REVIEW OF THE SIZE DISTRIBUTION OF CAGED EASTERN BLUEFIN TUNA (*THUNNUS THYNNUS*) IN TURKISH FARMS 2014-2020

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SUMMARY

During the 2018 stock assessment of East-Bluefin tuna it was noted substantial changes in the size distribution of caged bluefin in Turkish farms in the period 2017/2018. The size distribution of the caged fish is measured by the Stereo-camera systems when transferred from the towing vessel to the farm cages. A review of the time series of available stereoscopic measures (2014-2020) confirmed that changes in the overall size-distribution of caged fish. Since 2017, the proportion of fish size 100-140 SFL cm increased substantially while the proportion of larger fish >200 SFL cm has reduced. Analyses with auxiliary data indicated that the fishery has concentrated in the months of June – July, while no spatial expansion of the PS fleet has been observer, however the number of fishing operations and number of PS vessels participating has increased to complete the allocated BFT catch in recent years.

RÉSUMÉ

Au cours de l'évaluation du stock de thon rouge de l'Est de 2018, des changements substantiels de la distribution des tailles des thons rouges mis en cage dans les fermes turques au cours de la période 2017/2018 ont été observés. La distribution des tailles des poissons mis en cage est mesurée au moyen de systèmes de caméras stéréoscopiques lors de leur transfert du remorqueur aux cages d'élevage. Un examen de la série temporelle des mesures stéréoscopiques disponibles (2014-2020) a confirmé ces changements dans la distribution globale des tailles des poissons mis en cage. Depuis 2017, la proportion de poissons de taille 100-140 cm SFL a considérablement augmenté tandis que la proportion de poissons de plus de 200 cm SFL a diminué. Des analyses utilisant des données auxiliaires ont fait apparaître que la pêche s'est concentrée dans les mois de juin-juillet, alors qu'aucune expansion spatiale de la flottille de senneurs n'a été observée, cependant le nombre d'opérations de pêche et le nombre de senneurs participants ont augmenté pour compléter la capture de thon rouge allouée ces dernières années.

RESUMEN

Durante la evaluación de stock de atún rojo del este de 2019, se observaron cambios sustanciales en la distribución de tallas del atún rojo enjaulado en granjas turcas en 2017/2018. La distribución de tallas de los peces enjaulados se mide mediante sistemas de cámaras estereoscópicas cuando se transfieren desde el remolcador a las jaulas de la granja. Una revisión de la serie temporal de las medidas disponibles de cámaras estereoscópicas (2014-2020) confirmó estos cambios en la distribución de tallas global de los peces enjaulados. Desde 2017, la proporción de peces de talla 100-140 SFL cm aumentó sustancialmente mientras que la proporción de peces más grandes a > 200 SFL cm se ha reducido. Los análisis con datos auxiliares indicaron que la pesquería se ha concentrado en los meses de junio-julio, mientras que no se ha observado una expansión espacial de la flota de cerco, sin embargo, el número de operaciones de pesca y el número de cerqueros que participan ha aumentado para completar la captura asignada de atún rojo en años recientes.

KEYWORDS

Bluefin tuna, Thunnus thynnus, farm, size distribution

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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 about 60% of the annual catch of eastern bluefin are destined to farms. 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 estimates of the catch in both numbers, weight and size/age distribution of the wild fish caught is presently obtained from size measurement using Stereo-cameras systems as required by current management regulations of ICCAT Rec. 19-04. These measurements are submitted by the farm Flag CPCs to the Secretariat and constitute the main source of information for estimating the selectivity of the main Purse seine fisheries/fleets in the Mediterranean Sea for the Stock assessment evaluations (Anon. 2018, Anon. 2015).

However, during the last assessment in 2018, the Group identified that the Stock Synthesis Fleet PS-Other (Anon. 2018) had substantially change the size distribution of this particular fleet in 2017/2018, with a significant increase in the catch of medium size fish (120-140 SFL cm) compared to previous years where larger fish (> 160 SFL cm) where more prevalent (**Figure 1**). The Group then make a recommendation for revising the stereo-camera size distributions provided for this fleet and confirm with national scientist if the changes in size distribution in 2017/18 were correct and provide an explanation for such shift (Anon. 2018).

