REVIEW AND UPDATE OF THE FRENCH AND SPANISH PURSE SEINE SIZE AT CATCH FOR THE MEDITERRANEAN BLUEFIN TUNA FISHERIES 1970 – 2010

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SUMMARY

Since the 1970s, Purse seiners is one of the main fisheries targeting Atlantic bluefin tuna, particularly in the Mediterranean Sea. At the beginning of the fishery, French and Spanish vessels operated near the coast and mainly targeted small young schooling bluefin tuna. At the end of the 80s the French and Spanish vessels started targeting spawner aggregations as they discovered the Balearic spawning ground. Since then, the fleet gradually adapted its capacity and technology to target bigger tuna on distant grounds. By the early 2000s, the purse seine fishery became the main provider of live fish to the developing farming operations in the Mediterranean Sea. Although this fishery represents on average more than 50% of the catch since the 1980s, basic fisheries information on size of the catch and/or its age distribution is very limited. Indeed, past assessments have identified this lack of information as one of the major sources of uncertainty in their evaluations. The present manuscript reviews and incorporates past and new information available on size distribution of the catch of PS in the Mediterranean.

RÉSUMÉ

Depuis les années 70, la pêche à la senne est l'une des principales pêcheries ciblant le thon rouge de l'Atlantique, en particulier en Méditerranée. Au début de la pêcherie, les navires français et espagnols opéraient près de la côte et ciblaient principalement le thon rouge de petite taille en banc. À la fin des années 80, les navires français et espagnols ont commencé à cibler des concentrations de reproducteurs après avoir découvert la zone de frai des Baléares. Depuis lors, la flottille a progressivement adapté sa capacité et sa technologie pour cibler des thons plus gros à des distances plus éloignées. Au début des années 2000, la pêche à la senne est devenue le principal fournisseur de poissons vivants des fermes en développement en Méditerranée. Bien que cette pêcherie représente en moyenne plus de 50% des captures depuis les années 80, les informations halieutiques de base sur la taille des captures et/ou leur distribution par âge sont très limitées. En effet, les évaluations antérieures ont identifié que ce manque d'informations constituait l'une des principales sources d'incertitude dans leurs évaluations. Le présent document examine et incorpore des informations antérieures et de nouvelles informations disponibles sur la distribution des tailles des captures des senneurs en Méditerranée.

RESUMEN

Desde 1970, el cerco es una de las principales pesquerías que se dirigen al atún rojo del Atlántico, sobre todo en el mar Mediterráneo. En los inicios de la pesquería, los buques franceses y españoles operaban cerca de la costa y se dirigían sobre todo a pequeños juveniles de atún rojo en bancos. Al final de la década de los ochenta, los buques franceses y españoles empezaron a dirigir su actividad a concentraciones de reproductores, ya que descubrieron la zona de cría balear. Desde entonces, la flota ha ido adaptando gradualmente su capacidad y tecnología para dirigir su actividad hacia atunes más grandes y en caladeros situados en zonas distantes. A principios de la primera década de 2000, la pesquería de cerco se convirtió en el primer proveedor de peces vivos para las operaciones de cría en desarrollo en el Mediterráneo. Aunque esta pesquería responde como promedio de más del 50% de la captura desde los años ochenta, la información pesquera básica sobre la talla de la captura y/o sobre su distribución por edades es muy limitada. De hecho, evaluaciones pasadas han identificado que esta falta de información constituye una de las principales fuentes de incertidumbre en las evaluaciones. En este documento se revisa e incorpora información nueva y pasada disponible sobre distribución por tallas de la captura de cerco en el Mediterráneo.

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Introduction

Purse seiners (PS) became the main fishery catching Atlantic bluefin tuna (ABFT) particularly in the Mediterranean Sea since the 1970s. Initially the Spanish and French PS mainly targeted small young schooling bluefin tuna off the coast. But in the late 1980s the fishery expanded and began targeting spawner-aggregations particularly off the Balearic Islands. For instance, before the 1990s, the French PS typically targeted juveniles BFT in the Gulf of Lion and the Ligurian Sea and landed their catches in many different sites along the French Mediterranean coast, with no particular seasonal pattern (Farrugio 1981, Fromentin 2003). But in the 1990's the French and Spanish PS fishery rapidly expanded and began targeting bigger fishes in spawner-aggregations particularly off the Balearic Islands. After the TAC enforcement in 2007 and related national regulations, e.g. size limit, the fleet increased its focus on the exploitation of spawning areas over May-June. In the past few years, the fishing season began earlier and consequently larger fish were caught because the arrival of spawners is sequential and depends on size. The bigger fish are the first to arrive and to leave the Mediterranean (Rodriguez-Roda 1964). The PS fishery thus shifted from targeting juveniles over the whole year in the early 1970s, to a seasonal fishery on large individuals in the recent years.

