Improving the management of European Union and assimilated Purse Seine fleets size-frequency data received by the Secretariat

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SUMMARY

To write

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1. Introduction

The purse seine (PS) fleet of the Indian Ocean developed from the early-1980s after some exploratory cruises (Hallier and Marsac, 1985). Initially based on the sampling protocol conducted for the European purse seine fleet of the Atlantic Ocean (Bard and Vendeville, 1986), sampling procedures of the PS catch in the Indian Ocean quickly adapted to the logistical constraints of unloading in Victoria (Seychelles) and evolved over the 1980s and 1980s with the expansion of the fishery (Hallier et al., 1992).

Consequently, sampling of size frequency data for tropical tunas caught by the European and assimilated purse seiners varied over time (Pianet, 1999). Prior to August 1984, one single size sample of about 100 yellowfin and skipjack was collected at sea and at land for estimating the size structure of the catch. Bigeye was less abundant in the catch and samples generally included less than 100 fish. From September 1984, an additional sampling of the 'mixed sets', i.e. coming from fishing sets comprised of a mix of small tunas generally caught on floating objects, was performed to estimate the species composition of the catch. After 1987, the method expanded to all wells where the size sampling indicated a mix of species inconsistent with what was reported in the logbook or well plan. From 1989 to 1998, a simple random sampling procedure was implemented with one step aimed at estimating the size structure and a second one devoted to the species composition. The sampling protocols and processing procedures for the European and assimilated PS fleets were harmonized across the two oceans from the late-1990s through the EU project 'Échantillonnage Thonier' which established the foundation of the current sampling system in use in the fleets flying the Seychelles, French, Spanish, and Mauritius flag (Pallarés and Hallier, 1997; Pianet et al., 2000). Since 1998, a single sampling procedure has been implemented to estimate both size and species composition from size measurements.

Size-frequency datasets prepared by the IOTC Secretariat for stock assessments are based on the data provided on an annual basis by each CPC. While some assessment models (e.g. Statistical-Catch-At-Age) rely on a complete catch-at-age matrix which requires extrapolation procedures and assumptions (e.g. use of proxy fleet assumed to have a similar size structure), Multifan-CL and Stock Synthesis (SS) make use of the raw size frequency data available for the fleets considered in the model (Fournier et al., 1998; Methot and Wetzel, 2013). Precisely, a multinomial distribution is used to model the length composition data expressed in proportion, using an assigned sample size to scale the

variance of each bin in a composition vector (Methot and Wetzel, 2013). This sample size is typically in the range of 50–200 individuals, i.e much lower than the actual number of individuals measured. It is noteworthy that SS estimates an 'effective sample size' (ESS) which represents the size of the random sample needed, on average, to achieve a fit that is as good as the variance in the model's fit to the composition vector (Methot and Wetzel, 2013; McAllister and Ianelli, 1997). In the 2016 assessment of bigeye conducted with SS, all fisheries length frequency observations were assigned an ESS of 1 to down-weigh their importance in the fitting process while the PS log-associated fishery was assigned an ESS of 10 (Langley, 2016). PS size frequency data play therefore a crucial role in stock assessments of yellowfin and bigeye with regards to the issues encountered in longline size-frequency data (Geehan and Hoyle, 2013).

It was noted during the 2015 Scientific Committee and the 2016 Working Party on Tropical Tunas that the size frequency data used for purse seine catches in the recent stock assessment models developed for yellowfin and bigeye differed from the original size samples (Fonteneau, 2016). Preliminary analyses indicated that the size structure of the data processed by the Secretariat were very similar to the data available from the CPCs and this should not affect the assessment. It was agreed during the WPTT that the WPDCS would address the question of management of purse seine size data by the Secretariat. The present report describes the size-frequency data available for bigeye and yellowfin from the European and assimilated purse seine fleets to clarify the current procedures used by the Secretariat for producing the size data used as inputs in stock assessment models.

