RECENT ESTIMATES OF THE SPECIES COMPOSITION AND SIZE SAMPLING OF EU PURSE SEINERS: PROBLEMS IN THE ESTIMATED SPECIES AND SIZE COMPOSITION AND PROPOSAL FOR REVISED 1998 AND 1999 CATCHES AND SIZE STATISTICS

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Summary

This document analyzes the various problems and bias found during recent years (mainly 1998 and 1999) in the collection of size and species composition of the European Union purse seiners sampling in the Indian Ocean. The major problems detected were due to a combination of factors, primarily the difficulties due to the implementation during 1998 of a completely new sampling scheme, but also a poor quality of the samples on many landings. The paper analyses these problems. The quite poor coverage of recent sampling is probably in relation with inadequate instructions given by scientists concerning the sampling rules of the new larger strata. A bias of the odd/even classes was found on many samples in both predorsal and fork length samples. This bias seems to be due to a combination of poor sampling equipment and lack of care by some samplers. The more serious problem identified was a poor species identification between small yellowfin and small bigeye in many samples. A new data processing was carried out for the period 1998 and 1999 based on a selection of the best samples (size and species composition). This new set provides revised estimates of total catches by species and of sizes taken by species for each of the countries concerned (France, Spain and various NEI associated flags). This revised file appears to be more reliable because a reasonably large number of good samples covering quite well the entire fishery were used in its calculation. These new files have been submitted to the IOTC and should be used as a replacement of the files which were submitted in September 2000.

Résumé

Ce document analyse les divers problèmes et biais récemment identifiés (principalement en 1998 et 1999) dans la collecte des échantillons de tailles et d'espèces réalisée sur les senneurs de l'Union Européenne. Les principaux problèmes identifiés sont dus à une combinaison de divers facteurs. Le premier est du à la mise en œuvre en 1998 d'un tout nouveau système d'échantillonnage, mais aussi à la médiocre qualité de nombreux échantillons. Cet article analyse ces problèmes. Le faible taux de couverture des échantillonnages récents est probablement du à des instructions peu claires données par les scientifiques aux techniciens quant aux règles à appliquer pour bien échantillonner les nouvelles grandes strates. Un biais dans la distribution des classes paires et impaires a été fréquemment identifié tant dans les longueurs prédorsales que dans les longueurs à la fourche. Ce biais semble du à plusieurs facteurs, entre autres l'emploi de mauvaises règles de mensurations, et aussi un manque de soin dans certains échantillonnages. Le plus grave problème identifié est celui de la mauvaise identification spécifique entre les petits albacores et patudos. Un nouveau traitement des données de la période 1998 et 1999 reposant sur une sélection des bons échantillons (tailles et composition spécifique) a été réalisée. Ces nouveaux traitements permettent d'obtenir des estimations révisées

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des prises totales par espèces et des tailles capturées par les senneurs des divers pays concernés (France, Espagne et divers pays NEI associés). Ce fichier révisé semble être satisfaisant du fait qu'un nombre important d'échantillons corrects et couvrant assez bien la pêcherie. Ce nouveau fichier a été soumis à l'IOTC et il devrait être utilisé en lieu et place de celui qui avait été soumis en Septembre 2000.

1- INTRODUCTION

All purse seiners belonging to the European Union (and to various other NEI flags) have been well covered by detailed statistics since the beginning of their activity in the Indian Ocean in the early eighties. Very early a sampling scheme targeting a good estimation of the size composition of landings in various Indian Ocean ports, and so, to be able to correct the species composition of the log books, was developed by scientists in charge of this fishery. However, during the mid nineties the statistical analysis of the method used and of the results obtained by this sampling has shown that significant improvement in the data quality could be obtained with a new sampling scheme associated with an improved statistical data processing of log books and size samples. This new statistical sampling has been progressively implemented in the various landing places (Victoria, Diego and Mombasa) on all the EU purse seiners landings. However, and unfortunately, the analysis of this new data set done recently has shown various deficiencies in the data collected during these recent years due to additive reasons. These problems were mainly an incorrect implementation of the new sampling scheme in some ports, added to various technical problems and systematic biases in many samples. The goal of this paper will be first to explain briefly the old and the new statistical sampling (chapter 2), and to clearly identify the problems, their nature, location and periods encountered in the size and species sampling of the EU purse seiners (chapter 3). The last chapter will present an alternative data processing of the recent log book data base and sampling, which allows to partly circumvent the various sampling problems identified for recent years and to provide corrected figures of species composition and sizes (chapter 4) taken by the EU purse seiners.

2- OLD AND NEW BIOLOGICAL SAMPLING

The multi-species nature of tropical tuna surface fisheries gives rise to a series of difficulties at the time of estimating basic catch by species and catch by size statistics. This complex problem, which is common to all world tuna fisheries, is tackled at different levels according to the fisheries. On one side, this complexity is mainly coming from the heterogeneity of i) the species composition of the set, and ii) the size ranges of the larger species, yellowfin and bigeye; it is also largely associated to the set type, log or free school. It is clear that any reliable stock assessment needs to have a good estimate of the total catch and sizes taken. However, although the total purse-seiners landings are precisely known (they are always weighted), the species composition is often unreliable: on one side "eye-estimates" catch weight and species composition of each set are done by each skipper in the logbooks, on the other accurate weight of commercial categories for unloading. As an example, for the French fishery, bigeye less than 3 kg where classified as yellowfin, when the " skipjack" processed by canneries was in fact a mixture of skipjack, and small yellowfin and bigeye.

This problem of bigeye and yellowfin misidentification in the landing statistics was discussed first by the ICCAT SCRS in 1975 following the paper by Fonteneau (Fonteneau 1976). Following these discussions a multi-species sampling scheme was established in the Atlantic in 1979 on the landing of all purse seiners. Following this implementation, the ICCAT Working group on Juvenile Tropical Tunas held in Brest, 1984, analyzed the results of this new sampling scheme and fully confirmed that there were large biases in the species composition of both the log books and the landing commercial figures.

