PRELIMINARY INVESTIGATION USING STEREOCAMERA TECHNOLOGY TO LOOK AT THE CHANGES OCCURRING IN THE STRAIGHT FORK LENGTHS OF FARMED ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*) BETWEEN CAGING AND HARVESTING

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SUMMARY

*Atlantic bluefin tuna (*Thunnus thynnus*) are transferred cages on the farm in a caging procedure which requires the use of a stereocamera to determine the number and round weight (RWT) of caged fish. The weight of the caged fish is obtained by using appropriate SFL-RWT conversion factors based on the SFL data obtained during the stereocamera analysis. Caged fish in Malta normally show a bimodal distribution, with a smaller group having an average SFL close to 130cm and a larger group having an average SFL of about 210 cm. In this preliminary analysis, a stereocamera was deployed in a number of cages prior to harvest, i.e. after a number of months of intensive feeding on the farm. In each cage, the SFL of randomly measured groups of 100 fish, falling into one of the two size groups, were compared to the same size group in the cage at caging. The average SFLs of the small-sized fish and the big-sized fish increased by close to 20% and 7% respectively during the period of between four and five months post-caging.*

RÉSUMÉ

Les thons rouges de l'Atlantique (Thunnus thynnus) *sont transférés dans des cages à la ferme suivant une procédure de mise en cage qui nécessite l'utilisation d'une caméra stéréoscopique pour déterminer le nombre et le poids vif (RWT) des poissons mis en cage. Le poids des poissons mis en cage est obtenu en utilisant des coefficients de conversion appropriés SFL-RWT basés sur les données SFL obtenues lors de l'analyse des caméras stéréoscopiques. Les poissons mis en cage à Malte présentent normalement une distribution bimodale, un petit groupe ayant une SFL moyenne proche de 130 cm et un plus grand groupe ayant une SFL moyenne d'environ 210 cm. Dans cette analyse préliminaire, une caméra stéréoscopique a été déployée dans un certain nombre de cages avant la mise à mort, c'est-à-dire après plusieurs mois d'intense alimentation à la ferme. Dans chaque cage, la SFL de groupes de 100 poissons mesurés au hasard, appartenant à l'un des deux groupes de taille, a été comparée à celle du groupe de même taille se trouvant dans la cage lors de la mise en cage. La SFL moyenne des petits poissons et des poissons de grande taille a augmenté de près de 20 % et de 7 % respectivement quatre à cinq mois après la mise en cage.*

RESUMEN

*El atún rojo del Atlántico (*Thunnus thynnus*) es transferido a jaulas en la granja con un procedimiento que requiere el uso de una estereocámara para determinar el número y peso vivo (RWT) de los peces enjaulados. El peso de los peces enjaulados se obtiene utilizando los factores de conversión SFL-RWT adecuados basados en los datos de SFL obtenidos durante el análisis de la estereocámara. Los peces enjaulados en Malta, normalmente presentan una distribución bimodal, con un pequeño grupo con una SFL media cercana a los 130 cm y un grupo mayor con una SFL media de aproximadamente 210 cm. En este análisis preliminar, se colocó una estereocámara en varias jaulas antes del sacrificio, es decir después de varios meses de alimentación intensiva en la granja. En cada jaula, la SFL de los grupos de 100 peces medidos aleatoriamente, y que recae en uno de los dos grupos de tallas, se comparó con el mismo grupo de tallas en la jaula en el momento de la introducción en ella. Las SFL medias de los peces de menor tamaño y de los peces de mayor tamaño aumentaron en aproximadamente un 20% y un 7% respectivamente durante el periodo de cuatro o cinco meses posterior a la introducción en jaulas.*

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KEYWORDS

Atlantic bluefin tuna, Thunnus thynnus,
Stereocamera, Farmed Bluefin tuna, Growth

1. Introduction

A significant proportion of the East Atlantic quota available for the Atlantic bluefin tuna (*Thunnus thynnus*) (BFT) is caught by purse seiners and transferred to cages destined for farms in various countries. This process is regulated by numerous management procedures and requirements including the use of stereocamera technology to determine the number and round weight (RWT) (ICCAT, 2014). The stereocamera (AQ1 Systems Pty Ltd, Australia) currently being used is not specifically designed to measure the round weight of fish but to measure the straight fork length (SFL) which can then be converted to RWT using the appropriate conversion equations.

At caging fish are passed from the towing cage to the farm cage through a gate. The stereocamera is deployed at the is point to record this passage and these recordings are then analysed later to give a count of fish entering the farm cage and (from the average SFL of at least 20% of the fish determined in the analysis from a subsample of the fish passing through the gate) the average RWT and hence total RWT of fish caged.