2. Data and Methods

The size data submitted from stereo-camera system measurements was compiled from Turkish farms since their initial submissions in 2014. A total of 54,559 bluefin tuna size measurements have been submitted by 7 registered farms from 2014 to 2020 (**Table 1**). **Figure 2** shows the size distributions of caged fish by year showing the transition from a semi-bimodal distribution in 2014 with peak of small fish at about 120 cm SFL and large fish 220 cm SFL but with ample size ranges (80 to 300 cm SFL). By 2015 and 2016, size proportion of the smaller fish increased while the proportion of the larger fish decreased, although still have a wider size range of caged fish (80 to 280 cm SFL), then the next 4 years (2017-2020) clearly the proportions of smaller size increases with peaks at 100 - 120 cm SFL, while the larger fish proportions is substantially reduced and the size range also contracted, with few fish above 200 cm SFL.

Comparisons of size distributions by farm (**Figure 3**) shows that the reduction of mean size of fish caged is a common trend in all Turkish BFT farms, although some farms (011, 010) have overall caged primarily smaller size fish (< 140 cm SFL) particularly since 2017. **Table 2** shows the number of fish measured by farm-year, and if this can be used as an indicative of the total number of fish caged (assuming same proportion by farm and year of fish measure compared to number of fish caged) it indicates that recently the number of smaller fish is overall larger as these two farms account for over 50% of the caged fish since 2017.

Overall the size distributions of caged BFT in Turkish farms has decreased from a median of 170 cm SFL to 120 cm SFL and this shift took place in 2017 primarily as indicated by the density and cumulative density plots (**Fig 4**). Categorizing the BFT measured into size classes; small (< 140 cm SFL), medium (140 – 200 cm SFL), and large (> 200 cm SFL), it is clear that since 2014 there has been a shift in the relative proportion of each size class (**Fig 5**). Since 2017 the small fish represents over 75% of the caged fish, while the large fish that in 2014 represented 26% of caged fish, since 2018 they are less than 2%. Also the medium size class has decreased from 40% in 2015 to 20% in 2020.

3. Results and discussion.

The analysis of the stereo-camera size measures of caged fish in Turkish farms implied a shift in size distribution of the catch by the purse seine fleet that supplied the bluefin tuna between 2014 and 2020. It is clear that the proportion of fish size 120 to 140 cm SFL has substantially increase since 2017 and at the same time the proportion of larger fish (> 200 cm SFL) has considerable reduced or being absent in recent years. The following analyses aim to identify factors that may account for this shift in the Turkish farmed bluefin.

Figure 6 shows the size distribution of caged fish by year and month at time of caging. Assuming that time between actual catch by PS fleet and caging has been relative constant through 2014 – 2020 and is less than 3 weeks, the data indicated that the operation of the catching PS fleet has also changed; by 2014 catches were in June, July, August, September and even December. While since 2018 catch is exclusively in June and July. It seems that the large fish were caught later in the summer, e.g. August, September, although 2015 August seems to be an exception. Therefore at least there is some indication that nowadays the PS fleet that supplied the Turkish farms, operates exclusively in the months of June-July providing the small fish size class, while the operations later in the year has stopped completely since 2018.

