INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS

COMMISSION INTERNATIONALE POUR LA CONSERVATION DES THONIDES DE L'ATLANTIQUE

COMISIÓN INTERNACIONAL PARA LA CONSERVACIÓN DEL ATÚN ATLÁNTICO

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ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA

(ICCAT GBYP)

PHASE 5

EC GRANT AGREEMENT SI2.702514

GBYP SCIENTIFIC AND TECHNICAL FINAL REPORT FOR PHASE 5

April 14, 2016

ICCAT – Calle Corazón de Maria 8, 6° - 28002 Madrid – España

ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (ICCAT GBYP)

PHASE 5

FINAL REPORT

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ICCAT ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (GBYP)

FINAL REPORT FOR PHASE 5 (2015-2016)

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EXECUTIVE SUMMARY

The Atlantic-wide research programme on bluefin tuna (GBYP) officially began on October 2009, but it was practically initiated on March 2010. The Phase 5 of GBYP activities began on 24 February 2015 and ended on 23 February 2016, including (a) continuation of data mining, recovery and elaboration, (b) biological and genetic sampling and analyses, (c) tagging, including awareness and rewarding campaign, (d) aerial survey on bluefin spawning aggregations and (e) further steps of the modelling approaches.

Data recovery activities continued with the exhaustive analysis of the ancient trap data, covering a period from 1509 to 2009, recovered in previous phases of the Programme; this analysis is now completed and all data are available for ICCAT SCRS scientists. Under genetic data mining, a follow-up of the genetic analyses of the recovered historical samples of bluefin tuna bones was carried out, showing significant discrimination between the genetic code of modern and ancient populations, revealing details on the evolution of the species genome, probably in response to environmental pressure, but without any evidence of genetic erosion. The first two sets of the trade, auction and marked data were reviewed and incorporated into the ICCAT database, making them available to SCRS scientists.

In this Phase, the second extended aerial survey on spawning aggregations was carried out, over all potential Mediterranean spawning areas where it was possible to access and the results proved the major concentration of bluefin tuna spawners in areas already identified in previous studies, confirming the good election of the areas identified at the beginning of the GBYP. First analyses of additional variance in aerial survey were performed, showing large temporal and spatial variability. Still large CVs entail the need for concentrating the survey only to known spawning areas instead of covering an extensive area, and for surveying these four areas with increased effort, thus reducing the bias. A power analyses was also accomplished, providing the possible scenarios for different methodologies and also stressing the need for maintaining the same methodology and conditions in future surveys in order to reduce CVs. Results of the cost/benefit analysis revealed that GBYP aerial survey is cheaper than any other similar one, thus demonstrating both its meaningful and its feasibility.

The tagging strategy in Phase 5 was modified, cancelling the conventional tagging and addressing all activities only to the electronic tagging, specifically in the Moroccan and Sardinian traps and in Turkish purse seiners. Additional electronical tagging in a cage in the Tyrrhenian Sea and complementary conventional tagging in Morocco was also realized. In total, 83 electronical tags were implanted in 2015 and their results are already available. Some tracks of the fish electronically tagged this year reveal important behaviour of interchange between the eastern Mediterranean and other Mediterranean and Atlantic areas, thus rejecting previous hypotheses. This new evidence is in line with the results of genetic analyses which report mixing among all areas in the Mediterranean, without allowing so far for any specific subpopulation discrimination. The tag awareness and recovery activities were also continually carried out in this phase. A first part of the feasibility study for a close-kin genetic tagging has been performed and the second part will be done in the next Phase, providing the base for another

possible tool to be used for getting a further fishery-independent index. Independent cost/benefit analysis affirmed a high scientific value of the overall GBYP tagging programme, showing also very reduced costs compared to previous programmes in this field.

The large participations of scientific institutions to the biological studies keeps on, providing many interesting results. The sampling was quite successful, providing a high number of various types of samples (tissues, spines, otoliths) in different areas. An improved table by strata was adopted in Phase 5, and this will allow for any future data aggregation. Several types of otolith microchemical and genetic analyses were completed, as well as otolith shape analysis and age determination. Besides some technical problems, overall results of genetic analyses show possibility to discriminate with a great accuracy between tuna of Atlantic and Mediterranean origin and show no evidence of structuring within the Mediterranean, while analyses of otoliths reveal that its shape and microchemical composition is merely influenced by the environmental history rather than by the natal origin. Activities towards building the SNPs panel were successful, although some further efforts will be needed for building a final validated panel. Analysis of the bluefin tuna in the mixing zones in central and eastern Atlantic show considerable interannual variability in the degree of mixing between WBFT and EBFT, which seems much more important that previously known.

As concerns the modelling approaches, in 2015 a new modelling coordinator was appointed and the previously established ICCAT GBYP Core Modelling MSE Group is continuing its tasks. A second meeting of the Group was held in January 2016, drafting final specifications for MSE trials for Atlantic bluefin tuna, with agreed unified definitions and methodology. A detailed schedule of future ICCAT GBYP modelling activities up to 2018 was also provided. Furthermore, during the Phase 5, a spatial, multi-stock statistical catch-at-length operating model was developed, simulation tested and then conditioned on preliminary data. In the framework of the MSE, 192 operating models were described. Additionally, an R Shiny application for investigating MSE results and performance metrics was developed. The ICCAT GBYP Modelling MSE Group is already using all GBYP electronic tag data and the main results of the biological studies.

As a matter of fact, even in this difficult Phase, the GBYP is fulfilling all its obligations, reaching almost all objectives as planned, besides the operational constraints, the changes in strategy and the limited availability of funds, which reached so far only about 50% of the approved budget for the same period of time; the annual GBYP report provided to the SCRS and the Commission shows both the budged used for each activity and the results obtained so far, against the initial figures. The problem of ensuring a stable funding was raised again by the Steering Committee, but so far it was not possible for the Commission to find an agreed solution for this problem, which is particularly relevant for a multiyear research programme such us the GBYP, also taking into account the agreed extension up to 2021. The Commission, in its 2015 regular meeting, agreed about the need to carry out a second independent review of the GBYP, to be conducted in the very first part of Phase 6.

KEYWORDS

bluefin tuna, ICCAT, historical data, biological analyses, tagging, genetics, maturity, microchemistry, aerial survey, modelling, Mediterranean Sea, Atlantic Ocean..

1. Introduction

The ICCAT Atlantic-wide Research Programme for Bluefin Tuna was officially adopted by SCRS and the ICCAT Commission in 2008, and it started officially at the end of 2009, with the objective to:

a) Improve basic data collection, including fishery independent data;
b) Improve understanding of key biological and ecological processes;
c) Improve assessment models and provision of scientific advice on stock status.

Since the beginning, the Programme was conventionally identified with the acronym GBYP (Grande Bluefin Tuna Year Programme), for showing the ideal continuation of the previous multi-year ICCAT BYP.

The total budget of the programme officially approved by the ICCAT Commission in 2008 was 19,075,000 Euro in six years, with the engagement of the European Union and some other ICCAT Contracting Parties to contribute to this programme in 2009 and in the following years. The initial year had costs for 653,874 Euro (against the original approved figure of 890,000 Euro), the second phase had costs for 2,318,849 Euro (against the original figure of 3,390,000 Euros), while the third phase had costs for 1,769,262 Euro (against the original approved figure of 5,845,000 Euro). The fourth phase had a total budget of 2,875,000 Euros (against the original approved figure of 5,195,000 Euros) and final costs for 2,819,556 Euro. The fifth phase has a total budget of 2,115,000 Euro (against the original approved figure of 3,345,000 Euro)[1]. The overall GBYP operating budget for the first five phases, covering 6 years (a total of 9,676,542 Euro) is about 50.73% of what was supposed to be (19,075,000 Euro), as it was approved by the Commission. These sequential budget reductions had an obvious impact on all activities carried out so far. Several private or public entities[2] provided few additional funds or in kind support (see Section 12 of this report for the details).

Phase 1 (EU Grant agreement SI2.542789) and Phase 2 (EU Grant agreement SI2.585616) activities were jointly committed by the European Community (80%), Canada, Croatia, Japan, Libya, Morocco, Norway, Turkey, United States of America, Chinese Taipei and the ICCAT Secretariat. Other CPCs (Algeria, Egypt, Iceland and Korea) joined the first funders in Phase 3, 4 and 5, but some of CPCs did not paid their contribution, further limiting the use of available funds, because the EU has a maximum percentage of contribution of 80% under the firm condition to duly obtain the remaining 20%.

The third phase (7 months) officially initiated on June 20, 2012, after the signature of the Grant Agreement for co-financing the GBYP Phase 3 (SI2.625691) by the European Commission. Phase 3 officially expired on January 19, 2013, but closing the administrative issues took more time than scheduled, due to a delay of one contractor in

[1] The final cost of Phase 5 (which is lower than the operating budget) will be showed in the administrative report, due to the late arrival of some invoices.

[2] For the full list, see chapter 11 of this report.

providing the necessary documents. The GBYP activities up to the first part of Phase 3 were presented to the SCRS and the ICCAT Commission in 2012 and they have been approved, while the last part was present to the SCRS and the Commission in 2013 (documents SCRS/2013/144) and therefore approved.

The fourth phase of GBYP officially initiated on March 6, 2013, after the signature of the Grant agreement for co-financing the GBYP Phase 4 (SI2.643831) by the European Commission and then it was extended for a total of about 23 months, ending on 23 February 2015. The partial results were presented to SCRS and the Commission in 2013 and 2014 (documents SCRS/2013/144 and SCRS/2014/051) and they have been approved, while the final results were presented to the SCRS and the Commission in 2015 (documents SCRS/2015/154 and SCI/2015/APP.5), they were approved by the SCRS and endorsed by the Commission.

The fifth phase of GBYP officially initiated on February 24, 2015 after the signature of the Grant agreement with the European Union for co-financing the GBYP Phase 5 (SI2.702514) by the European Commission and ended on 23 February 2016. The Grant agreement was revised on December 15, 2015, taking into account the modification of the activities as recommended by the Steering Committee. A first report of the GBYP activities in Phase 5 up to September 2015 was provided to the SCRS and the Commission (SCRS/2015/144 and SCI/2015/APP.5; **Annex 1b, documents no. 16** and **32**); the activities were approved by the SCRS and endorsed by the Commission. The final report of Phase 5 activities will be submitted to SCRS and at the Commission in their respective 2016 meetings.

All final reports of all GBYP activities in Phase 5 have been provided to the ICCAT GBYP Steering Committee and published on the ICCAT GBYP web pages (http://www.iccat.int/GBYP/en/)

The ICCAT GBYP activity is being supported by a twin programme carried out by NOAA-NMFS, which will focuses its research activities on the western Atlantic Ocean.

For the purpose of reviewing the work carried out to date within the scope of ICCAT GBYP and evaluating the effectiveness of this complex research programme, a large comprehensive review of the first five Phases of ICCAT GBYP is envisaged in Phase 6, which will be presented at the PA2 meeting in July for the evaluation and feedback, then to the SCRS 2016 Plenary, and the final report will be presented to the Commission at its 2016 Special Meeting.

2. Coordination activities

In the first part of the Programme, the staff was composed by the GBYP Coordinator, the Coordinator assistant (up to February 2014) and one contracted technician for data management (up to 2 January 2014). In the second part of Phase 4, because of budget constraints and other reasons, the staff was reduced to the Coordinator only, while the previous staff level was resumed on May 2015. The Coordination assistant is now Mrs. Stasa Tensek, while Mr. Alfonso Pagá García is in charge of the data bases and the tags register. The GBYP staff history is showed on **Table 1**. The ICCAT Secretariat provided the necessary support for the GBYP activities.

Table 1. ICCAT GBYP staff over the different years of the programme.

GBYP STAFF		2010	2011	2012	2013	2014	2015	16
name	role	M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F
Antonio DI NATALE	coordinator							
M'Hamed IDRISSI	assistant							
Ana JUSTEL RUBIO	data expert							
Stasa TENSEK	assistant							
Alfonso PAGÁ GARCÍA	data expert							

A total of **43 reports** were produced in the framework of ICCAT GBYP in Phase 5 (**Annex 1a**). Several additional documents and reports have been also provided by GBYP for the needs of the Steering Committee for its meetings. A total of **34 scientific papers** have been produced in Phase 5 (list in **Annex 1b**), while others will be published in the following months. The copies (1814 pages) are in separate volumes (separate Annex Ia, volumes 1 and 2, and Annex Ib, volumes 1 and 2, to this report).

A total of 10 Calls for Tenders (out of which 3 were re-issued) and one invitation were released in Phase 5. A total of 18 contracts have been awarded to various entities (**Annex 2**). In total, the number of contracts provided by GBYP in the first 5 Phases is 91, including 83 entities, localised in 23 different countries; many hundreds of researchers and technicians have been working so far in the various GBYP activities; <u>this large and open participation to ICCAT GBYP activities is considered to be one of the best results of this research programme</u>. The coordination staff participated in 13 meetings in various countries in Phase 5 (**Annex 3**).

As usual, the administrative and desk work behind all these duties was huge and heavy and it was carried out in continuous and constructive contact with the ICCAT Secretariat and the Administrative Department, which had to face an important additional workload caused by all GBYP activities since the beginning of this programme, as well as the ICCAT Statistical Department.

Some delays in Phase 5 have been caused by changes in the previously agreed strategy, particularly by the lack of agreement among the members of the Steering Committee. Almost all delays were promptly recovered by the GBYP coordination with additional work.

A particular coordination effort was necessary for assisting the contractors engaged in the aerial survey activities and for assisting them for the many permits required, getting directly in touch with the relevant Authorities of the CPC concerned for operating in their air spaces (FIR). A continuous assistance, 7/7 days 24/24h, was necessary for solving various problems, emergencies and operational difficulties for the aerial survey. Additional coordination efforts were required at any time by the various contractors engaged in the field tagging activities, assisting them for many practical needs and problems.

Furthermore, the GBYP coordination is providing scientific support to all the national initiatives which are potentially able to increase the effectiveness of the GBYP and its objectives. For this reason, since 2010 the Coordinator joined the Steering Committee for the bluefin tuna programmes of the NOAA, together with some members of the GBYP Steering Committee; in this function he participated to the evaluation session of the US domestic research programmes for bluefin tuna also in 2013, 2014, 2015 and 2016.

The budget items included under the GBYP Coordination activity in Phase 5 were: Coordination staff salaries and benefits, Travel and subsistence (including SC), Computer hardware and software, Consumables and supplies, Contract for external SC member, ICCAT Secretariat overhead and ICCAT staff. The original budget (for the Coordination activity was 342,000.00 euro.

In conformity with the Atlantic-Wide Bluefin Research Programme (GBYP) adopted by the SCRS and the Commission for Phase 5 in 2014, as it was modified by the GBYP Steering Committee in 2015, the following research initiatives have been conducted or initiated (see also **Annex 2**).

3. Data mining and data recovery

3.1. Objectives of the data recovery and data mining

The objective of data recovery and data mining activities is to fill the many gaps existing in several data series currently present in the ICCAT data base, concerning both recent and historical data, which causes a large amount of substitutions in the assessment process, increasing uncertainties. At the same time, data mining activities should provide reliable data series, longer that those currently available, recovering data from many sources, including archives having difficulties for the access. The data mining activity can include also the recovery of old genetic and biological data. This activity will allow for a better understanding of the long-time catch series by gear, improving the data available for the assessment and possibly for replacing substitutions used for data gaps; old data will allow also for a better understanding and for improving our knowledge about Atlantic bluefin tuna. The data recovered so far in all ICCAT GBYP Phases are showed in **Table 2** and **Table 3**. The GBYP was also very active for organising the SCRS BFT Data Preparatory meeting in 2015 (**Annex 1a, document no. 4**), cooperating with the ICCAT Secretariat.

Table 2. Total data recovered by GBYP from Phase 1 to Phase 5.

TOTAL PHASES 1 to 5	origin	data	total data
# Records	OG	87.761	510.181
	TP	30.923	
	TAMD	311.415	
	FARM	49.354	
	HGEN	733	
	DTBV	29.995	
BFT (no.)	OG	34.753	26.377.901
	TP	23.247.666	
	TAMD	825.485	
	FARM	49.354	
	HGEN	733	
	DTBV	2.219.910	
BFT (tons)	OG	114.596	1.191.312
	TP	744.227	
	TAMD	80.408	
	FARM	474	
	HGEN	-	
	DTBV	251.607	
# BFT sampled (size and/or weigth or historical genetics)	OG	94.932	3.197.734
	TP	7.610	
	TAMD	825.485	
	FARM	49.354	
	HGEN	443	
	DTBV	2.219.910	
Legenda: OG = Other Gear; TP = Trap; TAMD = Trade, Auction and Market Data; FARM = Farmed tunas; HGEN = Historical Genetic samples; DTBV = Data To Be Validated			
Note: DTBV are concerning TAMD data which were collected but never validated by SCRS and therefore set aside for future validation if any.			

Table 3. Total data recovered by GBYP from Phase 1 to Phase 5 by century (<1500-1900) and by decade (1900 onwards).

DATA TYPE	Year / source	<1500	1500	1600	1700	1800	1900	1910	1920	1930	1950	1960	1970	1980	1990	2000	2010	TBFA	DTBV
TOTAL PHASES 1 to 5																			
# Records	OG						9	10	87	11.509	15.616	29.992	17.946	1.781	1.174	9.401	236		
	TP		252	171	211	6.100	3.005	4.353	6.705	2.301	1.021	1.040	2.032	777	3.868	1.548		3	3
	TAMD																	311.415	
	FARM														851	18.492	30.021		
	HGEN	145						110	155		2			30			291		
	DTBV																		29.995
BFT (no.)	OG														9.937	21.736	3.080		
	TP		3.978.087	1.292.782	425.335	4.472.749	1.613.889	1.883.967	2.971.129	2.013.583	1.787.209	1.566.956	614.611	70	204.806	186.199		4.717.140	6.111
	TAMD													178.743				825.485	
	FARM														851	18.492	30.021		
	HGEN	145						110	155		2			30			291		
	DTBV																		2.219.910
BFT (tons)	OG						44	163	601	2.497	6.057	29.059	14.492	17.880	17.086	26.514	203		
	TP					141.907	40.327	70.723	75.579	83.592	86.204	111.417	71.842	8.755	19.568	15.306	711	18.296	
	TAMD																	80.408	
	FARM														207	268			
	HGEN																		
	DTBV																		251.607
# BFT sampled (size and/or weigth or historical genetics)	OG											18.614	18.548	804	18.569	28.000	10.397		
	TP							153	170						2.225	5.062			
	TAMD																	825.485	
	FARM														851	18.492	30.021		
	HGEN	145						110	155		2			10			291		
	DTBV																		2.219.910

Legenda: OG = Other Gear; TP = Trap; TAMD = Trade, Auction and Market Data; FARM = Farmed tunas; HGEN = Historical Genetic samples; TBA = Data to Be Further Analysed; DTBV = Data To Be Validated

Note: DTBV are concerning TAMD data which were collected but never validated by SCRS and therefore set aside for future validation if any.

3.2 Data recovery

In the last part of the Phase 4 it was possible to recover a huge data base on historical tuna trap that was used for a Ph.D. Thesis by Christelle Ravier-Mailly in 2003 and also for several papers coordinated by Ph.D. Jean-Marc Fromentin. These data were provided on an excel file, having 10 spreadsheets and 6384 records (**Table 4**). The data cover the period 1525-1997 (**Table 5**), including about 50[3] traps from five countries. This huge data base was kindly provided by Dr. Fromentin to GBYP, as a donation in kind. It was initially examined by GBYP and the ICCAT Statistical Department and it was clear that several data and traps were already existing in the ICCAT GBYP data base. Therefore, it was necessary to plan a long and huge work in Phase 5 for checking all these data and removing possible duplicates.

