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ESTIMATION OF SIZE AT CATCH AND POTENTIAL GROWTH OF FARMED EASTERN BLUFIN TUNA (*THUNNUS THYNNUS*) FROM FARM HARVEST DATABASE 2014-2016

M. Ortiz[1]

SUMMARY

Fattening of bluefin has become one of the main operations and destination of the catches of eastern bluefin in the Mediterranean Sea. Since 2008 a regional observer program (ROP-BFT) collects size and weight measures of harvested bluefin. Data from 2014-2016 harvest operations were review to estimate size at catch of bluefin tuna purse seine operations in the Mediterranean. It was also estimated the potential growth in conditioning of fish (percent weight gain) associated with farming as function of days-at-farm, size at catch and farm. Results indicated an increase in average weight gain of 58%, although there is large variability among farms and within a farm. Harvest estimated size frequency match with stereo-camera information for medium large size fish that are in farms for < 2 years. However, for long term farming (> 3 years) of small bluefin predicting models did not fit suggesting that in this case intrinsic growth rates may be altered.

RÉSUMÉ

L'élevage du thon rouge est devenu l'une des principales opérations et destination des prises de thon rouge de l'Est dans la mer Méditerranée. Depuis 2008, un programme régional d'observateurs (ROP-BFT) collecte les mesures de taille et de poids du thon rouge mis à mort. Les données provenant des opérations de mise à mort de 2014-2016 ont été examinées pour estimer la taille à la capture du thon rouge capturé dans des opérations à la senne en Méditerranée. On a également estimé la croissance potentielle dans le conditionnement du poisson (pourcentage du gain pondéral) associé à l'engraissement en fonction des jours-à-la-ferme, de la taille à la capture et de la ferme. Les résultats ont indiqué une augmentation du gain pondéral moyen de 58%, bien qu'il existe de grandes variations entre les fermes et à l'intérieur d'une ferme. La fréquence des tailles estimée à la mise à mort coïncide avec les informations des caméras stéréoscopiques portant sur les poissons de taille moyenne à grande qui se trouvent dans les fermes depuis moins de deux ans. Toutefois, pour l'engraissement à long terme (> 3 ans) des petits thons rouges, les modèles de prédiction ne se sont pas ajustés, ce qui suggère que, dans ce cas, les taux de croissance intrinsèque pourraient être altérés.

RESUMEN

La cría de atún rojo se ha convertido en una de las principales operaciones y destino de las capturas de atún rojo del este en el Mediterráneo. Desde 2008, un programa regional de observadores (ROP-BFT) recopila mediciones de talla y peso del atún rojo sacrificado. Se revisaron los datos de las operaciones de sacrificio de 2014-2016 para estimar la talla de captura de las operaciones de cerco de atún rojo en el Mediterráneo. También se estimó el crecimiento potencial en el condicionamiento de los peces (porcentaje de ganancia de peso), asociado con la cría como función día en la granja, talla de captura y cría. Los resultados indicaban un incremento en la ganancia media de peso del 58%, aunque se observó una gran variabilidad entre las diferentes granjas y en una misma granja. Las frecuencias de tallas de sacrificio estimadas coinciden con la información procedente de cámaras estereoscópicas para los peces con una talla mediana grande que permanecieron en las granjas durante menos de dos años. Sin embargo, para la cría a largo plazo (más de tres años) de peces pequeños, los modelos de predicción no se ajustaron, lo que sugiere que en este caso las tasas de crecimiento intrínseco podrían alterarse.

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KEYWORDS

Bluefin tuna, Thunnus thynnus, farm, growth, size distribution

1. Introduction

Fattening of bluefin has become one of the main operations and objectives for the catches of eastern bluefin in the Mediterranean Sea during the last decades. Based on catches from purse-seine vessels close to 60% of the annual catch of eastern bluefin are destined to farms. Farms hold the fish from few months to over 2 years, depending on the size and other factors including market conditions.

Bluefin for farming operations is almost all caught with purse-seine vessels that transfer the live fish to holding pens, which are slowly towed and finally transfer to sea-cages in the farms. Because of the nature of the fishing operations it has been difficult to obtain estimates of the catch in both numbers, weight and size/age distribution of the wild fish caught, substantially increasing the uncertainty in recent stock assessment evaluations.

As with most aquaculture operations, farming of bluefin enhances the growth compared to wild populations, but whether this growth is only on weight (e.g. condition index) and or both size and weight (intrinsic growth rate) is unknown. Most studies with farming of bluefin for less than 2 years reported only increases in weight (Katavic *et al*. 2002, Orsi-Relini *et al*. 1996, Deguara *et al*. 2011), with size increments similar to wild fish. Only a study with small fish in the Adriatic reported increases in growth rates of both size and weight for farmed bluefin (Katavic *et al* 2010). There are however large variations in size/weight gains among farms, likely in response to differences in husbandry and environmental conditions. Assuming that intrinsic growth rates of bluefin tuna are not affected by farming, then it is possible to estimate the size at catch if size at harvest and the time in the farm is known. A previous study presented estimates of catch at size from harvesting size data provided by the farms and CPCs to ICCAT since 2008 (Ortiz *et al* 2014). This study provided size estimates for purse seine catches of bluefin in the Mediterranean Sea for 2008 – 2013, that were used in the last stocks assessment of eastern bluefin stock. The present study updates the size at catch estimates of farmed bluefin tuna for 2014 – 2016, and compared with the recent results from the stereo-camera size measures of caged bluefin tuna implemented in 2014.

2. Data

Size and weight of sacrificed bluefin tuna from farms started to be reported in June 2008, following the Rec. 08-05.In 2014 a database was created identifying each harvesting operation (per day when available) by registered farm and auxiliary data such date of catch, or the bluefin catch document number where the details of the catching operations are recorded. Harvest operations at farms requires the presence of a scientific observer from the ICCAT Regional Observer Program (ROP-BFT) currently operated by MRAG/COFREPECHE consortium, which collects and enter the data into a database and provided it to the ICCAT Secretariat. For 2014 -2016 there were 6507 harvest operations monitored in 22 farms from seven CPCs EU_Croatia (4 farms), EU_Spain (3 farms), EU_Malta (4 farms), EU_Italy (1 farm), Morocco (1 farm), Tunisia (4 farms) and Turkey (5 farms). The reports for 2016 are partial, as not all the information was available in time. The reported total harvest is over 37.8 thousand tons representing about 224 thousand fish (**Table 1**). Of the 6507 harvest operations monitored size and weight measures were collected on 2,389 (37%) operations with just over 51 thousand fish size and weight measurements reported (**Figure 1**). Size and weight measures were standardized to straight fork length (SFL, cm) and whole weight (WH, kg) using current conversion factors. The catch date was extracted from the bluefin catch document (BCD) id number and days-at-farm was estimated for each sampled fish.

3. Methods

As in prior analyses (Ortiz *et al*. 2014) it was assumed that farmed bluefin tuna maintain their intrinsic growth rates of size at age. Thus, estimated size at catch was simply estimated using the current growth equation (Cort 1991) for eastern bluefin tuna discounting for the days-at-farm. Once the estimated sized at catch was obtained, using the current monthly conversion factors for weight-at-size (Rodriguez-Marin *et al*. 2015), the expected weight at catch was estimated, as well the “expected” weight of the fish if it had remained in the wild (wild weight at harvest), to calculate the gain of weight during the farming operation.