This first multi-species sampling was developed in the Atlantic in 1979; it was a size sampling done in proportion of the weight of each species, with a stratification of sampling by large size categories (which are most often well coded in the logbooks). In 1985, an improved new sampling strategy was developed following the same guidelines (Bard and Vendeville, 1985) – implementing an allocation of samples by number and size and proportional to time-area strata catches – and tested during ICCAT's Yellowfin Year Program (1986-89). This resulted in the "traditional" sampling strategy – a multispecific simple random sampling, *i.e.* without any size or species selection – which is since used in the Atlantic. This scheme was transferred in the Indian Ocean in the beginning of 1989.

Relatively quickly, it appeared that these procedures were technically difficult to implement in the Indian Ocean; this led to a separation of sizes and species composition sampling, the sizes sample for the different species being done between two species composition samples. In theory, this method was supposed to keep the benefits of the random sampling strategy, avoiding the technical difficulties linked to the simultaneous sampling of all species landed. Another advantages was to limit the small tunas size sampling to a reasonable level. However it was not demonstrated if this procedure was statistically a valid one.

Another question raised with the rapid development of a new fishing strategy in the early 90ies: setting on artificial logs (Ariz *et al.*, 1993 and 1996; Bard *et al*., 1985; Fonteneau, 1993; Pallarés *et al*., 1995). This phenomenon and its consequences on the sampling procedures were soon identified in the Indian Ocean, where a specific sampling strategy allowing to separate log and free schools catches was developed (Hallier, 1985 and 1991) in order to improve the estimate of species and size composition of the purse seine catch. This has led to some divergence in the processing methodology between the Atlantic and the Indian Ocean fisheries, both dominated by the European Union fleets, as this was clearly confirmed at the 1991 ORSTOM workshop held in Paris (Pianet, 1995).

In order to maintain and to improve the quality of these data bases as well as to standardize the procedures in the Atlantic and Indian oceans, Spain and France – the countries most closely involved in the Atlantic and Indian Ocean purse seine fisheries – have conducted a joint project financed by the European Union (Pallares and Nordstrom, 1997) to undertake the analysis and design of a new sampling and processing system for surface fleet tropical tuna catches. Within the framework of that project, named "Analysis of the Tropical Tuna Multi-species Sampling Scheme" (*alias* ET), the appropriate studies were performed for the development of a new sampling scheme and data processing system for the purse seine fleet catches in the Indian and Eastern Atlantic oceans.

The main results of this analysis were to generalize the log/free school stratification already used in the Indian Ocean, to define a new spatio-temporal stratification for sizes and species composition sampling, to come back to a real (or as close as possible) random sampling scheme for each stratum, and to consider the whole European fleet as a single fleet.

At the same time, a new common software to enter and verify data (AVDTH) as well as a new data processing set of programs (T3) were designed in order to replace the old software ORSTHON in the Indian Ocean as well as the software and data base used in the Atlantic (using now the same software and data base system for the two oceans). This new system was set out in order to fully take in account the new sampling scheme as well as a better logbook information, particularly on the set type and size category of the catch. However, if this new system is efficient, it is much more dependant on the quality on the data gathered and more challenging in its implementation.

The results and conclusions of the ET research program and the new sampling procedures basis were presented at the last IPTP meeting (Pianet *et al*, 1998, Herrera *et al*, 1998), and a detailed description of the implementation of the old and new sampling procedures used in the Indian Ocean at the last WPDCS (Pianet, 1999).

3- OVERVIEW OF THE PROBLEMS ENCOUNTERED

The following types of problems were encountered

3.1- INADEQUATE SPECIES COMPOSITION BETWEEN SMALL YELLOWFIN AND SMALL BIGEYE,

It is well known that only well trained technicians doing a careful examination of each tuna, one by one, can identify with a low rate of misidentification small bigeye from small yellowfin when fishes are frozen. This simultaneous combined good training and great dedication of the sampling team is very difficult to maintain, especially when sampling technicians are mobile in the assignation of their job. This very serious potential problem has been faced world wide by many tuna sampling schemes.

Controls done recently in the field concerning the quality of the species identification between yellowfin and bigeye done by technicians has shown a significant proportion of species misidentification. This species misidentification seems to produce an overestimation of bigeye tunas in the samples, and then in the estimated catches of bigeye (and correspondingly an underestimate of yellowfin). It is clear that when this error occurs, the size distribution of both species becomes unreliable as it was obtained by a combination of the sizes taken from the two misidentified species. One immediate consequence of this species misidentification is that the size distribution of yellowfin and bigeye tend to become too much homothetic. This is for instance well shown by figure 1b, showing the total size distribution in the Somalia area, during the fourth quarter of 1999, for yellowfin and bigeye (a majority from the Victoria sampling). Based upon a long experience on size sampling of the two species, any tuna expert can conclude that the two size distributions of yellowfin and bigeye shown in figure 1b are too much homothetic.

It should be well accepted that the size distribution of small yellowfin and of small bigeye in a multi species sample are very much the same as shown by figure 1a, because both species are in the same range size of small fishes (as because of the gear selectivity all these small fishes are kept in the net). It should also be noted that when the data are processed using only the Mombasa and Diego sampling (as described in paragraph 4.1), the size distributions of the two species are now similar as shown by figure 1c, but with reasonable differences in their shape and patterns. This new corrected size distributions of yellowfin and bigeye was obtained on a large samples of 5324 yellowfin and 999 bigeye measured in Diego and Mombasa.

However, despite of this general similarity in their sizes, the modes and holes in the size distributions of the two species tend to show significant differences. These consistent differences in the size distribution of YFT and BET are due to the proper biological characteristics of each species, such as their natural mortality, growth, seasonality of recruitment, movement patterns, etc, and also of their specific behavior. It would be very unlikely to get exactly the same size distribution of the two species in any tuna school. All the detailed size sampling confirms this rule when they are done carefully and without errors in size measurement or in species identification.

This potential problem is also shown by figure 2 showing the YFT and BET sizes in two original samples taken in 1994 and in 1999. The sizes sampled in 1994 are quite typical of the similarities and differences most often seen for YFT and BET (for instance in the Atlantic where multispecies sampling has been done extensively since 1979). On the opposite, the excessive similarities between the YFT and BET sizes sampled in 1999 are quite unexpected and are probably the result of a poor species identification. When such homothetic sizes of YFT and BET are sampled, these size distribution should at least be validated immediately by a control of species composition done by another team.