After the process of caging, fish are then fed to improve the quality of the fish and increase the total RWT of the BFT in the cage. This process can last from a few months to a number of years, depending on the size of the fish, the farm management and the strategy applied at the particular farm. BFT can be harvested for the fresh market or frozen (after processing and freezing on board processing vessels).

In this study, a preliminary analysis was carried, using a stereocamera, to look at the distribution of SFLs of fish in farmed fish prior to harvesting from the cage in order to compare with the SFLs of the fish at caging.

2. Materials and Methods

A stereocamera (AQ1 Systems Pty Ltd, Australia) was deployed in a number of cages in Malta prior to the start of harvesting operations, between four to five months after caging (fishing season 2014). Footage was taken by a diver swimming at different depths in the cage itself with the fish swimming in front of the camera, and not during a transfer operation through a gate. No cages with carryover fish were analysed.

The footage of the fish in each cage was analysed for SFL determination using the Analyser software of the AQ1 stereocamera and according to available procedures and guidelines (e.g. Deguara *et al*., 2014, ICCAT, 2014; Gatt, 2015).

Analysis already carried out on harvest data and stereocamera data had indicated that the fish entering and being harvested from cages in Malta is typically bimodal (Ortiz *et al*., 2014; Ortiz, 2015). These two sizes will be designated as ‘small’ and ‘big’. In the analysis, randomly selected groups of 100 fish from either one or both size groups were taken from each of the cages sampled; in one cage two sets of 100 big fish were analysed to look at variations between fish randomly selected for measurement during the analysis.

The results of the analysis on the pre-harvest fish were compared to the results obtained at the point of caging in the same year.

3. Results and Discussion

From the caging data and previously submitted information, the ‘small’ fish were designated as any fish having a SFL less than 165cm, and ‘big’ fish as fish with a SFL over 165cm (at caging). Similarly, from the distributions of harvested fish, ‘small’ fish were designated as fish with a SFL below 185cm and ‘big’ fish with a SFL over 185cm.

Figures 1 to 3 present the distribution of SFLs from the results of stereocamera analysis at caging. The average SFLs of the small and big fish from each of the cagings are presented in **Table 1**.

Figures 4 to 8 present the distribution of SFLs from the results of stereocamera analysis of each of the three cages at the point of sampling at pre-harvest. Following analysis of the pre-harvest footage, the average SFLs of the small and big fish from each of the cagings are presented in **Table 2.**

The percentage increases in SFL, pre-harvest vs caging, are presented in **Table 3**. In both sizes of fish, and in all cages, there was an increase in SFL, more so in the smaller fish (19.6 %) than in the big fish (6.7% overall).
The difference in growth rates between the two sizes of fish would be expected in relation to the starting size of the fish. The increases in SFL are also clearly different to the increases seen in non-farmed BFT.

Using the latest L-W relationships for wild caught Eastern BFT in June, $RWT = (3.5080 * 10^{-5}) * SFL^{2.8831}$ (ICCAT, 2015), the corresponding average RWTs of the small (average SFL = 128.4cm) and big fish (average SFL = 210.5cm) sampled at caging were 42.1kg and 175.1kg respectively. Applying the farming L-W relationship, $RWT = (2.3139 * 10^{-5}) * SFL^{2.9840}$ (Deguara et al., 2010) the average RWTs of the sampled small (average SFL = 154.1cm) and big fish (average SFL = 224.1cm) pre-harvest were 78.1kg and 238.8kg respectively. This represents an average RWT increase of 85.5% and 36.4% for the small and big fish respectively over the 4 to 5 month farming period.

It should be noted that this preliminary analysis does not consider aspects such as the actual date of catch of the fish transferred into a particular cage, where they were caught, the towing period or farm management and strategy.

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Table 1. Average SFLs of the two sizes of BFT at caging for each of the cages.

	Cage 1	Cage 2	Cage 3
		Average SFL	
Small fish (<165cm)	128.8cm (n = 225)	127.4cm (n = 156)	131.6cm (n = 19)
Big fish (>165cm)	205.8cm (n = 63)	211.3cm (n = 143)	211.9cm (n = 142)

Table 2. Average SFLs of the two sizes of BFT at pre-harvest for each of the cages.

	Cage 1	Cage 2	Cage 3
		Average SFL	
Small fish (<185cm)	154.1cm (n = 100)		
Big fish (>185cm)	220.5cm (n = 100)	Group 1: 226.4cm (n = 100) Group 2: 226.7cm (n = 100)	222.7cm (n = 100)

Table 3. Average increases in SFLs of the two sizes of BFT at pre-harvest for each of the cages.

