REVIEW AND PRELIMINARY ANALYSES OF SIZE FREQUENCY SAMPLES OF NORTH AND SOUTH ATLANTIC ALBACORE TUNA (*THUNNUS ALANLUNGA*)

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SUMMARY

Size frequency data of north and south Atlantic albacore was reviewed and preliminary analysis performed for its potential use within the stock evaluation models. The Size data is normally submitted to the Secretariat by CPCs under the Task II requirements; optionally CPCs can submit Catch at Size, size samples or both for the major fisheries catching albacore. The size samples data was revised, standardized and aggregated to size frequencies samples by stock unit, main gear type, main fishing flags, calendar year and quarter. Preliminary analyses corroborate that a minimum number of fish measured is required to assure representativeness of the size frequency sample. Also indicators of distribution shape (skewness and kurtosis) provide information on the suitability of a size sample. For the north stock, the size sampling proportion among the major fishing gears is not consistent with the proportion of the catch, in general baitboat and troll fisheries are under-samples compared to the longline fisheries. For the south stock there are size sampling sufficient only the for the longline and baitboat gears. The number of fish measured in the south has increased substantially in the latest years for the south stock, while for north albacore the sampling has decreased. Review of the selected size frequency samples show a progression of modes of size in various gears and years, indicating that it is possible to identify the passing of large cohorts through the fisheries.

RÉSUMÉ

Les données de fréquence des tailles du germon de l'Atlantique Nord et Sud ont été examinées et une analyse préliminaire a été réalisée afin d'être potentiellement utilisée dans les modèles d'évaluation de stocks. Les CPC soumettent habituellement les données de taille au Secrétariat dans le cadre des exigences de la Tâche II ; les CPC ont le choix de soumettre la prise par taille, les échantillons de tailles ou les deux pour les principales pêcheries qui capturent le germon. Les données d'échantillons de tailles ont été révisées, standardisées et agrégées aux échantillons de fréquences de taille par unité de stock, type d'engin principal, pavillons de pêche principaux, année calendaire et trimestre. Les analyses préliminaires corroborent le fait qu'il est indispensable de mesurer un nombre minimum de poissons pour garantir le caractère représentatif de l'échantillon de fréquences des tailles. En outre, des indicateurs de la forme de la distribution (asymétrie et aplatissement) fournissent des informations sur le caractère pertinent d'un échantillon de taille. Pour le stock du Nord, la proportion de l'échantillonnage de tailles entre les principaux engins de pêche ne coïncide pas avec la proportion de la capture ; en général, les pêcheries de canneurs et de ligneurs sont sous-échantillonnées par rapport aux pêcheries palangrières. Pour le stock du Sud, l'échantillonnage de tailles est suffisant uniquement pour les engins de palangre et de canne et moulinet. Le nombre de poissons mesurés dans le Sud a considérablement augmenté au cours de ces dernières années pour le stock du Sud, tandis que pour le germon du Nord, l'échantillonnage a diminué. L'examen des échantillons sélectionnés de fréquences des tailles montre une progression des modes de taille dans divers engins et années, ce qui indique qu'il est possible d'identifier le passage de grandes cohortes par les pêcheries.

RESUMEN

Se revisaron los datos de frecuencia de tallas del atún blanco del Atlántico norte y sur y se llevaron a cabo análisis preliminares para su posible uso en los modelos de evaluación de stock. Normalmente, las CPC envían los datos de talla a la Secretaría en el marco de los requisitos de Tarea II; opcionalmente, las CPC pueden enviar datos de captura por talla, muestras de talla o ambos para las principales pesquerías que capturan atún blanco. Los datos de muestras de talla se revisaron, estandarizaron y agregaron a muestras de frecuencias de talla por unidad de stock, principal tipo de arte, principales pabellones pesqueros, trimestre y

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año civil. Los análisis preliminares corroboran que es necesario contar con un número mínimo de peces medidos para garantizar la representatividad de la muestra de frecuencias de talla. Además, los indicadores de la forma de distribución (asimetría y curtosis) proporcionan información sobre si una muestra de tallas es adecuada. Para el stock del norte, la proporción de muestreo de tallas entre los principales artes pesqueros no es coherente con la proporción de la captura, en general, las pesquerías de cebo vivo y curricán son submuestras en comparación con las pesquerías de palangre. Para el stock del sur, solo hay un muestreo de tallas suficiente para el palangre y el cebo vivo. El número de peces medidos en el sur ha aumentado bastante en los últimos años en el stock del sur, mientras que para el atún blanco del norte el muestreo ha decrecido. El examen de las muestras de frecuencias de tallas seleccionadas presenta una progresión de las modas de tallas en varios artes y años, indicando que es posible identificar el paso de grandes cohortes por las pesquerías.

KEYWORDS

Mean size, Albacore tuna, Size frequency

1 Introduction

Size samples for Atlantic albacore have been regularly submitted by the main fishing fleets targeting both the northern and southern stock units. Size and Catch at Size (CAS) information has been used as input for length base models (Anon, 2010; Anon 2008), or for estimating Catch at Age matrices for age-structure models during past assessments (Anon 2010).

Following the recommendations and directions in the work plan for the Albacore assessment in 2013, the Secretariat is providing a review and preliminary analysis of the available size information. This report aims to identify size samples representative of the main fleets by year and quarter and to consolidate and standardized the available information as input for the different assessment models.

2 Data

The ICCAT albacore task II data comprises size information since 1956 to 2012. For the northern stock CAS by main fleets and size frequency samples are available from 1956 to 2011. However, number of size samples increased only after 1970, with the highest peak in the 1980's. Since then the size sampling as decline to about 40 thousand in recent years. For the Southern stock sufficient size samples started in the 1980's, follow by declines in the 1990's and increasing again in the 2000's to an average of 140 thousand samples per year (**Figure 1**).