By the early 2000's, with the developing of farming operations in the Mediterranean, the purse seine fishery shifted operations and became the main provider of live fish to farms. Thus, the fishing grounds changed gradually from juveniles to spawners up to 2008, since then and after the implementation of the minimum size to 30kg the fleet restricted its activity to adult fish. Though this fishery accounts on average for more than 50% of the catch since the 1980's (**Figure 1**), basic fisheries information on size of the catch and or age distribution of the catch is very limited (Table 1 catalog MED). Furthermore, in recent assessments it has been identified as one of the major sources of uncertainty in the evaluations (Anon 2015).

In the early days of the French fishery 1970-1993, as most juvenile BFT were sold through local seafood traders, the size composition of the catches could be recovered (Farrugio 1981; Liorzou and Bigot 1999; Liorzou 2001). As French fishermen started to explore the exploitation of big spawners around the Balearic Islands in the 1990s and as the Spanish farms developed, the dynamics of the fishery changed rapidly and so did its marketing. By the mid-1990s, the size structure recovered from local seafood traders started to be incomplete as they only covered around 50% of the catch (Fromentin 2003). By the early 2000s, less than 10% of the French PS catch went through local seafood traders as the fleet concentrated on spawning-areas in May-June (Fromentin 2003). Since then, only the European logbook enforced in the 2000s allowed to follow the size composition of the French catches.

Since 2014, the uses of stereoscopic cameras have been enforced during the transfer of BFT from the purse seine to the cages and allow an accurate monitoring of the size structure of the PS catch in the Mediterranean (Ortiz 2016).

The current paper compares and reviews the available data for the size structure of PS catch in the Mediterranean for Spain and France and proposes a scheme to incorporate it within the 2017 stock assessment to represent the size structure for the Mediterranean PS fishery.

Data

The data provided for this analysis come from two main sources; A) Spanish purse seine vessel data logbooks, kindly provided by Balfegó ship-owners. The data was recuperated from their logbooks and reported by day purse-seine set operations with the total catch in weight (kg) and the corresponding number of fish of the total set catch and fishing area, counted and weighted at landing. B) The French purse seine vessel data is heterogeneous. From 1970 to 1998, it consists in information from the sale records of the local seafood traders collected by IFREMER (Fromentin 2004). Between 1998 and 2000, a French statistical document provided data on size structure and since 2001, the EU logbooks were used. The logbooks provided daily information on the fishing activity; fishing and landing locations, number of positive and negative sets and mean weight per day (Fromentin 2003, 2004). Even though it only represents the mean weight for each operation and not the individual fish sizes, since the 2000s it was the only available information for the French PS (and for other countries). However, because bluefin tends to aggregate in schools with homogeneous size/age distribution, it is assumed that a large number of set operations and hence mean weight per set, will capture the distribution of mean weights of the PS catch in a given year/month strata without accounting for individual variability.

The limitations of this approach are described in Fromentin (2003 and 2004). First, daily mean weights are not validated by any standard protocol, they are estimates provided by fishermen whose purpose is not to describe accurately the size composition, but recent results showed that average weight estimated by fishermen were close to those estimated from stereo-cameras (SCRS/2016/132). Second, in the French logbook data daily mean weights corresponded to all the catches done per day, which sometimes included (i) several shoals or (ii) a single shoal of heterogeneous age-classes. To circumvent the first issue, only days with one set were preserved in the dataset whereas the others were discarded (Fromentin, pers. comm.). Still for the French data, the second limitation was particularly strong for schools of spawners and was handled by disregarding sets including large fishes that appeared as outliers (Fromentin pers. comm.). The observer program of the French PS in place in 2003, did not allow furthering correcting for such biases as the sampling was insufficient (Fromentin and Farrugio 2005).

The data represents operations from 1970 to 2015 for the French PS fleet (150+ Vessels) and from 1985 to 2000 for the Spanish PS vessels (2 vessels). Overall there are over 20 thousand daily sets in the period, with vessels reporting several sets per day. **Figure 2** shows the distribution on daily sets per year, in the 1980's average about 900 sets per years, while in the 1990's increased to about 1800 sets per year, in the 2000's the number of observations declined to 450 set per year, and substantially declined, which was expected from the shift of targeting bluefin tuna for farming plus the reduction of overall quotas. Since 2010 there are least than 150 daily PS set data reports. The total catch in tons and numbers of fish of the data by year is shown in **Figure 3**, this data represents close to 100% of the reported Task I NC of the EU_FRA plus EU_ESP for 1970 – 2015.

Methods and Results

For observations with catch and numbers of fish per set operation, the estimated mean weights per set were converted to mean sizes per set using the monthly conversion factors for Mediterranean bluefin tuna (Rodriguez-Marin et al., 2015). Figure 4 presents the overall distributions of the mean weight per set and the corresponding estimated mean size (SFL cm) for all data. The average catch of the PS is of 34 kg bluefin, with an 80% quartile between 7 and 88 kg. However the data showed that PS did also catch medium and large-sized bluefin, particularly after they started targeting spawning aggregations off the Balearic Islands in the 1990s. The estimated mean sizes of PS catches ranged from 20 to 290 SFL cm, with a main mode around 96 cm, and a second mode about 210 cm. The weight and size distributions showed a relative wide range of catches of bluefin for purse seine operations, suggesting that although individual sizes were not available, the overall mean size/wt. per set operation captured the rough size distribution of PS catches. The seasonal distribution of the observations (**Figure 2**) shows two peaks for purse seine operations, the first one in April-May and a second one in late summer, August- September. However, the fleet has historically operated the whole year round, prior to the implementation of management regulations that established a restricted fishing season (Fromentin 2003). The data provided geographical information for about 90% of the records (**Figure 5**), Most of the sets were in the western and central Mediterranean Sea; Gulf of Lion, Balearic Islands.