Another factor to consider is the actual total catch during this period. Based on the reported Task 1 NC for Turkish PS gear that represents over 98% of the total BFT catches, it shows that the annual catches of BFT by the PS gear since 2014 (544 t) has triplicated by 2019 (1,761 t) (**Figure 7**). The plot also shows the estimated catch proportion by the size category of BFT, based on the reported stereo-camera size measurements and assuming the SCRS stock assessment size-weight conversion factor (Rodriguez et al, 2016). By 2019 the small fish (< 140 cm SFL) accounted for 62% of the total catch, compared to 2014 when they represented only 14%. It is expected that with an increased allowance of catch the PS fleet will also utilize the more abundant young age classes to complete their allocation. Finally, it was evaluated if there has been a change in the spatial distribution of the BFT catches by the Turkish PS fleet during this period. Data on the location of the catch was obtained from the regional observer program for bluefin tuna (ROP-BFT) that monitored most of the PS fleet operations in the Mediterranean Sea. Based on the total catch per operation as estimated by the ROP observers and compared to the Task 1 NC of Turkey by year, over 95% of Turkish PS catch is monitored by the ROP. **Figure 8** shows a map of the monitored PS catches 2011 – 2020. In general there has not been a major expansion or shift in the "fishing areas" targeted by the Turkish PS; catches are primarily in the Levantine Sea, with some expansion to the Aegean Sea (2015, 2016). Only in 2020 is noticeable the fishing operations in the central Mediterranean, around the Maltese archipelago. The number of 1x1 lat-lon squares where BFT catch were reported by Turkish PS vessels oscillate between 4 (2013) and 11 (2016). All of these fishing operations are joint fishing operations (JFOs), but with positive catch by the Turkish vessel(s). Nonetheless, the total number of fishing operations monitored by the ROP has increased from about 91 in 2014 to 557 in 2019, similarly the number of active fishing PS vessels monitored increased from 13 (2014) to 29 in 2019.

In conclusion, the stock assessment fleet PS Others, that includes the Turkish PS catches destined to farms in Turkey has experimented a shift in the size distribution of the catch and caged bluefin tuna in the period 2014 – 2020. Since 2017 the proportion of small fish (<120 cm SFL) has increased substantially to account for over 60 % in weight (80% in number) of the total catch, while the larger fish (> 200 cm SFL) has decreased to less than 5% in weight. The evaluation of potential factors indicated an increase in the number of active vessels (double) as well the number of fishing operations (five times), with the fishing concentrated exclusive in the months of June and July, and not indications of spatial expansion of the area of operations of this fleet. National scientist confirmed the changes in the catch size distributions reporting also that fishers have reported the absence of larger bluefin tuna in their fishing area, and that have increased the participation of other Mediterranean PS fleets supplying fish to their farming operations in recent years. It has been noted that current gas/oil search operations in the Eastern Mediterranean may have some impact on the distribution of bluefin tuna and recommended that research be carry out to evaluate this and other potential factors that have may contributed to the observed changes in the size distribution of E-BFT in this area.

References

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Table 1. Summary of the bluefin tuna size measures from stereo-camera systems submitted by Turkish farms 2014 2020.

Year	FarmICCATNo	N fish	Mean SFL cm	Media SFL cm	5% quantile	95% quantile
2014	AT001TUR00005	1,104	190	194	127	246
	AT001TUR00010	488	128	120	114	186
	AT001TUR00011	810	159	146	121	225
	AT001TUR00014	465	173	170	121	233
2015	AT001TUR00001	290	181	185	128	225
	AT001TUR00005	1,522	191	194	121	251
	AT001TUR00010	1,985	140	129	115	205
	AT001TUR00011	1,565	156	148	120	218
	AT001TUR00013	1,204	175	171	119	260
	AT001TUR00014	761	162	164	123	208
2016	AT001TUR00004	952	177	184	116	228
	AT001TUR00005	488	167	156	140	232
	AT001TUR00010	1,824	132	127	115	172
	AT001TUR00011	1,167	163	161	128	203
	AT001TUR00013	1,378	187	196	118	231
	AT001TUR00014	597	159	150	127	217
2017	AT001TUR00005	1,427	145	133	117	214
	AT001TUR00010	2,320	132	128	118	160
	AT001TUR00011	3,132	123	119	114	143
	AT001TUR00013	1,295	146	145	120	177
	AT001TUR00014	1,088	162	147	127	225
2018	AT001TUR00004	2,372	132	127	118	160
	AT001TUR00010	2,101	125	122	116	144
	AT001TUR00011	3,036	118	117	114	125
	AT001TUR00013	1,269	135	132	117	161
2019	AT001TUR00004	1,347	145	142	120	185
	AT001TUR00005	569	147	145	117	192
	AT001TUR00010	1,025	125	122	115	147
	AT001TUR00011	4,941	123	120	114	140
	AT001TUR00013	1,204	146	142	120	187
2020	AT001TUR00005	1,588	140	133	121	177
	AT001TUR00010	2,580	125	121	116	149
	AT001TUR00011	4,361	123	121	114	142
	AT001TUR00013	1,111	151	143	123	203
	AT001TUR00014	1,193	144	136	117	200

Table 2. Summary of the number of fish measured (SC) by farm and year of the caged BFT in Turkish farms 2014 – 2020 (top table). Below the corresponding percent of measured fish per farm-year.

