SCIENTIFIC COMMITTEE
FOURTH REGULAR SESSION

11-22 August 2008
Port Moresby, Papua New Guinea

SPECIES COMPOSITION OF TUNA CATCHES TAKEN BY PURSE SEINERS

WCPFC-SC4-2008/ST-WP-2

Fonteneau A[1]

[1] IRD, Sete, France

Species composition of tuna catches taken by purse seiners

By Alain Fonteneau[1], IRD scientist

Summary

This paper makes a presentation of the multi-species size sampling that have been conducted in the Indian and Atlantic oceans since the early eighties allowing to estimate the average species and size composition of tuna landings by pole and line vessels and purse seiners. The paper further discusses the structural biases that are expected when sampling the complex mixture of sizes and species that are observed on FAD schools, when done by observers. It advocates the necessity to sample these catches using large scale port multispecies sampling schemes. The data processing of these multi species samples is also discussed, based the methods developed by EU scientists in the Atlantic and Indian oceans. The paper recommends promoting a unified sampling scheme of purse seine landings in the WCP and a unified data processing of these size and species samples. . Based on the Atlantic and Indian oceans species sampling, the implementation would necessitate to develop permanent teams of species and size samplers in selected major ports were tunas are transhipped or landed. The paper recommend to process all the WCP historical data of species composition using this new method, and to promote as soon as possible in the WCP such optimized sampling scheme .

1-Introduction

The goal of this paper is to discuss the best methods that should be routinely used under the WCPFC framework to sample the sizes and species composition of tuna catches landed by purse seiners. These purse seine catches are very important, as they constitute a very large fraction of world tuna catches (about 50%). It should be noted upon this very important question that two widely different methods are presently used in the Western and in the Eastern Pacific to estimate and to correct species composition of purse seine catches. The goal of this paper will be to examine and to discuss the best ways to sample and to process, without bias and at the best cost, the data concerning the species composition of these very large catches, based on the experience obtained from species sampling programmes that have been routinely in the Atlantic and in the Indian oceans since the early eighties.

[1] Fonteneau Alain, IRD scientist, CRH, BP 171, 34203 Sète, France. FONTENEAU@IRD.FR

2- Species composition of purse seine catches

Purse seine world wide catches tend to be dominated by skipjack (60% of world purse seine catches during recent years), but it is well known that this commercial category that is called “skipjack” in both the log books and in the transhipment statistics, tend to mix a wide proportion of small size tunas belonging to other species, such as small yellowfin and small bigeye. It has been also well shown by historical ICCAT works (such as an. ICCAT 1984) that small bigeye tunas are often misidentified in the landing statistics or in the log books as being yellowfin. This bias is easy to understand, simply because these two species are quite difficult to identify at very small sizes. This problem was first shown by Fonteneau in 1975 when the careful biological sampling of 177 small tunas classified in the statistics as being yellowfin, were in fact bigeye tunas. These misidentification uncertainties between small bigeye and small bigeye have been since widely confirmed and at a world wide scale.

As a result of these major statistical uncertainties, tuna scientists and tuna RFOs need to permanently estimate the real species composition of these purse seine catches, as well as their size distribution, using a permanent species sampling of these catches as well as an ad hoc data processing of these sampling data. Furthermore similar misidentification in the log books species composition has been also often observed for pole and line baitboat fisheries (Ghana, Maldives).

These multispecies sampling schemes were first initiated in the Atlantic by the EU scientists under the ICCAT framework in 1979, using a multispecies sampling done during the port landings or transhipments. The basis of such sampling was to simultaneously identify the species and size composition of large samples of tunas (about 500 fishes in each sample). Similar port sampling schemes were also successfully developed on pole and line fleets (Ghana) and in other areas by NMFS scientists in Puerto Rico and soon later in the Western Pacific (in Guam) since the early eighties. Very similar sampling schemes have been also routinely and successfully conducted in the Indian Ocean since the beginning of the purse seine fishery in 1983. More recently (since 2000) the same multispecies sampling became also the rule in the Eastern Pacific in the IATTC area (Tomlinson 2002). This new port sampling has been established by the IATTC since 2000 based on the observation that the species composition of tuna catches estimated by the observers always tend to underestimate the catches of small bigeye (among other bias). This major problem was faced despite of the maximum rate of observers, nearly 100%, in the IATTC purse seine fleets. As a result, the species composition of all the purse catches in the Atlantic and in the Indian ocean (since 1980 and 1982) and in the Eastern Pacific (since 2000) have been fully corrected, using the results of these large scale multispecies port samplings that have been simultaneously targeting the size distribution and the species composition of the landed tuna catches.

On the opposite, in the Western Pacific the situation is more complex[2]: on one side, several of these ports sampling have also been conducted (see Crone and Coan 2002), but large samples of species composition have been also obtained from observers at sea during the fishing operations and these data have been primarily used to estimate the species composition (Lawson and William 2005). The sampling protocol used by these observers was to <u>randomly select five fish in every brail</u> taken from the set. As a consequence, there is not presently a standard best method adopted and recommended by WCPFC and routinely used to correct the species composition of purse seine or bait-boats catches taken in the Western and Central Pacific. Furthermore, it is striking to note that the species composition estimated by the 2 methods, from port sampling or from

[2] and not very clear, at least for tuna scientists working in other oceans…..

observers data, tend to be widely different. These differences in the methods used to correct species composition may explain part or all of the differences in the species compositions that are observed in the WCPFC and in the IATTC areas (figure 1).

