PRELIMINARY REVIEW OF BLUEFIN TUNA (*THUNNUS THYNNUS*) SIZE AND WEIGHT MEASURES TAKEN WITH STEREO VIDEO CAMERAS AT CAGING OPERATIONS IN THE MEDITERRANEAN SEA 2014

Mauricio Ortiz[1]

SUMMARY

Size frequency data of bluefin tuna from stereo video camera systems at caging transfer operations was compiled, revised and preliminary analysis done to estimate size at catch of farmed fish. Preliminary results indicate a multimodal size distribution for bluefin destined to farming in 2014; with a large mode of small fish of about 75 FL cm, and two modes for medium 120 FL cm and large 210 FL cm. Comparisons with alternative catch at size estimates from prior years (2010-2013) indicate significant differences of density and cumulative size frequency distributions by flag. At present, however it is not possible to conclude if these differences are due to changes in the catch of 2014 compare to prior years or to the methodology for estimating catch at size from the size at harvest reports. Weight estimates from the stereo video systems need to revise and standardize de size-weight relationship used in the video algorithms.

RÉSUMÉ

Les données de fréquences de tailles du thon rouge obtenues au moyen des systèmes de caméras stéréo lors des opérations de transfert dans les cages ont été rassemblées, révisées et analysées de manière préliminaire afin d'estimer la taille au moment de la capture des poissons élevés. Les résultats préliminaires indiquent une distribution de taille multimodale du thon rouge destiné à l'élevage en 2014, avec un mode important de petits poissons d'environ 75 cm FL et deux modes de poissons de taille moyenne (120 cm FL) et de grande taille (210 cm FL). Des comparaisons avec d'autres estimations de la prise par taille d'années antérieures (2010-2013) montrent des différences significatives de densité et de distributions cumulatives de la fréquence des tailles par pavillon. À l'heure actuelle, il n'est toutefois pas possible de conclure si ces différences se doivent aux changements de la capture de 2014 par rapport aux années antérieures ou à la méthodologie employée pour estimer la prise par taille à partir des rapports de la taille au moment de la mise à mort. Pour les estimations de poids obtenues à partir de systèmes de caméras stéréoscopiques, il convient de réviser et de standardiser la relation taille-poids utilisée dans les algorithmes de la vidéo.

RESUMEN

Se compilaron y revisaron los datos de frecuencias de tallas de atún rojo obtenidos mediante sistemas de cámaras estereoscópicas en las operaciones de transferencia a las jaulas y se realizó un análisis preliminar para estimar la talla de captura de los peces de las granjas. Los resultados preliminares indican una distribución de tallas multimodal para el atún rojo destinado a granjas en 2014, con una gran moda de peces pequeños de aproximadamente 75 cm FL y dos modas para ejemplares medianos 120 cm FL y grandes 210 cm FL. Las comparaciones con estimaciones alternativas de captura por talla de años anteriores (2010-2013) mostraron importantes diferencias de densidad y distribuciones de frecuencias de tallas acumulativas por pabellón. Sin embargo, en la actualidad, no es posible concluir si estas diferencias se deben a cambios en la captura de 2014 en comparación con años anteriores o a la metodología utilizada para estimar la captura por talla a partir de los informes de talla en el momento del sacrificio. Para las estimaciones de peso obtenidas a partir de sistemas de vídeo estereoscópicos se tiene que revisar y estandarizar la relación talla-peso utilizada en los algoritmos de vídeo.

KEYWORDS

Bluefin, Farm bluefin tuna, Size frequency

[1] ICCAT Secretariat. Corazón de Maria 8, Madrid Spain 28002. Mauricio.ortiz@iccat.int

1. Introduction

Farming has become one of the major destinations for most of the catches of eastern bluefin tuna in the latest decade. Based on the catches by purse-seine fleets, about 60% of the annual catch is destined to farms in the Mediterranean Sea. Because of the logistics of the fishing operation and transfers into the cage at farms, there has been limited information on the size and age distribution of wild bluefin. This has substantially increased the uncertainty in recent stock status evaluations (Anon. 2013). The SCRS has recommended exploring and implementing alternative methods for sizing the catches of bluefin tuna destined to farming operations. After several trials, research between scientist, government authorities and bluefin tuna farms have reached a point for implementing protocols with Stereo-video cameras at transfers between holding pens and farm cages for recording passing bluefin fish. With the assistance of specialized software, the video recordings allow to count and measure fish and using conversion factors, estimate the weight of individual fish.