The correlation between the size distribution of yellowfin and bigeye in each sample has been calculated using the rank correlation of Spearman (as this correlation is not assuming normal distributions of the variables). The probability of a significant correlation between size of the two species was calculated; the percentages of high correlation at a 99% level was calculated for all samples and they are given by port and year in figure 3.

The highest proportion of highly significant R was observed in Victoria sampling in 1999, but also in 1997. This problem of potential species misidentification should be further analyzed (for instance comparing results of sampling done in the various ports of yellowfin and bigeye taken in the same strata).

The results shown by this figure of increasing and high correlation between sizes of yellowfin and of bigeye cannot be used as a proof of species misidentification. However this very large frequency of significant correlation between sizes of the two species is obviously highly suspect. In fact, field controls were already done on the field in Victoria port and they have shown that some technicians were often misidentifying small bigeye in their size measurement (either by lack of expertise of by lack of care); it is obvious that when this error is frequent, the histograms of the two species will tend to be homothetic.

This bias in the species identification of small yellowfin and small bigeye is really the worse potential problem in such a multi species sampling scheme. Such a problem is ruining the entire sampling scheme, and leading to false estimates of total catches by species and to false estimates of catches by sizes and by age for the two species. It is then highly recommended to take every possible actions to solve this problem immediately and to ensure that a good species identification will be permanently maintained in the future.

3.2- TOO LOW SAMPLING RATES

The new sampling system is now based, to a wide extent, on the statistical result showing that tunas taken on free or logs schools do show similar sizes and species compositions over quite wide areas and during long periods of time. Based on this statistical result, the new sampling scheme developed since 1998 and fully implemented in 1999, is now targeting to obtain at least a minimum number of samples by large fishing areas (see figure 4) and by quarter. The goal of this new sampling was to avoid to do many substitutions of samples between very large numbers of small 1º squares, month and fishing mode strata, for the estimation of the total catches at size, a key data needed for VPA analysis.

The analysis of the implementation of this new sampling scheme has shown that serious misunderstandings between field technicians and scientist occurred in the interpretation of these new rules. As a result, the analysis of sampling rates is showing that:

- The recommended minimum level of sampling per quarter and large areas (figure 4) which was planned to well cover each stratum, has sometimes been misinterpreted, at least in some ports, as a sampling target.
- Many significant smaller strata, for instance at the 5° squares and month levels, were not well sampled, or not sampled at all, simply because the area-quarter strata was considered as already enough sampled. It is clear for every tuna expert that all these large areas show some spatial and seasonal variability during each quarter. This intra stratum variability cannot be neglected and is worth to be sampled.

This decrease of the sampling coverage is well shown by various indicators of the sampling results. This is for instance the case for the indicators given in table 1, based upon the sampling done in each of these 5°-month strata. This table gives the percentage of reasonably good samples by 5°-month strata, this rate of good sampling being chosen at a minimum number of 200 fishes of each species measured per strata. This table clearly shows that in most strata, with low, medium or high catches of the given species (yellowfin, skipjack or bigeye), the sampling rate has been quite poor since 1998, date of the implementation of the new sampling scheme. Similar results are found when other indices of “good sampling” are used in the analysis . This is for instance well shown by table 5 showing the total tuna catches by purse seiners in each area, by quarter, during 1998 and 1999, and the number of fishes sampled (from Diego and Mombasa only) for each of these strata (strata well sampled are in bold, The conclusion is then that a large proportion of small units, such as the 5°-month strata, have been poorly sampled during recent years. This tendency to decrease the sampling rates may be a consequence of the new sampling scheme, but however it should be noted that the recent number of samples are much lower than the levels recommended by the new ET sampling rules (see annex 1); it appears also that nowadays with this decreased sampling, many small scale strata are not well sampled.

The simple table 2 showing the numbers of multi-species samples collected yearly on the purse seine fleet is also pointing out the same tendency of reduced number of samples. This table shows that the lowest sampling rate was observed in 1998, partly because of the progressive implementation of the new sampling scheme and of the corresponding new data entry. It is also showing that the number of samples taken in 1999 is similar to the level obtained in 1997.

One of the most striking facts in the comparison between the 1997 and 1999 sampling is that for the same numbers of total samples taken in each of these 2 years (528 and 527), the coverage of this sampling by small strata 5°-month has been very poor in 1999, as it was well shown by table 1. This means that the samples taken have been concentrated in a small numbers of 5°-month units, instead of being well scattered over most of the significantly fished 5°-month strata, as it was highly targeted in the previous sampling scheme. In that order, the former sampling done in 1997 was clearly the better one.

Other indicators of this type of problems are also shown by the comparison of landings by size of fishes and sampling done; for instance a total of 1800 tons of small yellowfin (less than 10 kg) was fished during December 1999, and none of these fishes were sampled. This complete lack of samples can be explained, either because the minimum of samples needed for the quarter and area strata was already reached, or by other reasons.

As a conclusion, it should be recommended to increase the size sampling rate, going back for yellowfin and bigeye to levels of sampling which were obtained until 1997 (not for skipjack which was clearly over-sampled) and to better sample all the significantly fished 5°-month strata, without being prisoners of the new sampling rules which are providing quite confusing minima by large sampling areas and by quarter.

The **sampling tactics and strategy** should be quite simple to conduct:

- Strategy: The global plan would remain to well sample at the recommended levels the large time and area strata which are used in the data processing and raising of size frequencies.
- Tactics: the tactics of sampling within each of these strata would be to scatter this sampling as much as possible over time and areas. This tactics should for instance warrant that when a large amount of tunas is taken in any 5°-month sub area of each strata, it should be well sampled.

This sampling problem of the size of the sampling units targeted by the sampling scheme is in fact a fundamental one that needs to be further discussed by the Scientific Committee.

It is highly recommended that this question of the size of sampling units should be discussed by the IOTC Sub Committee of statistics, and a clear recommendation must be done on this matter.

3.3- BIAS IN THE EVEN AND ODD SIZE CLASSES

3.3.1- Overview of the odd/even bias

This bias has been often found in fish size sampling. It tends to produce an underestimation of all the odd classes (or of the upper ½ cm in the predorsal length), and a subsequent overestimation of the even class (or lower ½ cm). This bias can easily be simulated assuming a given percentage of “lost fishes” in the odd classes. The results from such a simulation are shown in figure 5.