Clearly such situation is not satisfactory, and it is now urgent for WCPFC:

a) to determine what is the best method to correct the species composition of its tuna landings by surface fleets, with a high priority given to purse seine catches, but also keeping some control on the species composition of pole and line landings (keeping in mind that in the Atlantic both the purse seine and the pole and line catches have been facing the same bias, most often underestimating bigeye catches (these bigeye catches being reported either as yellowfin or as skipjack)
b) to routinely promote the use of this selected "best statistical method" on all purse seine fleets,
c) And to develop the optimal ad hoc software to correct log book data using these samples and to estimate the corresponding catches at size for each species.

The goals of this paper will be:

1) To make a brief overview and summary of the sampling method used in the ICCAT and IOTC areas to do this species & sizes sampling,
2) to show some of the typical results obtained in the Atlantic and Indian oceans from these multispecies port samplings,
3) To discuss the potential bias in each of the 2 sampling methods: by observers and in port.
4) to discuss the data processing goals and problems of these species composition samples,

3- Overview of the Atlantic and Indian Ocean multi-species sampling

3-1- Sampling method used and amount of data collected

The sampling method targets to simultaneously identify in each of its sampled well the species and sizes of all the tunas that are landed from the well. The well has been selected by the sampling team, has containing fishes from homogeneous sets that are well identified in the log books. Each sample contains approximately 500 tunas. All these tunas are measured, except skipjack, a species for which only the 50 fishes are measured and the other accounted for. In the original sampling developed in the Atlantic, all tunas form each sample were measured, but this method was spending too much sampling effort on measuring skipjack tunas, a species easily sampled because of its homogeneous size distributions.

These sampling programmes are conducted in the Atlantic (in the 4 major landing ports of Abidjan, Tema, Dakar and Cumana) and in the Indian Ocean in the 4 major landing ports of Victoria, Antananarivo, Mombasa and Phukhet). These programmes are conducted by quite large teams of well trained field technicians, approximately with a dozen of technicians (or more) in each ocean, each of these teams working under a close permanent control of a scientist (Quality controls being done from time to time in order to check the quality of sampling identifications and of size samplings)

As a result of these routine samplings, ran since 1980 in the Atlantic and since 1983 in the Indian oceans (beginning of the purse seine fisheries in the Indian Ocean), large numbers of size & species samples have been collected: as an example a total number of 11456 samples each one of about 500 fishes have been collected in the Indian Ocean during the 1990-2006 period. i.e. a total weight of 40150 tons of tunas have been measured or accounted for by scientists.

3-2- Data processing:

Strata: There is first an absolute need to identify homogeneous strata within which the size and species composition of the catches (for a given fishing mode and for a size category: small or large tunas) are considered to be homogeneous. This identification of these homogeneous strata can be based, either on visual methods (good seasonal maps), or using ad hoc statistical analysis (Petit et al. 199x). In the Indian Ocean the selected areas are given as an example by figure 2, the time strata used in the processing being the quarters.

Flag: In both the Indian and Atlantic oceans, it has been shown that **the flag of the fishing vessels do not play a significant role in conditioning the species composition** (within a given size category of fishes and for a given fishing mode). This interesting result allows to combine all the samples done on all flags of the purse seine fleets, and to process them in a unique pool of sampling data that is available for all purse seine fleets (see figure 3).

In the EU data processing the species and size composition of each set, knowing if the set was a FAD or a free school set, by size category (for instance fishes smaller or larger than 10kg) are registered in the original log books. The data processing allows to estimate for each of these set a corrected species composition (as described by Pianet et al. 2000). These corrections are done in parallel but independently for each flag, but always using the full sample of size and species composition. Such data processing allows to create the basic catch and effort data by 1° squares as well as the extrapolated sizes distribution of the catches[3] taken by each flag, these data being later used by the ICCAT and the IOTC to do their stock assessments. These extrapolated sizes distribution of the catches also assume that sizes taken were homogeneous within each quarter and each area[4].

4- Typical results obtained by the ICCAT/IOTC sampling

This species sampling and its data processing have been tools to provide to the ICCAT and IOTC the best estimates of corrected species composition and the corresponding sizes of these catches. The comparison between the original log book species composition and the corrected one shows that this sampling has been widely increasing the proportion of small bigeye and of small yellowfin that were recorded in the purse seine log books, and always decreasing the amount of skipjack. These typical changes in the species compositions are well shown by figure 4, showing the species composition of FAD associated catches by purse seiners in the Indian Ocean: between log books and best scientific estimates, bigeye catches have been increased from 5 to 9% of the total catches, yellowfin catches from 19 to 27%, when skipjack catches have been decreasing from 76 to 64% (small yellowfin and small bigeye being often classified by fishermen and by canneries as being “skipjack”, simply because they have the same prices (at small sizes). Similar corrections are observed each year. This basic routine correction of the species composition as well as the estimated catches at size of the EU purse seine fleets have been the major goal of these port samplings work.

It should also be noted that in the IOTC and ICCAT scheme, the basic files received by these RFO, used by scientists and delivered to external scientists are only the corrected data set: the original log book species compositions remain in the national data base, but both

[3] Extrapolated sizes being estimated by 5° month strata

[4] Keeping in mind that the original non extrapolated samples by month and 1° squares are also available to the ICCAT and IOTC scientists.

the global yearly catches by species, as well as the detailed catches of purse seiners by ° and month are always the corrected files, with the best estimates of species composition. This “uniqueness” of the best data base delivered and used has been a great advantage and simplification in the purse seine data handling by the ICCAT and the IOTC (as it is quite a nightmare to simultaneously handle the log book and the corrected data…).

However, it should also be noted that such species and size sampling can also easily provide multiple additional scientific results that can be of wide interest for scientists and for management of tuna resources. Some examples of these detailed basic results can for instance be found in the recent IOTC paper by Fonteneau et al. 2007. Some of the scientific results that can typically be obtained from such species & sizes sampling are shown by figures 5 to 7 from the Indian Ocean purse seine fisheries (period 1990-2006).