Ortiz *et al*. (2014) addressed the potential growth of farmed bluefin tuna, concluding that gain in farms is primarily in fish condition, e.g. gain in weight with minimum change in the intrinsic rate of growth, at least for fish in captivity for 2 years or less. With the 2014-2016 size-weight harvest data is was modeled the potential growth in farms of bluefin tuna as function of the time spent in farm and size at initial caging, taking also into account the differences in farms that are likely associated with husbandry, biotic and environmental conditions. Because the actual weight at size is non-linear, it was decided work with the relative percent weight gain to linearize the response variable. The model selected is a GLM:

$$\frac{(wgt\ hrv - \widehat{wgtwld})}{\widehat{wgtwld}} = \beta_0 + \beta_1 * days\ farm + \beta_2 * size\ catch + \beta_{3i} * farm_i + \varepsilon$$

Where $wgt\ hrv$ is the weight at harvest time, $\widehat{wgtwld}$ is the expected weight of the fish if it had remained in the wild, estimated using the current weight at size conversion factors (by month) for Mediterranean bluefin tuna (Ref), and ε is the error $N(0, \sigma)$.Both days-at-farm and size-at-catch were considered continuous variables, while farms were in this case considered fixed factor $i = 1, \ldots farms$.

4. Results and conclusions

A preliminary quality control of the data indicated some errors in the data collection, particularly in the description of the type of size measure. **Figure 2** shows a scatter plot of the straight fork (SFL) length versus the curve length value. Clearly some of the reported SFL are measures of snout - first dorsal spine (LD1).For 99% of the 2,389 harvest operations, date of catch was assigned based on the BCD document reports. The days-at-farm ranged from 12 to 2684 (7 years and 4 months), but with a median of 260 days (**Figure 4**). However, it appears that farms split in general the holding of bluefin into two time periods; one group is harvest at 6-12 months, while the others are hold for almost 24 months. There are however, some exceptions in particular farms in Croatia, hold the fish for longer times at least 2 to 3 years, indeed in 2015 it was harvested a batch of fish that were caught in June 2008 being kept in captivity for over 7 years. The Spanish farms show a rather a distinct pattern, with more continuous harvesting of fish all year around.

Figure 5 shows a scatter plot of weight at size for harvest bluefin. In size harvested fish ranged from 95 to 302 (CFL cm) with a bimodal distribution of size, one peak at 150 CFL cm, and the second at 230 CFL cm. Similarly, the weights of harvested bluefin show a bimodal distribution with a firs peak at about 65 kg and second peak at 250 kg. But weights ranged from 8 to 648 kg. The scatter plot shows also the large variability of weight at size, with a mean coefficient of variance of 18%.At smaller sizes (< 100 CFL cm) the variance of weight at size is much larger. If we compared the weight at harvest vs. the expected weight if the fish had been in the wild, the percent gain in weight associated with farming can be estimated. **Figure 6** shows the trends of this percent weight gain vs days-at-farm, as expected there is positive correlation although there is substantial variability in the data. The smoother trend in **Figure 6** suggest that in 6 months at farm, roughly the fish increase 30% in mass compared to wild fish, and that by 2 years it will double their gain weight. Notice however that there are no few cases where fish actually weight at harvest less than wild counterparts.

The back-calculated size distribution at catch of farmed bluefin tuna is shown in **Figure 7**. From 51,738 harvested fish, a total of 49,329 (95%) were possible to estimate size at catch, most of the fish were caught in 2014 (21,839; 46.51%) and 2015 (16016, 36.27%) (**Table 2**). In 2013, the catch shows a bimodal size distribution with a peak of fish of 110 SFL cm and a second at 200 SFL cm. By 2014, the bimodal size distribution was also present, but in this year the larger fish were predominant and the size on average were larger compare to 2013, with a first mode at 130 SFL cm and the second at 210 SFL cm. In contrast by 2015 the bimodal is less evident and the smaller mode at 130 SFL cm and the second mode at 230 SFL cm. It is important to note, however that given the trends of farming, fish caught in 2014/15 are still likely in captivity, particularly the smaller fish that entered in 2015. Also interesting is that when the size-at-catch distribution is compared by farm-year; there is a relative consistent size of fish entering most of the farms, albeit the variance among farms is large (**Figure 8**). This may correspond with standard farming practices, where each farm prefers or specialized in a rather uniform size-group of fish, facilitating husbandry, feeding and marketing conditions (**Figure 3**).

The model results of percent gain in weight associated with farming of bluefin tuna are summarized in **Table 3** and **Figure 9**. Results show that the model accounted for close to 72% of the variability observed, with days-at-farm as the main explanatory factor in predicting increase in percent weight. The mean percent increase in weight is 67%, although the variance is large (mean square error) 0.37. The size at catch leverage plot indicate a negative slope, e.g. percent weight decreases for relative larger fish, which is expected as size increase is proportionally larger for smaller fish, with an inflection point around 180 SFL cm. The LSMean of the farm, show the variance associated with each farm, however all farms predicted a positive percent weight gain, with an average of 58% expected gain in weight for “average” farmed bluefin. The diagnostic plots indicate large variance in residual particularly for the small size fish (< 100 SFL), where the model fails to correctly predict the percent weight observed (**Figure 10**). This corresponds in particular with the long term farmed fish from the Croatian farms (red dots). Nevertheless the model predicted quite well the gain in weight for farmed bluefin of fish > 120 SFL cm (**Figure 10**).

Finally, for 2014 and 2015 there are two sources of bluefin size at catch distribution; the back estimates from the harvested data and the stereo camera size data at the caging events. If matched by year-farm then they should represent the same fish, although the main difference is whether the harvest data represent 100% of the fish caged (e.g. whether all fish has been sacrificed from a given year-farm). **Figure 11** shows the overall comparison of the size frequency distributions of farmed bluefin from the two sources; harvested fish and stereo camera 2014-2016. Overall there is good match in the size distribution of medium and large size fish (SFL > 100 cm) between the two sets of data. However, the harvest data is clearly missing the small fish (SFL < 100 cm) that compose and important component of the catch. If broken by year (**Figure 12**) it is more evident that small and now middle size fish is missing from the harvest size histograms, particularly in 2015, indicating that this portion of the farmed fish are still in the cages. When the size histograms were review by farm and year, when there is data from both sources, shows a rather interesting patterns (**Figures 13** and **14**). In a much Spanish farms that have the largest proportion of size harvest data submitted, match quite well in both years, similar for the Maltese farms, excluding the small, medium size fish that is still being held in the farm.

