REPORT OF THE 2011 TROPICAL TUNA SPECIES GROUP INTER-SESSIONAL MEETING ON THE GHANAIAN STATISTICS ANALYSIS (PHASE II)

(Madrid, Spain - May 30 to June 3, 2009)

1. Opening, adoption of Agenda and meeting arrangements

The meeting was opened by Dr. Pilar Pallarés on behalf of the Executive Secretary. Dr. Pallarés welcomed participants and highlighted the importance of improving the tropical tuna statistics. Dr. Joao G. Pereira, General Rapporteur of the Tropical Tunas Species Group, chaired the meeting.

The Agenda (**Appendix 1**) was adopted with some changes. The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**.

Dr. Pereira reminded the Group that the objective of the meeting was defined in the 2011 Work Plan for Tropical Species approved by the SCRS (ICCAT, 2011). The Work Plan included the revision of the data for the eastern tropical purse seine fisheries, in particular the Ghanaian statistics, as well as the accounting of "*faux poissons*". This revision is being conducted in two phases. In a first phase, a task group (TGG) was created to examine the available Ghanaian data, sampling and reporting programs in detail, as well as the relevant programs in Côte d'Ivoire for estimating "*faux poissons*". Following the Work Plan, the TGG included scientists from Ghana, the European Union, SCRS officers (the three tropical species rapporteurs, the Convener of the Sub-Committee on - Statistics and the SCRS Chair) and Mr. Papa Kebe as an expert on tuna statistics. The TGG defined its workplan and assigned Dr. Alain Fonteneau to lead the work in February during the meeting on the organization of the SCRS. Since February, a thorough review of data has been conducted, including a visit by Mr. Kebe to Ghana to seek additional information needed to better understand some aspects of the data collection, processing and reporting systems. The results of the analyses conducted as well as the new information obtained from the data mining were submitted to the Working Group for further analyses[1]. Due to the confidentiality of some of the data recovered, particularly those obtained by Mr. Kebe on his trip to Ghana, the Working Group decided to incorporate the relevant information held in Kebe's report into the appropriate items of the meeting report, with reference to Kebe's report.

The Working Group emphasized that all the work conducted during the meeting focused on obtaining the best scientific estimates of catch, effort and size data for the three main species of tropical tunas. These estimates will allow the SCRS to better estimate the stock status and to provide more accurate responses to the Commission requests.

The Working Group recognized the great effort made by the Ghanaian scientists since the beginning of the fishery in data collection and sampling. The result of this huge amount of work is more than 500,000 fish sampled and a significant amount of logbook data recovered, especially during recent years.

The following participants served as rapporteurs:

P. Pallarés	Items 1, 7 and 8
C. Palma, M. Ortiz	Item 2
D. Gaertner	Item 3
D. Die	Item 4
C. Brown, A. Delgado de Molina	Item 5
J. Santiago, G. Scott	Item 6

2. Review of Review of fishery statistics available at ICCAT databases

The Working Group reviewed all the Ghanaian statistical information (Task I and Task II) available in the ICCAT Database system. SCRS/2011/087 presents a summary of the available fishery statistics data (Task I and the various types of Task II series) available at the ICCAT Secretariat as of May 2011. This document was previously distributed to the task force group and has been used as base line for the revision of the statistics. Briefly, Task I, Task II and auxiliary information regarding Ghana fisheries (baitboat and purse seine) for

[1] All the presentations made to the Working Group summarizing the results of the work conducted by the TGG are available at the ICCAT Secretariat.

tropical tunas were summarize for the main catch species, yellowfin, bigeye and skipjack tuna. Ghanaian related data recovered through special projects (i.e. JDIMP program) from logbook and port sampling in Tema and Abidjan (Côte d'Ivoire), mainly size sampling and fishing effort that has been incorporated in the database. Additional data, such as that provided by ISSF participating canneries were also consulted during the meeting.

Table 1 presents the updates of statistics provided by the TGG during the meeting, particularly for the catch of so-called "*faux-poissons*" (non-reported landings that go to the local market in Abidjan). The new data covered 1984-1987 and 2001-2009. **Table 2** shows the number of size samples incorporated in the database, over 140,000 fish measurements mainly from the purse seine fishery (PS), and the tunas that go to the local markets in the region.

3. Review of yearly catch data

3.1 Total catch by species and by gear

Ghanaian bait boats and purse seiners target the three main tropical tuna species: Yellowfin, bigeye and skipjack. From the current Ghanaian Task I (i.e., not adjusted), changes in total catch over the years reflected 3 different periods of time characterized by low catch of bait boats (1973-1981), significant catch dominated by baitboats (1982-1996) and finally a total catch between 60,000 t and 80,000 t for both bait boats and purse seine gears, which represents 18% of the total tropical Atlantic catch (1997-2010, **Figure 1**).

3.1.1 Source of data

The ICCAT databases contain two public-domain vessels data sets: Task I fleet characteristics and the ICCAT Positive List of Vessels on the Ghanaian fleet, but the information collected from those databases does not reflect the vessels' activity. After a considerable revision of the information collected by the Ghanaian Marine Fisheries Research Division (MRFD) offices, and several discussions conducted with owners of vessels in Tema, Ghana, useful information was collected to estimate the number of active vessels and the potential number of trips made by vessel.

According to the vessels' characteristics, it was estimated that the Ghanaian vessels active for the last three years (2008 to 2010) can be divided into three categories. The first category includes all baitboats with an estimated landed catch of 300 t per trip. The second category refers to the medium-sized purse seiners with an estimated landed catch of 700 t per trip, and the last category includes the large purse seiners, mainly operated by a single company, with an estimated landed catch of 1,700 t per trip. This third category has been named PS_Other.

Using these three categories, and according to the number of trips reported by vessel, the potential annual landed catch by vessel was estimated. Based on this approach, results show that the Ghanaian tentative potential catches could be around 120,000 t, 110,000 t and 80,000 t, respectively for the years 2008, 2009 and 2010 (**Table 3**). These estimates, however, suffer from opposing biases (see section 4.1.1) and must be considered tentative until those sources of bias can be further evaluated.

Note that the carrying capacity of the PS_Other vessels, their large fishing area and their frequent transhipments at sea justified classifying them into a different purse seine category than medium Ghanaian purse seiners (see **Appendix 5**). However, to avoid double counting, these estimates did not account for catch unloaded by the two carriers operating with PS_Other and unloading in Tema and Abidjan (estimated at about 20,000 t per year). At the same time, catches re-exported to Abidjan should be deducted from the estimation of the potential catches. It was suggested to do bootstrapping of individual vessel information stratified by carrying capacity categories to estimate some level of uncertainty in the potential catch estimates in future work of the Group.

For the historical period (1991-2003), the data received from an active vessel were aggregated by year and by owner of the boat but without any complementary information on the number of trips by vessel and the vessel identification (and consequently its carrying capacity) (**Table 4**). If specific vessel names by company were available, estimates of the potential catch could be done in the same way as was done for 2008 to 2010.

Logbooks and size/species samples collected in Abidjan on Ghanaian baitboats and purse seiners were recovered and submitted to the ICCAT database for the period 1984 to 2009 (**Table 5**); the 2010 provisional data were also submitted to ICCAT prior to the Working Group. In addition, the Working Group was informed that within an ICCAT/JDIMP-Ghana agreement, data recovery of logbooks not yet submitted to ICCAT is currently ongoing. Logbooks not yet entered in a digital format were found for the periods 1985 to 1991 and for 1993, 2000 and

2002. Few are yet to be recovered for the period 1986-1989, 1993, 2000 and 2002 and these should be computerized in June 2011, which will assist in further revision of the Ghanaian statistics.

3.1.2 Cross-checking and other validation process

A new set of landing data was obtained for the first time from an ISSF cooperator on tuna catches processed by its Tema cannery in 2009 and in 2010. This confidential data set contains the trip by trip quantities of tunas sold by each boat (from Ghana and from others countries) with the name and date of each landing. Each of these landings is classified by species and size categories, as they have been estimated by the cannery. Data from the cannery is used for cross-checking. Previously, companies gave MFRD estimates from their stevedores at the quayside. Positional analysis from the Ports Authority gives an indication of the duration of trips and possible tonnages bases on vessels GRT.

3.1.3 Potential problems

Different types of problems related to the collection of catch and effort data were clearly identified for the Ghanaian tropical tuna fisheries:

- The transhipments from purse seiners to reefer vessels or baitboats serving as reefer vessels often takes place at sea, specifically for some segments of the Ghanaian fleet. It was noted that such practice could be a source of degradation of the data submitted by Contracting Parties to ICCAT. It was unclear to the Working Group if this practice was in violation of an ICCAT recommendation regarding transhipments. Based on what was implemented on longline fisheries, the presence of observers on board could mitigate this loss of information.
- It was also indicated that in addition to landings reported in Abidjan, part of the catch might be exported directly to Asian and other countries prior to being landed at port. This possibility must be checked with the use of the trade data at the ICCAT Secretariat before drawing any conclusion. If the exportation exists, it should also be checked if this exported catch is collected and reported to ICCAT.
- When vessels are landing in Abidjan, delays in receipt of the manifest (catch logbook samples) may slow or inhibit the transmission of information to ICCAT.
- Since 2006, data entry and validation of Ghanaian catches are done in Tema with the European AVDTH software. After some difficulties in the first years, all the information from logbooks was entered in the last two years. However, there are still some difficulties in the application of the subroutine (AKADO), which does the validation of data. This is mainly due to the lack of English translation of the AKADO warning and/or error messages. The 2007 data have not yet been entered in AVDTH.
- Another difficulty faced with data collection is due to the fact that around 60% of the Tema baitboats vessels actively participate in the fishing operations of the purse seiners, either by chumming the tuna school to maintain it at the surface during setting of the net, or by acting as a supply and/or a reefer vessel). However, these baitboats also fish by themselves at the beginning of the trip in a traditional baitboat fishing mode. A common situation is that the baitboats receive catches from the purse seiner and, therefore, their landings are a mix of two different gears. In those cases, when baitboats are operating in association with purse seiners there is no possibility to reconstruct the total yearly catch time series by fishing gears.
- Accurate reporting of the fishing mode (*i.e.*, FAD sets vs. free school sets) in the logbooks is an important element needed to accurately characterize the total catch in terms of species and size composition as requested by ICCAT Task I. Due to likely changes in fishing strategies over the years, it was unclear to the Working Group if the available information reflected these changes or not.

Significant amounts of small tuna caught by Ghanaian (and other) vessels are landed in Abidjan and sold at the local market (referred to as "*faux-poissons*" in Abidjan). "*Faux-poissons*" are not generally included in the landings statistics for fleets landing in Abidjan. Therefore, methods to estimate small tuna catches landed in Abidjan have been developed by CRO scientists and estimation for all the main fleets landing in Abidjan has been reported to ICCAT. However, in the case of Ghanaian vessels there exist possibilities of double counting which cannot yet be eliminated, since sampling of Ghanaian vessels first landings in Ghana is designed to permit reporting all fish including those going to the local market, termed "market fish" in Tema. This information (frigate tuna, dorado, wahoo, broken and damaged fish, including yellowfin, skipjack and bigeye) is included in the Ghanaian Task I statistics under the category "others". Although further information is needed to completely eliminate the possibility of double counting by including estimates of "faux poisson" from Abidjan sampling of

Ghanaian vessels, the Working Group considered that the new data set with estimates of the yearly quantities by species and sizes landed in Abidjan ("*faux-poissons*") from Ghanaian vessels during the 1988-2010 period (Chavance, et al 2011), submitted to ICCAT should provisionally be added to the overall catch estimates which could allow accurate estimation of the species composition and sizes of these landings, particularly since 2007 (as more than 40,000 tunas have been measured on these landings). Similar approaches also need to be applied to other fleets landing in Abidjan, since it is known that these catches are not included in Task I for those other fleets.

3.1.4 Species composition

In preparation for this meeting, the Secretariat performed a comparison of the species catch composition of Ghana against the European tropical fleets (Spain and France). Important differences were detected in the species catch composition during the last decade: 2000-2009 (**Table 6**).

The EU multispecies sampling scheme (in place for European fleet vessels since the early 1980s) has also been adopted by the Tema staff since the 1980s. Furthermore, Kebe's trip report indicated that it can reasonably be assumed that the external identification between juvenile yellowfin and bigeye is well known by MFRD technicians. The Working Group hypothesized that these differences in species composition (**Table 6**) could be attributed to different fishing strategies and areas by the different fleets and conducted analyses to test this hypothesis (see below). The Working Group also noted that the lack of large yellowfin in the size data submitted by Ghana to ICCAT could have consequences for accurately reporting species composition and, as a result, Task I estimated by species, if these catches occur, but are not appropriately sampled.

Based on preliminary analyses, and specifically in relation to the three periods of time characterizing different levels of total catch, in the non-corrected Task I, the Working Group decided to use the following criteria to updated total landings of tunas for the Ghana series:

− 1973-1981 Period:

This period was dominated by baitboats, but Ghanaian vessels were a minor component of the Tema-based fleet which was mainly comprised of Japanese and Korean/Panamanian vessels. Comparative analyses of species composition between Ghanaian and Japanese baitboats showed similar distribution (**Figure 2a** and **b**). Consequently, there is no basis for re-estimating the total yearly catch. Therefore, the Ghanaian Task I existing in the ICCAT database will be used.

− 1982-1996 Period:

During this period, the Ghanaian baitboat catch increased significantly (Ghanaian vessels being dominant in the Tema-based fleet in this period), and while some Ghanaian purse seiners were operating, it is reasonable to assume that the massive introduction of FADs fishing at the end of the1980s did not grossly affect species composition in this period for the overall Ghanaian catch. The only questionable point identified in the examination of data from this period concerns the relatively low percentage of bigeye in Task I compared to Abidjan port sampling in the period 1984-1988 (**Figure 3**). Seven Ghanaian purse seiners had been operating in the eastern Atlantic during the 1981-1987 period. Their total yearly catches are considered to be realistic. Recovery of a set of samples (1982-1983, not previously reported to ICCAT) indicated a need to re-estimate species composition for the Ghanaian purse seiners during this period since it seems unlikely the Ghanaian purse seiners landing in Abidjan were adequately sampled by Ghanaian technicians during this period.

Based on observed species composition sampled in Abidjan from 1984-1987 (5,250 t of tunas sampled for species composition), purse seine species composition in annual catches were re-estimated independently for baitboats and purse seiners. These newly recovered data show that during the period Ghanaian purse seiners had targeted free schools of pure, large yellowfin, that have not been observed in the Ghanaian samples reported to ICCAT in recent years.

− 1997-2010 Period:

The Working Group decided to focus on this last period which appears problematic in terms of total yearly catch as well as in terms of species composition. Different factors may have contributed to increase the uncertainties on the information submitted to ICCAT. The introduction since 2003 of a new fleet (PS_Other), which depicted totally distinct fishing and landing behavior (as previously mentioned, many transhipments in offshore areas,

increasing quantities of Ghanaian "*faux poissons*" – including tropical tunas - sold in Abidjan), the assistance brought by baitboats to purse seiners without clear identification of specific catch and effort, some difficulties in using the AVDTH software, an increase in FAD setting apparently not well reported in logbooks, low sampling and low logbook coverage rate (excepted for the most recent years) which could partially explain differences in species composition and in proportion of large fish compared to EU purse seiners operating in similar areas, etc.

3.1.5 Final estimate of the Ghanaian total annual catch

The Working Group made estimates of a scientific total annual catch for the Ghanaian fleet during recent years (period 2008-2010) based on the total of the three following components:

a) the total yearly catches declared by the PS_Other fleet, assuming that they are correct and include all the "*faux poissons*" Ghanaian catches estimated in Abidjan;

b) the total yearly landings in Tema of the rest of the Ghanaian fleet; and

c) the catches of the EU PS fishing under Ghanaian flag.

These scientific estimates of the Ghanaian total annual catches (**Table 7**) are higher (11% on average) than the yearly Ghanaian catch existing in the ICCAT database. Total 2006 and 2007 catches were also corrected, assuming the same (11%) underestimation rate.

For the years 1997-2005, the Task I data existing in the ICCAT database were considered as the Ghanaian annual catch by species.

3.2 Fleet

3.2.1 Source of data

The sources of data were: Vessel Register with the Ghana Maritime Authority (Fishing Commissioner) under the Ministry of Transport, Register of Fishing Licences from the Ministry of Food and Agriculture (Fisheries Commission under the Secretariat headed by the Director of Fisheries) and Ports Authority at Tema and Takoradi. In ICCAT, the characteristics of the different tuna fleets operating in the Atlantic are registered in the Fleet Reporting System and the Positive List of Authorized Vessels.

3.2.2 Updating process

With the aim of updating both ICCAT lists (the Fleet Reporting System, and the ICCAT Positive List of Authorized Vessels), information concerning the Ghanaian fleet was collected by P. Kebe during his recent trip to Ghana and discussed by the Working Group. Based on Kebe's report, a revision of the ICCAT List of Active Vessels by gear category for the period 2008-2010 was achieved making use of a census of dates concerning abandoned vessels. In addition, tentative estimates of potential yearly catches of all the active vessels became possible using these data (see sections 3.1.1 and 4.1.1).

4. Task 2 catch and effort data

4.1 Fishing operations

4.1.1 Fishing effort

From 1991 to 2003, the number of active Ghanaian fishing vessels based in Tema (**Table 8**) was estimated from records obtained from the MRFD (Kebe's report) and updated in 2010 from information on additional vessel activities for the "PS_Other" fleet.

The median number of active vessels over this period is 31, with a minimum of 24 and a maximum of 33. These values are smaller than the number of reported vessels for which the median is 33 and the minimum and maximum are 25 and 38, respectively.

For the more recent period of 2008 to 2009, an estimate of the number of active vessels and the number of trips per year conducted by each vessel is available from Kebe's report. It is noted that for the period of 2008-2010 for which ICCAT maintains a list of positive authorized vessels, there is a discrepancy of 1, 2 and 5 vessels between the active vessels and the positively authorized vessels for 2008, 2009 and 2010, respectively.

For the period 2008-2010, the total number of trips for three types of vessels (BB= baitboats, PS= purse seiners, PS(PS_Other) = large purse seiners, **Table 9**) was used to calculate the potential catch landed each year by assuming that each category had a constant maximum catch (BB = 300 t, PS = 700 t and PS _Other) = 1700 t). The estimates show a large increase in potential catch in 2010 that is driven by the increase of activity in the PS_Other fleet. The activity of that fleet doubled from 24 trips reported in 2008 to 49 trips in 2010. It must be noted that these estimates of "potential" catch suffer from two opposing biases: (1) the number of trips per year are only those reported and some trips may not have been reported, and (2) the maximum catch is only an index of the highest catches observed in equivalent vessels of the EU fleet, and it is highly unlikely that vessels will land such high catches in every trip.

There are differences between the information reported to ICCAT on vessels that are listed as authorized to fish and the list of active vessels for 2010 (Kebe's report). For 2010, thirty-five (35) vessels were identified as active from Kebe's report while only 31 were included in ICCAT's list of authorized vessels. The remaining four vessels were two purse seine and two baitboats (**Table 10**). Three of those four vessels were either on ICCAT's list of authorized vessels in 2009 or 2011. One vessel has not been on the list of positively authorized vessels in the period 2008-2011. The total number of trips reported by active vessels not included in the list of positively authorized vessels represented 7% of the total number of trips reported.

In addition, no data were found in the Kebe's report on the number of fishing trips made by six vessels that were on the list of vessels positively authorized to fish. It is possible that these vessels did not fish or, alternatively, that these vessels did fish but did not report it to the MRFD.

It is clear that during 2010 landings occur regularly throughout the year for both baitboat and purse seine fleets (**Table 11, Figure 4**).

The Working Group also took note that since 2011, four large purse seiners are operating for the Tema cannery according to the ICCAT list of positive vessels, but operating under Belize flag. It was not clear to the Working Group how the Task II of this new Tema-based fleet will be obtained and submitted to ICCAT in the future.

4.1.2 Use of FADs

A description of Ghanaian FADs and their technological equipment was presented in Kebe's report with the aim to allow comparison, if necessary, of Ghanaian fishing activities with EU purse seiners operating in the same areas. The number of FADs by vessel was estimated at about 30 and 50 for baitboats and purse seiners, respectively. Extrapolating, the fleet probably operates about 1000 FADs.

In general, Ghanaian FADs are equipped with radio range beacons to allow their geo-location, but are not equipped with sophisticated technology devices such as sonars or echo-sounders typical of EU fleet FADs. The impact of these differences in FAD instrumentation on species composition and per operation catch is not well known, but could be a factor in explaining differences in these metrics in comparison with other fleets. Recently, the Ghanaian fleet has been augmented by the purchase of former EU large purse seine vessels with sophisticated equipment. It is unclear if the fishing companies and the crew will be able to take advantage and properly maintain this new equipment (Kebe's report).

4.2 Logbook system: coverage, validation process, processing system

4.2.1 Data available in the ICCAT databases

According to SCRS/2011/087, three types of data on catch and effort for the Ghana fleet are available in the ICCAT databases:

a) official ICCAT reports of Task II catch and effort statistics (reported every year);

b) logbooks (by vessels and fishing operation obtained in 2010 under a JDIMP project) stored in a consolidated way in the ICCAT database; and

c) catch and effort data from ICCAT port sampling in Ghana.

All three data sets contain data for both types of fishing gear, baitboat and purse seine. The first data set contains data for the period 1976 to 2009, the second data set for the period 1993-2008, and the last data set for the period 1974-1988. Yearly coverage for all data sets is variable and many years within those periods have no data (**Table 1**). More details on the nature of these datasets are provided in SCRS/2011/087.

No information is available by operation mode (FAD, free school (FSC), etc.) in any of the three datasets. Additionally, the units of effort reported change through time. They can be in days fished (DF), successful days fished (SD), days at sea (DS), number of sets (NS), and hours at sea (HS). Effort records for the baitboat fleet are available for most years (**Figure 5**) but fewer are available for the purse seine fleet (**Figure 6**). Note that the lack of records for purse seiners for the period 1988-1994 is due to the fact that no Ghanaian purse seiners were active then.

Additional catch and effort data that have been collated since SCRS/2011/087 was completed, as explained in section 2 of this report. Detail on these new datasets is presented in **Table 1** of this report. This new data includes:

- recovering data on for the period 1984-1989 and 2000-2009 for the a) dataset, above;
- data on "faux poisons" landings at Abidjan from Ghanaian vessels for the period 1984-2010.

4.2.2 Problems related with the logbooks system and possible improvements

Ghanaian scientists are very familiar with the data entry and validation process based on the AVDTH system, including the use of the AKADO software for validation purposes. AVDTH files for 2008-1010 have been processed by Ghanaian scientists and are now available at the ICCAT Secretariat (SCRS/2011/087). Data available for 2007 have not yet been entered through the AVDTH system. There are, however, some difficulties with the use of the AVDTH system that require attention. Some of these difficulties are listed in Kebe's report but a few important ones relate to the fact that the validation system (AKADO software) is documented in French. This creates a barrier to the efficient use of this system by English-speaking Ghanaian staff.

The AVDTH and AKADO software continues to be developed by French IRD staff and improvements will continue to be made, including improvements in error documentation, troubleshooting and the user interface. While this improvement and development are positive, they can be negative for inexperienced users, if adequate training is not provided.

IRD staff will be staged in Abidjan in 2012 and may be able to collaborate with Ghanaian scientists in improving their capacity to use the AVDTH system. There is also the possibility that additional IRD staff will be available to carry out missions in Tema.

The TTGHANA software developed in 2005 to create the Task II catch and effort and sizes was never used by Tema based staff, but the data entered were at one point processed at the ICCAT Secretariat. In 2010, Côte d'Ivoire scientists collaborated with MFRD staff to develop a platform that allows conducting queries on AVDTH called ABJ-PGM, which is now being used instead of TTGHANA (Kebe's report). These queries are of limited interest for the creation of Task II C/E and CAS, since they cannot produce the results after necessary species composition correction for the catches, since this necessarily implies somewhat complex data processing (including a substitution scheme, etc.). The same applies for the extrapolation of the size frequency data. In this context, the Tema scientists have not yet been able to estimate the standard ICCAT Task II, C/E and CAS, based on their AVDTH database. As above, impediments to broad use of these systems include the lack of user-friendly interface and inadequate training for their implementation.

4.3 Extrapolation of catch and effort data to the total catch

In order to further stock assessment analyses it is useful to have catch and effort data to represent the total removals from the stock so that the species composition between the total yearly catch and the Task II are consistent. Current data on catch and effort contained in Task II need to be extrapolated to represent the total catch. This extrapolation was conducted in three periods 1973-1981, 1982-1996 and 1997-present.

4.3.2 Period 1973-1981

During this period, only baitboats were present in the Ghanaian fleet. Furthermore, few detailed Task II data for this period are available in the ICCAT database (**Table 11**) and no new data on catch and effort were recovered

during 2010. Therefore, the TGG decided to combine the available Ghanaian baitboat C/E data with those available for Japanese baitboat C/E under the assumption that they operated similarly. By combining them, it is hoped that the extrapolation of Task II data to the total catch will be more robust. Extrapolation was done by:

1) calculating a raising factor with the ratio of annual total catch and Task II catches by species;
2) raising the available Task II catch and effort with the raising factor, producing a C/E file by month and 1x1.

4.3.3 Period 1982-1996

This period includes the start of purse seine operations in Ghana. The amount of catch and effort data available in the ICCAT Task II database is considerable, but uneven (**Table 11**). Additionally, data on the catch, effort and sampling from logbooks and port sampling of Ghanaian boats landing in Abidjan collected by CRO and EU scientists can complement the Task II data (**Table 5**) (as discussed in Section 3.1.4).

The area covered by the Ghanaian fleet in this period is about half of the area fished by the EU fleet for this period 1984-1986 (**Figure 7**). (Note that the sizes of Ghanaian fishing zones are widely underestimated for the other years due to the absence or weakness of its logbooks.)

For the baitboats, the extrapolation was conducted as follows:

- The available data covered 1984-1989 (C/E file estimated with corrected species composition). For the missing years, a mean file by month and 5x5 was created from the 1984-1989 data file. The C/E data were then raised to the total annual catch by species (82-96).

For the purse seiners, the extrapolation was conducted as follows:

- The available data covered 1984-1986 (C/E file estimated with corrected species composition). For the missing years, a mean file by month and 5x5 was created from the 1984-1986 data file. Since the C/E species composition is correct, the C/E data were then raised to the total annual catch.

4.3.4 Period 1997-present

During this period, the purse seine fleet from Ghana has grown in size and complexity. A large portion of Ghanaian purse seiners fish in cooperation with baitboats. However, some vessels including a new fleet of large purse seiners known as PS_Other fished independently of baitboats. In the very recent time (2008-present), and for the first time since the start of purse seine operations in Ghana, there is information on the proportion of sets made on free schools vs. those made on FADs, although there is uncertainty about the accuracy of the information.

Due to the lack of time available, the Working Group was not in a position to obtain extensive estimates of corrected Task II C/E and sizes during this third period of 1997-2010.

Nevertheless, the Working Group agreed to obtain the Task II data for the years 2006 and 2008-2010 for which detailed logbooks and sampling data are available, considering the strata defined in section 5.3.2. These data were obtained after the meeting and are included as **Appendix 5**.

For the rest of the years (1997-2005 and 2007), the Ghanaian Task II will remain as before, but adding the recovered logbooks and samples (from regular landings and on “faux poisons” in 2007) data from Abidjan for these years.

The Working Group noted that two purse seiners owned by EU companies have been fishing under Ghanaian flag during the period 1998-2009. It appears that their logbooks have not been recovered by Ghanaian scientists and that their catches may not be included in the Ghanaian total annual catch. However, the logbooks of these vessels have been submitted to EU scientists and they have submitted the information to the ICCAT Secretariat under a Ghanaian NEI category. The analysis of these logbooks is showing that these purse seiners are fishing as the EU purse seine fleet.

5. Yearly Task II: Sampling system and estimated catch at size

5.1 Species and size sampling in Tema

5.1.1 Description of sampling scheme, coverage.

The tuna fishery in Ghana started in the early 1960s, targeting skipjack, with minor landings of juvenile yellowfin and bigeye. However, over the past four decades, tuna fishing in Ghana has been characterized by three major changes: (1) prior to 1982, this was primarily a classical baitboat fishery catching few bigeye, with some minor, sporadic purse seine activity in the 1970s and from 1980 on; (2) from 1982-1996, there were some periods of modest purse seine activity as well as the introduction of FADs in the early 1990s, which significantly increased the bigeye catches; and (3) during the period beginning in 1997, the development of an association with purse seiners and baitboats in which they often shared their catch at sea (Bannerman, 2010).