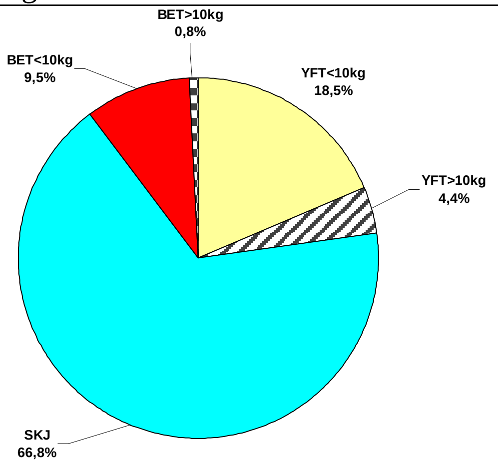
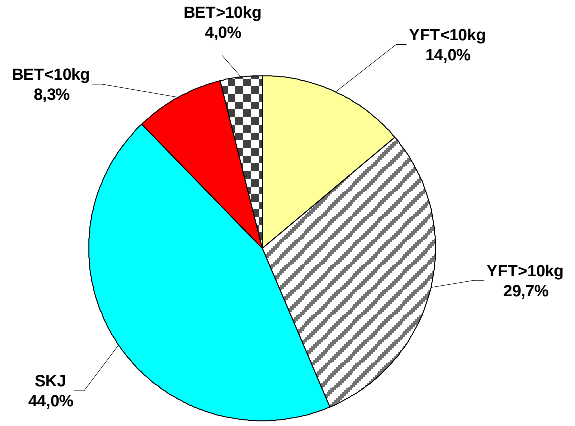
- ✓ Figure 5 showing the average species composition and the observed mixing of species in the FAD and in the free schools samples during the studied period; this figure shows how much the species compositions in the two types of schools are widely different in the Indian Ocean.
- ✓ Figure 6 shows the same result, but at a yearly scale and by area, and it shows that FAD species composition tend to be very stable (between areas and between years) when the free schools species composition tend to be much more variable between years and areas.
- ✓ Figure 7 shows the percentages of bigeye (in weight) in the FAD and in the free schools samples, classified by decreasing importance, observed in the Indian Ocean during the period 1990-2006. It appears that in the Indian Ocean these percentages of bigeye do show similar abundance patterns, bigeye being always much more abundant in FAD schools (being present in 80% of schools, and very abundant (more that 50%) in only 3% of the schools (figures taken from Fonteneau et al 2007)

5- Difficulties faced by observers and by port samplers to sample multispecies & multi-sizes sets

The average tuna school associated to FADs in the Atlantic and in the Indian oceans typically shows a wide range of species and sizes. As an example, 76% of the FAD schools sampled during recent years in the Indian Ocean had at least the 3 tropical species (yellowfin, skipjack and bigeye) and often in a wide range of sizes, but most often with a low proportion of large individuals. As an example the species and size composition of the average sample taken on FADs in the Indian Ocean is shown by the following table:

Species & size	Average weight of fishes (kg)	Average number	Weight of the category (kg)
YFT<10kg	3,1	102	315
YFT>10kg	28	24	669
SKJ	2,7	366	989
BET<10kg	3,6	52	187
BET>10kg	20	4	89
Total		548	2249

This table shows that large fishes over 10kg are quite rare in numbers (76 fishes on a total of 548, e.g. **14% of the total numbers**), when they have a large relative weight of **46%** in the same average sample. This table is more easily understandable by its corresponding pie figure:

	
Species and size composition in numbers of fishes of the average FAD associated school sampled in the Indian Ocean (1990-2006)	Same result expressed in weight of each species & size category

It is not clear how much the FAD schools in the Western Pacific do show similar patterns of sizes and species composition, but it appears that the type of heterogeneity dominant in the Indian Ocean would be very difficult or impossible to sample by the present WCPCF sampling scheme by observers, as the large fishes being very rare in numbers cannot be well sampled in a small sample: for instance in such an observer sample taking 10 times 5 fishes (e.g. 50 fishes sampled), the large yellowfin should have 2.4 large fish and the large bigeye 0.4 fishes sampled. And as these large tunas that are **rare in numbers, but abundant in weight** (nearly half of the school), and then **highly visible on the deck**, **will tend to be oversampled** (de facto in proportion of their weight, and not of their numbers, as it should be). Such well known sampling bias could easily explain the major differences noted in 2005 by Lawson and Williams, when catch estimates based on port samplings of the purse-seine catch during 1995–2003 was composed of:

=> skipjack =78.1%, yellowfin =19.7% and bigeye =2.2% ,

In the port samplings, when according to the observer data, these proportions were of:

=> skipjack =55,4% , yellowfin = 35.8% and bigeye = 8.8%.

The observer data also indicating that the main difference is the presence of more large yellowfin in the observer data than in the random sampling of catches done at landing.

On the other side, port sampling is not an easy task and it has been permanently facing various difficulties among others:

1) A need to have good log book data, with a precise identification of sets associations, and a good identification of wells were each set has been stored
2) A permanent difficulty for the sampling teams to identify small bigeye from small yellowfin even when they are frozen and in "bad shape" (this problem being perfectly solved for well trained technicians who are doing a careful sampling)
3) A permanent difficulty for the sampling teams to select the best wells to sample, based on the strata already sampled, and avoiding to sample heterogeneous wells (with FAD and free schools mixed, or with schools taken in remote strata)
4) The same need to select randomly each fish, giving to each fish an equal opportunity to be sampled, independently of its sizes or its facility to measure it

5) A need to have large samples, in a range of about 500 fishes each, and a need to do a rigorous counting of all the skipjack that are counted and not measured.
6) A need to permanently control the validity of size and species done in each port: a task that is easily done comparing species compositions and size distributions of fishes taken in the same 5°month strata but landed and sampled in various ports.
7) A need for scientists to control the validity of the strata used to process the data, and to permanently search for potential deficiencies in the samples or in the data processing.