The mean weight or estimated mean size per set represent a single value, but the catch and number of fish caught per set varied greatly. The distribution of the number of fish per set ranged from 1 up to 27 thousand fish caught in a single set (Figure 6). This distribution was found to be highly skewed towards small values (left), with a mean of 180 fish and a median of 44 fish. 80% of the observations reported catches between 3 and 476 bluefin per set, however occasional large sets were registered. It was decided to use the log-transformed number of fish per set as a weighting factor, as the distribution of logNfish (**Figure 6** right) is closer to a normal distribution than the equally weighted information when ignoring the number of fish in each mean weight observation (**Figure 6** left). This allows to give more importance to the sets with larger catches in terms of fish numbers, compared to the sets with few fish caught.

The estimated size frequency distribution of the catch from the PS fleets is shown in **Figure 7**. Overall the bluefin caught by PS ranged from 30 cm to 280 cm SFL, but fish about 80 -100 cm represented the bulk of the catch. However, a shift can be observed from 2008 onwards, as PS vessels began targeting larger fish (110-180 SFL cm) and further from the 2010s as catches focused on fish about 190-200 cm. This shift depicted the changes in fishing operations towards larger fish, following the development of tuna farms. The |French and Spanish datasets overlap during 1985 – 2000. The size distributions were found in general similar for each fleet (Figure 8), although the number of sets was substantially smaller (by about 10fold) for the Spanish data.

Finally, the size frequency data estimated from the new MED PS EU_FRA/ESP dataset was compared to the CAS MED PS used in the latest assessment. The cumulative frequency distributions (cdf) of the catch at size from the last assessment MED PS Catch at Size (CAS 2014) and the corresponding size frequency distributions estimated from the New PS data by year were compared. Comparisons of cdf are easier to interpret rather than histograms or density functions where focus tends to be given to peaks rather than to the overall distributions (**Figure 8**). In additions, the sum of squares of the differences between the cdf from the size matrices [20-399cm] corresponding to each of the two sources was estimated (**Figure 9, Figure 10**).

In the 1970s, the size frequency distributions were found similar between both data source for 7 out of 10 years. Different distributions were found in 1970/71/73. Although the number of samples in the New PS data was only about 34% of the CAS_2014. In the 1980s, again similar trends were found for most years (8 out 10), with differences only seen in 1980/88. In that decade the New PS data sampling is about 47% of the CAS_2014. In the 1990's the sum square difference is still relatively low (**Figure 9**). However the New PS data tended to display a shift towards larger fishes for all years except 1994. These cdf's displayed relatively similar distributions overall. In contrast, in the 2000s significant differences were observed between the two data sources. Although the number of size bins with observations was generally similar (~ 80%), the New PS data source displayed a progressive shift towards larger sized fish, whereas it occurred in a much more drastic way for the CAS_2014 between 2002 and 2003. For example, in 2002 both sets of data indicated a 0.5 cdf (e.g. median) at about 90 cm FL, whereas the median from the CAS2014 moves from 180 cm in 2003 to 220 cm in 2004.

Discussion and recommendations

The new information on size distribution from the purse seiner catch filled an important data gap, particularly for the 1980s and 1990s. The results did not show any significant differences between the size distribution from the French and Spanish fleets, which was indicative of comparable fishing strategies. This consistency between the two data sources gave confidence in the size distribution obtained. The combined frequency distribution showed a gradual shift towards larger sizes, which can be summarized in four periods. During the first period, before 1994, both fleets mainly targeted juvenile fish and the catch of adults was negligible as the purse seiners fishing capacity was still limited. The second period, 1994-2003, is characterized by a shift towards adult fish, shortly after the Balearic spawning grounds were discovered and following gradual changes in capacity and technology of the fleet. The third period, from 2004 to 2007, is characterized by the exploitation of fish for farms as a main strategy, clearly illustrated by substantial increase in the frequency of the larger size classes. The last period, from 2008 onwards, result from the enforcement of the size/weight restrictions (30kg minimum weight) illustrated by a strong reduction in the number of fishes smaller than 100cm.

The new PS data presented in this study were generally found in accordance with the CAS 2014. However, they differed from the CAS2014 at the beginning of the 2000s, but a gradual rather than abrupt change in length frequencies is more in accordance with the progressive change in fishing strategy. Using this new size structure seems thus the best available option for the 2017 stock assessment.

Although the information presented here allows filling a major gap in the purse seiner data, major issues remains. In particular it is still unclear whether the French and Spanish fleets can be used to represent the dynamics of other major PS nations from the Mediterranean Sea. Reconstructing past size structures for the PS of these countries would substantially improve the quality future assessments.

