

REVIEW AND PRELIMINARY ANALYSES OF SIZE FREQUENCY SAMPLES OF ATLANTIC BIGEYE TUNA (*THUNNUS OBESUS*)

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SUMMARY

Size frequency data of Atlantic bigeye was reviewed and preliminary analysis performed for its use within the stock evaluation models. 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 tropical tunas. The size samples data was revised, standardized and aggregated to size frequencies samples by fishery, calendar year and quarter. Preliminary analyses indicated a minimum number of 50 fish measured per size frequency sample. Also indicators of distribution shape (skewness and kurtosis) provided information on the suitability of a size sample. For the Atlantic stock, the size sampling proportion among the major fishing gears is not consistent with the proportion of the catch; in general purse seine is under-sample compared to the longline or baitboat fisheries. The number of fish measured has increased substantially in the latest years for the South Atlantic, mainly due to the complete observer coverage of China-Taipei longline fishery since 2006

RÉSUMÉ

Les données de fréquence des tailles du thon obèse de l'Atlantique ont été examinées et une analyse préliminaire a été réalisée afin d'être 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 taille ou les deux pour les principales pêcheries qui capturent des thonidés tropicaux. Les données d'échantillons de tailles ont été révisées, standardisées et agrégées aux échantillons de fréquences de taille par pêcherie, année calendaire et trimestre. Les analyses préliminaires indiquaient un nombre minimum de 50 poissons mesurés par échantillon de fréquences de 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 de l'Atlantique 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, la pêcherie des senneurs est sous-échantillonnée par rapport aux pêcheries des palangriers ou des canneurs. Le nombre de poissons mesurés a considérablement augmenté ces dernières années dans l'Atlantique Sud, principalement en raison de la couverture intégrale d'observation de la pêcherie palangrière du Taipei chinois depuis 2006.

RESUMEN

Se revisaron los datos de frecuencia de tallas del patudo del Atlántico y se llevaron a cabo análisis preliminares para su 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 túnidos tropicales. Los datos de muestras de talla se revisaron, estandarizaron y agregaron a muestras de frecuencias de talla por pesquería trimestre y año civil. Los análisis preliminares indicaban un número mínimo de 50 ejemplares medidos por muestra de frecuencia de talla. Además, los indicadores de la forma de distribución (asimetría y curtosis) proporcionaban información sobre si una muestra de tallas es adecuada. Para el stock del Atlántico norte, la proporción de muestreo de tallas entre los principales artes pesqueros no es coherente con la proporción de la captura, en general, la pesquería de cerco está infra muestreada en comparación con las pesquerías de cebo vivo y palangre. El número de ejemplares muestreados se ha incrementado en gran medida en años recientes para el Atlántico sur, sobre todo debido a la cobertura completa de observadores de la flota de palangre de Taipei Chino desde 2006.

KEYWORDS

Mean size, Bigeye tuna, Size frequency, Size samples

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1. Introduction

Size samples for Atlantic bigeye tuna (BET) have been regularly submitted by the main fishing fleets targeting tropical tunas. Size and Catch at Size (CAS) information has been used as input for length base models (Anon. 2011; Anon 2011b), or for estimating Catch at Age matrices for age-structure models during priors assessments (Anon 2011).

Following the recommendations and directions in the work plan for the bigeye assessment in 2014, the Secretariat is providing a review and preliminary analysis of the available size information. This report aims to identify size samples representative of the fisheries identified by the Tropical Working Group by year and quarter and to consolidate and standardized the available information as input for the various assessment models.

2. Data

The size data represents primarily the Task II SZ data provided by CPCs, including also data from specific observer programs, sampling initiatives and recovery data provided by CPCs. The size data included the latest updates and modifications recommended by the Working Group during the Data preparatory meeting (Anon. 2015). Briefly, the reported size data included over 403 thousand records representing over 6.6 million measured fish. The size samples extend from 1965 until 2014 with an average between 5 and 10 thousand samples per year since 1980 (**Figure 1**). The majority of samples come from longline gear (61%), follows by purse-seine (29%) and bait-boat (8.5%). Since 1991 some size samples from PS identified if were caught from sets on free schools (FSC) or associated floating objects (FADs). Samples included those reported as fish size measures of FL (95%) or CFL/LD1 converted to FL (3.2%) and few weight measures converted to FL (2.8%).

Samples from Mediterranean Sea were excluded, as well samples where FL size was < 20 cm or > 250 cm, as considered outliers. The size samples were aggregated by Fishery as defined by the Working Group in 2010, following the recommendations of the data preparatory meeting (Anon 2015). A total of 15 fisheries were categorized and size frequency samples between 20 and 250 FL cm in 2 cm size-bin were combined by fishery, year and quarter (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec). These generated 1683 observations for which descriptive statistics were estimated (**Fig 2**).

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. Within Catch-statistical models, size frequency samples are normally input as such and associated with a particular fishery fleet type and an index of abundance. It is therefore, important to evaluate whether or not a given size-frequency sample is representative, usually a combination of statistical “indicators” is used to inform whether a size-frequency observation departs substantially from the main trends of the data. For this is required first to define a minimum sample size such that the size frequency observation represents appropriately the size distribution of the population. This minimum sample is a function of the population size but it also depends on several factors, including variance of size at age, gear selectivity, population age/size structure, and natural and fishing mortality, etc. From sampling design experiment, the ‘optimal’ sample size should be a balance between the margin of error and the confidence level that the user wants to achieve, normally directly associated with a cost of sampling. Once a set of size frequency samples are defined, then other indicators of the mean trends and shape frequency distribution such mean size, variance of sample, coefficient of variation, skewness and kurtosis are evaluated often assuming that a “representative size sample” from a given gear-fleet and area-time strata should follow more and less similar trends of the same fleet for most years, at least a major change in selectivity can explain strong departures from the general trend.