Size and CAS data has been submitted by 37 CPCs and at least 30 different type of fishing gears. Fork length (FL) is the main size measurement reported (93%), but there are also weight frequency samples (WGT, 3.5%), curved FL, first dorsal (LD1), total length (TL) and opercula keel length (OPKELL) reports. Because the SCRS has adopted only one conversion factor for size (LD1 to FL), other size measures were excluded from further analyses. Not included in this analysis are also CAS or Partial CAS reported CPCs. Overall a total of 2,235,225 and 3,517,918 fish size measurements were available for the north and south stocks, respectively. Size ranges from 20 to 440 FL cm for the north stocks, and from 1 to 1000 FL cm for the south stock. A priori, it were excluded observations with FL sizes below 20 cm and above 200 cm, as the maximum size from most growth studies is about 160 FL cm (Ref). For standardization, all measures where converted to FL and rounded to 2 cm bin size intervals. Five main fishing gears were defined, longline (LL), bait-boats (BB), trolling (TR), gillnets (GN), rod & reel (RR), and others gears category (OT) which includes fewer size observations from purse-seines, hand lines, trawls and unclassified gears. Quarter was calculated from the month or quarter information provided; samples were assigned to the 1st and 3rd quarter for reports by semester or to 2nd quarter if reported yearly.

All size-frequency samples were then aggregated by major gear type, major fleet-CPCs, year and quarter. This generated 1,151 and 877 size frequency samples for the north and south stock respectively. Over these samples further analysis were perform to identified size frequencies that are likely non representative of a particular fishery.

3 Methods

The main purpose of size frequency input data is to provide information to the assessment models of the size and or age distribution of the catch. This requires that the size frequency data be representative of the fleet catch. In models where age composition is the input, normally the input CAA matrix is estimated from the combined CAS of all fleets. For north albacore, CAA has been generated from CAS by different approaches (Anon, 2010), if CPC report CAS for their fleets, this information is the main input to overall CAS, if only size frequency samples are provided, these are raised to estimate total CAS for a given particular fleet, or when neither CAS or Size data is available, a substitution size frequency data is used following the prior recommendations from the Albacore Working Group. In general, the substitutions are from comparable gear-area fleets.

However, with Catch-statistical models, size frequency samples are normally input as such and associated with a particular fleet type and index of abundance. This is the case for example for the Multifan-CL or the stock synthesis models. Either case, it is important to evaluate whether or not a given size-frequency sample is representative or not. Unfortunately this task is not a simple one. As done in prior analyses (Anon, 2010), normally a combination of statistical "indicators" is used to inform whether a size-frequency data is suitable or not. Of these indicators, sample size is the initial one to be evaluated. Then other indicators of the frequency distribution are evaluated often assuming that a "representative size sample" from a given gear-fleet and area-time strata should follow more and less a normal distribution.

Besides the evaluation of individual size frequency samples, it was considered also the proportionality between size samples and the total catch by major gears. In an 'optimal' sampling scheme, the percent of size samples by gear type should reflect the percent of catch by the different gears fleets within a given year.

4 Results and Discussion

With respect to the minimum number of fish within a size frequency sample it has been suggested 50 fish, based on variance analysis that indicates a stability of the variance for samples with 50 or more measurements (Anon 2010). In the case of albacore, a plot of the coefficient of variance (common scale of variance indicator) versus a category of number of fish per size-frequency sample (**Figure 2**) indicated, that for the northern stock, the variance of the size sampling increases as number of fish increases, showing a stability trend with samples over 50 fish at least for the major gears; longline, bait boat and troll. The picture is less clear for the south stock, but overall with 50 or more fish per size frequency sample, the variances tend to fluctuate much less for the main fishing gears (**Figure 2**).

Figure 3 shows the number of fish measured by year for each main fleet-gear type, red cells indicate size samples with less than 20 fish, green cells indicates more than 500 fish, the yellow shades the intermediate values, and empty cells no size samples. For the north stock troll and rod and reel, are poorly size sampled, for the south stock, longline samples from main fleets (Japan, Korea, Namibia) are particularly low or unavailable in recent years. The total numbers of size observations by year are comparable for the north and south stocks, except for the last decade when in the south the number of size observations has increased substantially while in the north it continue with a decreasing trend (**Figure 1**). However, it is not clear that all observations are strictly direct size measurements; large fluctuation by Fleet/gear/year may indicate that some cases correspond to raise CAS for that particular stratum. Unfortunately only CPCs can confirm these situations.

Figure 4 shows the catch by main gear (Task I) for the north and south albacore stocks. For the N-ALB, troll, bait boat and longline, respectively have been the main gears, accounting for over 95% from 1950 to 1980 and over 70% afterwards. Since 1980, trawl and other surface gears account for about 15-25% of the catch. A comparison of the percent of size samples per main gear against the percent of the catch by gear by year was performed. It is expected that within an "optimal size sampling", these proportions were similar. If these percentages were equally distributed, the ratio Size Sample/Catch by gear should be close to 1. Values of these ratio well below 1 (e.g. <0.1) may indicate that a particular catch from that gear was under-sampled, while values much greater than 1 (e.g. > 10) were over-sampled. The results indicated that the size-sampling for the longline has been over-sample in particular in the early years (1956-1967) and in the last decade (2004-2011) for the northern stock.

On the other hand, the troll and bait-boat show an proper sampling from 1968 to 1978, thereafter a rather large under-sampling, that in the last decade is about only 2% of what should be if compare to the catch percentage distribution. Finally, the trawl size sampling was over-sampled in the initial phase of this fishery (1980-1990) and under sampled in the last decade (2002-2011).

For the S-ALB, the bulk of the catch is by the longline and bait-boat fleets (over 95% since 1956). In the south, size sampling show a better distribution by gear, with slight under-sampling of the bait-boat particularly in the latest years. It is to note however, that these ratios of size samples/ catch doesn't account for particular flag-fleets as shown in **Figure 2**. In some instances, particular fleets are under sampled or have only submitted CAS and not the original size sample distributions.