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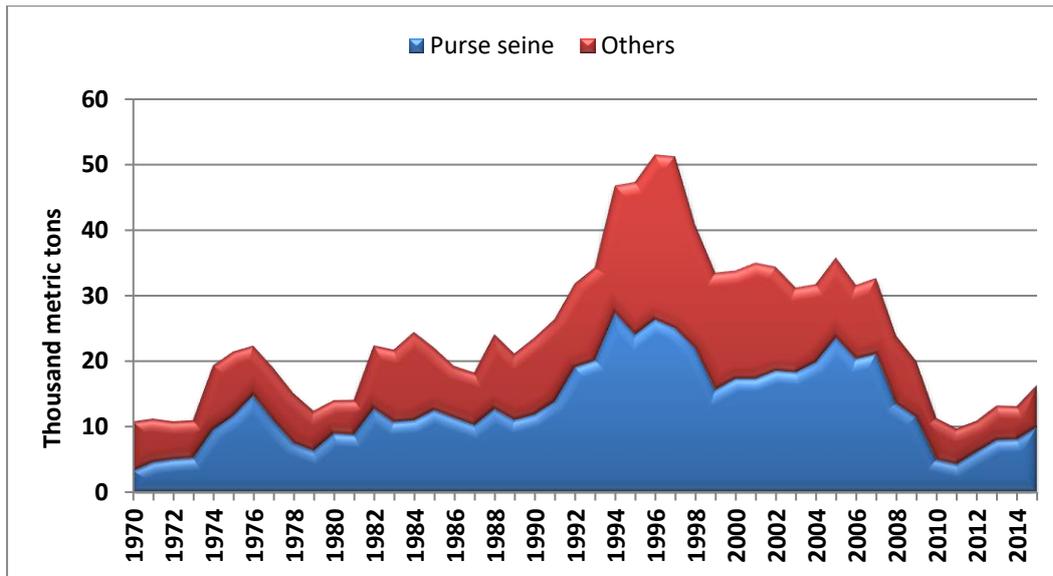
Figure 1. Total catch east Atlantic and Mediterranean bluefin tuna (tons) by purse-seine fleets and other gears 1970 – 2015.
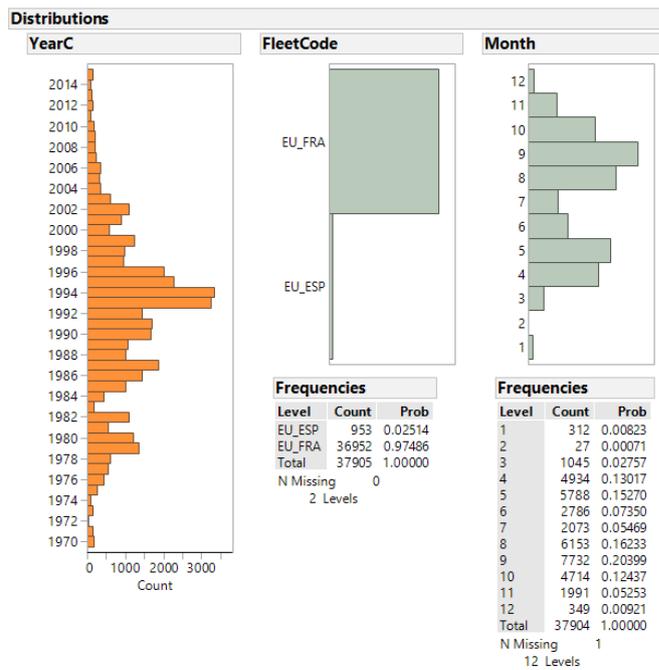