4. Results and Discussion

Size sampling of bigeye is by comparison with other tunas relative sufficient, size sampling has increased in recent years (**Figure 3**). However, the proportion of sampling by major gears in reference to total catch is not consistent, and on average the purse-seine fisheries is substantially under sample compared to the longline and Baitboat fisheries, especially since 2005.

For bigeye tuna the number of measurements per size frequency shows a strong left-skew distribution with a 25% and 75% quartile between 221 and 2880 measurements with a median of 979 (**Figure 3**). There are however size frequencies with over 10,000 measurements (7%). In principle with increase in the number of samples the variance of size of the sample should stabilize about the population variance once it reaches a minimum sample size as long as a random sampling is used. A plot of the number of fish measures versus the standard deviation of the sample (**Figure 4**) shows no clear trend pattern for all bigeye size frequency observations. Variance increases with sample size overall the range, albeit the absolute values of the standard deviation varies rather little, between 10 to 40 cm compared to the range of size samples between 10 to over 50,000 samples in some cases (**Figure 5**). Similarly, a scatter plot of CV versus sample size by fishery shows no consistent trend among fisheries (**Figure 6**). Larger CVs are observed with increasing sample sizes in the range of 100 to 10000 for fisheries 3 and 4 in particular, purse-seine fleets. In contrast, lower and stable CVs are seen for fisheries 9 through 15 (**Figure 6**) all longline fisheries or mostly longline gear samples. The cumulative density frequency (cdf) plot for sample size in log-scale shows a rather linear trend between samples of 200 to 10,000 range that covers over 65% of the data available. Based on these two indicators, a minimum sample size could be set at about 200. However for fisheries 5, 6, 8, 9, 12 this will significantly reduce the BET frequency samples available particularly for early years. From the quartile distribution, 50 samples per size frequency correspond to the 10% quartile, and can represent a suitable compromise as minimum sample size to include a size frequency observation for a given fishery-year-quarter strata. From the cdf plot is also recommended that effective sample size should be considered in the logarithmic scale (base 10) within fishery at least. As indicated before, about 7% of the size frequency samples reported over 10,000 measures (**Fig 6**), these are in particular for fisheries 14, which include sampling from the China-Taipei longline fishery that since 2006 have implemented 100% measure of all bigeye catch by their fleet.

Therefore, of the available size data for BET, once size samples were aggregated by fishery-year-quarter, size frequency observations were excluded for those where < than 50 fish were measured, effectively establishing a minimum size sample of 50. Overall the mean size shows a bimodal distribution with peaks of small fish 45 FL cm and large fish 125 FL cm, with a mean size ranging from 40 to 164 cm FL (**Figure 2**). The standard deviation and coefficient of variance (CV) show a rather unimodal distributions, with a median about 19.14 cm FL (std dev) and 17.1% CV. Extreme values of variance are observed in fishery 3, 4 and 1 mainly (**Figures 6 and 7**). By fishery the mean size density distribution (**Figure 8**) and the mean size by year shows some variable trends (**Figure 9**). Fleet 5 (PS-BB) catches the smallest BET (~ 48 cm FL) overall, through the time period 1973 – 2009 (**Figures 8 and 9**). Fishery 6, also a BB fleets also catch smaller size BET but with higher size variance, while the Fishery 8 and 9, BB fleets from the Canarias and Azores region and north Atlantic, catches larger size BET (70 – 100 cm FL). Overall the largest bigeye tunas are caught by the LL fleet of Fishery 11 and 14 in the tropical region (**Figure 8**). For purse seine fleets the early years (1965-1985) fishery 1 shows a decreasing trend of BET mean size from a peak of 110 cm FL to about 60 cm FL, in contrast for later PS fleets (Fishery 3 and 4), the BET mean size show some increasing trend in recent years, from about 65 cm FL to 90 cm FL (Fishery 3) (**Figure 9**). There are also indications of a seasonal size pattern, with larger fish being caught in quarter 3 (Jul-Sep) compared mainly to quarter 4 when the overall catch is of smallest fish primarily. Overall mean size of the catch shows some increasing trend in recent years for the major longline fleets (Fisheries 9, 10, 11, 13, and 14).

Measures of shape of the size frequency distributions, skewness and kurtosis were also reviewed (**Figs 9 and 10**). **Figure 10** shows the skewness of size frequency samples versus the mean size by Fishery ID. As expected, left skewed distributions are observed for smaller size fish (positive skewness), with a trend to reduce skewness as mean size increases, this is seen in the purse-seine and Baitboat fleets. Fishery 2, 4 and 7 show strong left skewed distributions. In contrast, no skewness is observed in the longline fleet fisheries. **Figure 11** shows the equivalent plot for the kurtosis of the size frequency samples. Kurtosis values represent the excess of kurtosis with reference to the kurtosis of a normal distribution (kurtosis = 0), positive values indicate a leptokurtic or “peaked” distribution, while negative values indicate a platykurtic or ‘flattened’ distribution. Purse-seine and some baitboat fisheries (except Fishery ID 8 and 9) show positive kurtosis or peaked distributions of size for smaller and medium size bigeye. Kurtosis values are high for fisheries 3 and 4 in particular. For longline fleets, the kurtosis values indicate a distribution close to a normal size frequency distribution.

In summary the skewness and kurtosis indicated that few (6 observations) size frequency observations show larger departure from the rest of the size frequency trends in each of the Fishery ID. Most of these observations are for Fishery 3.

Finally the density frequency distributions and the cumulative size frequency by fishery ID and year by 2 cm FL are shown if **Figures 12 and 13**, respectively. Overall trends by Fishery ID are presented in **Figure 14**.