The next evaluation was the skewness and kurtosis trends of each size-frequency sample. As indicated a size-frequency sample is been defined as the aggregated size measures by stock unit, fleet, gear, year and quarter. **Figure 6** shows the trends of skewness and kurtosis by stock unit of 2,028 size frequency samples, and **Figure 7** shows the average skewness as function of the sample size. First, with increase sample size the variation in skewness decreases, second with sufficient samples, there is a slight positive skewness for main gears, corresponding with a left heavier size-frequency distributions, which it can be expected with predominance of younger size/ages as function of natural and fishing mortality. The distribution of skewness however indicates that there are size-frequency samples with extreme values of skewness either positive or negative, which were also correlated with lower number of fish measurements. Samples with skewness outside the 90% quantile (skewness < -1.32 or skewness > 1.36) were considered non-representative and were excluded from further analyses. Similarly the kurtosis also indicated that in general size-frequency samples tend to show a leptokurtic shape or a peaked distribution of median sizes. By main gear, also the number of size measures did have an impact in the mean kurtosis, with increased sample size, the size-frequency distributions show a more normal distribution with values of kurtosis close to zero, at least for the north ALB stock (**Figure 7**). However, for the south ALB stock, kurtosis increased with sample size for most gears. Similar as with skewness, it was considered non-representative size frequency samples which estimated kurtosis was outside of the 90% quantile (kurtosis < -1.17 or kurtosis > 6.51).

After the evaluation of sample size, skewness and kurtosis, of the 2028 size-frequency samples, 1380 (66%) were concluded as representative of the catch for albacore stocks; 728 for the north ALB and 642 for the south ALB. **Figure 8** shows the annual trend of the medians for each size frequency samples by major gear and stock unit. Troll and gillnet catch on general smaller north albacore compare to other gears. It appear to be more annual variation of albacore mean size for the northern baitboat fishery, compare for example with the longline, but catching similar size fish overall. Instead in the south, the baitboat fishery catches consistently smaller fish compared with the longline fisheries.

Figures 9 and **10** show the histogram distributions by stock and major gear for each year. For the north-ALB stock, the size distribution shows bimodal patterns for some years which are consistent with different cohorts moving through the fishery, for example from 1972 to 1978, 1985 to 1988. While in the 1990's the catch size shows a single mode trend with rather not variation in mean size or size ranges. In the 2000s' instead it re-appeared the bimodal size distributions with some indications of cohorts moving through in 2005 to 2010. For the northern longline fishery, the size is more characteristic of an unimodal distribution at least from the 1960 until the 2000's, while in recent years 2008 forward it shows a bimodal or more peaks distributions. The range of size is wider for the longline fleet having fish from 60 to 140 cm in almost all years. The troll gear show a predominant catch of small albacore in the north, with some multimode distributions since de 1970's, except for the 2002 to 2004 period when the size distribution is more unimodal and towards larger size fish. The rod and reel gear show also a wider size distributions but unclear if multimodal or not due to the limited sampling in most years. The gillnet size distribution catch also is primarily of smaller fish (50-80 cm FL), except in 1995. Finally the Other gears category shows rather non-informative size distributions. The low sampling, and mixture or gears preclude any conclusion.

For the S-ALB, the size distributions of the catch show a model about 80 cm with a unimodal size distribution, for most years, some indications of cohorts also for 1993-95, 2005-2007. The range of fish caught however is wider with fish from 50 to 140 FL cm. By comparison the longline catch size distributions are wider in the south with an ample range of sizes from 50 to 200 FL cm; the general trend is a multimodal distribution by years with some sequential size increases of the mode, indicating again cohorts moving through the fishery. As in the north, the others gear category provide little information of the catch size distribution.

Literature Cited

Anon. 2010c, Report of the 2009 ICCAT Albacore stock assessment session (*Madrid, Spain, July 13 to 18, 2009*). Collect. Vol. Sci. Pap. ICCAT, 65(4): 1113-1253.

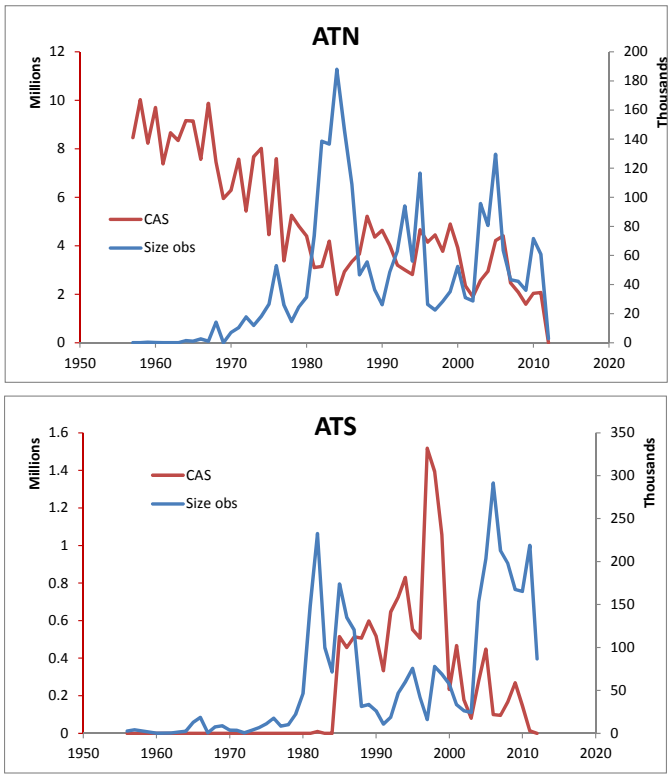

Figure 1. Number of CAS and Size samples ICCAT DB by year for the northern (top) and south albacore stocks.

