 Collect. Vol. Sci. Pap. ICCAT, 73(6): 2150-2163 (2017)

BLUEFIN TUNA (*THUNNUS THYNNUS*) GROWTH AND DISPLACEMENTS DERIVED FROM CONVENTIONAL TAGS DATA

Antonio Di Natale[1], Alfonso Pagá García[1] and Stasa Tensek[1]

SUMMARY

This paper analysed all data exiting in the ICCAT bluefin tuna conventional tags base, for extracting those high confidence data that can be used to detect growth in the wild. The analysis revealed that very few data can be used whenever considering SFL and RW without applying any conversion factor. Another analysis was carried out for showing the displacements of bluefin tuna that can detected from the conventional tags, separating also GBYP data and juveniles from adult.

RÉSUMÉ

Ce document analysait toutes les données existantes dans la base de données ICCAT de marquage conventionnel du thon rouge afin d'extraire les données qui pourraient servir à détecter la croissance à l'état sauvage avec un niveau de confiance élevée. L'analyse a révélé que très peu de données peuvent être utilisées lorsque l'on considère la longueur droite à la fourche (SFL) et le poids vif (RW) sans appliquer de coefficient de conversion. Une autre analyse a été menée à bien en vue de montrer les déplacements du thon rouge qui peuvent être détectés à partir des marques conventionnelles, en séparant également les données du GBYP et les juvéniles des adultes.

RESUMEN

Este documento analiza todos los datos existentes en la base de datos de marcas convencionales de atún rojo de ICCAT, para extraer los datos que podrían utilizarse para detectar el crecimiento en libertad con una elevada confianza. El análisis reveló que pueden usarse muy pocos datos al considerar la SFL y el RW sin aplicar primero un factor de conversión. Se llevaron a cabo otros análisis para demostrar los desplazamientos de atún rojo que pueden detectarse a partir de las marcas convencionales, separando también los datos del GBYP y los juveniles de los adultos.

KEYWORDS

Bluefin tuna, data collections, growth, conventional tags, migration

[1] ICCAT, GBYP – Calle Corazón de Maria 8, 6ª – 28002 Madrid (Spain).

1. Introduction

The conventional tagging is one of the traditional activities carried out on bluefin tuna (but also on many other species), ICCAT, since its first times, developed an important tag data base and ICCAT CPCs and scientists should provide all data from their tagging activities, with the objective to have a common reference for all recoveries in the ICCAT Convention area.

ICCAT GBYP carried out institutional conventional tagging activities since Phase 2 and up to Phase 4, then, according to the recommendation of the GBYP Steering Committee, the activities were continued only on a complimentary base by various institutions. The details of tagging activities were regularly provided by GBYP to the Commission and the SCRS (Di Natale *et al*., 2013, 2014, 2016; Di Natale 2015; Di Natale and Idrissi, 2015; Di Natale and Tensek, 2016).

The ICCAT tag bluefin tuna data base was preliminary reviewed with the GBYP activities (Justel Rubio *et a*l., 2014). The GBYP tagging activities have been recently examined under an external contract in Phase 5, which carried out a cost-benefit analysis (Righton *et al*., 2016).

The SCRS Bluefin tuna Species Group, in 2015, had requested GBYP to carry out a comprehensive analysis of the conventional tags exiting in the ICCAT bluefin tuna tag data base, for extracting only the data from those tags having the best quality sets in terms of tag release and tag recovery, trying to find useful data for detecting the bluefin tuna growth in the wild.

2. Growth at liberty

2.1 Methods

For the purpose of studying of Atlantic bluefin tuna (*Thunnus thynnus*) growth in the wild, we used the information stored in the ICCAT database on bluefin tuna conventional tagging (in its latest version of 30 June 2016). Previous studies on growth rates using the ICCAT bluefin tuna tag data base were carried out by Rodríguez-Cabello *et al*. (2007) and Ailloud *et al*., (2014).

The ICCAT conventional tag database includes information on more than 87 thousand conventional tag releases for the period between 1940 and 2016, provided by various entities and programmes, including about 25 thousand tags released by ICCAT GBYP. It is very clear that several conventional tags deployed on bluefin tuna by various entities were never reported to ICCAT.

Only 5,962 of these tagged fish were recaptured and reported to ICCAT. In addition to the low recovery rate (less than 7% in total), the records on release and recovery are incomplete for a large number of fish, lacking crucial information on release/recovery operations (such as date, coordinates, fish size or weight, etc.), thus even reducing the usable dataset (**Table 1**).

For calculating the bluefin tuna growth rate, as requested, we only focused to records that had full information on the date and fish length/weight at the time of both release and recovery. The available tagging dataset has only 1726 records that have complete information on fish length during both release and recapture (**Table 2**) and only 686 records that have complete information of fish weight (**Table 3**). Additionally, in spite of having full information, not all of these records can be used, given the different types and methods of measurement, which were not comparable. In the database, there are 11 different types of length measures (**Table 4)** and 3 different types of weight measures (**Table 5**). Additionally, the records include the information if these length and weight measures were taken by estimation or by actual measuring.

In order not to introduce any additional bias in further calculations, we decided not to use any conversion factor and keep only raw data, as they were reported. In addition, we decided to use only reliable data, thus removing all those where length or weight was estimated instead of measured and also excluding the records where the measurement method was unknown.

Therefore, we only kept the paired release-recovery records that have both information on fish length and where it was specified as straight fork length or lower jaw fork length (length type=FL, LJF and length method=M, MMT, MCA). Respective to data on weight, we only kept the records where the weight was specified to be round weight, not estimated, and taken by actual measuring (weight type=RD and weight method=M, MDY). Furthermore, size and weight data where recapture occurred in farms were also removed, presuming that those fish followed different growth rates.

