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Potential bias in multispecies sampling of purse seiner catches

Fonteneau Alain, Chassot Emmanuel, Abascal Francisco and Ortega Sofia

Summary

This paper discusses the various potential biases associated with species and size sampling carried out in the AtlanticOcean during landings of purse seiners. This paper is a follow- up of the 4th meeting of the WCPFC Scientific Committee during which there were serious doubts expressed upon the bias faced by the sampling schemes used in the Atlantic since 1980. The conclusion of the paper is that the sampling scheme currently used in the Atlantic appears to be consistent and satisfactory, but that minor potential biases in this sampling should be better identified and reduced by improvements in the current sampling and data processing. It is recommended that an international working group is organized to identify these uncertainties and to improve the multispecies sampling schemes and the data processing of their results.

Résumé

Cet article discute des divers biais potentiels des échantillonnages plurispécifiques des tailles et des espèces, qui sont réalisés dans l'Atlantique au débarquement des senneurs. Cet article fait suite au 4ième Comité Scientifique de la WCPFC durant lequel de sérieux doutes ont été exprimés quand à divers biais des échantillonnages plurispécifiques qui sont réalisés dans l'Atlantique depuis 1980. La conclusion de cet article est que les échantillonnages présentement mis en œuvre dans l'Atlantique semblent être cohérents et sans biais majeurs. Toutefois, il apparaît qu'il pourrait exister dans ces échantillonnages divers biais mineurs, et qu'il serait intéressant de mieux les identifier et de les réduire. Cette future amélioration porterait à la fois par diverses améliorations dans les procédures d'échantillonnages réalisées au port, ainsi que dans le traitement des données. Prenant en compte la grande similarité des problèmes à une échelle mondiale, il est recommandé d'organiser sur ce thème

un groupe de travail chargé de mieux identifier les incertitudes et à terme de les réduire en améliorant la collecte et le traitement de ces données.

1- Introduction: importance and status of multispecies size sampling of purse seine catches done worldwide

Multi-species size sampling has been conducted in various landing ports of the Atlantic ocean since the late seventies, in order to estimate the species and size composition of purse seiner tuna landings but also for pole and line vessels. This multispecies sampling has been first analyzed by the ICCAT WG on juvenile tropical tunas (Brest , An. ICCAT 1984) and its present implementation described by Pianet et al 2000. Very similar sampling schemes have also been developed in the Indian Ocean since 1984 and in the Eastern Pacific by the IATTC since 2000 (Tomlinson 2002). This sampling is considered to be of key importance to estimate the real catches and sizes of small yellowfin and of small bigeye tunas taken by surface fisheries, as these small tunas tend to be widely underestimated in most log book and landing statistics. These sampling schemes have been used since their implementation to estimate the catches and sizes landed by each gear that are used by ICCAT, IOTC and IATTC. However, it should be noted that in the Western Pacific, while some port sampling has been also conducted by some countries since the early 1980s (for instance by USA and NMFS in Guam, Crone et Coan 2002), the size and species sampling used by WCPFC has been mainly estimated from observer sampling, taking note that the species composition estimated by port and by observer sampling tend to be most often widely different (Lawson and Williams 2005). The potential causes explaining these differences have been widely discussed by the last Scientific Committee of WCPFC and these discussions are of some interest for the ICCAT

2- An overview of the WCPFC paper by SPC upon potential bias in multispecies sampling

The following text, taken *in extenso* from the WCPFC Statistics WG makes a good review of the new discussion of size & species sampling introduced by SPC

" T. Lawson (Secretariat of the Pacific Community - Oceanic Fisheries Programme, SPC-OFP) presented SC4-ST–WP-3 (Factors affecting the use of species composition data collected by observers and port samplers from purse seiners in the Western and Central Pacific Ocean). The species compositions of catches from associated schools determined from observer data and port sampling data are considerably different — 55.3% skipjack, 35.1% yellowfin and 9.6% bigeye from observer data and 72.4% skipjack, 19.8% yellowfin and 7.8% bigeye from port sampling data. Several factors that might explain this difference were examined.