In 2014 several CPCs began submitting data collected from the Stereo Video camera systems to the Secretariat, this document is a preliminary analysis of size and weight measures collected and submitted as of August 2014. The primary objective of this analysis is to consolidate, review and standardized the available information into a single database. Afterwards, and following recommendations from the SCRS, analyses were conducted to estimate size frequency at catch and compare these results with alternative estimates.

2. Data

As of August 30th 2014, the Secretariat received size and weight estimates at caging of bluefin tuna with stereo video camera systems from four CPCs: EU_Malta, EU_Spain, EU_Croatia and Turkey (**Table 1**). The data has been submitted in different formats; usually including a general report with date of recording, species, site (farm ID), vessel associated and files names. Some reports also include names of calibration files, and model formula to estimate weight. Summary statistics include average size (m) and weight (kg), minimum and maximum value, standard deviation, coefficient of variance and sample size. Individual fish measures include the size, estimated weight, error percent of FL, caudal fork, and nose measures, frame and video file name. However, not all CPCs provided complete detailed information. In some instances, the individual reports include only size and weight, even in few cases only the estimated weight. Information on the calibration procedures, estimation of the error measure or any other diagnostic of measurements by the system have not been provided to the Secretariat.

In total 12,332 observations are available with 11,522 sizes (FL) in meters and 12,332 weights in kilograms. These represent 49 different caging operations realized between April 29 and July 8, 2014. The data correspond to at least 9 different farms (not all records provide farm site) (**Figure 1**). Overall bluefin tuna size ranges from 73 to 303 cm FL, size distribution of all data shows a multimodal distribution, with peaks at 80, 120, and 210 cm (**Figure 2**).

As indicated before, weights were estimated by the software program using a conversion factor provided by the user. In most cases the current size weight relationship adopted by the SCRS were applied, but not in all cases (**Figure 3**). In fact, some CPCs used a different size-weight relationship among their farms. Few outlier size-weight observations were also identified (**Figure 3**). At least 9 different tuna farms were identified. By CPC, EU_Croatia reported from 2 farms, EU_Malta also 2 farms, EU_Spain from 3 farms, and Turkey at least 2 farms, however farm ID was missing from several observations from Turkey.

3. Methods

Preliminary analysis were done with the size data by CPC level and then estimating size frequency distributions to compare with previous estimates of size at catch distribution of purse-seine operations for the same CPCs, that were estimated from the size distributions at the harvest operations (Ortiz *et al.* 2014).

Figure 4 shows the size distribution (FL) and histograms by Flag of the stereo camera caging operations. Clearly, small bluefin were reported by caging operations from EU_Croatia, with fish ranging from 73 cm to 150 cm, but strong left-skew towards small fish with a high peak around 75 FL cm. By comparison EU_Malta and Turkey show a size catch of larger fish, with a bimodal distribution shape and peaks at 110 cm and 210 cm FL. Instead EU_Spain show a unimodal size distribution with peak at 210 cm FL and catches of mostly large fish ranging from 109 to 277 cm FL. Density and cumulative density plots show also the different size at catch distributions by Flag (**Figure 5**).

4. Results and discussion

The Stereo Video size data represent only a subset of the whole caging operations in 2014. It reported 11,522 fish from 49 different caging operations and at least 9 farms, with sampling size within operation varying from 49 up to 903 fish measured with a median of 207 fish sized per operation. For comparison and based on the e-BCD database (as of August 2014), it is estimated that at least 48,800 fish have been caught by purse seine operations from these CPCs in 99 fishing operations.

From the summary reports submitted with the stereo video data, it is concluded that the measured fish are a subset of the total count fish in each video of the caging operation. When the number of fish counted was provided the percent of measured fish is about 20% of the total fish the video file, it is assumed that the measured fish is randomly selected and it represents the size frequency of the whole catch.