The analysis of available records for calculating growth rate, showed that there were only 719 records with available data on fish length and only 14 that have available data on weight, following the aforementioned criteria. Therefore, we decided to calculate the growth rate based on the length increment over time in liberty. The dataset with available records was further reduced on 582, because we had to remove 81 records where the growth in length was negative (possibly due to measurement problems) and 56 records for a very short time at liberty where the growth was zero.

The absolute growth rate was calculated as the increase in length (the difference in length at recapture and release) over time at liberty (number of days tag stayed attached to the fish). The relative growth rate was calculated as the absolute growth rate divided by the length of the fish.

2.2 Results

The analysis of those records having known and presumably reliable fork length at the time of release and recapture for wild fish (N=1720) revealed that the most fish had the length between 50-110 cm at the time of release (**Figure 1**) and 50-130 at the time of recapture (**Figure 2**). Minimum length at release was 30 cm and maximum 259 cm, while the mean fork length was 73 cm (data in the period 1960-2016). For these fish, the recapture occurred from minimum 1 day to maximum 5,529 days, with a mean of 325 days. Regarding the length at recapture, the minimum one was 32 cm, maximum 292 cm, while the mean fork length at recapture was 90 cm (data for the period 1963-2016).

The analysis of the records of known round weight at the time of release and recapture for wild fish (N=680) revealed that most of the fish had the weight up to 20 kg at the time of release (**Figure 3**) and up to 120 kg at the time of recapture (**Figure 4**). The minimum weight at release was 2 kg and the maximum was 550 kg, while the mean round weight was 66 kg (data in the period 1940-2016). For these fish, the recapture occurred from minimum 1 day to maximum 13,681 days, with the mean of 555 days. Regarding the weight at recapture, the minimum was 2.27 kg, and the maximum was 476 kg, while the mean round weight at recapture was 86 kg (period 1961-2016).

The absolute growth rate is calculated for each fish and shown on a scatter plot (**Figure 5**) as a variable depending on the length category of the fish. The same principle was used for the relative growth rate as well (**Figure 6**). Finally, the absolute growth rate was shown on box and whiskers plot (**Figure 7**). Due to the poor number of reliable data for growth and the high variability, it was decided not to calculate any growth curve and rate for these fish, even if data are logically available for SCRS for any further study and calculation.

3. Displacements

The basic analysis on the bluefin tuna displacements for those fish that had both release and recovery positions showed a much better situation than the size data. As a matter of fact, over 5962 fish having both data, 5434 fish (equal to 91.14%) had position data that have been validated. The data by decade are shown on **Table 6**.

For plotting the displacements data by decade, it was decided to use the recovery date as reference. **Figure 8** shows the various maps by decade.

A separate plot was extracted for the conventional tags deployed by ICCAT GBYP, because in this case there was a high percentage of reliable position data (**Table 7**). All these tagged bluefin tunas are shown on **Figure 9**. Furthermore, taking into account that the GBYP conventional tagging activities were focused mostly on juveniles, as recommended by the GBYP Steering Committee, a separate plot for the displacements of juveniles is provided on **Figure 10**.

Long distance displacements are very clear in all decades, with some extremes when bluefin tuna had important presence in some areas like Norway and South Atlantic. As noticed in a previous paper (Di Natale *et al*., 2013), just few tagged fish arrived in the southern Atlantic Ocean and this fact might have several motivations, including the extremely low reporting rate from these areas and fisheries.

Intense transatlantic movements are also very clear, particularly when tagging activities were better distributed on both sides of the Atlantic Ocean. As shown by **Figure 10**, these transatlantic movements are related also to juvenile fish, sometimes recaptured after less than one year in liberty.

The recent GBYP conventional tagging activities in the Mediterranean Sea and in the Bay of Biscay showed also several interesting displacements within the Mediterranean, which supported other data provided by satellite tags.

4. Discussion

The evidences available from the analysis of the ICCAT conventional tag data base are the followings:

(a) several data sets, concerning tag deployments carried out under the control of various institutions, are not provided to ICCAT; this fact, pointed out in previous reports by both SCRS and GBYP, is not only undermining all efforts, but it is also producing several problems when one of these unreported tag is recovered; every time this happens, a huge amount of work is necessary for trying to find the release data and many times this work is finally unsuccessful.
(b) The low tag recovery rates may be improved with a better awareness of both the confidentiality provided to the fishermen recovering the data and a better knowledge concerning the scientific use of the tag data, something that must involve all stakeholders.
(c) The low number of the best quality data, along with the many types of measures taken by the different taggers create several serious problems for using the conventional tags data; even if practical problems can be sometimes understood, it should be more useful to use a common best practice for measuring the fish (SFL), at least when scientists are carrying out the tagging.
(d) Having different types of measures and weight in the data base automatically implies that it is necessary to apply the conversion factors for homogenising the data and obtain higher usable numbers of data sets; the use of conversion factors induces additional biases, which can be very important when studying a growth rate.

These conclusions are not entirely new, but this is the first time that there is a very clear evidence of the strong limits existing in the conventional tag data, besides what was already pointed out by Ailloud *et al*. (2014). It is important that SCRS should consider, as it was requested in the past, to request a specific Recommendation to the Commission, making mandatory for all ICCAT CPCs to provide the tag release data to the ICCAT data base. This is essential not only for bluefin tuna, but also for all other ICCAT species.

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Table 1. Number of records in the ICCAT conventional tagging database (as of 30 June 2016), showing number of usable paired release-recovery records.