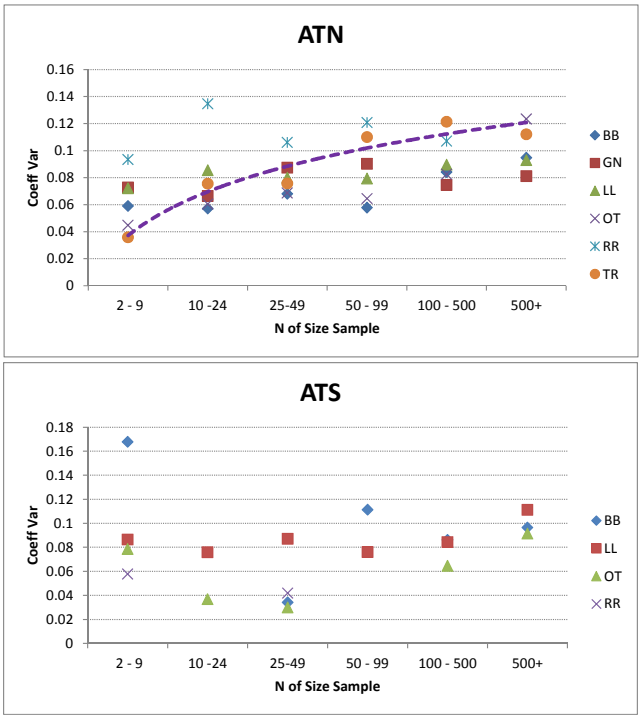

Figure 2. Mean relative variance (expressed as average of coefficients of variation) as function of the number of fish per size-frequency samples by major fishing gear. The x-asix shows the six categories of numbers of fish per sample. Each point represents the average from size-frequency samples of a given stock, fleet, gear, year and quarter strata. The broken line indicates de general trend of the data for the north stock.

Figure 3. Catalog of size samples by main gear and fishing fleet by year for north and south albacore stocks. Blank cells indicate no samples, red cells less than 20 fish measurements, yellow between 20 and less than 500, green cells over 500.

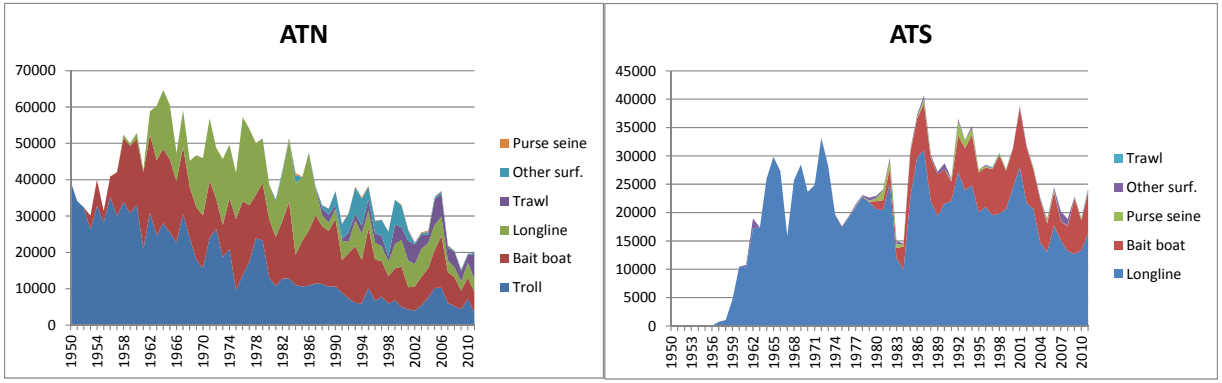

Figure 4. Distribution of catch (Task I) by main gear type for the north (ATN) and south (ATS) albacore.

Figure 5. Annual ratios of the proportion of size samples and the catch (task I) by main gear. Ratios at or near to 1 indicate sufficient and comparable size sampling for a given gear (green cells), values well below 1 (e.g. <0.1, red cells) indicate possible under-size sampling, while values well above 1 (e.g. > 5, yellow cells) indicate substantial over-size sampling.

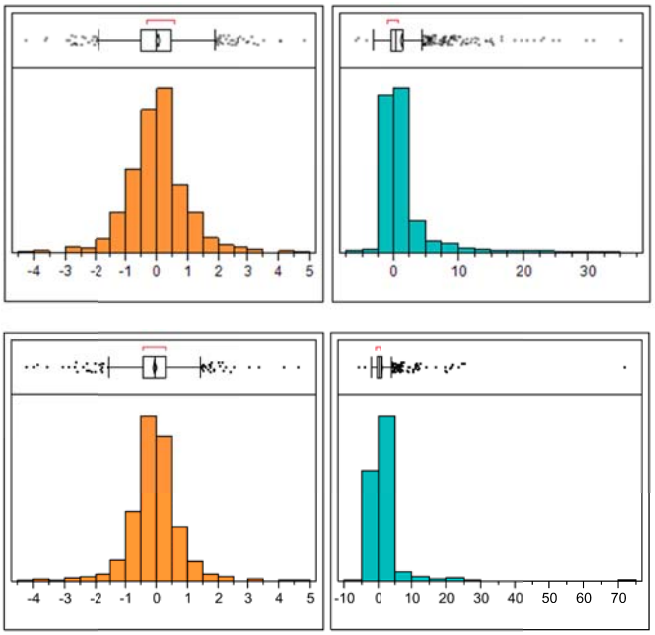

Figure 6. Distribution of Albacore size frequency samples skewness (left column) and kurtosis (right column) for the north (top row) and south (bottom row) stock.