- *Port sampling data were found to be subject to set weight bias, grab sample bias and well mixing, all of which result in over-estimation of the proportion of skipjack and under-estimation of the proportion of yellowfin.*
- *Observer data are also subject to grab sample bias, while size selection bias has been proposed as an explanation of the relatively low proportion of skipjack and the high proportion of yellowfin in observer data.*

Lawson paper also stated that bias induced by total weight by set in port sampling data occurs because the species composition of associated schools is related to the set weight, with the proportion of skipjack increasing, and the proportion of yellowfin decreasing, with the size of the school. The criteria used to select wells tend to result in the sampling of wells containing a small number of large sets, rather than a larger number of small sets. Since large sets contain a greater proportion of skipjack, the port sampling

data are biased. The sizes of the sets sampled by observers are representative of the sizes of sets fished and so the observer data are unbiased in this regard.

Lawson paper also stated that grab sample bias occurs because the sampling protocol for both observers and port samplers is to select a certain number of fish, whereas the species composition estimated from the data is in terms of weight. The magnitude of the bias depends on the sample size and the distributions of the species and sizes of fish in the set or well.

A new sampling protocol was tested by the SPC-OFP in March 2008 in Papua New Guinea. Under the "spill sample" protocol, fish were spilt from every tenth brail directly into a bin and then the observer measured all of the fish in the bin. Since there was no selection of individual fish by the observer, both grab sample bias and size selection bias were eliminated. In contrast to port samples, spill samples taken by observers at sea are neither subject to set weight bias nor well mixing. The conclusion of the study was that spill samples taken by observers is the only sampling protocol that can provide unbiased species composition data.

Lawson paper also stated that size separate analyses of observer data and port sampling data, wherein species compositions are estimated separately for small (< 80 cm) and large (≥ 80 cm) fish, were conducted. Given the biases to which the observer data and port sampling data are subject, it was considered that a species composition that is intermediate between those determined from the observer data and port sampling data would be more accurate. The intermediate analysis resulted in a species composition of annual catches during 1997–2006 of 68.0% skipjack, 26.2% yellowfin and 5.8% bigeye. The proportion of bigeye is twice as great as the proportion determined from the aggregated purse-seine data that are currently used for stock assessments."

This well documented paper was followed by extensive discussions and it was concluded that:
"*A very high priority for these issues was encouraged in next year's work program. It was noted that these issues require worldwide solutions and a collaborative approach among worldwide tuna RFMOs. And it was proposed to form (as soon as is possible) a technical working group in charge of comparing and analysing the size and species sampling presently done on purse seiners in the WCPFC, IATTC, ICCAT and IOTC areas. It was also recommended that catch sampling programs should be designed to overcome the sampling biases and other issues raised by the two working papers. Sampling designs should build on further comparative trials, which should include both observer sampling versus port sampling, and also comparison among different techniques within observer and port sampling"*

The goal of this technical paper will be to briefly examine the present situation of the port sampling done on the EU and Ghanian purse seiners and bait boats fishing in the Atlantic, to examine if this sampling may have been facing the sampling bias analyzed by the SPC paper, and to make recommendations to improve the present sampling modes and their data processing in the ICCAT area.

3- An overview of potential bias in the present Atlantic species and size sampling

3-1- Overview of the potential bias

Lawson's paper presented at the last WCPFC Scientific Committee made an extensive critical review of the various potential biases faced by the multispecies sampling done in the Atlantic since 1980, the so-called "grab sampling". This paragraph will examine and discuss how much of the various problems introduced by Lawson are real ones, or due to misinterpretation of the Atlantic sampling or its data processing.

3-2- Structural bias in the Atlantic "Grab" sampling

The grab sample bias analyzed and explored by Lawson's simulations shows that small samples tend to overestimate the quantities of small tunas, underestimating large tunas (large YFT and BET). This bias is for instance well shown by the Lawson's simulations of a 2 species sampling shown by figure 1