Details	*N*	*Notes*
Tags release records	87.199	
Tags recovery records	5.962	Recovery is less than 7%
Tags recovery records, known dates of release and recovery	5.668	
Fish recovered	5.662	6 fish were second released
Fish recovered, with both FL values measured	723	
Fish-wild recovered, both FL values measured	719	4 fish were recaptured in farms
Fish-wild recovered, with both FL values measured, growth >=0	638	81 fish show negative FL growth
Fish-wild recovered, with both FL values measured, growth >0	582	56 fish show 0 FL growth

Table 2. Number of records with unavailable information on length, available but not reliable and potentially reliable information, within paired release recovery records in the ICCAT conventional tags database.

Recovery	*Don't have one or both length values, or length type different than FL (LJF)*	*Have both FL values, but the method is estimated or unknown*	*Have both FL values, measured*	*Total*
Farm	26	2	4	32
Wild	3910	1001	719	5630
TOTAL	3936	1003	723	**5662**

Table 3. Number of records with unavailable information on weight, available but not reliable and potentially reliable information, within paired release recovery records in the ICCAT conventional tags database.

Recovery	*Don't have one or both weight values, or weight type different than RD*	*Have both RD values, but the method is estimated or unknown*	*Have both RD values, measured*	*Total*
Farm	26	6		32
Wild	4950	666	14	5630
TOTAL	4976	672	14	**5662**

Table 4. Possible length types and measurement methods in the ICCAT conventional tagging database.

Length types	
LenTypeCode	**LenType**
UNK	Unknown
FL	Fork-length (strait)
LD1	1st dorsal (LD1)
STD	Standard
LJF	Lower Jaw fork length
EYF	Eye-fork
TLE	Total length
CFL	Curved fork length
PAL	Pectoral -> Anal length
PFL	Pectoral -> Fork Length
CKL	Cleithorum to Keel

Length methods	
LenMethodCode	**LenMethod**
U	Unknown
E	Estimated (unknown method)
EWL	Estimated (W/L relationship)
EFR	Estimated (photo referencing techniques)
M	Measured (unknown method)
MMT	Measured (metric tape)
MCA	Measured (calliper)

Table 5. Possible weight types and measurement methods in the ICCAT conventional tagging database.

Weight types	
WgtTypeCode	**WgtType**
UN	Unknown
RD	Round weight
DR	Dressed weight
FL	Fillet

Weight methods	
WgtMethodCode	**WgtMethod**
UNK	Unknown
E	Estimated (unk. tech.)
EWL	Estimated (W/L rel.)
M	Measured (unk. tech.)
MDY	Measured: Dynamomete

Table 6. Number of bluefin tunas tagged and recovered with geo-data validated by decade.

Decade of recovery	*Number of tags recovered with validated data*
1950	5
1960	1802
1970	1566
1980	706
1990	758
2000	348
2010	249
TOTAL (without errors)	5434

Table 7. Number of bluefin tunas tagged and recovered with validated geo-data under the GBYP (2011-2016).

GBYP tags recovered with release and recovery tag data	192
GBYP juveniles with release and recovery tag data	144

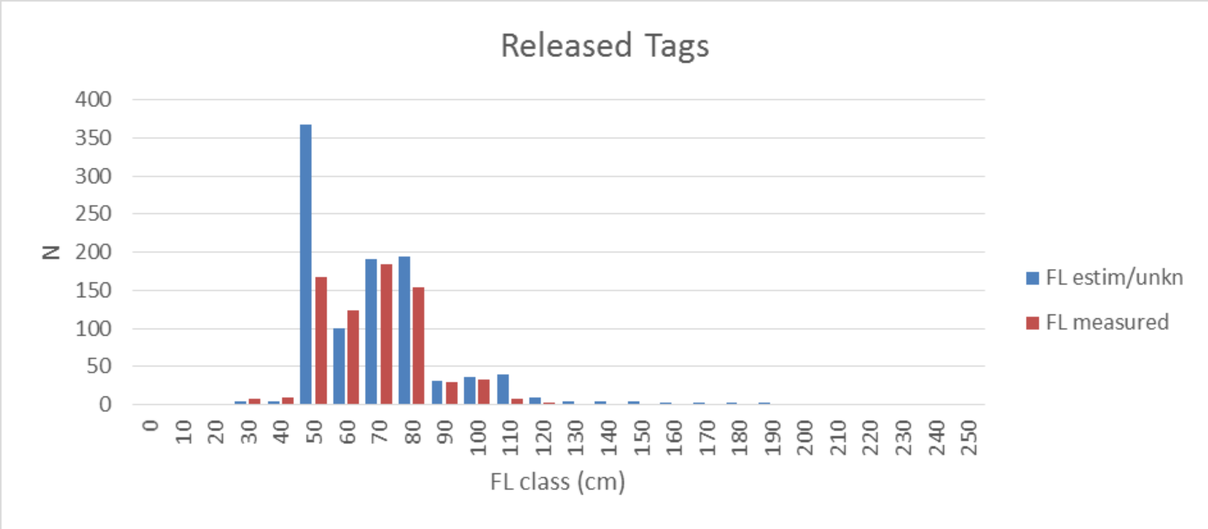

Figure 1. Sizes of recaptured fish at the time they were released (only fish with both FL and/or LJF values). Blue series indicate less reliable records where the size was estimated or the measure method was unknown, while red series indicate potentially more reliable measured values.