2. Materials and Methods

Purse seine fisheries are typically split between 2 main types of school association which result in catches of very distinct size and species composition: Log School (LS) and Free School (FS). The acronym 'LS' encompasses any type of drifting floating object to which tuna schools associate with. This definition includes "natural" objects (e.g. logs, palm branches) and anthropogenic floating objects, such as man-made bamboo rafts equipped with radio-range beacons, satellite transmitters and echo-sounders. The acronym 'FS' is used for free-swimming schools, i.e. unassociated. Fishing sets made on whales were classified as FS sets whereas sets made on whale sharks (*Rhincodon typus*) were classified as LS sets (Pallarés and Hallier, 1997).

2.1 Sampling protocol and processing

In the Indian Ocean, the sampling of the European and assimilated purse sein-
ers is conducted at unloading in the fishing ports of Victoria (Seychelles) and
Antsiranana (Madagascar). It consists in a 2-step approach: (i) the wells are
selected from among those containing homogeneous strata, i.e. same quarter,
type of school association and area (Fig. 2) and (ii) fish are randomly collected
from the wells and counted and/or measured. A total of 500 fish are sampled
for LS sets and 200 for FS sets in 2 distinct rounds made on the upper and
lower parts of the wells to reduce any stratification effect. Size measurements
are made with a caliper in fork length (i.e. projected straight distance from
the tip of the snout to the shortest caudal ray; F_L) to the nearest cm for tunas
<70 cm and in predorsal length (i.e. projected straight distance from the tip
of the snout to the anterior base of the first dorsal fin) to the 1/2 cm for tunas
>70 cm. Raw data are stored in the MS ACCESS relational database AVDTH
(Lechauve, 1999).

In a second step, all fish sizes are harmonized in fork length through species-
specific conversion keys, which determine the proportion of fork length at pre-
dorsal length, and stored in the PostgreSQL/PostGIS database BALBAYA
hosted on a secured IRD server. A quality code is assigned to each size-frequency
sample: (1) samples can be used for both estimation of species composition and
size structure, (2) samples can be used for description of size structure, (3) sam-
ples can only be used for describing some biological samples, (4) samples can
not be used as there was some sorting issues, etc.

All size-frequency data collected for the European and assimilated PS fleets
have been shared over the full time period through mutual agreements be-
tween the institutes in charge of the purse seine monitoring, namely the In-
stitute of Research for Sustainable Development (IRD), the Instituto Español
de Oceanografia (IEO), and the Seychelles Fishing Authority (SFA). At IRD, all
sampling data from 1990 have been stored in BALBAYA. The annual number of
samples varied from about 500 during 1990-1997 to about 50 during 1998-1999
and 200 in 2000 due to some issues in the monitoring of sampling activities (Fig.
1). The number of sampled increased thereafter consistently with the expansion
of the fishery and varied between 900 and 1700 during the 2000-2010s. Data
collected prior to 1990 are only available for the French PS fleet and accessi-
ble in AVDTH while Spanish samples collected prior to 1990 are currently not
available.

2.2 Data sets

Three types of size-frequency data sets are produced for the European and assimilated purse seine fleets:

1. **Raw samples** (file extension NN.T): Number of individuals by 2-cm fork length class (lower bound);

2. **Weighted samples** (file extension PON.TM5): Number of individuals by 2-cm fork length class (lower bound) raised to the catch of the fishing sets sampled and aggregated by 5x5 grid and month;

3. **Catch-at-size** (file extension NE.TM5): Number of individuals by fork length class raised to the total catch and aggregated by 5x5 grid and month.

It is noteworthy that the catch-at-size data set results from a processing procedure which merges all European and assimilated size samples to estimate the mean size distribution in a given stratum, i.e. area, quarter and type of school association (Fig. 2). The processing assumes that the flag of the fishing vessel does not affect tuna size distribution within each stratum. This results in the relative length frequency distribution to be identical for all the flags in a given stratum. When the number of samples is considered insufficient (<15), a substitution procedure is used, e.g. using length distributions from neighbouring grids, or different time periods for the same area. the file extension is (Pallarés and Hallier, 1997).

