Potential changes affecting species composition and tuna catch at size for purse seine fleets by using the new length-weight relationships for tropical tunas in the Indian Ocean

By Francis Marsac [1], José Carlos Báez[2] , Laurent Floch[3] and Alain Fonteneau[4]

Summary

This work analyzes a statistical bias that has been introduced in the PS catch estimates and catch at size (CAS) by species, by the use of an old length weight (LW) relationships until 2014 followed by the use of a new LW relationship for 2015-2016, to estimate the species composition, average weight and CAS for a large majority of purse seiners active in the Indian Ocean. Alternate corrected series of catches by species are produced by 2 methods based on the sampled sizes for each species, for both floating objects (FOB) and free school catches, during the 1982-2014 period. These tentatively corrected catches of PS are compared to the yearly catches presently declared to the IOTC. This comparison shows that minor but systematic bias have been introduced in the catches by species by the use of the old LW relationships used in the data processing. The paper makes the recommendations that the sensitivity of the current data processing and its uncertainties due to the LW relationship used should be better studied and that a revision of the datasets is necessary. Because of the importance of the LW relationship, further scientific investigations are also recommended in order to better monitor and explore the time and space variability of the condition factors of small and large tropical tunas. Corrected catch and CAS data of the concerned PS fleets should be re-estimated by scientists for the whole series 1982-2016 and submitted to the IOTC whenever possible.

KEYWORDS: Indian Ocean, purse seine logbook, fish aggregating device, tropical tuna, Form 3FA, data reporting, species composition, multispecies sampling.

1-Introduction

The species composition of the EU (France, Italy and Spain) and Seychelles purse seiners (PS), and also PS fleets of other countries landing in the area (for instance Cote d'Ivoire, Malta, Panama, Curaçao, St Vincent, Belize, and Mauritius) has been estimated since the beginning of the fishery in 1982 from multispecies sampling done by scientists during the landing operations. In this document, these PS fleets will be referred as the "studied PS fleet".

The nominal catches by species are corrected according to the TTT procedure (specific software), because species composition records are frequently biased due to misidentification

[1] IRD, UMR 248 Marbec, Sète, France
[2] Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Canarias. Vía Espaldón, dársena pesquera, Parcela 8 38180 Santa Cruz de Tenerife (Spain).
[3] IRD, UMR 248 Marbec, Sète, France
[4] Former IRD scientist, consultant, France

(Fonteneau, 1976). Consequently, routine processing corrections (based on a specific sampling design and multispecies size-frequency samples, collected during the landing operation) –in general about 500 tunas per sample- are randomly sampled since 1982 (Pallarés and Hallier, 1997; Pianet et al., 2000). Currently, the weight of each species in each sample is estimated by the TTT software (applied to PS data) using the species length-weight relationships. It is noteworthy that the same species-specific relationships have been used for 1982-2014 to produce the PS species composition. New length weight relationship have been proposed in 2016 (Chassot et al, 2016) for yellowfin, bigeye and skipjack. They are based on a larger number of samples that the previous ones and they have been used to generate the 2015 and 2016 PS species composition for the Indian Ocean. This means that the catch by species for the studied PS fleets are not strictly comparable before and after 2015. The problem faced by using the historical LW relationships is more serious for skipjack than for the two other species, as the LW relationship used was taken from the Atlantic Ocean (Cayré et al 1986). It should be noted that the introduction of the new relationships leads to larger weight of the 3 tropical tunas at all sizes compared to the weight of the historical period (see figure 1).