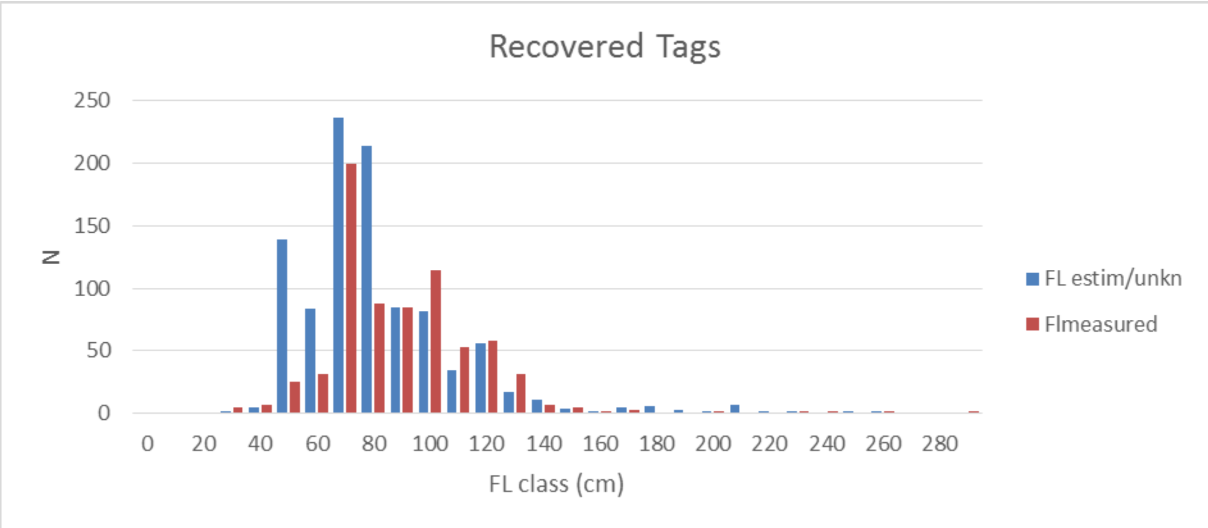

Figure 2. Sizes of recaptured fish at the time they were recovered (only fish with both FLand/or LJF values). Blue series indicate less reliable records where the size was estimated or the measure method was unknown, while red series indicate potentially more reliable measured values.

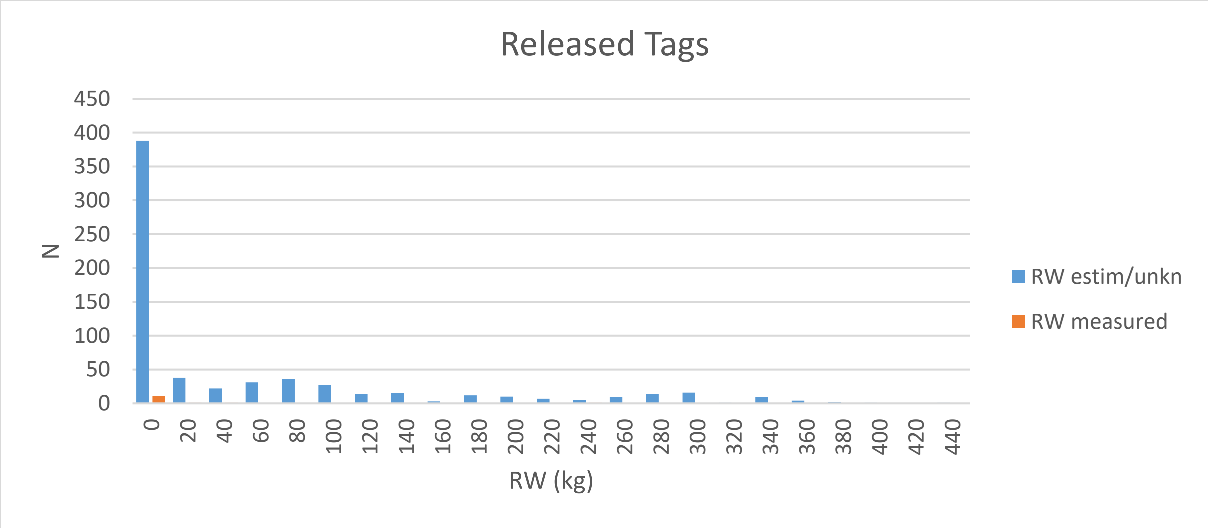

Figure 3. Weights of recaptured fish at the time they were released (only fish with both RW values). Blue series indicate less reliable records where the weight was estimated or the measure method was unknown, while red series indicate potentially more reliable measured values.

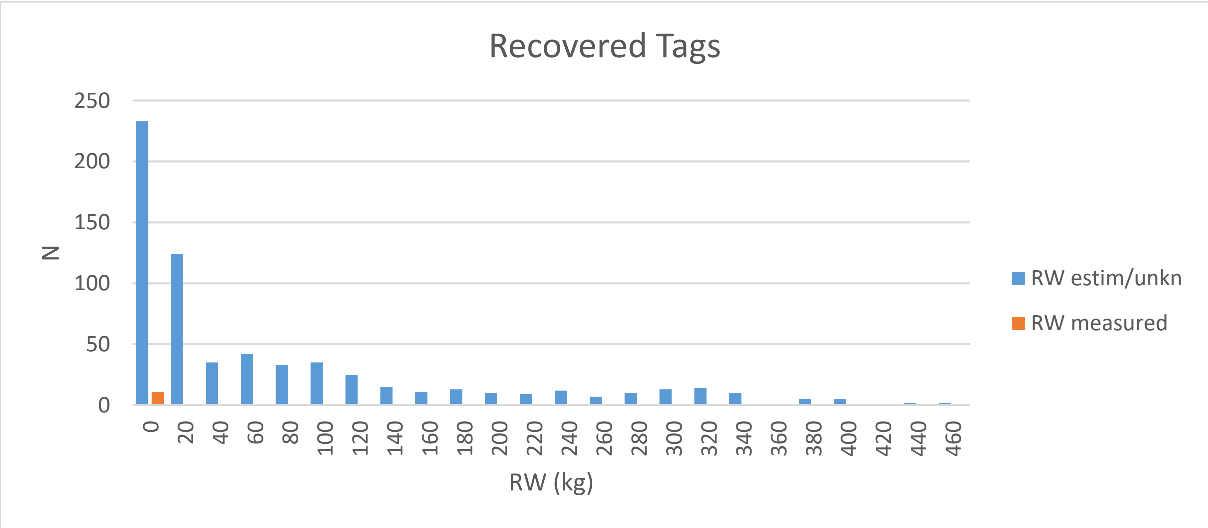

Figure 4. Weights of recaptured fish at the time they were recovered (only fish with both RW values). Blue series indicate less reliable records where the weight was estimated or the measure method was unknown, while red series indicate potentially more reliable measured values.