FarmICCATNo	2014	2015	2016	2017	2018	2019	2020	Total
AT001TUR00001	0	290	0	0	0	0	0	290
AT001TUR00004	0	0	952	0	2372	1347	0	4671
AT001TUR00005	1104	1522	488	1427	0	569	1588	6698
AT001TUR00010	488	1985	1824	2320	2101	1025	2580	12323
AT001TUR00011	810	1565	1167	3132	3036	4941	4361	19012
AT001TUR00013	0	1204	1378	1295	1269	1204	1111	7461
AT001TUR00014	465	761	597	1088	0	0	1193	4104
Tot yr	**2867**	**7327**	**6406**	**9262**	**8778**	**9086**	**10833**	**54559**

FarmICCATNo	2014	2015	2016	2017	2018	2019	2020	Avg
AT001TUR00001	0%	4%	0%	0%	0%	0%	0%	1%
AT001TUR00004	0%	0%	15%	0%	27%	15%	0%	8%
AT001TUR00005	39%	21%	8%	15%	0%	6%	15%	15%
AT001TUR00010	17%	27%	28%	25%	24%	11%	24%	22%
AT001TUR00011	28%	21%	18%	34%	35%	54%	40%	33%
AT001TUR00013	0%	16%	22%	14%	14%	13%	10%	13%
AT001TUR00014	16%	10%	9%	12%	0%	0%	11%	8%
Tot yr	**1**	**1**	**1**	**1**	**1**	**1**	**1**	