Initially, the sampling of tunas at port was done following the ICCAT *Field Manual* (Miyake and Hayasi, 1972) where 100 individuals per vessel were selected at random for measurement and species identification. It should be noted that there is no sampling by size or species at sea. Since there is mixing of catches from different sets into the same well, it is generally not possible to associate samples in a well to a particular set (or a precise location).

The SCRS Tropical Tunas Working Group met in Tema, Ghana (Anon. 2004) and, after a careful analysis of the current sampling scheme, suggested that the standard procedure used was convenient but necessitated a much larger sample size. Based upon the sampling protocol /analysis made on European purse seiners in the early 1980s, at least 500 fish for species composition would be considered sufficient for the estimation of species composition. Beginning in 2005 under the JDIP, the data entry software codenamed AVDTH (Lechauve, 2001) adopted by the European purse seiners operating in the Atlantic Ocean has been used.

Following the Port Sampling Manual Procedures for Tropical Tuna in the Atlantic and Indian Oceans (SCRS/2005/101), sampling is done while the wells are being offloaded. For baitboats, the entire vessel is considered a single unit, while individual wells are sampled in the case of the purse seiners. A total of 500 tunas are randomly sampled; 300 and 200 fish are measured (recording LF or LD1) during the first and second stages of offloading, respectively. Up to June 2010, a single sample was obtained for each vessel (both baitboat and purse seine). Currently, two samples are obtained for each vessel; that is, a target of 1,000 individual tunas per vessel. However, due to logistical difficulties and the lack of personnel, the actually realized average number of measured tunas is 900 (LF only) with LD1 measured as much as possible as they are being offloaded.

In addition to the port sampling, size data are also collected through an observer program (SCRS/2011/087). Observer data were collected beginning in 2006 and the program was emphasized beginning in 2008 with support from the ICCAT/JDIMP program. On average 3-4 vessels are covered for 3-4 months in a year (about 10-20% coverage). There is a strong need to place observers on all vessels, especially the purse seiners that are catching about 70% of all catches (including collaborations with baitboats). At this time, observer data have not been utilized for preparing catch at size. The Group recommended that these data be analyzed and, if possible, incorporated in the process.

The weight at size of Ghanaian tunas that have been sampled each year during the period 1973-2010 are shown in **Figures 8-10**. These figures combine all the size data collected in Tema and Abidjan on the Ghanaian landings, and they show well the changes in the sizes caught and in the size of the samples collected each year on this fleet.

5.1.2 Data processing: from size samples to catch at size. Data reported to ICCAT

The sampling results for years spanning the 1970s to 2005 have been reported to the ICCAT Secretariat by different statistical correspondents using various formats. For the more recent part of that period, especially from the 1990s onward, data have been reported by Ghana in the Excel format.

Beginning with 2006 data, sampling results have been reported in the AVDTH format and have been incorporated in the database using the AVDTH 2005 software. Raw data (vessel by vessel, trip by trip) are sent sporadically.

The Group defined some recommended protocols to create catch at size for Ghana by year, quarter and species. Nevertheless, it is important to also have the actual sample information upon which such extrapolation is based.

For the first period (1973-1981) the fleets were mainly baitboats. As the fishing fleets and size taken by each fleet were quite homogeneous during the period 1973-1981 (**Figure 11**), the Ghanaian CAS should be estimated, using not only the Ghanaian samples that include very small sample sizes in some years (**Figure 12**), but also using all the size samples taken by Ghanaian scientists on the combined Tema based fleets of Ghana and Japan, no matter which flag, when sample sizes are insufficient from Ghana vessels alone.

To create catch at size for this first period, the recommendations are:

- For sizing the Ghanaian baitboat catch, the data used were Ghanaian yellowfin, skipjack and bigeye size samples data and only Japanese skipjack and bigeye size samples data because the size distribution of yellowfin was considered too different between the two fleets.
- Data were stratified and then cumulated by year, quarter and species. When there are no data in a strata or the size sample is less than 100 fish, the strata is substituted by a mean strata created by quarter and species.
- The data were then raised to the total Task II catches by year, quarter and species.

The second period (1982-1996) was dominated by Ghanaian baitboat catches (minor Ghanaian purse seine catches occurred during 1982-1986, beginning again in 1996). During this period, Ghana was the major partner in the Tema-based fleet. Length distributions during this period appear to be quite homogeneous between the different years.

When purse seine catches did occur, the Ghanaian purse seine yellowfin size frequency distributions sampled in Ghana were quite different to the EU purse seine yellowfin distributions or the yellowfin samples collected in Abidjan from Ghanaian vessels, in that large yellowfin were very rare in the Ghanaian vessel samples collected in Ghana (**Figure 13**). This difference results in differences in the traditionally estimated catch at size between EU and Ghanaian purse seine catches (**Figure 14**). This apparent lack of information on the frequency of large yellowfin in the Ghanaian purse seine catches sampled in Tema may be worsened by a frequent lack of records of yellowfin catches by size category in the logbooks.

For this reason, the recommendations for creating catch at size for this second period are:

- Use the size frequency data collected from Ghanaian purse seine vessels landing in Abidjan, collected during 1984-1986, applied by year, quarter and species to all Ghanaian purse seine landings during 1984-1986. Strata without samples or with less than 100 fish sampled were substitute by a mean strata by quarter and species.
- Apply the 1985-1986 size frequency data collected from Ghanaian purse seine vessels landing in Abidjan quarter and species (i.e., pooling across years) to all Ghanaian purse seine landings during 1980-1983 and for 1987.
- In the case of Ghanaian baitboat landings during this period, apply the same protocols as for the first period, with the exception that only Ghanaian data should be used.

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. The PS_Other vessels must be considered separately. Due to the observed seasonal variations in size frequency (**Figure 15**), it is important to calculate catch at size at the quarter level, at least, whenever possible.

It is expected that reporting of “faux poisson” catches for the PS_Other fleet is incomplete because its catches were all landed by freezers in Tema and in Abidjan, and thus very difficult or impossible to trace and to sample them. The detailed samples collected in Abidjan during recent years will be used to estimate these catches, including species composition and sizes, for 2003-2010.
The recommendations for creating catch at size for this third period are:

- Use the Ghanaian size frequency data, collected from both Ghanaian purse seine and baitboat vessels, applied by year, area (in the case of the PS_Other vessels), quarter and species whenever possible.

- In cases of insufficient sample size, substitute the size frequency data from the prior year, same area (for PS_Other vessels) and quarter.
- If there are still insufficient size frequency data, substitute by pooling samples by species across the entire year of the catches (within area for PS_Other vessels).

It should be noted that the AVDTH database will be used to develop the catch at size data according to the protocols described above. For the long-term, it is recommended that a process is developed whereby this exercise may be conducted by the CPC (Ghana) for reporting to the Secretariat, or whereby the Secretariat has capacity to develop the catch at size by this process, if necessary.

5.1.3 Comparison between estimated PS CAS and cannery data

The catch by vessel data by obtained from the cannery was inconsistent with data for the fishery collected through scientific sampling, in that skipjack made up a much larger and bigeye a much smaller percentage of the catch in the cannery data when compared to the scientific sampling. The smaller percentage of bigeye estimated at the cannery could possibly be due to the difficulty of identifying very small bigeye from very small yellowfin. However, it remains unclear how to explain the differences between the percentages of skipjack observed at the cannery and in the scientific samples. Since the reason for these differences is unknown, the Working Group did not recommend using these data to estimate species composition, but a recommendation has been done in order to explain and to solve this major statistical uncertainty as soon as possible.

5.1.4 Comparison between EU and Ghana yearly catch at size by species

The Working Group conducted some preliminary comparisons during the meeting, observing some potentially important differences, and considered that more detailed comparisons should be conducted in the future.

The Working Group noted that the percentages of yellowfin in the Ghanaian scientific samples are always much higher than the percentage of yellowfin in the category of small tunas (<10kg) landed by the EU purse seiners and in the cannery data. As a consequence, the total catches of yellowfin estimated by the Working Group for the Ghanaian fleet is much larger than the catches of yellowfin that could be estimated based on the EU samples: 23 400 t vs. 14,100 t (see **Appendix 5**). It should be noted that as these yellowfin are taken at small sizes, they correspond to large numbers of yellowfin caught (8.7 vs. 3.2 million yellowfin). This uncertainty in the quantities of small yellowfin caught by the Ghanaian fleet should be incorporated in the upcoming ICCAT yellowfin tuna stock assessment.

5.2 Sampling in Abidjan

5.2.1 Description of sampling scheme, coverage

The Ghanaian flagged purse seine vessels landing in Abidjan have been sampled using the same multi-species sampling scheme that is applied to the European fleet. Since 2009 in Ghana, this has been conducted under an ICCAT/JDIMP program of collaborative sampling in Ghana and Côte d'Ivoire. But there are few samples obtained in Abidjan, representing the landings of only one or two purse seine vessels per year. **Table 12** shows the number of fished measured and the number of purse seiners by year.

Landings by other Ghanaian vessels are also sampled in Abidjan through the ICCAT/JDIMP program. Integration of the sample data into the ICCAT database can be problematic as the two parties (Ghana and Côte d'Ivoire) need to determine whether landings have already been sampled in the other country to avoid double counting. Task I landings obtained from manifests are most often provided to Ghana. Problems could occur if the vessel lands in Abidjan and offloads some catch prior to arriving in Ghana; in that case, Ghanaian samplers will then be unable to sample that portion of the catch. The protocol established between Ghana and Côte d'Ivoire should be strengthened and duplicate counting should be avoided, although additional sampling should be encouraged.

5.2.2 Data processing. Data reported to ICCAT

Data which are transmitted to MFRD from Abidjan are incorporated into the database using AVDTH 2005 software. In some cases, especially with that portion of the purse seine fleet that may transfer catches to carriers rather than offloading in port, it is necessary to incorporate data obtained from carrier landings.

5.3 Problems related with sampling and possible improvements

The Ghanaian sampling effort faces a number of challenges. A major difficulty is the lack of personnel, as only four staff members are responsible for sampling from more than 30 vessels. Additional trained personnel are needed. It may also be necessary to assign two samplers to sample from each purse seine trip, due to additional complexities of sampling these vessels.

According to the amount of catch (more than 60,000 t) landed in Tema by Ghanaian tuna fleets and the large number of tunas fishing vessels (around 30 boats), the Ghanaian authorities should pay more attention to the tuna issues in term of research and statistics, boosting the resources (human, financial and logistical) in Tema.

The human resources in the MFRD dedicated to the tunas sampling program are well trained but not sufficient to have good sampling coverage of all the vessels landings in Tema. Only one team is available, even though several boats can unload at the same time. An MFRD office at the port and special authorization for the staff to access all the fishing vessels, independently of their flags, and in all the Ghanaian landing sites, is needed. This logistics support in the harbour should include also an internet line and a few computers and printers.

A more thorough description of problems and recommended improvements for the Ghanaian sampling and data processing programs is contained in **Appendix 4**.

5.3.1 Potential bias: Apparent lack of large fish in the samples

There is an apparent bias in that there is a lack of large fish in the samples when compared to other sampling conducted in this fishery. It appears that samplers may have reduced opportunity to sample these large fish, as they are a priority for the canneries and are usually quickly offloaded. Also, there may be some tendency for samplers to avoid sampling the larger fish; it is recommended that care be taken to sample adequately across the entire size range of the catches.

A data entry problem was identified that occurred during 1997-2008. The Ghanaian samplers from MFRD record LD1 measurements from larger yellowfin and bigeye and record fork length for fish less than 85 cm. These different types of measurement are recorded on different forms, one containing FL measurements and another for LD1 measurements. It appears that the forms with the LD1 size frequencies were not processed or were lost and/or only the small fish was sampled, resulting in the biased size samples. It is recommended that this bias be considered during the assessment process.

It is also possible for Ghanaian catches to differ in species composition and/or size frequency distribution from other fleets in the fishery for a number of reasons, including: (1) the fishing area of Ghanaian vessels, on a finer scale, may differ to some extent from that of other fleets, and fish distribution and environmental conditions could differ between those finer scale fishing areas; (2) fishing strategies or equipment used (e.g. radar, sonar, etc.) may differ; and (3) the fishing mode often associated by live bait and baitboats may modify the species and size composition.

In general, however, the Group considered that for instances where there were insufficient Ghanaian sampling levels or evident biased sampling in the early period, then data from other years and/or other fleets using the same gears in the same general time-area could be used to describe the Ghanaian catches.

5.3.2 Other problems related with the sampling scheme stratification. Evaluation of potential stratification and substitution schemes for species and size composition estimation

During the most recent period, the Ghanaian fishery has become more and more complex. Detailed information on the main changes that occurred in the so-called third period of the fishery has been included in previous sections of this report. From the point of view of data processing, some of these changes should be included, particularly those affecting the size distribution and the species composition of catches, the main objectives of the multispecies sampling. Based on the sampling schemes applied to similar fleets, the most important source of variation should correspond to the gear, fishing mode (FAD vs. free school), time-area strata and size category in the case of the species composition.

In order to evaluate the amount of variance explained by the variables considered, TTG carried out different analyses of samples from the Ghanaian and European fleets over the period.

− General Linear Modeling

Following the methods of Pallarés and Petit (1998), an exploratory analysis of the available Ghanaian baitboat and purse seine and European purse seine sample data collected in Tema, Abidjan, and Dakar between 2001 and 2010 was undertaken by TTG to examine these data for indications of patterning to guide estimation of species and size composition of the Ghanaian catches through the AVDTH framework, commonly employed for the European tropical tuna fleet and recently adopted for processing Ghanaian purse seine and baitboat sample and logbook data (Bannerman and Sarralde, 2007). Overall for the analysis, there were 7,642 trip-level samples, summarized over sampling port, year, calendar quarter, and large areas (Balbaya zones, see **Figure 16** which are based on areas of the European multispecies sampling scheme: coastal Ghana and Côte d'Ivoire, Cape Lopez, and offshore). The data were further characterized by Metier (European purse seine, PS_Other, and Ghana baitboat or Ghana purse seine) and fishing method (free school, FAD, and unknown). Two metrics were used in analysis. First, the Shannon-Weaver index, taken as a measure of species composition of the sample, was calculated as:

$$H' = -\sum_{i=1}^{S} (pi\ (ln(pi\ ))\ -\ (S-1)/2N$$

where *pi* is the relative biomass abundance of species i, calculated in this case, as the proportion of individuals of a given species (in weight) to the total weight of individuals sampled per trip (*N*), and *S*, the number of species in the community. The number of species in the community were identified as five and included skipjack, yellowfin-YFT, bigeye-BET, frigate tuna-FRI, and Atlantic black skipjack-LTA. Not all trip samples reflected catch of all the species defined in the community and in these cases, the *pi* values were set to a low value (0.0001) to accommodate the required natural log transform for computing the index.

The second metric used in the analysis was the average weight of fish in the sample, across all of the species sampled per trip. This metric was taken as an indicator of the overall size composition of the sample. It should be noted that in the Ghanaian data case, fish considered *'faux poisson*' are included in the calculations while they are not in the European fleet data.

Two sets of analyses were conducted, one for all fish in the samples, and another using only fish <10 kg in the samples.

General linear models were fit to the data, controlling for year, quarter, area, Metier, gear, and fishing method. Least square mean estimates (balanced design marginal means) and associated approximate 80% confidence bounds on the predicted means were used to examine the results for consistent patterns that might be useful for stratified estimates of overall species composition in the catch and size composition of the catch.

− Results

Overall, the general linear models fit to the data did not explain a high proportion of variability in the overall data sets. **Figure 17** provides an example of typical results from these analyses, which generally accounted for 20% or less of the variability in the data. Finer scale time-area and vessel level information might be useful in explaining more of the variability.

Balanced design marginal means (Least Square Means) and associated 80% confidence bounds for the model factor levels are provided in **Figures 18** and **19**. **Appendix 5** provides a wider range of model diagnostics for judging adequacy of the models. In these results, the lower the degree of overlap between factor level average predictions, the stronger the basis for considering stratification for that factor level effect. In both sets of analysis, the strongest differencing appears due to the style of fishing effect (free school, FAD, and unknown). The Ghanaian fishing method is generally unknown at the trip (and set level) resolution and some part of the Ghanaian baitboat landings represent purse seine catch. The results indicate that the Ghanaian fishing style is higher in species diversity when only fish <10 kg in the sample are considered (**Figure 18**), but similar in diversity to European FAD fishing when all fish in the sample are considered (**Figure 19**). In terms of size composition, the Ghanaian fishery samples indicate that for fish <10kg, the model predicted average size is larger than either European FAD or free school fishing, but is similar to European FAD fishing predicted average size when fish of all size ranges are considered.

The time and large area used in the data also have different implications depending on the objective for estimation. For the <10 kg fish data (see **Figure 18**), the first quarter is predicted to have a higher diversity than

other quarters, but lower expected average size than in quarters 2 or 3. For the areas modeled, the <10 kg fish data model predicts a marginally higher diversity in the Cape Lopez area (CapL) than other areas and predicts highest average weight in the Cape Lopez area, with the lowest predicted average Offshore (Oth); Coastal Ghana and Côte d'Ivoire (CIGH) predicted average weight is intermediate. For the all fish data (see **Figure 19**), there is no obvious quarterly effect on predicted average diversity, but expected average sizes are highest in Q3 followed by Q2, with Q1 and Q4 nearly equal but smaller than Q2. For area effects, the all fish data model predicts no detectable difference in diversity expected averages, but average size to be larger in the coastal areas (Cape Lopez and Coastal Ghana and Côte d'Ivoire) than offshore.

While the analysis conducted on these data indicates some stratification in the data could be useful for estimation, a general stratification (or substitution) scheme to satisfy both species composition and size structure of catches is not apparent in the data at the level of resolution used and the overall predictive power of the models applied is quite low. Greater resolution might provide a stronger basis for developing such a scheme for the Ghanaian data.

− Cluster analysis for possible strata identification

Two different indicators were obtained for the species and size composition of samples from the tropical tuna fisheries data. One indicator is based on the Shannon-Weaver index (see above), which provides a measure of species diversity. The second indicator is based on the log transform of the average weight of the catch by observation as an indication of size composition of the sample. The objective of this cluster analysis was to use these two indicators as dependent variables to identify major factors affecting the catch and size composition in combination, and to further examine possible stratification and sampling designs for future sampling.

A hierarchical cluster analysis was first investigated using the observed proportions of catch (kg) of frigate tuna, bigeye, yellowfin, skipjack and Atlantic black skipjack (FRI, BET, YFT, SKJ and LTA) in each observation. Using Ward's method, the results indicated 12 clusters. A scatter plot of the Shannon-W index versus the log of the average number of the catch by set (five species) with the observations classified by the clusters estimated is shown in **Figure 20**. The figure also show the 90% confidence bounds for each cluster group, and the histograms distribution of the observations in each axis. The dark areas in the histograms indicated the location of the Ghana observations within the general data distribution.

In general, there are two clusters that can be easily identified (clusters 3 and 6) that represent observations with very low Shannon index values, basically single or two only species observations, and in general, few fish with high average weights. These observations are mostly catches made by European PS vessels on free schools with catches of large yellowfin and few other species. Other clusters overlapped in their central distributions of the index and or average size of fish caught. The results of the cluster are also summarized by the strata of year, quarter and area (**Figure 21**), which indicate relatively little consistency between clusters and time-area factors used in the analysis. The shade of the cells indicated the proportion of observations from each cluster, light yellow shades indicate a low proportion, red cell indicated a median proportion, and dark blue indicated a high proportion. The expected pattern in this figure is for a random distribution with average proportions for those factors that have no influence on the species composition. In general for the Cape Lopez area (CapL), some patterning is observed, but it changes by year and quarter. The Côte d'Ivoire and Ghana (CIGH) area also shows some patterning that is somewhat consistent with the Cape Lopez area, by year, and quarter. In these cases, the clusters may have some predictive power for species or size composition. The offshore area, on the other hand, shows no clear patterns, indicating that the clusters used would not be useful to reliably predict species or size composition in this region.

− Correlations amongst species composition in samples

Multivariate correlation analyses were also performed on the proportion of species composition of tropical tuna species data. These data included the European and Ghanaian observations stratified by year, quarter, area (Balbaya zone), port of landing, type of association operation (free school, FAD; all Ghana observations were set as unknown for the type of association), gear (PS or BB), and vessel. Further the data distinguished the catch in numbers and weight for fish of 10 kg or less. The species included in the analysis were frigate tuna, bigeye, skipjack, Atlantic black skipjack and yellowfin.

A correlation between species proportion estimated from the weight of the catches for all catch, is show in **Table 13**. By catch, skipjack is the predominant species in catch with Atlantic black skipjack the least commonly recorded. There are negative correlations indicated between catch composition for yellowfin and skipjack, and

for bigeye and skipjack. This negative correlation pattern is also found when considering only the catch of fish less 10 kg (**Table 14**).

Additional diagnostics for correlation analysis are found in **Appendix 6**. Again, higher resolution data might provide a basis for more discriminatory power in this form of analysis.

− Comparison of species composition between Ghanaian purse seiners and baitboats at finer scale

The data set of multispecies samples collected in Abidjan and Tema during 2001-2010 was used to investigate the difference in species composition between Ghanaian purse seiners and baitboats. The data set included 761 samples from 27 baitboats and 518 samples from 11 purse seiners, excluding the PS_Other vessels. Three spatial areas were considered in the analysis based on the eastern tropical areas of the European multispecies sampling scheme: coastal, Cape Lopez, and offshore (**Figure 16**). The distribution of sampled catches by gear type is shown in **Figure 22**. A linear model was used to explain the percentages of yellowfin, skipjack, and bigeye tunas as a function of year, quarter, gear (BB and PS), area, latitude (considered as a categorical variable), and an interaction effect between gear and area. A relatively higher proportion of variability in the data was explained by the model (~40%) and results showed significant effects of year, quarter, and area. Significant differences were found in the species composition between gears, more yellowfin and bigeye being found in the purse seine catch while more skipjack were found in the baitboat catch. The interaction effect suggested the importance of spatial/gear stratification. In addition to the area effect, a significant latitudinal effect was found and indicated increasing proportion of yellowfin accompanied by decreasing proportion of bigeye and skipjack in the catch with latitude, whatever the fishing gear. Further evaluation through comparison with the European purse seine observations could be of value in furthering this analysis.

5.3.3 Suggested improvements in historical data and recommendations for future sampling scheme

The Working Group recommended that efforts to recover historical data, such as unreported logbooks or data that were never entered in the database, be continued. These efforts should include in priority the entry of 2007 data into the AVDTH data base. Also, efforts should be made to recover and enter into the database the missing historical LD1 measurements from Ghana sampling. Data in the AVDTH database should be fully validated. Additionally, methods should be developed to incorporate the Ghana observer data, as appropriate.

Regarding data processing, the analyses conducted were not conclusive enough to clearly identify stratification criteria, particularly regarding the definition of the time-area strata. Nevertheless the group considered results of the analyses together with other information from the fishery and established some general rules for estimating the species composition and size distribution of the most recent period and to take into account in the future sampling design of the Ghanaian catches. The rules defined by the Group were as following:

- Gear: Considering BB + PS as only one gear. This decision was made considering that the collaboration between baitboat and purse seine does not allow identifying in the baitboat landings the catch carried out by baitboat and those transferred from purse seine. In addition, the fishing areas for baitboat and purse seine are overlapped and no large differences exist in both species composition and size distribution of the baitboat and purse seine catches.
- Fishing mode: Considering fishing on FADs and free schools together. Low coverage of logbooks and lack of detailed information on the fishing mode in the existing logbooks do not allow stratifying by fishing mode. Nevertheless, the analyses conducted showed a significant effect of the fishing mode in both the size distribution and the species composition of catches. Therefore, it is recommended to improve the logbook information as well as the coverage in order to incorporate the fishing mode in the future sampling scheme and data processing system.
- Fleet: Considering two strata, the PS_Other vessels and the rest of the fleet. The decision for this stratification was based in the specific characteristics and fishing practice (fishing zones...) of these vessels, which are clearly different from the rest of the Ghanaian fleet and also of the rate of log book coverage that was much lower for the PS_Other fleet.
- Size/weight category (only for the species composition): two strata were considered >10 kg and ≤ 10 kg and only correct the species composition for fish less than 10 kg.
- Time strata: quarter.
- Area strata: three areas were considered (**Figure 16**).

For the period for which bias in the size samples taken in Tema were detected (2001-2007), the Group decided to uses those samples to correct the species composition, taking into account that the correction is only made for fish less than 10 kg and to substitute the samples from those taken in Abidjan (2002-2004) and/or from Tema corresponding to the most recent period (2008-2010) to estimate the size composition of the catch.

6. Recommendations

The Working Group recognized the extraordinary work conducted by Ghanaian scientists with very limited resources for sampling and collection of fishery statistics corresponding to the Ghanaian fleet fishing tropical tunas. However, taking into consideration the relevance of tropical tuna catches landed in Tema by this fleet and fleets of other nationalities and the very limited material and human resources currently available, the Working Group remains concerned. While some positive steps have been taken Ghana to address staffing and infrastructure issues previously identified by SCRS, current levels are not yet sufficient to fully meet data collection obligations for Task I and II statistics for the overall fleet.

The Working Group found that for several fleet segments, very little sample data were available and only partial or no total annual catch was available through official data collection mechanisms. The behavior of certain segments of the fleet, which includes transfer of catch at sea to carrier vessels for landing at various ports, prevents adequate sampling of catch (by gear) and makes access to logbooks at port, difficult , if not impossible, to achieve for some fleet segments. While the Working Group made attempts to estimate catch and size characteristics for those fleet segments, these estimates remain highly uncertain. The Working Group is concerned that a fraction of the Ghanaian fleet behaves in ways that could be considered in contravention of the objectives of the ICCAT Convention. In particular, because obligatory data collection and reporting is generally not possible under the current practices, proper monitoring of the full fleet activity is not carried out.

The Working Group reemphasized the SCRS view of convenience for the Ghanaian sampling program to follow, as closely as possible, the sampling scheme protocol used in the EU fishery in order to facilitate the joint analysis of standardized data. In that sense, as different teams are responsible for the Ghanaian and European purse seine sampling in Côte d'Ivoire, it would be convenient to continue enhancing collaboration and coordination between both groups.

6.1 Improvements in data collection infrastructure and procedures to fully address data reporting obligations

- The Working Group recommends development of a permanent structure, adequately equipped, with the necessary human resources, in charge of collecting detailed information on the tropical tuna fisheries (Task I, Task II (C/E) and sampling of catches (Task II size, biological parameters).
- The Working Group recommends the Ghanaian authorities make the necessary efforts to conduct a proper monitoring of the activities of their fleet in order to guarantee the necessary coverage for the collection of statistical data required. Such monitoring should include at-sea observations, including sampling catches, as well as collection of complete and accurate fishing logbooks from the vessels.
- Furthermore, the Working Group recommends that data collection protocols be instituted in Ghana which in make it possible to sample catches landed, regardless of flag, as is the process used in Abidjan.

6.2 Mechanisms for meeting data obligations

- The Working Group recommended that mechanisms to improve capacity for meeting data collection and reporting obligations, including industry financial contributions or inter-governmental arrangements, be instituted to enhance financial support for staffing and infrastructure improvements needed to meet the above recommendations.

6.3 Technical recommendations

- The Working Group noted a difference in the percentage of skipjack sampled on Ghanaian landings by scientists and at the cannery. This divergency in species composition remains unexplained. The Working Group recommended that an intensive multispecies sampling scheme should be done in Tema, validating in parallel the tunas sampling and data entries done by scientists and at the cannery. This comparative sampling should be done under the responsibility of a scientist fully experienced in multispecies tuna sampling.