2.3 Data management at the IOTC Secretariat

Each of the 3 size-frequency data sets described above has not always been provided on an annual basis to the IOTC Secretariat. Hence, there is some heterogeneity in the data available at the Secretariat due to the temporal changes in sampling and processing conducted and associated tools Pianet (1999); Pianet et al. (2000). The IOTC database stores for each reported size-frequency stratum the 'sample size', i.e. the actual number of fish having been sampled for the stratum according to the data provider, and the number of fish for each length class, i.e. the length distribution. To prepare the files for stock assessment models (i.e. SS3), which use the original samples, the raised lengths (NE.TM5) are scaled down to the original sample size provided to the Secretariat in the PON.TM5 files. When producing the SS3 inputs - in terms of length distribution for each assessment stratum (year, quarter, fishery) - the process uses the size-frequency data as stored within the IOTC database and updates the actual

length distribution for each year, fleet, month, grid, gear, species so that the sum of number of fish by length class (for a given stratum) will be equal to the stored sample size for the same stratum. This is true for each and every stratum that has a sample size greater than zero: size-frequency strata with sample size set to zero are simply discarded.

3. Results & Discussion

3.1 Availability of size measurements

The number of tropical tuna measurements collected during 1983-2015 is very similar between the IOTC database and data available from IRD, IEO and SFA. The number of data available from IOTC for sets on floating objects (LS) appears to be equal or higher to IRD-IEO-SFA during 1984-1989, likely due to the current non-availability of Spanish samples during this period in the IEO database (Figs. 3-4). This indicates that the size data could be recovered from the IOTC for this period as the number of fish suggests that the raw samples were provided to the Secretariat at this time. It is noteworthy that all bigeye size measurements collected by IRD during 1986-1987 were lost while they are available for yellowfin and skipjack. Some data rescue from IRD historical records might be feasible and should be further explored (A. Fonteneau, pers. com.). For some years, there are more size measurements available from IRD, IEO and SFA than in the IOTC database. This could be due to the quality criteria used when data were provided to the Secretariat as the information is currently missing for some European and Seychelles size samples. A procedure was recently developed to determine the sample quality from samples characteristics (e.g. number of fish) and information on fishing set origin available from the well plans. This procedure should be used for all samples with unknown quality to ensure that only data of quality criteria 1 and 2 have been provided to the Secretariat. Finally, it seems that PS size data collected in 2014-2015 have not all been provided to the Secretariat and this should be checked once the criterion of data quality has been fully recovered.

3.2 Comparison of size structure

Overall, size frequency data available from IRD-IEO-SFA and the IOTC Secretariat are very similar over the period 1991-2015. For instance, the relative size frequency distribution of bigeye caught on LS in 2014 shows an almost identical pattern with a median size at 50 cm F_L and the 25% and 75% quantiles at 46

and 56 cm F_L, respectively (Fig. 5). There are however some small differences in the relative magnitude of the distribution for sizes in the interval 50-60 cm F_L and for fish >75 cm F_L. These differences are not due to size-frequency data available from purse seine fleets other than the European and assimilated fleet, i.e. Korea and Iran, since no information on LS size data was provided by these CPCs in 2014. Our results show that the IOTC FL data correspond to the CAS data sets provided by IRD-IEO-SFA over the period 1991-2015. SS3 inputs appear to be very similar to the CAS data with some small changes that due to the removal of size data from the strata where there was no sampling. Future stock assessments conducted with a similar approach as SS3 for dealing with size data, i.e. with a likelihood component for the length composition data, should use the size structure available from the weighted samples of PS size frequency data and not be derived from the CAS data that rely on some processing (merging of the samples of a same stratum) and substitution procedure.