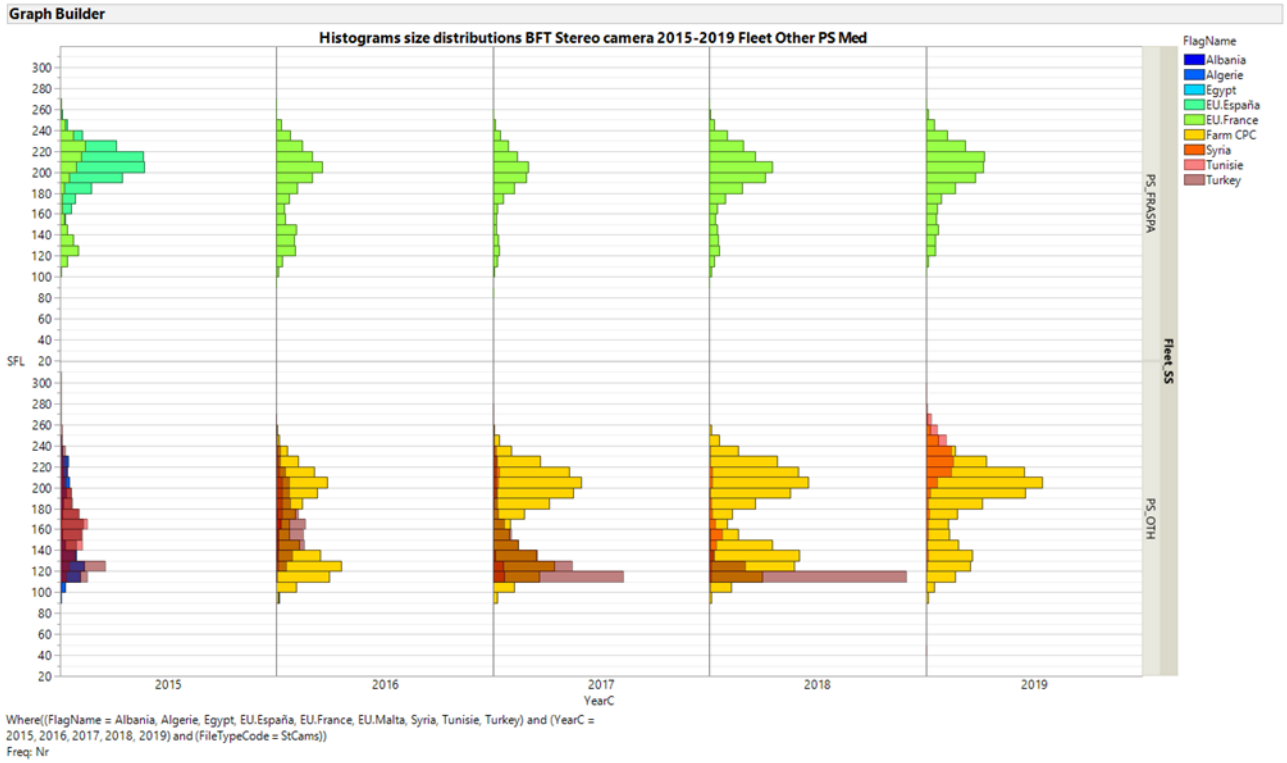

Figure 1. Size distributions of BFT catch for the Mediterranean purse-seine OTHERS fleet (PS_OTH) compare to the purse_seine EU_France/Spain (PS_FRASPA) by flag and year (2015 to 2019).

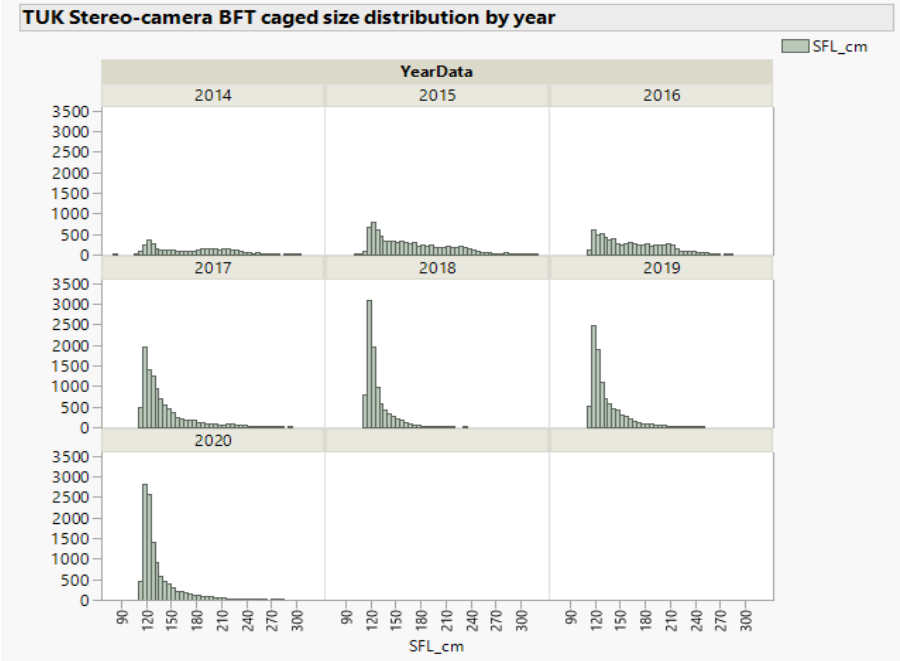

Figure 2. Size distribution of caged BFT in Turkish farms by year 2014 – 2020.

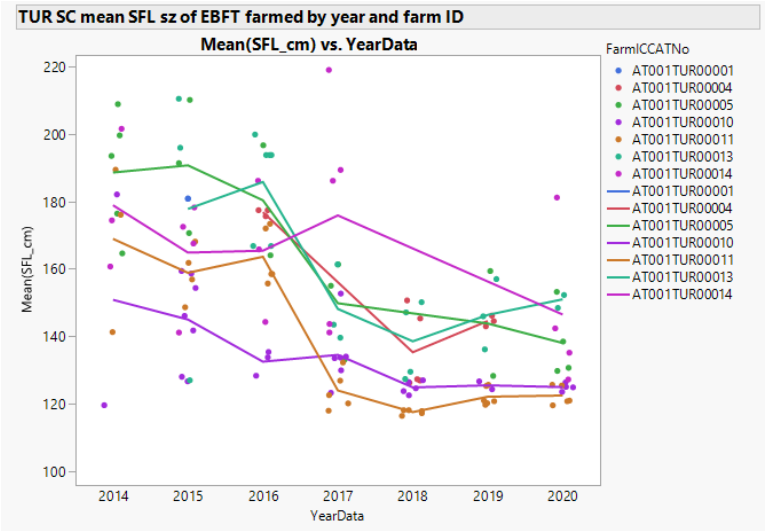

Figure 3. Annual trend of the mean size (SFL cm) of caged fish by Turkish farms 2014 - 2020.