One of the problems for checking and compiling these data sets arose from the fact that the system used for obtaining the total catch, when the quantity was not available, was based on a fix mean size by country. This method was not fitting the methodology used by the ICCAT Secretariat and therefore it was necessary to examine again the files and reconvert the number of fish to kg using the weight of the various size categories, when this information was available. The ICCAT Statistical Department decided to propose the comparison between the two methods to the SCRS Sub-group of Statistics and to the SCRS BFT Species Group, for adopting the most suitable method. The detailed results of this work were presented on SCRS/2015/148.

[3] The total number of traps is slightly uncertain, because some traps were reported with different names in different historical times, while they were exactly in the same location, just changing the name over the years; furthermore, sometimes data include groups of traps, some without any precise definition.

Table 4. Additional trap data recovered in the last part of Phase 4, which were checked and incorporated in the ICCAT BFT data base in Phase 5. The column on the left shows the initial data sets, while the column on the right show the additional data incorporated after the cross-checking and validation.

	Original trap data from JMF files	**Additional trap data added to ICCAT GBYP after cross checking validation**
# records	6,384	2,467
BFT (in no.)	17,441,811	4,486,957
BFT (in tons)	2,791,528	714,690

Table 5. Range of years covered by the trap data recovered from JMF archive for each country.

Country	1st year	Last year
Italy	1595	1997
Morocco	1916	1973
Portugal	1797	1933
Spain	1525	1980
Tunisia	1863	1997

The ICCAT SCRS shared the methodology proposed by both GBYP and ICCAT Statistical department for converting the weight of various commercial size categories to kilos. According to its recommendation, the ICCAT GBYP made all conversions and proceeded with the cross-checking of the last data from these files against the data already existing in the ICCAT GBYP historical trap data base, examining and solving any possible data conflict according to the best available knowledge, for eliminating duplicated data and for finally incorporating any missing data into the ICCAT GBYP data base, according to the format used by the Statistical Department at the Secretariat. The validation work was much longer and difficult than planned, because several mistakes and problems were identified in the original files, while just on February 2015 some old conversion factors used for the Spanish traps (from the old "Consorcio Almadrabero") have been made finally available. This last updating concerned the further revision of all the old trap data for the Spanish traps. The full revision work was completed anyway within the very last part of Phase 5. The total list of traps now includes 208 different traps for the various countries (76 in Italy, 52 in Spain, 34 in Portugal, 19 in Morocco, 18 in Libya, 8 in Tunisia and 1 in Turkey) (**table 6**). The graphs related to the old traps data are showed in **Figure 1** and **Figure 2**.

All data for periods previous to 1950 have been directly incorporated, while data sets after 1950 will be checked also by national scientists and agreed before incorporating them in the ICCAT BFT data base, even if provisional data are anyway available for SCRS scientists.

Table 6. Full list of tuna traps by country for which catch data are available for a variable number of years.

Country	TrapName	TrapName2	TrapName3	TrapName4	Lat	Lon
SPAIN	Agua Amarga				36,9369	-1,9335
SPAIN	Aguas de Ceuta				35,9139	-5,3334
SPAIN	Ancon de Cabo de Gata				36,7427	-2,2199
SPAIN	Arroyo Hondo				36,6400	-6,4300
SPAIN	Barbate				36,1660	-5,9200
SPAIN	Benidorm				38,5259	-0,1100
SPAIN	Cabo Termino				40,7261	1,0291
SPAIN	Cala del Charco				38,4876	-0,2787
SPAIN	Cala Punta				38,2619	-0,5060
SPAIN	Calabardina de Cope				37,4291	-1,5066
SPAIN	Calpe				38,6352	0,0513
SPAIN	Conil de la Frontera				36,2567	-6,1609
SPAIN	Conilejo				36,2538	-6,0805
SPAIN	Crusta				38,8327	0,1565
SPAIN	Cuevas de Lobos				37,3720	-1,6330
SPAIN	El Portil				37,1425	-7,1628
SPAIN	El Terron	La Tuta	Umbría	Punta Umbría	37,1038	-7,1467
SPAIN	Enderrocat				39,4732	2,6865
SPAIN	Escombreras				37,5728	-0,9878
SPAIN	Estepona				36,4517	-5,0170
SPAIN	Formentera				38,7308	1,3796
SPAIN	Granadella				38,8736	0,0222
SPAIN	Isla de Tabarca				38,1535	-0,4792
SPAIN	La Atunara	La Linea			36,1675	-5,3254
SPAIN	La Azohia				37,5537	-1,1743
SPAIN	La Barrosa				36,3715	-6,1858
SPAIN	La Caleta				38,5761	-0,0462
SPAIN	La Espada	Punta Espada			37,1808	-7,3054
SPAIN	La Higuera				36,9652	-6,6586
SPAIN	La Mojarra				37,1170	-7,3932
SPAIN	Lances de Tarifa				36,1400	-5,6320
SPAIN	Las Cabezas				37,1026	-7,2616
SPAIN	Las Huertas				38,3580	-0,4401
SPAIN	Las Torres				37,0078	-6,7564
SPAIN	Lentiscar				36,0718	-5,7750
SPAIN	Moraira				38,6553	0,1355
SPAIN	Nuestra Señora de la Cinta				37,0543	-6,9430
SPAIN	Nuestra Señora del Carmen				37,1853	-7,2772
SPAIN	Olla de Benicasim				40,0499	0,0796
SPAIN	Punta de la Isla	Sancti Petri	Hercules		36,3900	-6,2400
SPAIN	Reina Regente				37,0772	-7,3704
SPAIN	Rio Torres				38,5064	-0,1948
SPAIN	Rota				36,5930	-6,3580
SPAIN	San Miguel				36,8254	-2,3547
SPAIN	San Sebastian				36,5114	-6,3316
SPAIN	Terreros	San Juan de los Terreros			37,3556	-1,6601
SPAIN	Torre Atalaya	Conil de la Frontera	Conil		36,2567	-6,1609
SPAIN	Torre Carboneros				36,8950	-6,4960
SPAIN	Torre del Agua				38,4036	-0,3901
SPAIN	Torre del Puerco				36,3310	-6,1670
SPAIN	Torre Gorda				36,4580	-6,2630
SPAIN	Zahara				36,1360	-5,8700
ITALY	Angitola	since 1924: Mezzapraia			38,7667	16,2667
ITALY	Arenella				38,1520	13,3760
ITALY	Asinelli				38,0638	12,5696
ITALY	Avola				36,9150	15,1540
ITALY	Bafuto	Vindicari	Vendicari		36,8023	15,0993
ITALY	Bagno di Marciana				41,2000	10,1833
ITALY	Bivona				38,7116	16,1018
ITALY	Bonagia				38,0674	12,5948
ITALY	Brucoli				37,2840	15,1883
ITALY	Cala Pozzillo				38,1850	13,1350
ITALY	Calavinagra				39,1685	8,2525
ITALY	Camogli				44,3500	9,1500
ITALY	Capo Feto				37,6610	12,5400
ITALY	Capo Passero grande				36,6800	15,1300
ITALY	Capo Passero piccolo				36,6800	15,1300
ITALY	Castellammare del Golfo				38,0300	12,8820
ITALY	Cefalù				38,0410	14,0200

Country	TrapName	TrapName2	TrapName3	TrapName4	Lat	Lon
ITALY	Columbargia				40,0533	8,4550
ITALY	Curto				38,1117	12,6805
ITALY	del Pepe	Capo Bianco			37,3888	13,2744
ITALY	del Tono				38,2390	15,2410
ITALY	Torre della Tonnara Dell'Orsa	Dell'Orsa			38,1833	13,1167
ITALY	Detta				38,1746	13,0821
ITALY	Capo d'Enfola	Enfola			42,8300	10,2600
ITALY	Favignana				37,9333	12,3333
ITALY	Fiume di Noto				36,8600	15,1220
ITALY	Flumentorgiu				39,6842	8,4383
ITALY	Fontane Bianche				36,9640	15,2100
ITALY	Formica				37,9880	12,4250
ITALY	Gallipoli				40,0500	17,9667
ITALY	Isola delle Femmine				38,2030	13,2410
ITALY	Isola Piana				39,1833	8,3167
ITALY	La Punta				38,1659	14,7485
ITALY	Langhione				38,7202	16,0742
ITALY	Magazzinazzi				38,0167	12,9333
ITALY	Marzamemi				36,7400	15,1160
ITALY	Mondello				38,1907	13,3362
ITALY	Oliveri				38,1458	15,1584
ITALY	Palma di Montechiaro				37,1711	13,7187
ITALY	Peloso				40,1367	8,4025
ITALY	Pizzo	Torre Pizzo	Torre di Pizzo		38,7333	16,1500
ITALY	Porto Paglia				39,2500	8,4167
ITALY	Porto Scuso				39,1833	8,3667
ITALY	Portopalo				36,6803	15,1365
ITALY	Pozzallo				36,7272	14,8487
ITALY	Puntanera				38,0383	12,8708
ITALY	S. Antonino				38,2390	15,2410
ITALY	S. Caterina				40,1333	17,9833
ITALY	S. Elia				38,0960	13,5400
ITALY	S. Giorgio				38,1667	14,9000
ITALY	San Cusumano				38,0547	12,5470
ITALY	San Giuliano Palazzo	S. Giuliano			38,0274	12,5266
ITALY	S. Giuseppe				36,7404	15,1271
ITALY	S. Nicolò	S. Nicola			38,0160	13,6160
ITALY	S. Panagia				37,1114	15,2520
ITALY	S. Vito lo Capo	Capo S. Vito			38,1890	12,7340
ITALY	Salicà				38,1200	15,1200
ITALY	Saline				41,0333	8,2667
ITALY	Santa Lucia				38,2183	15,2733
ITALY	Sciacca - Lo Tono				37,5050	13,0727
ITALY	Scopello				38,0768	12,8190
ITALY	Secco	Monte S. Giuliano			38,1670	12,7700
ITALY	Sibiliana				37,7204	12,4687
ITALY	Siculiana				37,3373	13,3868
ITALY	Solanto				38,0740	13,5430
ITALY	Terrauzza				37,0148	15,3040
ITALY	Tonnara Capo Altano				39,1833	8,3167
ITALY	Tono di Milazzo				38,2238	15,2211
ITALY	Torre Caldura				38,0360	14,0390
ITALY	Torre Cofano				38,1287	12,7155
ITALY	Torre Sant'Isidoro				40,2174	17,9222
ITALY	Torre Squillace				40,2325	17,9172
ITALY	Trabia				37,9970	13,6550
ITALY	Trabucato				41,0333	8,2667
ITALY	Vaccarella				38,2217	15,2408
ITALY	Vergine Maria				38,1650	13,3700
LIBYA	Bu Fatma				32,4350	14,9050
LIBYA	Dzeira				32,4175	15,0035
LIBYA	Gebbana Sidi Mahfud	Sidi Bilal			32,8030	12,8847
LIBYA	Marsa al Hamra	Marsa Beltan			32,7412	13,9860
LIBYA	Marsa Dila				32,7897	12,7415
LIBYA	Marsa Marrecan				32,8550	12,2333
LIBYA	Marsa Sabratha				32,7960	12,4870
LIBYA	Marsa Soman				32,7908	12,5585
LIBYA	Marsa Zwaga				32,9180	12,0930
LIBYA	Mellaha Ras Tagiura	Sidi Azus			32,9042	13,2923

Country	TrapName	TrapName2	TrapName3	TrapName4	Lat	Lon
LIBYA	Mongar el Chebir				32,1742	20,1033
LIBYA	Punta Lebdi				32,6375	14,3007
LIBYA	Ras el Msel	Ras el Mouen			32,6872	14,2365
LIBYA	Ras Lahmar	Gargaresch			32,8757	13,1363
LIBYA	Ras Urih				32,4383	14,8000
LIBYA	Sidi Abdul Gelil	Zanzur			32,8348	13,0003
LIBYA	Sidi Ryeia				32,4930	14,5702
LIBYA	Sidi Sbeh Lahman				32,7912	13,7237
MOROCCO	Bouknadel				34,1667	-6,8000
MOROCCO	Briech				35,6083	-6,0486
MOROCCO	Cab spartel				35,7603	-5,9500
MOROCCO	Capo Negro				35,8200	-5,2900
MOROCCO	Es Sahel				35,3028	-6,1944
MOROCCO	Garifa				35,5475	-6,0853
MOROCCO	Gharb				34,3958	-6,6750
MOROCCO	Jolot				35,0936	-6,2372
MOROCCO	Kenitra1				34,9736	-6,3083
MOROCCO	Kenitra2				34,8500	-6,3500
MOROCCO	Kenitra3				34,7625	-6,3953
MOROCCO	Las Cuevas				35,4567	-6,1150
MOROCCO	Los Cenizosos				35,3847	-6,1625
MOROCCO	Mabrouka				34,6667	-6,4833
MOROCCO	Mansouria				34,4833	-6,5333
MOROCCO	Mansouria2				34,5758	-6,5167
MOROCCO	Principe				35,0569	-6,2636
MOROCCO	Punta Negra				35,1517	-6,2311
MOROCCO	Tahad Art				35,6756	-6,0150
PORTUGAL	Abobora				37,1780	-7,4500
PORTUGAL	Abóbora II				37,0600	-7,4900
PORTUGAL	Almadana				36,9800	-8,8000
PORTUGAL	Armação Nova				37,0900	-7,4000
PORTUGAL	Arrifana				37,2900	-8,9500
PORTUGAL	Barril	Barril ou Tres Irmaos			37,0100	-7,6100
PORTUGAL	Beliche				36,9300	-9,0100
PORTUGAL	Bias				36,9300	-7,7500
PORTUGAL	Cabeço				37,0900	-7,4400
PORTUGAL	Cabo de Santa Maria				36,8700	-7,9500
PORTUGAL	Cabo dos Corais				36,9300	-8,9800
PORTUGAL	Sul do Cabo Carvoeiro				37,0850	-8,4520
PORTUGAL	Farol				36,8600	-7,8500
PORTUGAL	Farrobilhas				36,9500	-8,0900
PORTUGAL	Forte Novo				37,0610	-8,0890
PORTUGAL	Fuzeta				36,9400	-7,7300
PORTUGAL	Pedra da Galé	Galé			37,0790	-8,3140
PORTUGAL	Livramento	Senhora do Livramento			36,9800	-7,6400
PORTUGAL	Medo Branco	Ramalhete			36,9300	-8,0400
PORTUGAL	Medo das Cascas				37,0500	-7,6200
PORTUGAL	Olhos de Agua	Valongo			36,9900	-8,2100
PORTUGAL	Oura				36,9800	-8,2500
PORTUGAL	Pedras Negras				36,9300	-8,9300
PORTUGAL	Penedo do Sono				33,1100	-16,3500
PORTUGAL	Ponta do Burgau	Burgau			37,0630	-8,7890
PORTUGAL	Senhora Da Rocha				36,9900	-8,3700
PORTUGAL	Sol de Ponta de Zavial	Zavial			36,9700	-8,8600
PORTUGAL	Sul da Ponta da Baleeira				36,9500	-8,8800
PORTUGAL	Torre Alta				37,0954	-8,6577
PORTUGAL	Torre Altinha				37,0300	-8,6500
PORTUGAL	Torre da Barra				37,0852	-8,5146
PORTUGAL	Torre d'Ares				36,9300	-7,7800
PORTUGAL	Torre d'Aspa				37,1158	-8,9497
PORTUGAL	Vau				37,0100	-8,6000
TUNISIA	Bordj Kadidja				35,2180	11,1620
TUNISIA	Cap Zebib				37,2680	10,0660
TUNISIA	Conigliera				35,7551	11,0132
TUNISIA	El Aouaria				37,0500	11,0100
TUNISIA	Kuriat				35,8000	11,0300
TUNISIA	Monastir				35,7700	10,8300
TUNISIA	Ras el Ahmar				37,0500	10,9000
TUNISIA	Sidi Daoud				37,0200	10,9000
TURKEY	Istanbul port				40,9871	28,9820

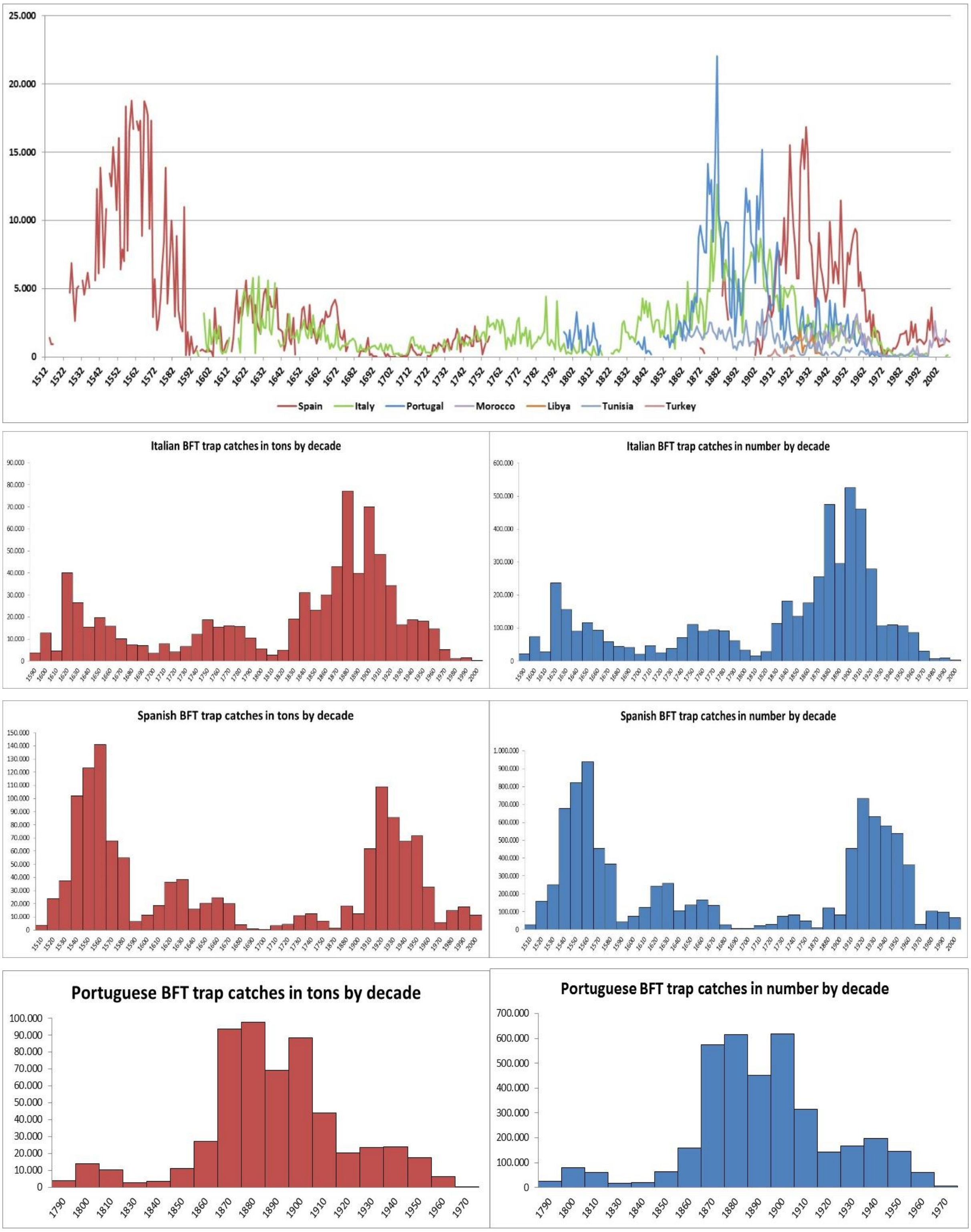

Figure 1. Historical traps data recovered by GBYP. The upper graph shows the total catch by year for all traps by country in weight (tons) for the period 1512-2009. The following graphs show, from the top to the bottom, the catches for Italy (1595-2008), Spain (1512-2009) and Portugal (1797-1972); the graphs on the left (red columns) show the catches in tons, while on the right (columns in blue) the catches are in number of fish.