More differences between data sources are found in the 1980s. In 1988 for instance, the CAS data available from IRD-IEO-SFA strongly differ from IOTC FL data and from SS3 input data (Fig. 5). Also, unweighted size data, only available from French purse seiners, appear to be skewed towards large sizes (median = 61 cm F_L) while the CAS is more consistent with a typical size structure of bigeye caught on LS (median = 54 cm F_L). Only less than 6,000 bigeye were measured in 1988 from some selected wells of the French purse seiners, i.e. non randomly (Pianet, 1999). In this case, the computation of the Catch-At-Size matrix accounting for the weight of each sample and non sampled strata might better reflect the size structure of the population. It might then be better to rely on the CAS data available from IRD-IEO over the period 1982-1990 to produce the size-frequency data required by stock assessment models such as SS3.

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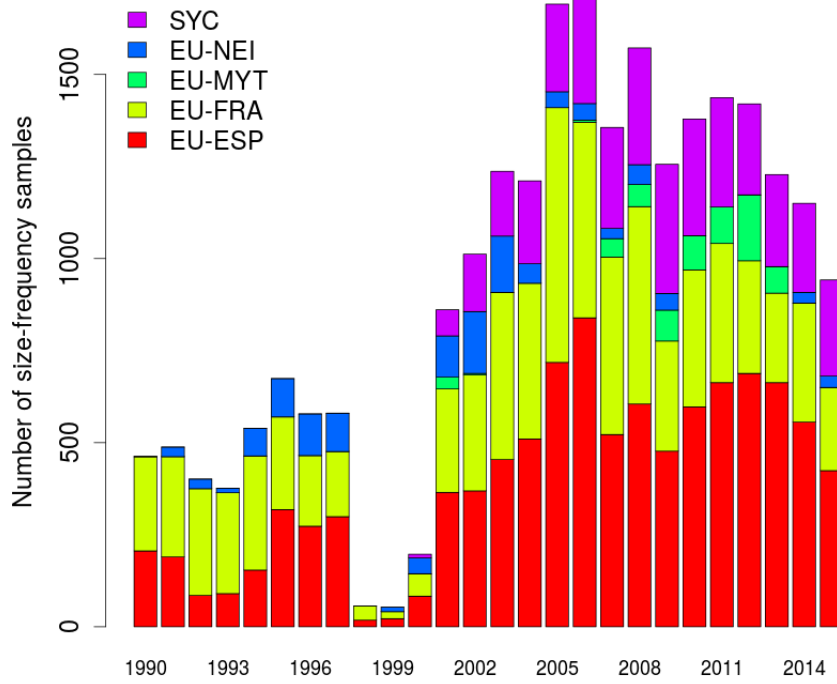
Figures