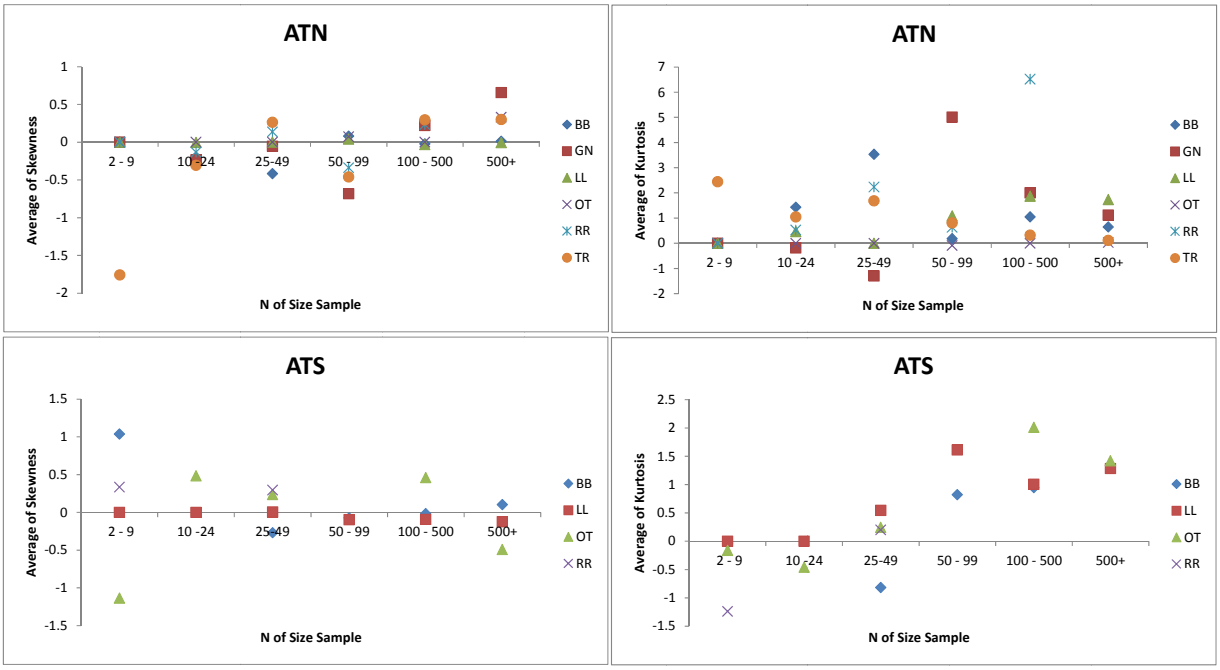

Figure 7. Mean skewness (left column) and kurtosis (right column) as function of the number of fish per Size-frequency samples of albacore by major fishing gear

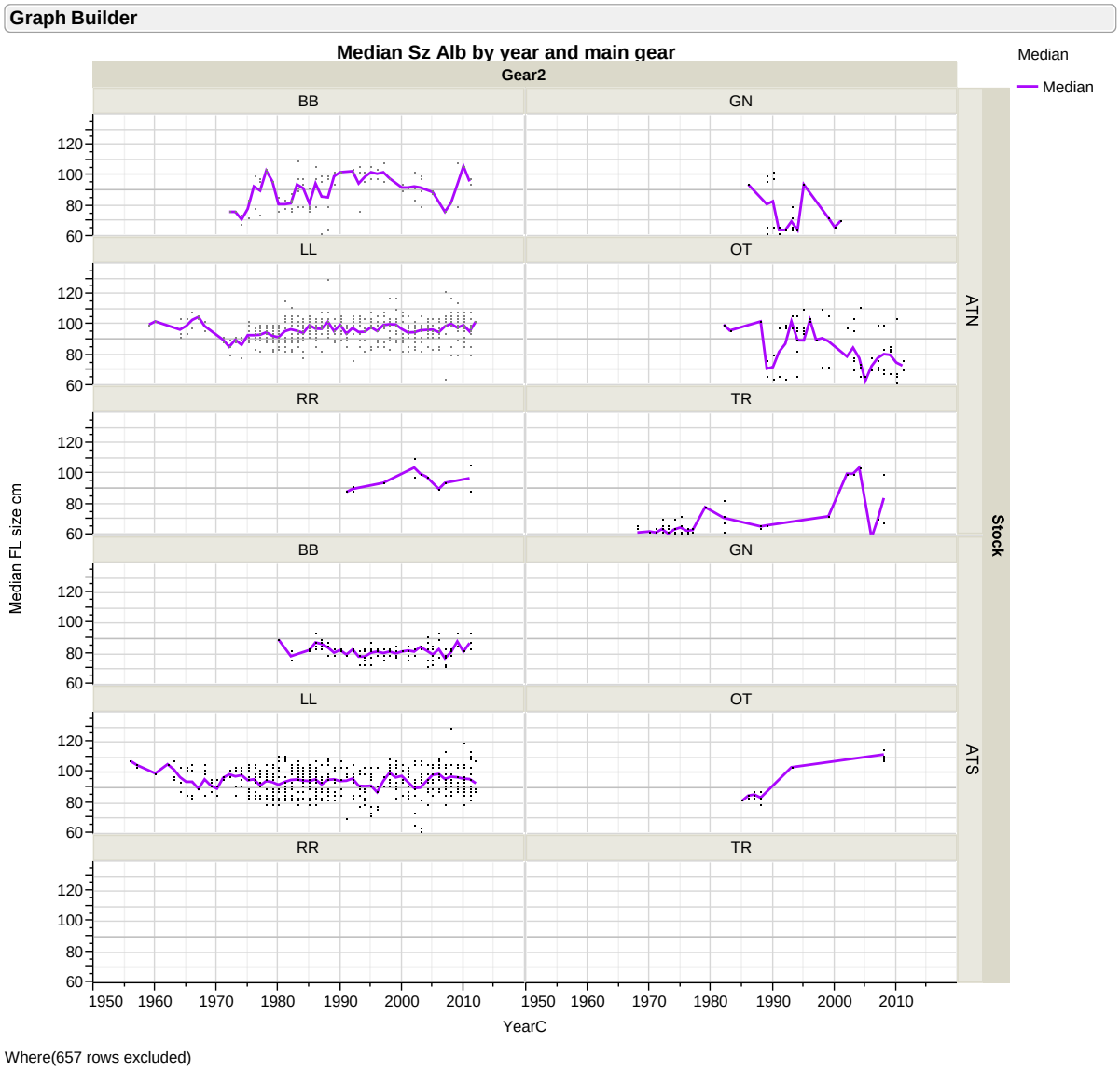

Figure 8. Mean annual trends (solid line) of median size (FL cm, dots) for Albacore stocks by major fishing gear. The plot represents those size-frequency samples considered representative of the catch (see text for details).