	Cage 1	Cage 2	Cage 3
		Average SFL	
Small fish (<185cm)	19.6%		
Big fish (>185cm)	7.1%	Group 1: 7.1% Group 2: 7.3%	5.1%

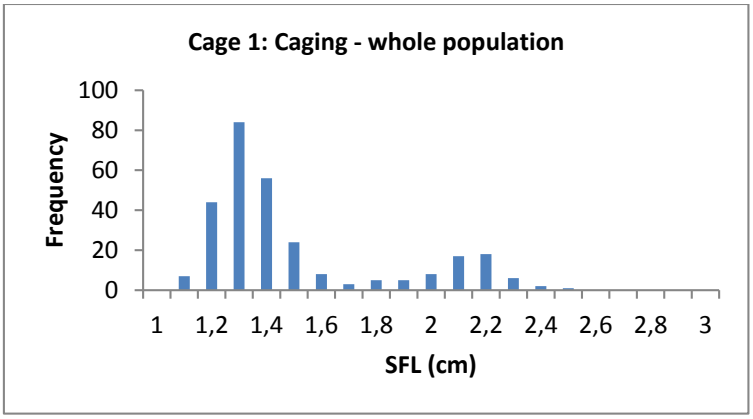

Figure 1. Distribution of fish as measured from stereocamera footage of Cage 1 at caging.

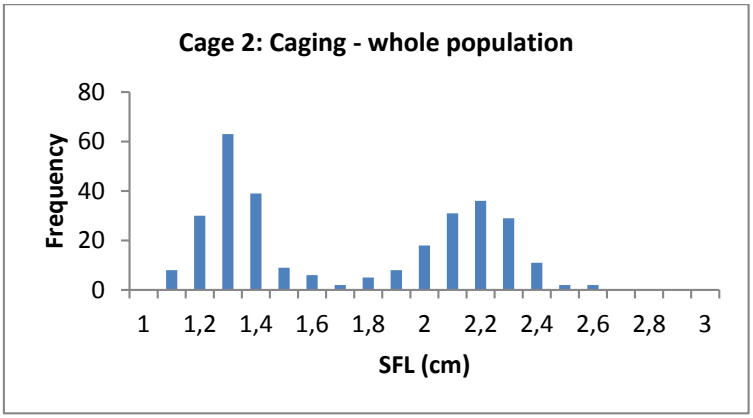

Figure 2. Distribution of fish as measured from stereocamera footage of Cage 2 at caging.

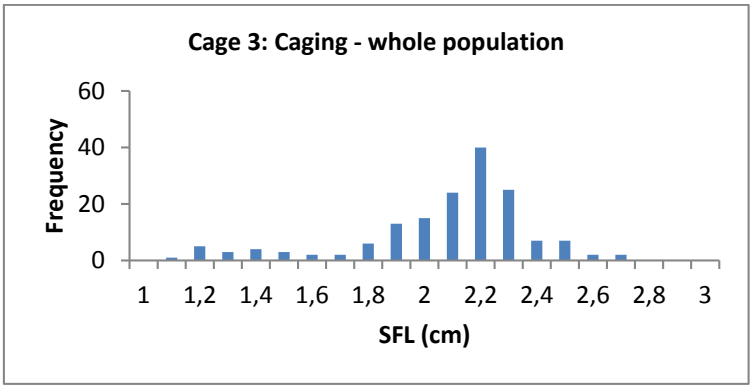

Figure 3. Distribution of fish as measured from stereocamera footage of Cage 3 at caging.

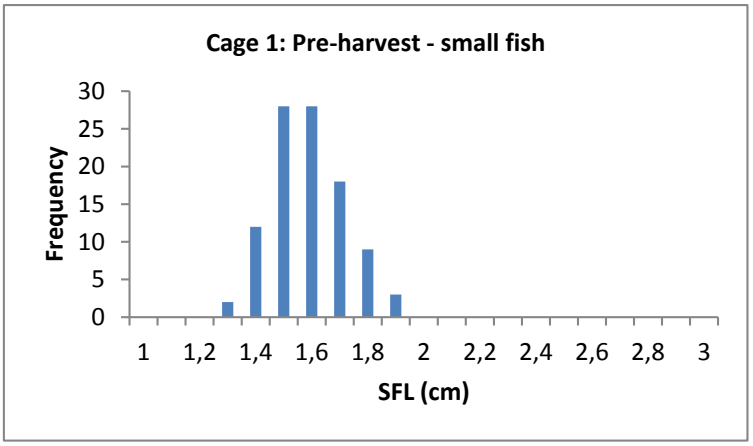

Figure 4. Distribution of small fish as measured from stereocamera footage of Cage 1 at pre-harvest.