In conclusion, the analyses of the harvested bluefin tuna in 2014-2016 provided confirmation of preliminary analyses (Ortiz *et al* 2014, Katavic *et al* 2001, Orsi-Relini *et al*, 1996, Deguara *et al* 2011), regarding gain in weight condition of fish farmed, rather than changes in the intrinsic growth rates of bluefin, at least for fish in farms for less than 2 years. However, in 2015 a batch of 249 fish were sacrificed that were in the farm for just over 7 years (Caught in June 2008). This fish show large deviations in the expected weight/size from the GLM model growth, which may suggest significant departures from the short term (0.5 to 2 year) farmed fish as indicated in early experiments where long term caging of smaller bluefin showed increases in growth rates, with faster growth compared to wild fish (Katavic *et al* 2010). The duration in farms is positive correlated with gain in weight, and percent weight increase is larger for smaller fish, due in part to the non-linear growth in size. The results also indicated differences among farms, and this reflects in summary differences in husbandry, biotic and environmental conditions to which fish are exposed in each farm. The estimated catch at size of farmed fish, shows a bimodal trend in the caging of bluefin tuna in recent years, smaller fish (~ 110 SFL cm) and medium-large (220 SFL cm) fish, which was also shown from the size-at-caging stereo-camera data in 2014-2015 (Ortiz, 2016). Although by comparison, the stereo-camera data shows a third peak of smaller fish (~ 75 SLF cm) that is also caged, but likely is not shown in the harvest data, as those fish are kept in farms for longer time. The comparison of size distribution at catch from the two sources of data did agreed in general, however it is important to confirm that all fish from a given year catch has been harvested, particularly small and medium size fish. Looking at the trends of farming operations, it likely that harvested data older than 3 years will have all fish killed, except those from Croatian farms. This supports the used of the back calculated catch at size frequency data based on harvest bluefin prior to the size data coming from the stereo-camera caging, as presented in the last assessment (Anon. 2015). Although some caution should be exercise in particular for fish with estimated size at catch less than 80 SFL cm that have been in farms for over 24 months.

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Table 1. Summary of harvest bluefin tuna from farming operations 2014 – 2016 as reported by the ROP-BFT program.

Year	Farm State	N fish	Wt. tones
2014	Croatia	31666	2160.62
	Malta	30425	5846.195
	Morocco	1074	334.885
	Spain (EU)	16103	4066.36939
	Tunisia	5954	905.941
	Turkey	11738	2500.1782
2014 Total		96960	15814.18859
2015	Croatia	18283	2085.5425
	Italy (EU)	1	0.0875
	Malta	39789	7550.598
	Morocco	1942	624.92
	Spain (EU)	18793	4557.932062
	Tunisia	5251	1043.065
	Turkey	13304	2250.0721
2015 Total		97363	18112.21716
2016	Croatia	19388	1664.672
	Malta	1061	229.285
	Spain (EU)	7102	1756.672208
	Turkey	2111	244.892
2016 Total		29662	3895.521208
Total		223,985	37,822

Table 2. Distribution of the number of bluefin tuna harvest in farms by year (Year harvest) and the corresponding year of catch.

	Year Harvest			
Year Catch	*2014*	*2015*	*2016*	*Total*
2008	0	232	0	232
2011	0	0	29	29
2012	759	1075	25	1859
2013	6581	2515	258	9354
2014	14052	4607	3180	21839
2015		12910	3106	16016
Total	21392	21339	6598	49329

Table 3. Summary results of the GLM model on the percent weight gain of farmed bluefin tuna as function of days at farm, size at catch and farm.

Generalized Linear Model Fit

Overdispersion parameter estimated by Maximum Likelihood

Response: Perc_wgtGain

Distribution: Normal

Link: Identity

Estimation Method: Maximum Likelihood

Observations (or Sum Wgts) = 45440

Whole Model Test

Model	-LogLikelihood	L-R ChiSquare	DF	Prob>ChiSq
Difference	29168.566	58337.13	22	<.0001*
Full	19327.3223			
Reduced	48495.8883			

Goodness Of Fit Statistic	ChiSquare	DF	Prob>ChiSq	Overdispersion
Pearson	6228.840	45417	1.0000	0.1371
Deviance	6228.840	45417	1.0000	

AICc
38702.671

Effect Summary

Source	FDR LogWorth	FDR P Value
Farm ID	2558.330	0.00000
DaysFarm	1744.807	0.00000
Est_Sz_Catch	698.855	0.00000

Effect Tests

Source	DF	L-R ChiSquare	Prob>ChiSq
DaysFarm	1	8026.4995	<.0001*
Est_Sz_Catch	1	3209.8211	<.0001*
Farm ID	20	11914.605	<.0001*

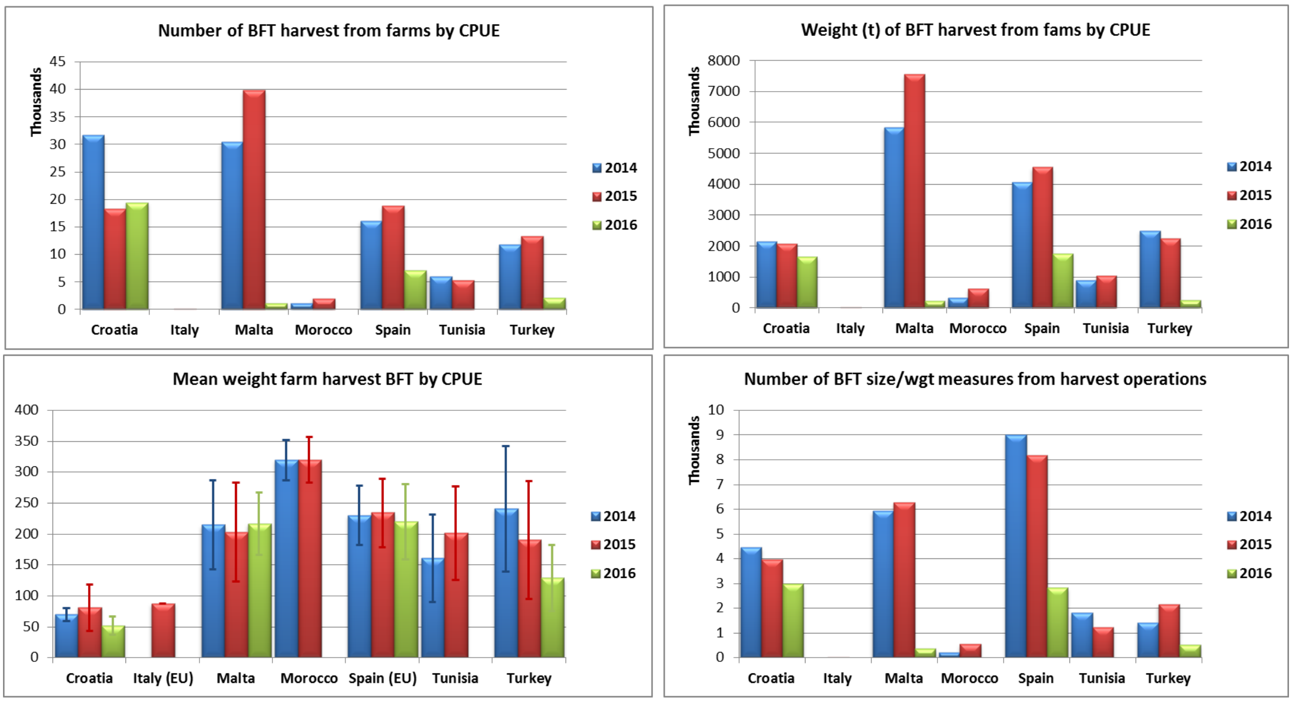


Figure 1. Summary of harvested bluefin tuna from farms 2014 – 2016 by farm CPC.