Comparison of the size frequency distributions from Stereo video systems were done against the estimated size frequency distribution at catch from the Farms Harvest reports previously presented (Ortiz *et al.* 2014). The ideal comparison would be same year catch and same farm/Flag, however from the Harvest reports the latest catches are from 2013, while the Stereo video measures are all from 2014. Density and cumulative density size frequencies were then compared by Flag using an average of the 2010-2013 data from the Harvest reports versus the 2014 Stereo video measures (**Figure 6**). There are differences in the density and cumulative density plots by Flag. For EU_Croatia the 2014 size distribution of catch is for smaller fish than the average of 2010-2013 years. Similarly for EU_Spain the 2014 size distribution is unimodal of large size fish, while the 2010-2013 average shows a bimodal distribution, with catches of smaller bluefin (110- 150 cm). In the case of EU_Malta, both distributions show the bimodal type distribution, but 2014 catches show a lower size for the larger fish peak and much lower proportions of fish over 250 FL cm compare to the averages of 2010-2013. In the case of Turkey, there also differences in the size frequency distributions showing overall smaller fish being caught in 2014 compared to the 2010-2013 averages. In a single case, with the EU_Spain data, comparison of the catch at size estimated from the Harvest of 2013 against the 2014 stereo video camera catch at size showed more similar trends (**Figure 7**).

The results indicate substantial differences in the size distributions of bluefin catch by Flag. These differences can be due to; a) the size frequency estimates are different for the two methods, the Stereo video system and the back-estimation from the Farm Harvesting reports, b) actual catch at size differences between 2014 and prior years, or a combination of both factors. Unfortunately same year data is not yet available from both methods, if farms Harvest reports continue, likely in a near future it will be possible to repeat the comparison with same year catch. Overall size frequency estimates from the Stereo video system are shift to the left compare to Harvest report estimates, (e.g. smaller sizes) but with the exception for the EU_Spain data. The margin of error reported from the Stereo video system is relative small, less or equal to 5%, however no details were provided on how this error was estimated, and or calibration procedures from the Stereo camera system. No comparisons were done with weight estimates, as they are directly from a size dependent formula defined by the user in the stereo video system. Nevertheless it is important to standardize what formulations should be used including reviewing the current size-weight relationships for bluefin tuna in general as recent analysis indicated that current size-weight relationship overestimated the weights of larger fish (Ref Size-weight review). In few of the stereo video reports it was indicated significant differences (above 10%) between the total weight estimated from the Stereo video recording and the values reported in the e-BCD, in all cases indicating greater total catch in weight to the values reported in the eBCDs.

Literature Cited

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Ortiz, M. A. Justel-Rubio and J. L. Gallego. 2014. Review and analysis of farm harvested size frequency samples of eastern bluefin tuna (*Thunnus thynnus*). Col. Vol. Sci. Pap. ICCAT, 71. *In this Volume.*

Table 1. Summary of bluefin tuna measures (size and weight) from stereo video camera systems submitted in 2014 by flag, farm ID and month.

CPC	FarmID	N Obs.	Apr-14	May-14	Jun-14	Jul-14	Aug-14
EU_Croatia	ATEU0HRV00003	2233			2233		
	ATEU0HRV00006	1745			1745		
EU_Malta	ATEU1MLT00003	375			375		
	ATEU1MLT00004	1014			804	210	
EU_Spain	ATEU1ESP00001	1388			1388		
	ATEU1ESP00004	648	75	573			
	ATEU1ESP00005	2062			2062		
Turkey		2057				1857	200
Turkey	AT001TUR00011	810				810	