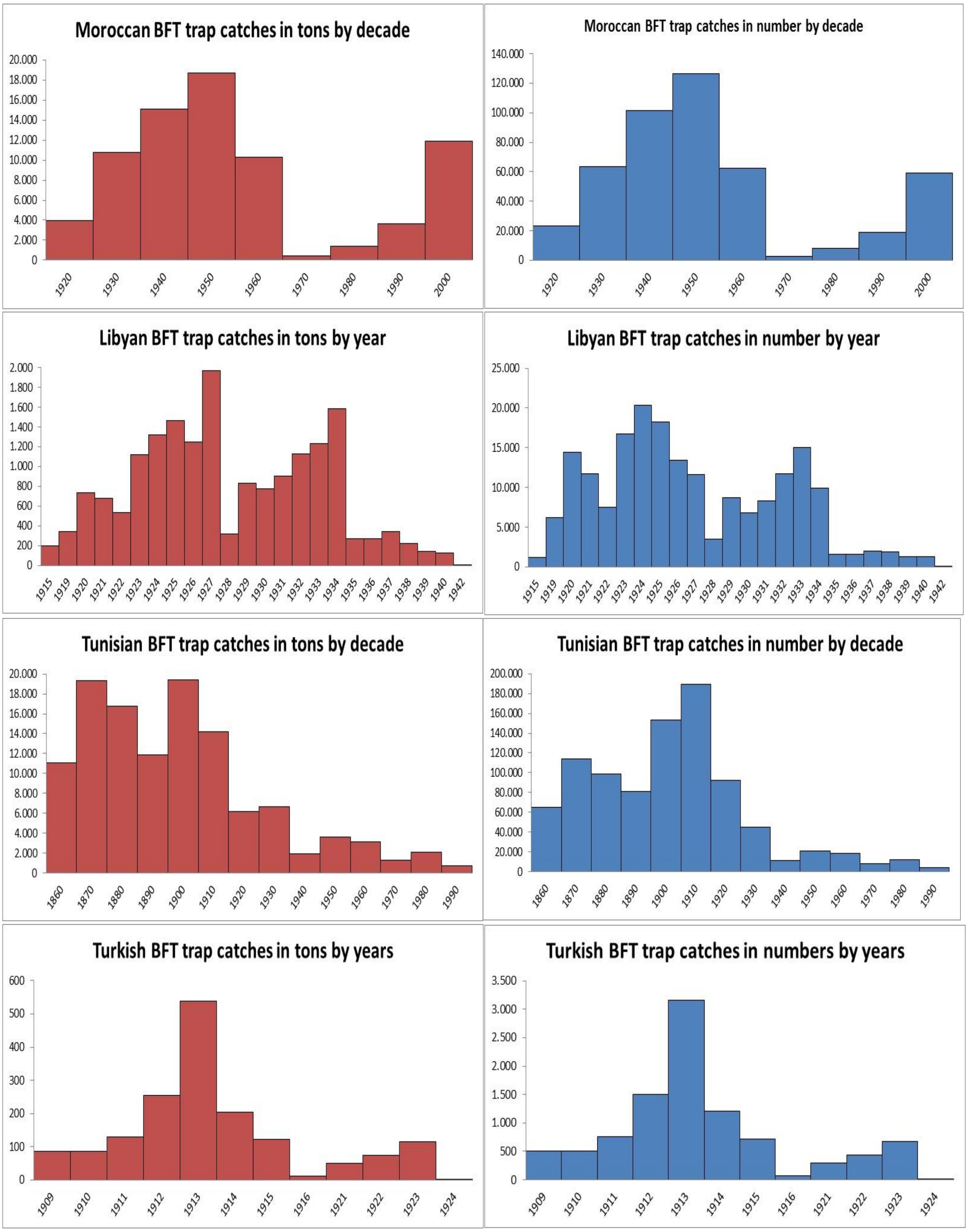

Figure 2. Historical traps data recovered by GBYP. The graphs show, from the top to the bottom, the catches for Morocco (1927-2007), Libya (1915-1942), Tunisia (1863-1997) and Turkey (1909-1924); the graphs on the left (red columns) show the catches in tons, while on the right (columns in blue) the catches are in number of fish.

3.3 Genetic Data Mining

Following the first activity carried out in Phase 4, which provided a preliminary overview of the effective opportunities for recovering historical samples of bluefin tuna bones over a long period of time and the feasibility of genetic analyses, the GBYP Steering Committee recommended extending the previous contract. A new short-time contract was provided to the same team who carried out the first set trial, with the objective of extending and completing these important genetic analyses on historical bluefin tuna samples.

During GBYP Phase 4 and 5, novel molecular techniques were developed, and DNA has been extracted in Phase 5 from Atlantic bluefin tuna (BFT) vertebrae excavated from late Iron Age and ancient Roman settlements in coastal Iberia (Portugal and Spain, 4th-2nd century BC, n=65) and Byzantine-era Istanbul (4th-15th century AD; n=60), as well as vertebrae from the Massimo Sella archive located at the University of Bologna (Ionian, Tyrrhenian and Adriatic Seas, early 20th century; n=145).

Comparing the genetic code of modern (n=291) and ancient samples reveals details on the evolution of the species genome, possibly in response to nearly two millennia of fisheries pressure, a changing climate and pollution of the sea, but at the same time the analyses do not show any evidence of genetic erosion. Comparisons have been made between the amount of DNA contained in each sample (measured via quantitative polymerase chain reactions), their age and environmental conditions. A high performance genotyping panel containing SNPs has been designed for the purpose of genotyping historical and modern samples collected from the same geographic areas.

SNPs selected for the panel show significant discrimination between the genome within modern populations and/or align with a variety of genes associated with the musculoskeletal system, development, metabolism, cellular function, osmoregulation and immune response. Most historical samples were successfully genotyped; however, the samples from Roman-era Iberia performed poorly.

The results revealed a degree of differentiation between modern and historical samples as well as an overall and significant divergence of modern samples from the Western Atlantic and samples from the Eastern Atlantic and Mediterranean. Within the Mediterranean, some pairwise comparisons involving samples from the Adriatic and Levantine Seas are showing partial differences that should be further understood (**Figure 3** and **Figure 4**). This pattern with patched and sporadic significant differences does not solidly support the existence of temporally persistent subpopulations within the Mediterranean.

Overall, the project aims have been achieved, with a very high success rate of genotyping among modern samples and an impressive number of ancient samples effectively genotyped. The failure of several loci to be genotyped by historical samples may be related to other changes in the genome that are not associated with the SNP loci themselves but with the sequence regions that flank the polymorphic sites.

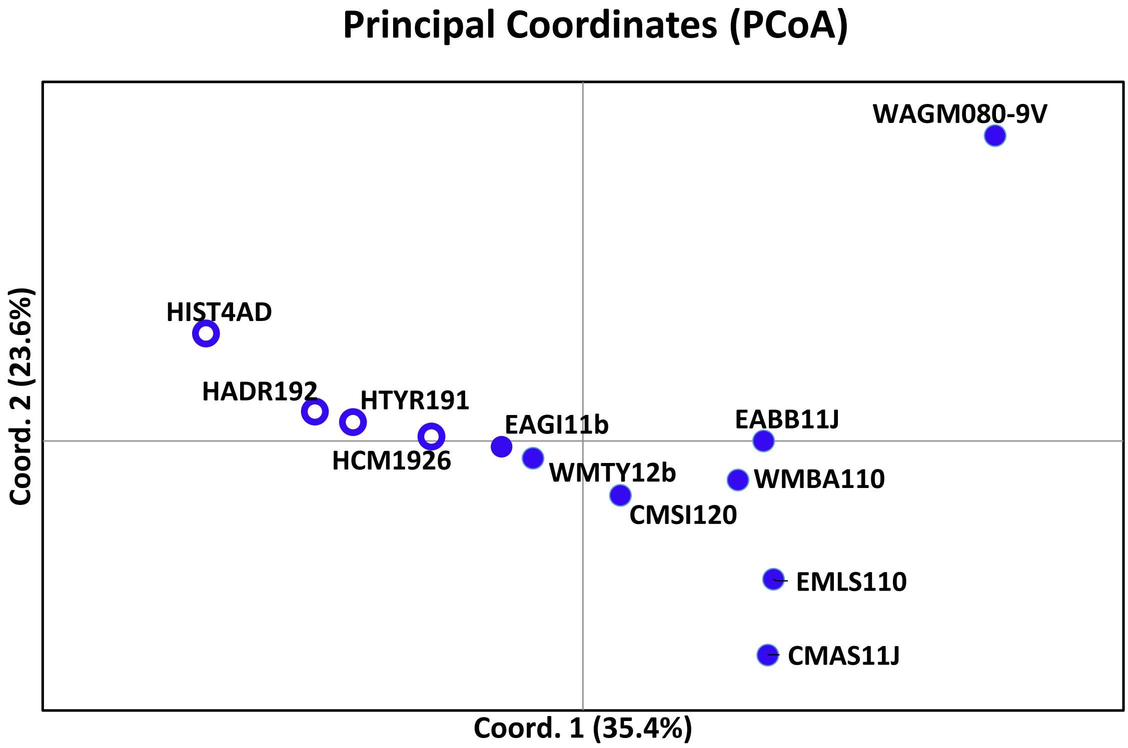

Figure 3: Principal coordinates analysis (PCoA) showing clustering of historical samples and isolation of samples from the Gulf of Mexico and the Levantine and Adriatic Seas.

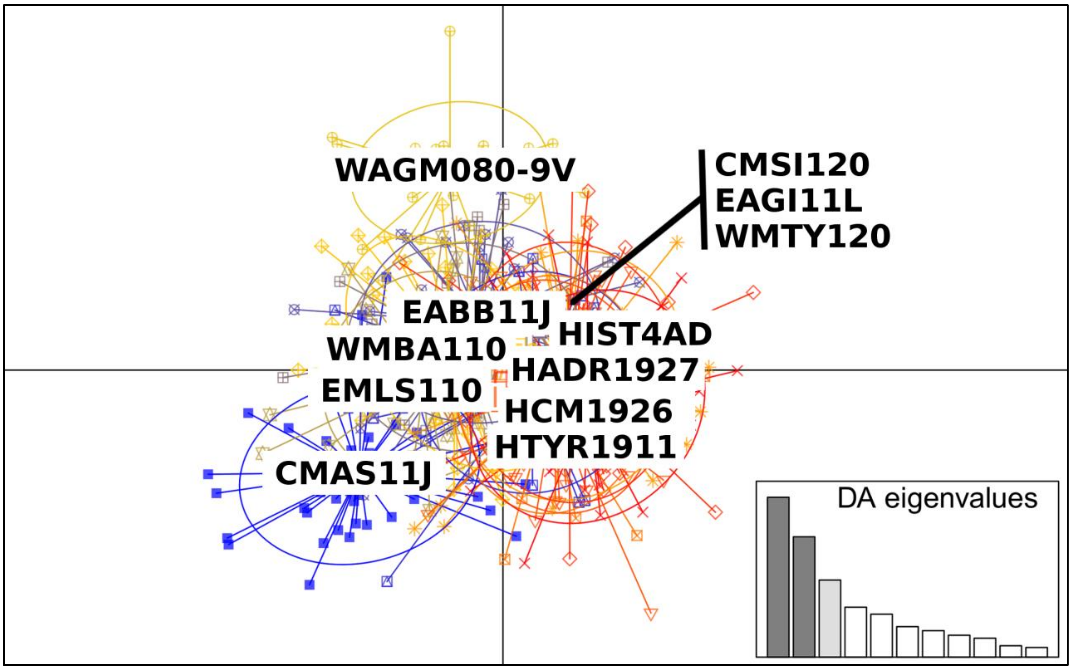

Figure 4: Discriminant analysis showing clustering of historical samples and isolation of samples from the Gulf of Mexico and the Levantine and Adriatic Seas.

Additional sequencing of these regions may be warranted, as they seem to be diagnostic of historical samples as well as individuals from the Tyrrhenian Sea. The DNA extracted from the historical samples has shown a great deal of promise and should continue to be studied. Ample powder was collected from each bone for several more extractions. Bones, extracted DNA and bone powder remain archived at the University of Bologna in ideal conditions for long term storage.

Preliminary results from this contract in Phase 5 were presented to the SCRS in September 2015 (SCRS/2015/144, **Annex 1b, document no. 16**), the reports on this activity are listed in **Annex 1a** (**documents 2** and **3**), while scientific papers were also produced by the contractor (**Annex 1b**, **documents 1, 10** and **11**).

3.4 Trade, auction and marked data validation

As agreed by the SCRS, the part of trade, auction and market data, which were validated by an external expert contracted by the GBYP in Phase 4 (**Figure 5**), were officially considered fully validated, without the need of forming any specific expert group for further data examination, as initially planned.

Data sets, in their original format did not comply with the requirements for the direct incorporation into the ICCAT data base and therefore an additional work needed to be undertaken to modify and adapt them accordingly, in Phase 5. The GBYP Coordination made some minor modifications in the content and modified the format of the data, following the precise instructions and requirements of the ICCAT Statistical Department and provided the processed data to ICCAT, for incorporating them in the ICCAT data base.

The remaining part of the trade, auction and market data sets, which are not considered fully reliable because they were not validated (form 3 of the sets), are kept in a separate data base, which is not public, and are subject to possible additional validation against statistical documents, BCDs or other support documentation, a work which would need much more additional time and efforts, and that would require the strict cooperation of the CPCs concerned, national experts and the ICCAT Secretariat.

According to the request made by the ICCAT GBYP Core Modelling MSE Group during its last meeting in Monterey, the data coming from the first two data sets validated so far, limiting them to those bluefin tunas having RW and GGW individual data, shall be prepared and submitted by GBYP to the SCRS Bluefin tuna Data Preparory Meeting in 2016, in GBYP Phase 6, for improving the size frequencies for the EBFT, after the removal of many previously used data sets which were considered not reliable.

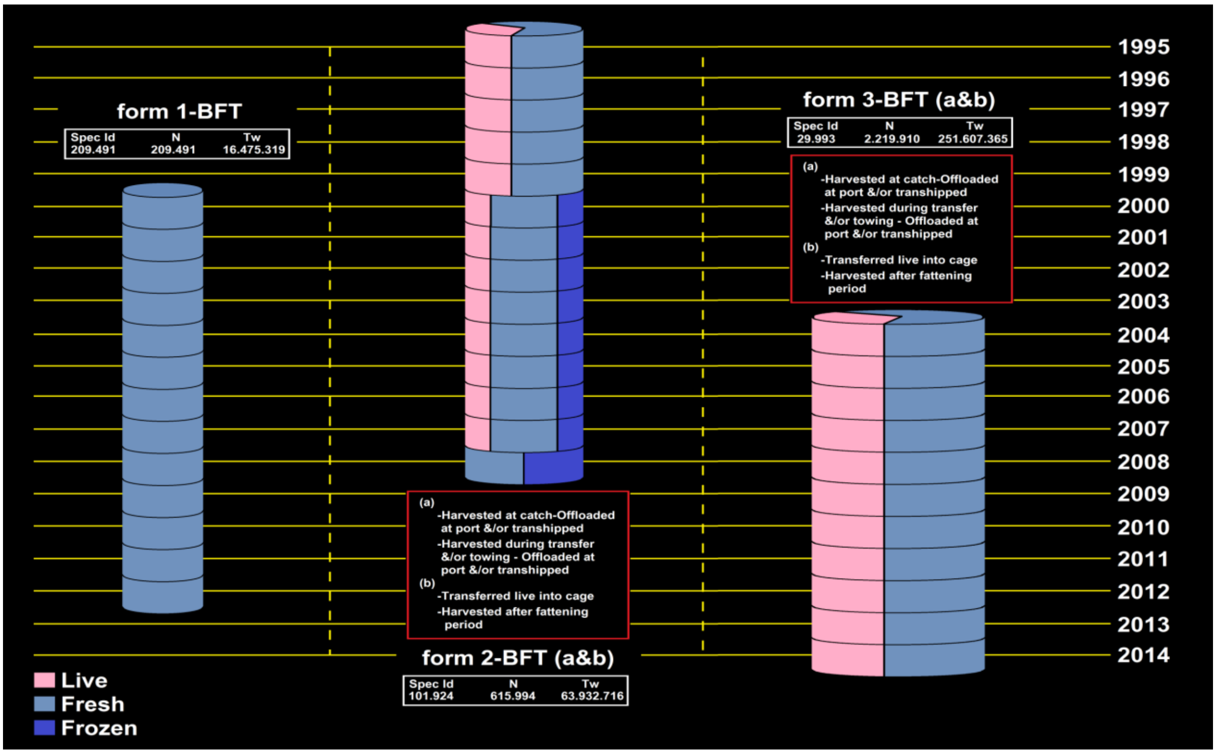

Figure 5: Chronology and structure of trade, auction and marked data (form1, form2 and form3) recovered by GBYP for the period 1995 to 2014. The data that were validated by the SCRS were included in form 1 and 2, but it was decided to use only data coming from fish under certain physical conditions (RW or GGW).

3.5 BFT Data Preparatory Meeting

A Bluefin tuna data preparatory meeting was organised by the SCRS, with the support of GBYP, in Madrid on 2-6 March 2015, at the early beginning of Phase 5. The meeting was attended by 42 scientists (plus the ICCAT Secretariat staff), including most of the members of the GBYP Steering Committee and several members of the GBYP Core Modelling MSE Group. The GBYP provided several documents and presentations about the pertinent data that were proposed to the group for consideration. The report of the meeting is attached (**Annex 1a, document no. 4**).

4. Aerial Survey on Bluefin Tuna Spawning Aggregations

4.1 Objectives of the aerial survey for bluefin tuna spawning aggregations

ICCAT GBYP Aerial Survey on bluefin spawning aggregations was initially identified by the Commission as one of the three main research objectives of the Programme, in order to provide fishery-independent trends on the minimum SSB. The original GBYP programme included only a total of three annual surveys over a maximum of three different areas, but this plan was later modified by the Steering Committee and the statistical study revealed that under the best possible conditions a minimum of six surveys will be necessary for detecting a trend with an acceptable CV level. The total original budget, set for 3 surveys in 3 areas, was 1,200,000 euro; the costs for carrying out the first 4 surveys in much more areas (up to 4 main "internal" areas and 7 "external" areas) are about 1,619,624 euro (134.97% of the original budget, but with much more than the double of the activities initially planned). So far, the GBYP objectives initially set for the aerial survey on spawning aggregations in these first Phases have been largely accomplished.

Two surveys on four selected areas have been carried out in GBYP Phase 1 and Phase 2, with many transect replicates. In Phase 2 the protocols were changed by the Steering Committee and it was made mandatory the use of bubble windows on all aircrafts. The aerial survey activity was suspended in Phase 3, following the recommendation by the GBYP Steering Committee, because it was requested an extended survey all over the potential Mediterranean spawning areas, which covers about 90% of the Mediterranean Sea surface, and because sufficient funds were not made available.

The paper SCRS/2012/149 (**Annex 1b, document no. 21**), among other biological contents concerning bluefin tuna, presented a summary of the available scientific knowledge also on the spawning areas in the Mediterranean Sea, including a map, which was used by GBYP and the SC. At the end of Phase 3, under the GBYP Modelling item, it was possible to have a study for assessing the feasibility of a large-scale aerial survey on bluefin tuna spawning aggregations in the Mediterranean Sea for obtaining useful data for operating model purposes, following the views of the SC (see: http://www.iccat.int/GBYP/Documents/MODELLING/PHASE%203/Aerial_Survey_Feasibility_Study_Phase3.pdf) and this document was used as the base for developing a third aerial survey in Phase 4.