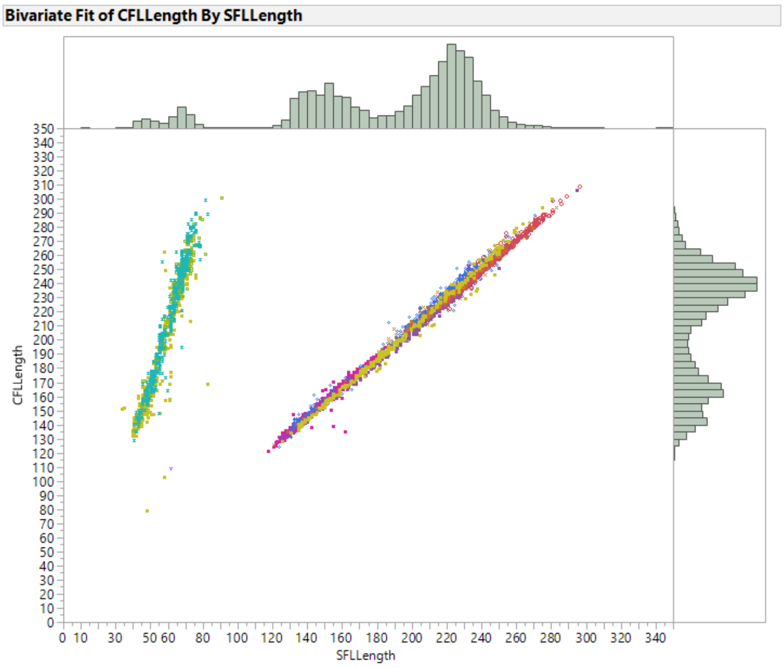


Figure 2. Scatter plot of straight fork length (cm) vs. curved fork length (cm) measures of harvested bluefin tuna 2014-2016.

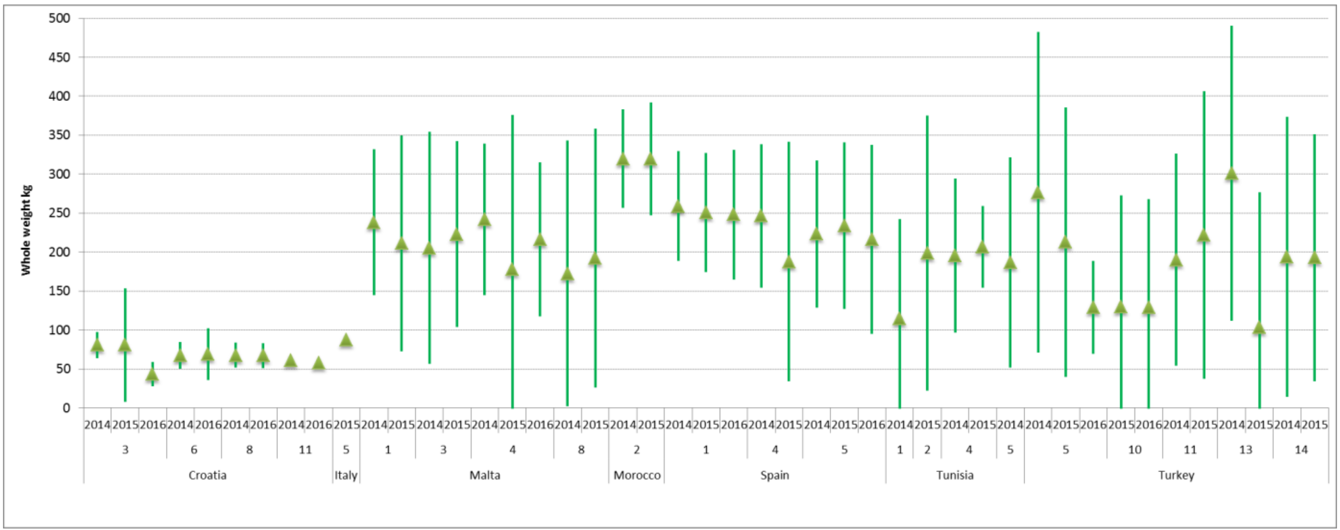
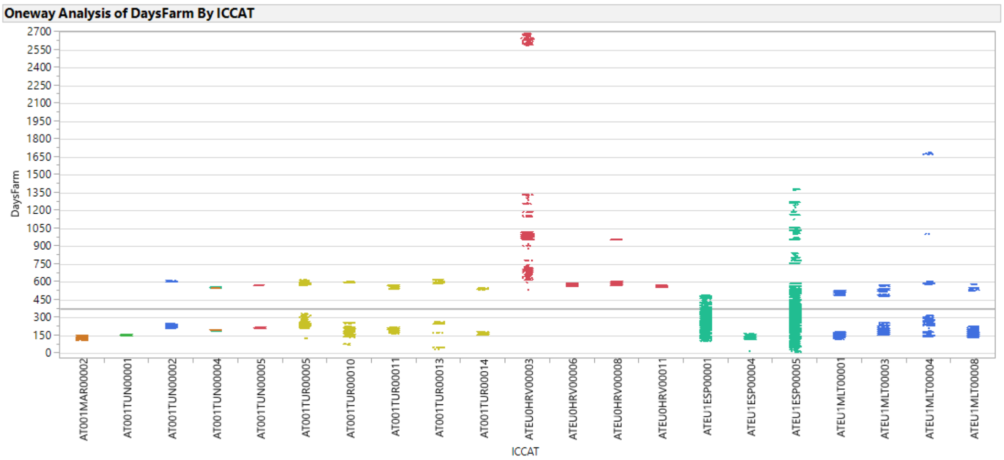


Figure 3. Overall mean weight ± 95% confidence interval of harvested bluefin tuna by CPC, farm and year as reported from the ROP-BFT 2014-2016.



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
AT001MAR00002	115	116	119	130	137	148	150
AT001TUN00001	149	150	151	156	157	158	160
AT001TUN00002	213	216	218	222	244	246	608
AT001TUN00004	187	192	193	196	550	555	559
AT001TUN00005	211	211	213	214	217	572	575
AT001TUR00005	130	225	235.75	251	321	584.1	615
AT001TUR00010	71	154	185	216	257	596	601
AT001TUR00011	167	176	191	206	545	566	576
AT001TUR00013	38	176	247	587	595	601	615
AT001TUR00014	157	158	161	172	538	546	548
ATEU0HRV00003	533	954	965	982	995	1017	2684
ATEU0HRV00006	563	566	568	578	583	585	590
ATEU0HRV00008	572	576	586	595	599	604	957
ATEU0HRV00011	559	559	559	560	566	570	572
ATEU1ESP00001	102	139	196	253	308	363	484
ATEU1ESP00004	17	121	124	129	143	157	163
ATEU1ESP00005	12	136	205	272	377	534	1375
ATEU1MLT00001	120	139	149	159	171	499	528
ATEU1MLT00003	156	163	183	203	519	535	574
ATEU1MLT00004	139	142	151	186	281	585	1688
ATEU1MLT00008	136	143	154	166	178	203	583

Missing Rows 748

Excluded Rows 160

Figure 4. Trends of days-at-farm by farm ID for bluefin tuna harvested in 2014-2016 from the ROP-BFT database.