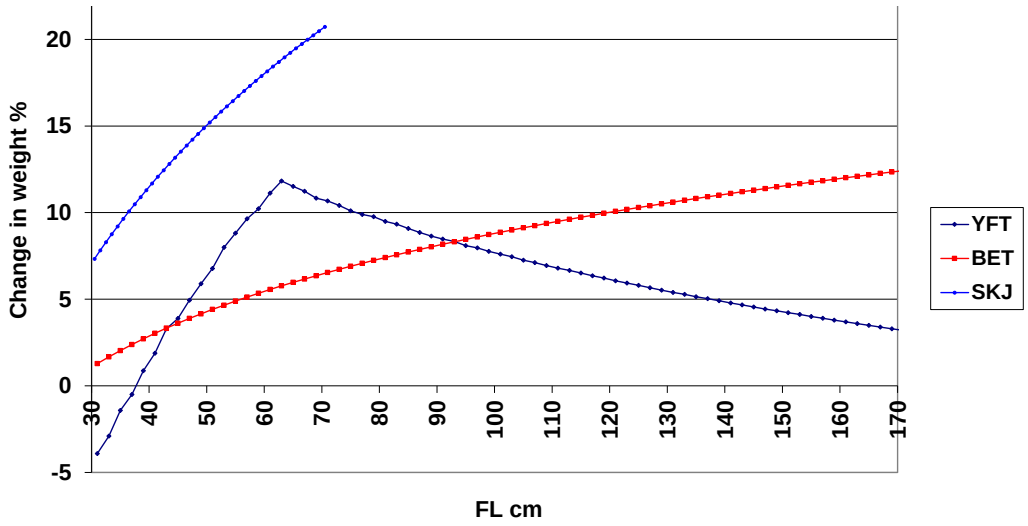

Figure 1: Relative changes (in %) in the weight at size of the 3 species, between the historical LW relationships used in the PS data processing (1982-2014) and the new LW relationship of Chassot & al 2016

It should be noted that the non linear relative change in YFT the weight at size is due to the fact that 2 distinct LW relationship were used for small and large YFT in the TTT data processing.

Consequently, the IOTC scientific community must question the magnitude of change on species composition and catch at size (CAS) of the PS fleets caused by using the new LW relationship before 2015, as the CAS datasets for 1982-2014 correspond to the historical LW relationships.

This paper will make first estimates of the potential changes that could occur in the historical PS statistics, catch by species & CAS, following the use of these improved LW relationships.

2-Data and method used

The ideal method to perfectly estimate these changes should be to run a new TTT data treatment applying the new LW relationship for 1982-2014 on the studied PS fleet. Such processing would provide new catch & effort series by 1°month and CAS by 5° month for each species. This targeted work has been difficult to implement for practical reasons, and an alternate method is proposed here to estimate the change in species composition and CAS. The yearly catches of the studied PS fleet are given in Table 1 and shown in Figure 2. This figure shows the great importance of the studied PS fishery, its total catches during the period 1984-2014 corresponding to an average of 82 % of the total catches by purse seiners in the entire Indian Ocean. The percentage in catch for each component of the studies PS fleet is shown in Figure 3.

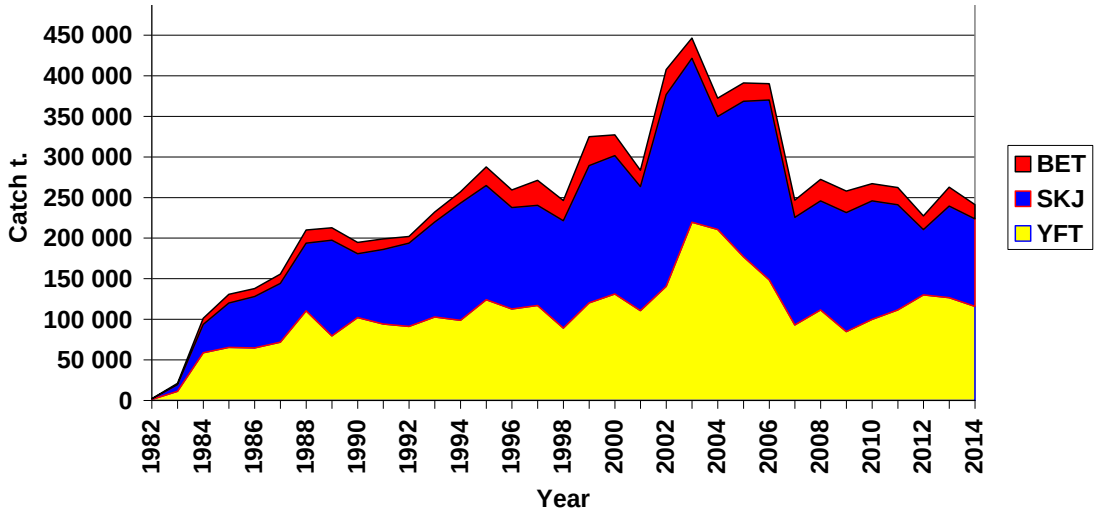

Figure 2: Yearly catches by species for the studied PS fleet concerned by the multispecies sampling and by the TTT data processing during the 1982-2014 period.