These difficulties are never perfectly solved, but they should at least remain “under control” in a well managed sampling system fully coordinated by expert scientists. At least such system should provide realistic estimates of catches by species, including for small bigeye and for small yellowfin, as well as a realistic size distribution of these catches.

6- Data processing and extrapolation of species and size sampling

A quite complex task in the estimation of the log books corrected species composition is the data processing of the log books and size/species composition files. The data processing done in the EU purse seiners is summarized by figure 3, showing the framework of these calculations. Further details upon this species correction process are given in various EU working documents and in the paper by Pianet et al 2000. The main point is that all data processing are done using the same multispecies and multi countries file of size/species samples. The first an more important step of the calculations is to correct the species composition of each record in the log books files (a correction done country by country, but using the same sampling file). This correction uses large time and area strata (area shown by figure 2, and by quarter) based on the conclusion obtained by statistical analysis showing that species composition tend to be homogeneous within these large areas and quarters (within a given size range of mixed species). There is no doubt that this calculation of the best corrected species composition is quite difficult as it has been shown by the statistical analysis of this process done by US, IATTC and EU scientists. The statistical validity of these corrections being dependent of the quality and quantities of the sampling available, of the time and area variance of size and species compositions, and the quality of log books, and the data processing used. Despite of these multiple cascading difficulties, the corrected figures are probably always better and more realistic than the uncorrected ones.

The second step in the data processing is the standard preparation of 1° squares and monthly catch and effort data that will be later submitted to the various tuna RFOs.

7-Conclusion and recommendations

There is now an urgent need to select and to promote in the western and central Pacific the best sampling method allowing to estimate the exact quantities and sizes of tunas taken by purse seiners. This work is essential to estimate the exact level of small yellowfin and small bigeye caught by fisheries and then to make a realistic stock assessment of these two stocks of major importance. The sampling scheme should preferably be very similar in the entire Pacific Ocean, unless it can be demonstrated by the analysis that the regional fishing or landing “conditions” are so different that they do not allow having such best unique sampling scheme applied in the entire Pacific ocean.

Three recommendations could be envisaged at this stage:

- As a first recommendation, the easiest way to solve the present sampling uncertainties faced in the WCP would be to organize a **large scale port sampling of catches that have been already sampled by**

observers. Such double sampling by the 2 methods should be conducted on various trips; and the subsequent analysis of such double sampling should easily allow understanding the potential bias. It should also explain the large differences presently observed in the results obtained from the various sampling schemes.

- A second recommendation would be to **make a full use of the already collected port sampling data**, processing these data in an optimal statistical way, for instance combining all samples and processing them for all flags, and using an ad hoc time and area stratification.
- The final and main recommendation would be to **establish a routine global sampling scheme at the scale of the WCP** covering most major landing ports and more importantly all the major fishing strata. It could be accepted in such scheme that some flags would not be sampled, as in these case their species composition could be estimated by samples taken in the same strata (a method that has been often used in the ICCAT and IOTC areas for various IUU unsampled fleets of purse seiners). This potential sampling would be of course more difficult to conduct in the western and central Pacific than in the Atlantic and Indian oceans. As in these 2 oceans most of the tuna catches have been permanently landed by purse seiners in the ports of Abidjan (Cote d'Ivoire) in the Atlantic and Victoria (Seychelles) in the Indian Ocean. This permanent of the tuna landing and tuna transhipments allowed to establish in each of these 2 ports large teams of well trained technicians that have been permanently in connection with the tuna scientists from the fishery laboratories in Abidjan (CRO) and in Victoria (SFA). However, secondary sampling points well also established in various secondary ports (in Senegal and in Ghana for the Atlantic, and in Diego Suarez Madagascar and in Mombasa Kenya, in the Indian Ocean). In these 2 countries, smaller teams of sampling technicians have been permanently running the same sampling programme, using the same software to "key punch" their data. These data are transmitted in quasi real time to the central points where the data are centralized and processed. These technicians may well be "out of business" during several months due to the lack of tuna landings, but they are permanently paid by the sampling programme, and this running cost has been considered as being a reasonable one, taking into account the immense value of these sampling data. In the immense zone of multiple purse seine fisheries of the Western Pacific 14 ports of Pacific Island countries this programme should be centered on the port where the bulk of the tuna landings took place during recent years such as Pohnpei, Majuro and Rabaul. Other ports such as Honiara, Tarawa and Chuuk could also need smaller secondary sampling teams. These tuna sampling should/could also be envisaged in the ports where canneries and/or loining plants are established and where purse seiners may land there catches such as Pagopago, Noro, Madang, Lae, and Wewak. This sampling scheme should of course also cover the Indonesia/Philippines purse seine fisheries, but this question is now treated under a peculiar and separate sampling programme. As a conclusion, there is no doubt that a full scale permanent sampling of purse landings in the Western and central Pacific would be much more difficult and more expensive to run than in the Atlantic and in the Indian oceans. There is no doubt that if this sampling programme is envisaged, it should be necessary

to carefully analyse the optimization (maximum of statistical efficiency) and on the cost (minimal cost), targeting the selection of the best landing places where the most efficient sampling can be done at a reasonable cost and under a permanent scientific control. This sampling plan should also take into account the time and space variability of the landing ports of mobile purse seiners, for instance being ready to sample catches during El Niño years, even if landing ports are different.

