DOES ORIGIN OF CATCH AFFECT THE LENGTH-WEIGHT RELATIONSHIP AND SEX RATIO OF ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*)?

Ana Caria[1], Nesrine Boulila[1], Simeon Deguara[1]

SUMMARY

As part of the ICCAT GBYP research program, samples were taken, at harvest, from Atlantic bluefin tuna (Thunnus thynnus*) caught during the fishing season and subsequently caged and harvested in the same year. As part of this sampling, biometric data was collected, including straight fork length (SFL), round weight (RWT) and sex. Fish sampled during the three-year period 2016 to 2018 had been caught in different geographical regions (Malta (MA), Sardinia (SA), Tyrrhenian Sea (TY), Gulf of Gabes (TU). This data was analysed to determine any differences in sex ratio, length-weight (L-W) relationships and condition factor by area and sex. Differences were noted in the sex ratio between geographical area and year. The average weight and condition factor of female BFT were found to be generally lower than that of male BFT whatever the origin of catch or the year of harvest.*

RÉSUMÉ

*Dans le cadre du programme de recherche GBYP de l'ICCAT, des échantillons ont été prélevés, lors de la mise à mort, sur des spécimens de thon rouge de l'Atlantique (*Thunnus thynnus*) capturés pendant la saison de pêche, mis en cage et mis à mort la même année. Dans le cadre de cet échantillonnage, des données biométriques ont été recueillies, notamment la longueur droite à la fourche (SFL), le poids vif (RWT) et le sexe. Des poissons échantillonnés au cours de la période de trois ans (2016 à 2018) ont été capturés dans différentes régions géographiques (Malte-MA, Sardaigne-SA, mer Tyrrhénienne- TY et golfe de Gabès-TU). Ces données ont été analysées pour déterminer toute différence dans le ratio des sexes, les relations taille-poids (L-W) et le facteur de condition par zone et sexe. Des différences ont été observées dans le ratio des sexes entre la zone géographique et l'année. Le poids moyen et le facteur de condition des femelles de thon rouge se sont avérés généralement inférieurs à ceux des mâles quelle que soit l'origine de la capture ou l'année de mise à mort.*

RESUMEN

Como parte del programa de investigación del GBYP, se tomaron muestras, durante el sacrificio, de atún rojo del Atlántico (Thunnus thynnus) *capturado durante la temporada de pesca y posteriormente enjaulado y sacrificado en el mismo año. Como parte de este muestreo, se recopilaron datos biométricos, lo que incluye longitud a la horquilla recta (SFL), peso vivo (RWT) y sexo. Los peces muestreados durante el periodo de tres años (2016-2018) habían sido capturados en diferentes regiones geográficas, Malta (MA), Cerdeña (SA), mar Tirreno (TY) y golfo de Gabés (TU). Estos datos se analizaron para determinar cualquier diferencia en la proporción de sexos, relaciones talla-peso (L-W) y factor de condición por área y sexo. Se observaron diferencias en la proporción de sexos entre la zona geográfica y el año. Se halló que el peso medio y el factor de condición de los atunes rojos hembras era generalmente inferior al de los atunes rojos machos independientemente del origen de la captura o del año de sacrificio.*

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[1] AquaBioTech Ltd, 'Central Complex', Naggar Str, Mosta MST1761 Malta. Corresponding Author: dsd@aquabt.com

1. Introduction

A significant percentage of the quota allocated to the Eastern stock of the Atlantic bluefin tuna (BFT) is caught by purse seiner and transferred to farming cages for the purpose of increasing the weight and quality of the fish. In addition to the fish caught by purse seiners, some of the fish caught by traps are also being transferred to cages.

In line with the ICCAT GBYP research objectives, it was considered very important to improve the understanding of key biological and ecological processes for the BFT, with the aim of optimising the management of the stock. As part of this data collection, samples were required from the various fish farms operating in the Mediterranean into which adult BFT caught in diverse areas of the Mediterranean were placed. This process included the collection of biometric data (straight fork length (SFL), curved fork length (CFL), length to the first dorsal (LD1), total round weight (RWT), sex) in addition to other samples (otoliths and muscle).

This document presents an analysis of the biometric data as obtained during the ICCAT GBYP sampling carried out in Maltese farms between the years 2016 and 2018.