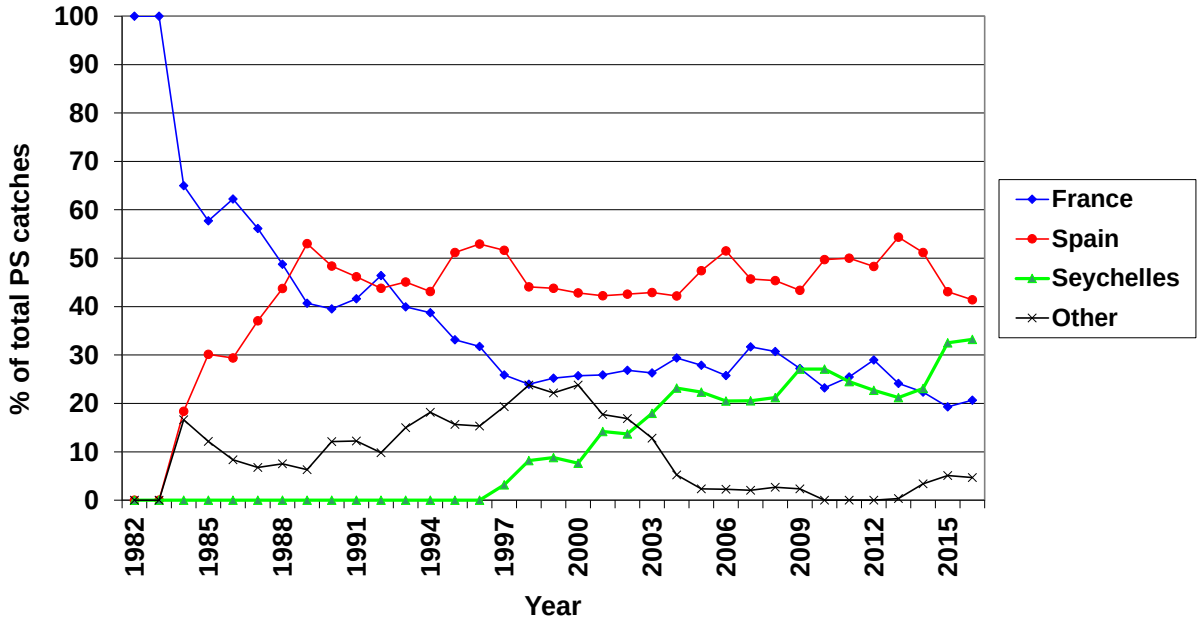

Figure 3: Relative contribution (in %) in catch by flag for purse seiners included in the studied PS fleet

Two similar methods were developed in parallel in order to estimate the consequences of the introduction of the new LW relationship:

A. The first method (so called "NNT method", is based on a reanalysis of the original multispecies size samples weighted to the sampled catches
B. the second method (so called "TM5 method"), is based on a reanalysis of the CAS file (TM5 file), a file that provides the species CAS, using variable numbers and types of strata substitutions[5], and extrapolated to 100% of the PS catches processed by the TTT software.

The following rules have been used for the 2 methods in these calculations:

1) during the 1982-2014 period, we have kept unchanged the length distribution for each species (NNT sizes sampled, and TM5 extrapolated/substituted sizes)
2) for each of the length distributions aggregated by year (sampled and extrapolated numbers), the theoretical weights were estimated in 2 ways: (1) using the historical LW relationship; and (2) using the new LW proposed by Chassot & al (2016).
3) As the 3 species of tunas are heavier with the new LW relationships, the yearly total catch re-calculated with these relationships (C') exceed the total catch estimated previously and submitted to the IOTC (C). Then we calculated the ratio between the new total and the previous total catch (RF = C'/C). The yearly species composition (in terms of %) estimated with the new LW relationship was kept, however the number of tuna sampled (NNT and CAS) by species were divided by RF.
4) The final step was to estimate the relative changes in the catches of each species due to the new LW relationships. This result was calculated for the FOB catches (predominantly small tunas from the 3 species), for the free school catches (predominantly large YFT and with some large BET) and for the combined PS catches.