Figure 2. Distribution of MED PS set operations from EU_FRA/ESP vessels by year, flag and month.
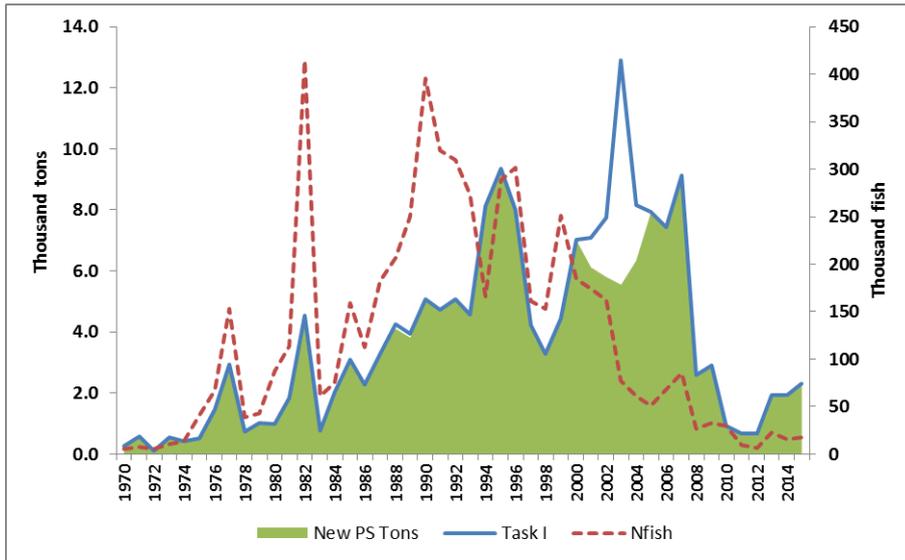
Figure 3. Comparison of the total catch (tons) of bluefin tuna from the MED PS EU_FRA/ESP fleets (New PS tons) and the Task I Nominal Catch of the same fleets 1970 – 2015. Broken line represents the catch in number of fish for the New PS data.
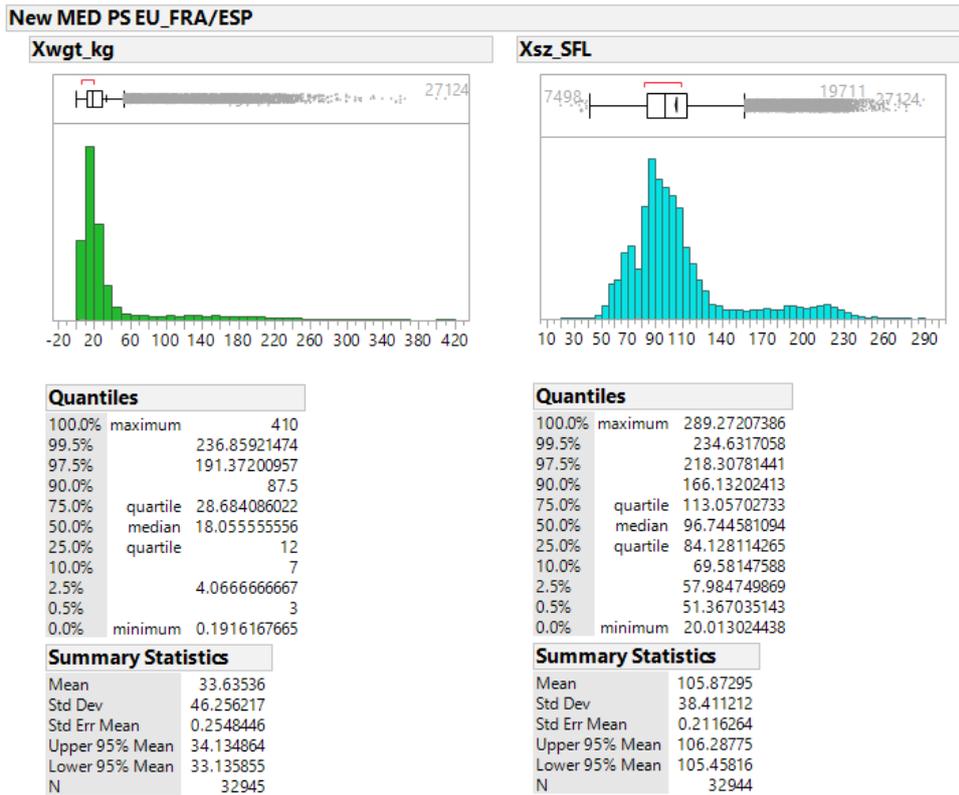