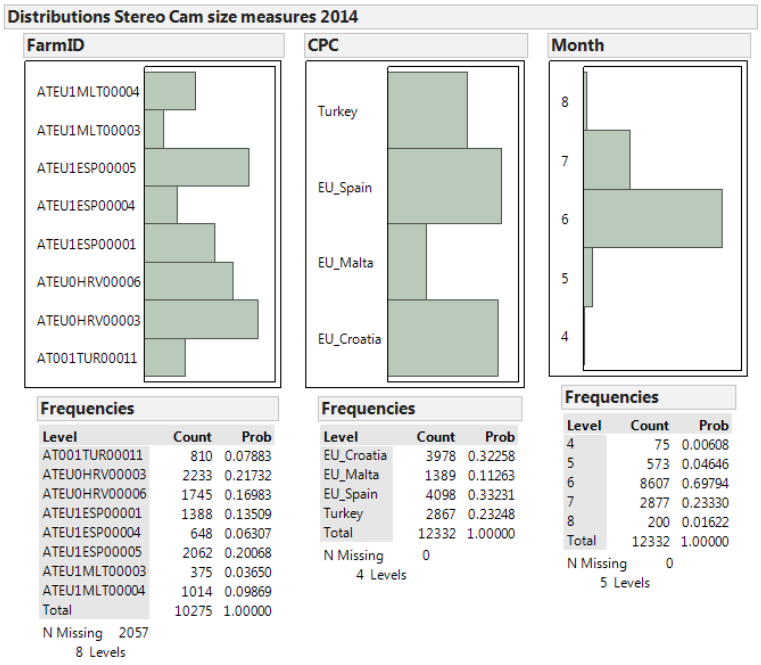

Figure 1. Distribution of size measures from stereo video systems by Flag, Farm ID and month.

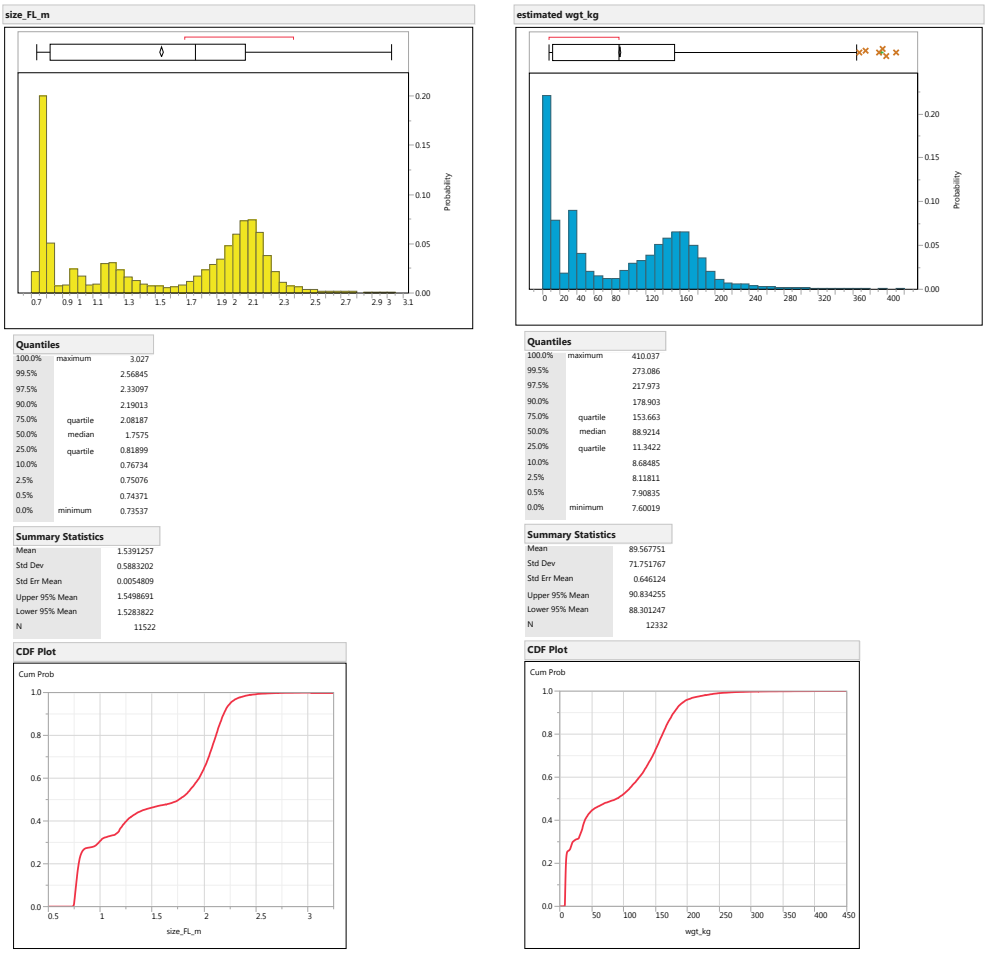

Figure 2. Overall size (left) and weight (right) distribution from stereo video data 2014.