Figure 1: Annual number of size-frequency samples collected during 1990-2015 from European and assimilated purse seiners having operated in the Indian Ocean
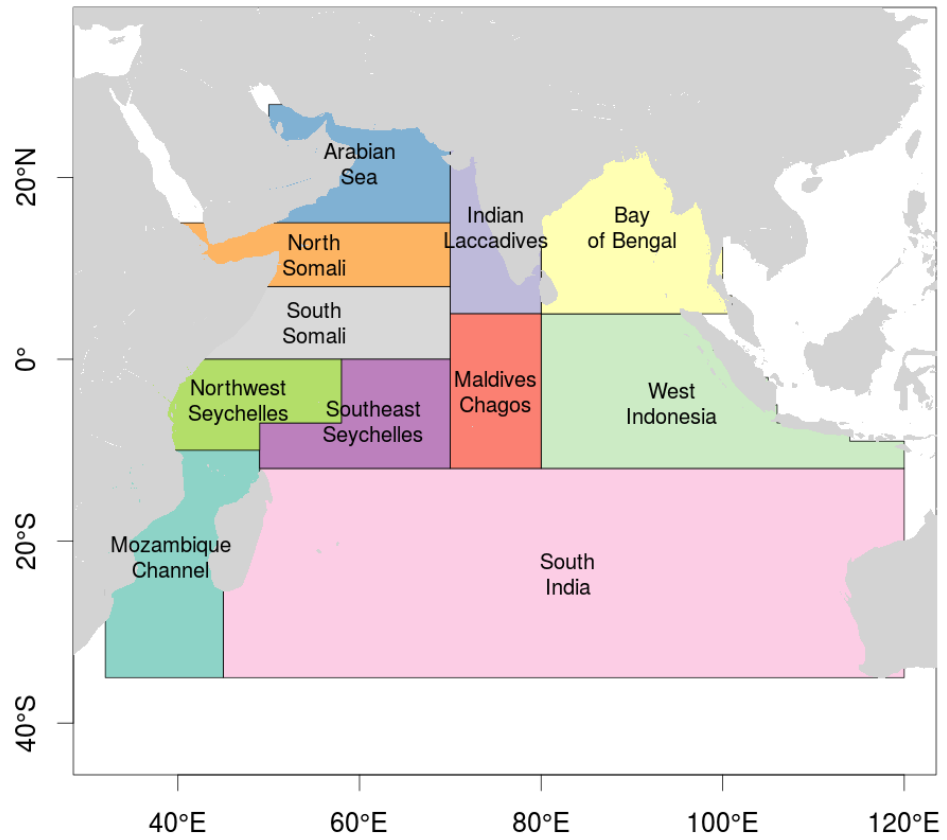
Figure 2: spatial areas used in the processing of size-frequency data collected from the European and assimilated purse seine fishery in the Indian Ocean
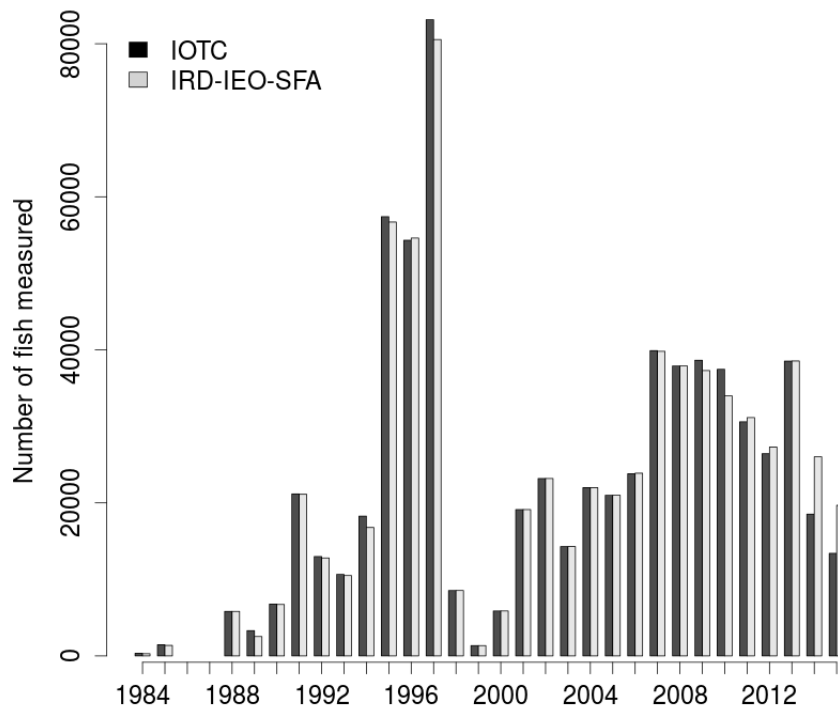
Figure 3: Annual number of size measurements for bigeye caught on schools associated with floating objects (LS) by the European and assimilated purse seiners having operated