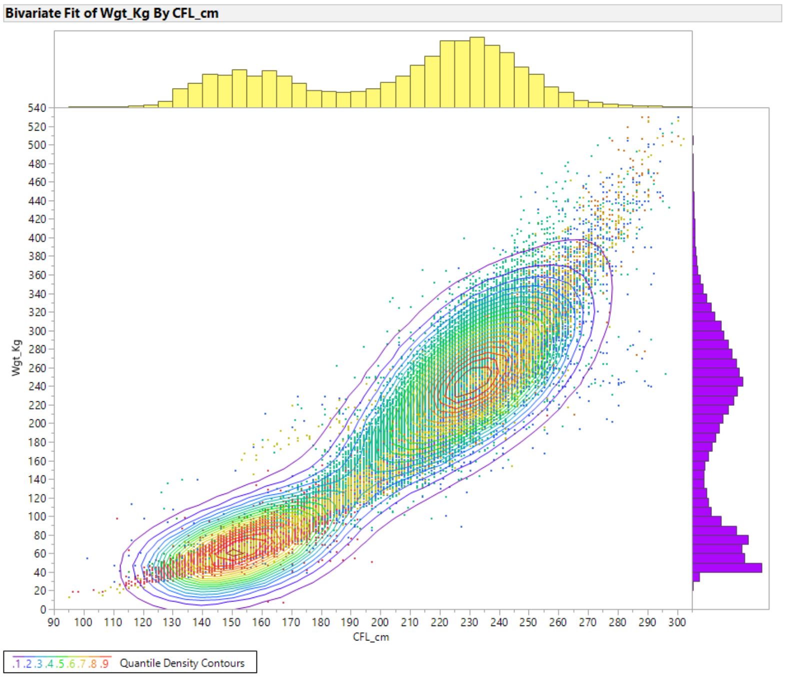


Figure 5. Scatter plot of weight (whole weight kg) vs. size (CFL cm) at harvest for bluefin tuna 2014-2016.

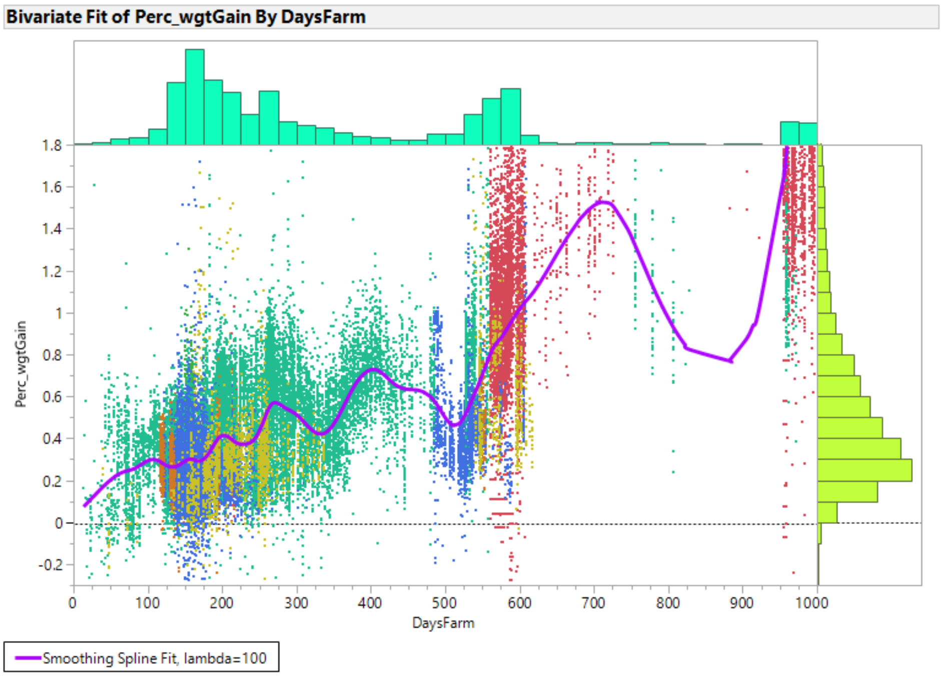


Figure 6. Scatter plot of percent weight gain vs. days-at-farm for harvested bluefin tuna 2014-2016 from the ROP BFT program.

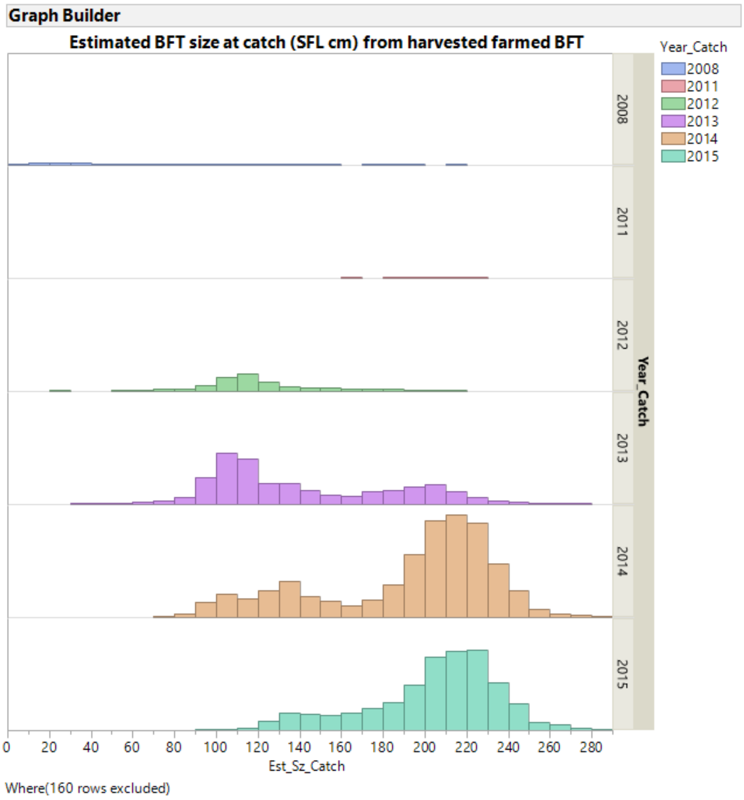


Figure 7. Estimated size-at-catch distribution of farmed BFT harvested by year of catch from the ROP-BFT program.