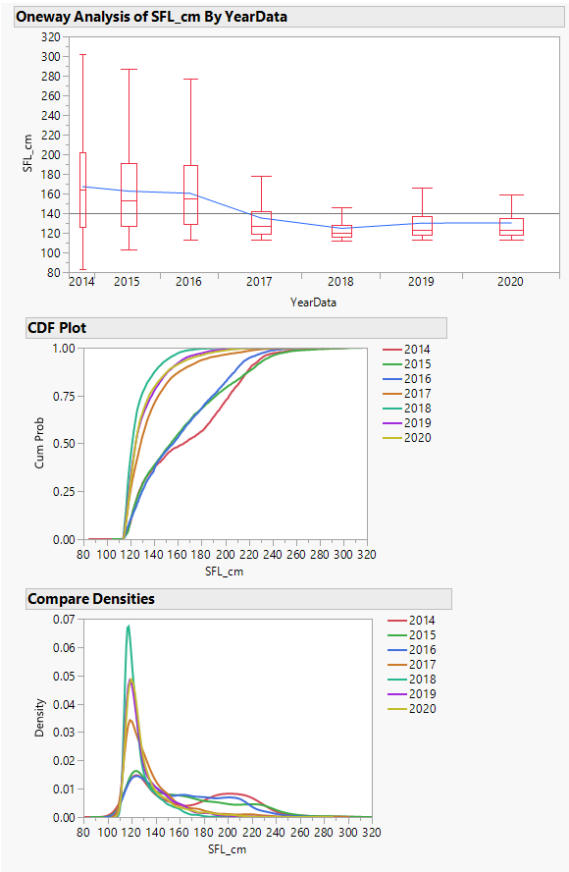

Figure 4. Boxplot distribution of size measures (top), cumulative density distributions, and densities for the caged BFT in Turkish farms 2014 - 2020.

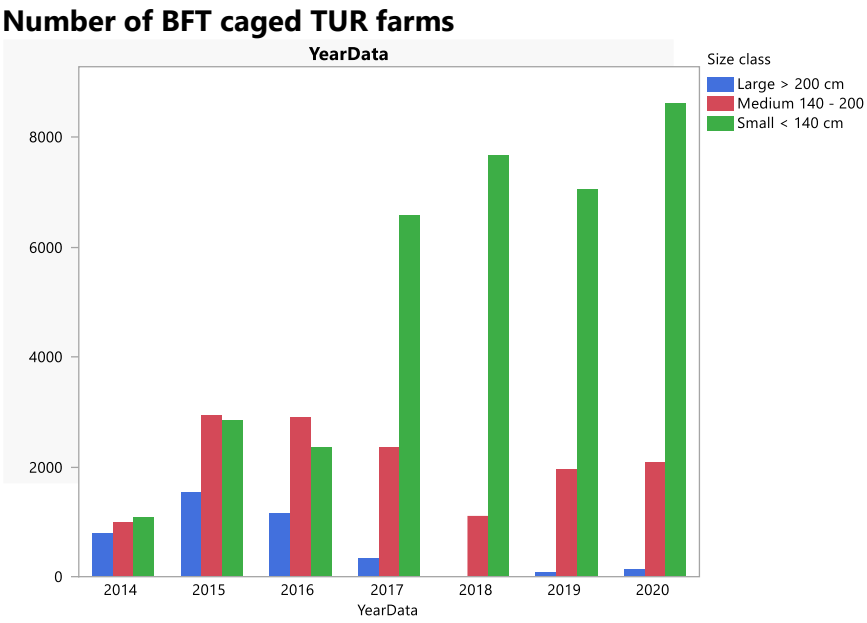

Figure 5. Number of BFT caged in Turkish farms by size class category 2014 – 2020**.**