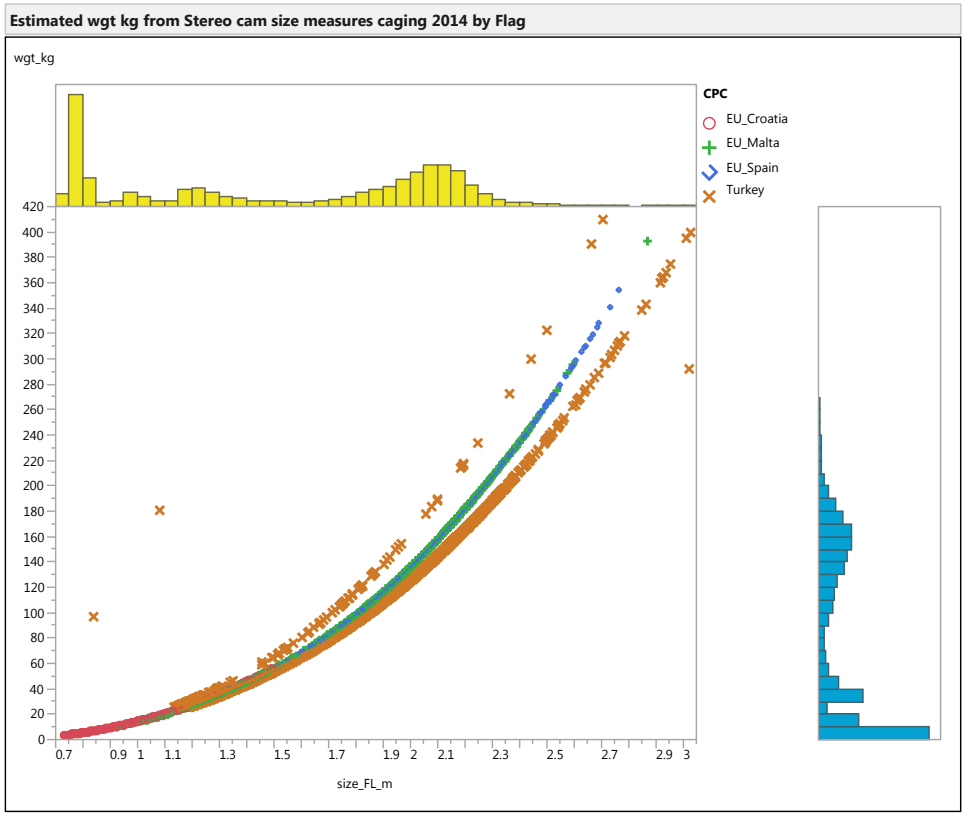

Figure 3. Scatter plot of weight at size from the stereo video data by flag for 2014.