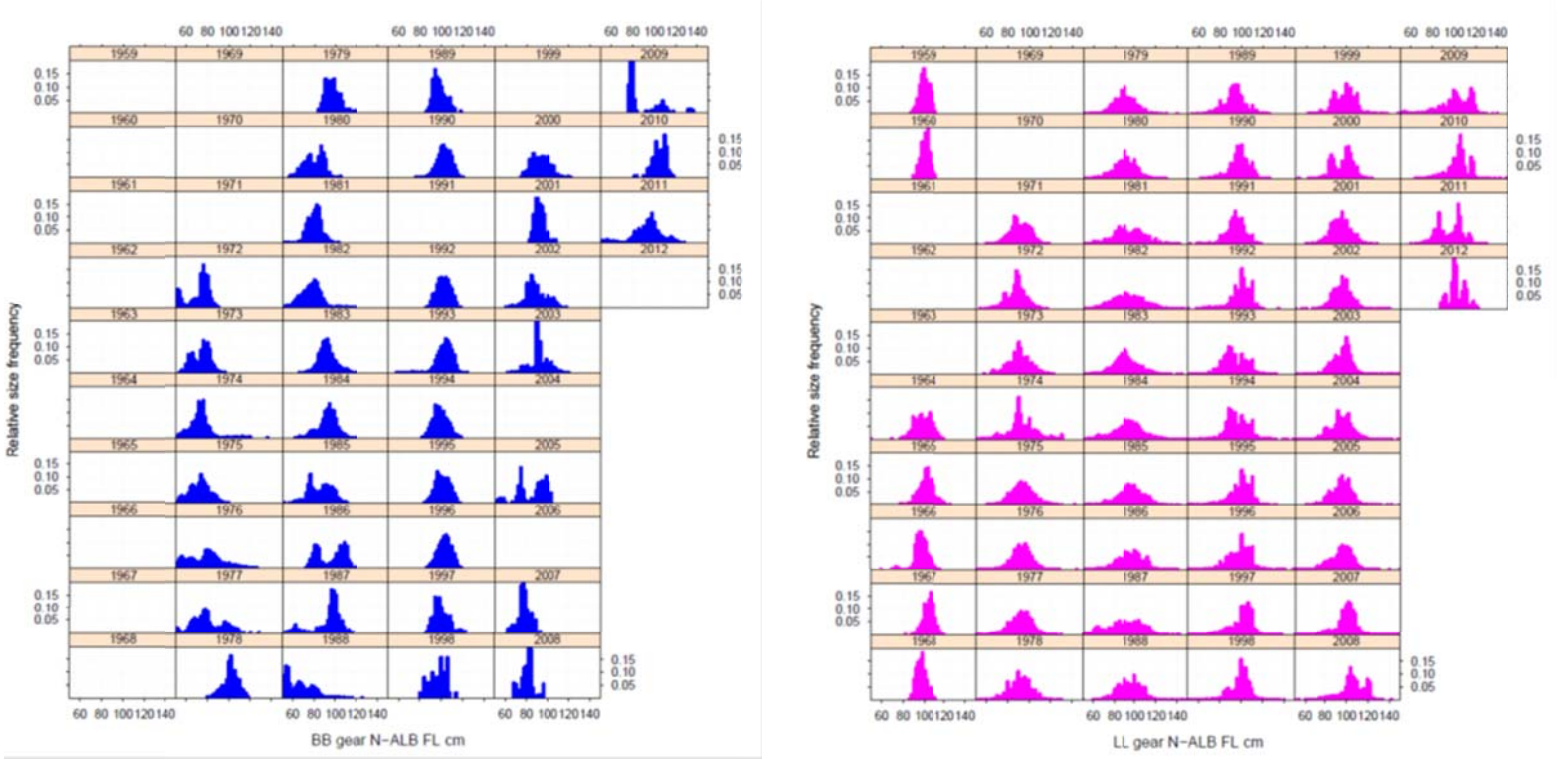

Figure 9. North Albacore relative size frequency distributions by year and main fishing gear 1959 – 2012. Left baitboat fisheries, right longline fisheries.