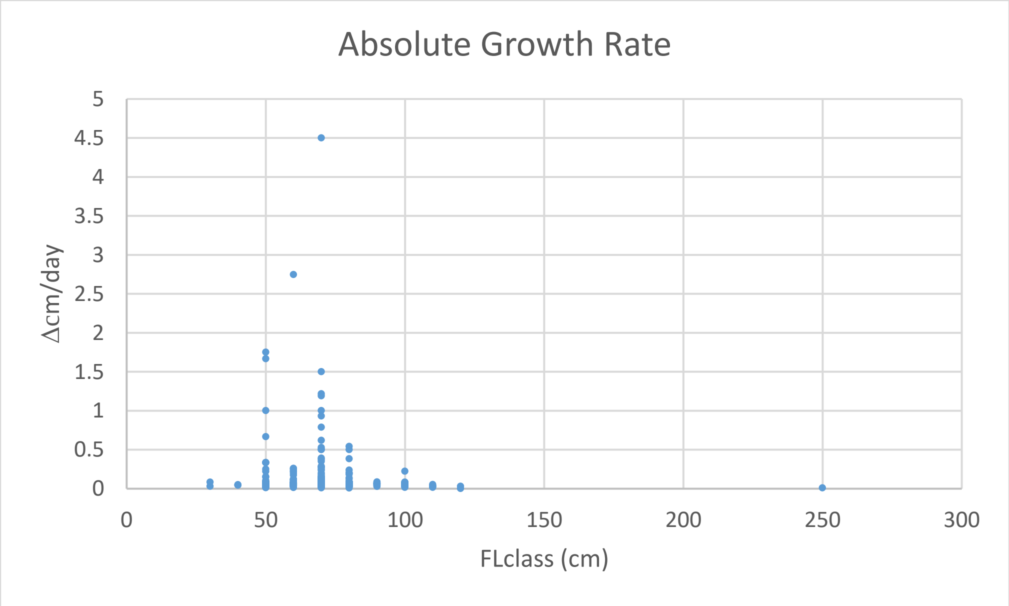

Figure 5. Absolute growth rate of bluefin tuna at length, calculated as increment in centimetres per day at liberty.

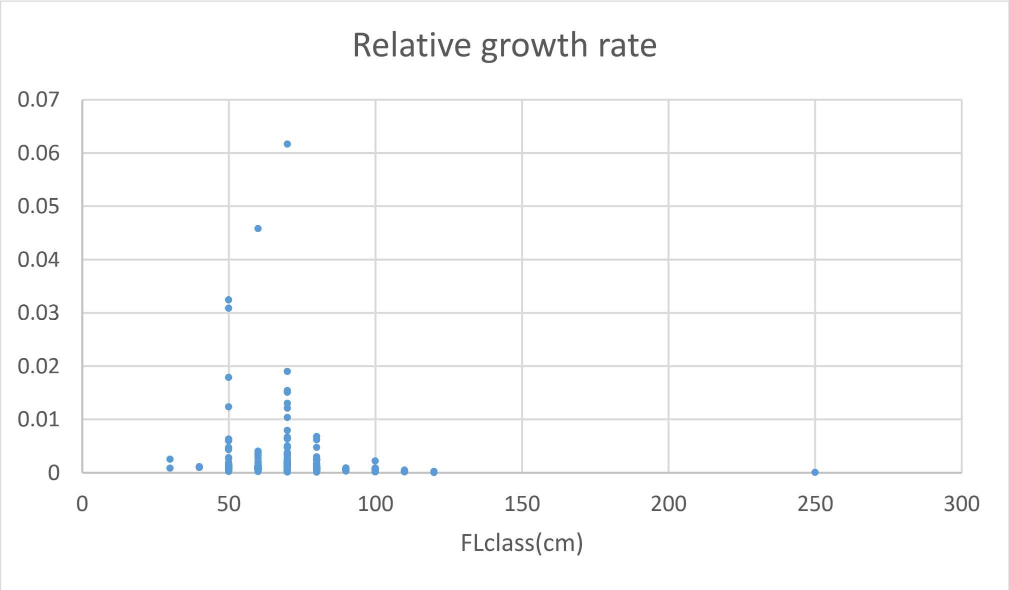

Figure 6. Relative growth rate of bluefin tuna at length, calculated as increment in centimetres per day at liberty per length.