Cited litterature

An. ICCAT 1984. Meeting of the working group on Juvenile Tropical Tunas (Brest July 12-21). Col. Vol. Sci. Pap. ICCAT, 21 (1): pp 1-289.

Crone P. and A. Coan 2002. Sampling design and variability associated with estimates of species composition of tuna landings for the US purse seine fishery in the Central and Western Pacific (1997-2001). Doc SWG 9, submitted to the SCTB 15 meeting in Hawaii; 9 p.

Fonteneau A. 1975 Note sur les problèmes d'identification du bigeye dans les statistiques de pêche. Rec. Doc Scient ICCAT, Rec. Doc. Scient. ICCAT, Vol IV, 8p.

Fonteneau A, J. Ariz, A. Delgado de Molina, J. Dorizo, V. Lucas, and R. Pianet. 2007. Species composition of FAD and free swimming schools fished by purse seiners in the Western Indian Ocean during the period 1991-2006. Document IOTC-2007-WPTT-05. 26 pages.

Lawson T. and P. Williams 2005. Comparison of the species composition of catches by purse seiners in the Western and central Pacific Ocean determined from observer and other types of data. Document WCPFC-SC1, ST WP-4; 21p.

Pianet R, P. Pallares and C. Petit 2000. New sampling and data processing strategy for estimating the composition of catches by species and sizes in the European purse seine tropical tuna fisheries. IOTC Proc., Vol. 3, pp. 104-139.

Tomlinson P.K. 2002. Progress on sampling the Eastern Pacific Ocean tuna catch for species composition and length-frequency distributions. Inter-Amer. Trop. Tuna Comm., Stock Assess. Rep., 2: pp 357-365.

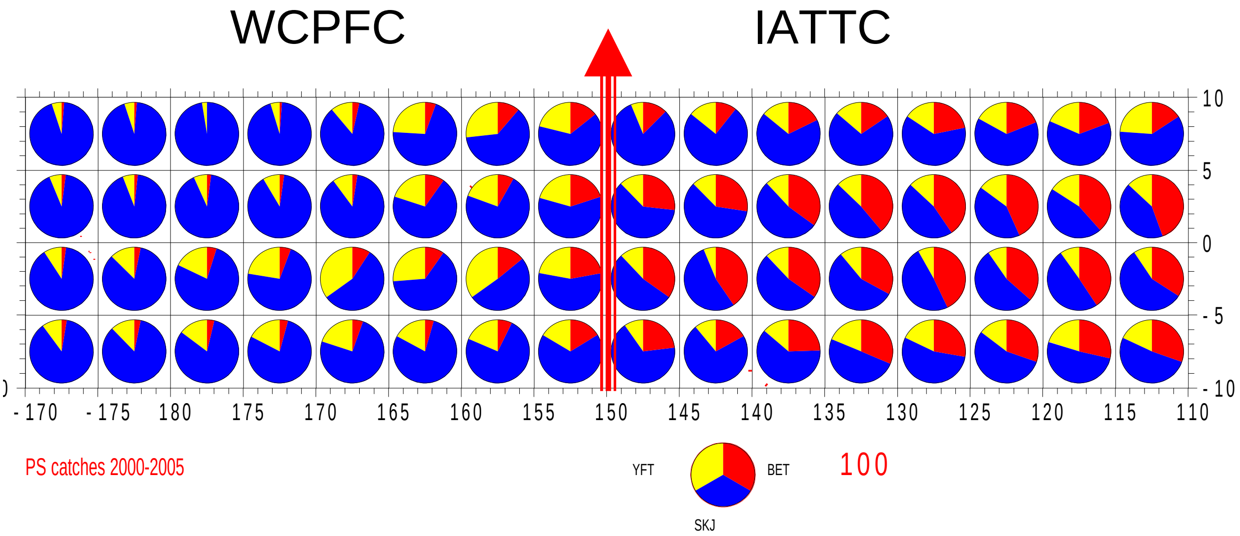


Figure 1: Average species composition (in %) of the FAD associated catches during the period 2000-2004.
NB: The difference between the large percentage of bigeye observed in the Eastern pacific IATTC area (east of 150°W) and the areas West of 150°W m ay be real real ones (2.5 % of bigeye in the mapped Western area and 21 % in the Eastern area), but they may also be due to the heterogeneity in the statistical methods used in the 2 areas.