2. Methodology

Biometric measurements (and other samples) were taken from adult fish caged and farmed in Maltese registered farms between 2016 and 2018 as part of the ICCAT GBYP research project. Measurements and samples were taken during the harvesting of BFT on the farm (from the same year as caged) by on-board measurements and sample collection. Throughout this period, the BFT were sampled from cages of farms where fish had initially (same year) been caught in different areas of the Mediterranean (Malta (MA), Sardinia (SA), Tyrrhenian Sea (TY), Gulf of Gabes (TU)).

The data was analysed by area of catch, year of catch and sex. The numbers of BFT included in the analysis is summarised accordingly in **Table 1**.

3. Results and Discussion

Table 2 summarises the L-W regression relationships for the different data sets analysed. Table 2 also provides an estimation of the RWT of a 200cm SFL fish, based on the corresponding L-W equation, and the average Fulton's condition factor ($K = 10^5 * RWT/SFL^3$).

There was a wide variation of sex ratios obtained from the samples taken (**Table 1**). The highest percentage of female BFT caught in TU in 2016 (58.22%). On the other hand, the lowest was seen in the samples taken from TY fish caught in 2016 (21.96), followed by that of TY of the year after, 2017 (25.53%). The sex ratios seen here cannot be taken to be representative of the whole cage (or catch) population as the samples were taken from numerous cages during the harvest season with a predominance (except of SA) of larger fish (>175cm) (**Figure 1**). Nonetheless, the data does indicate that there are clear differences in sex ratio within the size ranges presented here, with typically more females in the sampled population in fish under 230cm and more males being represented over with fish over 230cm in length. Although the overall data set is limited, there appear to be interannual differences between fish caught in the same area, for example TY 2016 and TY 2017 fish vs TY 2018 fish, but also differences between areas of catch, such as seen between MA 2016 fish and TU 2016 fish.

Differences were also noted in the L-W equations between the various sample populations (**Table 2**). These differences were reflected in the calculated RWT of a 200cm fish, with female BFT generally having a lower RWT and condition factor than the equivalent-sized male BFT.