Figure 4. New MED PS EU_FRA/ESP mean weight (RW) per set operation (left) and estimated mean size (SFL cm) per set operation distributions.
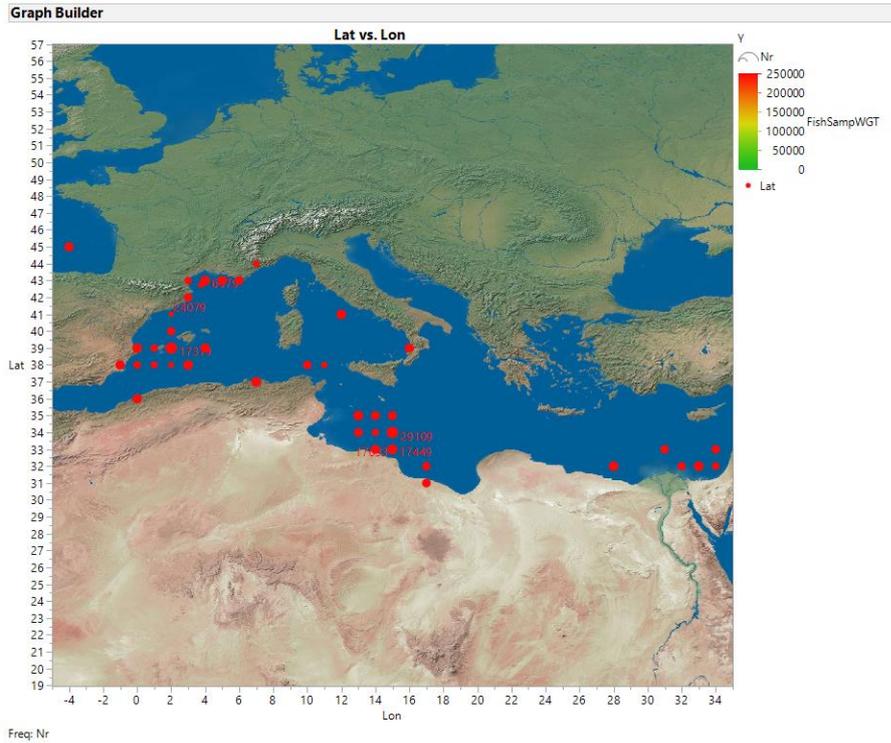
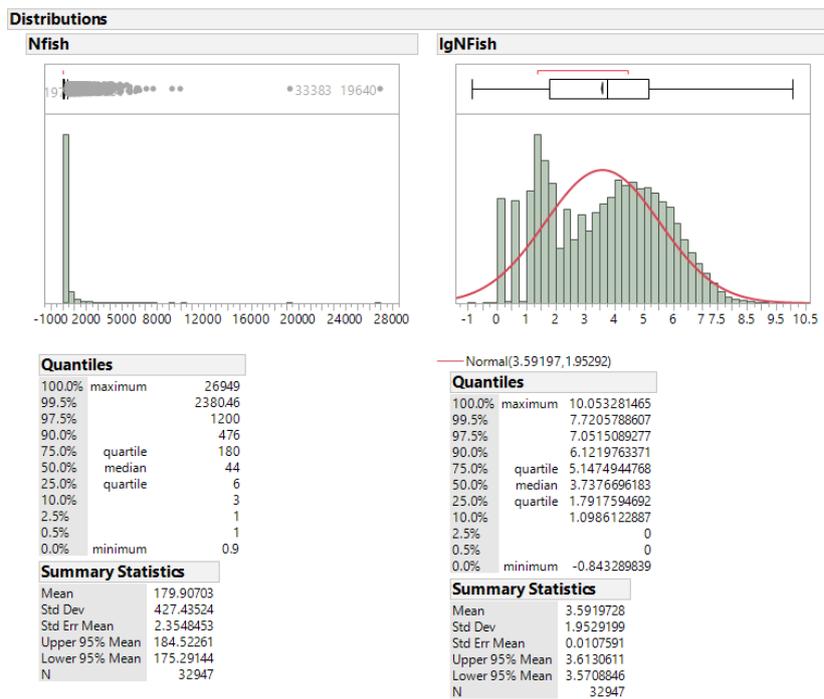**Figure 5.** Geographical distribution for the New PS EU_FRA/ESP fishing operations 1970 – 2015.