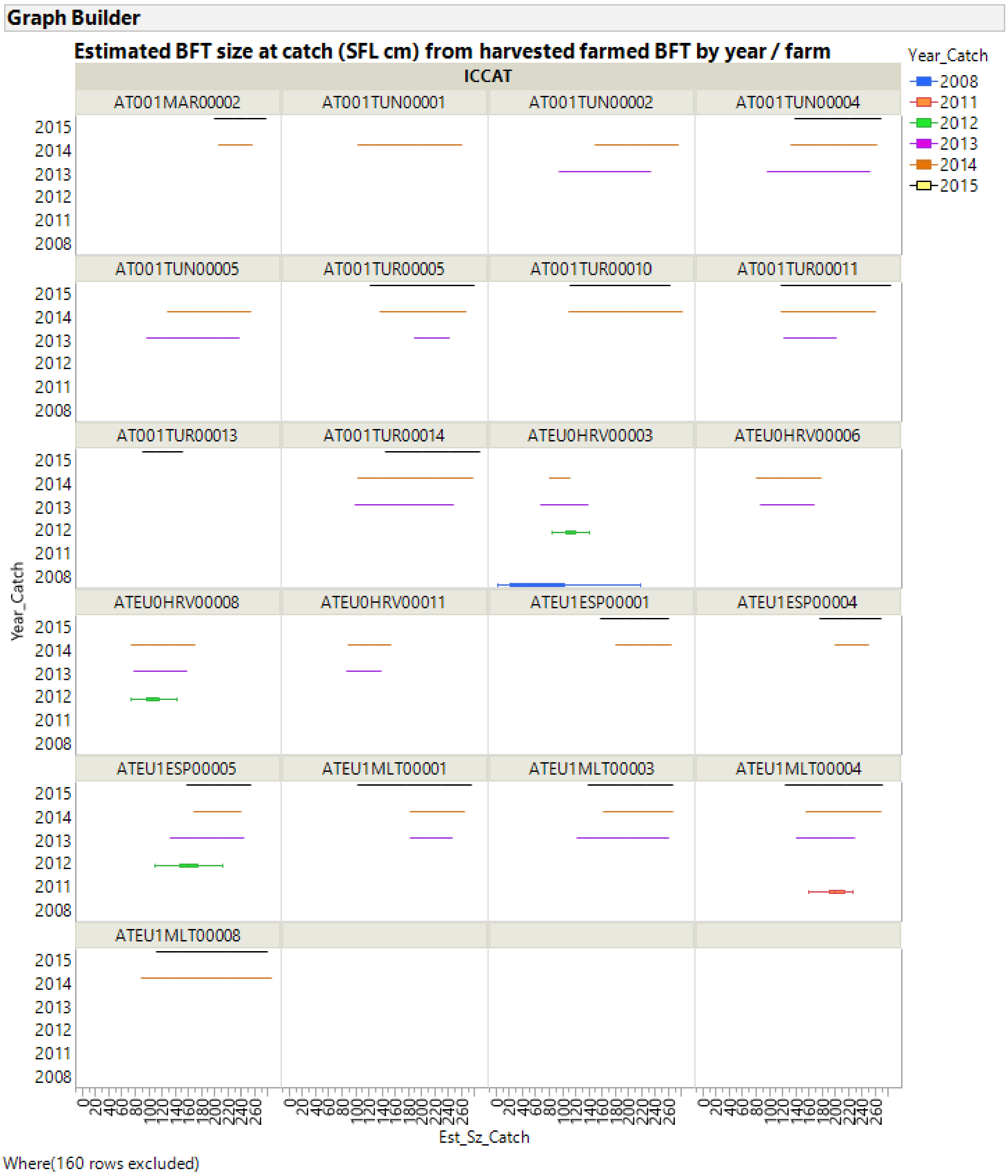
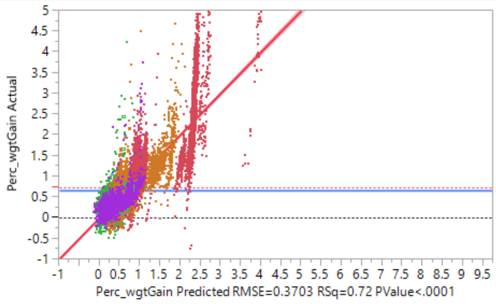


Figure 8. Box-plots for the estimated size at catch distribution of farmed BFT by year of catch and farm ID.

Response Perc_wgtGain

Actual by Predicted Plot



AICc	BIC
38702.67	38912.02

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	22	16259.970	739.090	5389.002
Error	45417	6228.840	0.137	Prob > F
C. Total	45439	22488.810		<.0001*

Parameter Estimate Population

Term	Estimate	t Ratio	Orthog Coded	Orthog t-Ratio	Prob>|t|
Intercept	0.898349	66.2282	0.672782	387.2568	<.0001*
DaysFarm	0.001035	93.6729	0.551647	317.5312	<.0001*
Est_Sz_Catch	-0.003856	-57.6561	-0.111462	-64.1583	<.0001*
ICCAT[AT001MAR00002]	0.144650	10.3020	0.026680	15.3572	<.0001*
ICCAT[AT001TUN00001]	0.049284	3.8844	0.005042	2.9020	0.0037*
ICCAT[AT001TUN00002]	-0.043428	-3.6012	-0.018517	-10.6587	<.0001*
ICCAT[AT001TUN00004]	-0.003565	-0.2539	-0.013670	-7.8687	<.0001*
ICCAT[AT001TUN00005]	-0.027465	-1.7105	-0.005070	-2.9186	0.0035*
ICCAT[AT001TUR00005]	-0.111374	-8.5748	-0.020055	-11.5440	<.0001*
ICCAT[AT001TUR00010]	-0.191556	-15.1918	-0.023475	-13.5126	<.0001*
ICCAT[AT001TUR00011]	0.071643	5.7283	0.008436	4.8560	<.0001*
ICCAT[AT001TUR00013]	-0.385383	-7.3792	0.012675	7.2957	<.0001*
ICCAT[AT001TUR00014]	-0.008303	-0.4929	-0.000968	-0.5574	0.5773
ICCAT[ATEU0HRV00003]	0.810042	76.9196	0.174900	100.6736	<.0001*
ICCAT[ATEU0HRV00006]	0.010887	1.2828	0.012257	7.0549	<.0001*
ICCAT[ATEU0HRV00008]	-0.170096	-17.7545	-0.030714	-17.6790	<.0001*
ICCAT[ATEU0HRV00011]	-0.237502	-20.2904	-0.039648	-22.8219	<.0001*
ICCAT[ATEU1ESP00001]	0.103395	15.3408	0.015859	9.1287	<.0001*
ICCAT[ATEU1ESP00004]	0.016877	1.6079	-0.002904	-1.6716	0.0946
ICCAT[ATEU1ESP00005]	0.171083	33.1289	0.069559	40.0386	<.0001*
ICCAT[ATEU1MLT00001]	-0.006097	-0.9393	0.002907	1.6732	0.0943
ICCAT[ATEU1MLT00003]	-0.064959	-8.9272	-0.015464	-8.9012	<.0001*
ICCAT[ATEU1MLT00004]	-0.035153	-2.2021	-0.003826	-2.2021	0.0277*

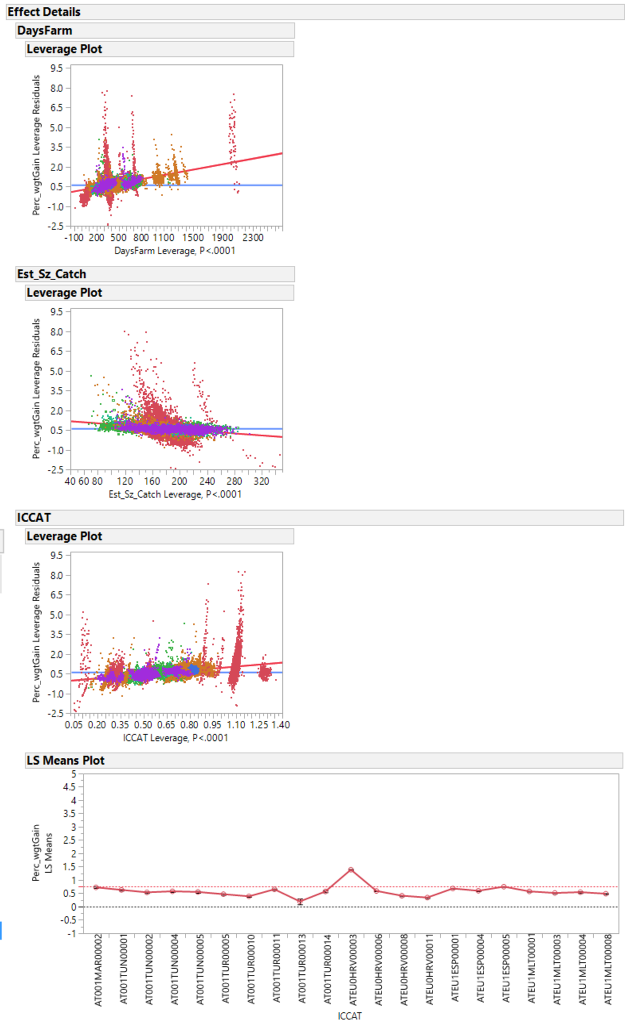


Figure 9. GLM results for the percent weight gain of farmed bluefin tuna as function of days at farm, size at catch and farm. Observations are color coded by Flag of farm.