- The Working Group noted a relative lack of larger yellowfin tuna in the sample records from Ghana for a series of years. While the Working Group found that very large yellowfin are infrequently encountered in the Ghanaian fleet, compared to the European purse seine fleet, it was discovered during a site visit to Ghana and in subsequent discussion, that while larger fish are sampled, they are measured in a different way and recorded on separate sheets, which may not have been computerized. The Working Group recommended that all measures of fish should be on the same sheet, to avoid loss of these measures.
- The Working Group noted that there are some observer data now available and becoming available for the tropical tuna fleets for characterizing size composition and potentially species composition of the catches as well. Currently these data are not used in the processes for estimating species and size composition of the catches for the European fleet because of concerns about their potential bias. The TGG recommends that observer data be fully analyzed and compared to port sampling information to judge the adequacy of current observer sampling protocols for these purposes.
- The Working Group noted that the metrics used for comparing Ghanaian and European fleet performance make use of somewhat different components of the catch. For Ghanaian vessels landing in Tema, *"market fish"* which do not go to canneries are recorded and officially reported in Task I data. For European vessels and Ghanaian vessels landing outside of Tema, the landed fish which do not go to canneries are characterized as *"faux poisson"* but are not recorded or officially reported as part of Task I. While there is now ongoing sampling to estimate *"faux poisson"*, it is not yet considered part of official Task I. The TGG recommends that official Task I statistics should include all sources of fishery induced mortality and that CPCs endeavour to achieve this recommendation.
- The Working Group also noted that the procedures used during the meeting for re-estimating Ghanaian species and size composition made use of both newly available observations and assumptions for time-area combinations where no direct observations were available. While the Working Group considered the assumptions used to be plausible and resulting in a substantial improvement in the available Task II data base, there are other assumptions that are also plausible and the Group did not have sufficient time to evaluate sensitivity of the outcomes to a range of plausible assumptions. The Working Group recommends that such evaluations be carried out in the future before accepting any one set of assumptions as the best available.
- The Working Group recommended working toward development of an improved and harmonized sampling and data processing process for the Ghanaian fleet. In this sampling scheme, it is necessary to separate free school from FAD sets in the data collection and processing. The data validation software (AKADO) needs to be English-language and the processing system made more user friendly and should be introduced into the ICCAT software catalogue as one means of validation. Furthermore, the Working Group recommended that data recovery efforts continue.
- The Working Group recommends that discrepancies identified between the ICCAT authorized vessel list and the results of in-field investigation of active vessels in the Ghanaian fleet be further evaluated.

7. Other matters

No other matters were discussed.

8. Adoption of the report and closure

The Chairman again thanked the participants of the meeting for the hard work conducted and the Secretariat for the assistance provided. The report was adopted and the meeting adjourned.

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Table 1. Catalog of Task II catch and effort series. Green shading indicates the series recovered.

Dataset	FleetCode	FileType	GearCode	TimeStrata	GeoStrata	EffortTypes	CatchUnit	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
a)	GHA	OFF	BB	mm	1x1	D.FISH	kg			1	1	1	1	1	1	1	1																													
					5x5	D.FISH	kg															1						1	1		1		1				1	1								
						HOURS.SEA	kg																																			1					
						SUC.D.FI	kg																1		1	1			1		1		1	1	1			1	1			1			
			PS	mm	1x1	D.FISH	kg			1				1	1	1																													
					5x5	D.FISH	kg																							1		1				1	1								
						HOURS.SEA	kg																																			1					
						SUC.D.FI	kg																									1		1	1	1			1	1			1			
b)	GHA	CONF	BB	mm	1x1	NO.SETS	kg																				1	1	1	1	1	1		1	1	1	1	1			1	1		
			PS	mm	1x1	NO.SETS	kg																								1	1	1	1		1		1	1	1	1			
c)	GHA.ICCAT	REFF	BB	mm	1x1	D.AT SEA	kg	1	1	1	1	1																																
						D.FISH	kg											1	1	1	1	1																								
			PS	mm	1x1	D.FISH	kg											1	1	1	1																								
						Faux poissons																																								

Table 2. Catalog of Task II size data series. Green shading indicates the series recovered.

DS	Fleet	Species	Gear	TimeStrata	GeoStrata	szFreq	Interval	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
a)	GHA	BET	BB	mm	1x1	FL	1 cm								x	x	x																												x
							2 cm				x	x	x	x																															
					5x5	FL	1 cm																					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm										x	x	x					x	x	x	x																	
			PS	mm	1x1	FL	1 cm									x																													x
					5x5	FL	1 cm																								x	x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm											x																											
		SKJ	BB	mm	1x1	FL	1 cm								x	x	x																												x
							2 cm			x	x	x	x	x																														
					5x5	FL	1 cm																							x	x	x	x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm										x	x	x					x	x	x	x																	
			PS	mm	1x1	FL	1 cm									x																													x
					5x5	FL	1 cm																								x	x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm										x	x	x																									
		YFT	BB	mm	1x1	FL	1 cm								x	x	x																												x
							2 cm			x	x	x	x	x																														
					5x5	FL	1 cm																							x	x	x	x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm									x	x	x	x						x	x	x	x																	
			PS	mm	1x1	FL	1 cm									x																													x
					5x5	FL	1 cm																										x	x	x	x	x	x	x	x	x	x	x		
					ICCAT	FL	1 cm										x	x	x																									
b)	GHA (Port sampling)	BET	BB	mm	1x1	FL	1 cm													x	x	x	x	x	x																			
					5x5	FL	1 cm																		x	x																			
						FL	2 cm		x																																				
					ICCAT	FL	1 cm																		x																			
			PS	mm	1x1	FL	1 cm																																					
					5x5	FL	1 cm																																					
		SKJ	BB	mm	1x1	FL	1 cm													x	x	x	x	x	x																			
					5x5	FL	1 cm	x																	x	x																			
						FL	2 cm		x																																				
					ICCAT	FL	1 cm																		x																			
			PS	mm	1x1	FL	1 cm																																					
					5x5	FL	1 cm	x																																					
						FL	2 cm		x																																				
		YFT	BB	mm	1x1	FL	1 cm													x	x	x	x	x	x																			
					5x5	FL	1 cm																		x	x																			
						FL	2 cm	x	x																																				
					none	FL	1 cm																		x																			
			PS	mm	1x1	FL	2 cm	x	x																																			
c)	Observer data	BET	BB	mm	1x1	FL	1 cm																																			x	x	x	x
			PS		1x1	FL	1 cm																																			x	x	x	x
		SKJ	BB		1x1	FL	1 cm																																			x	x	x	x
			PS		1x1	FL	1 cm																																			x	x	x	x
		YFT	BB		1x1	FL	1 cm																																			x	x	x	x
			PS		1x1	FL	1 cm																																			x	x	x	x
d)	GHA (Port sampling)	BET	BB		1x1 (lbooks	FL&LD1	1 cm																																						x
			PS		1x1 (lbooks	FL&LD1	1 cm																																						x
		SKJ	BB		1x1 (lbooks	FL	1 cm																																						x
			PS		1x1 (lbooks	FL	1 cm																																						x
		YFT	BB		1x1 (lbooks	FL&LD1	1 cm																																						x
			PS		1x1 (lbooks	FL&LD1	1 cm																																						x

Table 3. Estimated potential catch by Ghanaian vessels according to number of trips an using an average of GRT/vessel 300 t for baitboat, 700 t for purse seine and 1700 t for PS_Other purse seine.

Code	*Active vessel name*	*Gear*	*2010*	*2009*	*2008*	*2010*	*2009*	*2008*
762	ACE 1	BB	8	8	1	2400	2400	300
643	ADJOA AMISABA/ILE DE KERBIHAN	PS	10	10	11	7000	7000	7700
365	AFKO 305	BB	1	4	4	300	1200	1200
366	AFKO 306	BB	5	4	5	1500	1200	1500
368	AFKO 308	BB	2	4	4	600	1200	1200
432	AFKO 312	BB	3	8	4	900	2400	1200
418	AFKO 313	BB	1	0	5	300	0	1500
639	AFKO 805	PS	3	8	9	2100	5600	6300
539	AFKO FOODS 801	BB	1	2	4	300	600	1200
540	AFKO FOODS 802	BB	0	0	6	0	0	1800
564	AFKO FOODS 803	BB	2	7	8	600	2100	2400
694	AGNES 1	PS	7	6	6	4900	4200	4200
714	BERMEOTARAK CUATRO	PS	0	0	7	0	0	11900
766	CAP DES PALMES	PS	8	9	1	5600	6300	700
765	CAP LOPEZ	PS	10	12	3	7000	8400	2100
769	CAP STAINT PAUL	PS	7	2	0	4900	1400	0
764	CHALLENGER I	BB	8	4	1	2400	1200	300
644	DELALI	PS	5	9	9	3500	6300	6300
642	DRAGO	PS	7	5	9	4900	3500	6300
373	GBESE 8	BB	0	1	7	0	300	2100
636	GBESSE 11	BB	0	0	6	0	0	1800
383	MAKOKOS	BB	1	0	0	300	0	0
558	JITO 5	BB	0	3	4	0	900	1200
562	JOE B	BB	0	0	4	0	0	1200
431	EDEM	BB	8	9	6	2400	2700	1800
558	ELI	BB	5	0	0	1500	0	0
531	MARINE 703	BB	8	7	8	2400	2100	2400
577	MARINE 707	BB	8	9	7	2400	2700	2100
773	OWUOPE SIKA	PS	1	0	0	700	0	0
718	PANOFI FRONTIER	PS	1	4	8	1700	6800	13600
719	PANOFI MASTER	PS	0	5	8	0	8500	13600
720	PANOFI VOLUNTEER	PS	1	7	8	1700	11900	13600
638	RICO SIETE	BB	8	4	0	2400	1200	0
761	RICO UNO	BB	3	8	8	900	2400	2400
375	SEAPLUS 87	BB	6	5	7	1800	1500	2100
374	SEAPLUS 89	BB	6	9	7	1800	2700	2100
749	TRUST 77	BB	5	8	8	1500	2400	2400
767	TRUST 79	BB	5	7	0	1500	2100	0
763	VICTORY	BB	5	3	2	1500	900	600
768	YOUNGBOK	PS	9	8	0	6300	5600	0
	TOTAL		**168**	**199**	**195**	**80000**	**109700**	**121100**

Table 4. Number of active vessels by year and company.

Company/Year	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*
AGNES											1	1	1
AFKO	7	7	7	9	9	9	9	9	9	9	8	9	9
CENTRAL	3	3											
D&H												1	1
GAAS												1	
GHAKO		1		1	1	1	1	1	1	1	1	1	
GHANA TUNA DEV.	8	5	5	5	5	5	4						
GOSHEN	2	2	2	1									
GREENWICH								2	1	1	1	1	1
INFITCO	4	4	4	3	4	4	3	4	4	3	3	3	
INTERSEA				1	2	2	2	2	2	2	2	2	2
MANKOADZE	1												
NOVA	1												
OCEAN FLOWER						1	2	2	3	2	2		
PANOFI													3
PIONNEER	3	4	4	4	5	5	4						
PROVIDER										1	1	1	1
SUN-HAN							1	1	1	1	1	1	1
TTV								8	8	8	8	8	8
UNI				2	2								
WINGS VENTURE							1	1	1				
WORLD MARINE	1	2	2	2	3	4	4	3	3	3	3	2	2
TOTAL	**30**	**28**	**24**	**28**	**31**	**31**	**31**	**33**	**33**	**31**	**31**	**31**	**29**

Table 5. Ghanaian baitboat and purse seine landings in Abidjan for the period 1984 to 2009.

Year	*BB*	*PS*	*PS UE Ghana*	*Ghanaian "faux thons" ABJ*	*Total*
1 984	7 765	6 287			14 052
1 985	13 658	5 937			19 595
1 986	11 273	4 737			16 010
1 987	14 669	1 051			15 720
1 988	14 546				14 546
1 989	14 237				14 237
1 990					0
1 991					0
1 992					0
1 993					0
1 994					0
1 995					0
1 996					0
1 997				1 325	1 325
1 998			2 893	203	3 096
1 999			3 988	588	4 576
2 000			2 268	1 829	4 097
2 001	818	1 299	3 167	156	5 441
2 002	1 034	1 989	3 940	0	6 963
2 003	1 959	6 667	2 709	2 536	13 871
2 004	3 811	4 017	3 160	2 785	13 773
2 005			0	5 272	5 272
2 006			510	3 723	4 233
2 007			3 085	3 904	6 989
2 008			3 849	5 382	9 230
2 009			2 608	7 147	9 755
2 010				7 328	7 328

Table 6. Task I catch (t and relative ratios) of BET, SKJ and YFT, by year and gear of the major tropical fleets (EU-ESP, EU-FRA, GHA).

		PS									BB		
		EU.ESP-ES-ETRO			EU.FRA-FR-ETRO			GHA			GHA		
Qty	Year	BET	SKJ	YFT	BET	SKJ	YFT	BET	SKJ	YFT	BET	SKJ	YFT
t	1990	6060	43189	66201	2284	13644	41901				5031	23663	11808
	1991	8770	75593	50822	3318	31781	30217				4090	24464	9074
	1992	8791	47244	48093	4996	20383	30861				2866	18379	9223
	1993	11731	60840	38895	10701	31582	33477				3577	19637	13283
	1994	12095	45268	38824	10076	30233	32935				4738	21258	9984
	1995	9600	45834	37148	6363	22491	27803				5517	18607	9268
	1996	8912	33494	31779	6814	21409	32161	1623	3312	3641	4182	16290	8079
	1997	5985	31438	23517	4234	13322	29079	2863	6043	5754	6966	20293	9683
	1998	4535	27414	27788	3682	14203	30420	3483	13027	5452	9887	21156	12205
	1999	5021	38912	18599	3503	18001	30178	9141	16149	10931	8622	24068	14337
	2000	6427	33445	24050	4013	16686	29373	3483	9990	6966	2427	18984	10696
	2001	5923	27798	30433	3355	14043	31527	6497	8433	16903	5544	34056	16643
	2002	7038	21595	30343	3463	14298	31291	6000	15468	13962	1106	15031	9713
	2003	6372	37658	23330	3182	18021	31672	7707	11101	10200	5850	13496	8257
	2004	3943	31514	20086	2339	20127	23364	5087	6639	4396	9814	19087	10658
	2005	3012	18005	10979	1913	12604	22075	8551	23211	8551	5365	21460	8942
	2006	3328	14537	10453	2402	5424	18352	4853	12897	4731	4288	17339	7200
	2007	3310	17292	12766	261	3373	10901	8342	22907	8851	4925	11665	6612
	2008	5266	26760	23287	989	3661	15929	2902	11876	4431	6367	25511	9819
	2009	7769	28047	31861	1936	6427	16882	6089	17909	10029	4465	18155	8326
%	1990	5	37	57	4	24	72				12	58	29
	1991	6	56	38	5	49	46				11	65	24
	1992	8	45	46	9	36	55				9	60	30
	1993	11	55	35	14	42	44				10	54	36
	1994	13	47	40	14	41	45				13	59	28
	1995	10	50	40	11	40	49				17	56	28
	1996	12	45	43	11	35	53	19	39	42	15	57	28
	1997	10	52	39	9	29	62	20	41	39	19	55	26
	1998	8	46	47	8	29	63	16	59	25	23	49	28
	1999	8	62	30	7	35	58	25	45	30	18	51	30
	2000	10	52	38	8	33	59	17	49	34	8	59	33
	2001	9	43	47	7	29	64	20	26	53	10	61	30
	2002	12	37	51	7	29	64	17	44	39	4	58	38
	2003	9	56	35	6	34	60	27	38	35	21	49	30
	2004	7	57	36	5	44	51	32	41	27	25	48	27
	2005	9	56	34	5	34	60	21	58	21	15	60	25
	2006	12	51	37	9	21	70	22	57	21	15	60	25
	2007	10	52	38	2	23	75	21	57	22	21	50	28
	2008	10	48	42	5	18	77	15	62	23	15	61	24
	2009	11	41	47	8	25	67	18	53	29	14	59	27

Table 7. Scientific estimate of the Ghanaian total annual catch by species.

Year	*YFT*	*SKJ*	*BET*	*Total*
1973	177	204	49	430
1974	252	716	79	1 048
1975	722	1 445	106	2 273
1976	863	2 300	151	3 314
1977	610	3 503	237	4 350
1978	332	3 074	129	3 536
1979	1 313	4 446	204	5 963
1980	2 340	5 458	320	8 118
1981	6 789	6 611	747	14 148
1982	11 528	16 522	809	28 860
1983	9 225	22 759	572	32 556
1984	10 899	19 118	1 881	31 898
1985	13 401	18 484	1 635	33 519
1986	13 391	20 724	1 694	35 809
1987	10 669	24 436	1 250	36 355
1988	8 560	26 569	1 237	36 366
1989	7 023	22 704	2 217	31 944
1990	12 032	24 111	5 126	41 270
1991	9 259	24 963	4 174	38 396
1992	9 434	18 799	2 931	31 164
1993	13 497	19 953	3 634	37 085
1994	9 984	21 257	4 738	35 980
1995	9 268	18 606	5 517	33 392
1996	10 505	21 184	5 438	37 127
1997	15 437	26 336	9 828	51 601
1998	17 656	34 182	13 369	65 207
1999	25 268	40 215	17 763	83 246
2000	17 662	28 973	5 909	52 544
2001	33 545	42 488	12 041	88 074
2002	23 673	30 498	7 105	61 276
2003	18 457	24 596	13 557	56 610
2004	15 053	25 726	14 900	55 679
2005	17 492	44 671	13 916	76 079
2006	17 735	29 136	10 286	57 157
2007	24 334	33 617	12 560	70 511
2008	21 818	33 793	12 124	67 734
2009	28 118	33 480	14 318	75 916
2010	31 448	38 087	13 737	83 271

Table 8. Estimates of the number of fishing vessels in the Ghana fishery. Active vessels taken from data from MRFD (summarized from Kebe's Report. Data on active vessels for 2010 was updated at the meeting. Reported vessels for 2008-2010 represent the number of vessels from the positive list of authorized vessels maintained at ICCAT (from SCRS/2011/022).

YEAR	*91*	*92*	*93*	*94*	*95*	*96*	*97*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*
Active	30	28	24	28	31	31	31	33	33	31	31	31	29	35	35	33	30	30	31	*29*
Reported	29	28	25	26	30	33	33	33	33	36	36	36	36					*34*	*34*	*38*

Table 9. Estimates of the number of trips and "potential" catch for three types of vessels in the fishing fleet of Ghana for the period 2008-2010 (summarized from Kebe's Report) with updates of received at the meeting on the activities of the PS_Other fleet in 2010. (See text for definition of "potential catch").

		Number of trips				*Potential catch (t)*		
		2008	*2009*	*2010*		*2008*	*2009*	*2010*
BB		116	114	99		34,800	34,200	29,700
PS		55	69	67		45,500	48,300	46,900
PS_Other		24	16	*49**		40,800	27,200	83,300*
TOTAL		195	199	215*		121,100	109,700	159,900

* At the meeting, Ghana provided additional information on activities of the "PS_Other" fleet not reported in Kebe's Report.

Table 10. List of active and positively authorized vessels from Ghana in 2010. Data sources are Kebe's Report and SCRS/2011/022.

List	*No. of vessels*
ICCAT List and Active	31
ICCAT List and Inactive	6
Not ICCAT List and Active	4

Table 11. Number of fishing trips per month for each type of vessel (BB= Baitboat; PS=Purse seine) during 2010. Data from Kebe's Report including recently reported trips (see note to Table 9 above).

Month	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
BB	12	7	7	10	8	11	7	10	9	10	6	6
PS	9	9	16	9	12	9	11	9	14	5	5	7

Table 12. Number of fish measured and number of Ghanaian flagged purse vessels sampled by year in Abidjan. Note: Multiple trips were sampled for each vessel.

	2001		*2002*		*2003*		*2004*		*2005*		*2006*		*2007*		*2008*		*2009*	
Measured	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*	*FAD*	*FS*
No. PS	5939	0	14969	0	5919	1665	0	1118	1529	1349			11102	733	9591	1011	7071	735
	2		1		2		1		1		1		1		1		1	

Table 13. Correlation between proportion of catch (in wgt kg units) by species in the combined data set. Variable names pWsz_ indicate proportion of total weight in the sample of the species indicated.

	pWsz_FRI	*pWsz_BET*	*pWsz_LTA*	*pWsz_SKJ*	*pWsz_YFT*
pWsz_FRI	1.0000	-0.1661	0.1290	-0.0684	-0.1575
pWsz_BET	-0.1661	1.0000	-0.1274	-0.4116	-0.2215
pWsz_LTA	0.1290	-0.1274	1.0000	-0.1531	0.0585
pWsz_SKJ	-0.0684	-0.4116	-0.1531	1.0000	-0.7306
pWsz_YFT	-0.1575	-0.2215	0.0585	-0.7306	1.0000

Pairwise correlations

Variable	*by Variable*	*Correlation*	*Count*	*Signif Prob*	*Plot Corr*
pWsz_BET	pWsz_FRI	-0.1661	7661	<.0001	
pWsz_LTA	pWsz_FRI	0.1290	7661	<.0001	
pWsz_LTA	pWsz_BET	-0.1274	7661	<.0001	
pWsz_SKJ	pWsz_FRI	-0.0684	7661	<.0001	
pWsz_SKJ	pWsz_BET	-0.4116	7661	<.0001	
pWsz_SKJ	pWsz_LTA	-0.1531	7661	<.0001	
pWsz_YFT	pWsz_FRI	-0.1575	7661	<.0001	
pWsz_YFT	pWsz_BET	-0.2215	7661	<.0001	
pWsz_YFT	pWsz_LTA	0.0585	7661	<.0001	
pWsz_YFT	pWsz_SKJ	-0.7306	7661	0.0000	

Table 14. Correlation between proportion of sample catch (in weight for fish < 10 Kg) by species in the combined data set. Variable names pW10sz_ indicate proportion of total weight for fish in the sample <10kg for the species indicated.

	pWL10sz_FRI	*pWL10sz_BET*	*pWL10sz_LTA*	*pWL10sz_SKJ*	*pWL10sz_YFT*
pWL10sz_FRI	1.0000	-0.1788	0.1334	-0.2085	-0.0697
pWL10sz_BET	-0.1788	1.0000	-0.1290	-0.5547	-0.1386
pWL10sz_LTA	0.1334	-0.1290	1.0000	-0.1992	0.0649
pWL10sz_SKJ	-0.2085	-0.5547	-0.1992	1.0000	-0.6283
pWL10sz_YFT	-0.0697	-0.1386	0.0649	-0.6283	1.0000

Variable	*by Variable*	*Correlation*	*Count*	*Signif Prob*	*Plot Corr*
10sz_BET	pWL10sz_FRI	-0.1788	7661	<.0001	
pWL10sz_LTA	pWL10sz_FRI	0.1334	7661	<.0001	
pWL10sz_LTA	pWL10sz_BET	-0.1290	7661	<.0001	
pWL10sz_SKJ	pWL10sz_FRI	-0.2085	7661	<.0001	
pWL10sz_SKJ	pWL10sz_BET	-0.5547	7661	0.0000	
pWL10sz_SKJ	pWL10sz_LTA	-0.1992	7661	<.0001	
pWL10sz_YFT	pWL10sz_FRI	-0.0697	7661	<.0001	
pWL10sz_YFT	pWL10sz_BET	-0.1386	7661	<.0001	
pWL10sz_YFT	pWL10sz_LTA	0.0649	7661	<.0001	
pWL10sz_YFT	pWL10sz_SKJ	-0.6283	7661	0.0000	

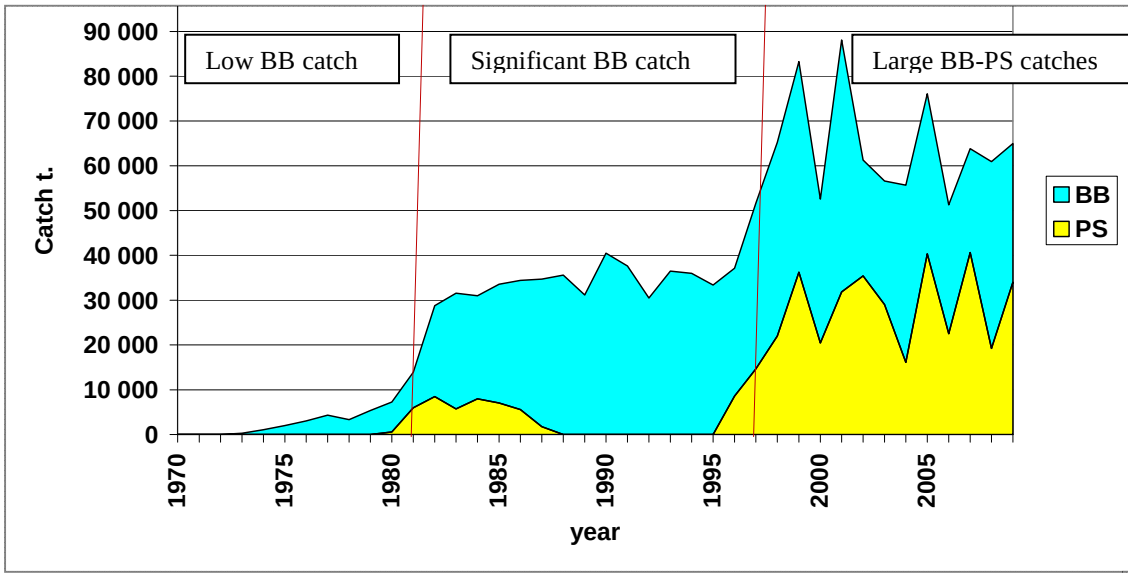
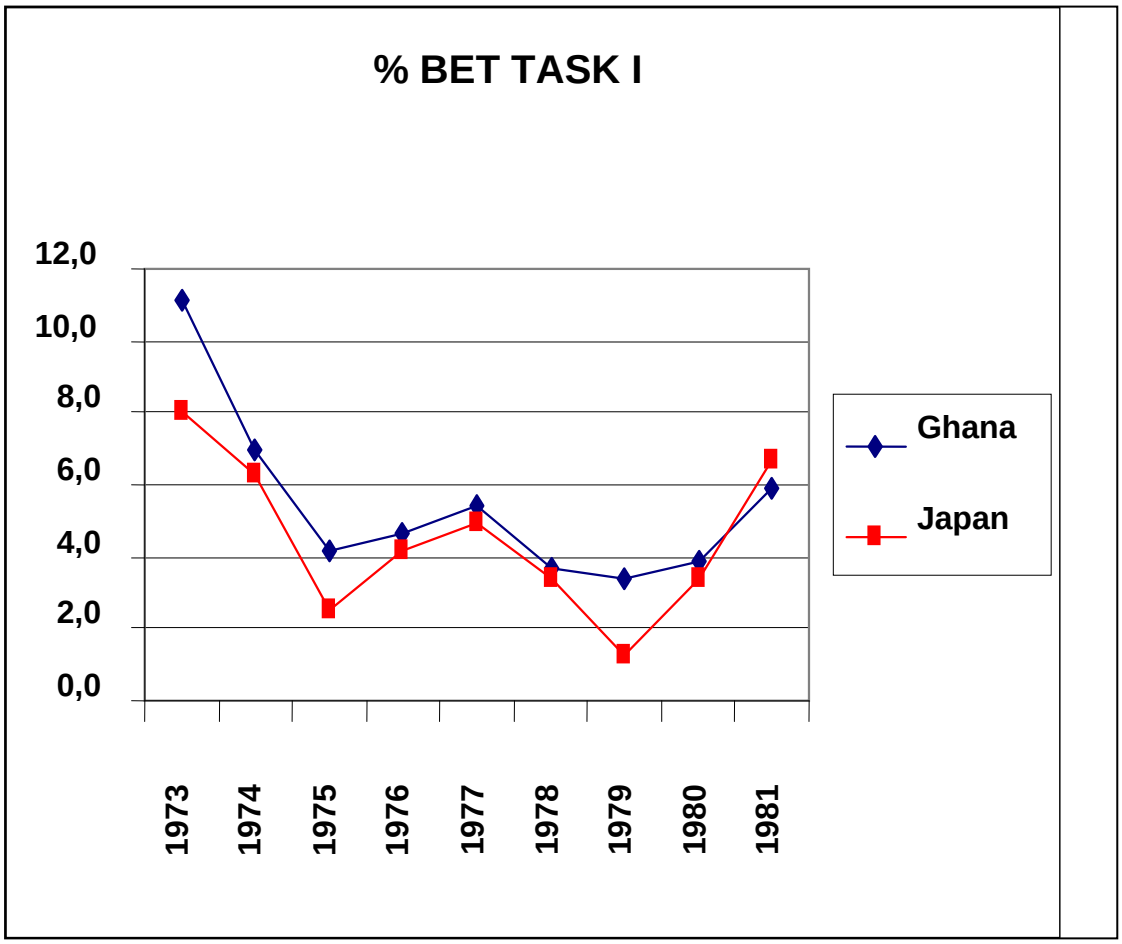


Figure 1. Ghanaian overall tropical tuna catches by gear.

a)



b)

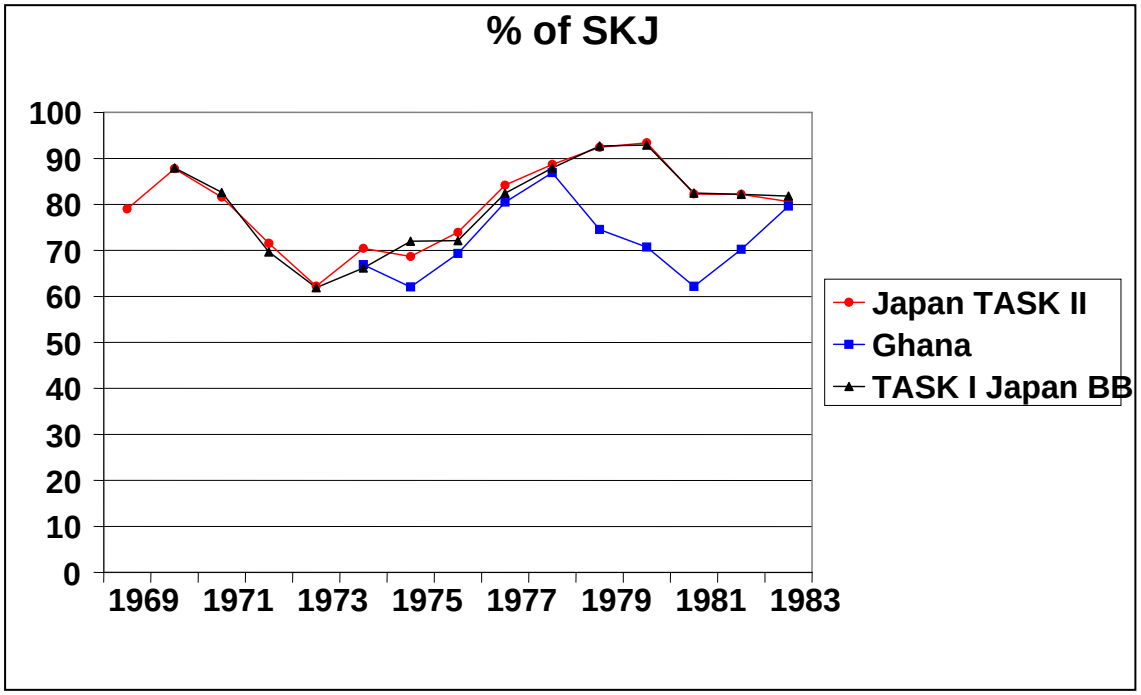


Figure 2. Comparison between the percentages of bigeye (a) and skipjack (b) in the Ghana and Japan baitboat Task I for the first period of the fishery (1969-1983).