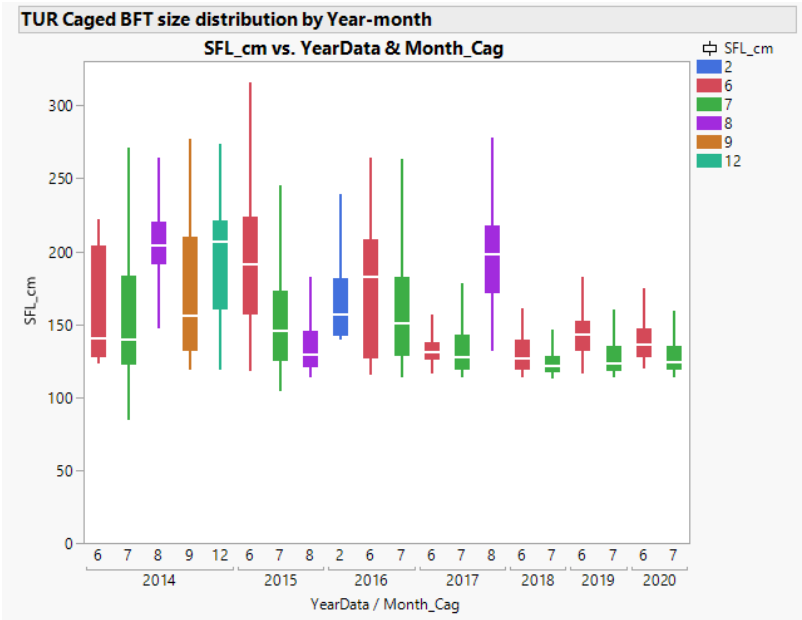

Figure 6. Box plot size distribution of caged BFT by month and year in Turkish farms 2014 - 2020.

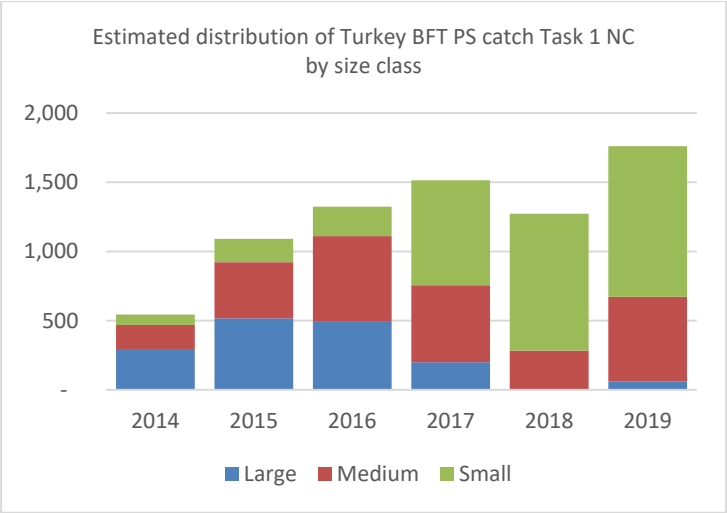

Figure 7. Annual trend of Turkish PS catch (t) Task 1 NC 2014 – 2019 and estimated proportion of catch in weight by BFT size category based on the stereo camera measurements reported.