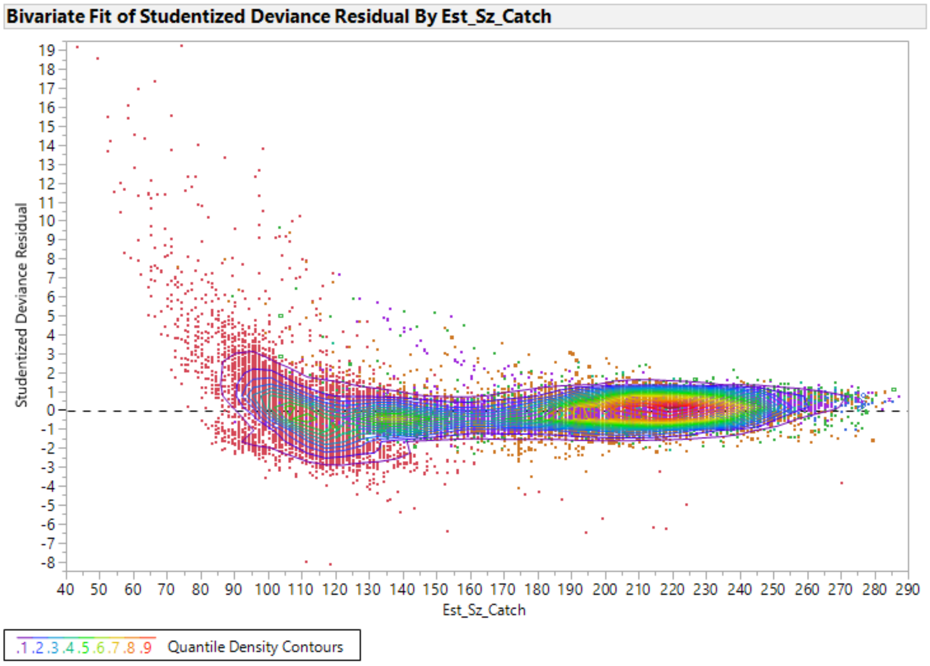


Figure 10. Scatter plot of the studentized deviance residuals of the GLM percent wt. gain model for farmed bluefin tuna vs. estimated size at catch. Bivariate quantiles shows the density of observations, outer line correspond to the 0.1 quantile of the data.

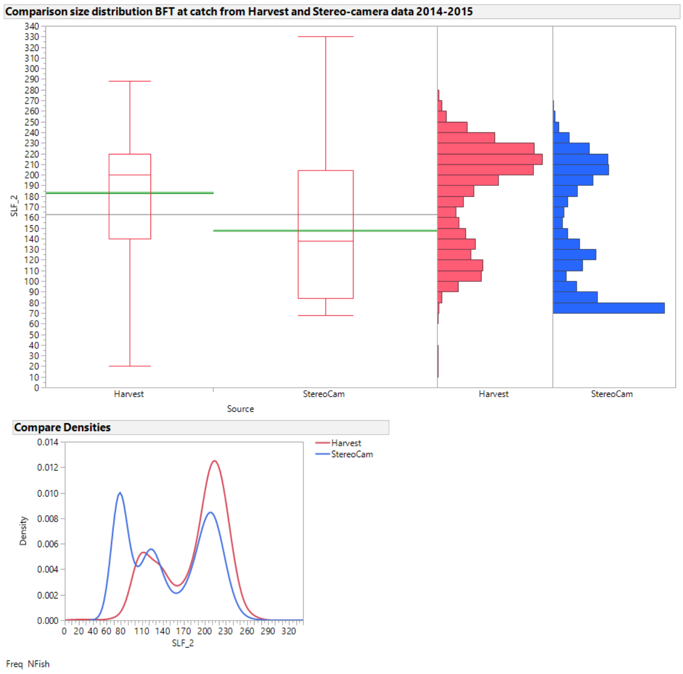


Figure 11. Size frequency distribution of farmed bluefin tuna estimated from the harvest back calculation and the stereo-camera measures at caging operations in 2014-2015.