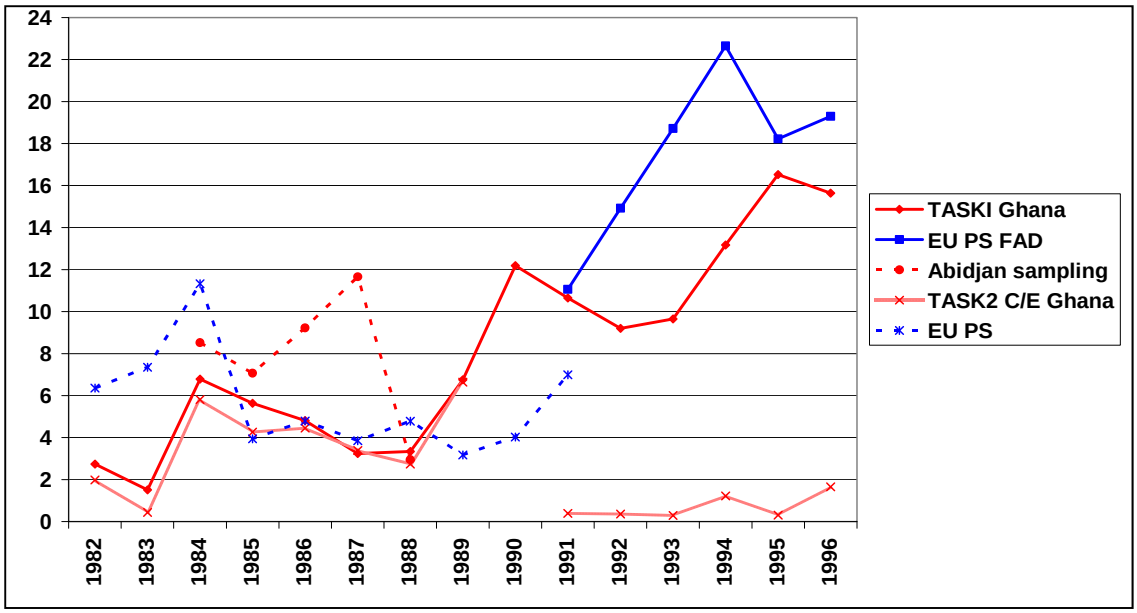


Figure 3. Comparison between the percentages of bigeye obtained from different sources for the second period of the fishery (1982-1996). (NB: Ghanaian Task I species composition was primarily based on the species composition of the multispecies Ghanaian samples)

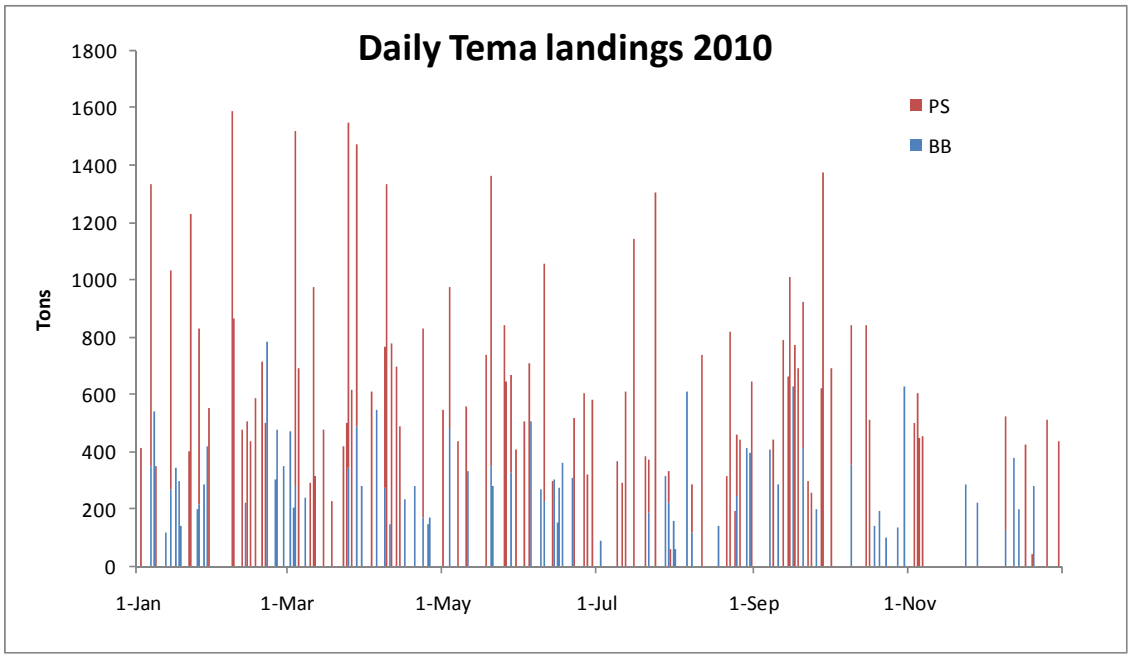


Figure 4. Daily landings during 2010 by fleet type (Purse seine PS and baitboat BB) in Tema, Ghana from data provided by MRFD (Kebe's report).

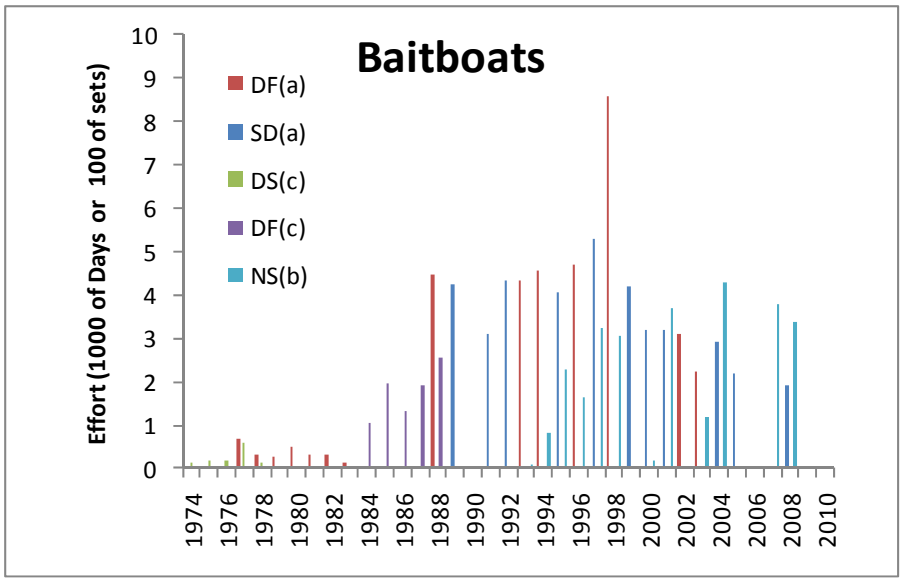


Figure 5. Baitboat fishing effort by the Ghana fleet available in ICCAT databases expressed in different units of fishing effort: (a) in thousands of days or hundred of sets (NS); (b) days fished (DF); (c) successful days fished (SD); or (d) days at sea (DS). Datasets (a,b,c) are those identified in SCRS/2011/022.

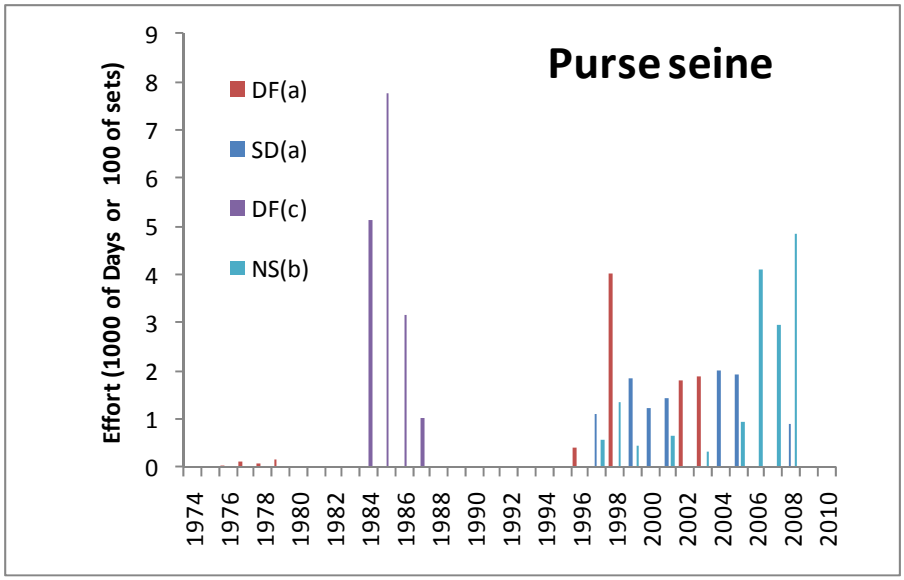


Figure 6. Purse seine fishing effort by the Ghana fleet available in ICCAT databases expressed in thousands of days or hundred of sets (NS). The specific type of day reported changes through the time series, days fished (DF), successful days fished (SD). Datasets (a,b,c) are those identified in SCRS/2011/022.

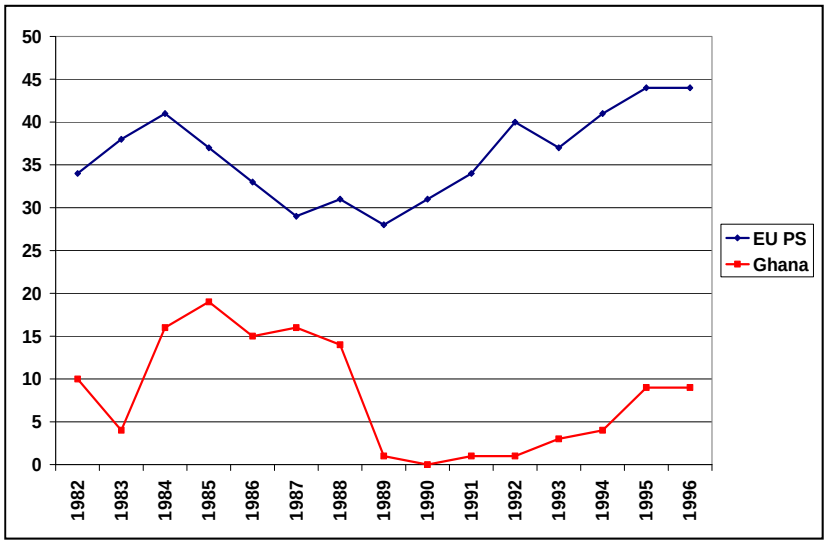


Figure 7. Number of 5 degree squares fished by the EU and Ghana fleets from 1982 to 1996, estimated from the ICCAT Task II database available before the Working Group.

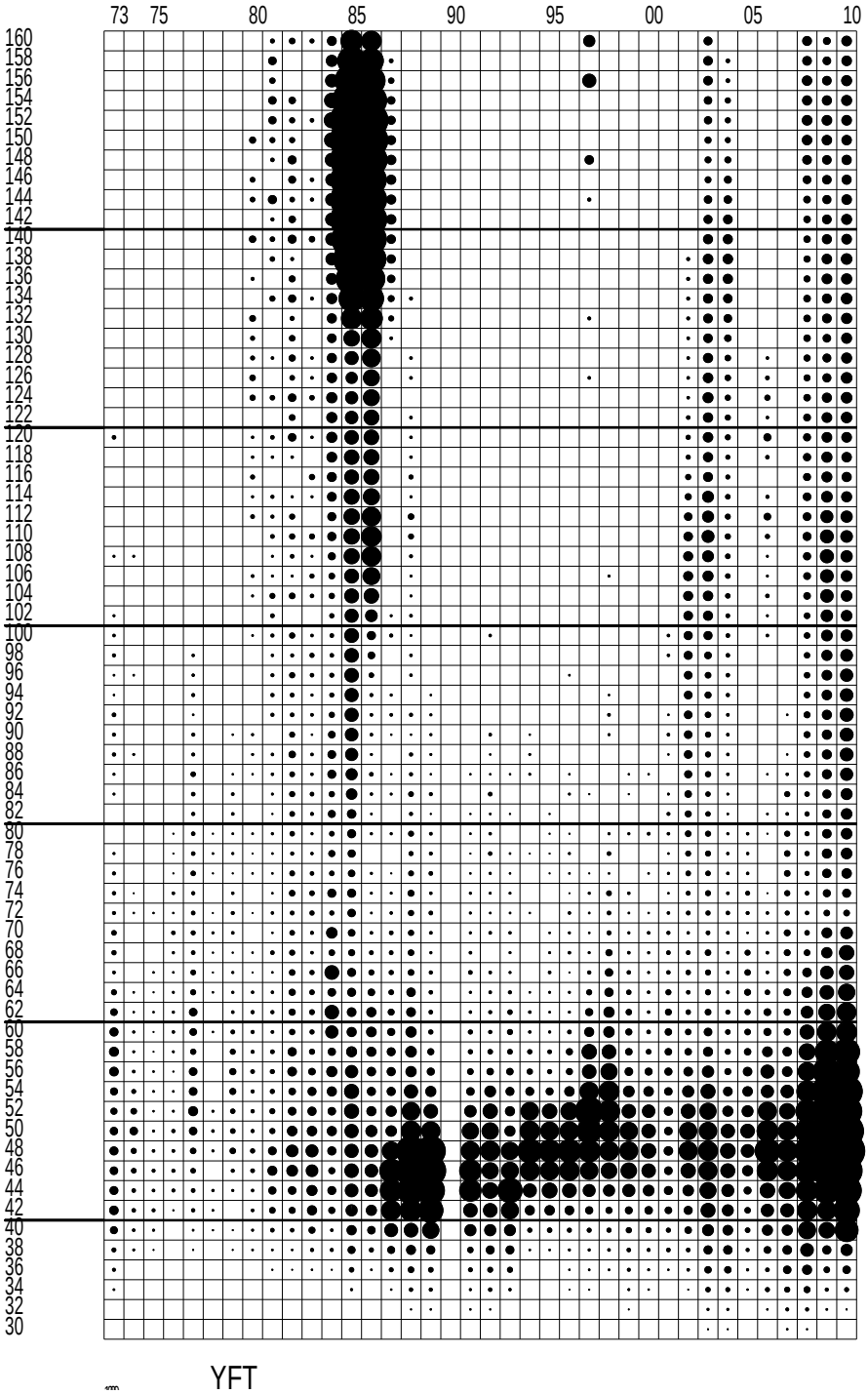


Figure 8. Yellowfin (YFT) size distribution in weight of Ghanaian samples during the period 1973-2010. This figure combines all the yellowfin size data collected in Tema and Abidjan on the Ghanaian landings.

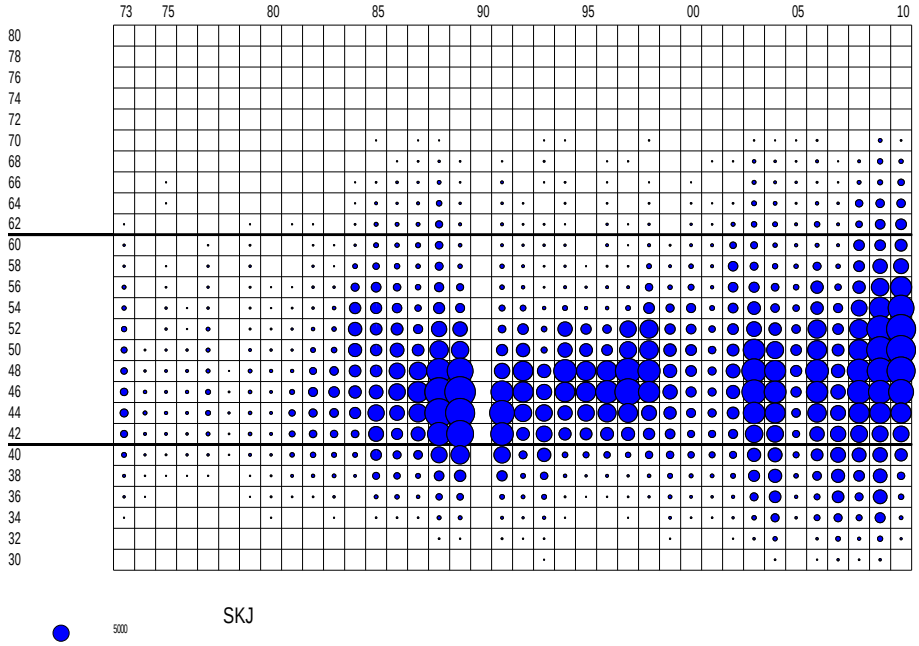


Figure 9. Skipjack (SKJ) size distribution in weight of Ghanaian samples during the period 1973-2010. This figure combines all the skipjack size data collected in Tema and Abidjan on the Ghanaian landings.

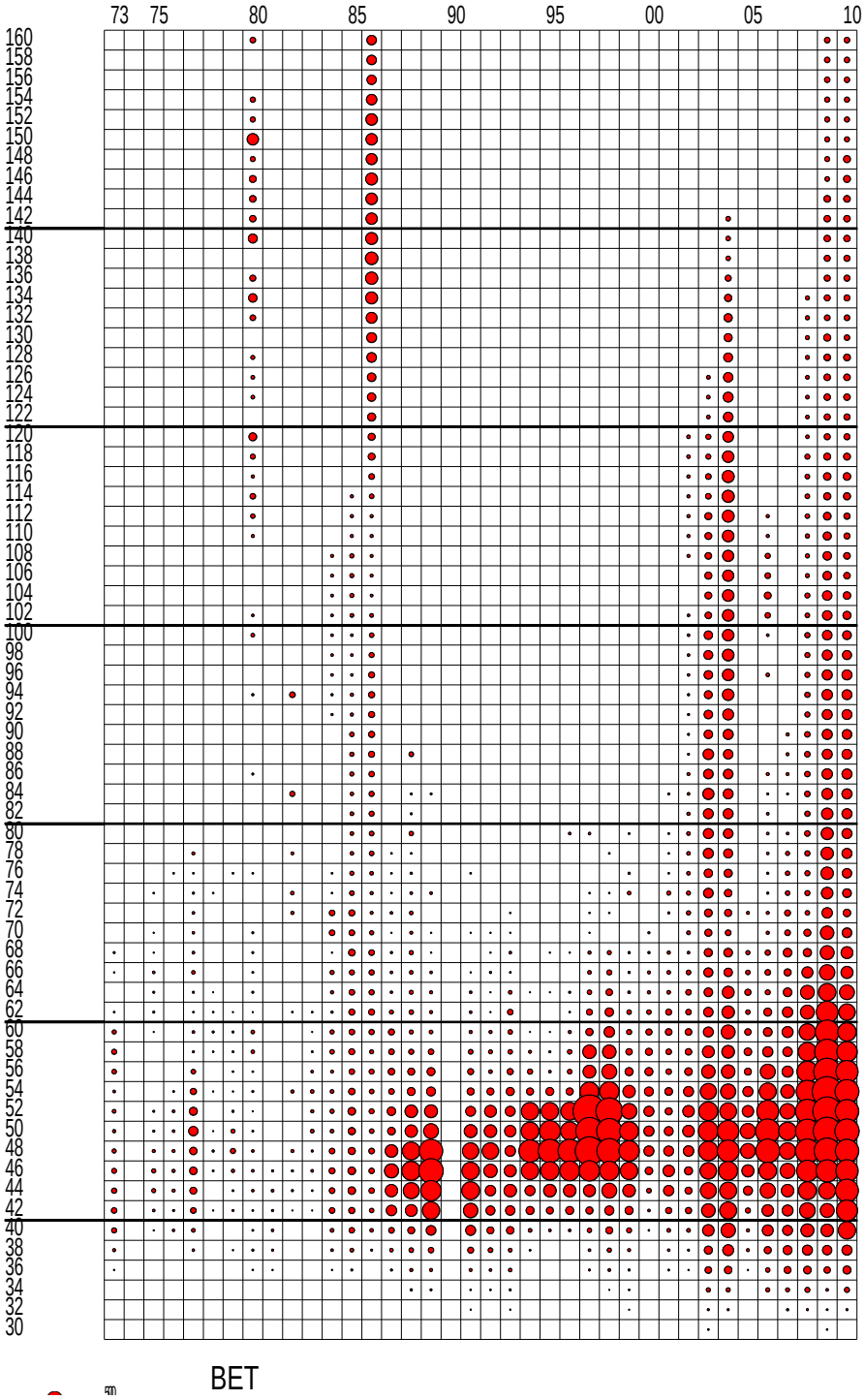


Figure 10. Bigeye (BET) size distribution in weight of Ghanaian samples during the period 1973-2010. This figure combines all the bigeye size data collected in Tema and Abidjan on the Ghanaian landings.

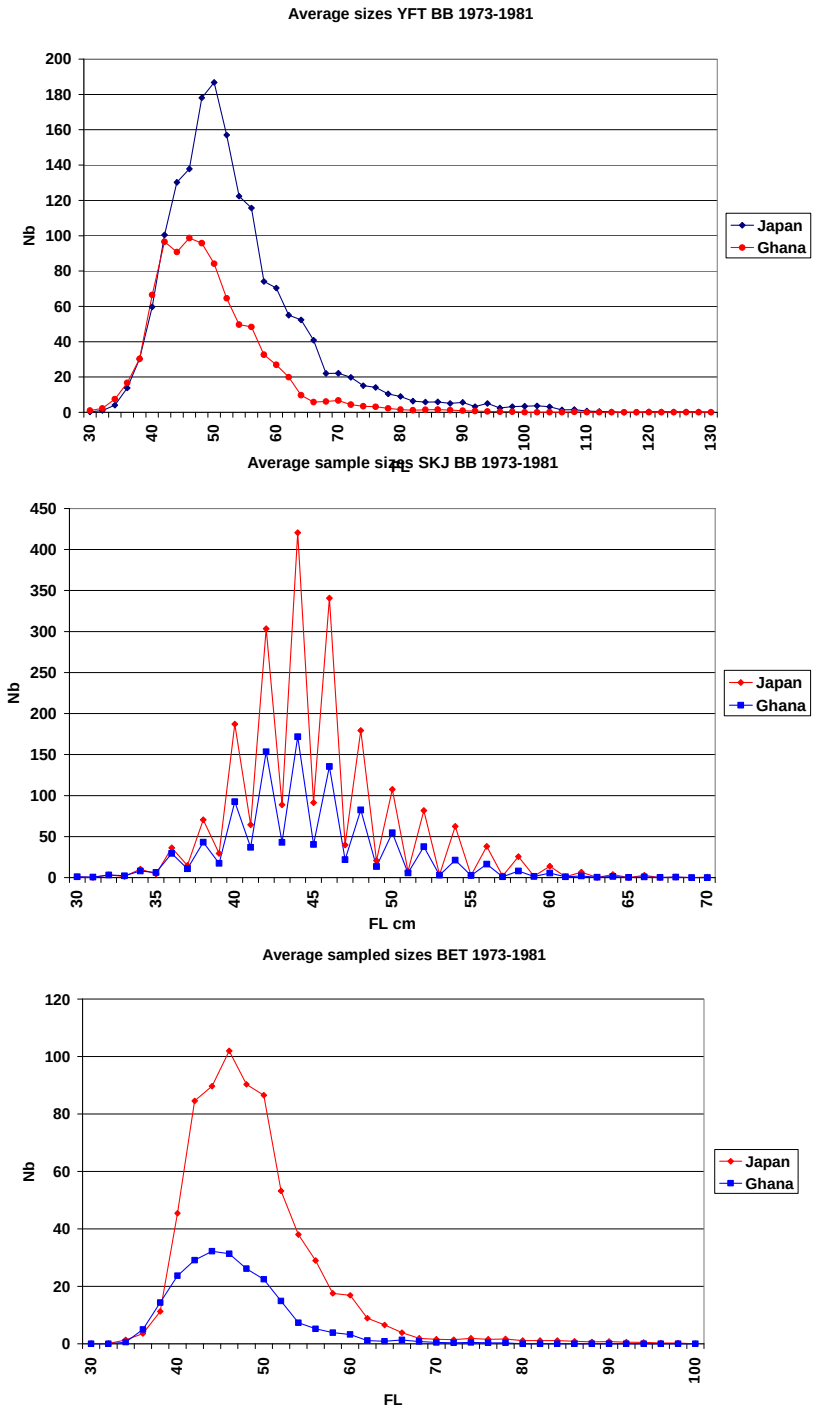


Figure 11. Comparison of the length frequency distributions collected from the Japanese baitboat fleet landings in Ghana and from Ghanaian vessels. For some years, data were recorded by 2 cm intervals, and in other years data were recorded by 1 cm intervals (resulting in the jagged distribution evident in the skipjack plot).

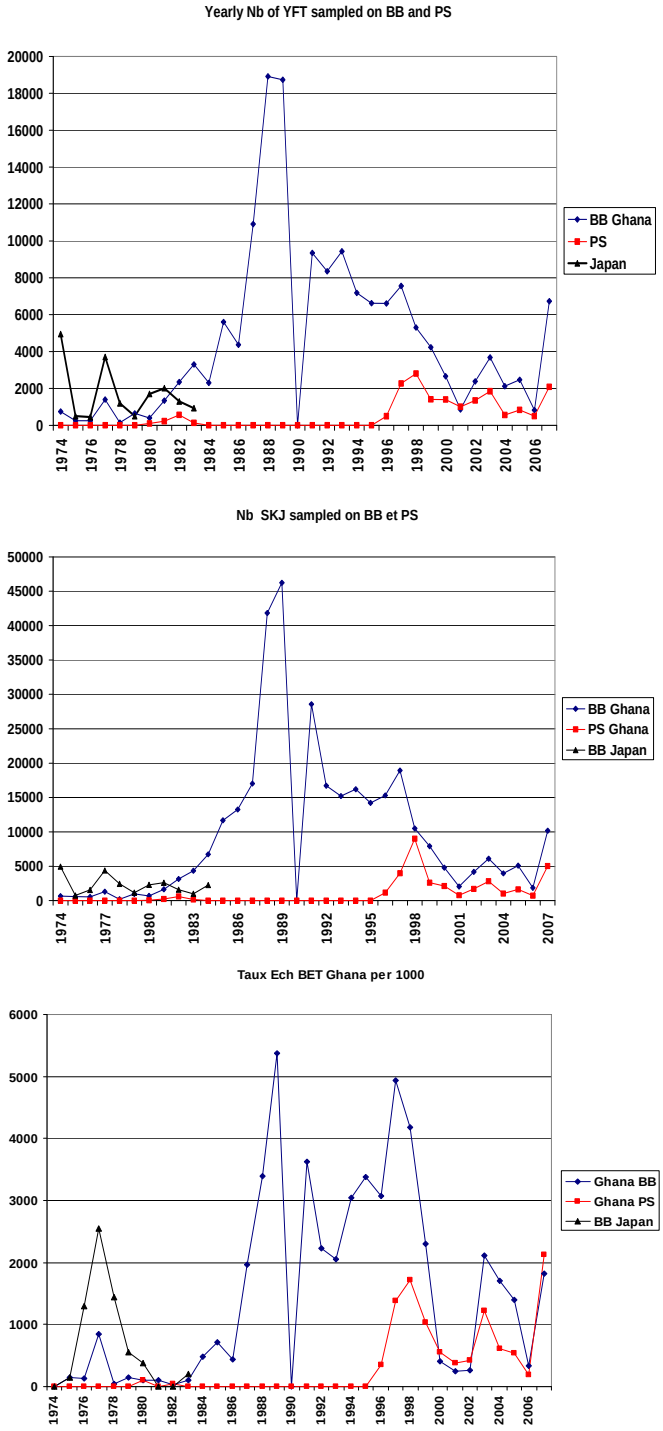


Figure 12. Number of fish measured by Ghanaian scientists, by flag/gear.