3-Results

The yearly percentages of total catch increases (by fishing mode and all combined) resulting from the above described methodology are shown in Figure 4. The increase in FOB catches fluctuates between 10 and 14% (average 1982-2014= 12.2 %) whereas the increase in free schools catches ranges from 6 to 11% (average 1982-2014= 8.3 %).

[5] Strata substitution are frequent when the sampling the catches are poorly sampled (for instance in 1998-2000), and they are rare when most catches have been well sampled. When these strata substitutions are needed, they are implemented following fixed rules of strata substitutions that have been defined for the TTT data processing in the Indian Ocean.

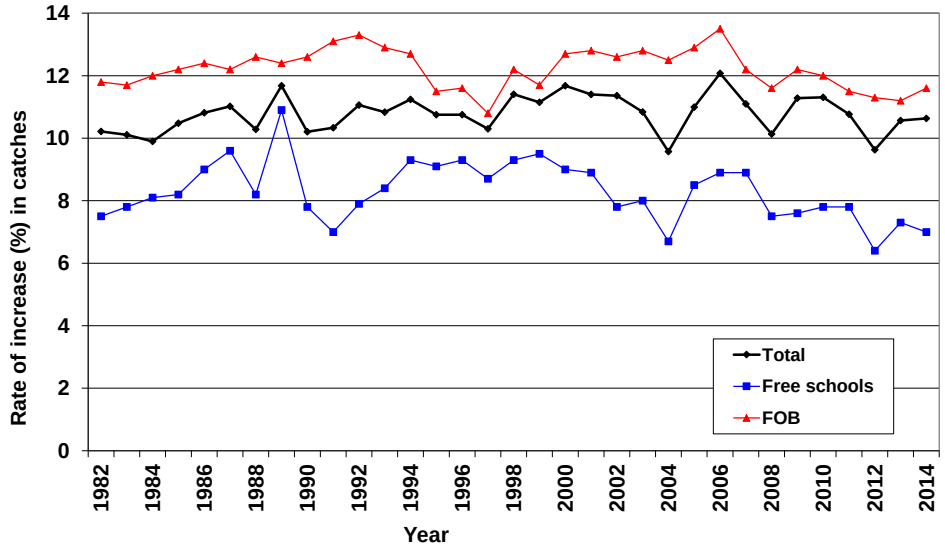

Figure 4: Rate of change (%) in the weight of the PS catches by fishing mode (FOBs, free schools and total) estimated from the current CAS and using the new LW relationships

3.1 – Changes in species composition

The species composition is by nature affected by the recalculated weight of catches for each species. The rate of change in catches, estimated with the 2 methods (NNT and TM5) is shown in Figure 5 for all fishing modes, in Figure 6 for FOB and in Figure 7 for free schools.

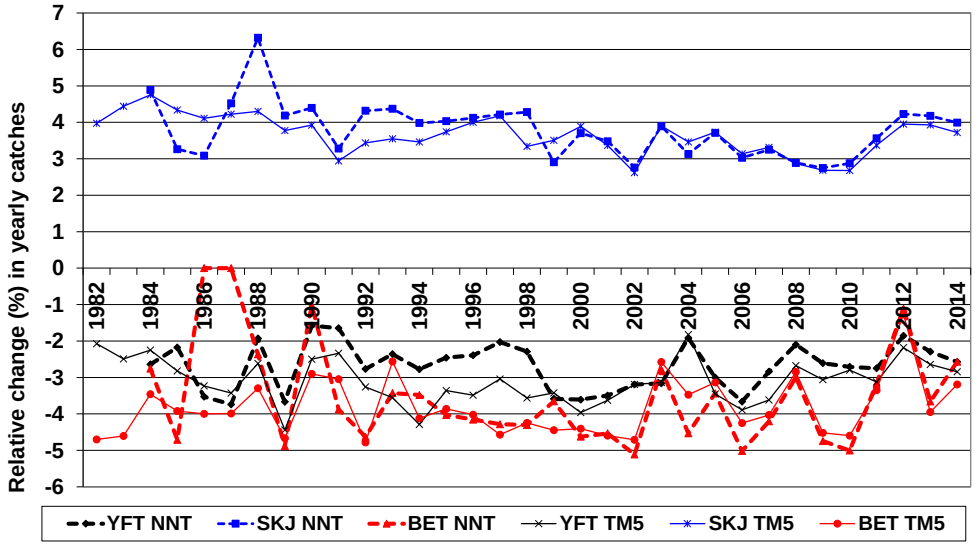

Figure 5: Rate of change (%) in catch by species, for all fishing modes, from the NNT and CAS methods with the new LW relationships. (black: yellowfin; blue: skipjack; red: bigeye),