References

- Anon 2011. Report of the 2010 ICCAT bigeye tuna stock assessment session. Collect. Vol. Sci. Pap. ICCAT 66(1):1-186.
- Anon 2001. Report of the 2010 ICCAT bigeye tuna data preparatory meeting. Collect. Vol. Sci. Pap. ICCAT 66(2):187-284.
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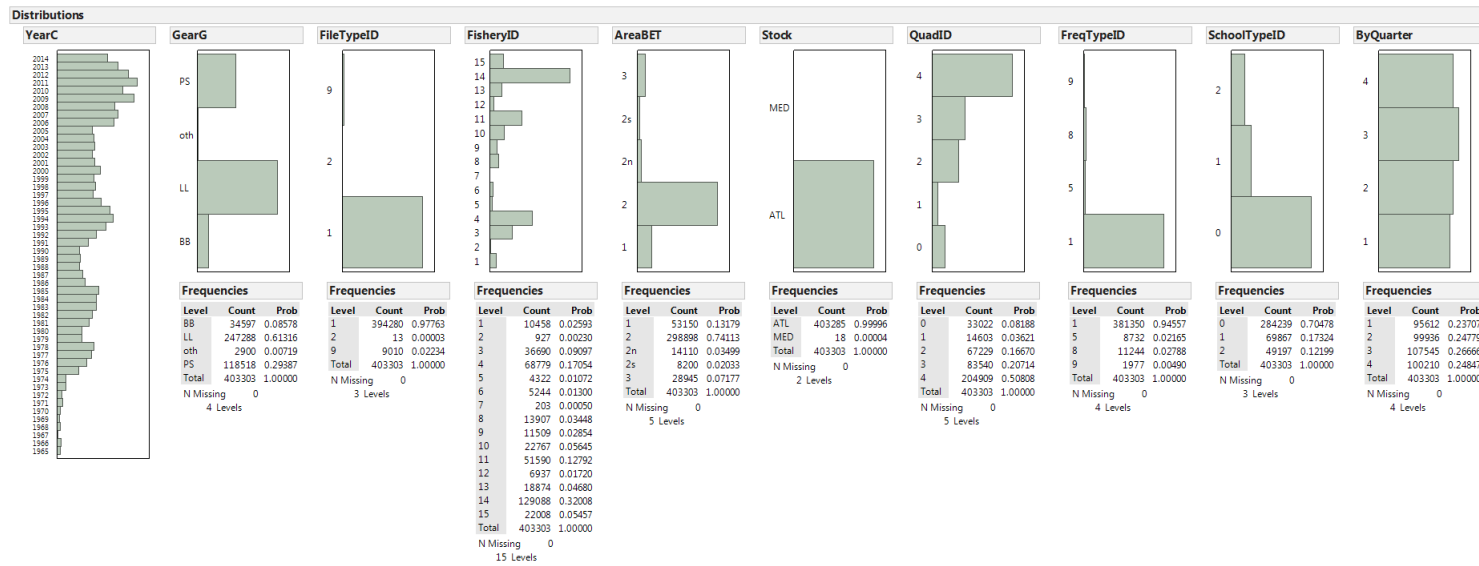


Figure 1. BET size data information ICCAT DB 1965-2015. Distribution of size frequency observations by year, gear, Fishery ID (Stock Synthesis structure), Area, stock, type of measure (FreqTypeID), school target (SchoolTypeID) and quarter.

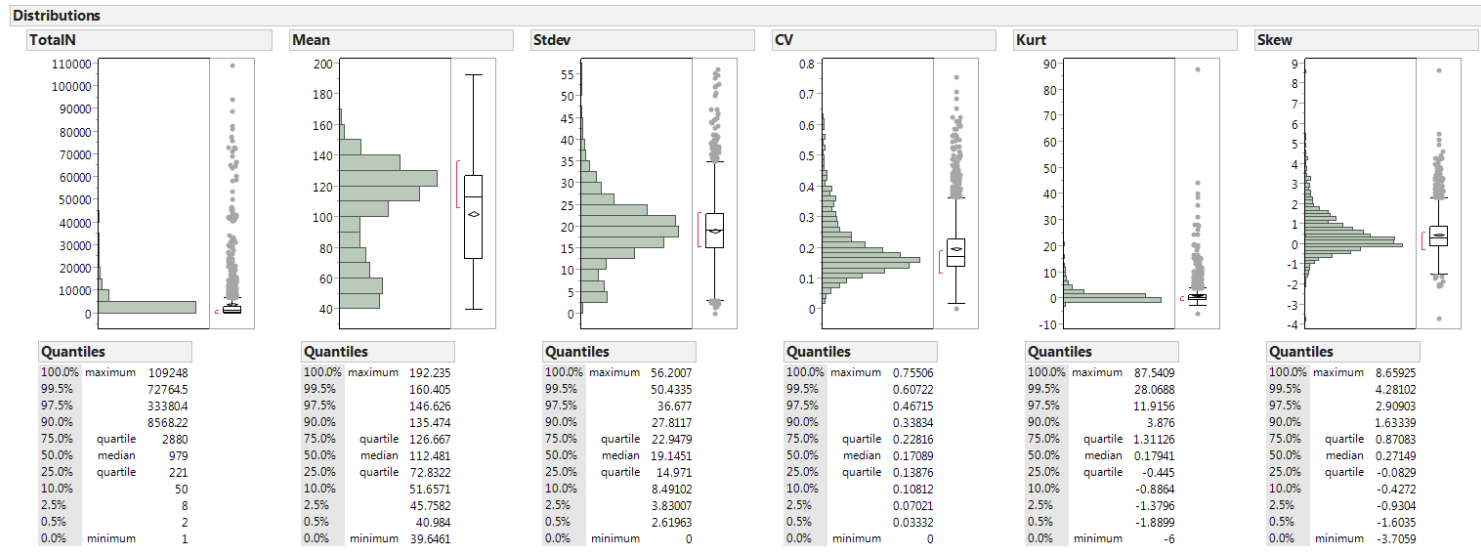


Figure 2. BET size frequency data. Distributions of sample size (TotalN), Mean size (FL cm), standard deviation (FL cm), coefficient of variance (CV), kurtosis and skewness for all size frequency observations aggregated by Fishery ID, year and quarter available from 1965 to 2014.