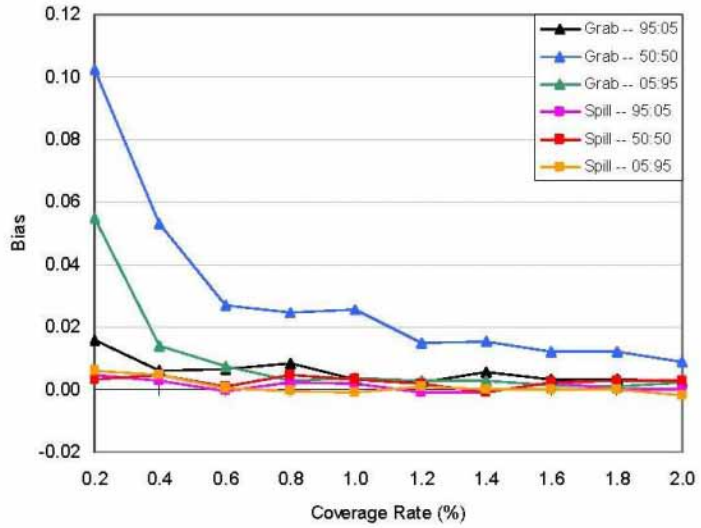

Figure 1: (taken from Lawson 2008 paper): bias of estimates of the proportion of SKJ in simulated sampling under "Grab" and "Spill" protocols as a function of the species composition, % of SKJ and YFT. The 2 numbers indicates the % of the numbers of SKJ and of YFT in the sampled population. The conclusion by Lawson from this figure is the following:
"The highest degree of bias in the proportion of skipjack is for the set with equal amounts of skipjack and yellowfin in terms of weight; for a coverage rate of 0.2%, the average estimate of the proportion of skipjack is 60.2%, compared to the true value of 50.0%, giving a bias of +10.2%. The bias declines with an increase in the sample size, e.g., with an increase in the coverage rate for a given size of set or (not shown here) with an increase in the size of the set for a given coverage rate"

This bias is interesting to consider as it is quite surprising and again our previous sampling hypothesis. Such potential sampling bias has never been studied in the Atlantic.

It can then be considered that if such bias is potentially real, it should not be significant in the Atlantic samples, due to the **very large sizes of each sample, about 500 tunas in each sample**, and also due to the **large number of samples collected each year, reaching 31,900 multispecies samples** collected for the EU purse seine fleet during the 1980-2007 period (on a yearly total average catch lower than 150000 tons taken in a quite small area of the Eastern Equatorial Atlantic). Knowing that the percentage of each species and size will be estimated at the level of each time and area stratum, and not at the level of each individual sample, it can be concluded that this high level of sampling should not produce the grab bias sampling due to a low coverage of these sampling. This conclusion should of course be validated by an *ad-hoc* statistical study, for instance using simulation and bootstrap analysis similar to the method used by Lawson 2008, but at this stage, this potential "intra sample bias" can probably be considered as being a very minor one, as most of the uncertainties in the species composition and size caught come from between strata sources.

The most important question is probably to maintain a good sampling coverage in all the time and area strata where large quantities of tunas have been caught and upon all major fleets (including the fleet of Ghana, a fleet that has been poorly sampled during recent years).

3-3- Data processing stratified by size categories

Lawson's paper concludes that it would be essential to process the results of species/size sampling using a stratification between small and large tunas, taking note that the quantities amount of tunas landed in each of these two categories are very seldom available in the Western and Central Pacific fisheries.

There is no doubt that the species sampling should be conducted by size categories, and this is why all the data processing in the Atlantic ocean have been stratified by tunas less and larger than 10 kg (this group being further subdivided in 2 sub categories: < and > 30 kg), the quantities of tunas landed in each of these categories being most often available to scientists (from the log book and landing/transhipment data). As a conclusion, catches by size categories have been permanently collected and used in the multispecies sampling and the bias due to a lack of stratification in sizes sampled does not exist in the Atlantic.

3-4- Species composition variable as a function of set sizes

Lawson's paper shows that the species composition is highly variable as a function of the school sizes, showing an increased proportion of SKJ for larger school sizes.