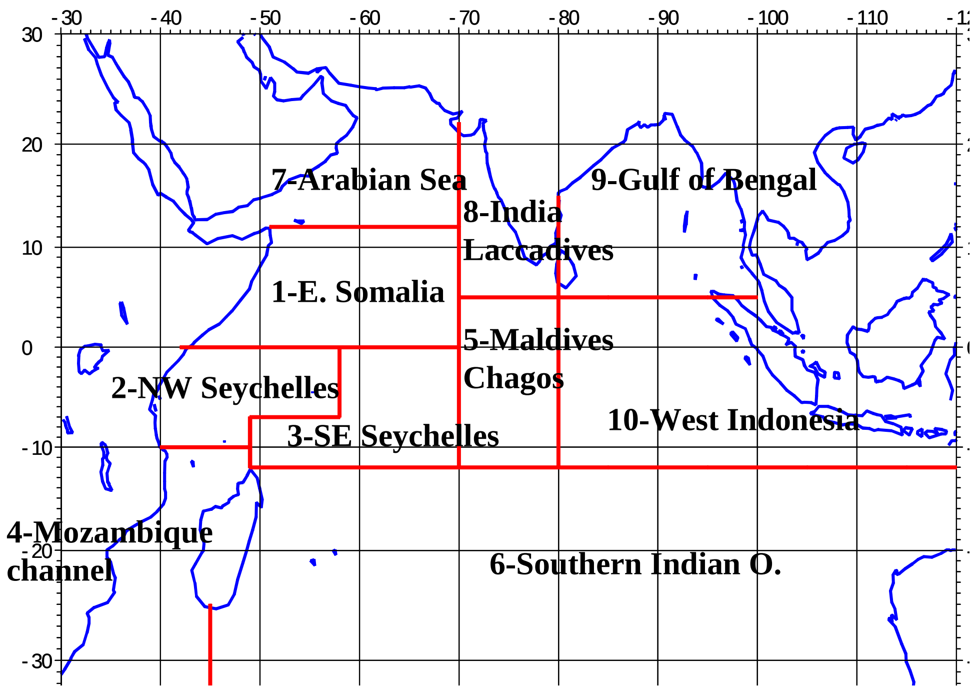


Figure 2: Example of the areas used in the data processing and extrapolation of species samples of purse seiners in the Indian ocean

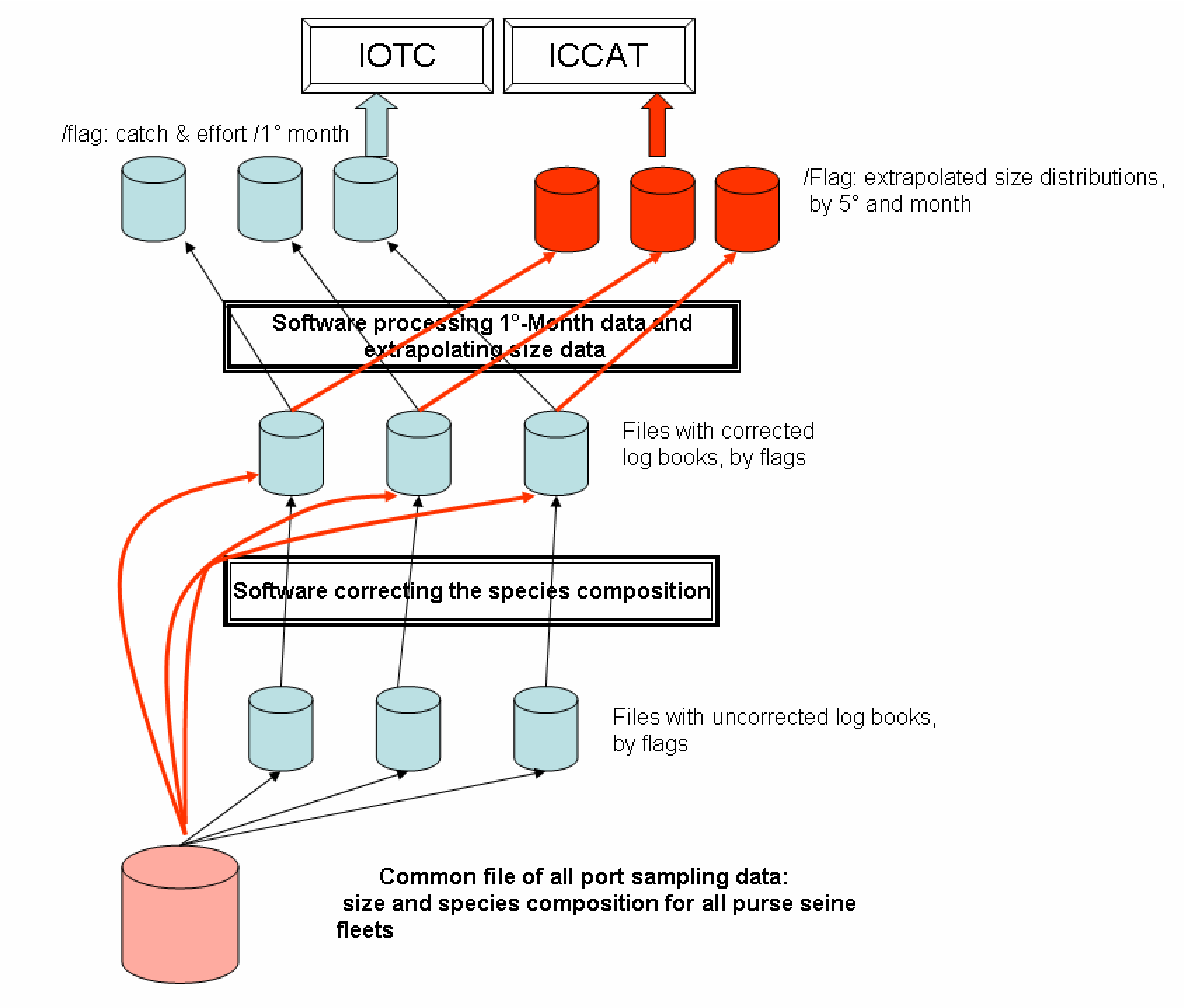
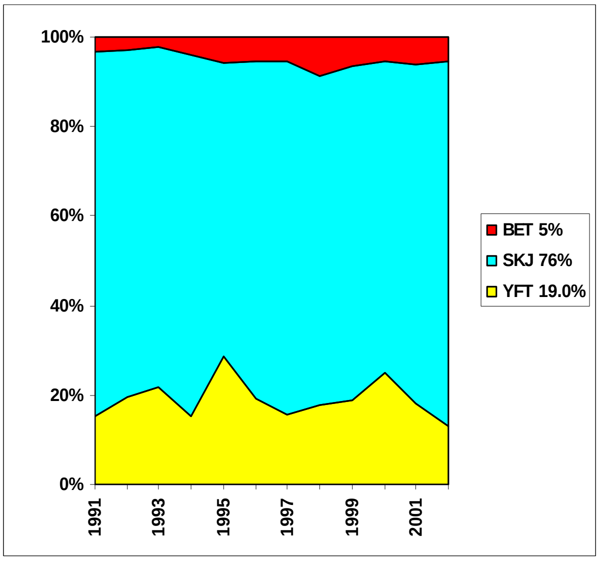