Various authors have indicated differences in sex ratios based on size class, with differences from year to year, catch area and even gear (de la Serna *et al*., 2003; Fenech *et al*., 2003; El Tawil *et al*, 2004; Vella, 2009; Percin and Akyol, 2010; Lino *et al*., 2018) which reflect some of the differences seen here.
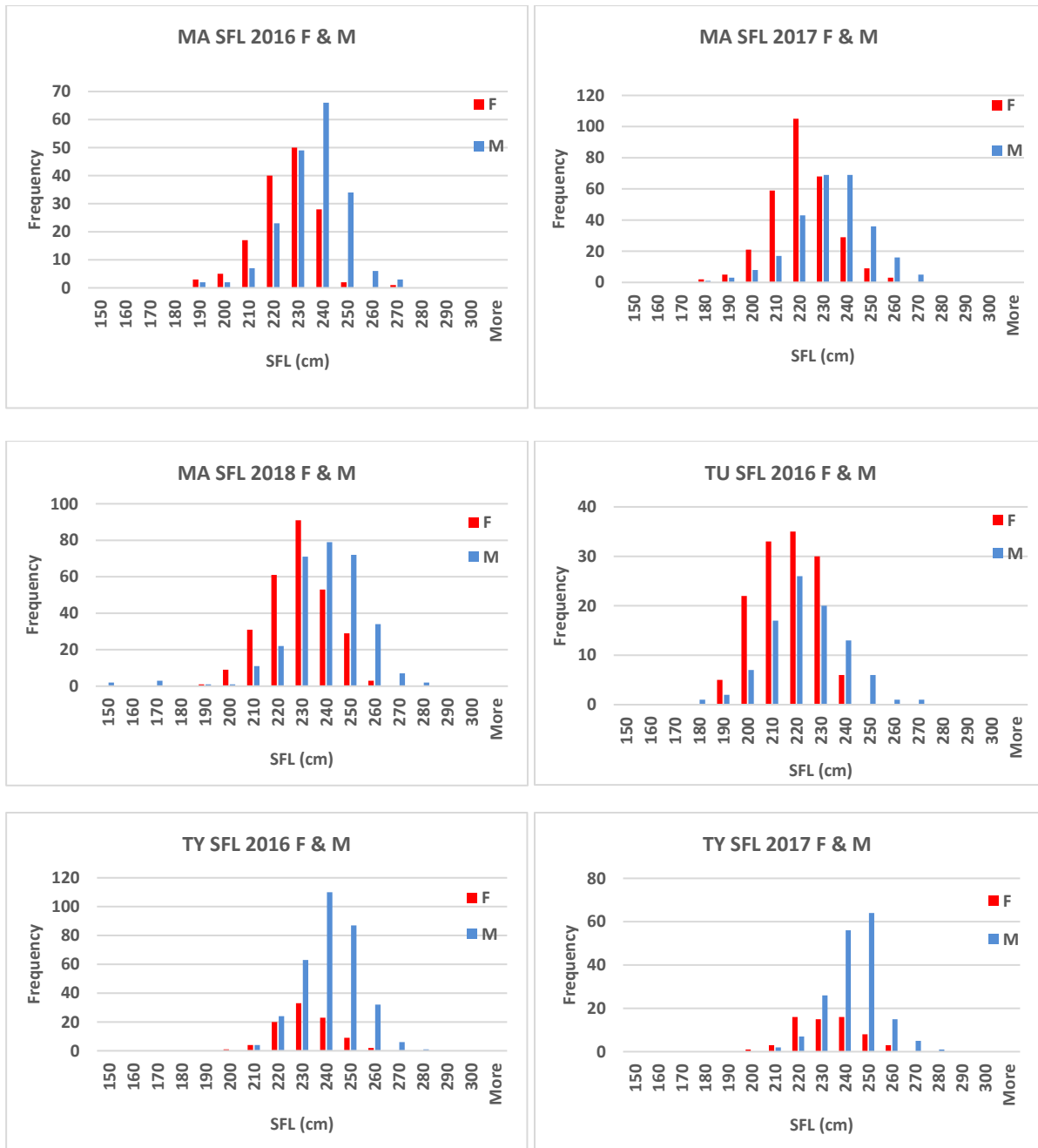
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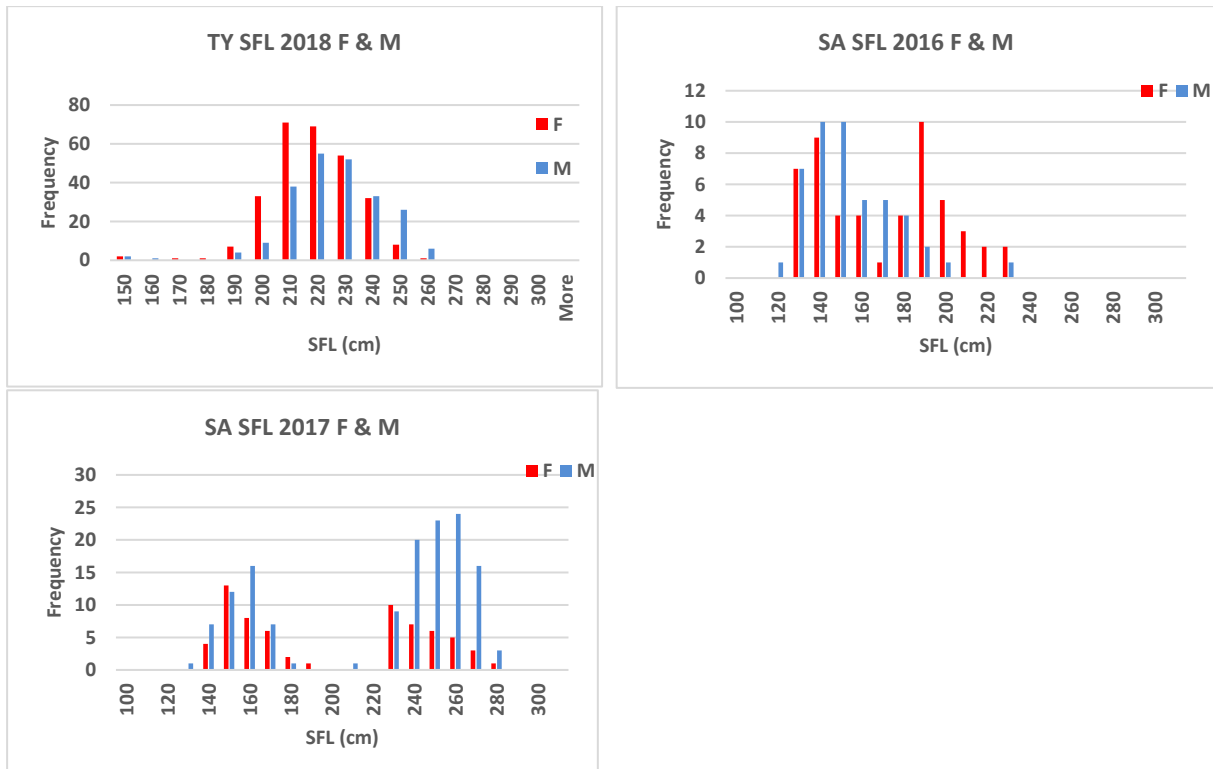**Table 1.** Summary of data used by area of catch, year of catch and sex.