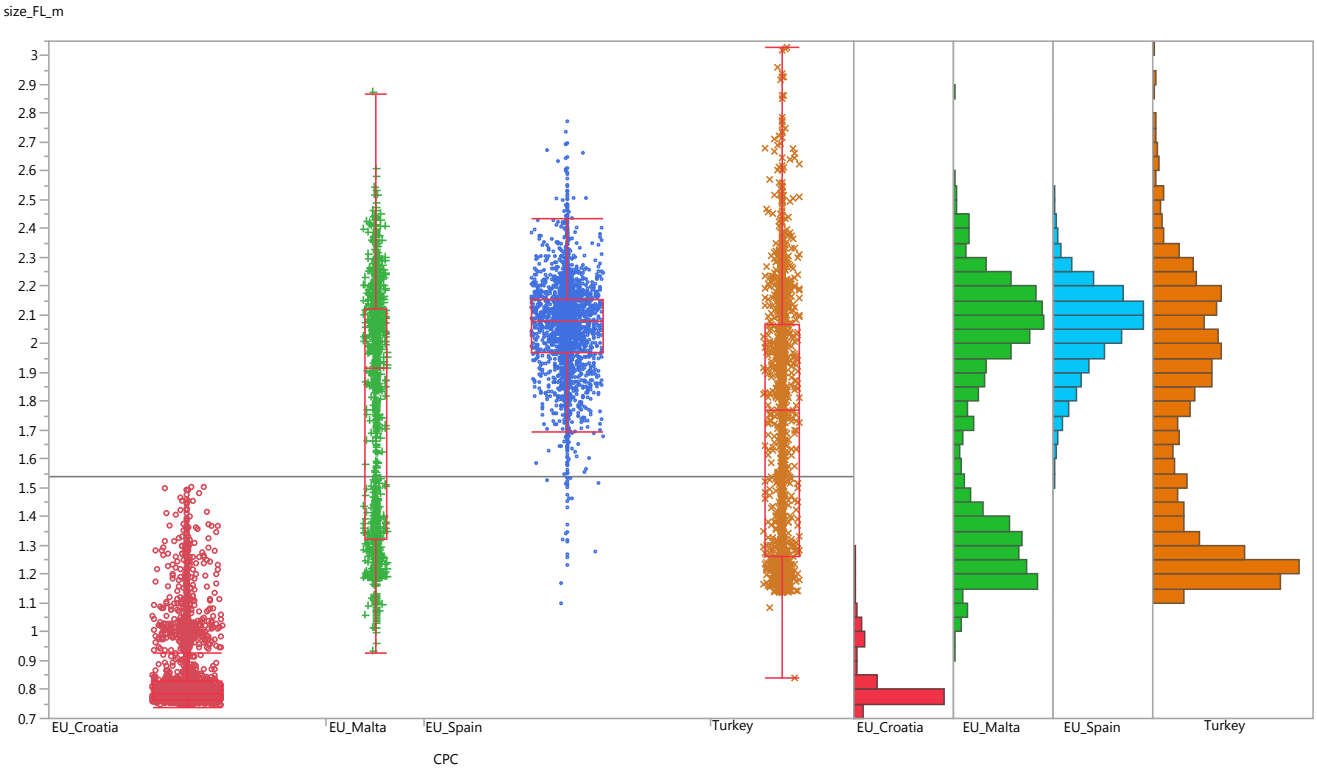

Figure 4. Bluefin tuna size FL (m) measures from stereo video cameras at caging operations by flag for 2014.