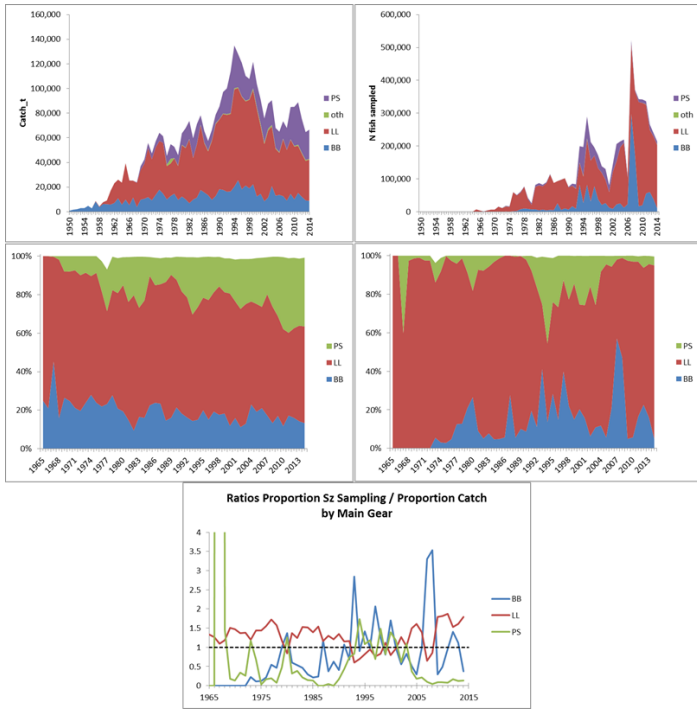


Figure 3. Year trends of catch (t) by major fishing gear (top-left) and size sampling (N fish sampled) of BET. The middle row shows the proportion of catch (left) and size sampling (right) by main fishing gear for 1965 - 2014. The bottom plot show the ratio of the proportion of catch to proportion of size sampling for the purse-seine (PS), longline (LL) and Baitboat (BB) fisheries for BET since 1965.

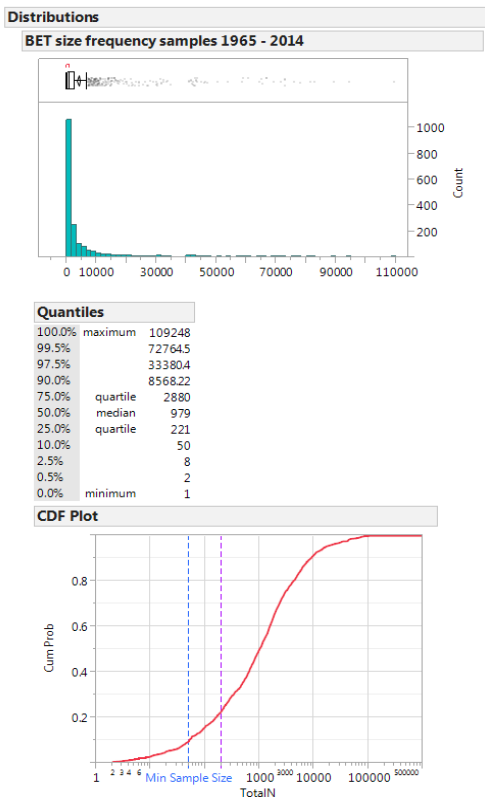


Figure 4. Histogram, quantiles and cumulative frequency distribution (cdf) in log-10 scale of sample size (Total N) for BET size frequency data.

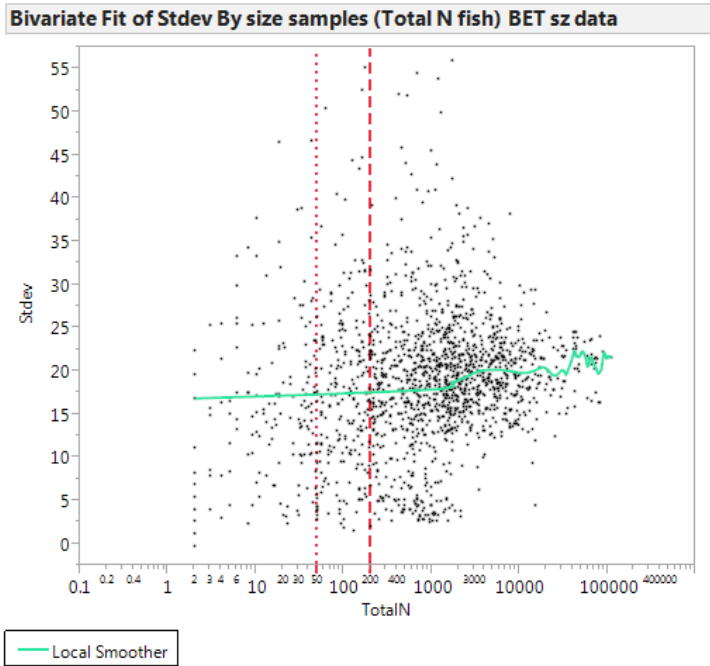


Figure 5. Scatter plot of sample size (TotalN) versus variance (Stdev) of the BET size frequency observations. Solid line represents the smoother trend of the data; vertical broken lines are reference for sample sizes of 50 and 200 units per size frequency.