Figure 6. Distribution of the number of fish per MED PS set operation (left) and log-transformed number of fish.
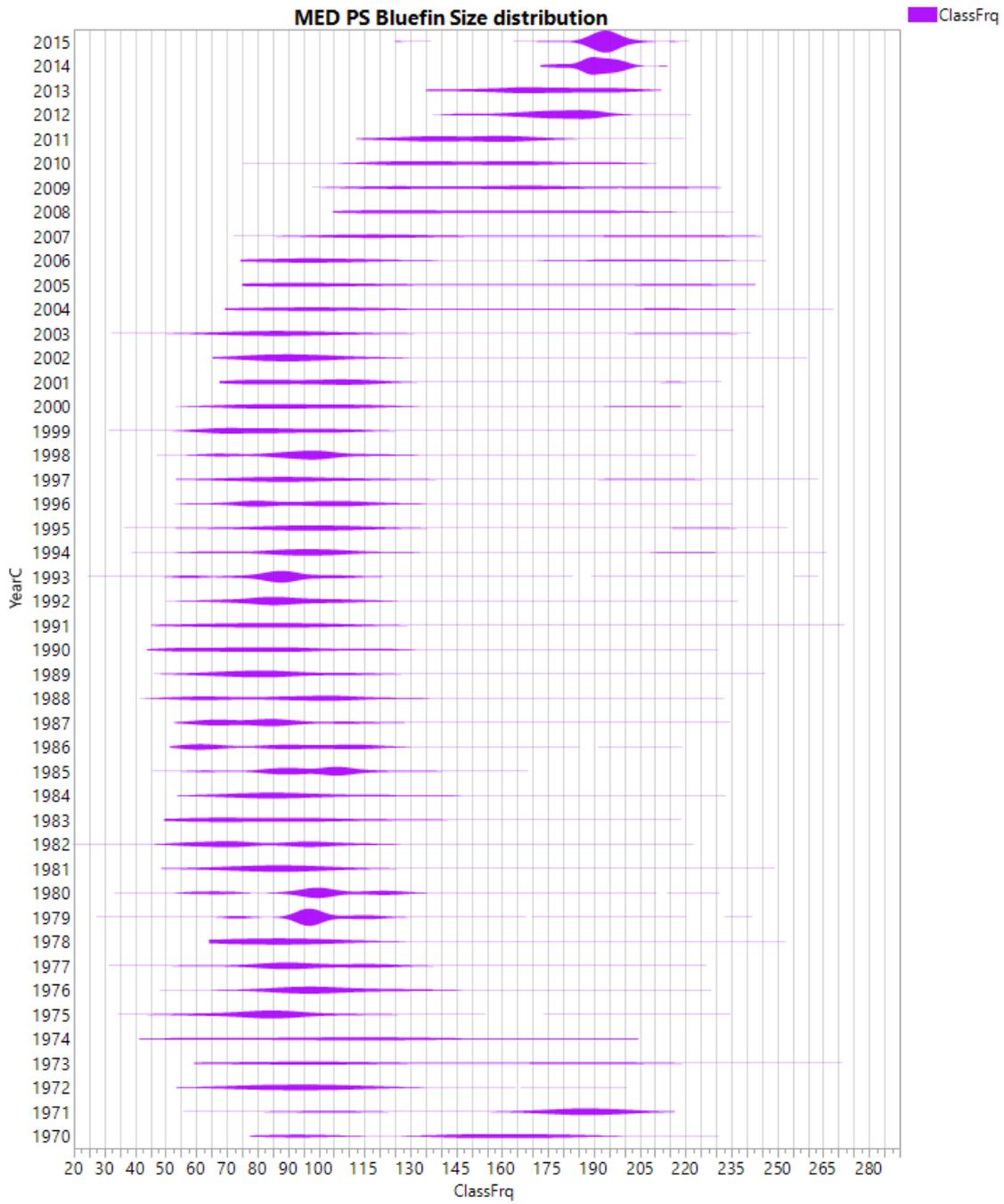
Figure 7. Estimated size frequency distributions of MED PS bluefin tuna by year from the EU_FRA/ESP new information. Mean weight/size per set operation is weighted by the log-transform number of fish.
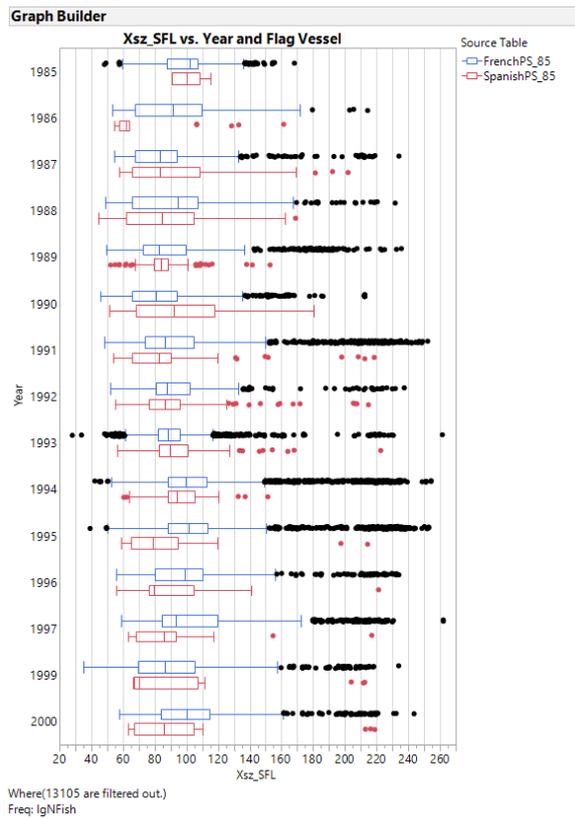
Figure 8. Comparison of the mean size distributions of PS catches from the French (blue) and the Spanish (red) vessels for the overlapping years.
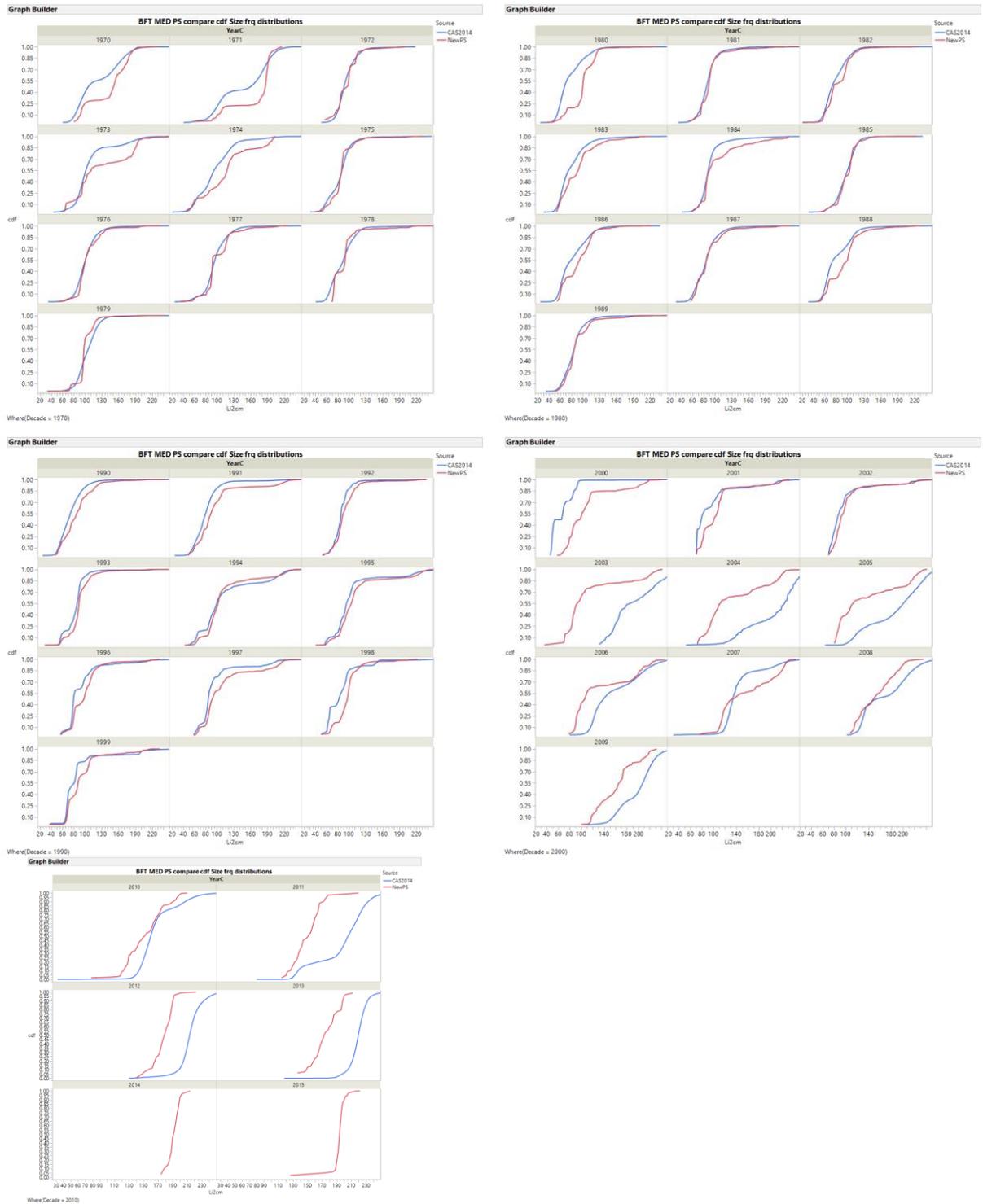