in the Indian Ocean during 1984-2015 available from IOTC (black) and IRD-IEO-SFA (grey). Data prior to 1990 from IRD-IEO-SFA only include samples from French purse seiners
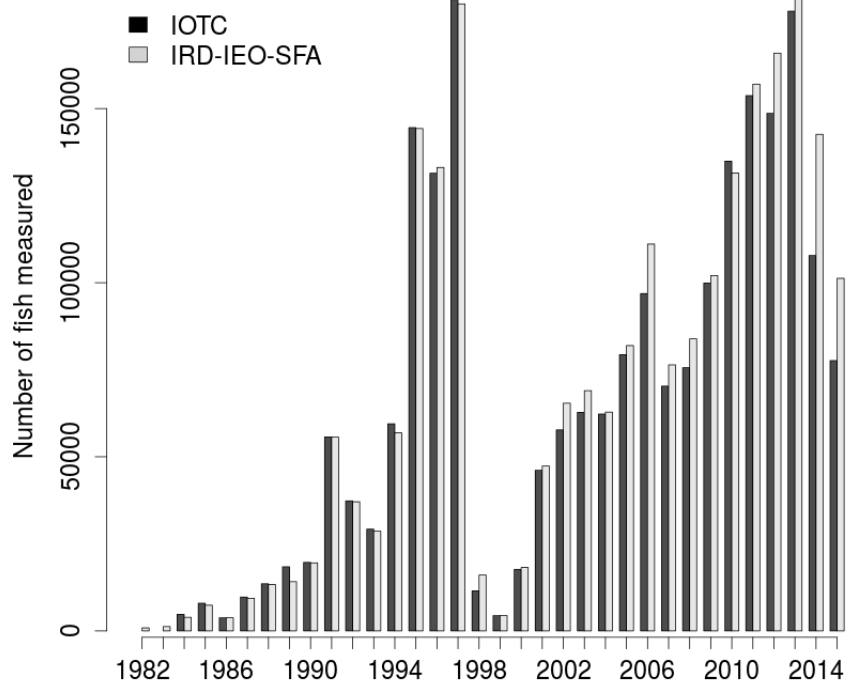
Figure 4: Annual number of size measurements for yellowfin caught on schools associated with floating objects (LS) by the European and assimilated purse seiners having operated in the Indian Ocean during 1984-2015 available from IOTC (black) and IRD-IEO-SFA (grey). Data prior to 1990 from IRD-IEO-SFA only include samples from French purse seiners