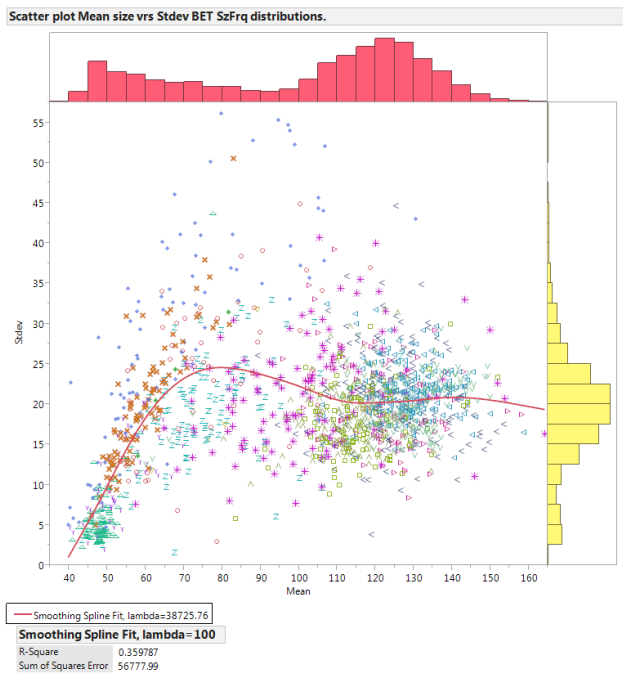


Figure 6. Scatter plot of mean size (FL cm) against standard deviation of BET size frequency observations 1965-2014.

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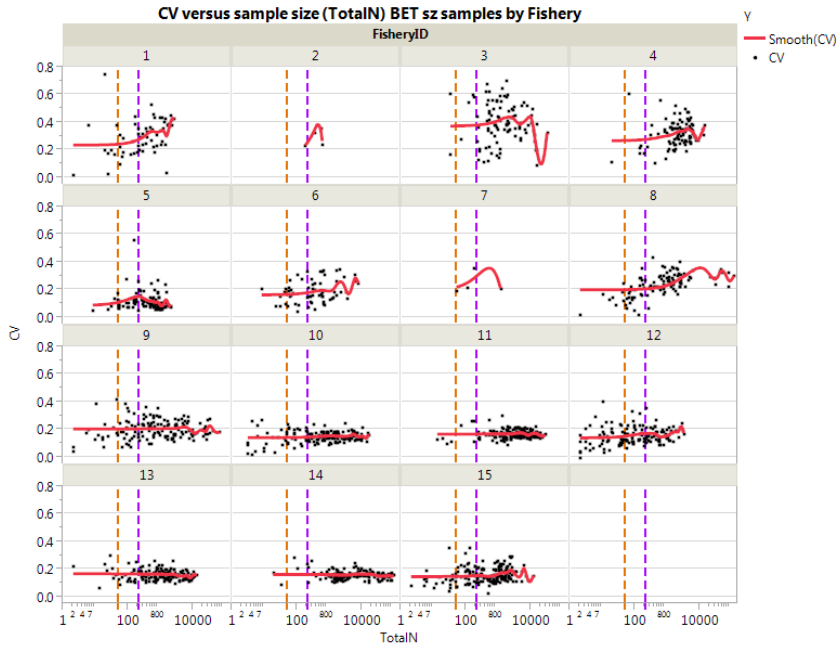


Figure 7. Plot of sample size (Total N) versus the coefficient of variance (CV) for BET size frequency observation by Fishery ID. Red line represents the smoother general trend of the data, vertical broken lines the reference sample sizes of 50 (orange) and 200 (purple) fish measurements.

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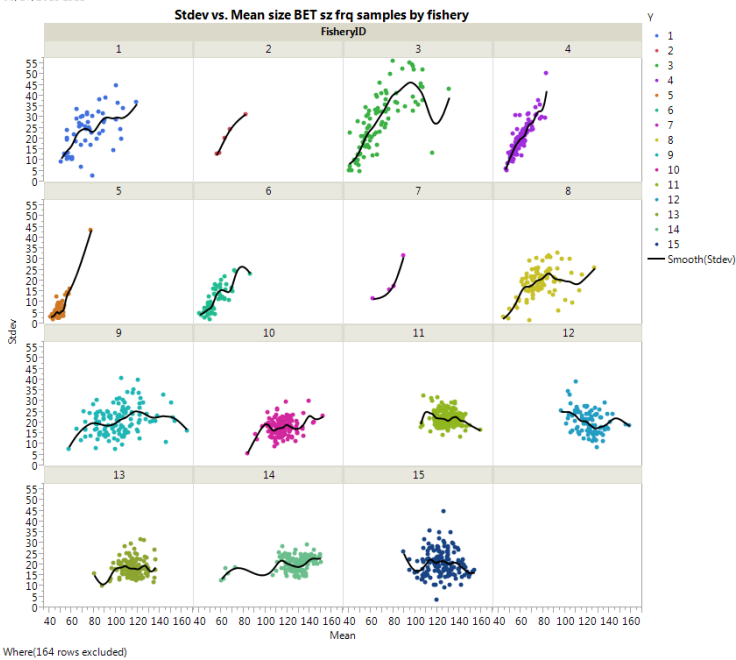


Figure 8. Scatter plot of standard deviation vs. Mean size for the BET size frequency distributions by Fishery ID.

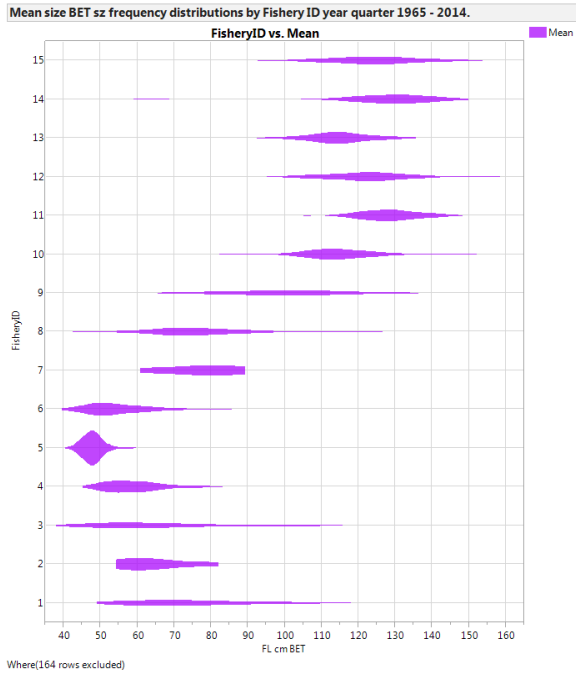


Figure 9. Density distributions of the BET mean size (FL cm) by fishery ID.