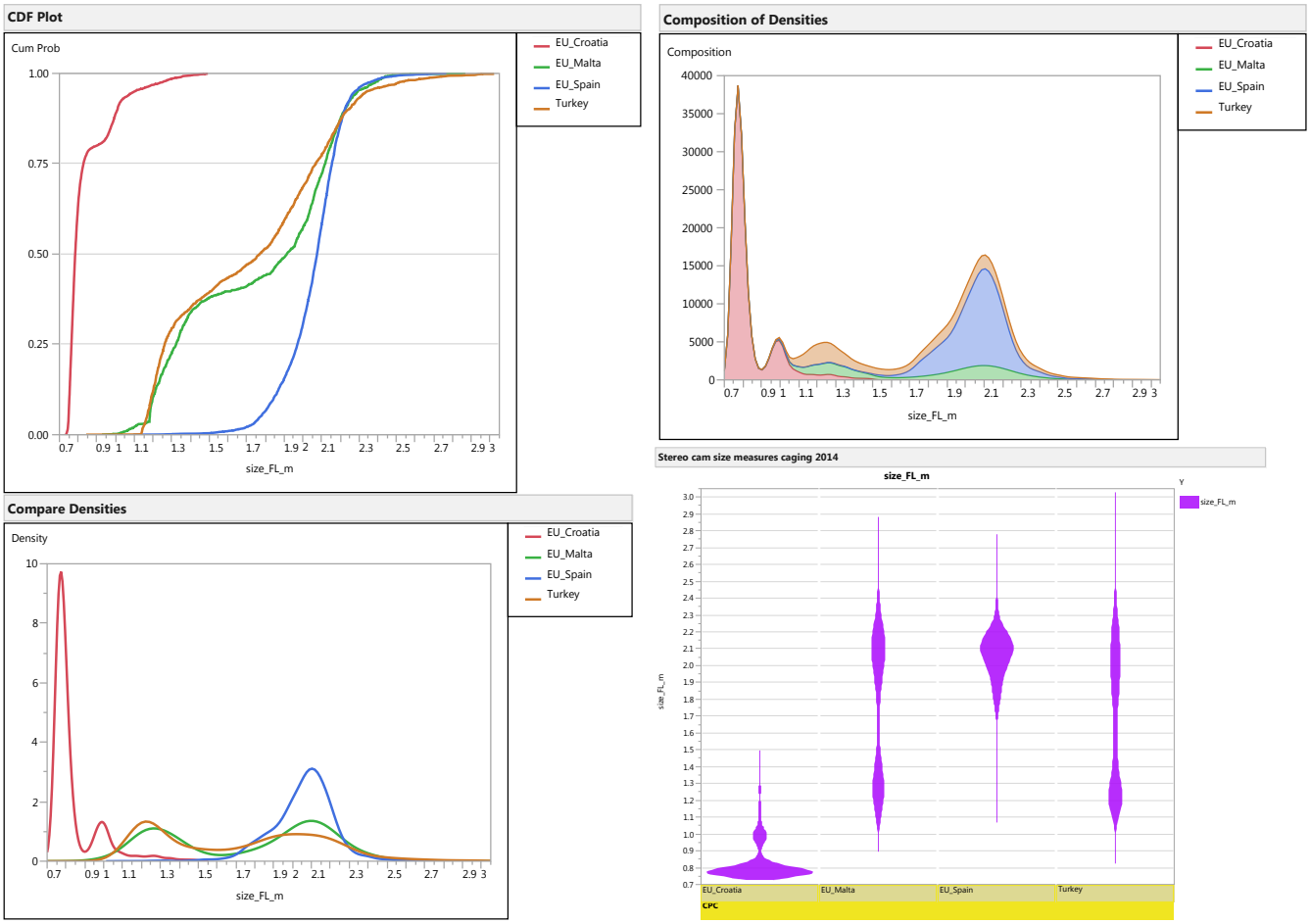

Figure 5. Cumulative and density size distributions of catch at size from the stereo video for bluefin tuna by flat 2014.