The following comments can be made on these results:

- Species composition estimated from the 2 datasets (NNT and TM5) are very similar in their levels and trends
- Total catches show increased percentages of SKJ at an average rate of 3.7 %, while the YFT and BET catches show average reductions of 2.9 and 3.7 % respectively.
- SKJ percentage increases on FOBs (Fig. 6) at an average rate of 3.1 %, whilst YFT and BET catches are showing average reductions of 4.1 and 5.6 % respectively.

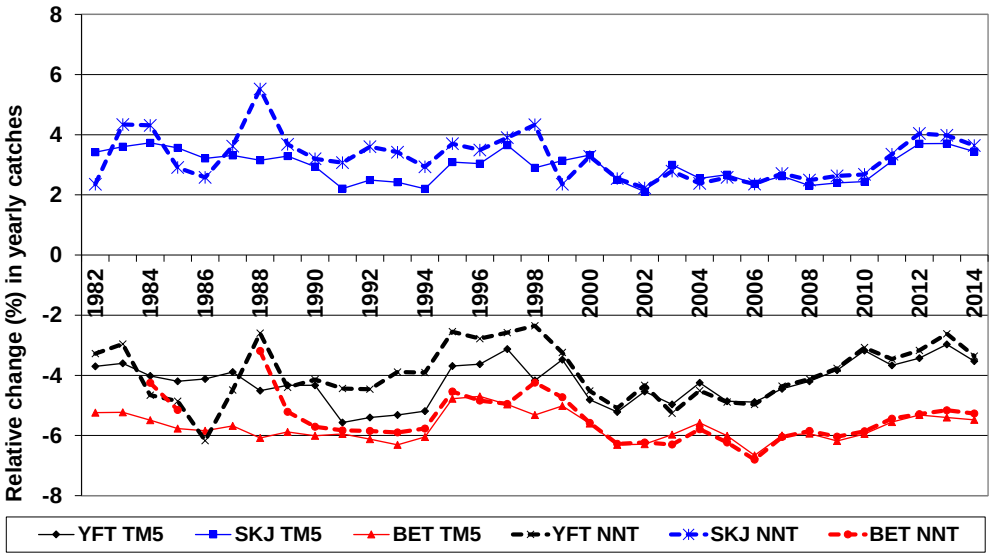

Figure 6. Rate of change (%) in catch by species on FOBs, from the NNT and CAS methods with the new LW relationships (black: yellowfin; blue: skipjack; red: bigeye).

- Free school catches (Fig. 7) exhibit increased percentages of SKJ at an average rate of 7.7%. The reason of such increase is that SKJ on free schools is essentially made of large individuals, and the increase in weight between the previous and revised LW relationships is more pronounced for large individuals than for small ones (cf Fig. 1). YFT catches show an average reduction of 2.1 %, while BET catches are showing an average increase of 1.7 %, because of the large change in weight at large sizes (cf Fig. 1) similarly to skipjack.