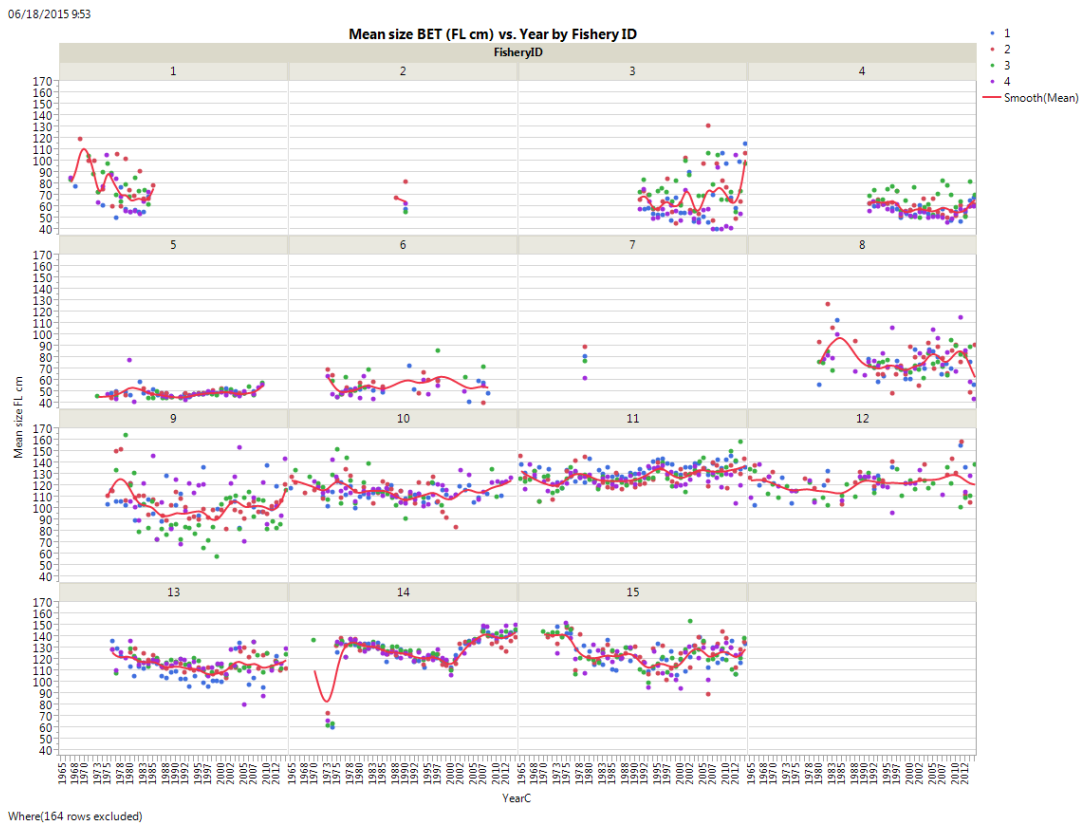


Figure 10. Scatter plot of mean size BET (FL cm) and year by Fishery ID. Red lines represent the smoother trend of the data, and the color code the quarter value.

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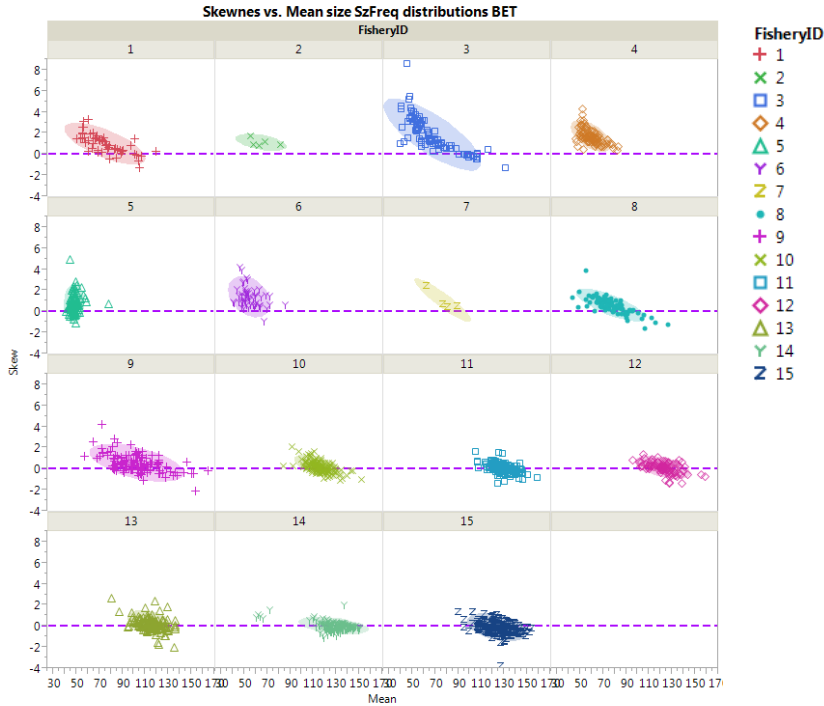


Figure 11. Scatter plot of skewness versus mean size by fishery ID for the BET size frequency observations. Shadow areas represent the 95% bivariate confidence bounds.