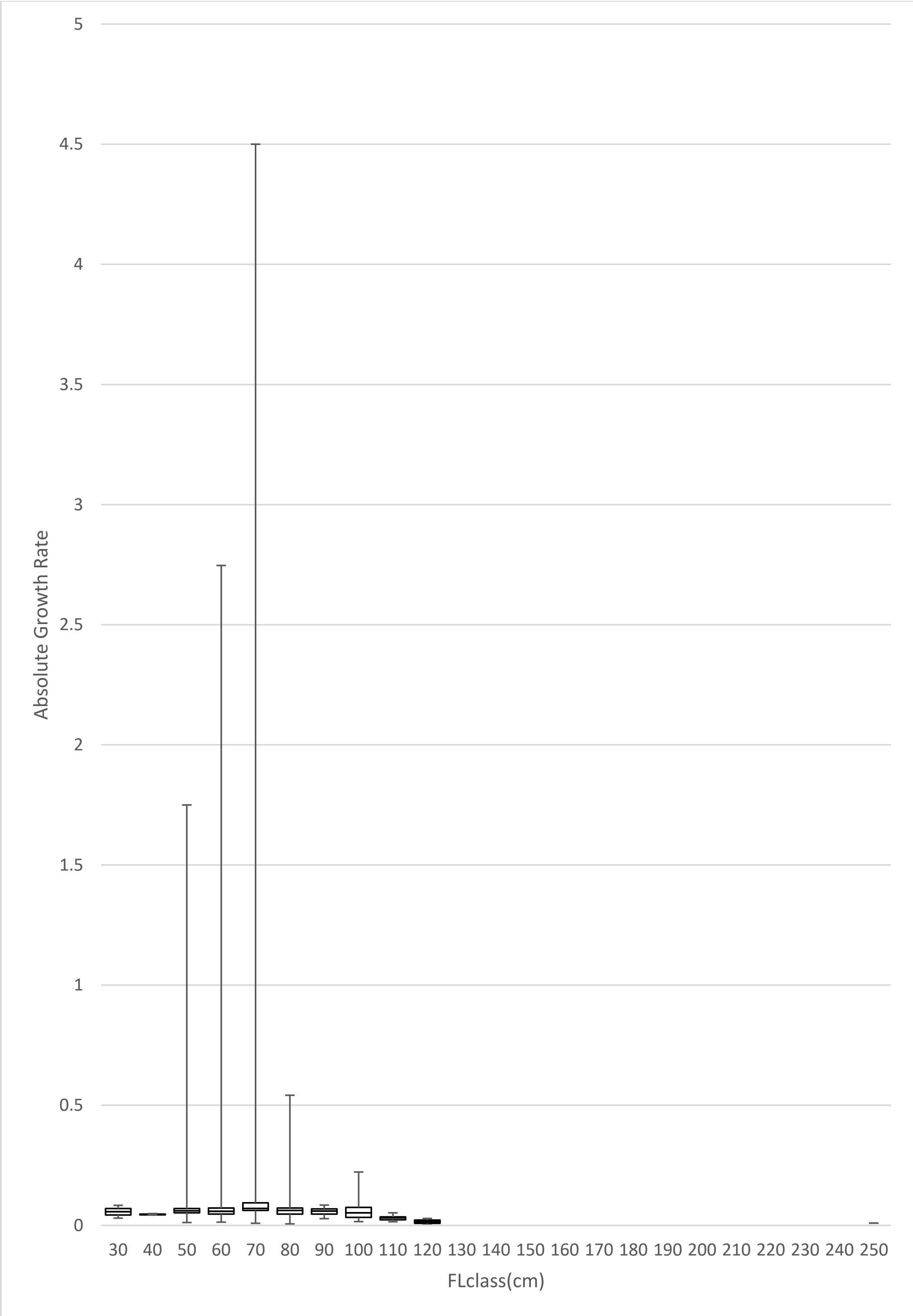

Figure 7. Box and whiskers plot of absolute growth rate at length.