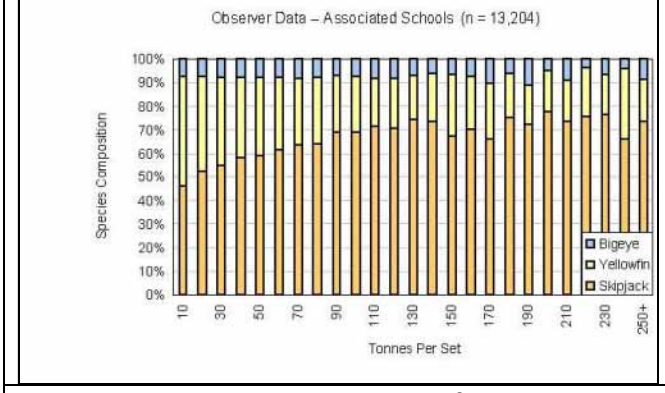

Figure 2: Species composition of FAD sets as a function of set sizes in the Western Pacific (Lawson 2008)

This heterogeneity appears to be a real biological fact in the Western Pacific, but it has never been examined in the Atlantic, but if it exists, it would introduce a potential bias, as the present data processing is not stratified by size categories of sets, and because the sampling rates tend to take more samples on the larger sets that are better identified in the wells and thus easier to sample.

In order to examine this potential bias, the species composition of all the FAD sets collected in the Atlantic during the period 1991-2007 has been analyzed as a function of the sizes of the "sampled units" (a sampling parameter that is in most cases similar to the size of sets) (classified by 10 tons) (Figs. 3-5). The percentages of SKJ, BET and YFT have been examined in each of these sizes of sets (all areas and all years). This analysis indicates that if the percentage of BET tends to be fairly stable independently of set size (at 15.6%) (Fig. 5), the percentage of SKJ

decreases for small sets (Fig. 4) while the percentage of YFT increases for small sets (Fig. 4). For instance the average percentage of SKJ was estimated at 50.2 % for small sets (Which size range of set?), and at 54.8 % for larger sets (which size range of set? Average?). On the opposite, the average percentage of YFT was estimated at 29.6 % for small sets, and at 24.5 % for larger sets.