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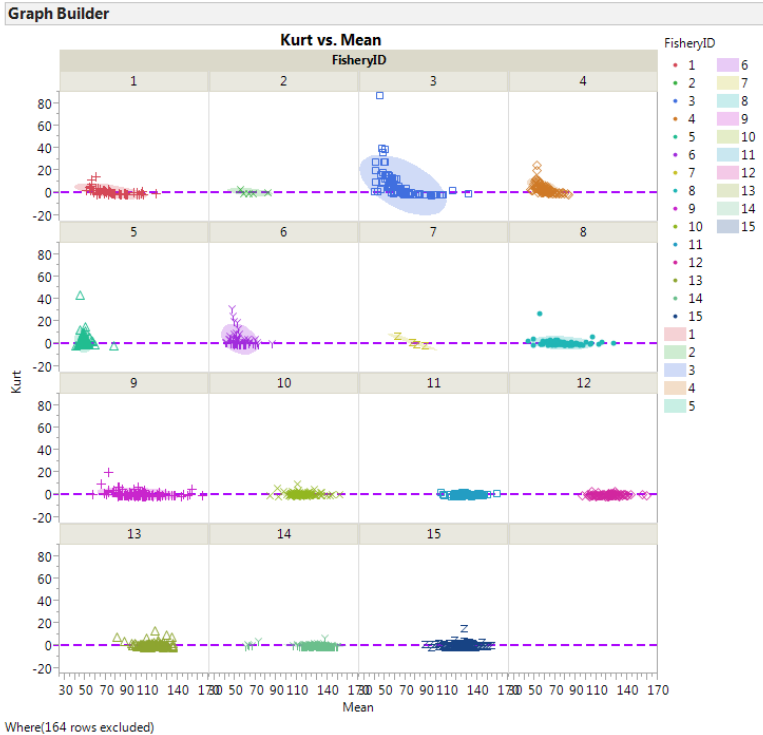


Figure 12. Scatter plot of kurtosis versus mean size by fishery ID for the BET size frequency observations. Shadow areas represent the 95% bivariate confidence bounds.

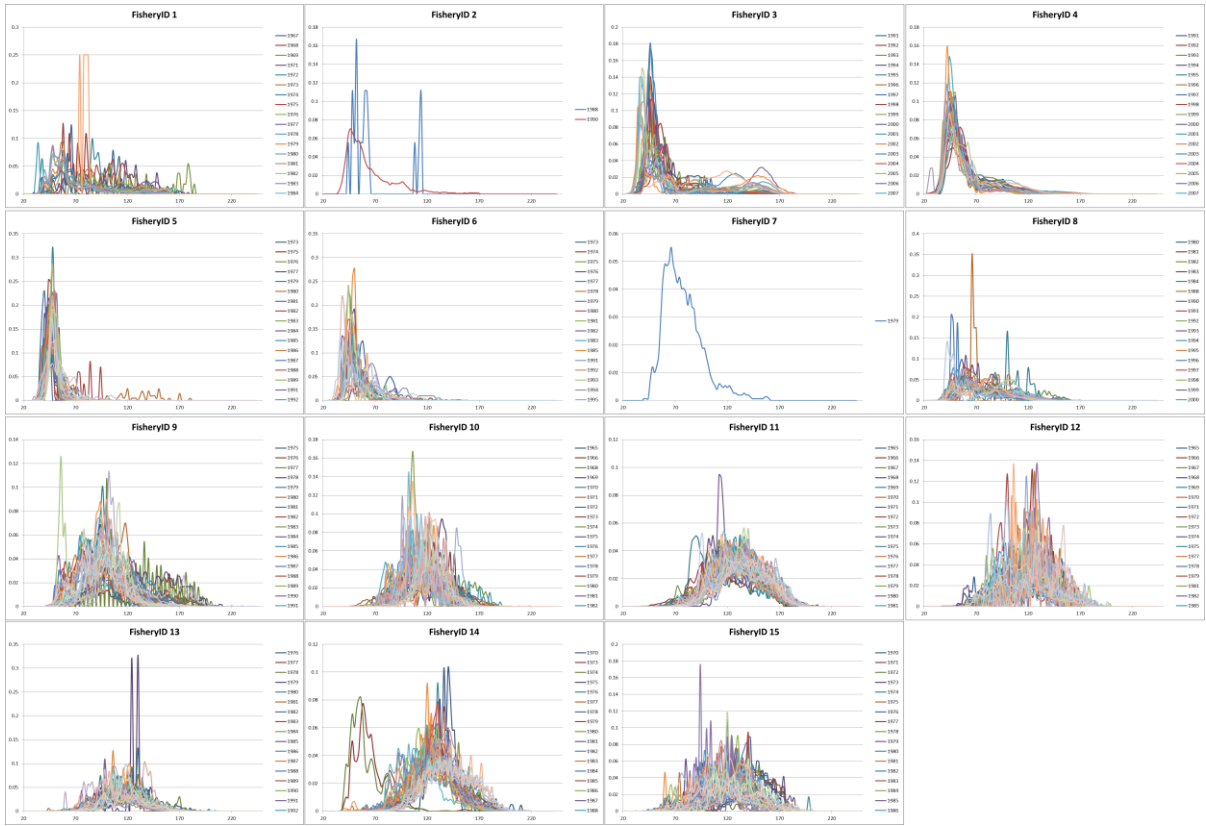


Figure 13. BET size frequency distributions by Fishery ID year and quarter 1965-2015.