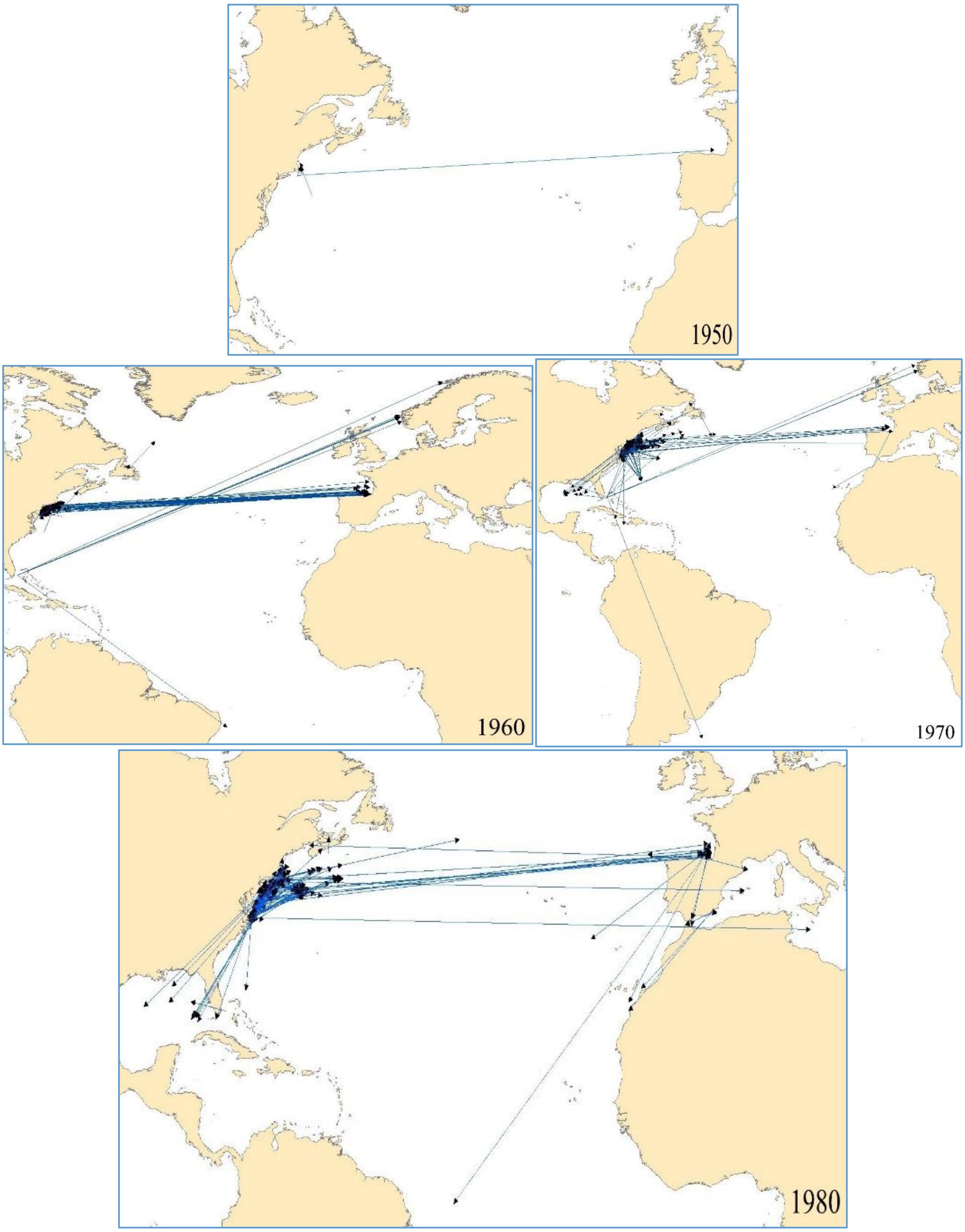

Figure 8a. Bluefin displacements detected using validated conventional tag data plotted by decade recoveries.

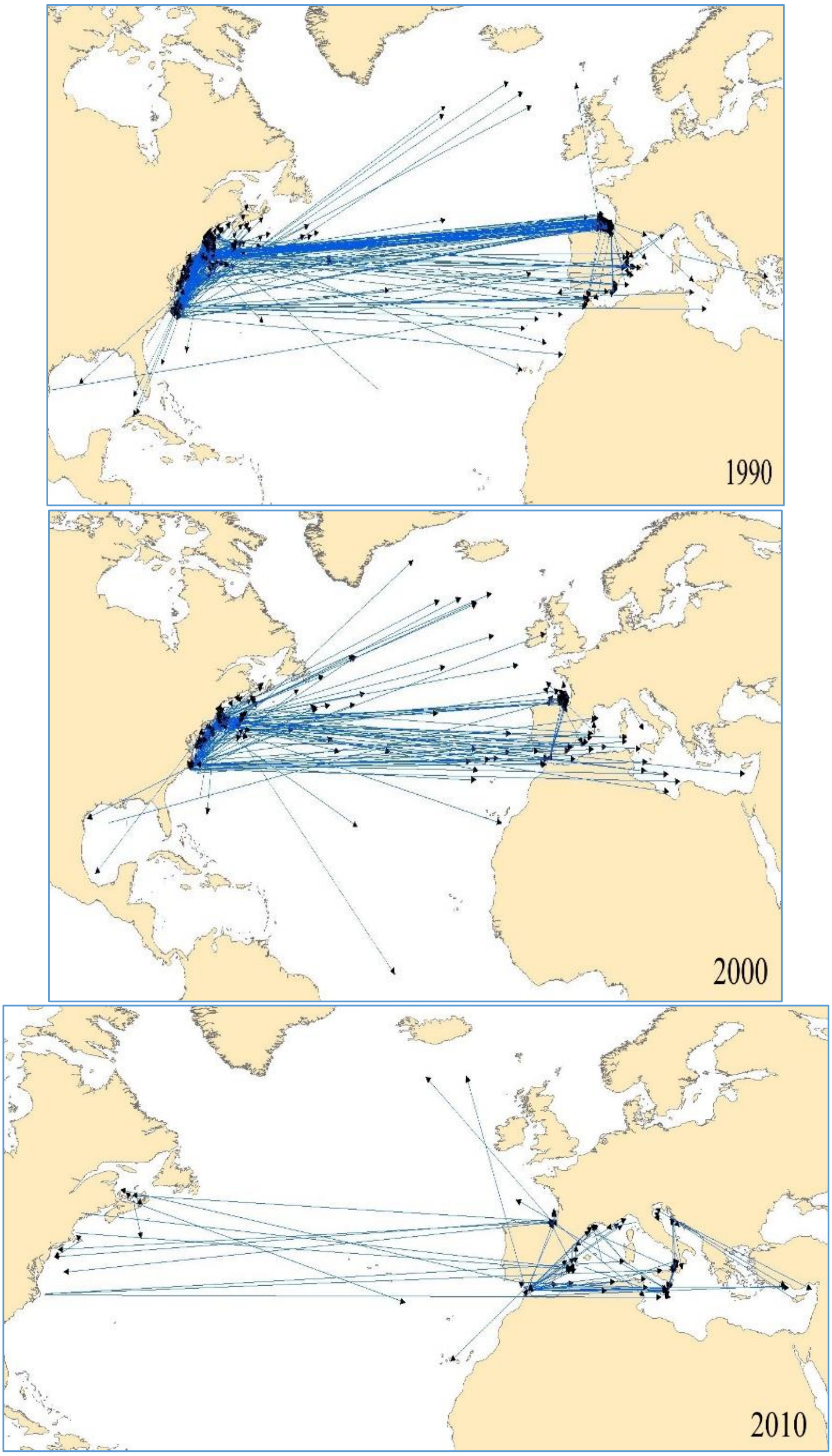

Figure 8b. Bluefin displacements detected using validated conventional tag data plotted by decade recoveries.