Figure 9. Comparison of the cumulative size frequency distributions (cdf) of bluefin tuna caught by the MED Purse seine fleet 1970 – 2015 (each plot a decade) from the CAS used in the latest assessment (CAS2014, blue line) and the New PS data (red line).
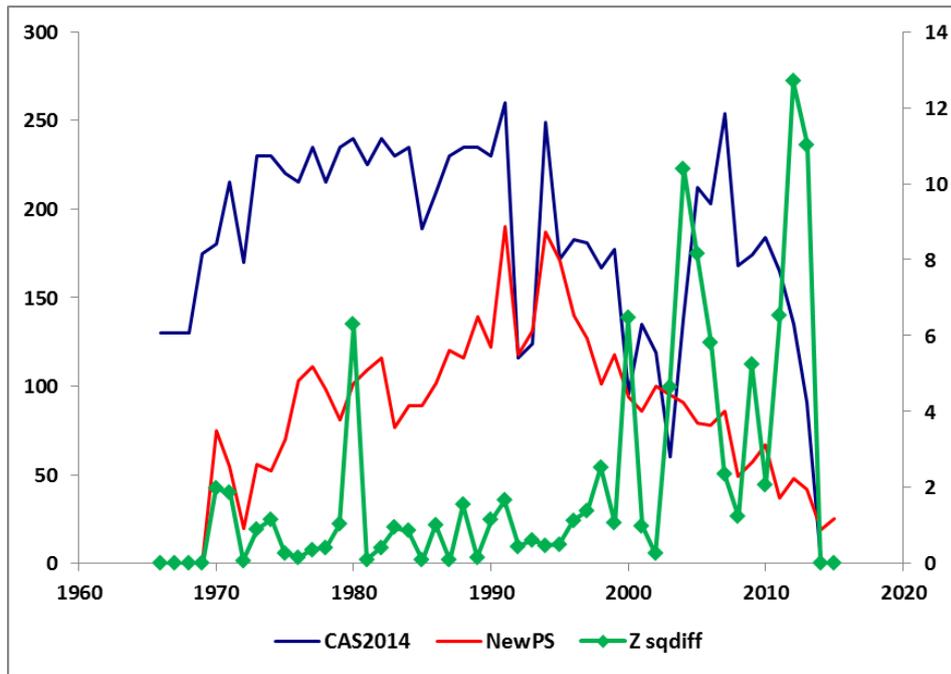
Figure 10. Comparison Size frequency distribution BFT MED PS EU_FRA/ESP 2014 CAS and New PS data. The Z sqdiff diamond-green line (right y-axis) is the sum of the square difference between the CAS cdf matrices by year; large values indicated diverging cdf's. The solid lines represent the number of size bins (1 cm) from 20 to 399 cm that have size samples in each matrix, blue the CAS 2014 and red the New PS data, this is an indicator of the effective size sample of each component.