The extended survey was conducted in 2013 and the results were presented to the SCRS and the Commission. This was the first extended aerial survey conducted in more than 60% of the Mediterranean Sea, under very difficult situations, and using a budget that was not proportionally increased for keeping the same effort on the four main areas; therefore, the replicates in the main areas (defined as "inside") were much less, while they were reduced to the minimum in the additional areas (identified as "outside"). Even in this survey, security and permit problems have been serious constraints.

Due to severe budget constraints, it was impossible to carry out any aerial survey in 2014, during the extension period of Phase 4.

The GBYP Steering Committee, in September 2014, included again an extended aerial survey within the activities of Phase 5; this survey included 7 extended areas and 4 main areas. In the very last part of Phase 4, after the meeting of the GBYP Steering Committee in February 2015, a further analyses of the previous data was requested, for better assessing any variance possibly induced by the use of bubble windows since 2011 and the various types of aircrafts, and the study was included in the final report of GBYP Phase 4 for the EU. The possible use of a calibration exercise was discussed at the same meeting and a first draft on a SWOT analyses was presented by the GBYP coordination (SCRS/2015/143, **Annex 1b, document no. 15**). This preliminary document was therefore discussed by mail with some well-known experts in aerial survey (Dr. Phil Hammond and Dr. Greg Donovan), who shared the contents, and therefore revised and presented to SCRS at the 2015 BFT Species Group meeting. The main results of the SWOT analysis indicates that a calibration for an aerial survey which uses so many pilots and spotters of different nationalities is not feasible, also taking into account the many legal constraints. Furthermore, a calibration limited to the rotation of scientific spotters (when feasible) would concern only one of the many variance factors which can bias an aerial survey. The GBYP Steering Committee, after many discussions, finally confirmed the agreement to include again the extended aerial survey in the activities of Phase 5, and a map of areas to be surveyed was designed for that purpose (**Figure 6**).

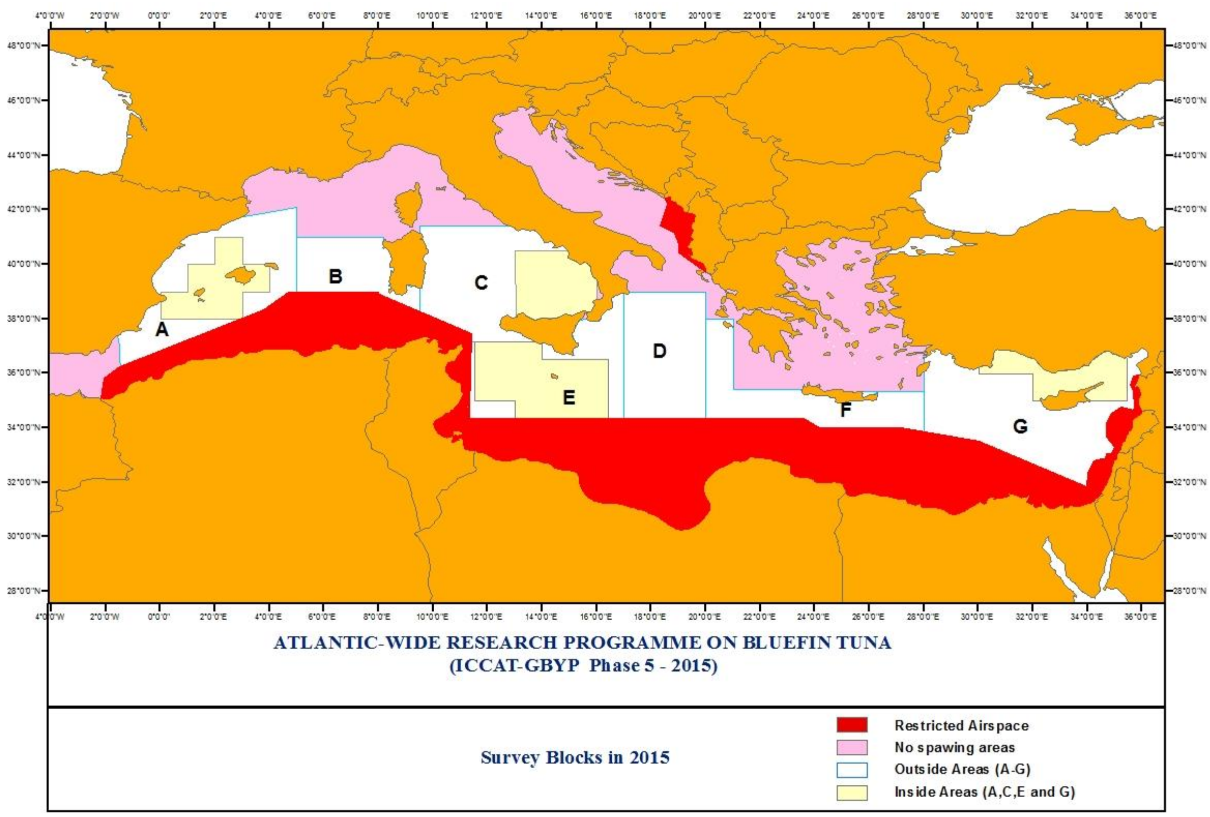

Figure 6. Blocks identified through the aerial survey design for the purpose of 2015 GBYP aerial survey on spawning aggregations.

4.2 The revision of the aerial survey design for Phase 5

Following the recommendation of the GBYP Steering Committee and taking into account the new map, it was agreed to extend the contract for the aerial survey design to the same entity who made it in previous years. The design was revised always following the DISTANCE methodology, according to the approach which was recommended by the Steering Committee, trying to balance the limited budget with the relevant research needs of an extended survey. The study provided a design for the 4 most documented spawning areas ("inside") already surveyed in previous years, having a more dense number of transects (two replicates), and a less dense design for the 7 other areas ("outside"). The design was made with additional tracks, in order to provide opportunities when necessary (**Figure 7**). At the same time, the team in charge of the design was ready to provide modified tracks in case of any problem or need.

The design was provided with the maximum urgency (**Annex 1a**, **document no. 5**) and, after the agreement of the Steering Committee, it was attached to the Call for tenders.

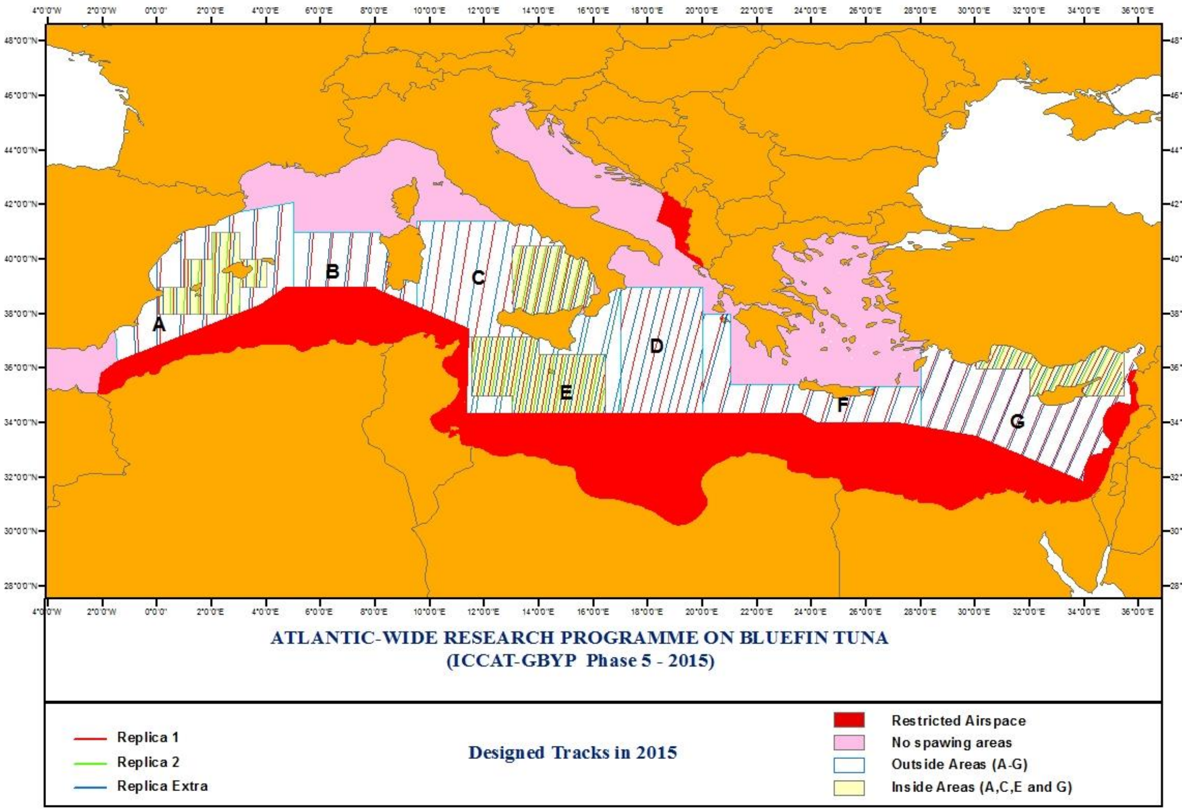

Figure 7. Designed transects for Aerial Survey 2015

4.3 The aerial survey for bluefin tuna spawning aggregations in Phase 5

This year, for the first time, the Call for tenders for the aerial survey (ICCAT GBYP 03/2015, ICCAT Circular 1796 on 8 April 2015) was set for two different activities, as requested by the Steering Committee: activity A for providing aircrafts, pilots and one scientific spotter for each aircraft, and activity B for providing only professional and scientific spotters to be rotated among the areas. Some tenders provided offers for both components together, because of the legal problems existing for taking on board crew members from other companies and for all the complex procedures linked to the flight permits. Therefore, after additional consultation with the Steering Committee, three companies were awarded the contracts for various areas, but for A and B components together.

A training course for pilots, professional spotters and scientific observers was organised at the ICCAT Secretariat in Madrid, on 26 May 2015, attended by 21 fellows (pilots, professional spotters, scientific spotters and GBYP staff), trained by two external experts (Dr. A. Cañadas and Dr. J.A. Vasquez) and by the GBYP Coordinator (**Annex 1a**, **document no. 6**). The new GBYP Protocol for Aerial Survey for Bluefin Tuna Spawning Aggregation (**Annex 1b**, **document no. 7**), provided by the two expert, was reviewed by GBYP and officially circulated among all the contractors and the GBYP Steering Committee.

Once awarded the contracts (on May 14, 2015), the ICCAT Secretariat immediately informed all concerned CPCs and assisted all contractors in all procedures for getting the necessary permits, because the field activities were planned to begin on 1 June 2015. This work needed a continuous assistance by the GBYP Coordination, because of the many delicate aspects concerned and many daily difficulties encountered for various reasons. Tunisia, after several letters and besides of the many interventions of the ICCAT Executive Secretary, the GBYP staff and the efforts made by the Companies, provided a letter of availability for providing a flight permit[4] which arrived too late, on 3 July 2015, just two days before the final date for finalising the survey. Therefore, it was impossible to survey the Tunisian FIR.

One of the major difficulties was obtaining the permits for documenting the sightings with photos, because these permits are under the control of various different authorities. These permits, in some cases, caused a delayed beginning of the survey activities in some areas. It was necessary to partly readapt the survey design of areas C, E and G, taking into account the lack of permit from the Tunisian authorities and the need to cut few coastal areas in the Turkish air space, according to specific requests of the Turkish authorities for safety reasons or for other flight restrictions. A Turkish observer was available for surveying the Turkish air space and he was taken on board of the aircrafts operating in the eastern Mediterranean.

Additional problems were registered in 2015, due to the few number of airports having the right type of fuel for some aircrafts, the unexpected limitation of fuel quantities in Malta (which created serious limitation to the autonomy of the aircrafts and therefore the maximum range for the survey), the impossibility to flight outside the national air space when the take-off was done from a non-international airport, the need to provide well in advance the list of crew for each aircraft for clearance reasons, the limitation for carrying on board cameras when high security circumstances suddenly occurred (like in the island of Pantelleria, Italy). All these constraints caused a

[4] The release of the permit was conditioned upon the obligation to leave for the survey from a Tunisian airport, to take on board local observers, with the prohibition to use cameras and the obligation to provide the data.

strong impact on the logistics in various areas and the need for a continuous assistance at any time of the day, including week-ends and at night, by the GBYP coordinator.

Several times, in 2015, the aircrafts operating in various areas for ICCAT GBYP survey were approached and checked by military aircrafts belonging to various countries.

The survey was carried out using a total of 6 aircrafts, 4 Partenavia P68 of various types and 2 Cessna F377G. Other four aircraft were kept in stand-by in case of need, as reserve. Each aircraft had a specific ICCAT identification number and this number was communicated to the national authorities concerned, along with the associated crew list. The surface to be surveyed was about 1,284,859 km^2 (312,491 km^2 of “inside” areas and 972,368 km^2 for “outside” areas), representing about 54.35% of the whole surface of the Mediterranean Sea, a surface never covered by any other scientific survey in the Mediterranean. Furthermore, this last survey covered about 87.6% of the total potential areas where spawning of bluefin tuna may even occasionally occur. The total length of transects was 25,493 km (14,404 km in “inside” areas and 11,079 km in “outside” areas.

Strong winds, scarce visibility, bluefin tunas travelling well below the surface (many purse-seiners got most of the catches by fishing with sonar in 2015) due to abnormal extreme oceanographic conditions[5] and military activities have been operative and environmental problems that caused troubles for the survey in some areas.

It is important to note again that this very extended aerial survey, even considering the various limitations and problems, was possible only thanks to the remarkable help of various national officers in the many CPCs concerned and the extreme good-will and availability of all the three Companies and crew contracted by ICCAT GBYP, and also of the team in charge of the survey design.

4.4 Elaboration of Aerial Survey Data

At the end of the survey, each Company provided a report for each area, including the excel forms with the detailed data on sightings. A contract for elaborating the 2015 aerial survey data was provided to the same team which carried out the same type of analysis in previous years, after inviting three different team of experts (one never responded, while another one decided not to submit a bid). The GBYP staff carried out a quality check of each report, while the detailed data were checked directly by the external experts, cross-validating them with a continuous direct contact with the observers, whenever this was necessary. Some files had various problems, particularly those provided by a team of French spotters, and it was necessary to cross-check the data directly with the spotters and the company; this specific problem created a considerable delay for the data elaboration. The results of this study are now available on http://www.iccat.int/GBYP/en/asurvey.htm .

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[5] See document SCRS/2015/154, considering that July 2015 was the hottest so far in the Mediterranean Sea in the history of oceanographic records.

The survey revealed that most of the school sightings were concentrated in the areas initially selected by GBYP for conducting the surveys in 2010 and 2011 (which were also the "inside" areas of the extended survey (**Figure 8**), confirming the full validity of the initial choice based on scientific knowledge and recent fishery data obtained by a VMS analyses of the purse-seiners activities from 2007 to 2009. Only very few sightings were made in other areas where spawners usually travel not so close to the surface.

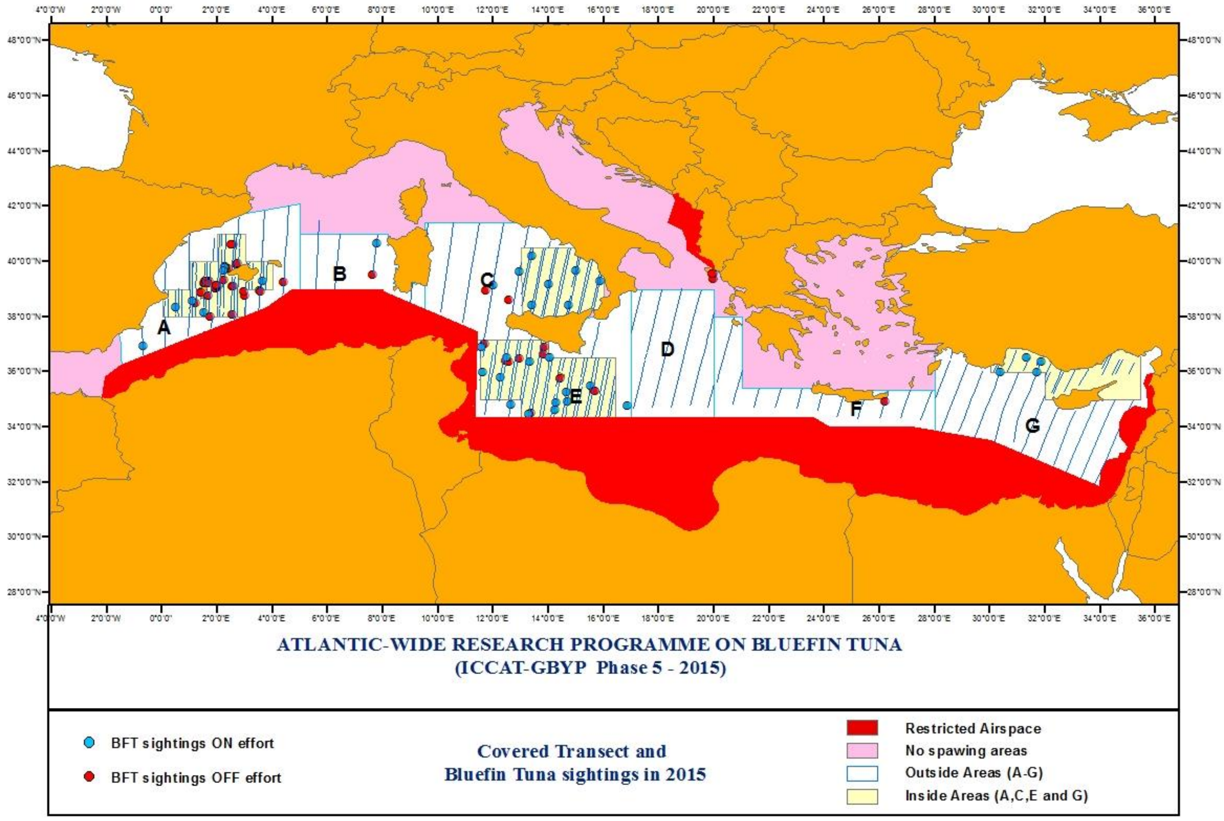


Figure 8. Transects flown on effort and sightings of bluefin tuna on and off effort.

One exception, in 2015, was in the area between East Algeria, North Tunisia, western Sicily and SW Sardinia, where a huge schools of spawners (estimated at about 15,000 fish in total, maybe one of the biggest aggregation of bluefin tuna reported so far in the Mediterranean) was spotted at the surface and this event was confirmed also by the contemporary presence of a bluefin tuna electronically tagged by GBYP in Morocco (see paragraph 4.5). This area is not usually one of the main spawning areas, because of the Mediterranean water circulation, even if some historical papers report the occasional presence of spawners.

The logistic of such an extended survey was extremely complex and long transfers had a very serious impact on the effective available effort on transects and on the related CVs, which showed a remarkable increase in the last two surveys, when the extended strategy was requested by the Steering Committee, while the number of replicates necessarily decreased, due to budget constraints. As a matter of fact, the total number of flight hours was about 385 h, which implied flying over 25,493 km on designed transects, although the total amount of flight effort (including logistic flights) was more than three times bigger. **Tables 7, 8** and **9** show the results of the aerial survey in total and in both “inside” and “outside” areas.

Table 7. Mean school size, density and total weight and abundance of bluefin tuna for the total “inside” and “outside” sub-areas in 2015.