The typical result of such a bias is a length frequency showing a typical “switchback graph” (with lower odd values) which should never be observed in tuna size distributions when large numbers of samples are available.

- The three main causes of such bias are:a lack of care by the technicians in the sampling,
- a ruler of poor quality, with a poor design or poor condition of the numbers in the rulers,
- the classical problem linked to ½ cm intervals using conventional rulers.

3.3.2- The odd/even bias for small tunas measured in fork length

 # The problem

In the size data submitted to the IOTC for the EU purse seiners, this problem is visible for skipjack, small yellowfin and small bigeye data during recent years (given by 1 cm) as it is shown by figure 6 giving the recent yearly size distribution of skipjack. The same bias was also found for small yellowfin and small bigeye when these small classes are often quite interesting for various stock assessment analysis (growth studies and others). This bias is observed mainly in the recent Victoria sampling, and not so much in Mombasa or Diego, or in any previous sampling (figure 6).

This bias is difficult to identify and to demonstrate on a given sample, as most samples have a small number of fish measured (about 50 to 100 fishes are measured per sample, and distributed in a range of about 15 to 30 different classes). The ideal analysis would be to analyze this potential bias knowing the name of the technician in charge of the size reading for each sample, and analyzing the combined samples taken by each technician over a given period. However, this information on the names of samplers is not available in the computerized data base and this analysis will then be limited to the analysis of the potential bias by port and year.

 # Extent of this bias in the data base

This bias is quite easily identified by eye when the histograms of size distributions are available on a screen or on paper. However it is quite difficult to handle the size distribution of several species, during many years, and by port of sampling. An empirical test of suspected “switchback effect” was then built on an ad hoc basis. This test was established as following:

- Good histogram of tuna sizes are always showing smoothed values when enough fishes are sampled: in this case, the smoothed size distribution and the original ones are always very similar,
- The smoothed sizes (using mobile averages over 3 points) were then calculated for each yearly size distribution collected in each of the three sampling locations of the purse seiners (Victoria, Diego, Mombasa);
- This smoothed size distribution was compared with the original one, calculating an index of cumulated differences between these two curves. This SE index gives, in percentages, the level of heterogeneity between the two curves, which is most often due to this “switchback effect”.

$$\mathbf{SEI} = ?\ i\,\mathrm{abs}(FL_i - \text{smoothed } FL_i)/Nb*100$$

(for each size class in the distribution)

It was shown on simulated data (see figure 7) that high levels of this index (for instance over 25 or 50) are most often in good agreement with a visual inspection of histograms and they do indicate that this “switchback effect” is significantly occurring.

The comparison between recent samples done in the three ports of Victoria, Diego and Mombasa shows the following results (table 3):

These indices shows that the highest rates of SEI were observed in the Victoria sampling during the two recent years 1998 and 1999 (and also in 2000, not shown in the table). The high rate of SEI observed in Mombasa in 1994 and 1998 are probably in relation with the very low number of skipjack sampled these years (so this high SEI may not be indicative of such bias). These results indicated by these SEI are very well supported by the visual inspection of the various corresponding histograms of sizes sampled.

 # *Missing classes*

One peculiar case in this type of serious bias should also be noted: a sampling problem of missing classes is clearly apparent in a significant number of Victoria samples. This bias is for instance well shown by figure 2 giving the size distribution of a multispecific sample taken on a French purse seiners in June 1999. This figure shows that the 45.0-45.9 cm class (called 45), a size positioned close to the modal sizes of the 3 species, was never measured in any of the measurements done on the 3 species (skipjack is not shown on the figure, but its 45 cm class is also blank). These missing classes are also probably causing the very strange pattern of skipjack sizes observed in the Victoria sampling in August 1999 and in September 1999 (with several hundreds of fishes measured) (figure 6e). The very low levels observed for two size classes 53 and 55 cm are also probably in relation with such missing classes on some of the measuring rulers. It should be noted that the size distribution of skipjack sampled in Diego and Mombasa (figure 6f) are clearly more realistic. The strange similarities between the two monthly size distributions taken in Victoria in August and September should also be noted, as they may seem very unlikely.

Such extreme lack of a given centimeter class goes outside the traditional odd/even bias. This bias was probably due to a combination of factors, such as a poor condition of the sampling rulers and/or also a lack of care by the sampling technician. It is also quite obvious that this type of errors, nil class, which were quite often observed in the Victoria sampling should have been detected and corrected earlier:

- First by the technicians in charge of the sampling: such zero class in the middle of a mode should not be accepted,
- Second by the technicians in charge of data entry, as the computer system draw an histogram of the sampled size when data are entered; this missing class becomes an obvious sampling problem when it is located in the middle of a mode and in the same class for the three species.
- Third by scientists working on the processed size data, where this bias is less obvious, but often still easily visible.

This technical problem is well demonstrating the need for more dedication to the sampling by technicians, and for more team work between scientists and technicians in order to identify and to correct these errors.

3.3.3- Bias in the ½ cm classes for LD1 for large YFT and BET

The causes explaining this bias, its consequences and its remedies are very similar to the traditional “switchback effect” noted for odd/even classes. The goal to introduce ½ cm classes for the measurement of predorsal length was fully justified by the too small numbers of these classes in the measurement of large yellowfin and large bigeye (about 25 classes of LD1 in a range of 100 cm of fork length, e.g. such 1 cm LD1 classes were equivalent to 4 cm classes of fork length). However if these measurements are biased by ½ cm interval, the sampling goes back to the initial problem of having too wide 1 cm measurements intervals.

The analysis of this potential sampling bias indicate that this bias was increasingly observed in various locations (table 4). This index is worsening since 1996 in Victoria and since 1997 in Diego. The worst year in Victoria was 1999, despite of the quite large number of large yellowfin sampled in LD1 (14484 fishes). The sampling in Mombasa shows the worst SEI in 1998 and 1999, but this result is probably not very significant and due to the low number of large yellowfin sampled in Mombassa during each of the two years (only 573 and 543).

The results indicated by the SEI are very well supported by the visual inspection of the corresponding histograms of sizes sampled (figure 7).