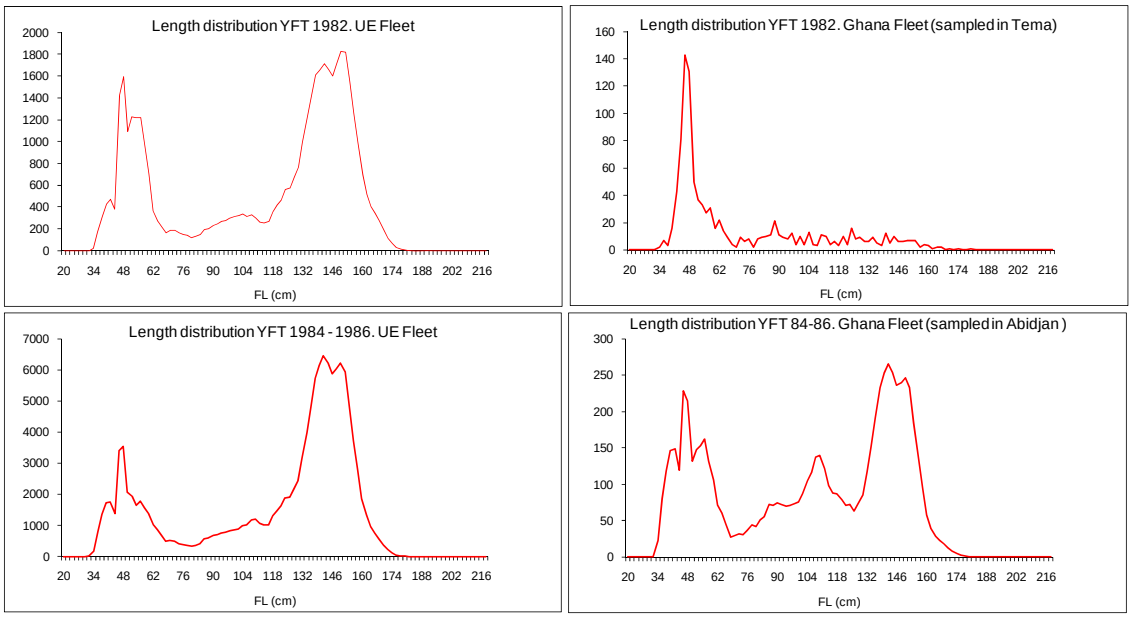


Figure 13. Comparison of the length frequency distributions collected from the EU purse seine fleet (left) and from Ghanaian vessels (in Tema, upper right, and in Abidjan, lower right). Large fish are very infrequent in the samples collected from Ghanaian vessels in Tema.

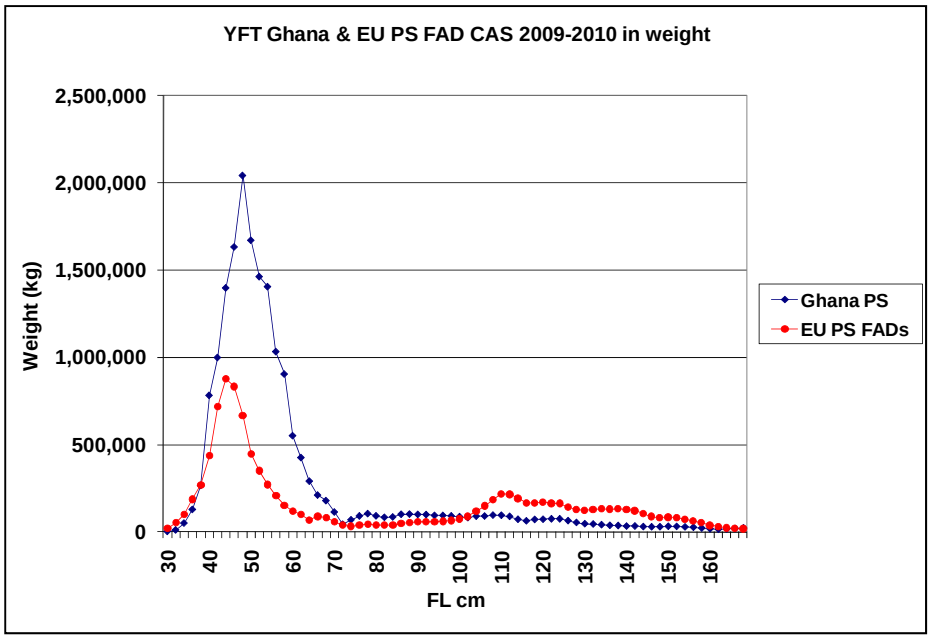


Figure 14. Comparison of the catch-at-size frequency distributions estimated for the EU and Ghana purse seine fleets by the traditional approach. Note that the EU purse seine catch at size is somewhat bi-modal (large fish are more represented in the catch at size).

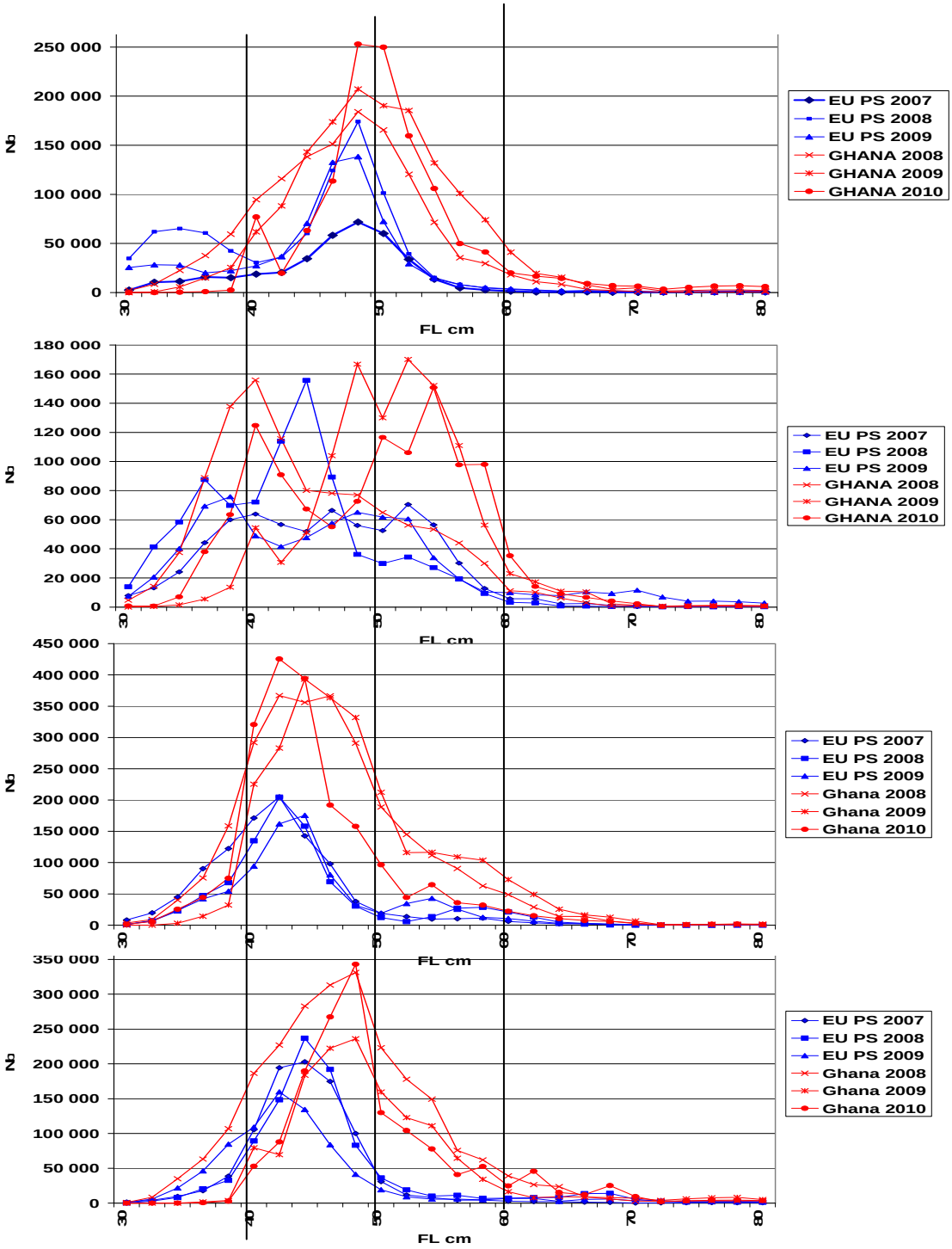


Figure 15. Comparison of the length frequency distributions collected from EU purse seiners and from Ghanaian landings plotted by quarter.

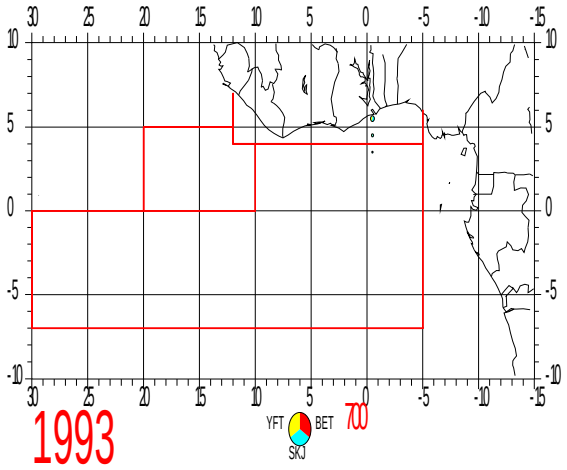


Figure 16. Areas used in the analysis.

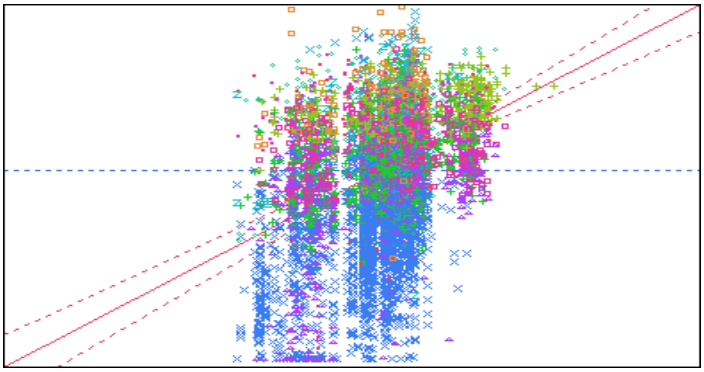


Figure 17. Residuals from a general linear model which accounts for 20% of the overall variability in the Shannon Index (of diversity) applied to the European purse seine and Ghanaian baitboat and purse seine sampling data from the tropical Atlantic region. The model controls for year, quarter, (large) area, Metier, gear (PS and BB) and fishing style (log, free school, and unknown). While this model adjusts for general tendency in the observations, a very large amount of unexplained variability remains. These patterns are typical of the evaluations conducted with these data regardless of the data treatments or indices applied. Different colors represent data clustered at 12 association levels of the Shannon Index, showing substantial overlap in most clusters.

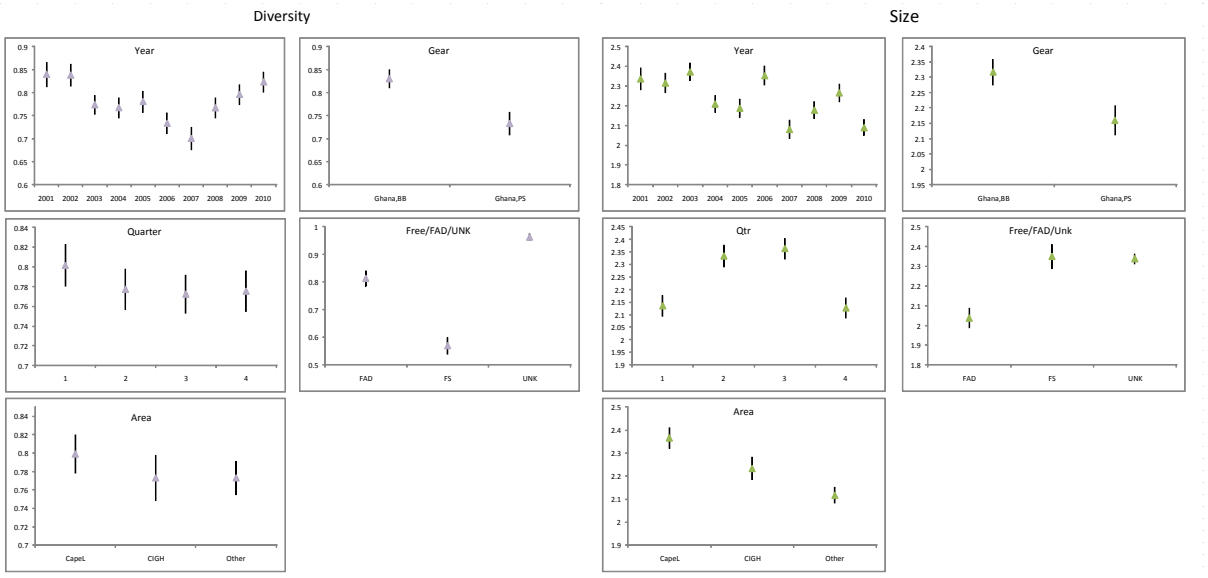


Figure 18. Shannon Index (left hand panels) and average size (right hand panels) predictions (mean and 80% confidence regions) of the factor levels from the linear model applied to samples with total average weight of <10kg. Lack of overlap in the 80% confidence regions is an approximate 2-tailed 5% test of significance. In this case, potential stratification or substitution schemes based on these indicators differ depending on the metric considered. The largest factor differencing in this case is seen in the free school/FAD factor, which is largely unknown for the Ghanaian fleet.

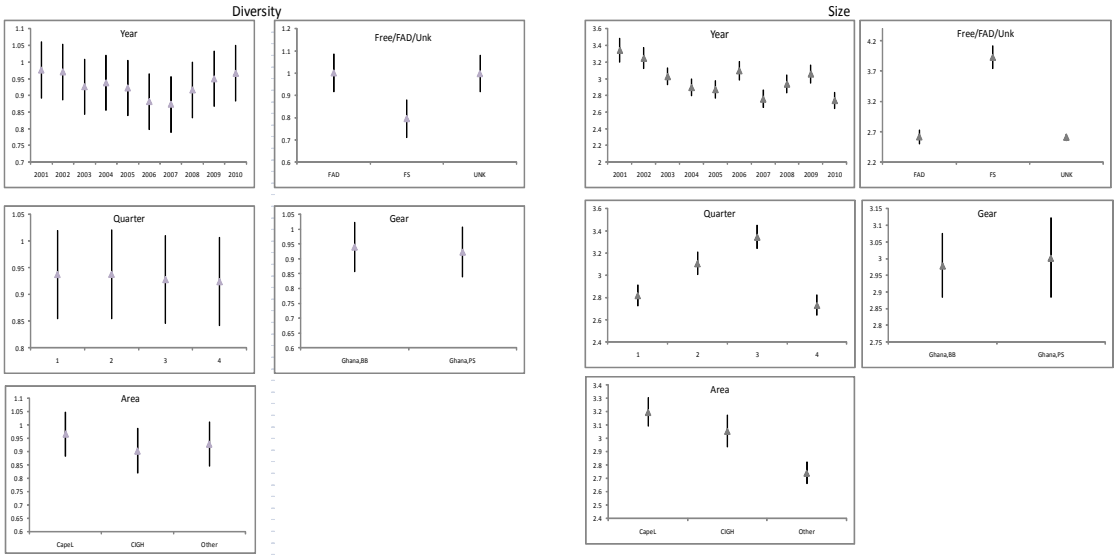


Figure 19. Shannon Index (left hand panels) and average size (right hand panels) predictions (mean and 80% confidence regions) of the factor levels from the model applied to samples regardless of fish weight in the samples. Lack of overlap in the 80% confidence regions is an approximate 2-tailed 5% test of significance. In this case, potential stratification or substitution schemes based on these indicators differ depending the index used (species composition or size composition) and also differ from those implied in the data with average sizes limited to <10kg (**Figure 18**. As in **Figure 18**, the factor differencing accounting for the highest proportion of overall variance in observations explained is seen in the free school/FAD factor, which is largely unknown for the Ghanaian fleet.

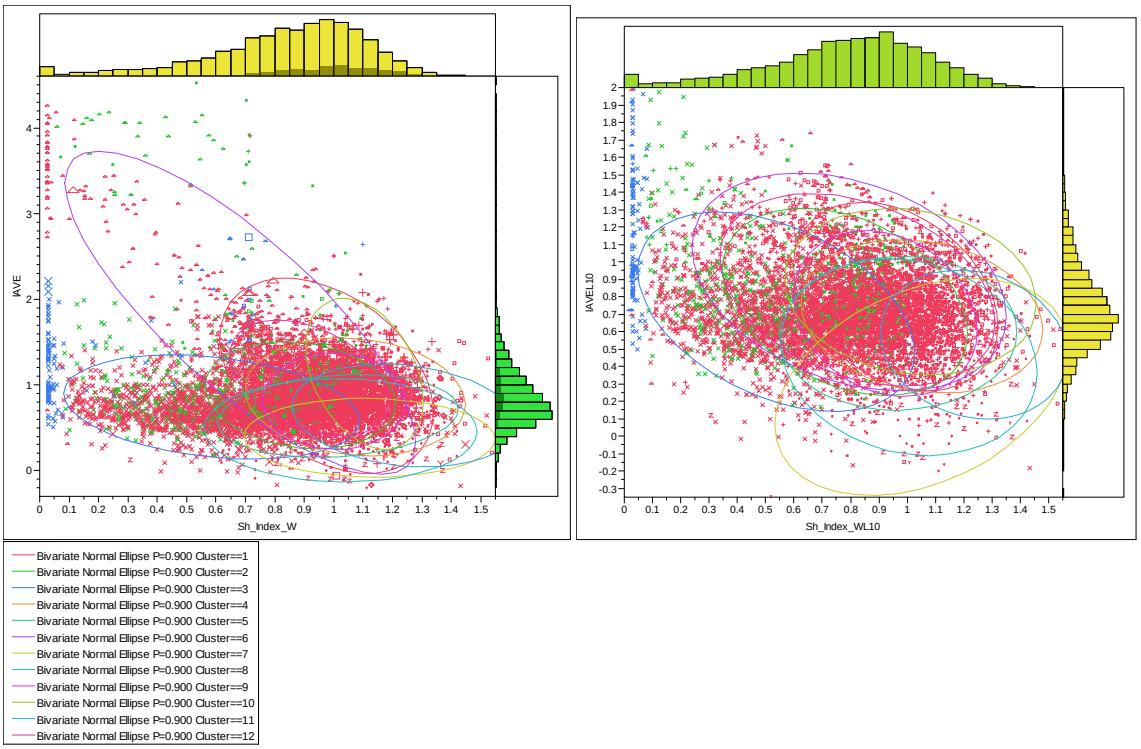


Figure 20. Bivariate plot of Shannon Index by ln(average fish weight) in samples for the all fish data (left panel) and for the fish <10 kg data (right panel). Overlaid on the plots are bivariate normal elipses (90%CI) for a 12 level cluster analysis applied to the data, which might be expected under a 3 area x 4 quarter stratification scheme. Histograms provide a view of the overall distributions of these variables while the shading in the left panel histogram represents the Ghanaian data. Few, if any, distinct (non-overlapping) clusters exist in these data; especially so for the right hand panel. In the left hand panel, the European free school sets with low diversity and high average weight can be partially discriminated, although these sets represent only about 20% of the overall samples from European free school sets.

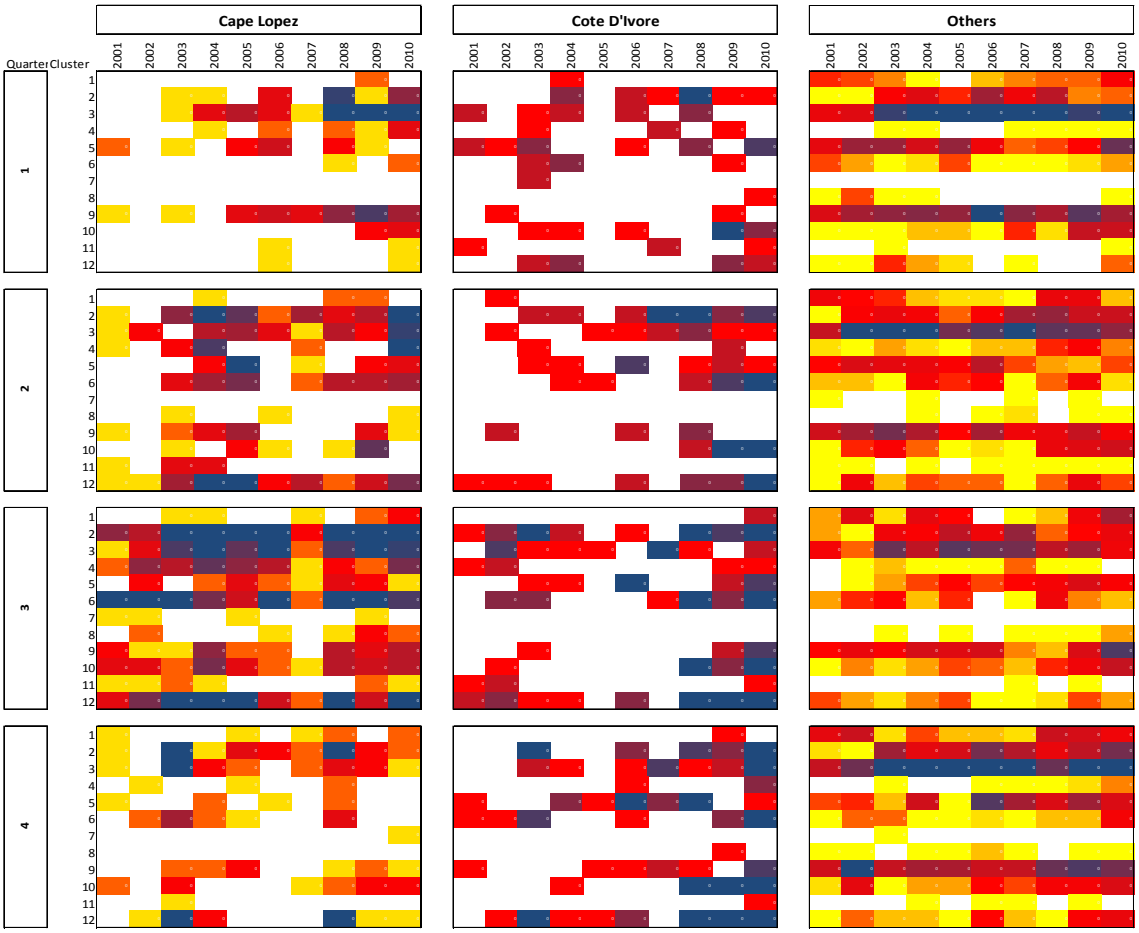


Figure 21. The results of the cluster analysis summarized by year, quarter and area, which indicates relatively little consistency between clusters and time-area factors used in the analysis. The shade of the cells indicated the proportion of observations from each cluster, light yellow shades indicate a low proportion, red cells indicate a moderate proportion, and dark blue indicates a high proportion. Empty cells represent no observations. The expected pattern in this figure is for a random distribution with average proportions (red) for those factors that have no influence on the species composition.

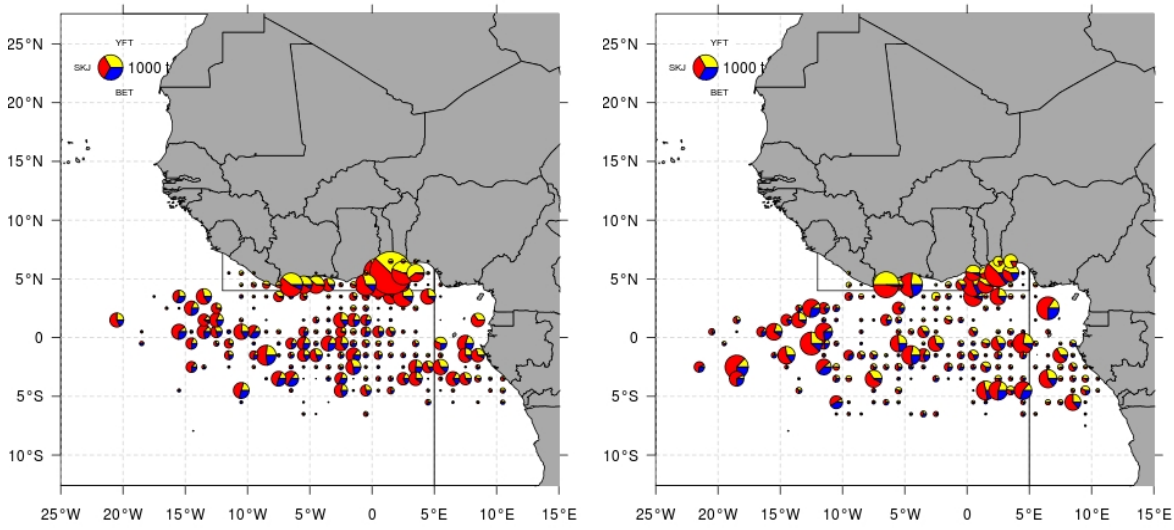


Figure 22. Fine-scale (1x1) distribution of Ghanaian baitboat (left plate) and purse seine (right plate) BET/YFT/SKJ sampled catches used in the fine-scale analysis.

Appendix 1

AGENDA

1. Opening
2. Historical overview
   - 2.1 Summarized background information on the different data collection and processing systems used before the JDIP started its contribution to the improvement of statistics
   - 2.2 Information on the Ghanaian data (Task I and Task II data) existing in the ICCAT database
3. Yearly Task I data
   - 3.1 Total catch by species and by gear
     - 3.1.1 Source of data: Skipper's declaration, canneries data, logbooks (including description of information provided and coverage)
     - 3.1.2 Cross-checking and other validation process
     - 3.1.3 Potential problems: Landings in Abidjan, transshipments (at sea and in foreign ports), BB-PS collaboration, "*faux poissons*", potential under reporting of total catches
     - 3.1.4 Species composition
   - 3.2 Fleet
     - 3.2.1 Source of data
     - 3.2.2 Updating process
4. Yearly Task II: Catch and effort data
   - 4.1 Logbooks system: coverage, validation process, processing system
     - 4.1.1 Data available in the ICCAT data base: summary of information received including description, format in which the information was received and analyses conducted by the Secretariat
     - 4.1.2 Problems related with the logbooks system and possible improvements
     - 4.1.3 Species composition sampling and comparison between EU and Ghana yearly species composition
   - 4.2 Observers program: coverage, data processing
     - 4.2.1 Data available in the ICCAT data base: summary of information received including description, the format in which the information was received and the analyses conducted by the Secretariat
     - 4.2.2 Problems related with the observer's program system and possible improvements
5. Yearly Task II: Sampling system and estimated catch at size
   - 5.1 Species and size sampling in Tema:
     - 5.1.1 Description of sampling scheme, coverage
     - 5.1.2 Data processing: from size samples to catch at size. Data reported to ICCAT.
     - 5.1.3 Comparison between estimated PS CAS and cannery data
     - 5.1.4 Comparison between EU and Ghana yearly catch at size by species
   - 5.2 Sampling in Abidjan:
     - 5.2.1 Description of sampling scheme, coverage
     - 5.2.2 Data processing. Data reported to ICCAT.
   - 5.3 Problems related with sampling and possible improvements
     - 5.3.1 Potential bias: apparent lack of large fish in the samples. Comparative analyses with EU samples, canneries information and other possible sources should be done in advance to the meeting
     - 5.3.2 Other problems related with the sampling scheme stratification. Evaluation of potential stratification and substitution schemes for species and size composition estimation
     - 5.3.3 Suggested improvements in historical data and recommendations for future sampling scheme
6. Recommendations
7. Other matters
8. Adoption of the report and closure

Appendix 2

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Kell, Laurence
Palma, Carlos

Appendix 3

LIST OF DOCUMENTS

SCRS/2011/087	Review of the available Ghana statistics on tropical fisheries. Palma, C., Pallares P., Ortiz, and Kell, L.