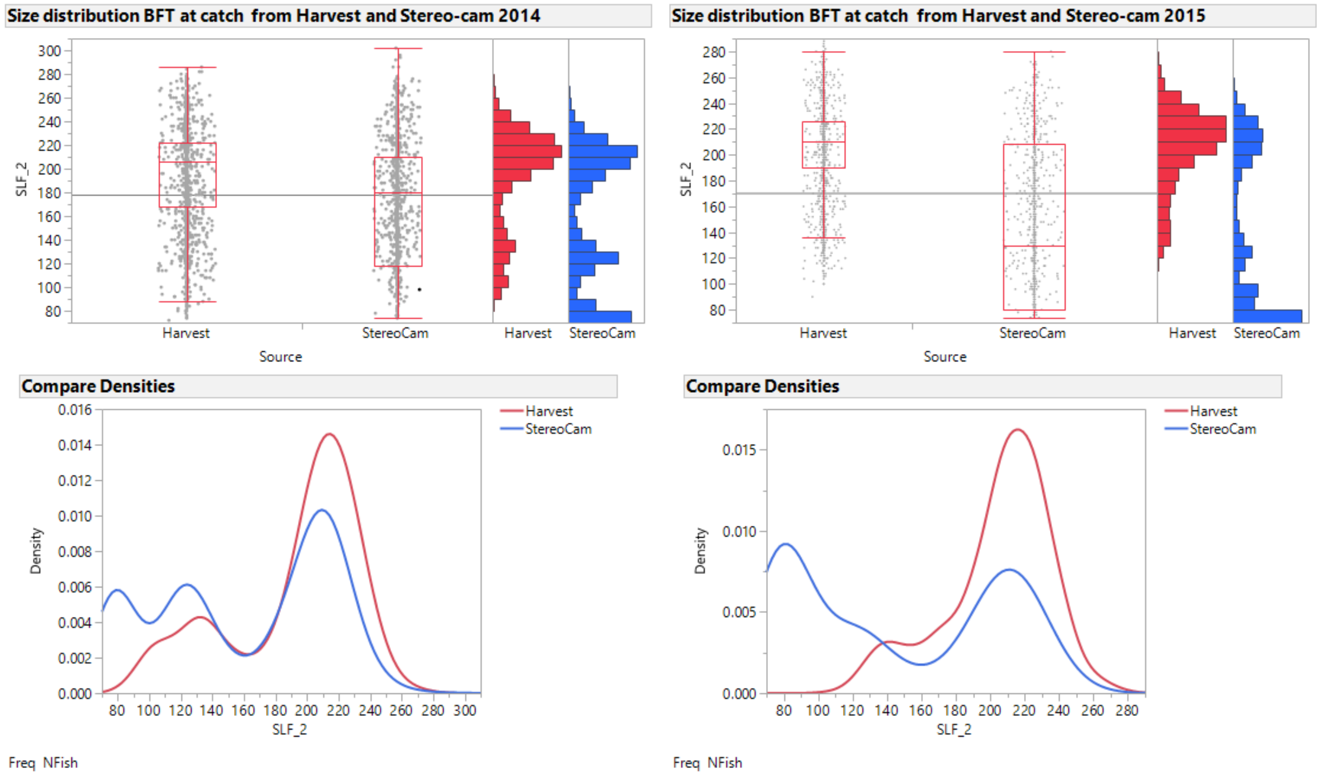


Figure 12. Size frequency distribution of farmed bluefin tuna estimated from the harvest back calculation and the stereo-camera measures at caging operations for 2014 (left) and 2015 (right).

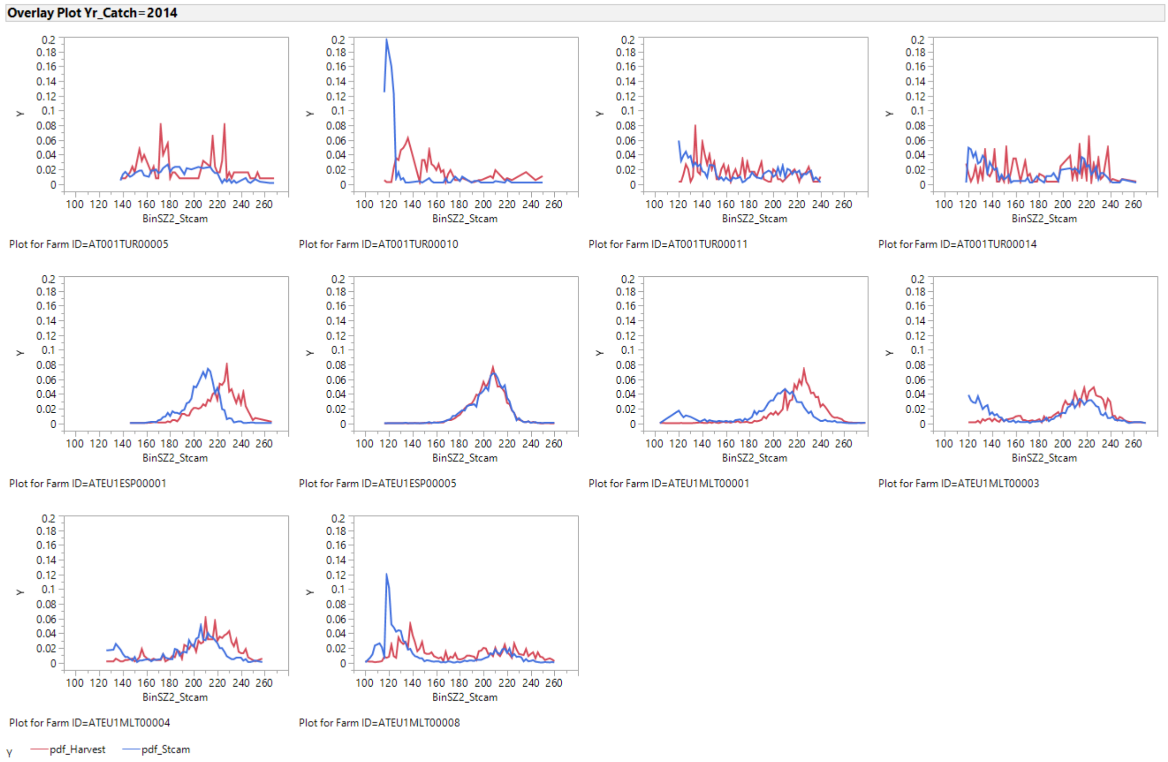


Figure 13. Size frequency distribution of farmed bluefin tuna estimated from the harvest back calculation and the stereo-camera measures at caging operations for 2014 by farm when there information from both sources.

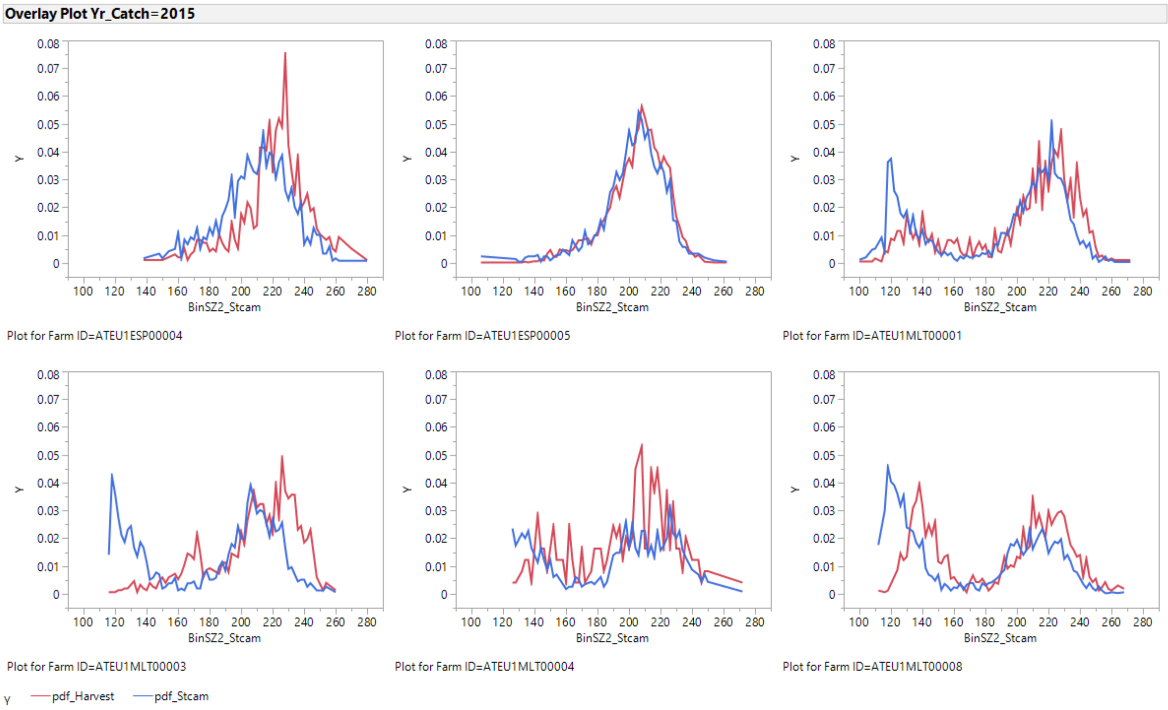


Figure 14. Size frequency distribution of farmed bluefin tuna estimated from the harvest back calculation and the stereo-camera measures at caging operations for 2015 by farm when there information from both sources.