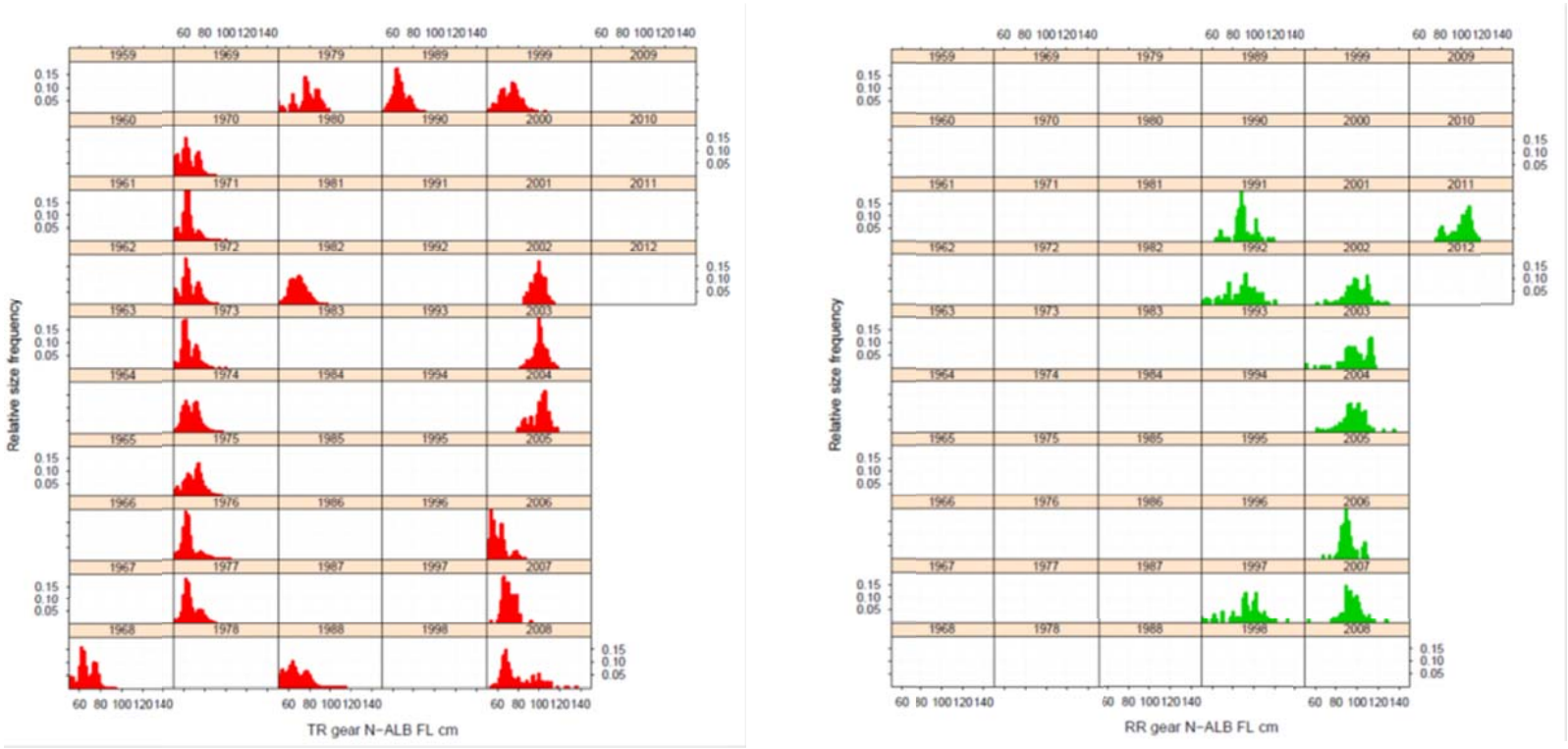

Figure 9. Continuation. North Albacore relative size frequency distributions by year and main fishing gear 1959 – 2012. Left trawl fisheries, right rod & reel fisheries.

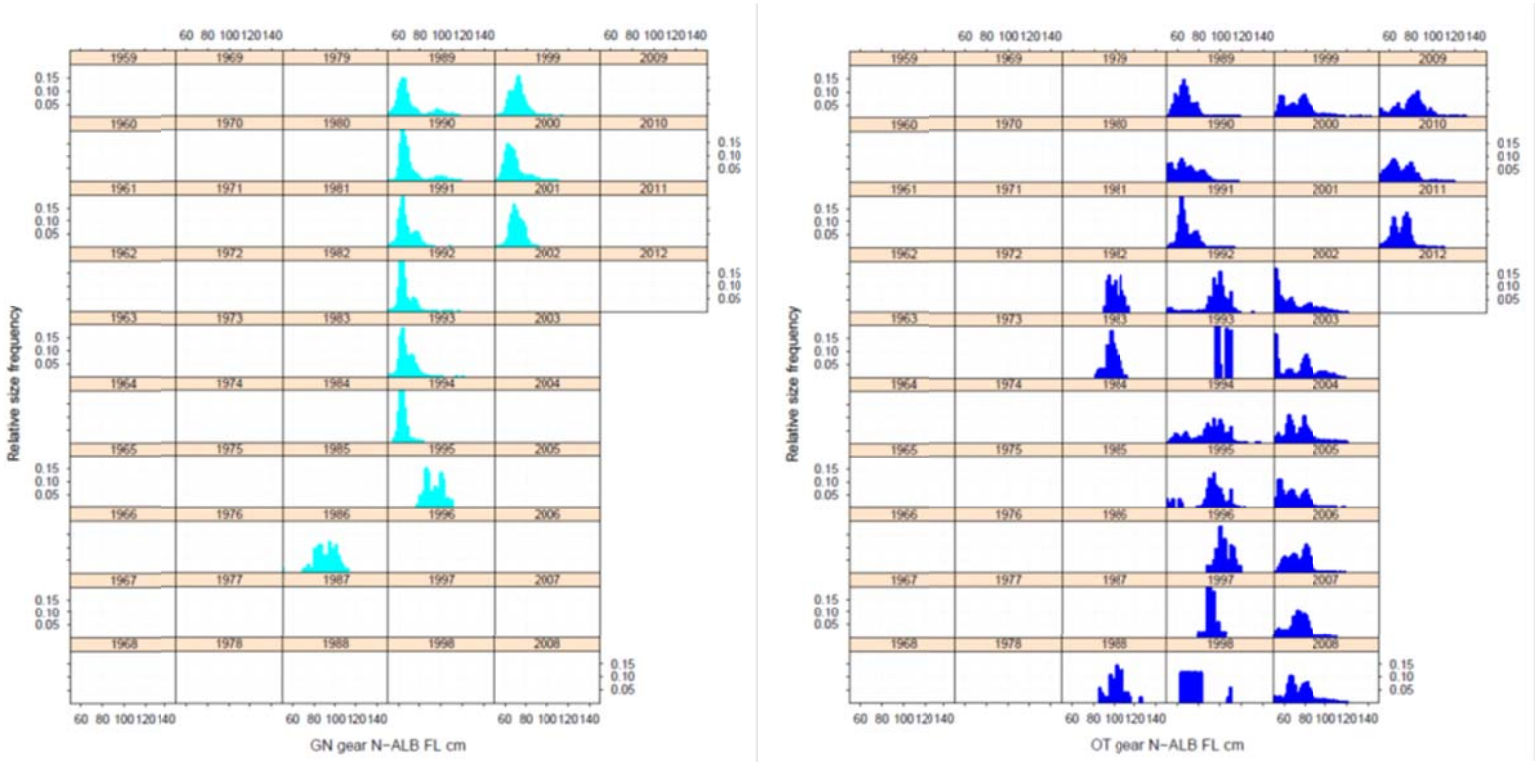

Figure 9. Continuation. North Albacore relative size frequency distributions by year and main fishing gear 1959 – 2012. Left gillnet fisheries, right other fisheries.