Appendix 4

MAIN CONCLUSIONS AND RECOMMENDATIONS FROM THE EXPLORATORY TRIP CONDUCTED BY PAPA KEBE TO TEMA

As part of the preparatory work carried out by the Task Group, Mr. Papa Kebe, an expert in tropical tuna fisheries, visited Tema in order to get basic information on some issues of the Ghanaian statistics and fisheries. The main conclusions and recommendations from this trip are:

1. The lack of large yellowfin and bigeye in the historical Tema sampling of purse seine catches was a matter of concern. Apparently, the Ghanaian samplers from MFRD use a caliper to measure the large yellowfin and bigeye in LD1 and an ichthyometer to measure fish less than 85 cm in strait fork length. For each of those kinds of measurement, two different sheets were used to transpose the observations. One form is dedicated only to record fish measured in fork length and another form for fish in LD1. Looking at the Task II size distribution submitted by Ghana, we noted the absence of fish greater than 85cm for several years. One possible explanation could be that the form with the LD1 size frequencies might not have been processed or could have been lost and/or only the small fish might have been considered. The fact that the report prepared by a technician from Senegal, after a stage in Tema in 2009 as well as logbook and observer's information include large yellowfin and bigeye support this explanation.

   During this trip, we were not able to recover information on large yellowfin and bigeye not entered or lost. Consequently, the years where data were missed could be substituted by other Ghanaian data from the observers program or the following years. For some years, particularly 2009, we have good sampling size data and this data could be used as standard to substitute others years. Also, some observer's data could be also used.

2. The use of the data provided for the canneries could be a good source of information to validate the species composition and size distribution of Ghanaian catch. Nevertheless, before using these data, it was fundamental to verify that both species and sizes are well identified in the canneries. However, it was impossible for Mr. Kebe to access the canneries during his trip and, consequently it was not possible to validate the data provided by the canneries.

3. The AVDTH software, a relational database developed for the European and associated fleets, was facilitated to Ghana and has been installed in the Tema laboratory since 2006 with the objective of improving the quality of the tuna statistics submitted to ICCAT. With the contribution of the JDIMP, two training courses on the use of AVDTH were provided in 2005 and 2006. During the three years of 2007, 2008 and 2009, the Ghanaian staff working with this tool experienced several difficulties in running the software and taking full advantage of the facilities generated by this software. ICCAT, with substantial financial assistance from Japanese and EU funds, approved some projects to improve the capacity of technicians from Tema in the use of AVDTH. In the last two years, all the information from their logbooks was entered using this software. For now, they are very familiar with this program but there are still some difficulties. The main problem is related with the subroutine AKADO, dedicated to the data validation. The report generated by AKADO is in French. Other problems are related with the classification of purse seine, area definition, etc.

   It is important to have an English version of the subroutine AKADO and to provide more training for better use of this tool.

4. The data set in AVDTH for 2008, 2009, and 2010 was now available and circulated.

5. The estimation of Ghanaian catches based on the number of active vessels was only possible for recent years 2008-2010. For previous years we only receive the number of active vessels by company without the details.

6. The human resources in MFRD dedicated to the sampling program are well trained but are not sufficient to conduct sampling for all the vessel landings in Tema. It is fundamental to increase the number of technicians in order to have two sampling teams. Currently, only one team is available.

7. According to the amount of catch (more than 60,000 t) landed in Tema and the large number of tuna fishing vessels, the Ghanaian authorities should pay more attention to the tuna issues in terms of research and statistics.

Appendix 5

ANNOTATED TASK II RESULTS CONCERNING THE 1997-2010 PERIOD, C/E AND CAS, OBTAINED AFTER THE COMPLETION OF THE WORKING GROUP

1. Introduction

Due to the lack of time available, the Working Group was not in a position to obtain extensive estimates of corrected Task II C/E and sizes for the third period, 1997-2010.

Nevertheless, the Working Group agreed on the following:

- that the four years during which detailed logbooks and sampling data are available (2006 and 2008-2010), should be processed according to the agreed rules (combining baitboat and purse seine, FADs and free school catches but with a Ghanaian fleet stratified in its two components (Panofi (P) and Other (A) fleets). These data will be obtained after the Working Group, and their results have not been examined nor discussed by the Working Group.
- that during the other years (1997-2005 and 2007), the Ghanaian Task II would remain as before, but adding the newly recovered logbooks data from Abidjan and adding to the catch at size of these years the newly recovered samples from Abidjan (from regular landings and on "*faux poissons*" in 2007).
- That C/E and CAS of the other years (1997-2005 and 2007) should also be corrected as well as possible in a near future, based on the wide range of data and results that are now available and also incorporating the Ghanaian data that are still in non electronic format, a priority being given to the 2007 data processing.

The Working Group has approved these recommendations for such new improved data processing, but it was not in a position to analyse these results, for instance, to compare the results obtained by the new method (especially the species composition estimated during these four data rich years and from fully stratified data processing).

2. Data processing and main results of the new data processing of 2006 and 2008-2010 data

2.1 A FLEET, BB and PS

The data processing of the A fleet was conducted as it was planned by the Working Group, and without technical difficulties, using moderate numbers and levels of strata substitutions, as the log book coverage was fairly consistent during the entire period (and during the 12 months of each year) and as there was significant numbers of size and species samples collected during this period. As a result, the C/E by 1° and 5° squares, as well as the corresponding catch at size of yellowfin, skipjack and bigeye, by month and quarter have been obtained for the A fleet during these four years. However, a pending question is remaining concerning the quantities of large yellowfin that have been estimated in the basic CAS: this average amount of large yellowfin +10kg is less than 10%, then much lower than the 26 % of large yellowfin entering in the Pionneer cannery from Ghanaian vessels in 2009 and 2010 and than the % of large yellowfin caught under FADs by the EU PS fleet (42%). As it was concluded by the Working Group that this low % of large yellowfin in many Ghanaian samples was probably due to a sampling bias and also to the poor reporting of large yellowfin quantities in many Ghanaian log books, it was decided that the yearly Ghanaian CAS should preferably be corrected. This correction was done extrapolating the numbers of large yellowfin by a yearly raising factor, allowing to obtain a constant 26% of large yellowfin (the proportion estimated at the Tema cannery), and to correct correspondingly the numbers and weights of small yellowfin <80 cm. The results of this correction are shown by the following figure.

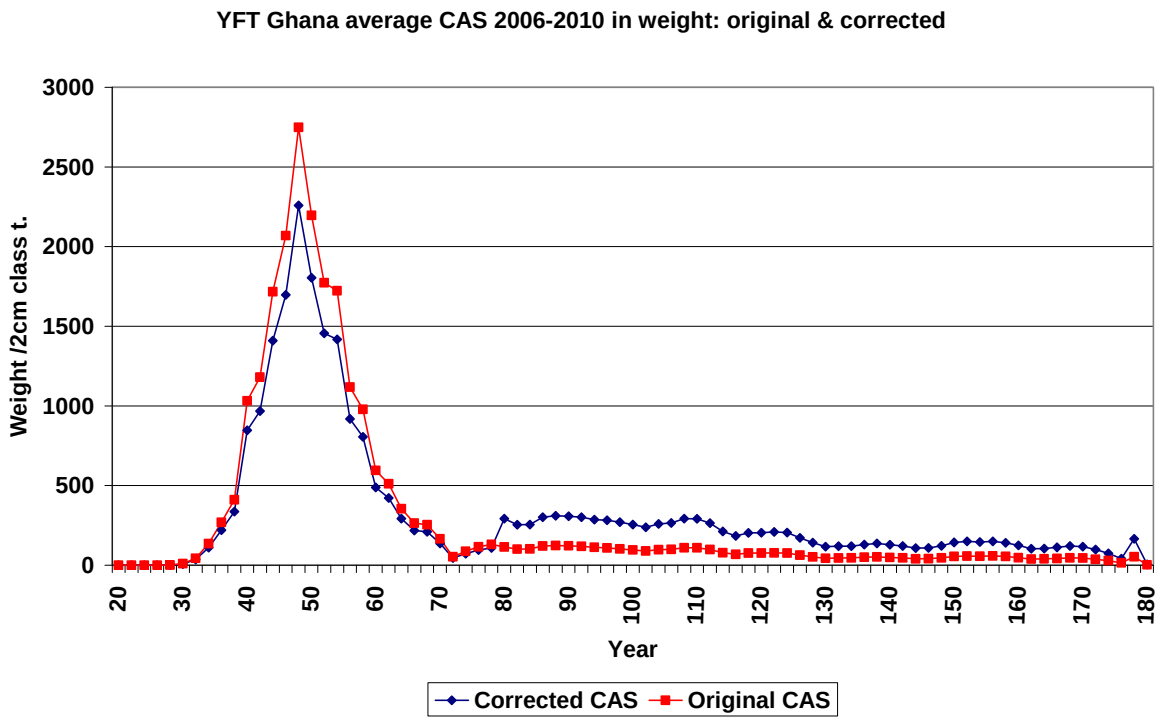


Figure 1. Average CAS of yellowfin estimated for the Ghanaian fleet, in weight, with and without correction of quantities of sampled large yellowfin. The corrected figure was based on the hypothesis of a constant proportion of large yellowfin, equal to 16% of the yellowfin catches, a percentage estimated in the Tema Pionneer cannery in 2009 and 2010.

The average fishing areas of the A fleet during this 2006-2010 period are shown by the following **Figure 2**.

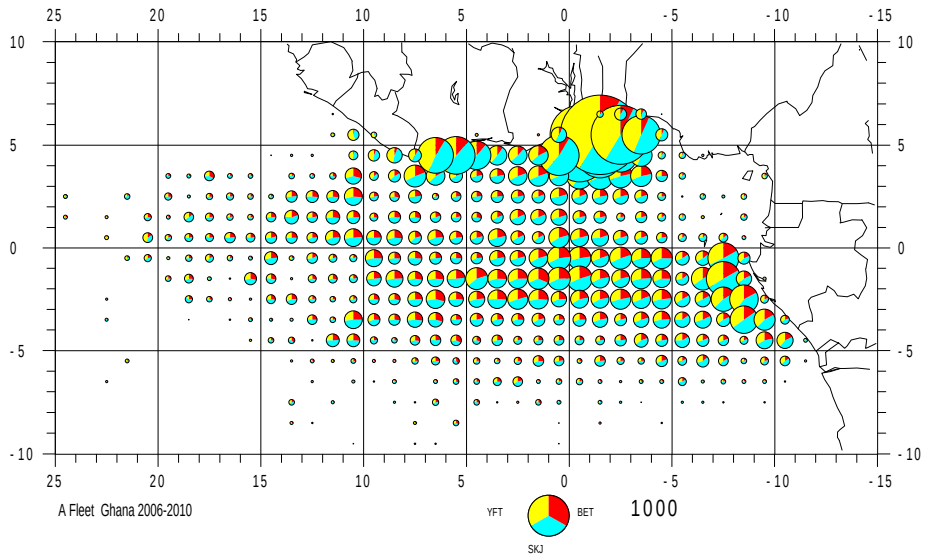


Figure 2. Average catches by species taken by 1° squares by the Ghanaian fleet during the years 2006 and 2008-2010.

2.2 P Fleet

The data processing of the P fleet has been severely hampered by the lack of catch and effort and of size sampling data and new hypothesis had to be developed in order to estimate realistic C/E and CAS files concerning this fleet. The lack of log book data was the first critical difficulties faced in the data processing, as none of the 2006-2010 years, even 2010, had a stable coverage covering the entire year (see the following **Figure 3**) keeping in mind that this fleet has been permanently active during the period.

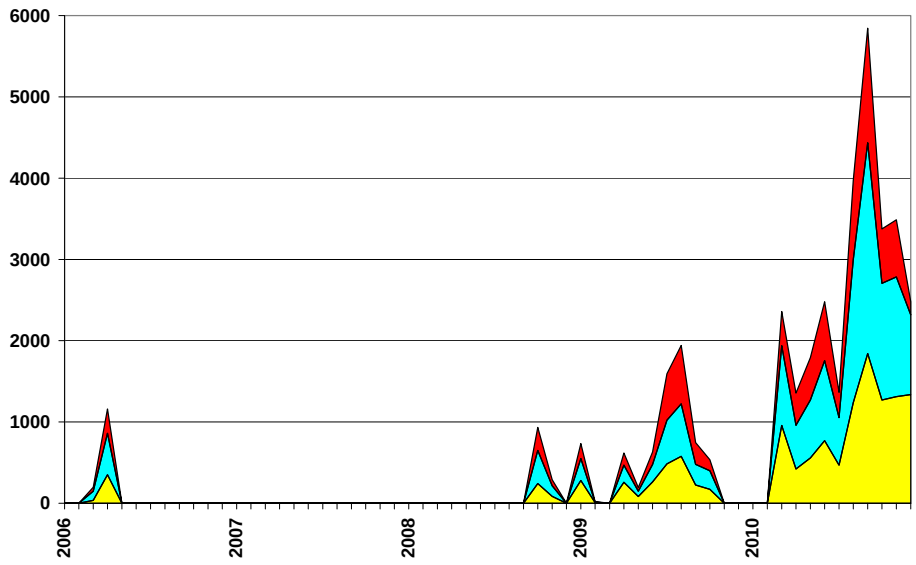


Figure 3. Monthly catches of the P fleet covered by log books during the 2006-2010 period.

Furthermore, there were no size and species samples collected on this fleet during this period, because its catches were all landed by freezer vessels in Tema and in Abidjan, and thus it was very difficult or impossible to trace and to sample.

As a result, the C/E series of the P fleet have been estimated only in 2009 and 2010. Assuming in 2010 that the C/E by area in January and February (two missing months) were identical to the March 2010 catches. These logbook data of the year 2010, observed or estimated, have been extrapolated to the P Fleet estimated 2010 Task I of YFT+SKJ+BET. The 2009 C/E was estimated combining real log book data (2nd and 3rd quarters) and data estimated from 2010 (1st and last quarter). The C/E during the two other years, 2006 and 2008, were entirely substituted from the 2010 C/E data, being extrapolated to the Task I of the P fleet during each year.

The average fishing zones of the P fleet during the year 2010 mainly used in this statistics are shown by the following figure.

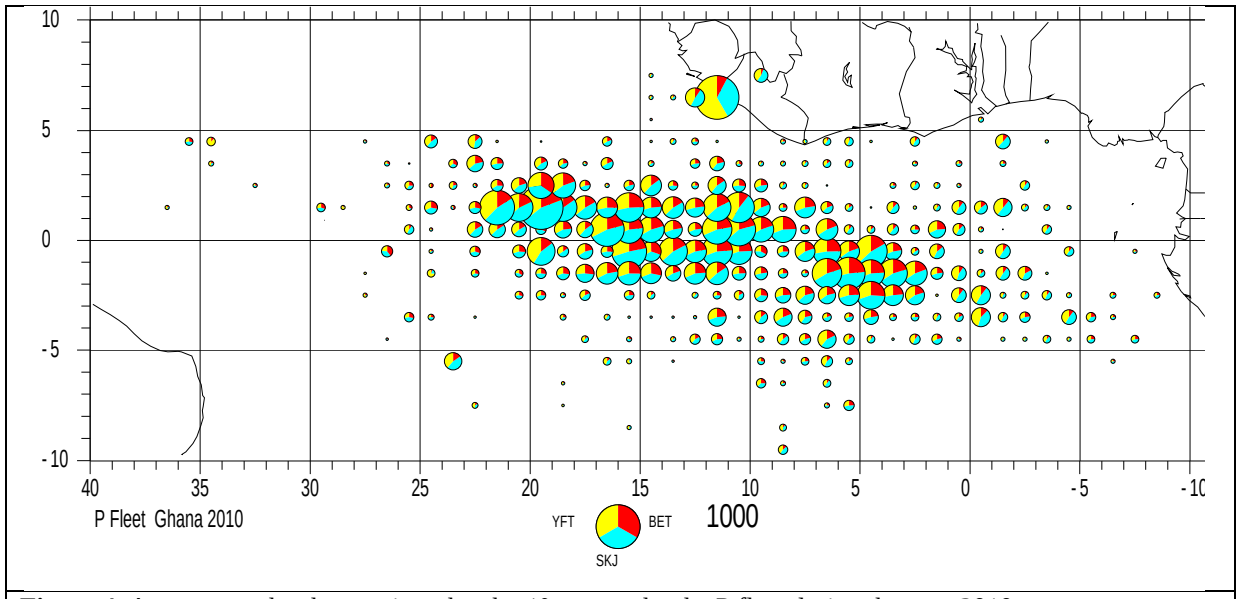


Figure 4. Average catches by species taken by 1° squares by the P fleet during the year 2010.

The CAS of the P fleet was entirely estimated from size and species samples obtained on the A Fleet (Maintaining the basic time and area strata data processing). Furthermore it was assumed that all the "faux poissons" landed in Abidjan was taken by the P fleet, and the CAS of "*faux poissons*" estimated on the Abidjan local markets have been added to the P Fleet CAS. The quantities of large yellowfin in these CAS should also be corrected (as for the A Fleet) as they are probably underestimating the real amount of large yellowfin landed assuming the same proportion of 26% of large yellowfin.

2.3 Combined fleet

As a result of this new data processing, the yearly species composition of the Ghanaian fleet appears to be quite different than previously estimated, see **Figures 5** to **7**.

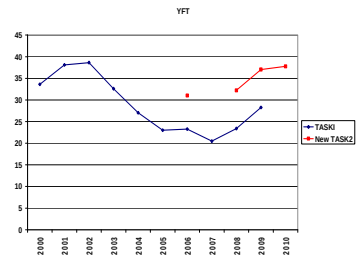


Figure 5. % of yellowfin in the Ghanaian catches, in the previous Task I and from the new data processing.

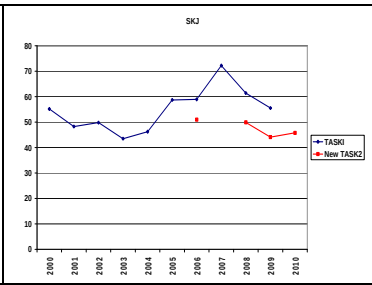


Figure 6. % of skipjack in the Ghanaian catches, in the previous Task I and from the new data processing.

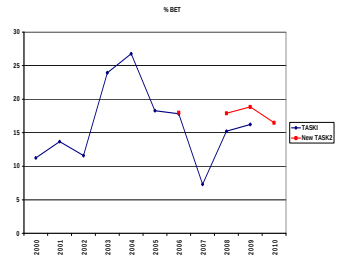


Figure 7. % of bigeye in the Ghanaian catches, in the previous Task I and from the new data processing.

The average fishing zones of the Ghanaian fleets combining catches taken by the A and P fleets during the 2006-2010 period are shown on the following figure, and these quite large fishing zones appear to be quite realistic.

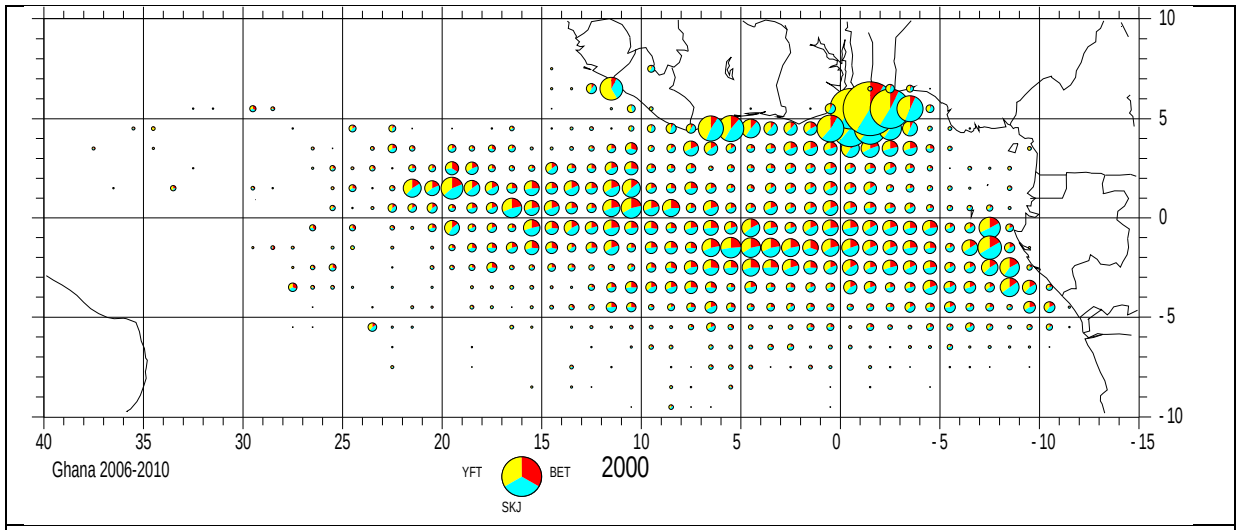


Figure 8. Average catches by species taken by 1° squares by the Ghanaian fleet during the period 2006 and 2008-2010.

The total yearly CAS of yellowfin, skipjack and bigeye taken by the Ghanaian fleet during the years 2006-2010, including the landing of faux poisons sampled in Abidjan and combining CAS of the A and P fleets, are shown in **Figures 9 to 11**.

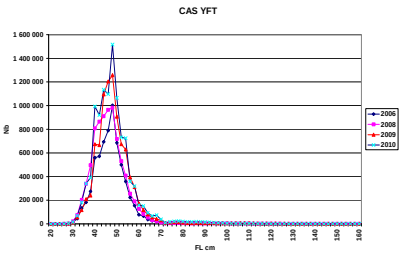


Figure 9. Yearly yellowfin catch at size estimated for the Ghanaian fleet.

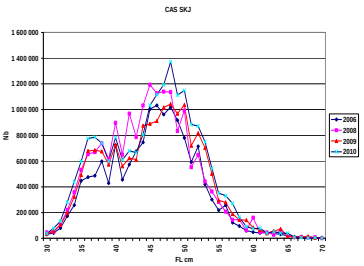


Figure 10. Yearly skipjack catch at size estimated for the Ghanaian fleet.

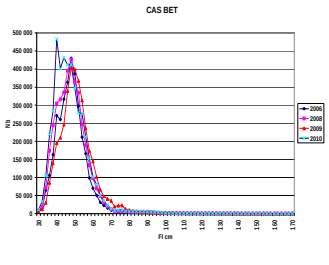


Figure 11. Yearly bigeye catch at size estimated for the Ghanaian fleet.

The corresponding yearly average weight of the three species is shown by **Figure 12**, the average weight of yellowfin being given with and without the correction of large yellowfin.

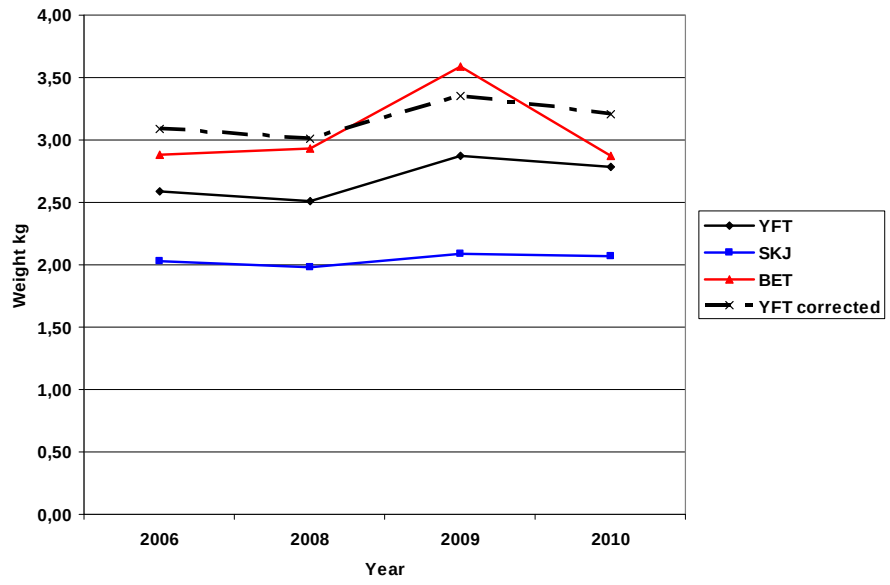


Figure 12. Present estimates of the average weight of yellowfin, skipjack and bigeye landed by the Ghanaian fleet in 2006 and in 2008-2010. Yellowfin weight given as the original estimates based on sampled sizes, and after correction of the amount of large yellowfin caught by the Ghanaian fleet.

It should also be noticed and kept in mind that unfortunately, an heterogeneity remains in the present new Ghanaian Task II, between:

1) the catch and effort file by 1° and month, based on log books and on the routine multispecies sampling of the regular landings. This catch and effort file has been tentatively extrapolated to Task I, but without the Ghanaian tuna catches sold in the "*faux poissons*" market in Abidjan. These yearly quantities of Ghanaian major tunas sold in this market are given in the following **Table 1**.

Table 1. Yearly amount of major tunas sold in the Abidjan "*faux poissons*" market and estimated by their multispecies sampling.

Year	YFT	SKJ	BET	total
1997	173	1017	135	1325
1998	26	156	21	203
1999	77	452	60	588
2000	239	1404	187	1829
2001	20	120	16	156
2002	0	0	0	0
2003	331	1947	259	2536
2004	363	2138	284	2785
2005	708	3870	694	5272
2006	545	2736	442	3723
2007	480	3025	400	3904
2008	638	4241	503	5382
2009	779	5769	599	7147
2010	1138	5571	618	7328

These catches have been sampled, but their fishing time and area strata remain unknown, so they have not been incorporated in the catch and effort data processing.

2) The catch at size of the 3 species, that combine the routine tuna multispecies tuna samples and the Abidjan samples of "faux poisons", each one with its proper weight.

As a consequence, the species composition of the Task II C/E and CAS files are slightly different, because the species composition sampled in the "*faux poissons*" market is different from the Ghanaian species composition of tunas routinely sampled during the landings.

3. Discussion of these new results

A new species composition has been estimated based on Ghanaian samples and using an improved data processing (see **Figure 13**).

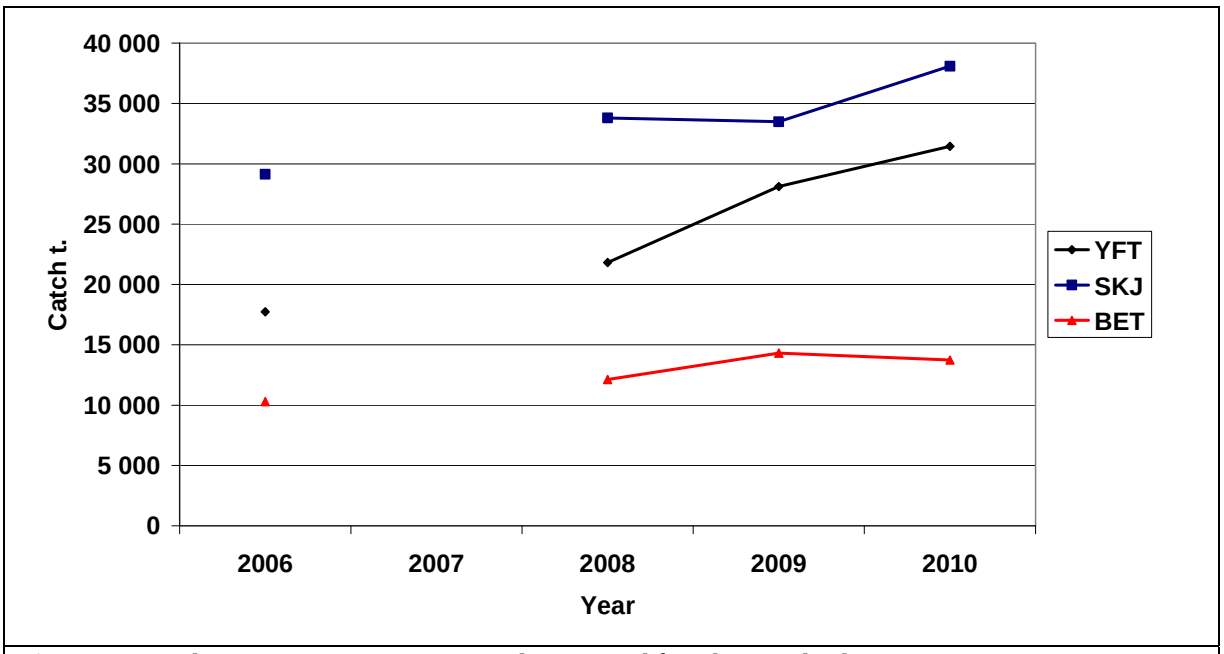


Figure 13. Yearly species composition presently estimated for Ghanaian landings.

