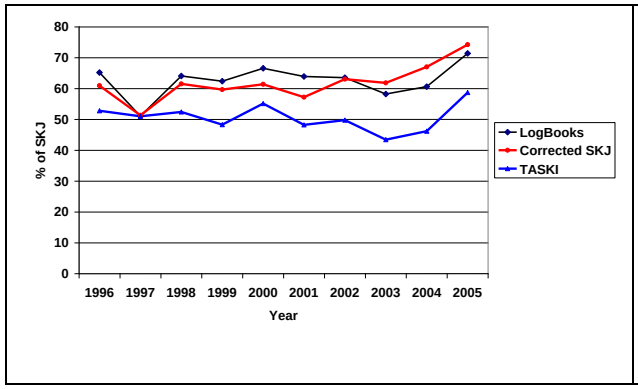

Figure 43a. Yearly percentages of SKJ in Ghanaian landing estimated from 3 sources

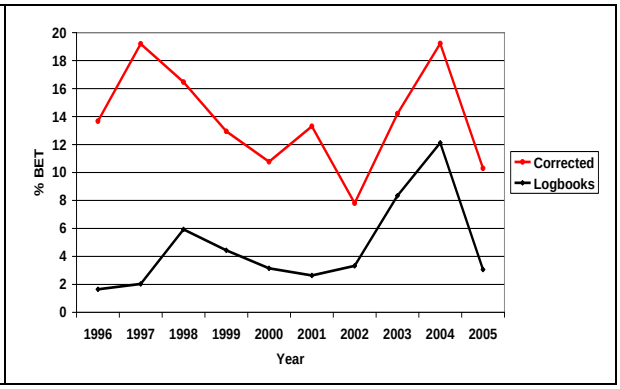

Figure 43b. Yearly percentages of BET in Ghanaian landing estimated in log books & after correction