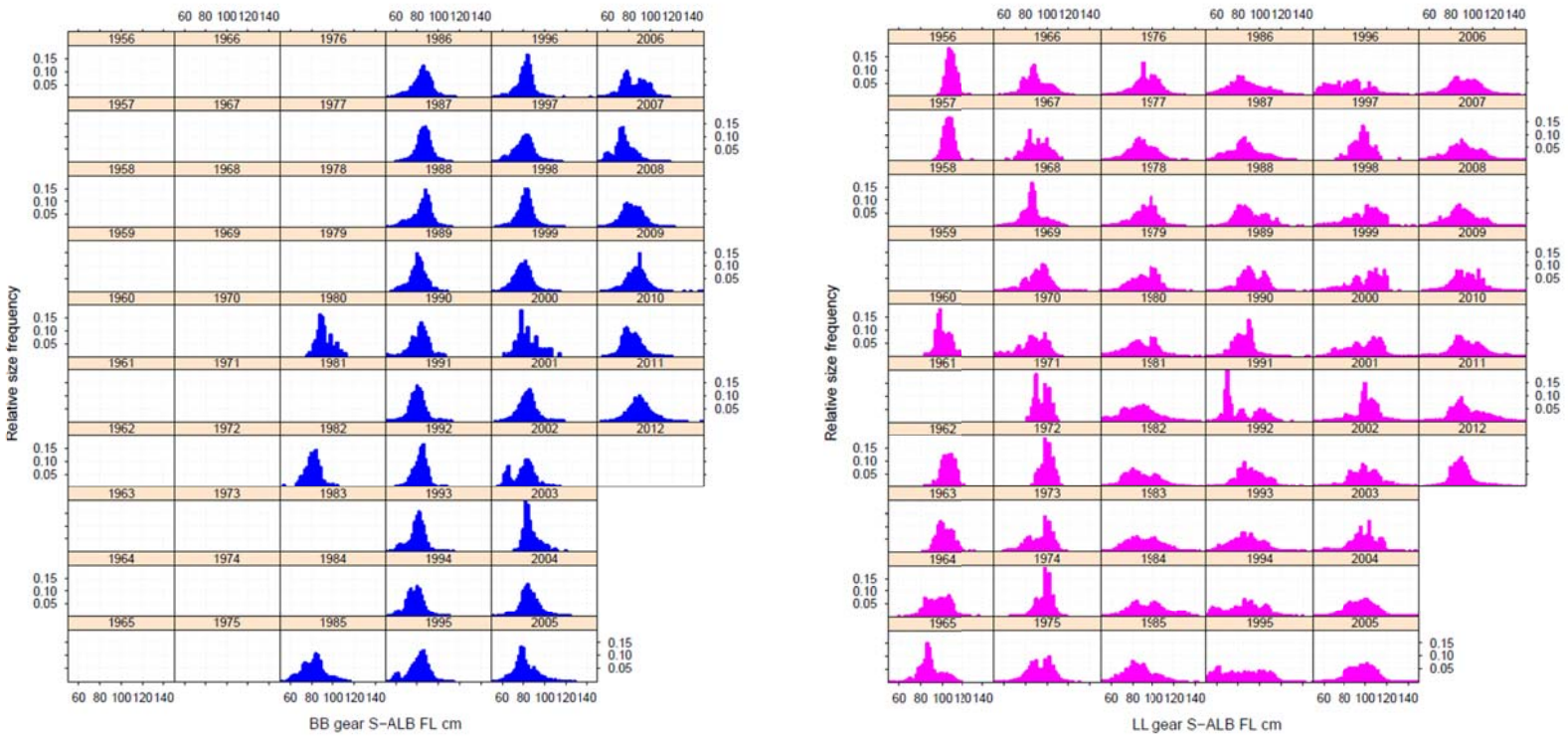

Figure 10. South Albacore relative size frequency distributions by year and main fishing gear 1956 – 2012. Left baitboat fisheries, right longline fisheries.

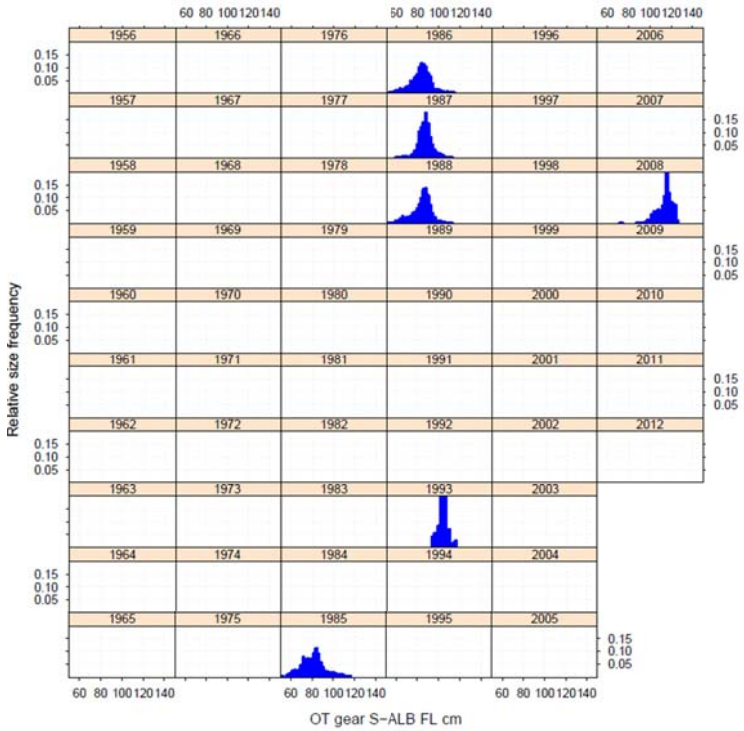

Figure 10. Continuation. South Albacore relative size frequency distributions by year and main fishing gear 1956 – 2012. Other fisheries.