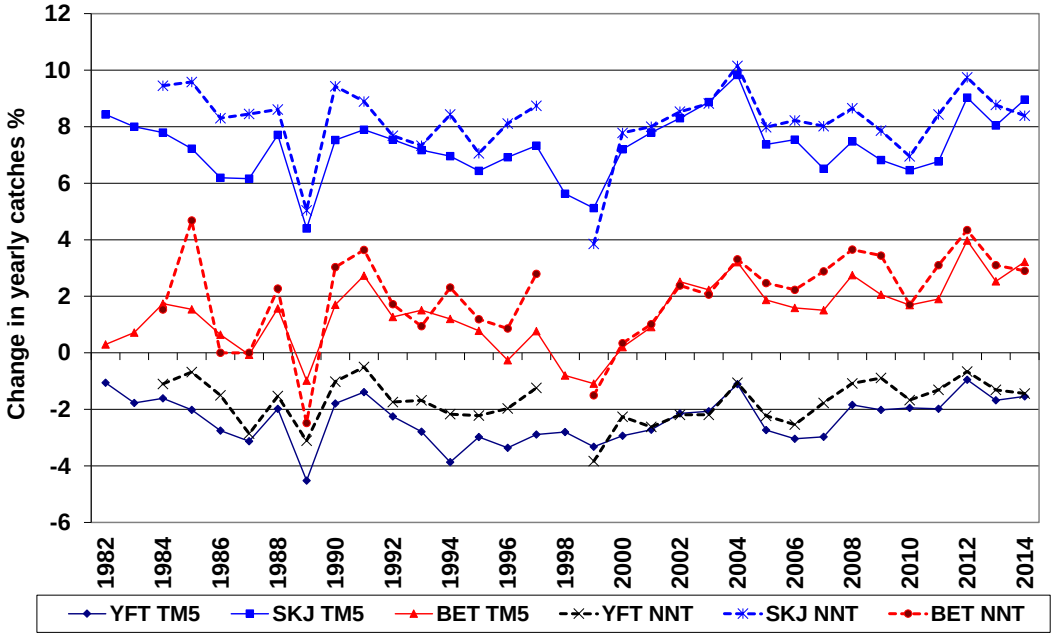

Figure 7: Rate of change (%) in catch by species on free schools, estimated from the NNT and CAS methods using the new LW relationships.

3.2 – Changes in the estimated catch at size (CAS)

A comparison between the presently estimated CAS based on the historical LW relationships, and the alternate CAS based the new relationships shows that all the new CAS are now estimated at a lower level, this decline of the CAS being quite similar for the 3 species and for all sizes.

- Total yearly catches of the 3 species remain unchanged, as they are based on strong landing data
- Catches of each species show distinct levels: an average increase of 3.7 % for SKJ and a reduction of the YFT and BET catches at average rates of 3.1 and 3.8% respectively during the 1982-2014 period
- The average weight of each species has been increased by an average of 7.8 % for YFT, 15.8 % for SKJ and 7.8 % for BET (same period). Concerning this point, it should be noted and kept in mind that the sudden increase in the average weight of SKJ described by Marsac & al (2017) for 2016 on purse seine free schools is likely to be a statistical artefact, due to the use of the new LW relationships since 2015.
- Consequently, this leads to an average reduction of 11 % in the number of tunas caught at size for each of the 3 species.

Although this reduction in number of tuna caught is moderate, it should preferably be taken into account in stock assessment analyses that are based on CAS, as reduced catch in numbers will produce, in many analytical models (such as VPA type models), reduced fishing mortality.

4-Conclusion and recommendations

While there is no doubt that species composition and CAS are closely dependent on the length-weight relationships, we must acknowledge that the potential changes induced by revisions of such relationships has been poorly addressed so far. Recently the datasets have been revised using the new relationships but this has been performed only for the last 2 years of the series. This study aimed at assessing the magnitude of changes that will affect the current PS species composition (for the studies PS fleets) when the new LW relationships will be applied to the whole PS series since 1982.

We have shown that the new LW relationships to be introduced in the TTT processing will not lead to excessive change, however they can be considered as sufficiently significant to deserve attention and implement a prompt action. Table 1 and 2 indicate respectively the changes between the old LW relationships and the revised one during the average period 1991-2016. These changes in catch by species and average weight of tunas caught by the studied PS fleet are also summarized in the following table.