Area of Catch	Year of Catch	N (SFL, cm)	F (SFL, cm)	M (SFL, cm)	% F
MA	2016	338 (182-267)	146 (185-267)	192 (182-265)	43.19
MA	2017	568 (177-270)	301 (177-255)	267 (177-270)	52.99
MA	2018	583 (144-277)	278 (184-258)	305 (144-277)	47.68
TU	2016	225 (180-262)	131 (183-239)	94 (180-262)	58.22
TY	2016	419 (197-271)	92 (197-255)	327 (206-271)	21.96
TY	2017	235 (200-272)	60 (200-254)	175 (209-272)	25.53
TY	2018	505 (143-260)	279 (167-257)	226 (159-260)	55.25
SA	2016	97 (114-225)	51 (124-225)	46 (114-221)	52.58
SA	2017	206 (130-278)	66 (139-271)	140 (130-278)	32.04

Table 2. Summary of L-W regression equations obtained from the samples taken from the farms by area of catch, year of catch and sex.

Area of Catch	Year of Catch	Sex	a	B	R^2	RWT 200cm	K
MA	2016	F	$4.1888*10^{-5}$	2.8764	0.7567	174.09	2.16
MA	2016	M	$1.6421*10^{-4}$	2.6307	0.7014	185.66	2.21
MA	2017	F	$3.5247*10^{-5}$	2.9120	0.8042	176.90	2.20
MA	2017	M	$1.0186*10^{-4}$	2.7195	0.8358	184.35	2.23
MA	2018	F	$1.0431*10^{-4}$	2.6989	0.6474	169.27	2.06
MA	2018	M	$5.2426*10^{-5}$	2.8339	0.7694	173.95	2.13
TU	2016	F	$5.5296*10^{-4}$	2.4074	0.8087	191.51	2.32
TU	2016	M	$6.5463*10^{-4}$	2.3852	0.8227	201.56	2.40
TY	2016	F	$7.3163*10^{-4}$	2.3492	0.7099	186.15	2.15
TY	2016	M	$1.4041*10^{-3}$	2.2348	0.6996	194.87	2.15
TY	2017	F	$1.3050*10^{-4}$	2.6740	0.8758	185.59	2.23
TY	2017	M	$8.1318*10^{-4}$	2.3445	0.7408	201.81	2.25
TY	2018	F	$9.0103*10^{-5}$	2.7259	0.8003	168.70	2.08
TY	2018	M	$5.8526*10^{-5}$	2.8099	0.8425	171.01	2.11
SA	2016	F	$1.2878*10^{-4}$	2.6552	0.9641	165.78	2.23
SA	2016	M	$1.6243*10^{-4}$	2.6166	0.9114	170.43	2.40
SA	2017	F	$2.2839*10^{-5}$	2.9952	0.9690	178.12	2.24
SA	2017	M	$6.5280*10^{-5}$	2.7948	0.9698	176.08	2.19

Figure 1. Length (SFL) distributions of sampled BFT versus weight (RWT) samples taken from the farms by area of catch, year of catch and sex.

Figure 1 (continued). Length (SFL) distributions of sampled BFT versus weight (RWT) samples taken from the farms by area of catch, year of catch and sex.