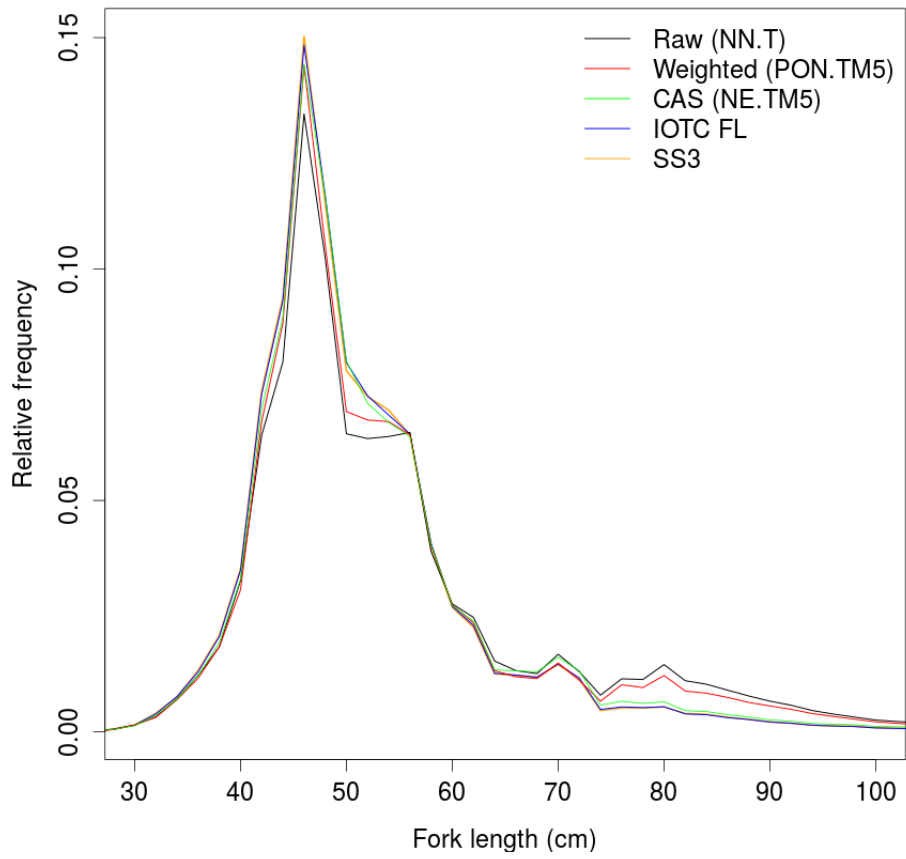
Figure 5: Relative size-frequency histograms of bigeye caught on schools associated with floating objects (LS) by the European and assimilated purse seiners having operated in the Indian Ocean in 2014 based on the different data sets available
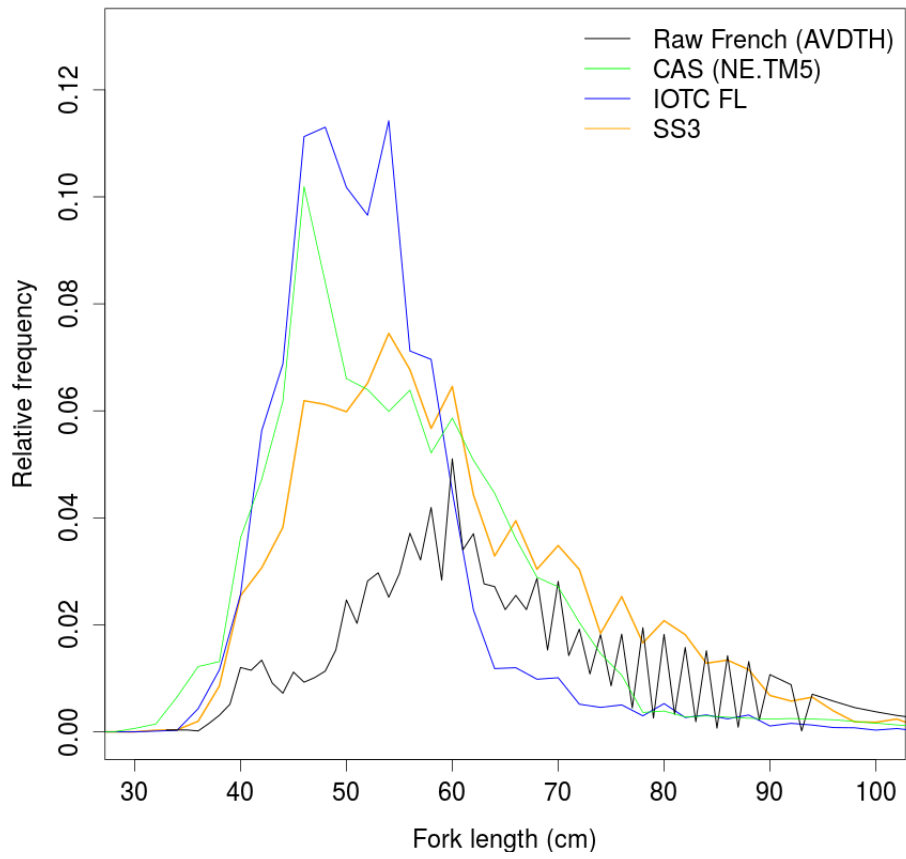
Figure 6: Relative size-frequency histograms of bigeye caught on schools associated with floating objects (LS) by the European and assimilated purse seiners having operated in the Indian Ocean in 1988 based on the different data sets available