	Change in total catches in weight (%)	*Average weight (kg) with old LW relationships*	*Average weight (kg) with revised LW relationships*	*Change in average weight (in %)*
Yellowfin	-3.1	11.2	12.1	+7.8
Skipjack	+3.7	2.6	3.0	+15.8
Bigeye	-3.8	5.6	6.0	+7.8

Such changes in the catch by species correspond to an increase of the average weight of the three tropical tuna species landed by purse seiners, and correlatively to a reduction of the numbers of tunas caught. Our study also clearly points out that changes are significant but relatively limited; this is because the increase in individual weight is not limited to a single species, but rather simultaneously concerning all 3 species, then reducing the relative changes in the estimated species composition. For instance, the changes in the estimated species composition would have been much more important if the SKJ LW relationship was the only one changed

Pending a full reprocessing of PS logbooks and multispecies samples with the TTT software, the results presented in this paper remain indicative and preliminary. However we consider that they are already quite realistic to show the order of magnitude of the statistical changes that should be introduced in the PS catch and CAS statistics when the new LW relationships will be used in the PS data processing. The catch of the studied PS fleet represent about 80 % of the total PS catches in the Indian Ocean, then a significant fraction especially for the FOB catches. It should be reminded that PS is the fishing gear that has always showed the best coverage rate and quality status in its statistics.

In this context, we propose several recommendations to be discussed by the concerned scientists, by national statistical administrations and by the IOTC Secretariat, in order to improve further the quality of PS catch and effort statistics:

1) **A TTT reprocessing of the PS catches and CAS** using the Chassot et al 2016 LW relationships for the 3 tropical tuna species should be performed as soon as possible, spanning the whole series of statistical data for the EU (France, Italy and Spain), Seychelles, Mauritian and also the PS fleet fishing under associated flags (from Cote d'Ivoire, Belize, Panama, Saint Vincent, Curaçao, etc). Such work should then be conducted in full cooperation between scientists collecting and processing PS data of these flag countries. The results of this new data processing should be carefully analyzed and discussed. The revised PS data sets should then be used in all IOTC scientific analyses, especially in stock assessments and especially in all specific research activities being developed in relation to the FOB fishery.

2) **To reduce the excessive smoothing in the data processing:** in addition to the statistical bias due to the introduction of new LW relationships that has been addressed in this paper, another statistical problem discussed by Fonteneau and Lucas (2015) should also be kept in mind in a future revision of the PS data: the issue of too large and too heterogeneous time-area strata used to generate the final PS catch and effort datasets submitted each year to the IOTC. This statistical issue, a quite complex one, is being addressed through in-depth investigations. The main effect of the current time-area stratification is to produce an excessive smoothing in the statistical results (species composition and sizes by 1° square). Ideally, the 2 statistical corrections (LW relationships and time-area stratification) should be conducted simultaneously, however the identification of the most appropriate time-area stratification may take a while to be fixed, while the bias related to the LW relationships can be solved easily and promptly.
.
3) **A better analysis and continuous monitoring of the tuna condition factors:** as the LW relationship appears to be of great potential importance in the PS catch statistics, the possible time and space heterogeneity in growth and condition factors of tropical

tunas caught by PS, should be better monitored and analyzed by scientists. The improvement in collection of biological and ecological information is already listed as a high research priority by the WPTT, but the question of the space-time variability of these biological parameters is not explicitly underlined. For instance it should be questioned whether condition factors of tunas were improved during the *"Natosquilla"* event which occurred from 2002 to 2006, when large schools and large catches of tropical tunas were recorded in association with *Natosquilla*, a small epipelagic crustacean that was exceptionally abundant in the west Indian Ocean, providing an easily available forage resource for all sizes and species of tropical tunas.

4) **An improved version of the TTT data processing software** should be developed by concerned scientists in order to introduce a full flexibility in potential changes of the LW relationship and other parameters used by the software. The yearly values of the LW relationship used each year in the TTT data processing should also be fully transparent and traceable in the TTT statistical results, a situation that currently requires some improvement.

Cited literature

Cayré P., F. Laloe (1986). Relation poids-longueur de listao (*Katsuwonus pelamis*) de l'Océan Atlantique. In: ICCAT Conference on the International Skipjack Year Program, Tenerife (ESP), 1983/06/21-29 (ed.) Proceedings of the ICCAT conference on the international skipjack year program

Chassot E., C. Assan, J. Esparon, A. Tirant, A. Delgado de Molina, P. Dewals, E. Augustin and N. Bodin. (2016). Length-weight relationships for tropical tunas caught with purse seine in the Indian Ocean: Update and lessons learned. IOTC-2016-WPDCS12-INF05, 11p.

Fonteneau A. and J. Lucas (2015). Alternate improved estimates of the species composition of FOB catches by purse seiners in the Indian Ocean. IOTC-2015-WPDCS11-INF06, 15p.