Figure 3: Conceptual organigram of the data processing of size and sampling composition of the EU purse seine data in the Atlantic and Indian oceans (since 1980)



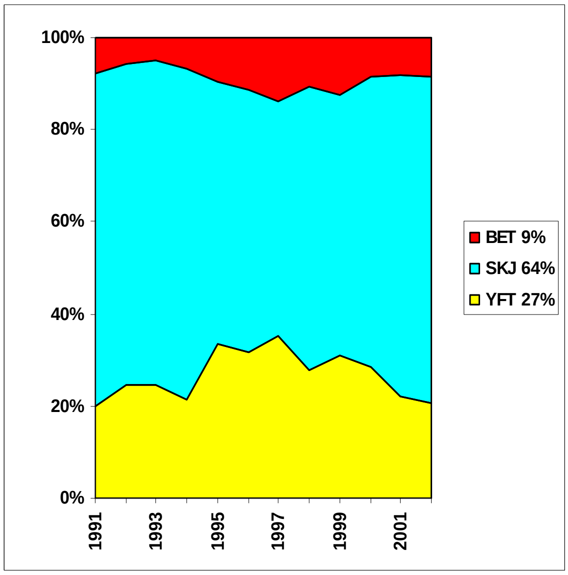
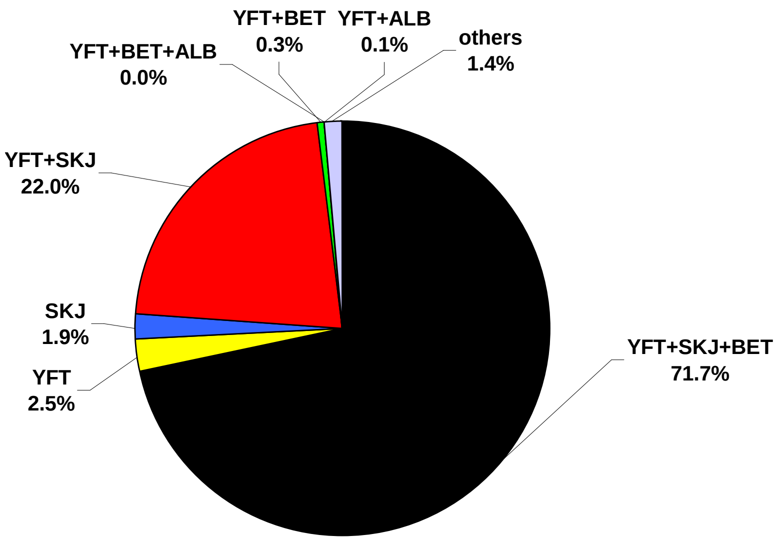


Figure 4: Species composition of FAD associated purse seine catches in the Indian Ocean as recorded in the log books and after correction of their species composition



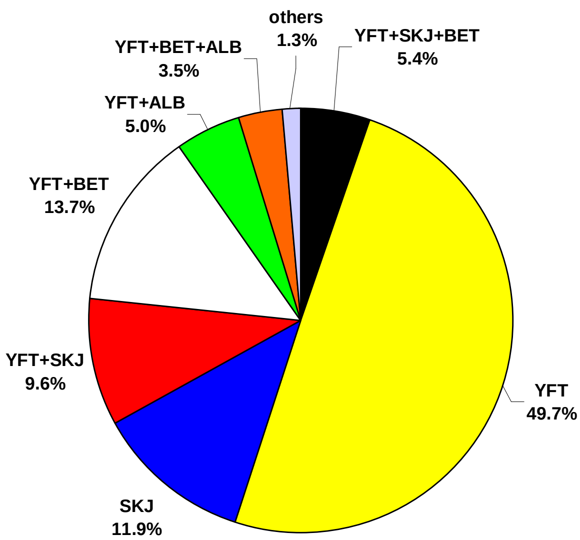


Figure 5: Average species composition of the FAD (5a) and Free schools (5b) samples and frequency of the various types of species composition observed in the Indian Ocean selected species samples (1990-2006) (figure taken from Fonteneau et al 2007)