Sub-area	2015 ‘inside’	2015 ‘outside’	TOTAL
Survey area (km^2)	312,491	972,368	**1,284,859**
Number of transects	44	47	**91**
Transect length (km)	14,413	11,079	25,493
Effective strip width x2 (km)	5.0	5.0	5.0
Area searched (km2)	46,740	35,928	82,668
% Coverage	15.0	3.7	6.4
Number of schools	25	8	33
Encounter rate of schools	0.0017	0.0007	0.0013
%CV encounter rate	30.5	44.8	25,2
Density of schools (1000 km^{-2})	0.941	0.507	0.613
%CV density of schools	29.1	57.1	31.5
Mean weight (t)	140.2	592.9	257.6
%CV mean weight	26.6	68.1	42.5
Mean cluster size (animals)	**827**	**3,319**	**1,473**
%CV mean cluster size	19.7	59.2	36.6
Density of animals	**1.329**	**1.191**	**1.225**
%CV density of animals	42.9	83.0	66.0
Total weight (t)	**70,412**	**212,887**	**283,299**
%CV total weight	53.4	103.8	72.9
Total abundance (animals)	**415,301**	**1,158,043**	**1,573,344**
%CV total abundance	42.9	83.0	66.0

Table 8. Mean school size, density and total weight and abundance of bluefin tuna for each "inside" sub-area.

		Sub-area				
		A	C	E	G	TOTAL
Survey area (km²)		62,150	64,610	117,718	68,013	**312,491**
Number of transects		15	7	12	10	**44**
Transect length (km) (L)		4,143	3,237	5,862	1,172	14,413
Effective strip width x2 (km)		5.0	5.0	5.0	5.0	5.0
Area searched (km²)		13,435	10,496	19,010	3,799	46,740
% coverage		21.6	16.2	16.1	5.6	15
Number of sightings (n)		7	3	13	2	25
Encounter rate of schools	**n/L**	0.0017	0.0009	0.0022	0.0017	0.0017
	CV (%)	37.9	60.5	26.1	70.6	30.5
Density of schools (km²)	**Density of schools**	0.521	0.286	1.203	0.723	0.941
	CV (%)	40.2	61.9	29.7	71.1	29.1
Weight (tonnes)	**Mean weight**	160.7	190.0	391.62	9.0	**140.2**
	CV (%)	11.7	19.9	54.76	66.7	26.6
School size (animals)	**Mean school size**	708	1,533	2,030	600	**827**
	CV (%)	19.8	19.0	56.83	66.7	19.7
Density of animals (per km²)	**Density of animals**	0.369	0.438	2.442	0.478	**1.329**
	CV (%)	44.8	64.8	64.1	98.3	42.9
Total weight (tonnes)	**Total weight**	**5,419**	**3,654**	**56,004**	**484**	**70,412**
	CV (%)	40.4	65.2	62.3	98.2	53.4
	Lower 95% CL	2,449	1,099	16,957	55	
	Upper 95% CL	11,991	12,150	184,960	4,265	
Total abundance (animals)	**Total abundance**	**22,912**	**28,317**	**287,420**	**32,523**	**415,301**
	CV (%)	44.8	64.8	64.1	98.3	42.9
	Lower 95% CL	9,814	8,569	84,285	3,688	
	Upper 95% CL	53,491	93,569	980,150	286,780	

As it was expected, most observations of bluefin tuna schools occurred in "inside" areas; in fact with 23% less effort in the outside sub-areas, there were 68% less observations, 41% less encounter rate and 54% less density of schools than in the inside sub-areas. This survey was considered quite cost/effective, another good result obtained also thanks to some complimentary flight time or specially reduced costs and besides of the logistics.

Additionally, an analyses on overlapping "inside" areas over the four surveys (Figure 9) was carried out, because it was supposed that looking at the same areas over the differ years may possibly provide a more homogenous comparison, even if further standardisation might be necessary, because the number of replicates or coverage was different in the various surveys. The final results are shown on **Table 10**.

Table 9. Mean school size, density and total weight and abundance of bluefin tuna for each "outside" sub-area.

		Sub-area							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**TOTAL**
Survey area		123,351	87,334	149,607	147,666	92,378	130,585	241,447	**972,368**
Number of transects		8	6	6	6	2	11	8	**47**
Transect length (km) (L)		1,508	888	1,866	2,122	284	1,171	3,241	**11,079**
Effective strip width x2 (km)		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Area searched (km2)		4,889	2,880	6,051	6,881	922	3,797	10,509	35,928
% coverage		4.0	3.3	4.0	4.7	1	2.9	4.4	3.7
Number of sightings (n)		2	2	1	1	1	0	1	7
Encounter rate of schools	**n/L**	0.0013	0.0023	0.0005	0.0005	0.0035		0.0003	0.0007
	CV (%)	72.2	73.7	105.2	101.4	97.1		103.0	44.8
Density of schools (per sq km)	**Density of schools**	0.719	1.221	0.291	0.256	1.908		0.167	0.507
	CV (%)	73.5	75.0	106.1	102.3	98.1		103.9	57.1
Weight (tonnes)	**Mean weight**	240.0	1575.0	300.0	200.0	0.3		20.0	**592.9**
	CV (%)	50.0	90.5						68.1
School size (animals)	**Mean school size**	1,400	7,800	2,500	1,000	8		1,333	**3,319**
	CV (%)	42.9	92.3						59.2
Density of animals (per sq km)	**Density of animals**	1.007	9.527	0.727	0.256	0.015		0.223	**1.191**
	CV (%)	85.1	119.0	106.1	102.3	98.1		103.9	83.0
Total weight (tonnes)	**Total weight**	**21,513**	**169,700**	**13,176**	**7,625**	**57**		**816**	**212,887**
	CV (%)	88.9	117.5	106.1	102.3	98.1		103.9	103.8
	Lower 95% CL	3,861	7,090	2,210	1,294	8		146	
	Upper 95% CL	119,870	4,061,300	78,545	44,919	417		4,572	
Total abundance (animals)	**Total abundance**	**124,250**	**832,060**	**108,710**	**37,746**	**1,410**		**53,867**	**1,158,043**
	CV (%)	85.1	119.0	106.1	102.3	98.1		103.9	83.0
	Lower 95% CL	25,424	31,921	18,238	6,408	193		9,618	
	Upper 95% CL	607,170	21,688,000	648,010	222,350	10,315		301,680	

There seems to be large inter-annual variations as well as geographical variations. Overall, pooling all areas together, there is a strong interannual variability both in terms of total weight and density of animals (and taking into account that sub-area G was not surveyed in 2011, the variability may be even larger). In 2010 the total weight (density of animals not being available due to the lack of information that year on cluster size) was almost half as that in 2011, but still much larger than in 2013, but in 2015 we observe the highest total weight of all years, much larger than in 2011. In terms of abundance of animals, 2011 has the larger estimate (and even more considering that area G was not surveyed that year), decreasing to around one third in 2013 (considering only A, C and E) but increasing again to less than two thirds in 2015.

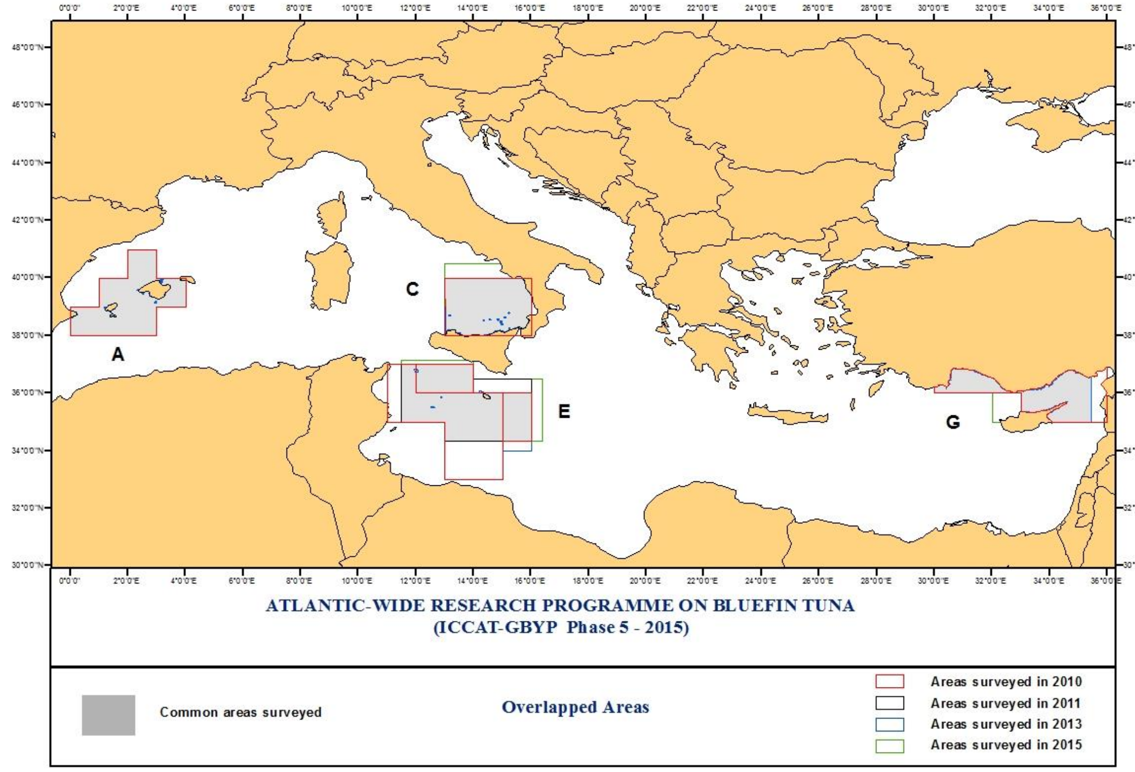


Figure 9. Overlapped Survey blocks for the four GBYP aerial surveys.

As noted before, the quantities registered by the survey were also negatively biased by the particular oceanographic situation in 2015. On the opposite, large schools were noticed close to the surface in outside areas where they were not usually seen, but were transits to or from the main spawining areas logically happen. A delay of about three weeks in spawning aggregations was noticed in several areas and this was totally unpredictable when the survey was launched. Fishery patterns in June 2015 confirmed this abnomalous situation.

Clearly, these are the “normal” variance factors when carrying out an extended survey in a fixed period (which was set according to the peak of bluefin tuna spawning in June, as it is known since a couple of centuries, Piccinetti *et al*., 2013). This effect shold be smoothed in a sufficiently long series of surveys if oceanographic conditions get close to the usual average over most of these years.

In 2015, for the first time, it was checked the possibility to include into the analyses also the additional variance, considering the variable amount of time tuna spends in the upper layer of the water where it can be visible from the airplane. For this purpose, it was presumed that electronic tag data can be used for calculating the average amount of tima tuna spent in upper sea layer in spawning areas during the spawning season.

Some preliminary tests were done on the data obtained by several electronic tags deployed in the most recent years and a first paper (SCRS/2015/146, **Annex 1b**, **document no. 17**) proposing a methodological approach was submitted to the SCRS.The detailed report for the aerial survey activity in 2015, based also on the provisional results of the preliminary analyses, was already provided by SCRS/2015/147 (**Annex 1b**, **document no. 18**). A detailed analysis of the additional variance was executed and for this purpose two sets of additional variance have been used: one that comes from evaluating spatial and vertical differences between spawning seasons using electronic tagging data and the other one from the results of the software Distance using a joint model between the density and the school size. The results show that there is a great spatial (inter-area) and temporal (inter-annual) variability, that has a big impact on the final CV, what is further confirmed by the power analysis.

Table 10. New assessment of Bluefin tuna spawning aggregations in the four main areas ("inside"), after the revised calculation for the overlapping surfaces. The different surface in 2011 was caused by the lack of permit in area G and therefore by the lack of data for this area and year.

All sub-areas				
Year	**2010**	**2011**	**2013**	**2015**
Survey area (km^2)	265,627	209,416	265,627	265,627
Transect length (km)	29,967	26,247	14,862	12,046
Effective strip width x2 (km)	2.96	1.36	3.00	3.03
Area searched (km^2)	88,803	35,697	44,539	36,556
% coverage	33.4	17.0	16.8	13.8
Number of schools ON effort	76	65	52	24
Abundance of schools	328	420	397	147
%CV abundance of schools	23.3	20.6	22.0	33.0
Encounter rate of schools	0.0025	0.0025	0.0035	0.0020
%CV encounter rate				20.2
Density of schools (1000 km^{-2})	1.236	2.004	1.494	0.553
%CV density of schools	23.3	20.6	22.0	33.0
Mean weight (t)	87.9	101.1	52.5	272.2
%CV weight	1.7	2.8	1.8	41.4
Mean cluster size (animals)		1,275	582	1,548
%CV abundance		37.3	18.5	40.5
Density of animals (km^{-2})		**2.8363**	**0.789**	**1.556**
%CV density of animals		30.0	30.4	46.9
Total weight (t)	**26,882**	**45,639**	**17,818**	**70,256**
%CV total weight	25.6	28.7	30.1	49.4
L 95% CI total weight	14,243	26,133	9,902	26,420
U 95% CI total weight	38,347	79,703	32,061	186,820
Total abundance (animals)		**593,968**	**209,486**	**413,410**
%CV total abundance		30.0	30.4	46.9
L 95% CI total abundance		332,640	116,000	165,000
U 95% CI total abundance		1,060,600	378,330	1,035,800

4.5 Serendipity results from the aerial survey in 2015

In 2015 the oceanographic conditions were favourable for opportunistic spawning in some days in some areas outside the four main spawning areas, as a side effect of the hottest year in the Mediterranean area since temperature data are collected, and the GBYP had the opportunity to document one event, a clear serendipity result but, also, the collateral result of the daily scientific activities carried out by the GBYP team. This was duly documented in real time and reported to the SCRS by the GBYP staff by SCRS/2015/154 (**Annex 1b**, **document no. 22**). As a matter of fact, during an incidentally extended transect by one of the aircraft engaged in the GBYP aerial survey, it was possible to encounter and spot one huge school of adult bluefin tunas, estimated at about 15,000 fish and for a total weight of about 3,000 tons (distributed over a space of about 5 km x 1.2 km), slowly swimming eastward just below the surface, possibly direct towards one of the two main spawning grounds (the southern Tyrrhenian Sea or the central-southern Mediterranean Sea, south of Malta). The school was spotted on June 24, 2015, exactly in coincidence with a few days of suitable oceanographic conditions for a potential bluefin tuna spawning as it was clear from the daily monitoring routinely carried out by GBYP. When the data of an electronic PSAT (no. 150293) deployed in the tuna trap of Larache (Morocco) on 30 May 2015, in a bluefin tuna of 234 cm and 197 kg, undoubtedly a mature spawner, were provided by the ARGOS satellite, the further coincidence was clear, because this tuna was showing a potential spawning behaviour more or less in the same area, exactly on the same days. This is the first time that a series of coincidences like these are reported at the same time (**Figure 10**).

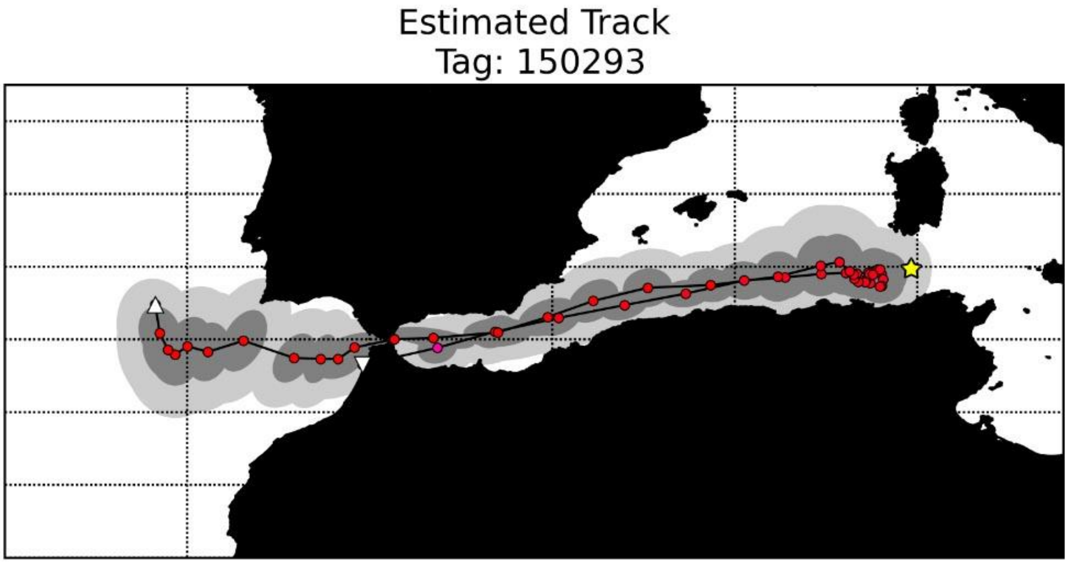


Figure 10. Displacement of a bluefin tuna tagged in Larache (Morocco), which moved to NW Tunisia, remaining in the area between June 12 and 25, under oceanographic conditions potentially favorable for BFT spawning, particularly on June 24 and 25. An aerial sighting of an enormous school of bluefin tuna spawners (yellow star) in the area was reported on June 24, 2015.

4.6 Power analysis and cost-benefit analysis for the aerial survey

As requested by the Steering Committee, and endorsed by the SCRS and Commission, a power analysis and cost benefit analysis for the aerial survey on spawning aggregations was done in the last part of Phase 5, in order to have a more focused overview of the works carried out so far within the GBYP and have further details for adopting the best research strategy in Phase 6.

After the Call for Tenders, a short term contract was provided to the only company that submitted a bid: Alnilam Investigación y Conservación SL, from Spain, which has a huge experience on ICCAT GBYP aerial surveys, and which specifically contracted an external expert on statistical analysis and modelling.

The analysis was carried out for responding to a long list of terms of reference set by the GBYP Steering Committee, and it was quite complex, due to the many research aspects concerned, possibly having almost no previous references in many cases.

The results of this power analysis and cost-benefit analysis for the aerial survey programme will represent one of the key elements of the second review of the GBYP and will be an essential step prior to adopt any important decision or possibly change the work plan. This st6udy was immediately transmitted to the GBYP Steering Committee, in order to have the necessary elements for discussing the strategy for GBYP Phase 6.

4.6.1 Results of the analyses

As concerns the costs of the GBYP aerial survey, it was decided to include all possible components of the aerial survey, including training courses and all the design and analytical work carried out every year. The analysis showed that the average cost per km on effort in the GBYP survey was quite low (between 10.14 and 11.23 euro/km) when the survey was carried out only over the main spawning areas, while it increased in a considerable manner when the strategy was turned toward an extended survey covering most of the Mediterranean Sea (from 17.91 to 18.81 euro/km). This relevant increase in the last two extended surveys was due almost exclusively to the extremely complex logistic for surveying the "outside" areas, something that no other survey had faced so far.

Therefore, for comparing the GBYP cost per km on effort with other aerial survey it was considered reasonable to add an additional 10% to the average of the first two surveys, for taking into account any possible increase for some cost components in the last years. The other surveys taken into account for the comparison had a logistic quite similar to the one adopted by the GBYP survey for the main BFT spawning areas. The comparison showed that the GBYP cost (even if the effective transect length was the highest) are the lowest among all recent aerial surveys carried out in the European or Mediterranean area for various marine species (**Table 11**).

Table 11. Comparison of costs for different aerial surveys in recent years in the European or Mediterranean area.

Name of the aerial survey	Cost per km on effort (euro)		
	Field work	Other costs	TOTAL
ICCAT GBYP (+10%) on BFT spawning aggregations	10.85	1.11	11.96
ISPRA (2013) Adriatic survey on protected species	12.28	0.91	13.19
ASCOBANS SCANS-III Marine Mammals (budget 2016)	11.35	2.05	13.41
Tethys – Marine Mammals (budget forecast 2016)			15.05

The cost analysis compared also the costs for other GBYP research activities (tagging and biological studies) in the same years, showing that the aerial survey was at the lower edge, but it was not possible to compare the different cost/benefits, because of the too different components. When the survey was carried out only on the main spawning areas, the cost was absolutely the cheapest among the three GBYP activities.