As a conclusion, it appears that the ½ cm measurement presently done was not a very positive measurement because of the switchback bias frequently observed in this sampling. This ½ cm measurement should be continued, but with a higher quality in the lecture of sizes sampled and/or with new measuring equipment which are neutral in term of this potential bias (for instance measurements in mm or in ½ cm classes which are fully equivalent for the sampling technicians).

3.3.4- Future systematic identification of odd/even bias

It is recommended to permanently identify the potential occurrence of this odd/even bias in the size frequency distributions of tunas (for both LF and LD1 measurements). Such validation should be done for instance monthly (allowing to work upon significant size sampling) in each sampling location. This validation should preferably be done on the size data collected by each individual sampler. The validation should be done simultaneously:

- By eye, with a careful examination of the monthly size samples histograms collected by each sampler. This examination should for instance track the odd/even anomalies, the missing classes and also the excessive similarities in size between yellowfin and skipjack.
- By an indicator of the "switchback effect", that should be calculated routinely, each month by landing port, on the same size histograms.
- Other tests could probably be identified and they should be used routinely to identify in real time the sampling problems

The consequences of this bias may be considered as a relatively minor one, compared for instance to the bias in species identification, because this problem can be partly solved using larger 2 cm classes instead of 1 cm ones (or be reduced with a smoothing). However, this type of error can be avoided with a minimum of care in the maintenance of the equipment and of dedication in the sampling. Its effects are very negative to conduct later modal progression analysis. Consequently scientists and technicians in charge of sampling should permanently make controls and pressure on their field technicians to ensure a maximum quality in the size reading, specially for LD1 measurements.

A potential method used by some laboratories to solve this bias has been to measure tunas in millimeters and not in cm. This very small interval may seem to be too small to measure tunas, but this type of measurement should probably eliminate this bias.

3.5- FUTURE ANALYSIS AND CORRECTION OF THE SAMPLING PROBLEMS

This analysis was limited, for practical reasons of time available, to a survey of the major and more apparent sampling problems. At time, the present conclusion is that the problems presently identified are already very clear and serious. They need various immediate actions to be more completely identified and solved as much as possible. It is clear however that this study should be improved with a more comprehensive and more detailed analysis of the species composition and size databases. This analysis should for instance track the various

5°-month strata[6], which have been well sampled simultaneously in the ports of Victoria, Mombassa and Diego. This statistical comparative "zoom analysis" of samples of the species compositions and sizes which were taken independently will be quite complex to do, but it should provide a valuable understanding of the nature and periods of the various sampling biases.

Following the results of these in depth analysis, other statistical tests should be developed to track in real time all the potential anomalies in the size distributions and in the species composition. Among other tests it should be interesting to compare in each sampling port, each month, the species composition and estimated sizes, in comparison with the historical fishery data (by fishing strata). As most tuna fisheries show quite stable patterns in term of species composition and sizes taken by each time-area stratum (at least for each fishing mode), this systematic comparison should allow to identify a potential sampling problem when some significant anomalies in the traditional species composition or sizes are observed. It should then be the responsibility of the scientists to establish if this change is a real one (due to a change in the fisheries or in the stocks) or due to a sampling bias.

4- ALTERNATE IMPROVED DATA PROCESSING:

4.1- METHODS AND HYPOTHESIS

The official statistics submitted to the IOTC for the EU purse seiners (and their associated NEI fleets) during recent years were based on the biased or problematic sampling identified in this paper. The EU scientists consider that a better solution to estimate total catches and sizes taken during this period would be to redo a new data processing for recent years. These corrected results can be compared to the official results already submitted to the IOTC, and even though this alternate processing cannot be perfect, its results should preferably be used.

For this new data processing, only the years 1998 and 1999 were reprocessed (even if some doubts are still flying over some 1997 samples) assuming the following assumptions:

- None of the samples collected in Victoria during 1998 and 1999 was used, and all the Mombassa and Diego samples were kept and used (as they look much better than Victoria sampling, even though some problems are also apparent in these samples). The average samples of the 1993-1996 period (all samples) was used when necessary for strata substitution. The 1997 samples were not included voluntarily because of some doubts in the validity of some samples.
- All strata which were not significantly sampled by this Diego-Mombasa sub sample were substituted (for species composition and size), as a function of the fishing mode (free and log schools), with the samples from the 1993-1996 period. This strata substitution was done by the two standard programs which are estimating the species composition and the sizes taken. The strata substitution was done only when the samples available in each quarter/sampling area were estimated to be insufficient. In this case the strata substitution was done assuming a stable species composition and stable sizes over this period.

4.2- REVIEW OF THE REVISED ESTIMATES OF CATCHES

The total catches are the same in the official statistics and in this revised estimates (both the total catches and the catches by fishing mode, free and log schools). However it appears that the estimated species composition in the official statistics of EU and associated flags purse seiners and in this new estimate are quite different, as shown by table 6.

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[6] 5°*month strata are smaller than the quarter-large sampling areas strata, but these smaller units are more homogeneous and probably better for detailed comparisons.

- Yellowfin catches by purse seiners are increased during each of the 2 years: 2.2% in 1998 and more significantly of 15.8 % in 1999.
- Skipjack catches by purse seiners are suffering less changes, +2.6% in 1998 and –6.5 % in 1999.
- Bigeye catches by purse seiners are significantly decreased during each of the 2 years: -17.5% in 1998 and 11.3% in 1999.

The global changes of the species composition are given in this table for the entire purse seiners fleet, but they are of course obtained for each flag (each flag showing a variable rate of specific change, as a function of its fishing mode and fishing strata).

The catches estimated now for each country are given in table 7.

> It is recommended to use this new statistical estimation, even though it is obvious that the use of substituted data for the non sampled strata may produce unknown bias that would need to be further evaluated. This may be a problem if the stock and fisheries have shown significant changes in their species composition and/or sizes in the unsampled fishing zones since 1996.

4.3- REVIEW OF THE REVISED ESTIMATES OF SIZES

The new size distribution of tunas caught in 1998 and 1999 was estimated using the same sampling as described previously, this sample being extrapolated to the new catches by fishing mode, by flag and by strata.