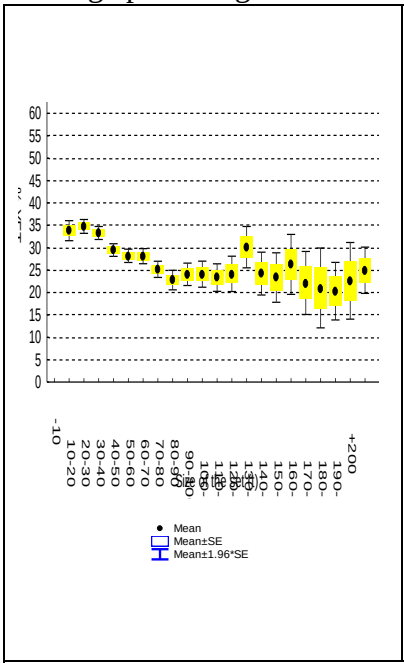

Figure 3: Percentage of YFT as a function of set size

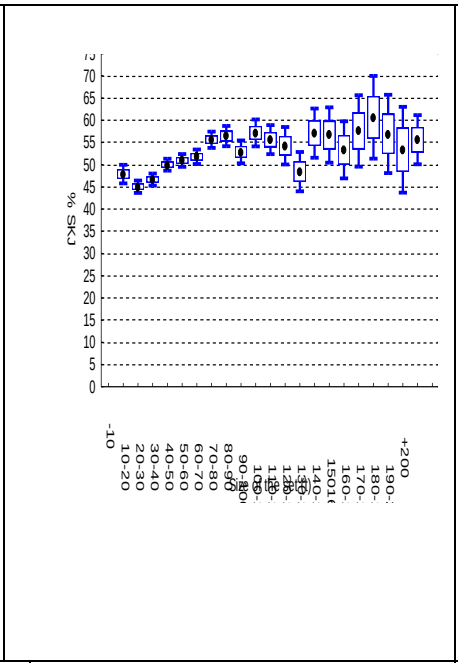

Figure 4: Percentage of SKJ as a function of set size

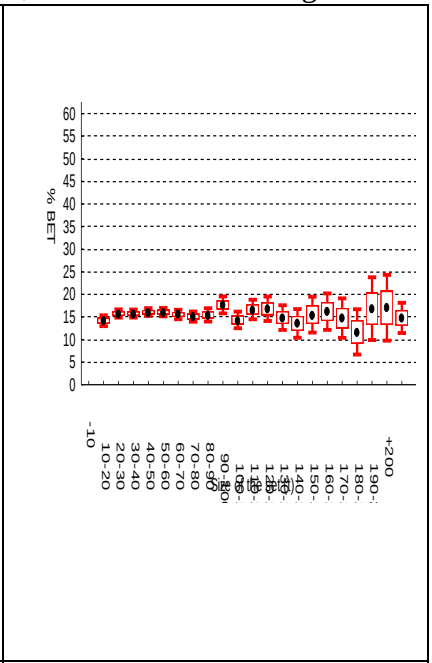

Figure 5: Percentage of BET as a function of set size

This variability of SKJ and BET percentages as a function of set sizes should be further analyzed, for instance taking into account a subset of samples selecting all the samples associated to given sizes of sets. Such potential variability, if it does exist, should not constitute a real bias in the present data processing, for instance if this variability is linked with a time and area stratification or to a size heterogeneity (fishes + or – 10kg). In this case, this variability would not introduce a bias in the results. If this is not the case the percentage of YFT estimated in the present data processing would be underestimated, as the larger sets (with a lower percentage of YFT) tend to be more frequently sampled than smaller sets with a larger percentage of YFT.

3-5- On board sorting of tunas

Lawson's paper takes note that there is on board of western Pacific purse seiners a frequent sorting of tunas when they are placed in the wells: small tunas being stored in given wells, and large tuna (for instance >10kg) being stored in other wells, noting that this sorting is never reported in the log books.

It is clear that such sorting of tuna has been very seldom observed in the Atlantic Ocean, and when it occurs, they are well reported in the log book and in the forms managed by the chief engineers in order to describe the well content and the exact origin of tunas in each well (traceability of catches). These boats can easily be eliminated from the sampling, and without introducing any bias in the sampling scheme and its results.

3-6- Other potential bias and errors

Furthermore, it also appears that the results obtained by present multispecies sampling may also be facing various types of errors and bias that have not been listed in this review, for instance:

- Errors in the species identification: risk of a potential misidentification between small BET and YFT: this bias is assumed to be a minor ones, as technicians are fully trained to identify BET, but this question is still pending.
- Errors in the random selection grab process: the perfect multispecies sampling should be perfectly random, independently of species and sizes, but this is a difficult target, probably seldom reached. With 2 potential opposite bias: (1) a tendency to grab an excess of the more visible large YFT and BET, or the opposite bias (2) to abandon the sampling of these large and heavy tunas in favour of small ones.
- Bias in SKJ counting vs measuring YFT and BET: as these 2 last species are measured when SKJ are simply accounted for after measuring 50 SKJ, there may be a tendency for some observers to give an unequal probability to the SKJ counting (an easy task) compared to measuring YFT and BET (thus artificially creating an excess of SKJ).
- Errors in the catch at size data reported in the log books and used as weighting factors
- Errors and problems in the data processing: this process is a quite complex one. It has been carefully analyzed and programmed, but it may not be optimal.
- And various potential types of other errors

3-7- Conclusion

The review of Lawson's paper and of the multi species sampling presently done in the Atlantic Ocean allows us to conclude that our port sampling has not been facing any of the major biases envisaged and discussed by Lawson's paper. Taking note of this positive result, it is recommended that further studies of the present sampling schemes and of its present data processing should be conducted by scientists in order to improve its results and possibly to reduce its running cost.

4- Conclusion and recommended future work to improve size and species sampling

The SPC "Bin sampling" should also be considered, at least indirectly. The recommendation to better test by observers the so called "bin sampling" proposed by SPC, may be an interesting prospect, but probably not so much in the Atlantic Ocean because of multiple cascading difficulties faced by such sampling, such as:

- **Manoeuvre of the bin?** (paragraph 2): the practical difficulties to handle the bin itself and its load of tunas may be a major hampering factor. Most skippers will not enjoy the slowing down of the manoeuvres due to such Bin sampling (the observers are well accepted onboard purse seiners, but their activities should never interact negatively with the fishing operations)
- **Bin sampling: bias in large tunas?:** There are some serious doubts upon the fact that larger tunas (large YFT and large BET, for instance > 50kg) may easily avoid the bin when tunas are dropped from the brail, and then be underestimated in the bin sample. This point should be well evaluated.