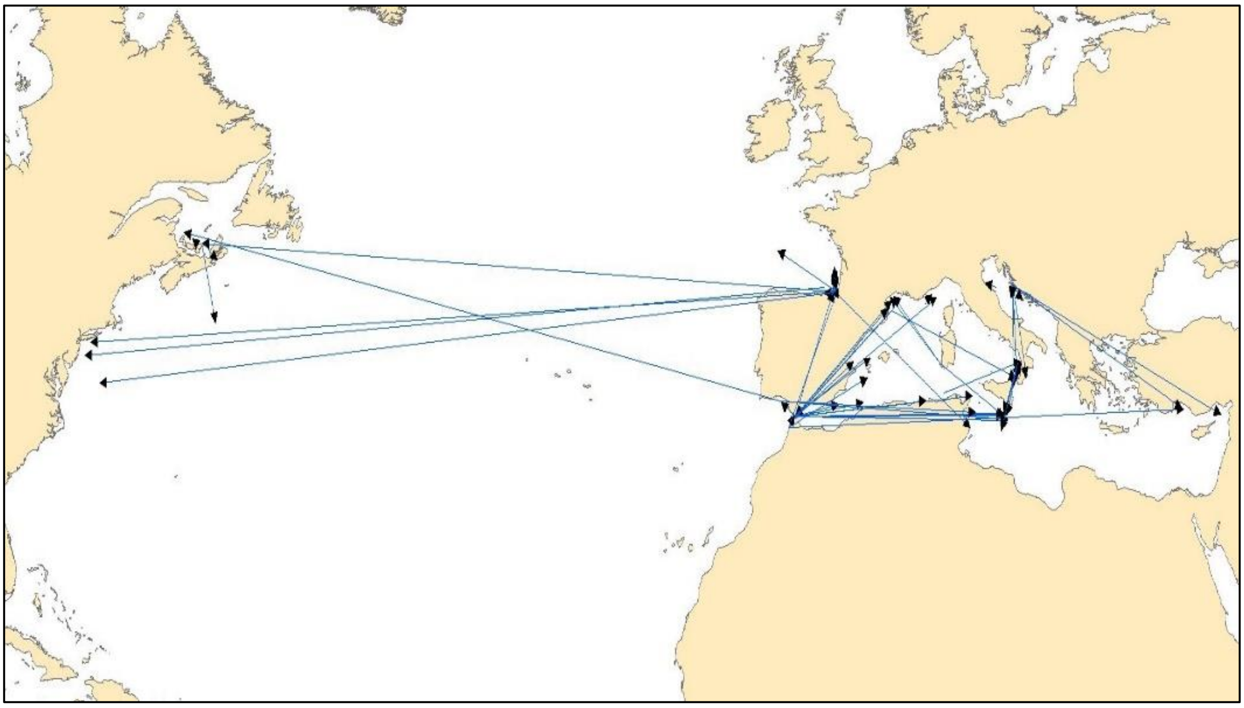

Figure 9. Bluefin tuna displacements for all individuals tagged and recovered under the GBYP (2011-2016) with geo-data validated.

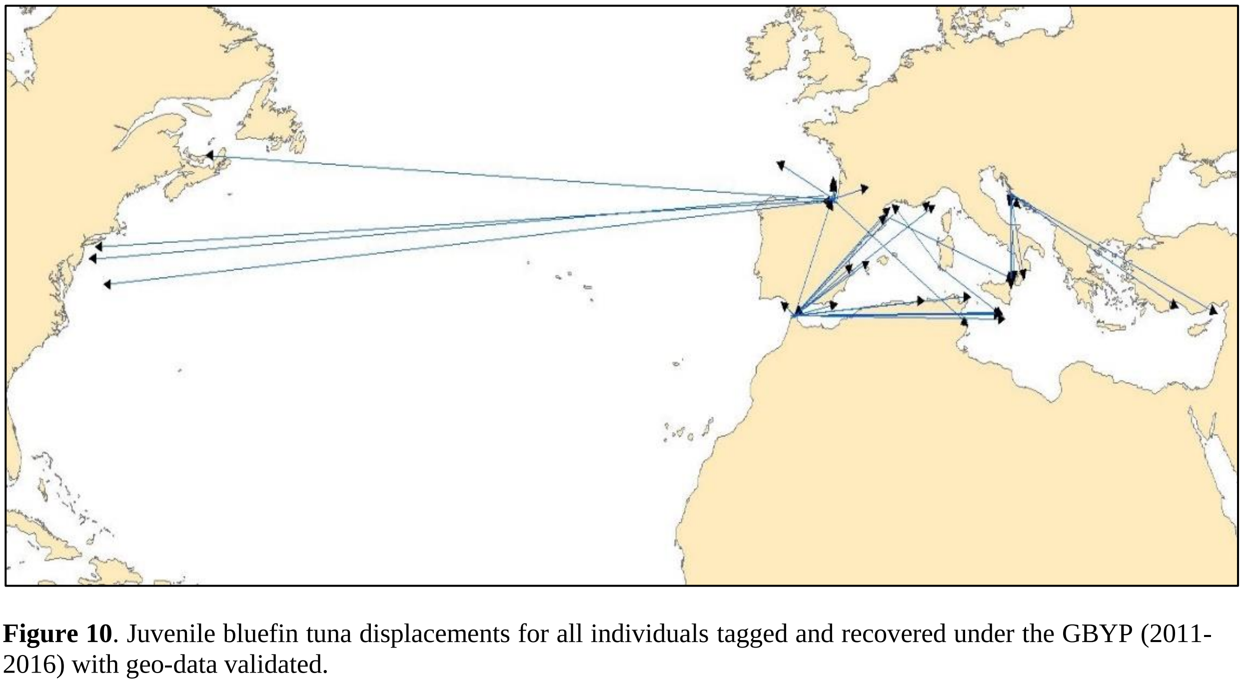

Figure 10. Juvenile bluefin tuna displacements for all individuals tagged and recovered under the GBYP (2011-2016) with geo-data validated.