It appears that this data processing done for each species requires more strata substitution for the species composition. In this new processing the historical size data (average period 1993-1996) was used for 38% of the catches in 1998 and for 40% of catches in 1999 for size distributions, while only 13.2% and 2.2% were necessary for species composition. This rate of substitution is quite high compared to the low rate observed before.

Tables 8 and 9 shows the average yearly estimated weight and number of individual (yellowfin, skipjack and bigeye) caught by EU purse seiners in the old (September 2000) and new data sets (November 2000). It appears that this new data processing is providing figures of average weight and of total number of fishes caught which are quite different from the previous ones and without common rules between species. The average weight of yellowfin increases in 1998, but decreases in 1999. The average weight of skipjack remains quite stable in the two data sets. Small increase in the average weight of bigeye is observed in each of the two years.

It should also be noticed that although the shape of the new size histograms are similar between the two data sets, the old and the revised ones, various anomalies observed in the old data set are now well corrected (see figure 8). This is a further additional indication that the present data processing is probably better than the old one.

4.4- DISCUSSION ON THE VALIDITY OF THE REVISED ESTIMATES

The new data processing done on 1998 and 1999 data without the Victoria sampling seems to be providing quite good results, as its results were obtained for species composition with a low rate of strata substitution with the 1993-1996 samples (as only 13.2% and 2.2% of catches were substituted with the 1993-96 data in the 1998 and 1999 data processing). This quite surprising and “happy result” was due to the redundancy in the sampling network between Diego, Mombasa and Victoria, a large amount of tuna catches taken in each strata being landed and sampled simultaneously in the three ports.

Concerning this estimated species composition, it should be kept in mind that the low substitution rates between years was obtained after various substitution between adjacent quarters of the same year (32% in 1998 and 13% in 1999, as shows by table 5). It appears then that this redundant sampling did allowed to estimate quite well and without serious bias, both the species composition and sizes of catches taken in 1998 and 1999, but these estimates could of course have been much better with a better coverage of the sampling. The estimated sizes remains more problematic because of the higher rate of strata substitutions (respectively 38% and 40% for 1998 and 1999).

5- CONCLUSION

The present analysis of the sampling problems faced recently by the EU sampling program has shown that these problems were very serious, at least in some ports. They clearly need some drastic action to identify them with more details and to correct them immediately on the field. The exact targets of the new size and species sampling recommended since 1998, by large area and quarter or by smaller time and area strata, should be explicitly clarified by scientists.

A new data processing taking into account various identified problems was carried out. This data processing provides statistical estimates for the years 1998 and 1999, which appears to be quite good, at least much better than the ones presented in September 2000, but which are still carrying significant uncertainties, especially for the estimation of total number of fishes caught by size. This new series of statistical data should be used for the French, Spanish and NEI associated fleets for the years 1998 and 1999 instead of the official statistics, submitted to the IOTC in September 2000.

It is recommended and planned that more effort should be devoted to fully identify and to correct the original sampling databases. This should allow to make a full use of every good samples collected during the recent period. Unfortunately the same statistical problems will also be faced for the 2000 data, as the sampling problems have been identified and corrected during the second half of the year 2000. All *ad hoc* measures should be taken now to ensure that 2001 sampling will be unbiased in each of the sampling locations.

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Table 1: Percentage of well sampled strata (5°-month), this rate of good sampling being chosen as a minimum number of 200 fishes measured per strata.

YFT	-50	50-99	100-199	200-500	500-1000	1000-2000	+2000t
1991	1,7	5,3	17,4	27,8	57,1	75,0	88,9
1992	4,3	6,7	29,4	48,1	76,5	84,2	100,0
1993	4,2	13,3	31,6	50,0	73,7	100,0	87,5
1994	3,5	15,0	35,3	47,4	71,4	88,2	100,0
1995	3,3	22,2	38,9	52,2	70,6	95,4	100,0
1996	6,7	29,2	54,5	71,4	73,1	80,0	93,7
1997	8,2	30,4	53,8	69,1	95,2	95,4	100,0
1998	*0,7*	*0,0*	*15,1*	*25,6*	*50,0*	*80,0*	*100,0*
1999	*1,1*	*7,7*	*2,3*	*20,0*	*54,5*	*66,7*	*87,5*
%1991-97	**4,56**	**17,44**	**37,28**	**52,28**	**73,95**	**88,34**	**95,73**

SKJ	-50	50-99	100-199	200-500	500-1000	1000-2000	+2000t
1991	18,4	18,8	35,3	41,9	44,0	64,7	90,0
1992	3,4	23,1	54,5	57,1	92,9	100,0	100,0
1993	9,4	14,3	21,0	51,5	88,2	90,5	100,0
1994	5,7	21,1	47,1	54,5	78,9	88,9	100,0
1995	10,8	30,8	52,2	77,8	95,0	100,0	100,0
1996	13,0	37,0	55,6	72,7	78,6	94,7	100,0
1997	10,5	33,3	64,0	66,7	86,4	95,0	100,0
1998	*1,9*	*8,9*	*28,9*	*34,2*	*62,5*	*68,7*	*94,4*
1999	*3,1*	*6,5*	*16,2*	*16,3*	*47,4*	*52,6*	*92,0*
%1991-97	**10,17**	**25,49**	**47,10**	**60,33**	**80,57**	**90,55**	**98,57**

BET	-50	50-99	100-199	200-500	500-1000	1000-2000	+2000t
1991	0,0	6,3	9,1	33,3	60,0	*	*
1992	1,0	5,3	33,3	100,0	100,0	*	*
1993	0,0	10,0	39,1	70,0	100,0	100,0	*
1994	0,0	18,5	18,7	65,0	60,0	*	*
1995	1,0	17,4	29,4	70,4	85,7	100,0	*
1996	4,7	25,9	47,8	64,7	100,0	100,0	*
1997	8,1	37,5	57,7	71,9	100,0	100,0	*
1998	*0,0*	*5,1*	*15,8*	*51,8*	*61,5*	*100,0*	*
1999	*0,0*	*0,0*	*9,4*	*30,3*	*25,0*	*60,0*	*50,0*
%1991-97	**2,11**	**17,27**	**33,60**	**67,90**	**86,53**	**100,00**	

Table 2: Numbers of samples collected yearly in each of the three sampling ports:

Year	Victoria	Diego	Mombasa	Total
1994	407	316	20	**743**
1995	427	378	56	**861**
1996	481	151	74	**706**
1997	417	80	31	**528**
1998	192	77	9	**278**
1999	297	209	21	**527**
Moyenne	**370**	**202**	**35**	**607**

Table 3: Switchback Effect Indices for skipjack measured in the three landing ports:

Switchback Effect Index	**94**	**95**	**96**	**97**	**98**	**99**
Victoria	7	12	9	15	21	33
Diego	8	8	7	8	9	9
Mombassa	24	6	10	7	18	9

Numbers of SKJ sampled	**94**	**95**	**96**	**97**	**98**	**99**
Victoria	41264	52618	45839	31151	8629	10647
Diego	50729	79165	25140	14035	9736	9680
Mombassa	595	7235	7451	2164	587	836

Table 4. Switchback Effect Index in the yellowfin predorsal measurement in the three landing ports

Switchback effect Index	**94**	**95**	**96**	**97**	**98**	**99**
Victoria	6	8	16	16	15	23
Diego	6	8	8	13	12	14
Mombassa		9	22	27	41	46

Numbers of YFT sampled LD1	**94**	**95**	**96**	**97**	**98**	**99**
Victoria	14239	28128	28583	21141	7221	14484
Diego	23360	15039	11889	7259	2349	12048
Mombassa		4951	3760	2082	573	543

Table 5: Total tuna catches by purse seiners in each area, by quarter, during 1998 and 1999, and number of fishes sampled (from Diego and Mombasa) for each of these strata (strata well sampled are in bold, strata with a catch larger than 4000 tons and no samples are shaded)

Purse seine catches (tons) - 1998											
Quarter	**Area**										**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	*1206*	*4471*	*5269*	**27976**	**5837**	**0**	*16*	**0**	*11*	**21763**	**66549**
2	**5147**	**13074**	*10688*	**26816**	*44*	*60*	*0*	**0**	*4*	*1979*	**57812**
3	*36658*	*16689*	*6031*	**0**	*691*	**0**	*1021*	**0**	**0**	*367*	**61457**
4	**37040**	**4386**	*6179*	*18*	*4137*	**0**	*120*	**0**	**0**	*9890*	**61770**
Total	80051	38620	28167	54810	10709	60	1157	0	15	33999	**247588**
Number of sampled fishes											
1	0	0	0	12222	792	0	0	0	0	4733	**17747**
2	740	3456	0	18710	0	0	0	0	0	0	**22906**
3	0	0	0	0	0	0	0	0	0	0	**0**
4	2356	1247	0	0	0	0	0	0	0	0	**3603**
Total	3095	4703	0	30933	792	0	0	0	0	4733	**44256**
Number of fishes sampled / 1000 tons fished											
1	0	0	0	437	136		0		0	217	**267**
2	144	264	0	698	0	0			0	0	**396**
3	0	0	0		0		0			0	**0**
4	64	284	0	0	0		0			0	**58**
Total	39	122	0	564	74	0	0		0	139	**179**

Purse seine catches (tons) - 1999											
Quarter	**Area**										**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	*8795*	**22066**	**17274**	**22533**	*5902*	**0**	**0**	**0**	**0**	*1172*	**77742**
2	**22561**	**9540**	*228*	**21168**	**0**	**0**	*30*	**0**	**0**	**0**	**53527**
3	**84785**	**7931**	*754*	*17*	**0**	**0**	*1868*	**0**	**0**	**0**	**95355**
4	**68333**	**9220**	*16201*	**0**	*480*	**0**	**4267**	**0**	**0**	*964*	**99465**
Total	184474	48757	34457	43718	6382	0	6165	0	0	2136	**326089**
Number of sampled fishes											
1	0	9584	1962	19874	0	0	0	0	0	0	**31420**
2	5676	504	0	14145	0	0	0	0	0	0	**20325**
3	6303	573	0	0	0	0	0	0	0	0	**6876**
4	10259	2694	0	0	0	0	1591	0	0	0	**14544**
Total	22238	13356	1862	34020	0	0	1591	0	0	0	**73067**
Number of fishes sampled / 1000 tons fished											
1	0	434	114	882	0					0	**404**
2	252	53	0	668			0				**380**
3	74	72	0	0			0				**72**
4	150	292	0		0		373			0	**146**
Total	121	274	54	778	0		258			0	**224**

Table 6: Total yearly catches by purse seiners, by species, in the old and revised statistics (in tons) and changes in percentages between the 2 series.

	Year	YFT	SKJ	BET	Total
Official Sept. 2000 data	1998	87288	128748	30176	246212
	1999	103633	180943	40141	324717
New November 2000 estimates	1998	89213	132106	24893	246212
	1999	119992	169101	35625	324718
Change in % old-->new	1998	2,2	2,6	-17,5	0,0
	1999	15,8	-6,5	-11,3	0,0

Table 7: Total yearly catches by country of purse seiners, by species, in the old and revised statistics (in tons).

Year	Country	Yellowfin	Skipjack	Bigeye	Total
1998	France	22387	30346	6378	59111
	Spain	38573	58661	11223	108457
	NEI	28253	43098	7292	78643
	Total	89213	132105	24893	246211
1999	France	30754	42703	8526	81983
	Spain	51797	74346	16051	142194
	NEI	37442	52053	11048	100543
	Total	119993	169102	35625	324720

Table 8: Estimated average weight of fishes caught, in the old and revised estimates (in kg):

	Year	**Yellowfin**	**Skipjack**	**Bigeye**
old	**1998**	7,93	2,52	4,87
	1999	6,52	2,43	4,53
new	**1998**	9,25	2,63	5,77
	1999	6,07	2,50	5,09

Table 9: Estimated number of fishes caught in the old and revised estimates (in millions of fishes):

	Year	**Yellowfin**	**Skipjack**	**Bigeye**
old	**1998**	11,00	51,12	6,20
	1999	15,90	74,61	8,87
new	**1998**	9,65	50,18	4,31
	1999	19,78	67,62	7,00

NOTE SUR L'ECHANTILLONNAGE DES SENNEURS
CONCLUSIONS DU GROUPE DE TRAVAIL « ET »
ANALYSE DE LA STRATEGIE D'ECHANTILLONNAGE MULTISPECIFIQUE DES THONS TROPICAUX
TENERIFE, 23-27 JUIN 1997

LES NOUVELLES PROCEDURES

1- STRATEGIE D'ECHANTILLONNAGE : LE CHOIX DES STRATES

On procédera donc à un échantillonnage stratifié multispécifique classique simultané de la structure des tailles et de la composition spécifique des captures. Pour les calculs ultérieurs dans l'**océan Indien,** les mêmes strates seront utilisées pour les deux échantillonnages, et c'est le modèle **Zone*Trimestre*Association** qui a été retenu. Enfin, rappelons que ce sont les calées individuelles qui seront échantillonnées par intermédiaire des cuves.