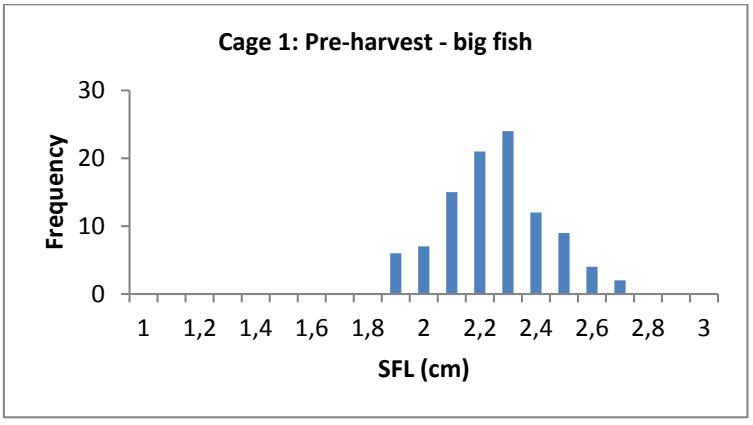

Figure 5. Distribution of big fish as measured from stereocamera footage of Cage 2 at pre-harvest.

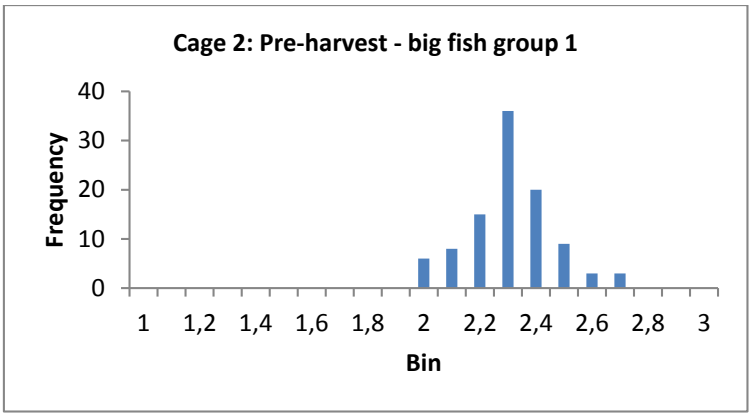

Figure 6. Distribution of the first group of big fish as measured from stereocamera footage of Cage 2 at pre-harvest.

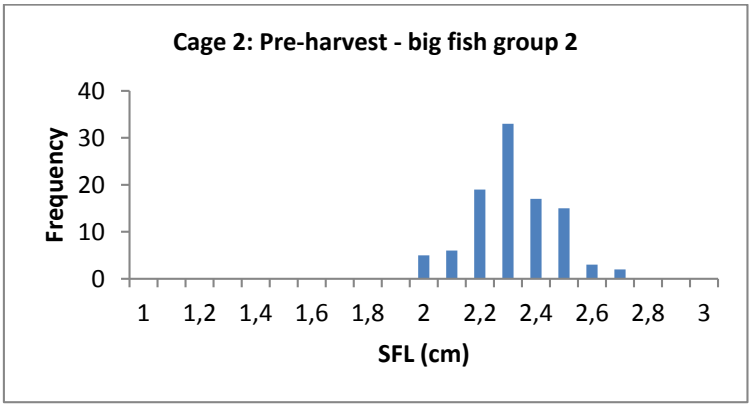

Figure 7. Distribution of the second group of big fish as measured from stereocamera footage of Cage 2 at pre-harvest.

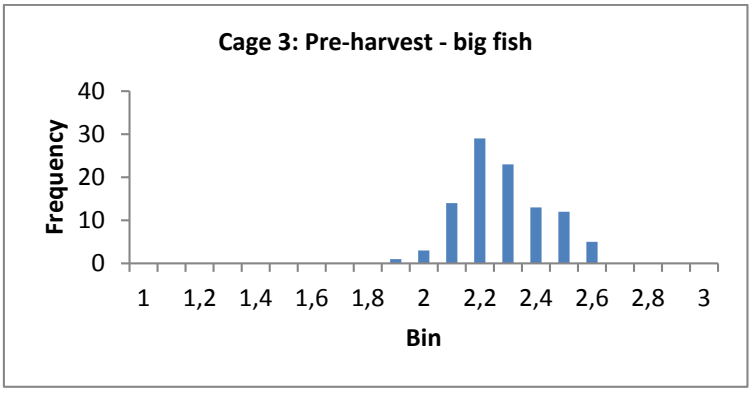

Figure 8. Distribution of big fish as measured from stereocamera footage of Cage 3 at pre-harvest.