The power analysis showed a remarkable increase of the CVs when the aerial survey adopted the new strategy and covered a much broader surface of the Mediterranean, without the possibility of maintaining the same number of replicates that have been done in 2010 and 2011 (this reduced survey coverage was obviously imposed by a budget constraint). This was reflected also in the analysis of the CV trends in abundance under different coverage scenarios, where CVs get close under the two survey strategies only when the coverage is quit high (**Figure 11**).

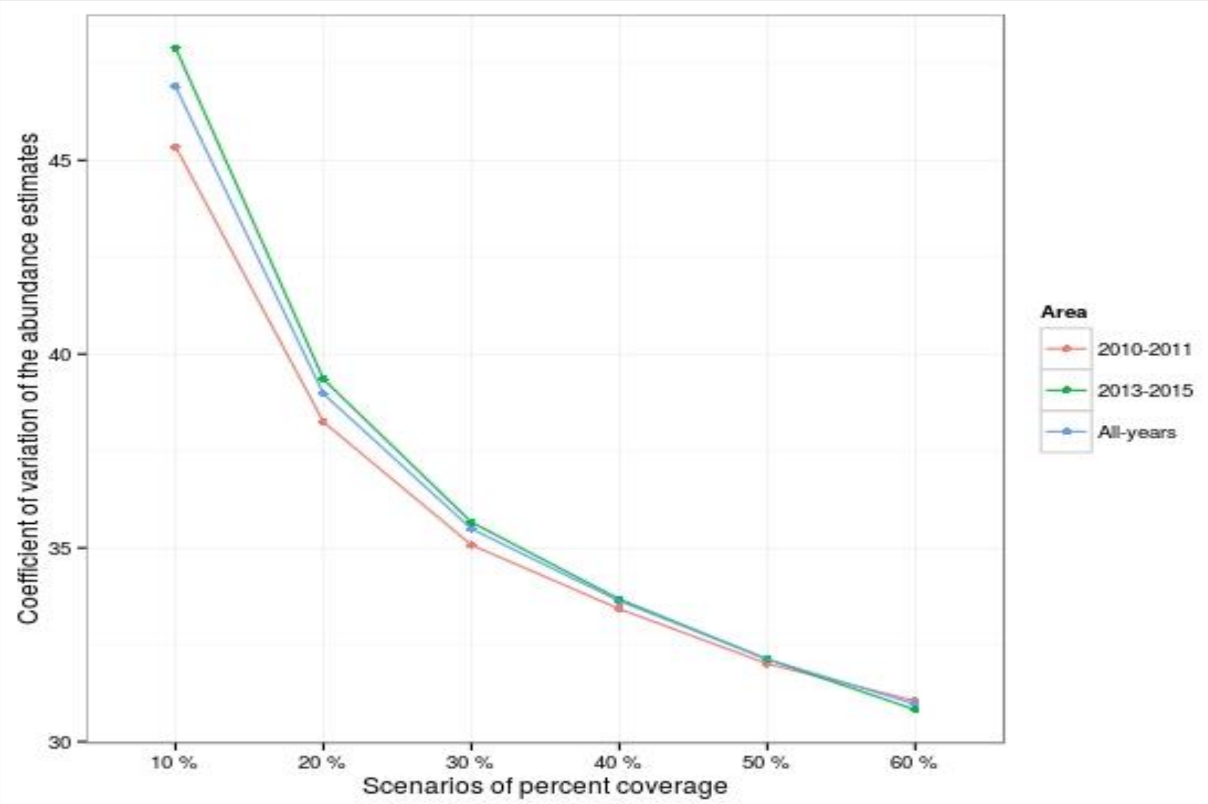


Figure 11. Trend of the CVs of abundance under various scenarios of area coverage in the overlap areas, based on the CVs of 2010-2011 (surveying only the inside areas), 2013-2015 (surveying both inside and outside areas), and the whole period; the graph does not include the associated costs, which are very different according to the survey strategy (the “extended” strategy has costs 71.83% higher than the original one).

The additional variance has been assessed and it is very high, when considering spatial and temporal variability. However, if additional variance would be applied for each area in particular, so that trends can be detected in each of them, then only temporal variability needs to be considered in the area-specific additional variance. These could not be estimated with the available data due to the small sample size. It is possible that one more year of survey will provide enough additional data to estimate the area-specific additional variances. But the requirement for area-specific or global (or any combination of areas) additional variations would ultimately depend on the consideration of the population structure. The additional variance from tagging data could probably be reduced even further if more data from the tags are provided and the sample size gets increased. Information on population structure could help in this sense. The reduction of the additional variance and the improvement of the power to detect a trend could be handled by increasing the sample size.

Furthermore, the analysis shows that it is currently very difficult assessing the bias which can be attributed to the individual observers, the type of aircraft or the many environmental factors. This results in the recommendation to improve the skills of each observer (professional or scientific) and to keep always the same team in each area, for smoothing the effects at least of individual variability in the bias.

Anyway, the last power analysis, considering the current CVs after the extended survey, provided much more pessimistic results than those provided with previous analyses based only on the surveys carried out on the most important spawning areas. Figure 12 shows the different scenarios for various CVs under annual and biannual surveys hypothesis.

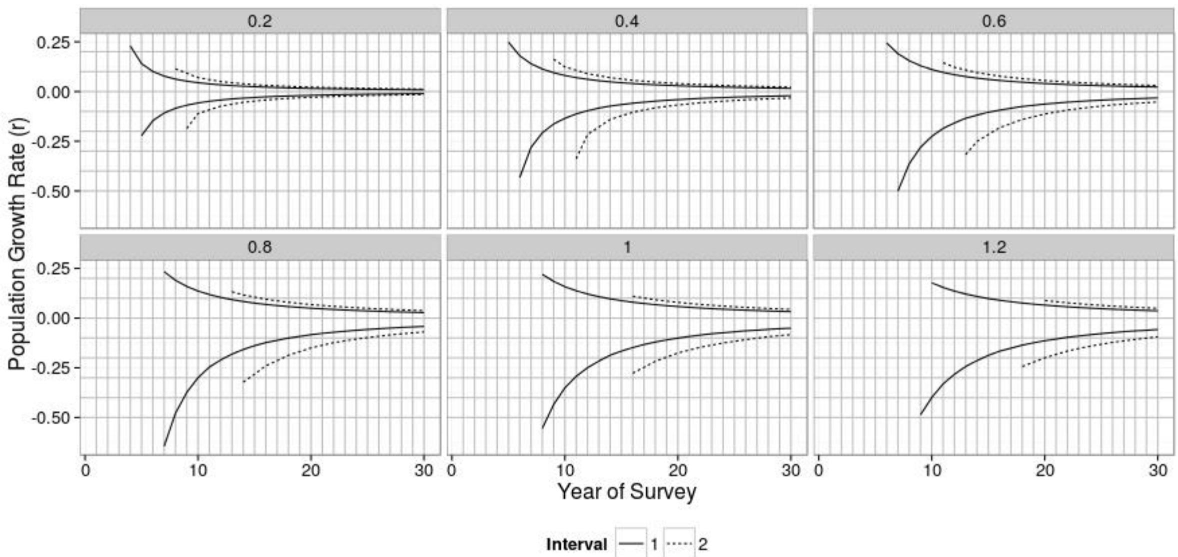


Figure 12. ICCAT GBYP aerial survey on spawning aggregations power analysis: contours correspond to a probability of 0.6 that the null hypothesis (i.e. no change in the population) will be rejected when the null hypothesis is false. Panels correspond to the range of assumed CV of the survey abundance estimate (0.2 to 1.2) and lines to annual and biennial survey cycles. Horizontal lines correspond to a given population growth rate and where this intercepts a power curve the number of years required before a change in the population is detectable can be read off the x axis.

The power analysis report (**Annex 1a, document no. 17**) provides all details and also a list of recommendations.

The main recommendation coming out from the power analysis is that a reduction of the coefficients of variations, at several levels (encounter rates, school size, detection function and additional variances) is required to be able to detect trends in population abundance within an acceptable time frame. Furthermore, increased coverage in terms of kilometers of tracks (which means several replicates) on effort should be necessary. Tables of different cost analysis and power analysis have been provided for the purpose of evaluating the level of power (and therefore coverage) that could be achieved in the future aerial surveys, in correlation with the available level of financial resources.

The last part of the report includes the following: “The current assessment of the aerial survey activity is that it is a clear operational success so far and that the scientific results need more years and efforts for providing the necessary trends to be used for scientific and management purposes. This was already clearly stated in previous power analyses, because any trend needs several years to be duly detected and assessed, considering any possible improvement included in this report. The necessary budget should be provided in the following years to ensure that the aerial surveys will continue following a more stable strategy.”

5. Tagging activity

According to the general programme, after the adoption of the ICCAT GBYP Tagging Design and GBYP Tagging Manual in Phase 1, it was planned to begin the tagging activity in GBYP Phase 2 and continue it in the following Phases. The tag awareness and recovery programme was also launched in Phase 2 and continued in the following Phases, including a new tag rewarding policy. All details are in document SCRS/2015/149 (**Annex 1b, document no. 21**).

5.1 Objectives

The specific objectives of the GBYP tagging activity on the medium term were set as follows:

a) Validation of the current stock status definitions for populations of bluefin tuna in the Atlantic and Mediterranean Sea. If the hypothesis of two stock units (eastern and western stocks) holds, the tags should provide estimates of mixing rates between stock units by area and time strata (ICCAT main area definitions and quarter at least). It is also important to consider possible sub-stock units and their mixing or population biomass exchange, particularly in the Mediterranean Sea[6] (this point included both conventional and electronic tagging).

b) Estimate the natural mortality rates (M) of bluefin tuna populations by age or age-groups and/or total mortality (Z) (this point was related to conventional tagging).

c) Estimate tagging reporting rates for conventional tags, by major fishery and area, also using the observer programs currently deployed in the Mediterranean fisheries (ICCAT ROP-BFT).

d) Evaluate habitat utilization and large-scale movement patterns (spatio-temporal) of both the juveniles and the spawners (this point was mostly related to electronic tagging but not only).

e) Estimate the retention rate of various tag types, due to contrasting experiences in various oceans.

Electronic Pop-up tags should provide data over a short time frame, while conventional tags, internal archival tags and PIT tags should provide data over a longer period of time, always depending on the reporting rate.

The initial, short-term GBYP objective was to implant 30,000 conventional tags and 300 electronic tags in three years in the eastern Atlantic, with a total budget of 9,765,000 euro; the absolutely necessary tagging design study and protocol, as well as the tag awareness and rewarding campaigns, were not included in this initial budget. So far, with only 37.65% of the funds (a total of 3,767,593 euro), GBYP deployed 81.98% of the conventional tags (24,594) and 81.87% of the electronic tags (238; 180 mini PATs, 50 internal archival tags and 8 acoustic tags); furthermore, the tagging design and protocols, the awareness and rewarding campaigns were included in the activity carried out so far. It is very clear that the general objectives sets for the tagging activities in these first Phases were largely accomplished so far, taking into account the proportion of the available budget.

[6] Additional elements will be provided by the GBYP biological and genetic sampling and analyses.

The final reports of all electronic tagging activities in Phase 5 are in the **Annex 1a (documents no. 21, 22, 23, 24, 25** and **26)** and the activity was reported to the SCRS and the Commission by SCRS/2015/149 (**Annex 1b, document no. 21**).

5.2 Tags and correlate equipment

At first, ICCAT GBYP acquired a considerable amount of tags during these first Phases of the programme, allowing both the tag delivery to all stakeholders who have a bluefin tagging activity (either opportunistic or institutional) and to the GBYP contractors. The details of the materials and tags acquired so far by ICCAT GBYP or donated by various institutions are on SCRS/2015/149 (**Annex 1b, document no. 21**).

5.3 Tagging activities

The Steering Committee, in September 2014, adopted a different tagging strategy for Phase 5, and initially recommended continuing the conventional tagging by baitboats in the Bay of Biscay and in the Strait of Gibraltar, continuing the electronic tagging in Moroccan traps, and extending it to the western Mediterranean (Italian traps, Sardinia) and to the eastern Mediterranean Sea (Turkish purse seiners). The budget for Phase 5 was set and approved accordingly. The draft call for tenders was ready at the beginning of Phase 5 (February 2015).

In February 2015, the Steering Committee, taking into account the clear difficulties for assessing the recovery rate by fishery and that the tag reporting rate for conventional tags was still too low, recommended revising the plan for Phase 5, cancelling the conventional tagging, and addressing all activities only to the electronic tagging in the three areas (Morocco, central Mediterranean and Turkey), increasing the number of tags as much as possible, according to the availability of tags by Wildlife Computers and the budget possibilities.

After several discussions, a revised Call for tender was agreed by the Steering Committee and it was issued on 22 April 2015. After selecting the bids, the contracts were provided to an international consortium headed by INRH with the participation of Maromadraba and WWF MedPO for the Moroccan traps, to an Italian consortium headed by COMBIOMA for the Sardinian traps, and to a joint team made by the University of Istanbul and UNIMAR for tagging in the eastern Mediterranean. Further tagging activities were carried out on a complimentary base by INRH (conventional tagging in Moroccan tuna traps) and by Federcoopesca and others associated (electronic and conventional tagging in southern Tyrrhenian Sea, taking advantage of some tunas to be released from a cage).

The ICCAT GBYP electronic tagging with mini-PATs in Phase 5 was carried out on adult fish in all areas, as planned.

The updated situation of the tagging activities in Phase 5 is showed on **Table 12**. In total, up to February 23, 2016, the total number of bluefin tunas tagged so far in all GBYP Phases is 17,155, and a total of 24,832 tags of various types have been implanted (**Table 13**). 45.9% of the fish were double tagged, against a target of 40%.

Table 12. Details about the number of bluefin tunas tagged with various types of tags in Phase 5 and on the number of the various types of tags implanted by area.

Phase 5

	ALL FISH TAGGED	FISH SINGLE TAGGED					FISH DOUBLE TAGGED						
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic	Double Tags - Conventional	Mini-PATS + Conv.	Mini-PATS + 2Conv.	MiniPAT+ Acoustic+ Conv.	Archivals + Conv.	Archivals + 2Conv.	Acoustic + Conv.
Canada	198		198										
Bay of Biscay (a)	0	0											
Morocco*	44		24	20									
Portugal	0												
Strait of Gibraltar***	0												
West Med. **	29	1		28									
Central Med. ****	136	1	130	5									
East Med.	30			30									
		2	352	83	0	0	0	0	0	0	0	0	0
GRAND TOTAL	437	SUBTOTAL = 437					SUBTOTAL = 0						

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Canada	198		198			
Bay of Biscay (a)	0	0				
Morocco*	44		24	20		
Portugal	0					
Strait of Gibraltar	0					
West Med. **	29	1		28		
Central Med.	136	1	130	5		
East Med.	30			30		
	437	2	352	83	0	0

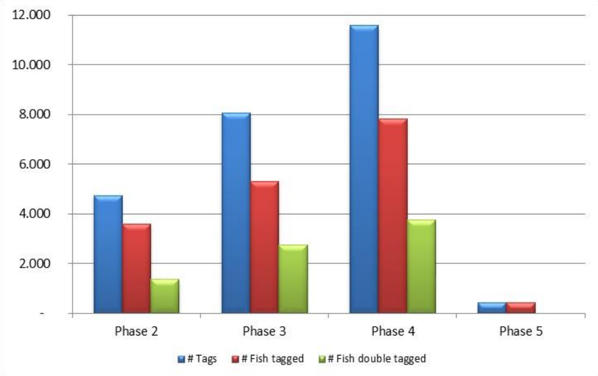
Table 13. Details about the number of bluefin tunas tagged with various types of tags in all Phases of GBYP and on the number of the various types of tags implanted by area.

All GBYP Phases (2, 3, 4 & 5) (up to 31/12/2015)

	ALL FISH TAGGED	FISH SINGLE TAGGED					FISH DOUBLE TAGGED							
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic	Double Tags - Conventional	Mini-PATS + Conv.	Mini-PATS + 2Conv.	MiniPAT+ Acoustic+ Conv.	Archivals + Conv.	Archivals + 2Conv.	Acoustic + Conv.	% by area
Canada	204	0	199	0	0	0	0	5	0	0	0	0	0	**1,2%**
Bay of Biscay (a)	7701	4173	1	3	0	0	3493	18	0	0	13	0	0	**44,9%**
Morocco*	327	129	24	32	0	0	121	13	0	7	0	0	1	**1,9%**
Portugal	116	17	11	0	0	0	88	0	0	0	0	0	0	**0,7%**
Strait of Gibraltar***	5561	2254	43	0	0	0	3212	22	5	0	23	2	0	**32,4%**
West Med. **	1675	932	358	28	0	0	352	5	0	0	0	0	0	**9,8%**
Central Med.	1541	773	265	5	0	0	479	7	0	0	12	0	0	**9,0%**
East Med.	30	0	0	30	0	0	0	0	0	0	0	0	0	**0,2%**
		8278	**901**	**98**	**0**	**0**	**7745**	**70**	**5**	**7**	**48**	**2**	**1**	
GRAND TOTAL	**17155**	**SUBTOTAL = 9277**					**SUBTOTAL = 7878**							**100,0%**

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED					
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic	% by area
Canada	209	0	204	5	0	0	**0,8%**
Bay of Biscay	11225	7697	3494	21	13	0	**45,2%**
Morocco*	476	258	158	52	0	8	**1,9%**
Portugal	204	139	65	0	0	0	**0,8%**
Strait of Gibraltar***	8618	5491	3075	27	25	0	**34,7%**
West Med. **	2031	1285	713	33	0	0	**8,2%**
Central Med.	2039	1252	763	12	12	0	**8,2%**
East Med.	30	0	0	30	0	0	**0,1%**
TOTAL	**24832**	**16122**	**8472**	**180**	**50**	**8**	**100,0%**
%	**100%**	**64,9%**	**34,1%**	**0,7%**	**0,2%**	**0,0%**	

(*)7 miniPATs (GBYP) + 7 miniPATs (WWF) + 8 Acoustic (SU)
(**) 11 fish were tagged in the Balearic Sea; all tags were single barb (FT-1-94)
(***) 10 fish had a second tagging and release, 1 with double tagging - not included in the table
West Med = Gulf of Lions, Balearic Sea, Ligurian Sea and Sardinia.
Central Med = Tyrrhenian Sea, Adriatic Sea, Malta.
(a) one fish was recaptured in the Bay of Biscay and retagged with a third tag in 2015. This fish was not double counted.



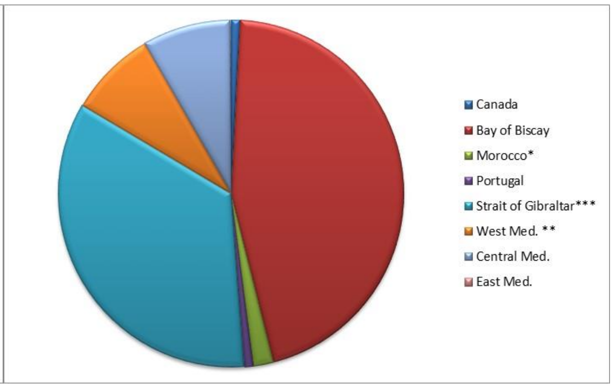


Figure 13a shows the progression of the ICCAT GBYP tagging activities in the various years, clearly showing the yearly improvements up to 2014 and the remarkable reduction in Phase 5, due to the cancellation of the conventional tagging. **Figure 13b** shows the percentage distribution of tags implanted in the various geographical areas, up to February 23, 2016.