Based on the improved Ghanaian database and on the improved data processing, it could be concluded that this new species composition (obtained only for the years 2006, 2008, 2009 and 2010) is probably more realistic than the previous ones. This species identification estimated for recent years is showing a peculiar but typical pattern that is quite different from the species composition observed on the EU purse seine FAD samples.

This structural difference in the species composition between EU and Ghanaian landings estimated by the present data processing was well very shown by the species composition observed in the Ghanaian samples.

This sampled species composition is well demonstrated by the De Finetti ternary diagrams which show the observed proportion of each species in the sampled catches in the way shown by **Figure 14**.

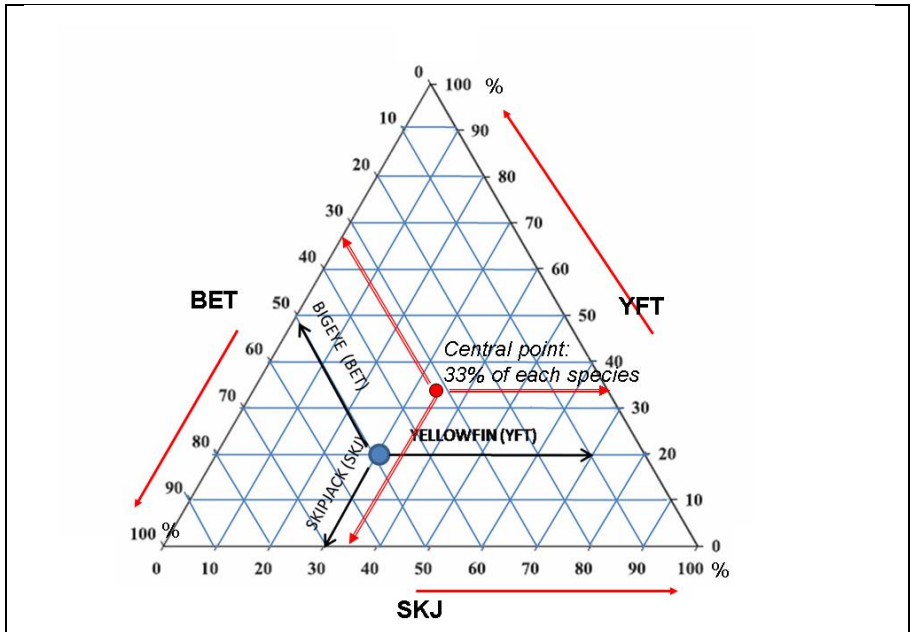


Figure 14. Principle of a De Finetti diagram presently used to show the species composition of a set of multiple samples. In their present version each pie has an area proportional to the frequency of the species composition observed for the three species

Figures 15 and **16** show that most Ghanaian samples have percentages of yellowfin and skipjack that are close to 50/50, whereas the EU purse seine FAD samples most often show a predominant % of skipjack in a mixture of the three species.

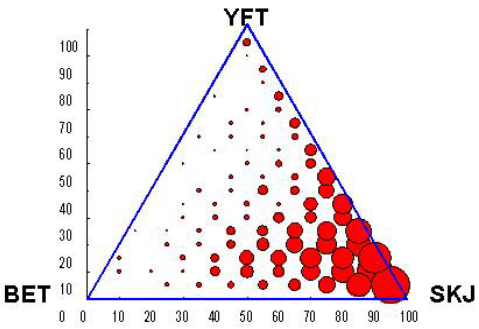


Figure 15. Ghana species composition observed during the 2006-2010 period.

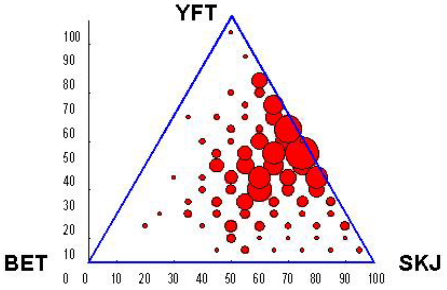


Figure 16. EU purse seine FAD species composition observed during the 2007-2009 period.

This scientific species composition observed in the Ghanaian samples is also widely different from the species composition estimated by the MW Brands PS at the Tema cannery, shown by **Figure 16.** Concerning the species identification done by the Tema MW Brands cannery, it should be noted that the species identified in the group of small tunas less than 10 kg landed by EU purse seine in 2009 and in 2010 are very similar to the species identification done on the catches taken by the same and landed in Abidjan done by EU scientists (see the Task II CAS of EU purse seine submitted to ICCAT) (see the following **Table 2**).

Table 2. Average percentage of each species in the category of small tunas less than 10kg, sampled on the EU purse seiners landing at the Tema cannery, and on the whole fleet in Abidjan, during the same years 2009 and 2010.

	YFT	SKJ	BET
% MW BRANDs	20,6	75,8	3,6
% EU PS	18,1	75,2	6,8

It can be noted that the dominant species was skipjack showing the same high percentage of 75% in the two sampling schemes, when bigeye catches were estimated at a lower percentage in the Tema cannery landings (probably due to a misidentification of some bigeye?). This great similarity between two species compositions would allow concluding that the species identification of the EU purse seine landings was well done by the cannery. This conclusion would tend to reinforce the questions or doubts expressed on the species composition estimated by the Working Group from the scientific samplings.

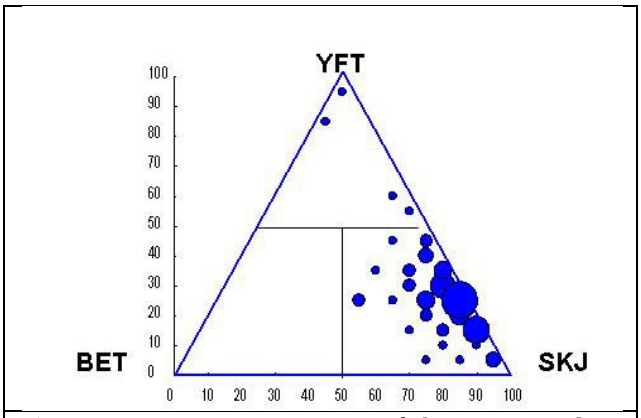


Figure 17. Species composition of the MW Brand PS sampled at its Tema cannery in 2009 and 2010.

This estimated species composition of Ghanaian catches, shown by **Figures 13** and 14, remains very difficult to understand, as it is widely or totally different from other species composition observed (see **Figure 18**).

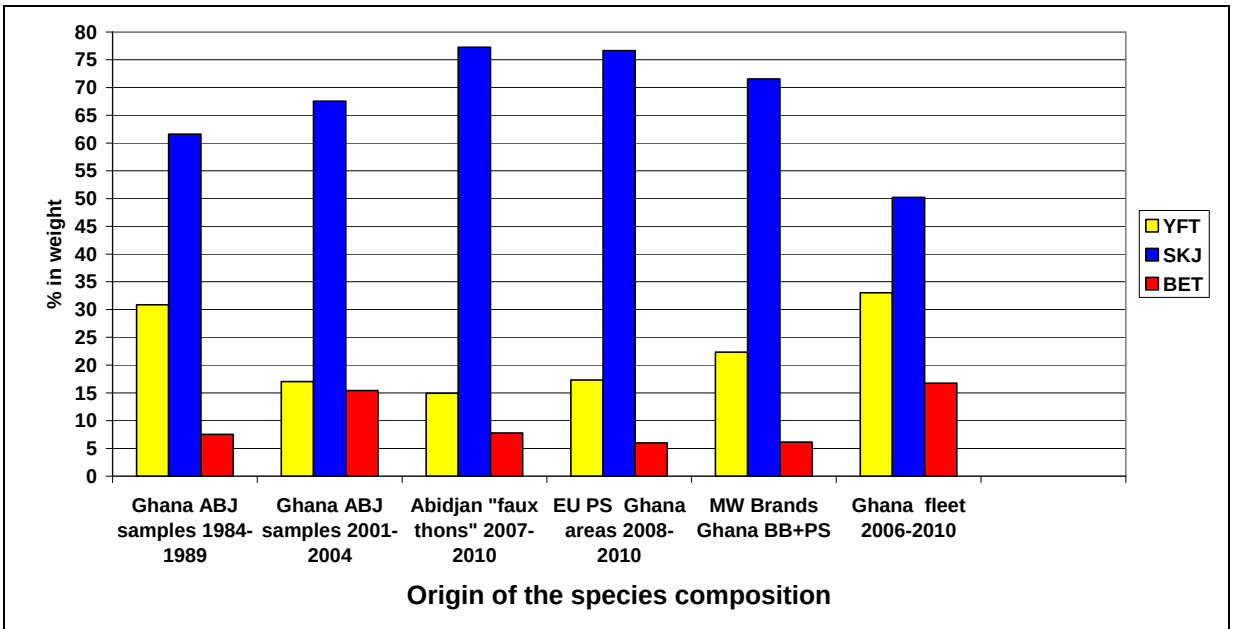


Figure 18. Average species composition of catches, Ghanaian and EU, during various periods and sampling types.

1) compared to the same Ghanaian fleet sampled in Abidjan during previous years,
2) to the same Ghanaian fleet sampled at the MW Brands cannery, and
3) to all the other EU purse seine samples, on FAD and on free schools, even those taken in the same fishing strata.

This major peculiarity of the Ghanaian species composition may be real, but it remains totally unexplained today. It may be a real and interesting result, but it would need to be fully explained by scientists, as it may also be artificial, being the consequence of a bias in the sampling process, in the data entry or in the data analysis.

It should be kept in mind that if this peculiar species composition is the result of a sampling bias, then this bias would have significant effects on the yellowfin stock assessment. A corrected alternative yellowfin catch at size taken by the Ghanaian was tentatively estimated, simply and solely based on the EU PS FAD samples (sizes and species composition): the total catches of yellowfin in this hypothesis are much lower than the presently estimated catches. The comparison between CAS and catches by species in the estimated Task II based only on Ghanaian or on EU purse seine FAD samples is given in the following **Table 3**.

Table 3. Total catch at size and catches in weight of the three species yellowfin, skipjack and bigeye presently estimated during recent years for Ghanaian fleet and EU purse seiners, Ghanaian catches being estimated based on Ghanaian samples (following the rules agreed by the Working Group) and based solely on the EU FAD samples.

	Total catches CAS		Total catches by species in weight			
	f(Ghanaian samples)	f(EU PS FAD samples)	f(Ghanaian samples)	% Basic	f(EU PS FAD samples)	alternate %
YFT	8 679 002	3 181 188	23 463	33,0	14 123	19,9
SKJ	17 458 972	27 474 094	35 664	50,2	48 624	68,5
BET	3 882 915	2 480 550	11 891	16,7	8 271	11,6

This table shows that when the total catches of juvenile yellowfin taken by the EU purse seine and by the Ghanaian fleets are nearly identical when using the EU purse seine samples to estimate Ghanaian yellowfin CAS (3.1 million fish), the same Ghanaian fleet is by far the highest source of fishing mortality exerted on juvenile yellowfin tuna when its Task II and CAS are based solely on Ghanaian samples.

Recommendation: An intensive comparative sampling done in parallel at the landing spot and at the cannery, and managed by an expert in tuna multispecies sampling, should necessarily and urgently be conducted in order to solve this major statistical uncertainty.

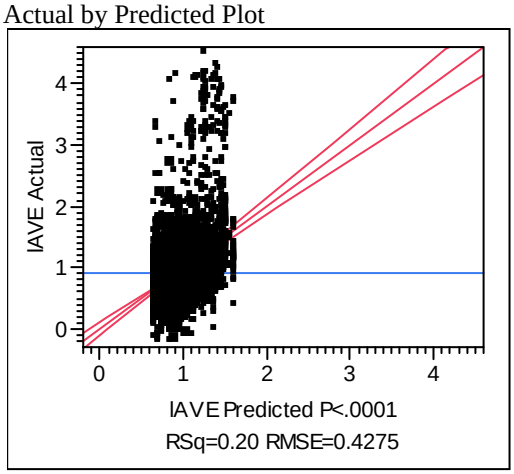
EVALUATION OF POTENTIAL STRATIFICATION AND SUBSTITUTION SCHEMES FOR SPECIES AND SIZE COMPOSITION ESTIMATION

General Linear Modeling. Additional model diagnostics

Response lAVE

Whole Model

Actual by Predicted Plot



Summary of Fit

RSquare	0.198448
RSquare Adj	0.19656
Root Mean Square Error	0.427462
Mean of Response	0.905115
Observations (or Sum Wgts)	7661

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	18	345.7136	19.2063	105.1113
Error	7642	1396.3735	0.1827	**Prob > F**
C. Total	7660	1742.0871		0.0000

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	308	283.5029	0.920464	6.0660
Pure Error	7334	1112.8706	0.151741	**Prob > F**
Total Error	7642	1396.3735		<.0001
				Max RSq
				0.3612

Parameter Estimates

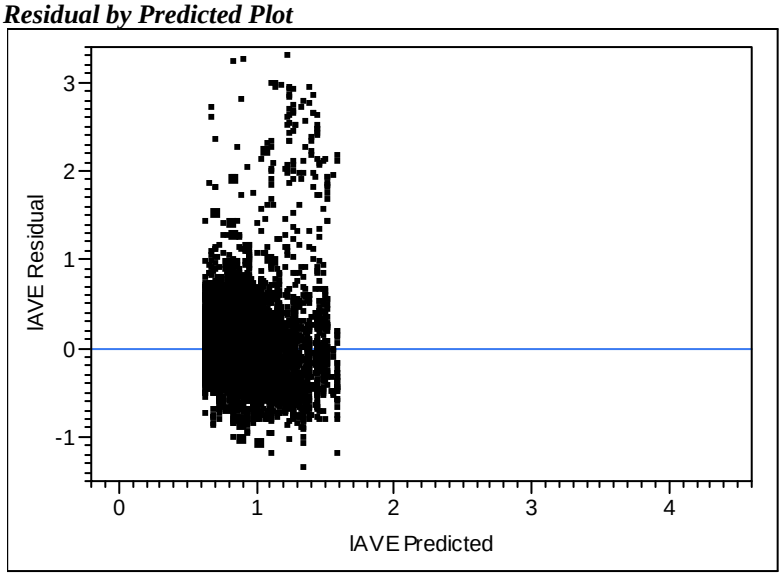
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.0951956	0.023692	46.23	0.0000
Fish_Year[2001]	0.1104262	0.020723	5.33	<.0001
Fish_Year[2002]	0.0816332	0.016632	4.91	<.0001
Fish_Year[2003]	0.0116822	0.014773	0.79	0.4291
Fish_Year[2004]	-0.032448	0.01442	-2.25	0.0245
Fish_Year[2005]	-0.040952	0.015063	-2.72	0.0066
Fish_Year[2006]	0.034225	0.014012	2.44	0.0146
Fish_Year[2007]	-0.080882	0.016267	-4.97	<.0001
Fish_Year[2008]	-0.018094	0.014309	-1.26	0.2061
Fish_Year[2009]	0.022081	0.013587	1.63	0.1042
Quarter[1]	-0.059198	0.008832	-6.70	<.0001
Quarter[2]	0.0379895	0.00869	4.37	<.0001
Quarter[3]	0.1120687	0.008956	12.51	<.0001
FreeSch[FAD]	-0.135098	0.013114	-10.30	<.0001
FreeSch[FS]	0.2721908	0.015459	17.61	<.0001
Balbaya_Zone[CapeL]	0.0665153	0.010999	6.05	<.0001
Balbaya_Zone[CIGH]	0.0210252	0.014753	1.43	0.1542
Metier[EU PS]*Gear[BB]	0.0656987	0.032711	2.01	0.0446

Term	Estimate	Std Error	t Ratio	Prob>|t|
Metier[Ghana]*Gear[BB]	-0.003838	0.014231	-0.27	0.7874

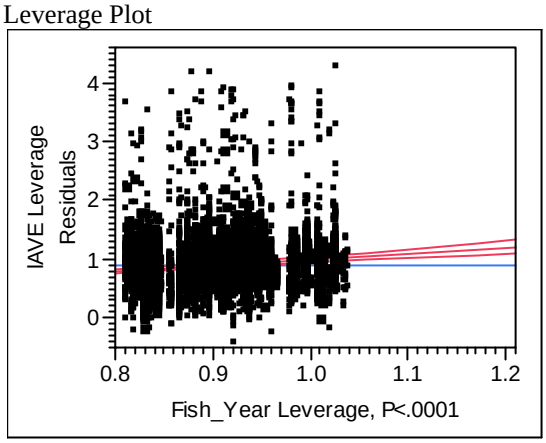
Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fish_Year	9	9	23.55824	14.3254	<.0001
Quarter	3	3	45.20703	82.4689	<.0001
FreeSch	2	2	149.42178	408.8738	<.0001
Balbaya_Zone	2	2	25.49824	69.7727	<.0001
Metier*Gear	2	2	0.74406	2.0360	0.1306

Residual by Predicted Plot



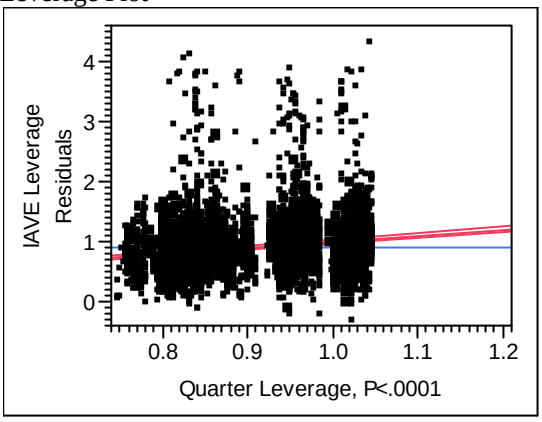
Fish_Year
Leverage Plot



Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
2001	1.2056217	0.03245134	1.04370
2002	1.1768287	0.02920717	1.00883
2003	1.1068778	0.02593084	1.00034
2004	1.0627478	0.02664123	0.93902
2005	1.0542434	0.02869118	0.87554
2006	1.1294206	0.02790938	0.91139
2007	1.0143131	0.02959120	0.75693
2008	1.0771013	0.02761392	0.88767
2009	1.1172765	0.02722511	0.91108
2010	1.0075246	0.02690720	0.81334

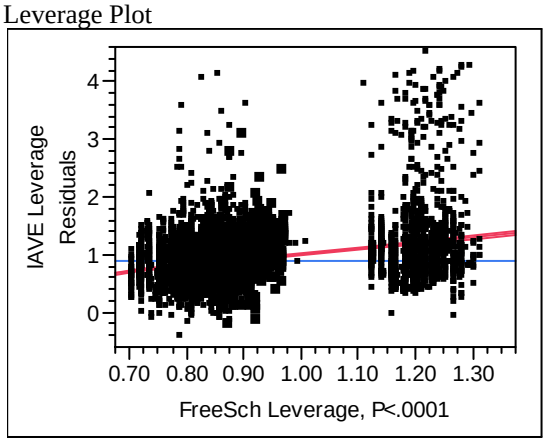
Quarter
Leverage Plot



Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
1	1.0359977	0.02603231	0.80594
2	1.1331851	0.02538551	0.96968
3	1.2072643	0.02420622	1.06969
4	1.0043352	0.02529463	0.78688

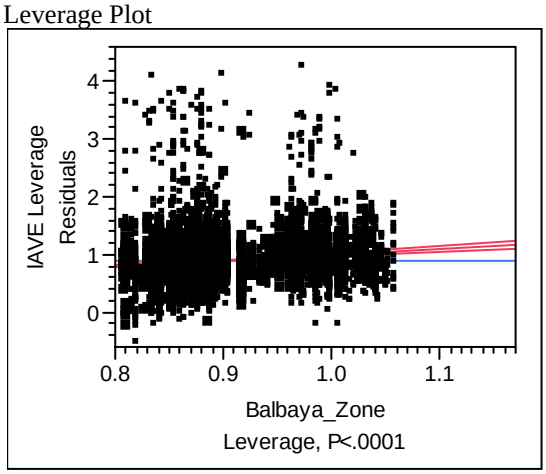
FreeSch
Leverage Plot



Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
FAD	0.9600978	0.03405668	0.81733
FS	1.3673863	0.03657872	1.29538
UNK	0.9581026	0.01470161	0.91024

Balbaya_Zone
Leverage Plot

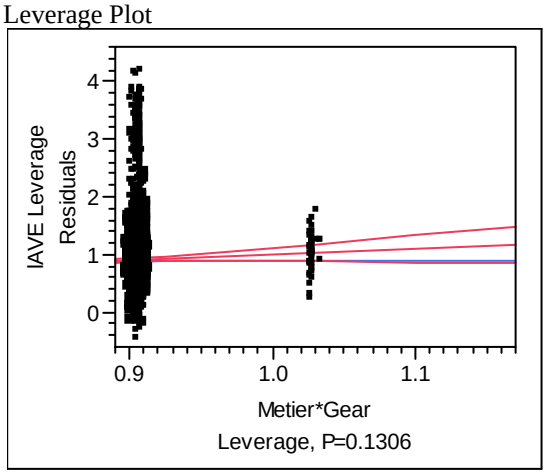


Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean

Level	Least Sq Mean	Std Error	Mean
CapeL	1.1617109	0.02571903	1.12114
CIGH	1.1162207	0.03049864	0.96522
Other	1.0076550	0.02264643	0.84632

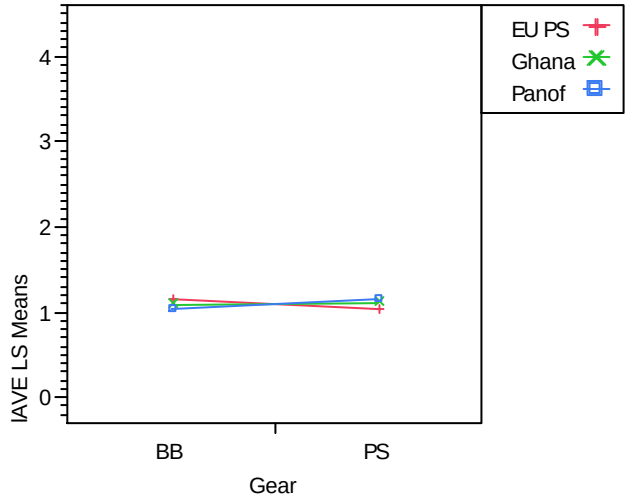
Metier*Gear
Leverage Plot



Least Squares Means Table

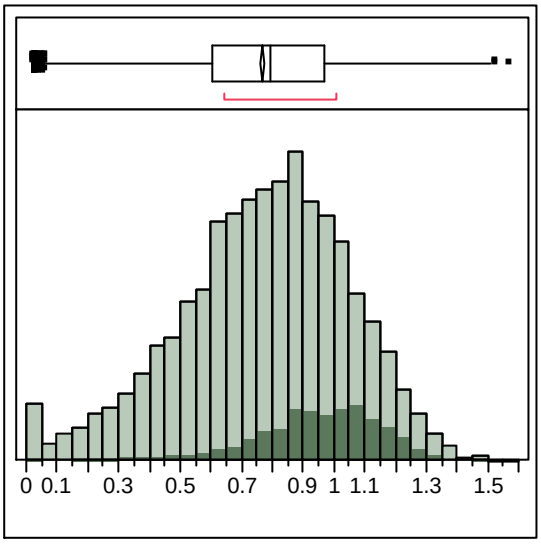
Level	Least Sq Mean	Std Error
EU PS,BB	1.1608942	0.05548321
EU PS,PS	1.0294969	0.01357445
Ghana,BB	1.0913579	0.02454953
Ghana,PS	1.0990332	0.03041371
Panof,BB	1.0333345	0.01829695
Panof,PS	1.1570566	0.05391275

LS Means Plot



Distributions

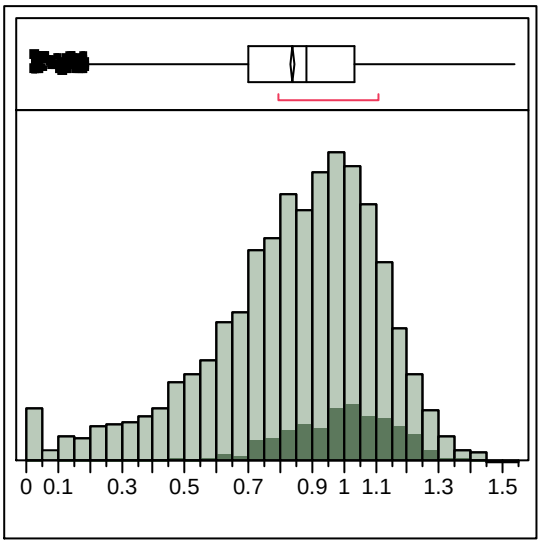
Sh_Index_N



Moments

Mean	0.7701391
Std Dev	0.275606
Std Err Mean	0.0031488
upper 95% Mean	0.7763116
lower 95% Mean	0.7639666
N	7661
Sum Wgt	7661
Sum	5900.0355
Variance	0.0759587
Skewness	-0.393921
Kurtosis	-0.048484
CV	35.786528
N Missing	0

Sh_Index_W

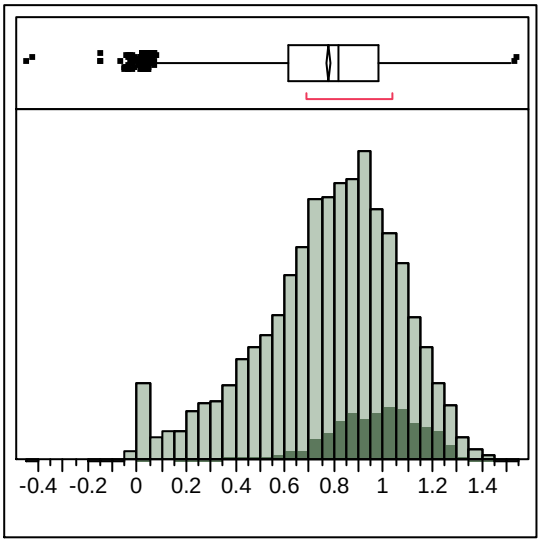


Moments

Mean	0.8400259
Std Dev	0.2715228
Std Err Mean	0.0031022
upper 95% Mean	0.8461069
lower 95% Mean	0.8339448
N	7661
Sum Wgt	7661
Sum	6435.4381

Variance	0.0737246
Skewness	-0.818409
Kurtosis	0.5763386
CV	32.32315
N Missing	0

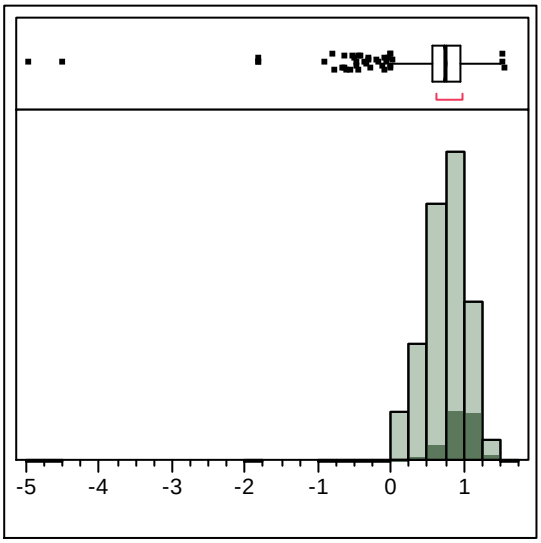
Sh_Index_WL10



Moments

Mean	0.77872
Std Dev	0.2877848
Std Err Mean	0.0032879
upper 95% Mean	0.7851653
lower 95% Mean	0.7722747
N	7661
Sum Wgt	7661
Sum	5965.774
Variance	0.0828201
Skewness	-0.597381
Kurtosis	0.1563773
CV	36.956136
N Missing	0