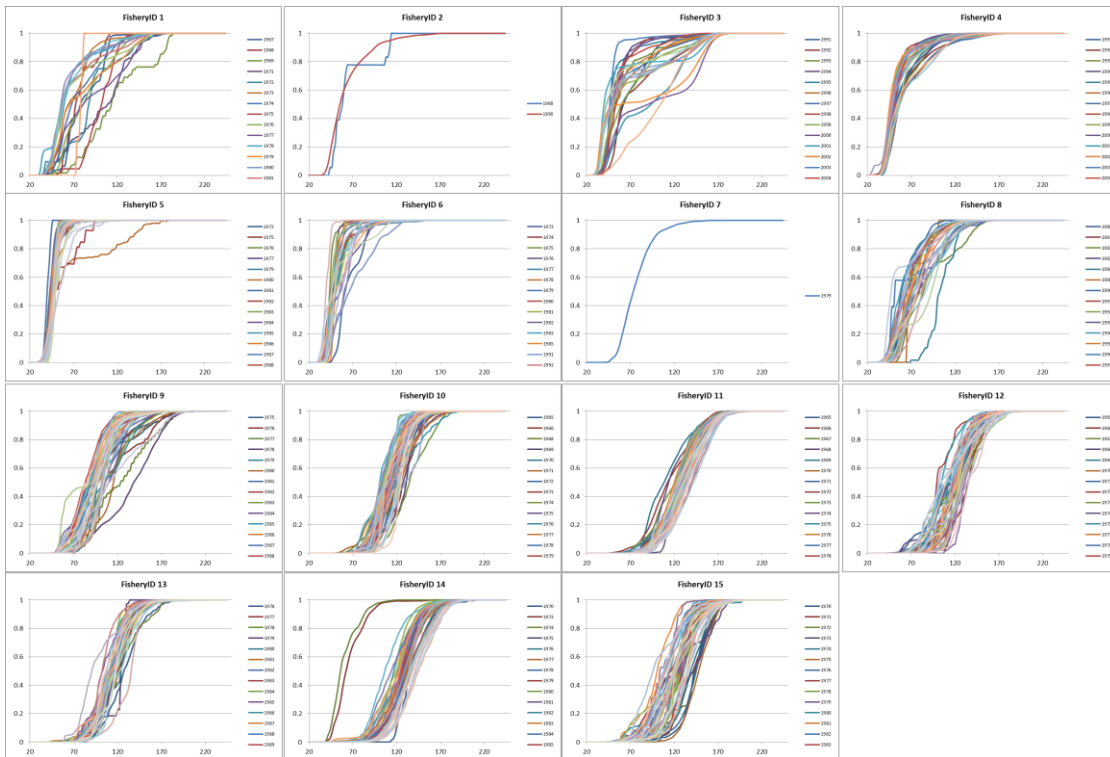


Figure 14. BET cumulative size frequency distributions (cdf) by Fishery ID year and quarter 1965-2014.

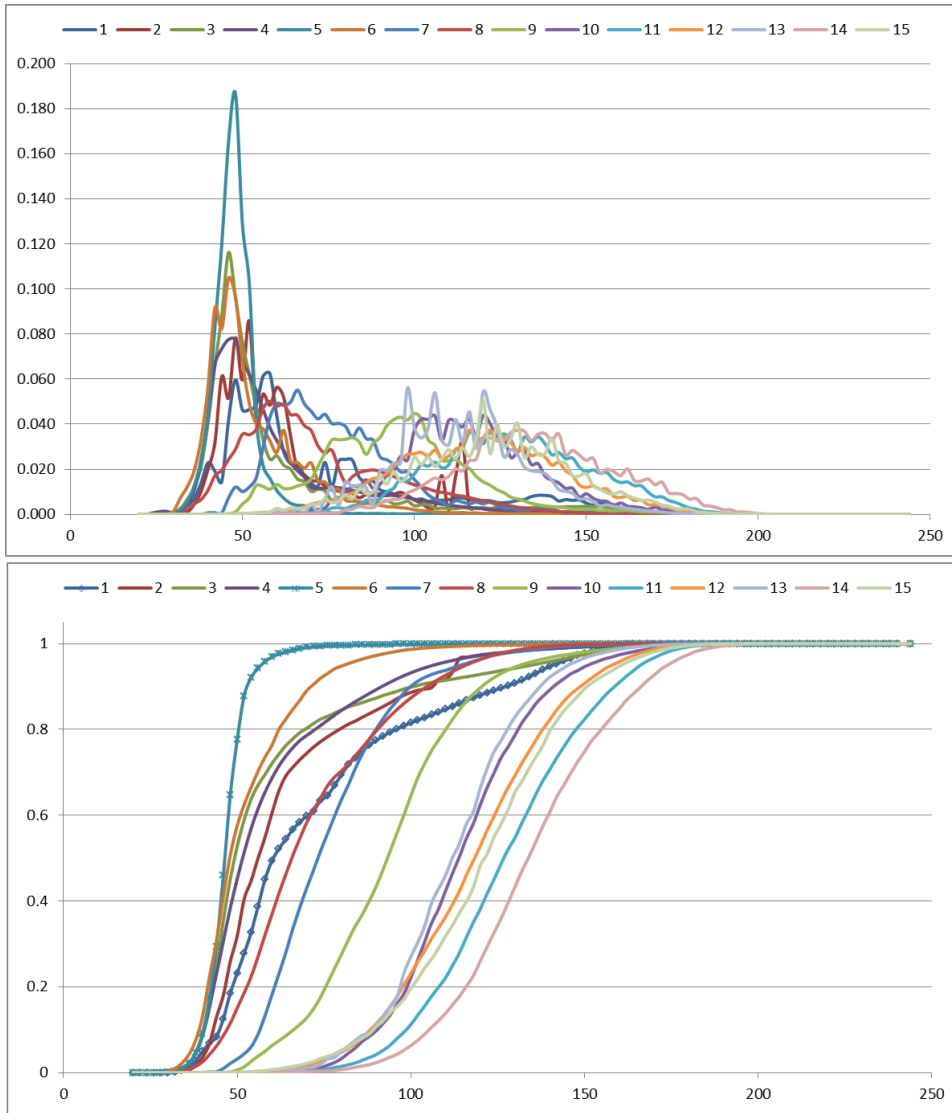


Figure 15. Overall BET size (FL cm) frequency distribution (top) and cdf (below) by Fishery ID.