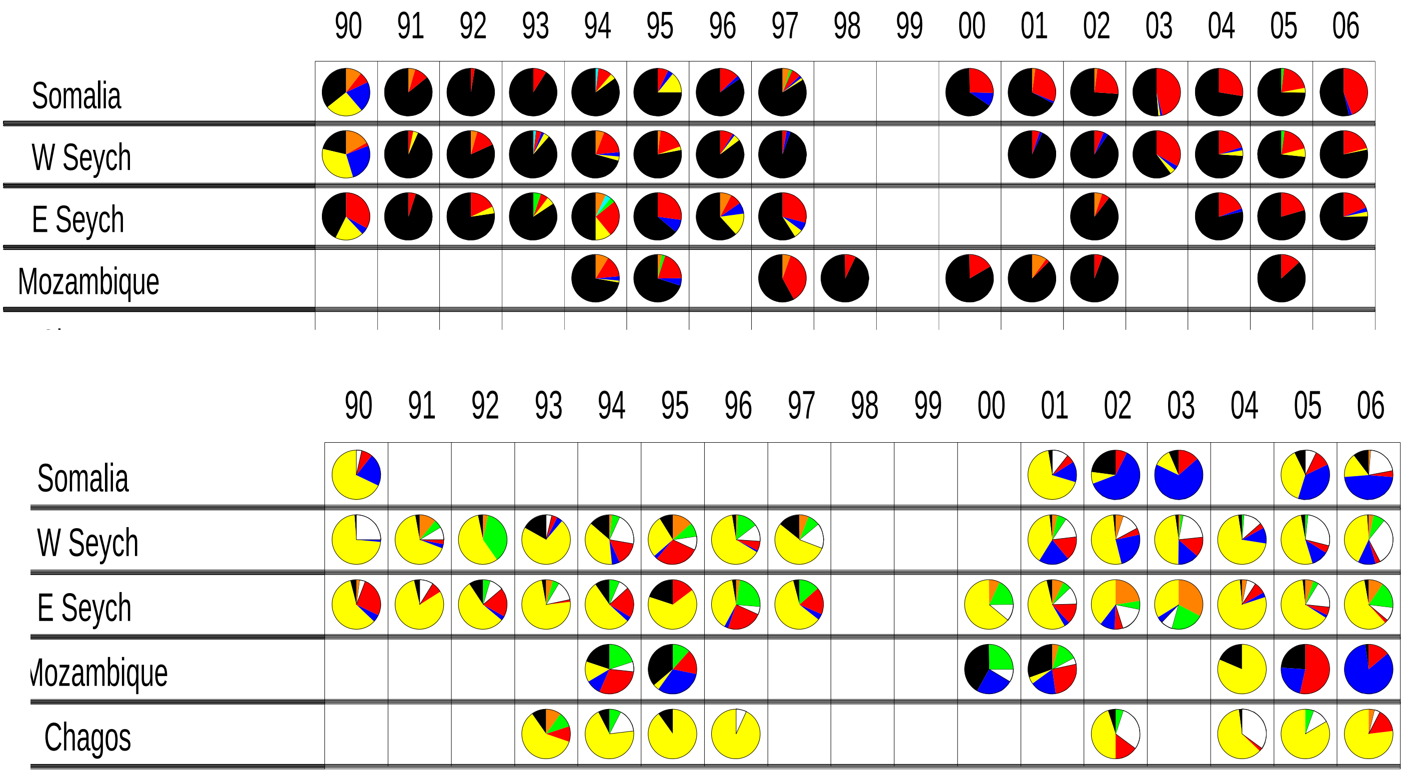
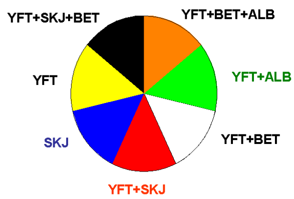


Figure 6: Frequency of species composition observed In the FADs (upper fig) and in the free schools samples (lower fig) expressed in % (only for strata with more than 10 samples each year) (figure taken from Fonteneau et al 2007)



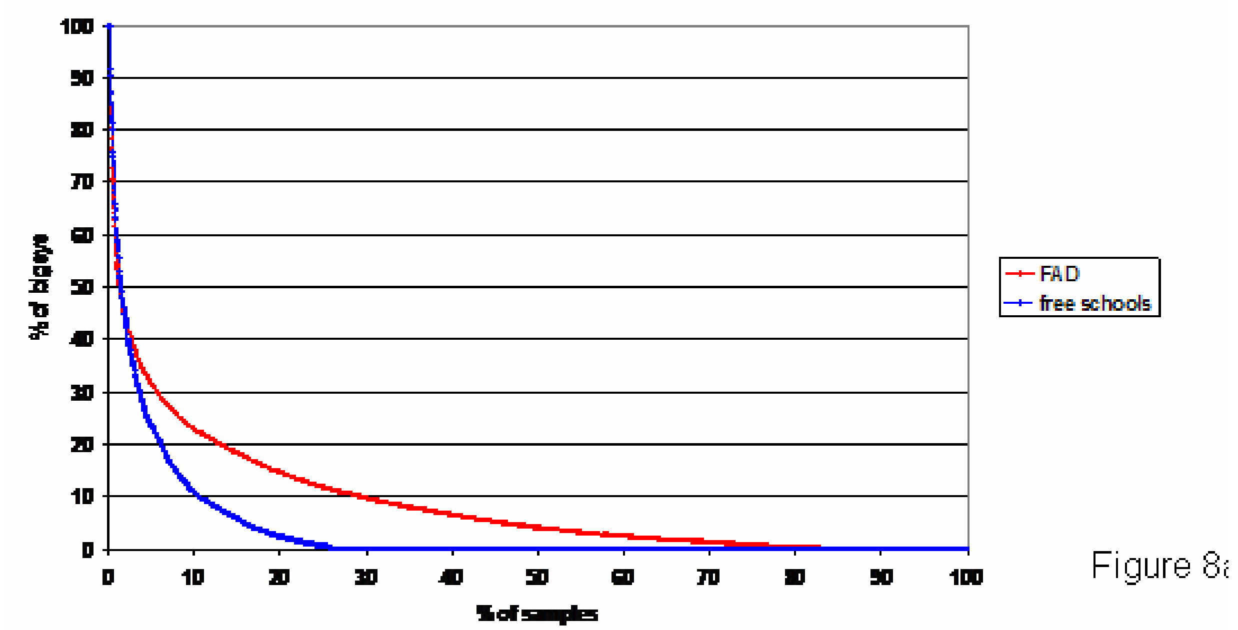


Figure 7: Percentages of bigeye (in weight) of in the FAD and in the free schools samples, classified by decreasing importance, observed in the Indian Ocean during the period 1990-2006 (the 5440 FAD and 3813 free schools samples being classified in the same scale of percentages) (figure taken from Fonteneau et al 2007)