It is important to note that several premature detachments[7] were noticed for mini-PATs since the beginning of their first deployments; this problem was discussed with various specialists and with the manufacturer Company. Different anchors were supplied by Wildlife Computers in Phase 4 and used by GBYP contractors and the situation improved. In Phase 5 it was decided to use only the type of anchor which was unanimously considered the best by the most experienced colleagues, the "Domeier large" type. One of the experts hired by ICCAT GBYP carried out some tests with a speargun, trying to detach the dart from a dead bluefin tuna that was used for this purpose. The trial revealed that the dart was holding very well (independently from the angle of insertion) and it was impossible to extract it even by strongly polling. This test confirms the reliability of the choice made with this type of dart. At the same time, the wound made by the dart is not minimal and, even using the best disinfectants and local antibiotics as set by the protocol, we cannot exclude that the friction made by the wire could create a later infection in the wound, which might result in weakening of the skin itself around the wound in few weeks. It is to be noted that most of the "premature detachments" happened in areas and times where several fishing vessels were operating and that the preliminary analyses of the tag data seem confirming that the premature transmission was mostly caused by fishing activities.

The most important result of the tagging activity in Phase 5 is the evidence that all previous hypotheses about the lack of interchanges between the tunas in the eastern Mediterranean and the other Mediterranean and Atlantic areas, which were supported by all previous tagging activities, do not hold anymore. As a matter of fact, in 2015 we had 3 fish tagged in Turkey which moved into the central Mediterranean, one fish tagged in Turkey which moved to the NE Atlantic in 53 days, another one moved up to Faroe Islands in 82 days, one tuna tagged in the Strait of Gibraltar in 2013 with a conventional tag that was reported in Turkey and two tunas tagged in Croatia in 2013 (one was double tagged) that were recovered also in Turkey. This absolutely new evidence is in line with the

[7] In some cases it is not clear if the premature detachment was a real one or due to a fishing activity.

results of the genetic analyses, which report mixing among all areas in the Mediterranean (**Figure 14**), without allowing for any specific subpopulation discrimination according to the current available evidences.

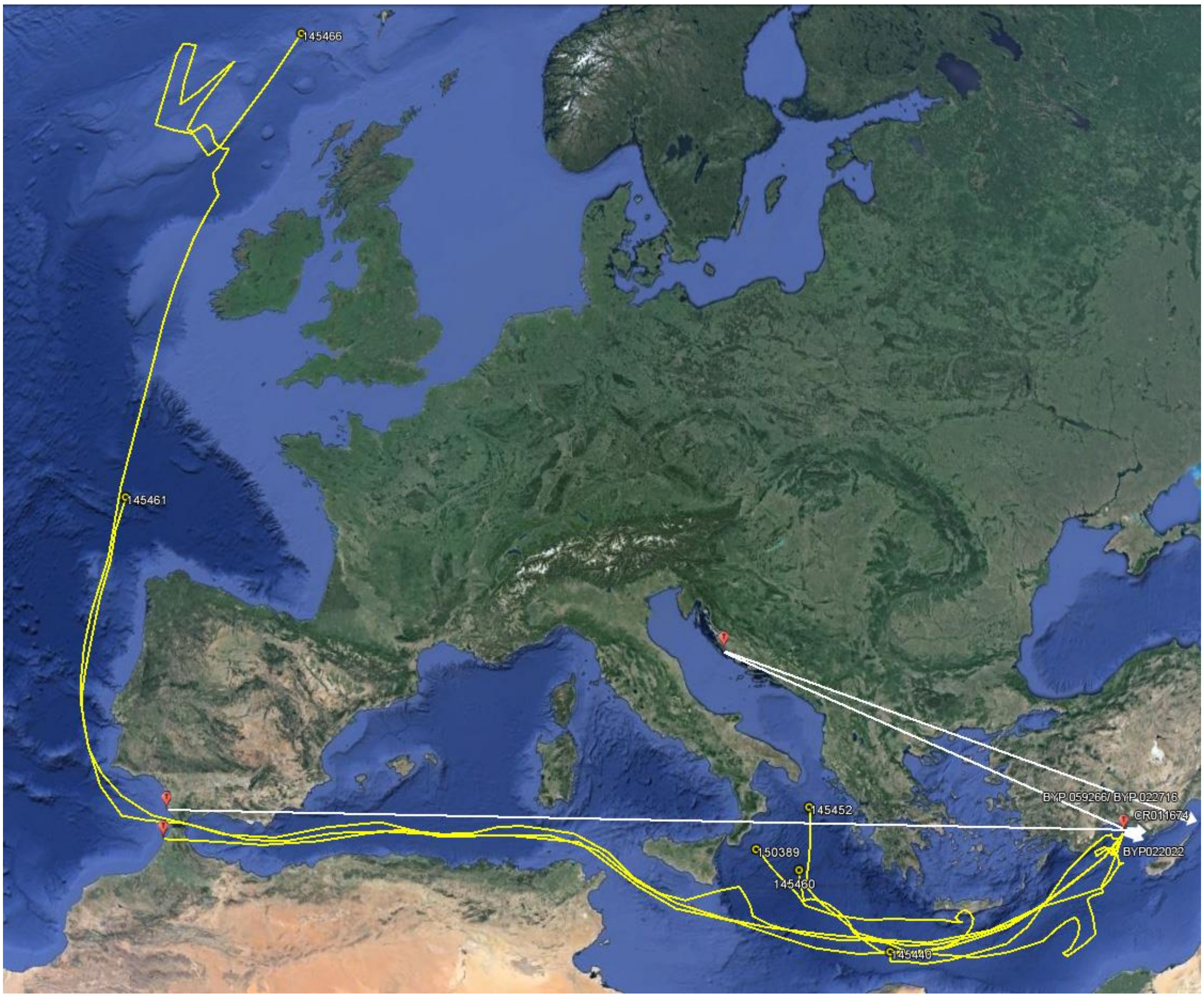


Figure 14. Tracks (in yellow) of 5 miniPATs deployed in Turkey in 2015, moving westwards from the eastern Mediterranean, of one miniPAT deployed in a Moroccan trap in 2015 which reached the eastern Mediterranean, and trajectories (in white) of three bluefin tunas conventionally tagged, one in 2011 (in the Strait of Gibraltar) and two in 2013 (one single tagged and one double tagged in Croatia), which were recovered in Turkey.

This year it was possible to have a preliminary overview of the behaviour of the adult bluefin tunas tagged in Moroccan traps in 2011, 2012, 2013 and 2015. As discussed at the SCRS in 2015 (SCRS/2015/149, **Annex 1b, document no. 21**), now it seems that a possible explanation might be that some of these fish had a western origin and therefore these “western” fish entering the Moroccan traps did not have any biological reason for entering into the Mediterranean during the spawning period (**Table 14**). On the opposite, if we trust the hypothesis of the full homing behaviour for those fish born in a given area, they had good reasons for going back to the western Atlantic areas for spawning.

Table 14. Displacements of the bluefin tuna tagged in Moroccan traps by year

Year	ATL	MED	Grand Total
2011	4	1	5
2012	8	13	21
2013	4	9	13
2014	1		1
2015	1	18	19
Grand Total	**18**	**41**	**59**

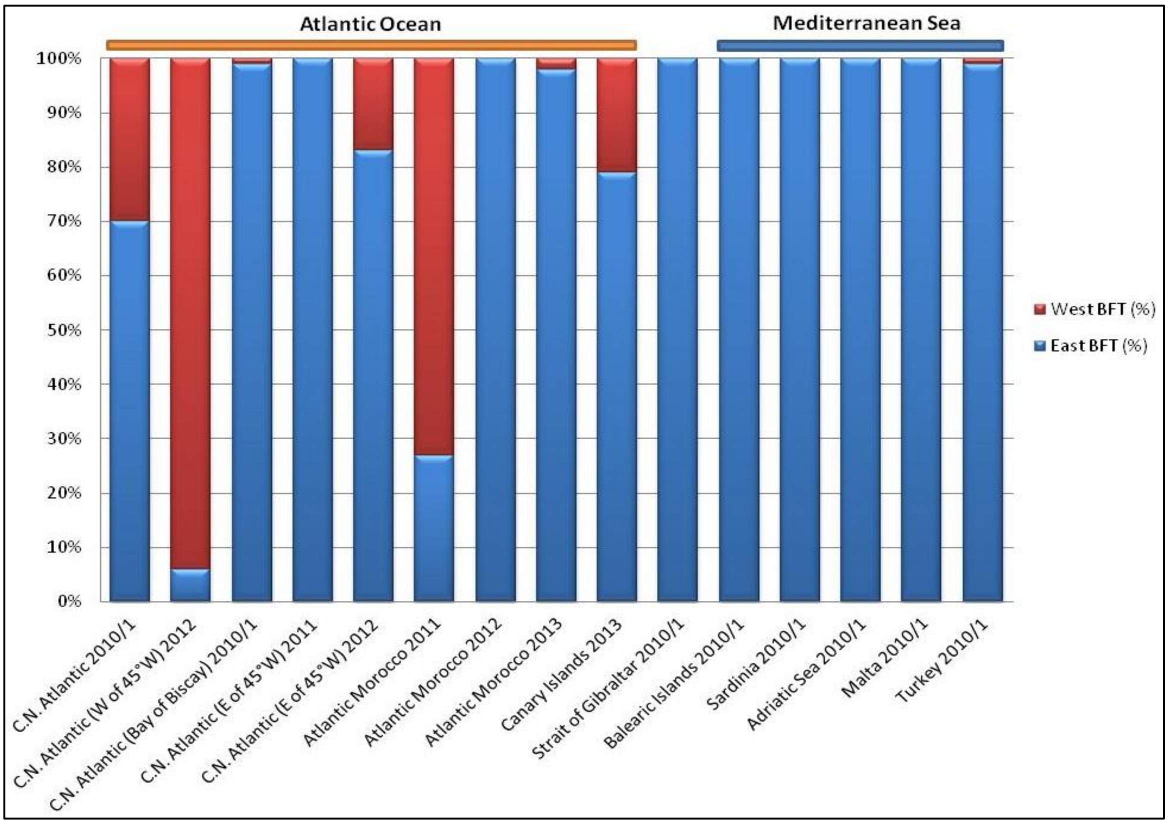


Figure 15. Graphic presentation of maximum likehood prediction of the origin of bluefin tuna collected from various areas and analysed in Phase 3 and Phase 4. Estimates are given by percentages and mixed-stock analyses (HISEA program) was run under bootstrap mode with 1000 runs to obtain standard deviations (~error) around estimated percentages (re-elaborated from the final reports of Phase 3 and 4 provided by the Consortium headed by AZTI to GBYP).

This variable presence of western-origin Bluefin tuna in the Moroccan traps and in general in the Ibero-Moroccan area (**Figure 15**) was fully unknown when all the discussions about the possible impact of the tagging technique took place at the SCRS BFT Species Group in 2012 and 2013, and its interannual variability can further support the different percentages of tunas entering into the Mediterranean after being tagged. Therefore, now it seems that the behaviour of these fish was mostly influenced by other factors rather than the tagging technique and that the different behaviour most probably informs us about a different individual natal origin, even if other additional reasons cannot be fully excluded. Of course, any further observation of these data should take into account that we are still missing all details about those bluefin tuna which are distributed in the central-southern Atlantic.

5.4 Tag awareness campaign

This activity is considered essential for improving the very low tag reporting rate existing so far in the Eastern Atlantic and the Mediterranean Sea. The tag awareness material was produced in 12 languages, considering the major languages in the ICCAT convention area and those of the most important fleets fishing in the area: Arabic, Croatian, English, French, Greek, Italian, Japanese, Mandarin, Portuguese, Russian, Spanish and Turkish. In total, more than 15,750 posters of various sizes (A1, A3 and A4) and more than 18,000 stickers were produced so far; two posters and all stickers were revised in 2014. All posters are also available on the ICCAT-GBYP web page http://www.iccat.int/GBYP/en/AwCamp.asp . A capillary distribution of the tag awareness material was carried out directly by GBYP, sending copies to all stakeholders such as: Government Agencies, scientific institutions, tuna scientists, tuna industries, fishers, sport fishery federations and associations, the RFMOs and MEDAC and other RACs concerned; the coverage was complete in the ICCAT Convention area, including also non-ICCAT countries and entities fishing in the area. The map on the web clearly shows the distribution effort. The ICCAT-GBYP web page has the full list of contacts http://www.iccat.int/GBYP/images/mapamunditicks.jpg .

The GBYP staff actively participated every year to the formation of ICCAT ROPs, with a specific focus on tag awareness and tag recovery, but also for having reports of any natural mark in bluefin tuna harvested in farms. In 2015 the formation of ICCAT ROPs was further improved and their reporting rate also improved.

Posters are now present in most of the ports where bluefin tuna are usually or potentially landed, in tuna farms, tuna traps, industries, sport fishers clubs, fishers associations, bars where fishers are usually going, local port authorities and on many fishing vessels. Some articles were also promoted and they have been published on newspapers and magazines. According to the data which show enhanced reporting rate, this activity was very important for providing better tag reporting results.

5.5 Tag reward policy

Following the recommendations made by SCRS and the GBYP Steering Committee, the ICCAT GBYP tag reward policy was considerably improved since the beginning, with the purpose of increasing the tag recovery rate which was extremely and unacceptably low. The current strategy includes the following rewards: 50€/ or a T-shirt for each spaghetti tag; 1000 € for each electronic tag; annual ICCAT GBYP lottery (September): 1000 € for the first tag drawn and 500 € each for the 2nd and 3rd tag drawn. According to the recovery data, this policy (along with the strong tag awareness activity) was very useful for considerably improving the tag reporting.

5.6 Tag recovery and tag reporting

This activity is the final result of the activities listed in points 5.3, 5.4 and 5.5. For further improving the results, meetings with ICCAT ROPs were organised, further informing them about the ICCAT GBYP tag recovery activity and asking them to pay the maximum attention to tags (and to natural marks) when observing harvesting in cages or any fishing activity at sea. Special information forms have been provided to ICCAT ROPs.

Preliminary data were already provided to the SCRS and the Commission by SCRS/2015/149 (**Annex 1b, document no. 21**). While examining the results of the ICCAT GBYP tag recovery/reporting activities, it is very important to consider that about 90% of the conventionally tagged fish in Phases 2-4 were juveniles (age 0-3); about 70% were surely immature fish (age 0-2) and then it is difficult for these fish to be caught by most of the fisheries, particularly taking into account the ICCAT minimum size regulation and the fact that the baitboat fishery in the Bay of Biscay in the last years was almost cancelled, because fishermen sold their quota to other fisheries. Since the first year of the GBYP and up to February 23, 2016, there have been 403 tags recovered by GBYP. The GBYP recoveries are summarized as follow:

- 251 Conventional “Spaghetti” tags (62.3% of the total)
- 115 Conventional “Double-barb” (two types) tags (28.5% of the total)
- 23 External Electronic “mini-PATs” tags (5.7% of the total)
- 9 Internal Electronic “Archivals” tags (2.2% of the total)
- 1 Acoustic tag (0.2% of the total)
- 4 Commercial “Trade” bluefin tuna tag (1.0% of the total)

The distribution of tag recovered by area and fishery[8] is showed on **Table 15** and **Table 16**.

Table 15. Geographical distribution of the areas where the tag recoveries occurred, in numbers and percent, by type of tag (up to February 23, 2016).

Fishing Area / Tags	Spaghetti Tags	Double BarbTags	External Elec. Tags	Internal Elec. Tags	Acoustic Tags	Commercial Tags	Grand Total	%
East Atl	57	30	11	1		1	100	24,81
Med	187	77	8	7	1		280	69,48
North Atl	4	1				2	7	1,74
West Atl	3	7		1		1	12	2,98
Unknown			4				4	0,99
Grand Total	251	115	23	9	1	4	403	100
%ge	62,3%	28,5%	5,7%	2,2%	0,2%	100,0%	100,0%	

The number of tags reported by two important commercial activities in the Eastern Atlantic and in the Mediterranean Sea (purse-seiners/cages and tuna traps) is surprisingly very low. The purse-seine fishery is historically the most productive in the last decades, reaching over 70% of the total catch in some years; since 1999, almost all purse-seine catches (and, in recent years, also most of the trap catches) are moved to cages and then to fattening farms and these activities are strictly monitored by ICCAT observers (ROPs). Consequently, the GBYP was supposed to have a high tag recovery and reporting rate from purse-seiners/farms, but the data are showing a different reality: the farms had recovered 65 tags, of various types (48 single-barb spaghetti, 13 double-barb

[8] For comparison purposes, but also because the data were not previously reported, we included in the table also the tags recovered by ICCAT between 2002 and 2009, before GBYP. These tags were only 7 (4 spaghetti, 1 double barb spaghetti and 2 internal archival).

spaghetti, 3 archival and 1 acoustic), while 21 were recovered from purse-seiners (13 single-barb spaghetti, 6 double-barb spaghetti, 1 Psat and 1 archival). Even considering that most of the last conventional tagging activities were targeting juveniles, the recovery and reporting rate is unrealistically too low (16.13% of the total reported tags for the traps and 5.21% for the purse-seiners). The same conclusions can be stated for the traps, because they have reported only 7 tags to ICCAT within the period taken into account (4 single-barb spaghetti, 1 double-barb spaghetti, 2 internal archival). Even in this case, the recovery and reporting rate (1.74% of the total recovered tags) is unrealistically too low. A similar consideration is applicable even to the long-line fishery; including both the bluefin tuna targeted fishery and the many long-liners targeting other pelagic species having the bluefin tuna as a by-catch (33 tags in total, 21 single-barb spaghetti, 10 double-barb spaghetti and 2 archival, equal to 8.19% of the total). The possible reasons for the low reporting rates from all these relevant fisheries have been already discussed (http://iccat.int/Documents/CVSP/CV070_2014/n_2/CV070020556.pdf).

Table 16. Details of tag reported to ICCAT GBYP by fishery, in numbers and percent, up to February 23, 2016.

Fishery -Gear / Tags	Spaghetti Tags	Double BarbTags	External Elec. Tags	Internal Elec. Tags	Acoustic Tags	Commercial Tags	Grand Total	%
BB	115	61					176	43,67
FARM	48	13		3	1		65	16,13
HAND	11	9	1				21	5,21
LL	21	10		2			33	8,19
LLHB	2	2					4	0,99
NF			13			4	17	4,22
PS	13	6	1	1			21	5,21
RR	5	8		1			14	3,47
SPOR	11	1					12	2,98
TN	1	1					2	0,50
TRAP	4	1		2			7	1,74
TROL	7	2					9	2,23
UNCL	13	1	8				22	5,46
Grand Total	251	115	23	9	1	4	403	100

Table 17. BFT tags reported by year to GBYP (yellow shading means tags reported to ICCAT prior to GBYP).

Recovery Year / Tags	Spaghetti Tags	Double BarbTags	External Elec. Tags	Internal Elec. Tags	Acoustic Tags	Commercial Tags	Grand Total	%
2002	1	1		1			3	
2006	1			1			2	
2008	1						1	
2009	1						1	
TOT 2002-2009	4	1	0	2	0	0	7	
2010	3						3	0,74
2011	8		1				9	2,23
2012	36	7	6	1		1	51	12,66
2013	60	28	9	2		1	100	24,81
2014	72	30	1	3		2	108	26,80
2015	68	46	3	3	1		121	30,02
2016	4	4	1				9	
Undefined (2012 or 2013)			2				2	0,50
Grand Total	251	115	23	9	1	4	403	100

The important tag reporting improvement registered after the beginning of the tagging and tag awareness activities by ICCAT GBYP is impressive (**Table 17** and **Figure 16**): the average ICCAT recovery for the period 2002-2009 was only 0.88 tags per year, while during GBYP tag recovery activities the average was 67.17 tags per year, with 7,533% increase. The first significant increase in the rate of the tag recoveries was recorded in 2014, when GBYP recovered a total of 108 tags, about 31.8% of the total over the whole period since. Such a success should probably be attributed, not only to the recent tagging activities, but to the settled tag awareness campaign as well. In the year 2015, a total of 121 tags were recovered, in spite of the fact that conventional tagging was almost suspended in that year and that in 2014, due to budget constraint, it was poorly done. We have to note that, for the first time in ICCAT bluefin tuna tagging activities, the number of tags recovered and reported from the Mediterranean Sea is higher than from any other area. Considering that reported tags from the Mediterranean were almost nil before GBYP, this is the clear evidence that GBYP tag awareness campaign is producing positive effects.