Fonteneau, A. (1976). Note sur les problèmes d'identification du bigeye dans les statistiques de pêche. Col. Vol. Sci. Pap. ICCAT 5, 168–171.

Marsac F., A. Fonteneau, J. Lucas, J.C. Baez, L. Floch (2017). Data-derived fishery and stocks status indicators for skipjack tuna in the Indian Ocean. Doc. IOTC WPTT19-09, 22p

Pallarés P., Hallier J.P., 1997. Analyse du schéma d'échantillonnage multi-spécifique des thonidés tropicaux. Document UE DG-Pêche n˚95/37

Pianet, R., Pallarés, P., Petit, C. (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. In: IOTC Proceedings IOTC No. 3, pp. 104–139.

Tables

Table 1: Yearly total catches of the studied PS fleet by species, according to the historical LW relationships.

Year	YFT	SKJ	BET	Total
1982	1 110	780	149	2 039
1983	11 167	7 903	1 563	20 634
1984	58 771	33 287	7 545	99 601
1985	65 406	52 149	10 632	128 186
1986	64 656	60 540	9 934	135 128
1987	71 786	69 169	11 537	152 491
1988	110 282	79 599	16 226	206 105
1989	79 567	112 698	15 427	207 688
1990	102 027	75 240	14 031	191 293
1991	94 041	88 092	12 994	195 125
1992	91 171	98 075	8 326	197 569
1993	102 815	111 930	12 365	227 106
1994	98 626	138 496	13 767	250 884
1995	124 095	135 125	22 914	282 128
1996	112 504	119 974	21 755	254 227
1997	116 881	118 734	30 744	266 352
1998	89 191	126 762	24 943	240 886
1999	120 189	162 393	35 586	318 156
2000	131 134	162 565	25 497	319 185
2001	110 445	146 478	20 105	277 018
2002	140 485	226 997	30 990	398 453
2003	219 504	192 833	24 804	437 123
2004	210 700	133 385	22 422	366 495
2005	177 124	183 041	22 496	382 643
2006	148 574	211 514	20 030	380 106
2007	92 982	127 278	21 208	241 458
2008	111 409	129 780	26 487	267 664
2009	84 712	141 317	26 464	252 481
2010	99 778	140 767	21 287	261 814
2011	111 543	124 516	21 440	257 486
2012	129 972	77 227	16 884	224 074
2013	126 589	108 410	23 302	258 285
2014	115 776	103 533	17 503	236 800

Table 2: Yearly total catches of the studied PS fleet by species: according to the new LW relationships proposed by Chassot et al 2016.

Year	YFT	SKJ	BET	Total
1982	1 087	811	142	2 039
1983	10 889	8 254	1 491	20 634
1984	57 450	34 869	7 284	99 601
1985	63 562	54 410	10 215	128 186
1986	62 565	63 028	9 537	135 128
1987	69 325	72 089	11 077	152 491
1988	107 395	83 022	15 691	206 105
1989	76 032	116 952	14 707	207 688
1990	99 479	78 194	13 624	191 293
1991	91 845	90 684	12 598	195 125
1992	88 200	101 444	7 928	197 569
1993	99 160	115 902	12 048	227 106
1994	94 397	143 291	13 200	250 884
1995	119 927	140 177	22 029	282 128
1996	108 582	124 773	20 880	254 227
1997	113 324	123 695	29 340	266 352
1998	86 013	130 998	23 884	240 886
1999	116 077	168 089	34 003	318 156
2000	125 937	168 884	24 374	319 185
2001	106 438	151 407	19 181	277 018
2002	136 001	232 939	29 531	398 453
2003	212 618	200 358	24 165	437 123
2004	206 858	138 004	21 643	366 495
2005	171 003	189 866	21 790	382 643
2006	142 795	218 150	19 178	380 106
2007	89 620	131 495	20 353	241 458
2008	108 430	133 512	25 733	267 664
2009	82 118	145 106	25 268	252 481
2010	96 985	144 536	20 309	261 814
2011	108 061	128 715	20 722	257 486
2012	127 135	80 277	16 670	224 074
2013	123 245	112 669	22 382	258 285
2014	112 484	107 383	16 944	236 800