Sh_Index_NL10



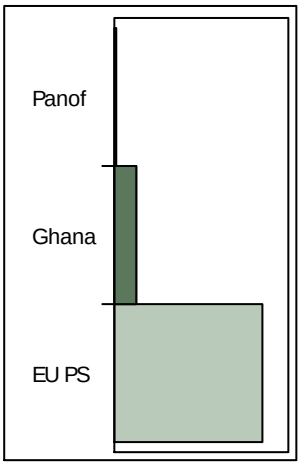
Moments

Mean	0.7475673
Std Dev	0.3072584
Std Err Mean	0.0035104

upper 95% Mean	0.7544487
lower 95% Mean	0.7406859
N	7661
Sum Wgt	7661
Sum	5727.1133
Variance	0.0944077
Skewness	-2.180233
Kurtosis	28.795846
CV	41.101096
N Missing	0

Distributions

Metier

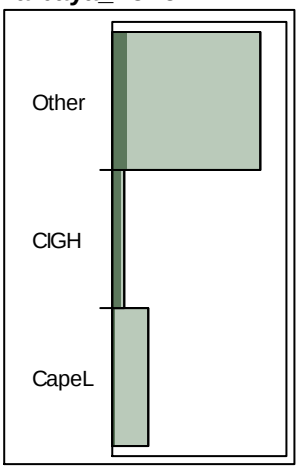


Frequencies

Level	Count	Prob
EU PS	6627	0.86503
Ghana	987	0.12883
Panof	47	0.00613
Total	7661	1.00000

N Missing
0
3 Levels

Balbaya_Zone



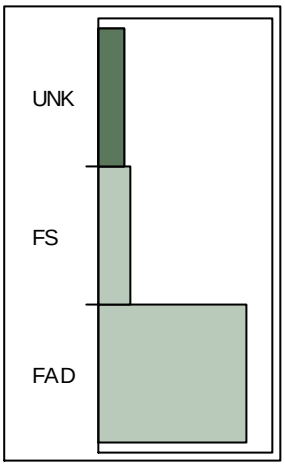
Frequencies

Level	Count	Prob
CapeL	1415	0.18470
ClGH	518	0.06762
Other	5728	0.74768
Total	7661	1.00000

N Missing
0

3 Levels

FreeSch

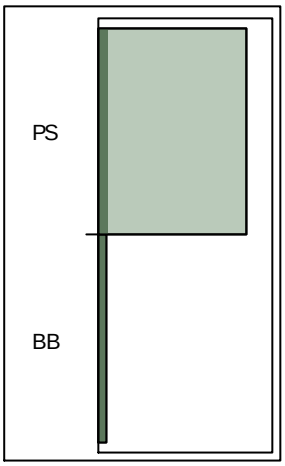


Frequencies

Level	Count	Prob
FAD	5459	0.71257
FS	1215	0.15860
UNK	987	0.12883
Total	7661	1.00000

N Missing
0
3 Levels

Gear

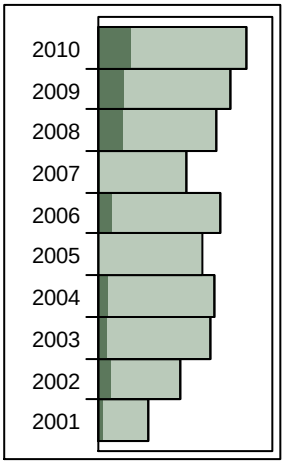


Frequencies

Level	Count	Prob
BB	469	0.06122
PS	7192	0.93878
Total	7661	1.00000

N Missing
0
2 Levels

Fish_Year

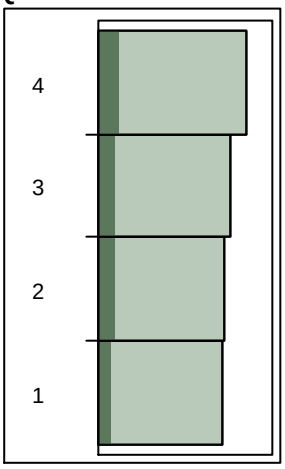


Frequencies

Level	Count	Prob
2001	364	0.04751
2002	594	0.07754
2003	797	0.10403
2004	824	0.10756
2005	744	0.09712
2006	874	0.11408
2007	630	0.08223
2008	841	0.10978
2009	937	0.12231
2010	1056	0.13784
Total	7661	1.00000

N Missing
0
10 Levels

Quarter



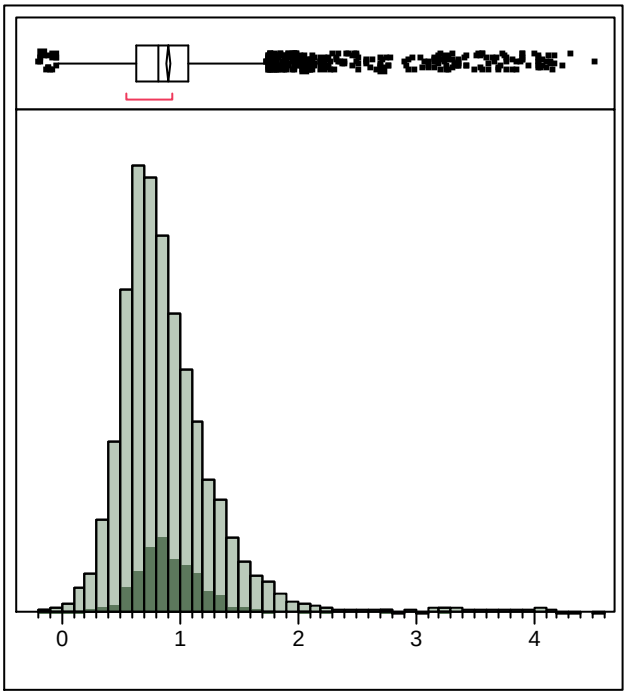
Frequencies

Level	Count	Prob
1	1796	0.23443
2	1816	0.23704
3	1908	0.24905
4	2141	0.27947
Total	7661	1.00000

N Missing
0
4 Levels

Distributions

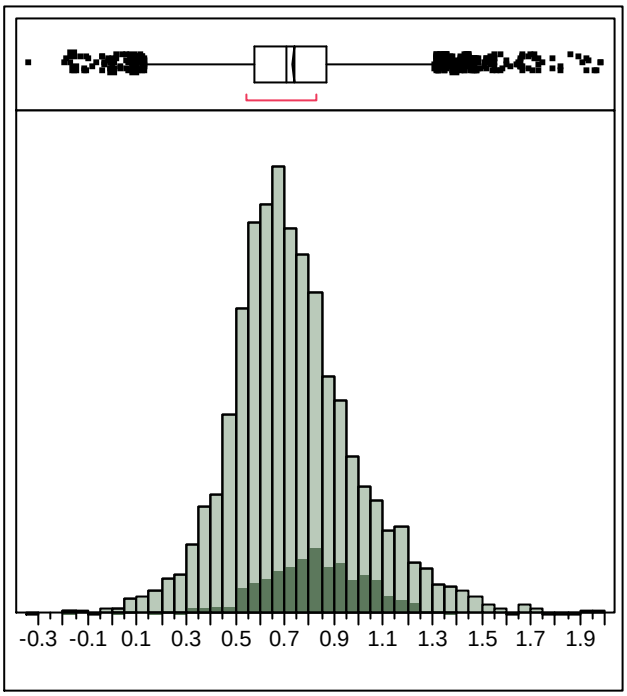
IAVE



Moments

Mean	0.9051152
Std Dev	0.4768926
Std Err Mean	0.0054485
upper 95% Mean	0.9157958
lower 95% Mean	0.8944347
N	7661

IAVEL10



Moments

Mean	0.7358714
Std Dev	0.2609559

Std Err Mean	0.0029973
upper 95% Mean	0.741747
lower 95% Mean	0.7299959
N	7580

Additional diagnostics for correlation analysis

Multivariate Correlations

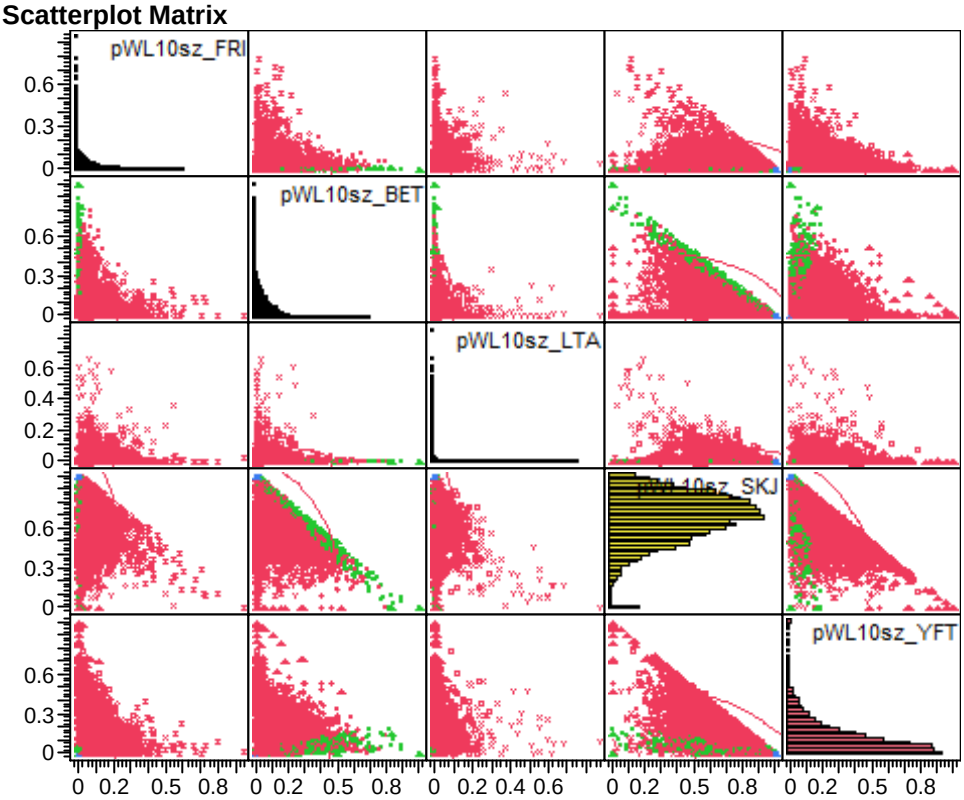
	pWL10sz_FRI	pWL10sz_BET	pWL10sz_LTA	pWL10sz_SKJ	pWL10sz_YFT
pWL10sz_FRI	1.0000	-0.1788	0.1334	-0.2085	-0.0697
pWL10sz_BET	-0.1788	1.0000	-0.1290	-0.5547	-0.1386
pWL10sz_LTA	0.1334	-0.1290	1.0000	-0.1992	0.0649
pWL10sz_SKJ	-0.2085	-0.5547	-0.1992	1.0000	-0.6283
pWL10sz_YFT	-0.0697	-0.1386	0.0649	-0.6283	1.0000

Partial Corr

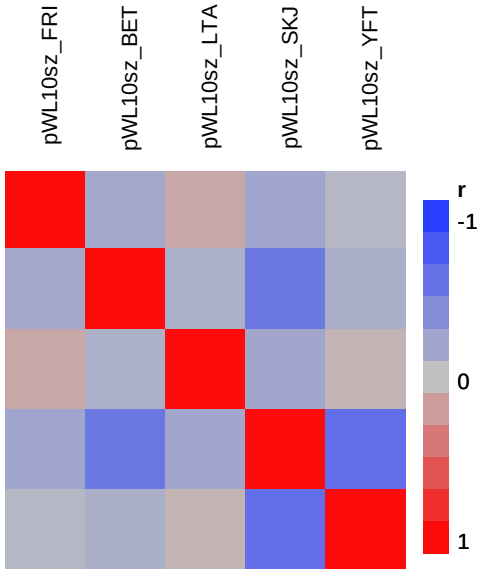
	pWL10sz_FRI	pWL10sz_BET	pWL10sz_LTA	pWL10sz_SKJ	pWL10sz_YFT
pWL10sz_FRI	.	-0.9999	-0.9997	-0.9999	-0.9999
pWL10sz_BET	-0.9999	.	-0.9998	-1.0000	-1.0000
pWL10sz_LTA	-0.9997	-0.9998	.	-0.9998	-0.9998
pWL10sz_SKJ	-0.9999	-1.0000	-0.9998	.	-1.0000
pWL10sz_YFT	-0.9999	-1.0000	-0.9998	-1.0000	.

Partialed with respect to all other variables.

Scatterplot Matrix



Color Map On Correlations



Pairwise Correlations

Variable	by Variable	Correlation	Count	Signif Prob	Plot Corr
pWL10sz_BET	pWL10sz_FRI	-0.1788	7661	<.0001	
pWL10sz_LTA	pWL10sz_FRI	0.1334	7661	<.0001	
	pWL10sz_BET	-0.1290	7661	<.0001	
pWL10sz_LTA	pWL10sz_FRI	-0.2085	7661	<.0001	
pWL10sz_SKJ	pWL10sz_BET	-0.5547	7661	0.0000	
pWL10sz_SKJ	pWL10sz_LTA	-0.1992	7661	<.0001	
pWL10sz_YFT	pWL10sz_FRI	-0.0697	7661	<.0001	
pWL10sz_YFT	pWL10sz_BET	-0.1386	7661	<.0001	
pWL10sz_YFT	pWL10sz_LTA	0.0649	7661	<.0001	
pWL10sz_YFT	pWL10sz_SKJ	-0.6283	7661	0.0000	

Multivariate Correlations

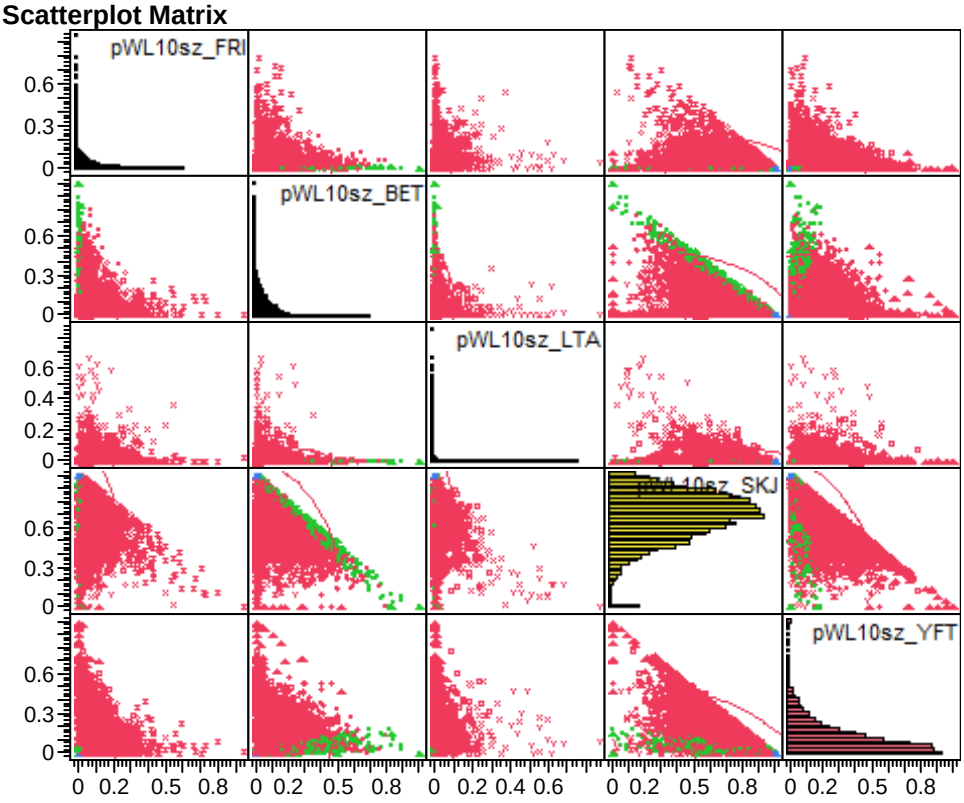
	pWL10sz_FRI	pWL10sz_BET	pWL10sz_LTA	pWL10sz_SKJ	pWL10sz_YFT
pWL10sz_FRI	1.0000	-0.1788	0.1334	-0.2085	-0.0697
pWL10sz_BET	-0.1788	1.0000	-0.1290	-0.5547	-0.1386
pWL10sz_LTA	0.1334	-0.1290	1.0000	-0.1992	0.0649
pWL10sz_SKJ	-0.2085	-0.5547	-0.1992	1.0000	-0.6283
pWL10sz_YFT	-0.0697	-0.1386	0.0649	-0.6283	1.0000

Partial Corr

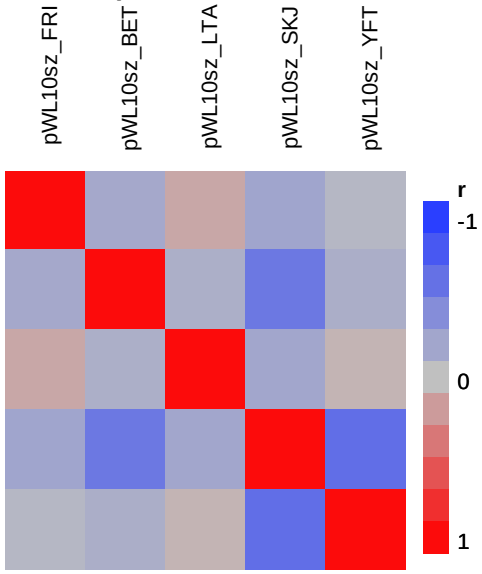
	pWL10sz_FRI	pWL10sz_BET	pWL10sz_LTA	pWL10sz_SKJ	pWL10sz_YFT
pWL10sz_FRI	.	-0.9999	-0.9997	-0.9999	-0.9999
pWL10sz_BET	-0.9999	.	-0.9998	-1.0000	-1.0000
pWL10sz_LTA	-0.9997	-0.9998	.	-0.9998	-0.9998
pWL10sz_SKJ	-0.9999	-1.0000	-0.9998	.	-1.0000
pWL10sz_YFT	-0.9999	-1.0000	-0.9998	-1.0000	.

Partialed with respect to all other variables.

Scatterplot Matrix



Color Map On Correlations



Pairwise Correlations

Variable	by Variable	Correlation	Count	Signif Prob	Plot Corr
pWL10sz_BET	pWL10sz_FRI	-0.1788	7661	<.0001	
pWL10sz_LTA	pWL10sz_FRI	0.1334	7661	<.0001	
pWL10sz_LTA	pWL10sz_BET	-0.1290	7661	<.0001	
pWL10sz_SKJ	pWL10sz_FRI	-0.2085	7661	<.0001	
pWL10sz_SKJ	pWL10sz_BET	-0.5547	7661	0.0000	
pWL10sz_SKJ	pWL10sz_LTA	-0.1992	7661	<.0001	
pWL10sz_YFT	pWL10sz_FRI	-0.0697	7661	<.0001	
pWL10sz_YFT	pWL10sz_BET	-0.1386	7661	<.0001	
pWL10sz_YFT	pWL10sz_LTA	0.0649	7661	<.0001	
pWL10sz_YFT	pWL10sz_SKJ	-0.6283	7661	0.0000	

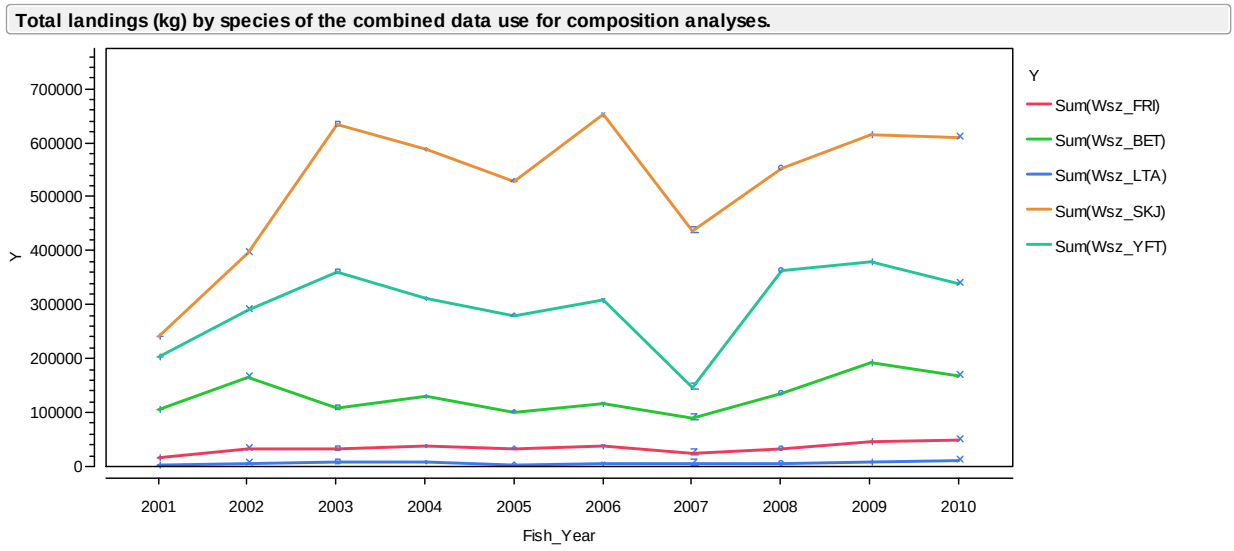
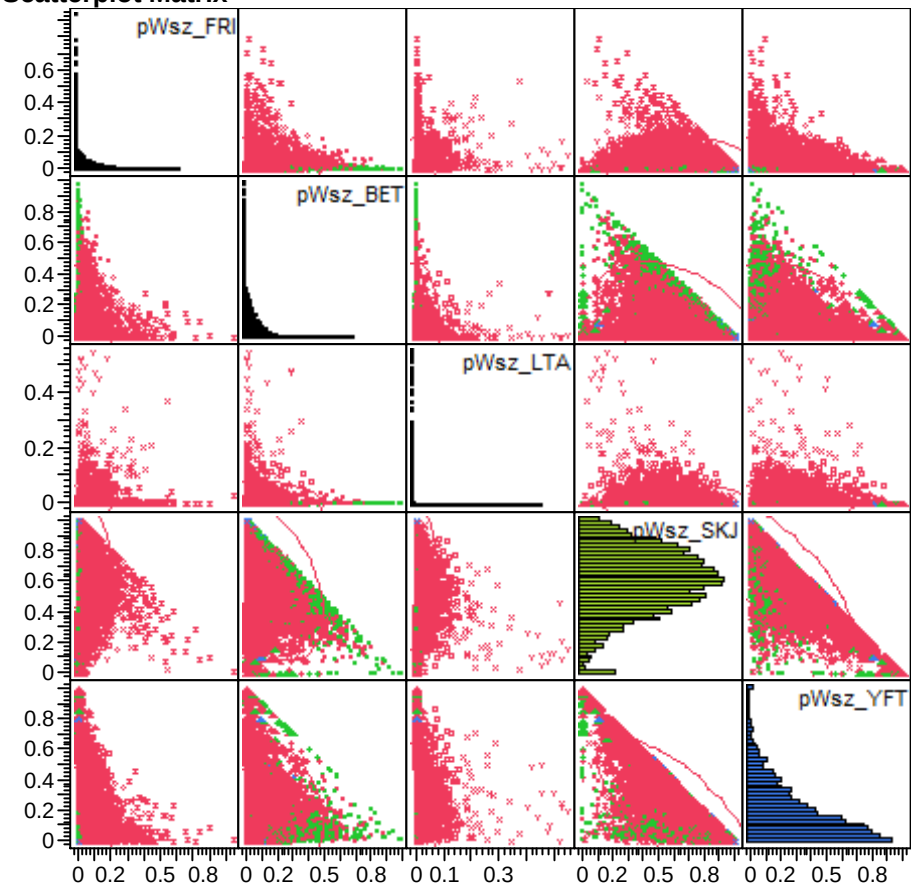


Figure App. 6_1. Total catch by species (kg) for the tropical tunas catch composition database.

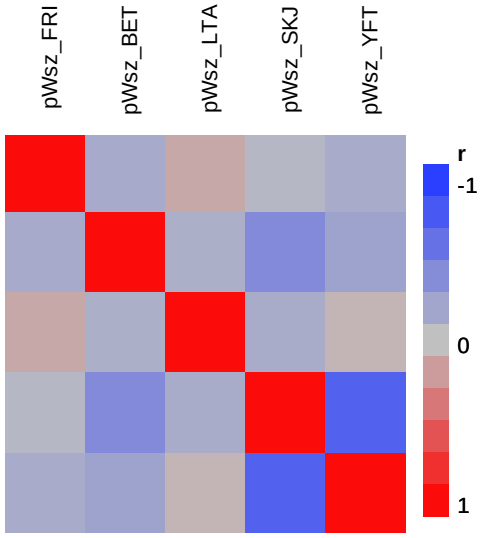
Multivariate Correlations

	pWsz_FRI	pWsz_BET	pWsz_LTA	pWsz_SKJ	pWsz_YFT
pWsz_FRI	1.0000	-0.1661	0.1290	-0.0684	-0.1575
pWsz_BET	-0.1661	1.0000	-0.1274	-0.4116	-0.2215
pWsz_LTA	0.1290	-0.1274	1.0000	-0.1531	0.0585
pWsz_SKJ	-0.0684	-0.4116	-0.1531	1.0000	-0.7306
pWsz_YFT	-0.1575	-0.2215	0.0585	-0.7306	1.0000

Scatterplot Matrix



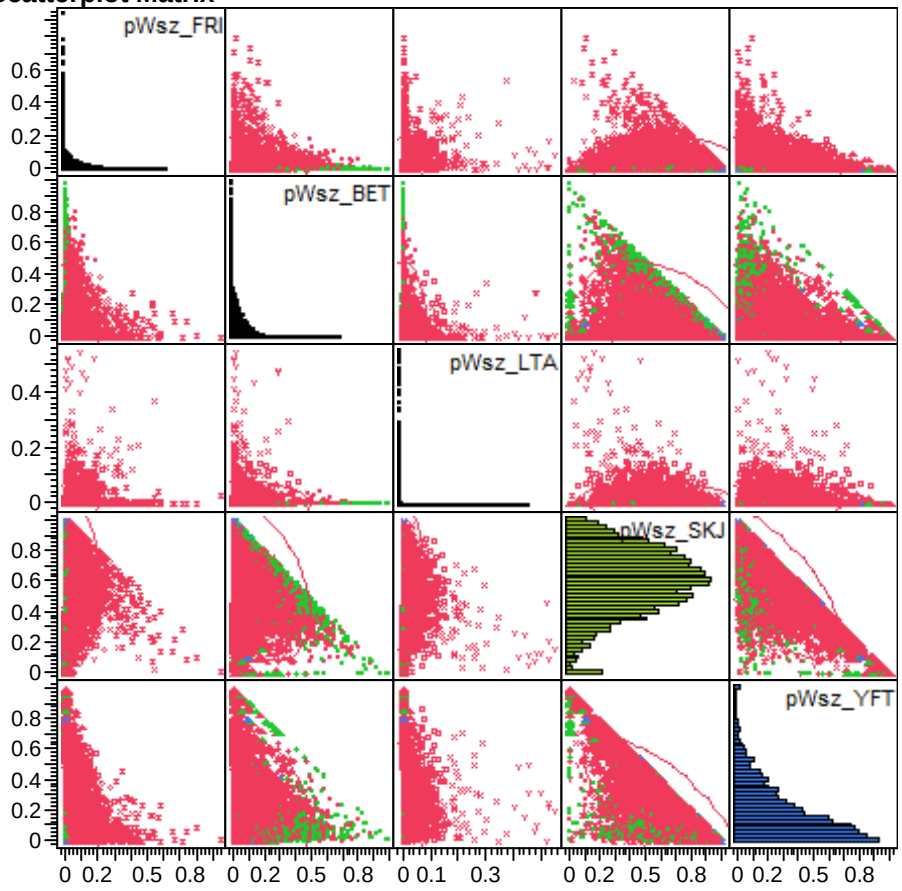
Color Map On Correlations



Multivariate Correlations

	pWsz_FRI	pWsz_BET	pWsz_LTA	pWsz_SKJ	pWsz_YFT
pWsz_FRI	1.0000	-0.1661	0.1290	-0.0684	-0.1575
pWsz_BET	-0.1661	1.0000	-0.1274	-0.4116	-0.2215
pWsz_LTA	0.1290	-0.1274	1.0000	-0.1531	0.0585
pWsz_SKJ	-0.0684	-0.4116	-0.1531	1.0000	-0.7306
pWsz_YFT	-0.1575	-0.2215	0.0585	-0.7306	1.0000

Scatterplot Matrix



Color Map On Correlations