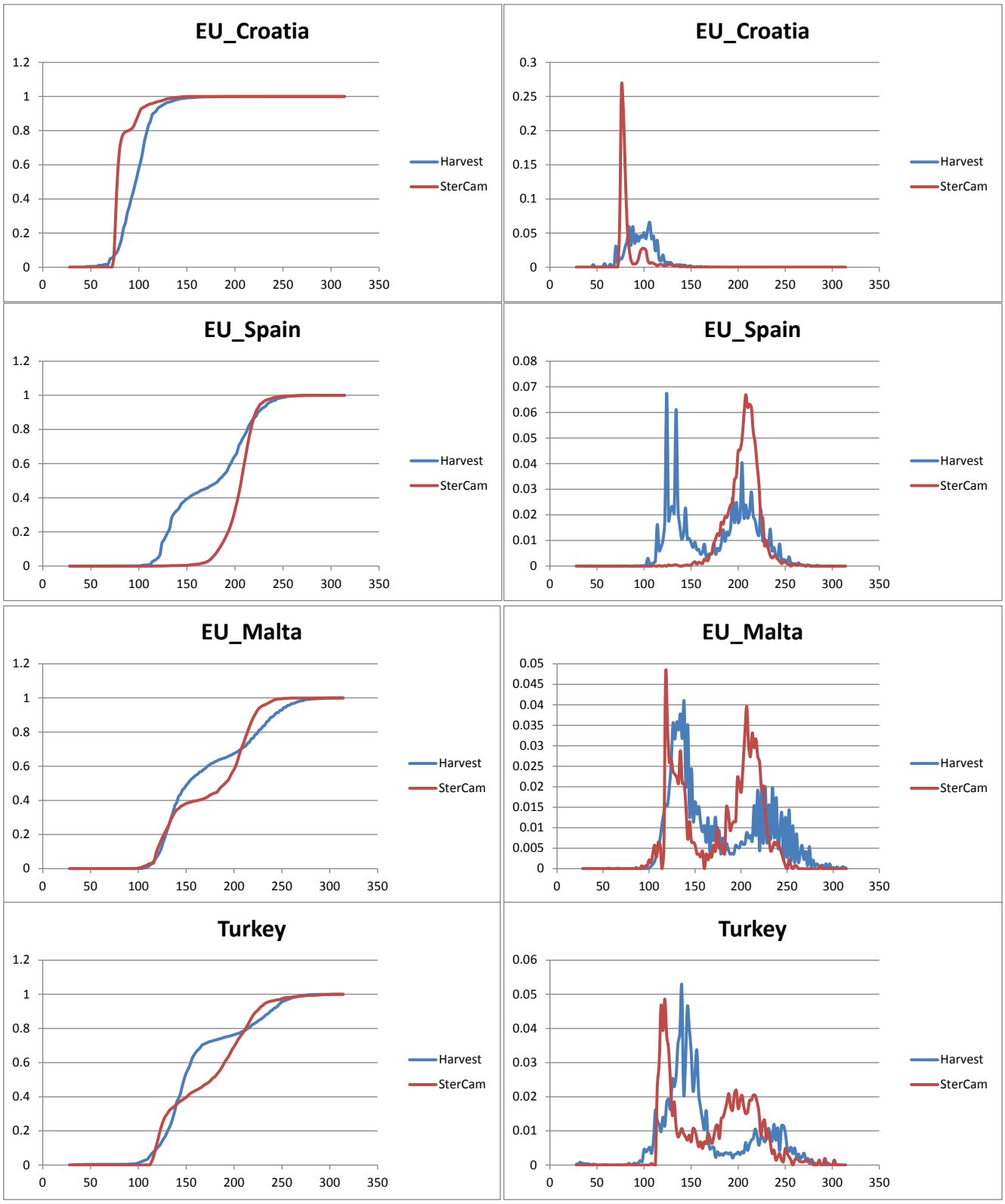

Figure 6. Comparison of cumulative (left) and density (left) size frequency distribution of catch at size for eastern bluefin tuna destined to farming operations by flag. The Harvest line represent estimated size at catch from the size at harvest reports (2010-2013 average) while the Ster Cam line correspond to size data from the stereo video camera systems and size data from 2014 caging operations.

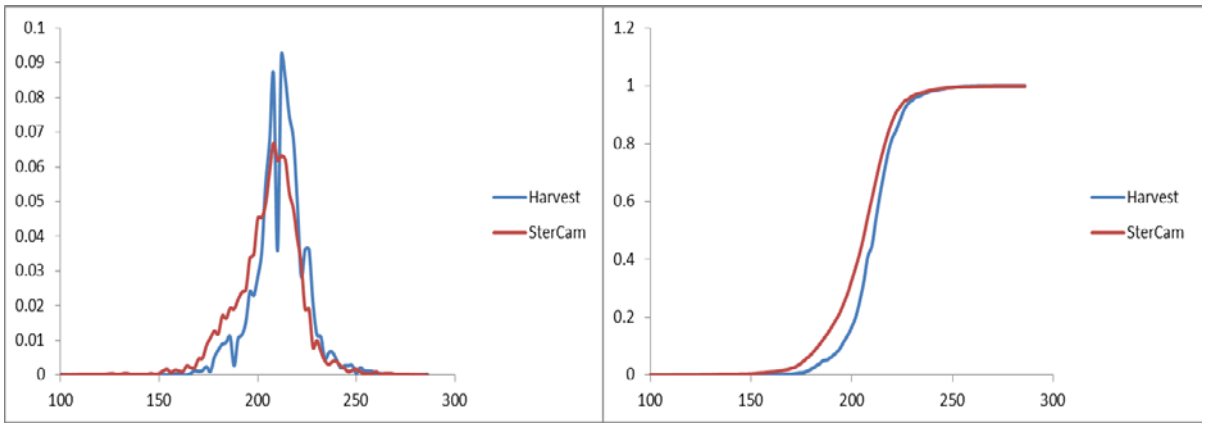

Figure 7. Comparison of catch at size distribution (density and cumulative) for bluefin tuna destined to farming operations from EU_Spain. Harvest line represents the catch at size estimated from harvest reports of 2013, while the Ster Cam line corresponds to the stereo video systems data from 2014.