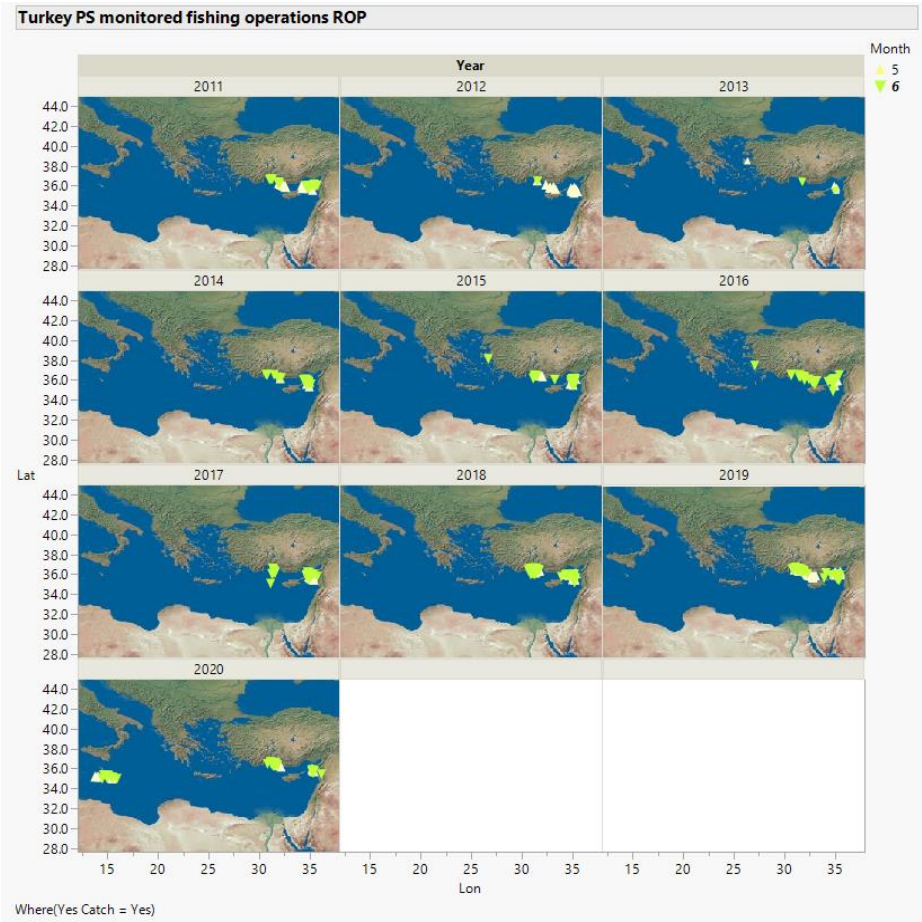

Figure 8. Spatial distribution of Turkish PS operations monitored by the BFT-ROP 2011-2020.

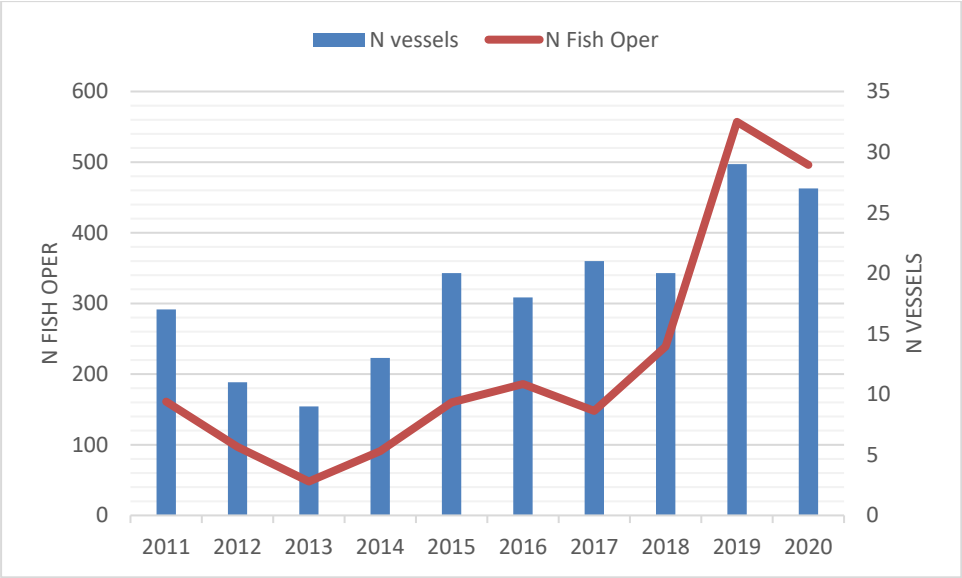

Figure 9. Annual trend of the number of vessels (right *y*-axis) and number of fishing operations (left *y*-axis) monitor by the BFT-ROP for Turkish PS fleet 2011-2020 as recorded by the regional observer program database.