Le choix des strates Il se fera en fonction des échantillonnages déjà réalisés, et selon les nouvelles strates qui ont été définies par le GT :

- **Strate « Zone »** : dix grandes zones de pêche (Cf. Figure 4)
- **Strate « Saison »**, le trimestre :
  Janvier - Mars, Avril - Juin, Juillet - Septembre, Octobre - Décembre.
- **Strate « Association »** :

Banc libre (BL)	codes type de banc 2, 4, 6 et 7
Banc sur objet (BO)	codes type de banc 1 et 5

A partir du carnet de pêche et du plan de cuve, les strates à échantillonner seront donc déterminées et les cuves choisies en conséquence.

2- PROCEDURES D'ECHANTILLONNAGE

Comptages et mensurations

Une fois déterminée la cuve à échantillonner, trois cas peuvent se produire selon le type de la calée et l'information dont on dispose :

1. <u>Banc libre d'albacore</u> : le comptage spécifique portera sur 200 individus, et les mensurations se feront sur les 50 premiers individus de chaque espèce présente ;
2. <u>Banc libre de listao (ou mélangés) ou banc sur objet, individus de tailles homogènes</u> : le comptage spécifique portera sur 300 individus ; les mensurations porteront sur les 30 premiers listaos et sur tous les individus des autres espèces présentes ;
3. <u>Banc libre de listao ou banc sur objet, individus de tailles hétérogènes dans des proportions connues</u> (carnet de pêche ou pan de cuve) : le comptage spécifique portera sur 300 individus ; les mensurations porteront sur les 30 premiers listaos et sur tous les individus des autres espèces présentes pour les petits individus ; les grands individus feront l'objet d'un échantillonnage de tailles séparé ;
4. <u>Banc libre de listao ou banc sur objet, individus de tailles hétérogènes dans des proportions inconnues</u> : le comptage spécifique portera sur 300 individus ; les mensurations porteront sur les 30 premiers listaos et sur tous les individus des autres espèces présentes, les grands individus étant considérés comme une espèce différente ;

Enfin, en raison des variations non négligeables des compositions spécifique et en tailles au cours du déchargement des cuves, les échantillons devront autant que possible être faits à différents stades du débarquement de la (ou des) cuves, un double échantillonnage de la cuve devant être réalisé chaque fois que ce sera possible ; chaque échantillon se composera de 200 ou 300 individus selon le type de la calée, afin qu'il reste significatif au cas où le second échantillon ne pourrait être réalisé.

Choix des cuves

Lors du déchargement d'une cuve que l'on souhaite échantillonner, quatre cas peuvent se présenter :

1. Débarquement à sec sans station du filet sur le pont : de manière générale, les cuves déchargées ainsi ne sont pas échantillonnables dans des conditions de sécurité raisonnables ;
2. Débarquement à sec avec station du filet sur le pont : les cuves déchargées ainsi peuvent être échantillonnées pendant qu'elles sont sur le pont avec l'accord du bord ;
3. Débarquement en saumure avec tapis roulant : on mesurera les gros individus sur le tapis, tandis que les petits sont retirés et mesurés ultérieurement ;
4. Débarquement en saumure sans tapis roulant : cette situation (fréquente sur les bateaux espagnols) est plus complexe. Soit la cuve se trouve sous l'ouverture de la cale, et on ne pourra en général pas l'échantillonner ; dans le cas contraire, les petits poissons sont mis dans des paniers où ils pourront être échantillonnés, tandis que les gros sont mis à part (et pourront aussi être échantillonnés) ; dans ce cas, on sera ramené à un échantillonnage de type 3 ci-dessus (petits et grands individus font l'objet d'un échantillonnage de tailles séparé).

De manière générale, le choix de la cuve qui sera effectivement échantillonnée parmi celle qui auront été identifiées n'a pas grande importance ; aussi on pourra choisir d'une certaine manière celles qui sont le plus facile à travailler sans introduire de biais majeur dans la mesure où cela ne favorise pas un certain type de calée.

Intensité de l'échantillonnage

Avec ces nouvelles procédures, il est conseillé de procéder avec des équipes de 2 techniciens : un chargé du comptage et de l'identification des espèces, l'autre des mensurations. Par ailleurs, la procédure de choix des cuves à échantillonner peut amener à devoir travailler pendant les week-end et jours fériés, ce qu'il faudra prendre en compte dans les prévisions budgétaires.

Bien que l'analyse statistique ne permette pas actuellement de déterminer le nombre souhaitable d'échantillons par strates, il a été estimé à partir des effectifs actuels par strates mois*carrés 5° que, dans un premier temps, de 40 à 60 échantillons par strate sont nécessaires.

Actuellement, on peut estimer à environ 12 le nombre de strates spatio-temporelles dans l'océan Indien, soit en tout quelques 24 strates à échantillonner dans l'année, ce qui amène à un total de 1000 à 1500 échantillons par an pour les flottilles franco-espagnoles et assimilées dans l'océan Indien. Au niveau de Victoria, pour environ 10 mois d'activité, ceci donne de 4 à 6 échantillons par jour ouvrables, soit 2-3 par équipe si on table sur deux équipes.

Pour y arriver, et compte tenu des besoins en échantillonnage de la pêche palangrière (les équipes devant être communes), ceci nécessiterai que service dispose d'un pool permanent de 6 échantillonneurs (soit 3 équipes) « de terrain » afin d'avoir la garantie d'en avoir au moins deux de disponibles en permanence.