- **Grabbing large tunas from the bin?:** there are also serious doubts upon the practical difficulties faced by the observers to handle and to extract from the bin the very large tunas (for instance YFT and BET > 50kg).

Sampling of discards?: The sampling observers will do only the size/species sampling, as it would be impossible to do simultaneously a sampling of discards and of frozen tunas. This limitation would be a serious problem in the Atlantic where the observer rate is quite low (about 10%) (when 100% of observers are soon targeted in the Western Pacific, an area where most tuna catches are taken by PS in various EEZ). As a provisional conclusion, the bin sampling experiments by SPC will be interesting to follow, but the development of this method does not appear to be a priority in the Atlantic, an area where the efforts of scientists should preferably be concentrated on the improvement of port sampling and its data processing, the observer work being concentrated on the sampling of the discards.

This conclusion is based on the fact that the various potential biases in the Atlantic port sampling of purse seine catches do not appear to be significant ones:

- The **grab sampling bias** can be neglected because of the large size of the average samples and because of the large numbers of samples in all the main strata (then a bias probably well <1%?).
- The **stratification of the data processing by size categories** of fish landed eliminates one of the most serious biases envisaged by SPC.
- The **sorting of tunas** between the brail and the well may be sometimes observed, but in theory these "sorted sets" are well identified and not sampled during their landing. Further pressure should be placed on skippers and on port samplers in order to permanently keep track of these pre-sorting of the tunas.
- The fact that the coverage of **size and species sampling are excessive** in the Atlantic, may be a real one: the present sampling rate could probably be reduced without any major negative impact on the validity of their results. However such basic oversampling of the purse seine landings should not be considered as being a problem, taking into consideration the moderate cost of the port sampling schemes, as it also produces major advantages. It provides an improved safety in the data processing, allowing to eliminate some questionable samples. Furthermore, it also allows to do a wide range of external scientific investigations, for instance on the changes in the species/size composition of sets as a function of fine scale time and area strata (for instance month and 1°), of exploitation rates and the environment, and in the long run as a function of stock status, these wider scientific investigations being presently conducted by the IRD in the Sète laboratory.
- The heterogeneity of **species composition as a function of the sizes of the set** is a new and interesting question in the Atlantic. Based on the Atlantic data it would appear to be only a minor one in this ocean. Furthermore, this problem should not be classified as being a bias (as in the Lawson study), as this problem could be solved introducing an improved data processing stratified by set sizes. This question would need further studies.

As a global conclusion, the sampling scheme presently used on purse seiners in the Atlantic during their sampling under the ICCAT framework since the late 1970^{ies} appears to be consistent and quite satisfactory. However the Lawson study shows that some of its potential biases, probably minor ones, should be better identified and reduced by improvements in the present sampling and in the data processing. This sampling could for instance be widely improved making a full use of all the trips observed by scientists

(about 10% of the EU trips) and during which there is a perfect knowledge of any potential fish sorting and of the detailed wells/sets structure. Tuna catches landed after these observed trips should then preferably be sampled actively by field technicians, in full cooperation with the observer.

Furthermore, it has also been recommended by the WCPFC Scientific Committee that this analysis of the multi-species landings of purse seiners should preferably be conducted by an ad hoc international working group with scientists from the ICCAT, the IOTC, the IATTC and SPC/WCPFC. As the problems faced by scientists in these samplings are very similar (often identical?) world wide, there is no doubt that a such multi RFO working group could be an efficient way to optimize the multispecies sampling and the data processing of its results. Such working group should also evaluate all the main potential types difficulties and errors involved in the multispecies sampling, and not only the errors and bias envisaged by Lawson. This WG should have of wide participation of field scientists and of statisticians, as it should work in parallel on the theoretical uncertainties in the sampling and data processing, but also taking into account the reality and complexity in the real fisheries and practical sampling processes.

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