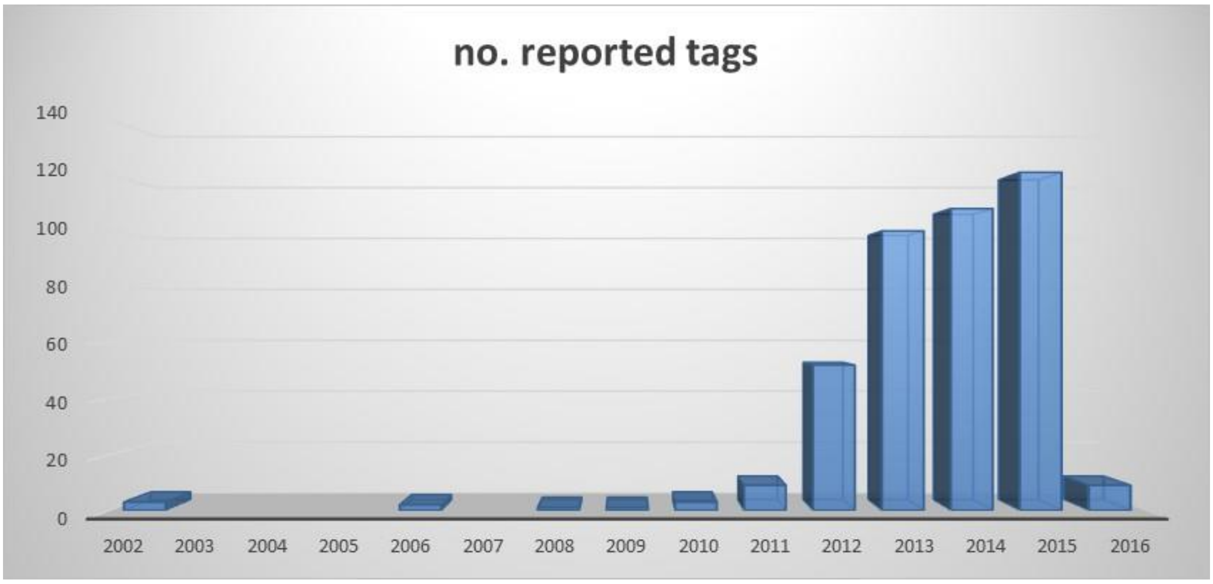


Figure 16. Number of bluefin tuna tags reported to ICCAT by year, up to February 23, 2016.

It is extremely difficult and almost impossible at the moment to define a recovery rate for GBYP conventional tagging activities, taking into account that most of the conventionally tagged tunas were juveniles and they will be possibly available in most of the fisheries within the ICCAT Convention area only in future years. Whenever we consider, as a preliminary exercise, the number of tags recovered so far in comparison with the number of GBYP tags deployed, the provisional recovery rate is only 1.64%, but this rate is clearly negatively biased by the juvenile ages of about 90% of the tagged fish. At the same time, it is impossible assessing the recovery rate of tags which were not deployed by ICCAT GBYP, because ICCAT does not have the insight in the total number of implanted tags by each tagging entity in the ICCAT area.

Interesting information is slowly coming from the double tagged tunas (**Table 18**): up to February 23, 2016, tags were recovered from 110 double tagged fish and both tags have been recovered from 78 fish (70.91% of the double tagged fish recoveries). 16 fish had only the billfish (double-barb) tag on, while other 16 fish had only the single barb spaghetti on. According to these first data, it seems that both types of tags are equally resistant. The tag recovery rate for all double tagged fish by GBYP is currently 1.40%.

Table 18. BFT tag recoveries from double tagged fish by type (up to 23 February 2016).

Release	Spaghetti tag only	Double Barb Tag only	Both	TOTAL FISH	TOTAL TAGS
2011	0	4	5	9	14
2012	9	5	34	48	82
2013	7	7	39	53	92
Total	16	16	78	110	**204**
%	14,55	14,55	70,91	100	

RcCode: 2conv			**both recovered**			
			Year of Recovery			
Year of Release	**2012**	**2013**	**2014**	**2015**	**2016**	**TOTAL FISH D/T**
2011	1	3	2	0	0	6
2012	5	15	10	3	0	33
2013		6	15	17	1	39
2014				1	0	1
TOTAL	6	24	27	20	1	78
%	7,69	30,77	34,62	25,64	1,28	100,00

Reiterating what it was said in the first part of the ICCAT GBYP, the extreme importance of having all tag release data related to all tagging activities carried out on bluefin tuna (but also on all other species under the management of ICCAT) concentrated in the ICCAT tag data base should be mandatory. That is essential because recoveries can be logically reported to ICCAT at any time and it is not always easy, rather time/effort consuming, finding the entity which implanted the tags if data are not properly stored. As usual, the GBYP staff had experienced a lot of difficulties in recovering the tag release data in several cases, with an important additional workload. At the moment this tag release communication is not mandatory, but it should be, because it has a general interest, including for the various entities and institutions carrying out this activity.

As concerns the displacement data provided by the conventional tags, in the last part of Phase 5 it was possible to elaborate the first set of maps (even if this was never specifically requested to GBYP), for better representing the current situation and for have images of the various movements of the bluefin tunas using tag release/tag recovery data. Even in this case, the analysis of the ICCAT BFT tag data base revealed that there are 35 reported tags for which ICCAT has not the release data. This not a problem due to any GBYP tagging activity, but it is the consequence of what it was discussed in the previous paragraph and concerns data deployed some years ago. Of course, the data from these tags cannot be used for any elaboration. The general image of all BFT tags deployed by various entities and programmes on both sides of the Atlantic and in the Mediterranean and reported to ICCAT so far (after checking the files and tags with unreliable data) is shown in **Figure 17** (n=5428), while **Figure 18** shows only the tags related to tags implanted on juvenile bluefin tunas. The natal origin of tagged fish is mostly unknown.

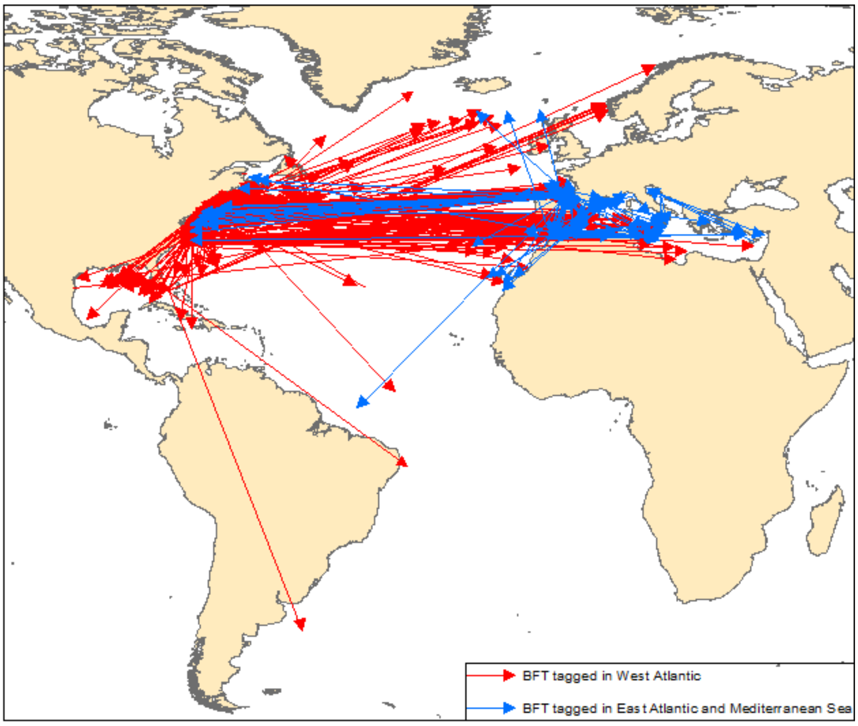


Figure 17. Displacements of bluefin tunas tagged on both sides of the Atlantic and in the Mediterranean (n=5428) by various entities and programmes for which tags were reported to ICCAT up to February 23, 2016.

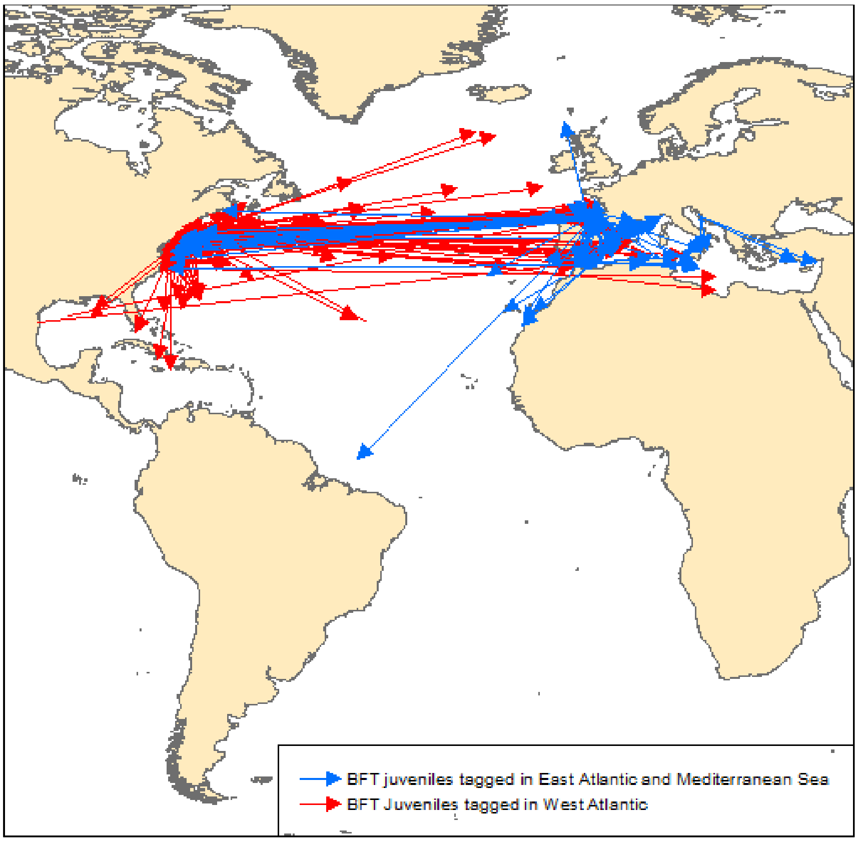


Figure 18. Displacements of juvenile bluefin tunas tagged on both sides of the Atlantic and in the Mediterranean (n=4311) by various entities and programmes for which tags were reported to ICCAT up to February 23, 2016.

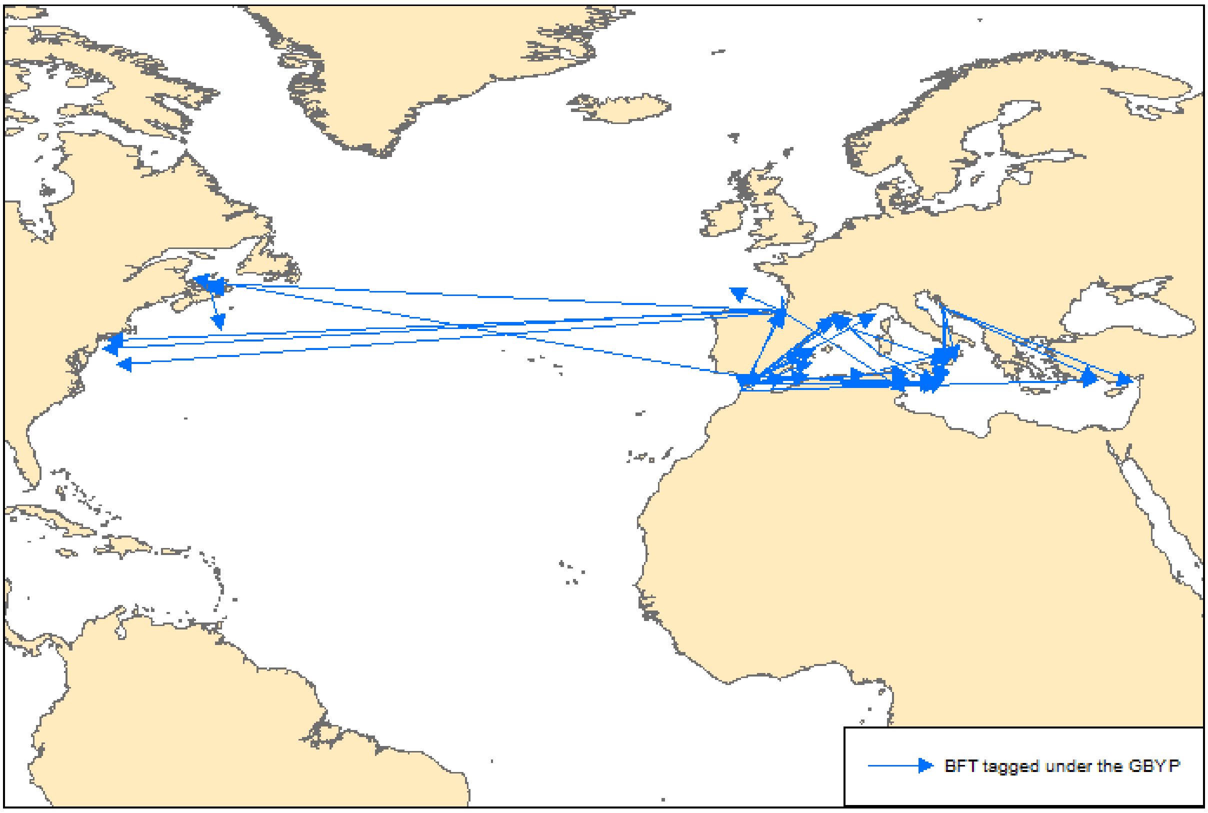


Figure 19. Displacements of all bluefin tunas tagged on both sides of the Atlantic and in the Mediterranean by GBYP for which tags were reported to ICCAT up to February 23, 2016.

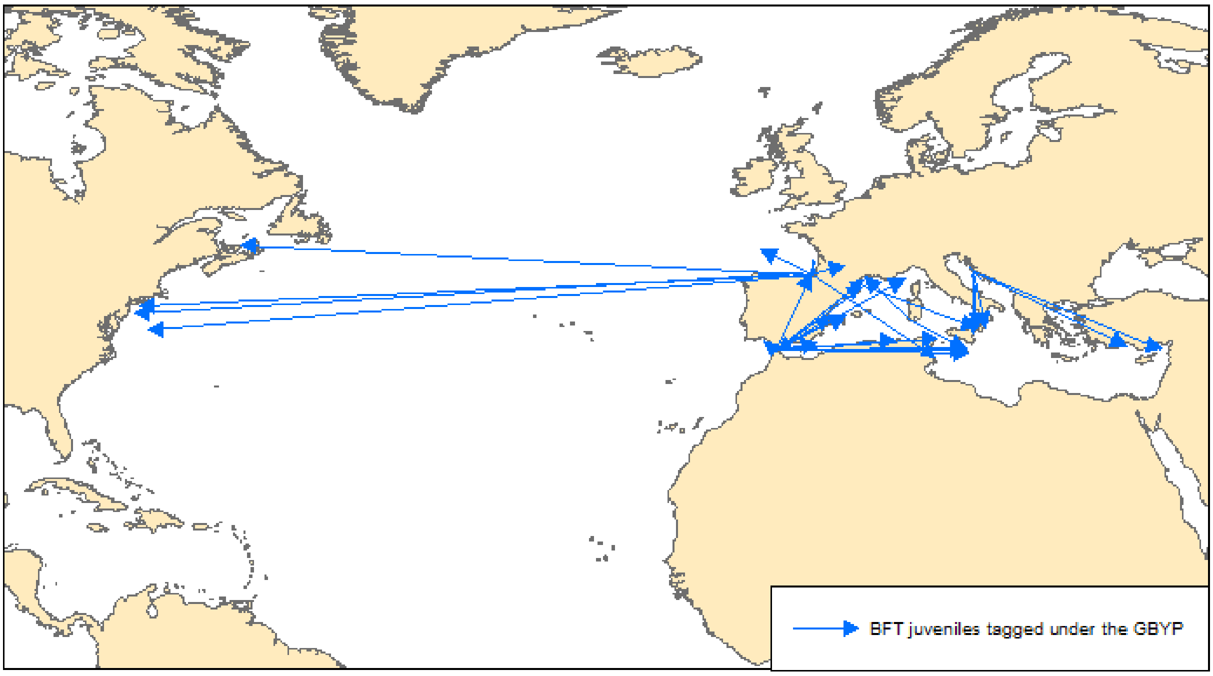


Figure 20. Displacements of juvenile bluefin tunas tagged on both sides of the Atlantic and in the Mediterranean by GBYP for which tags were reported to ICCAT up to February 23, 2016.

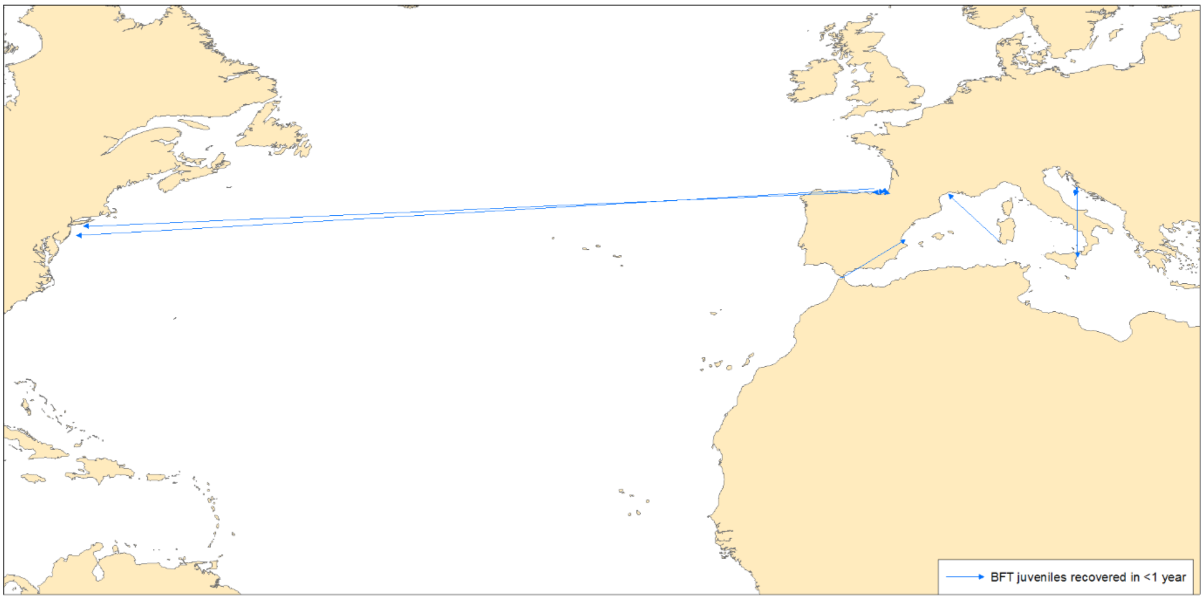


Figure 21. Displacements of juvenile bluefin tunas tagged in East Atlantic and in the Mediterranean by GBYP for which tags were reported to ICCAT within one year from tagging up to February 23, 2016.

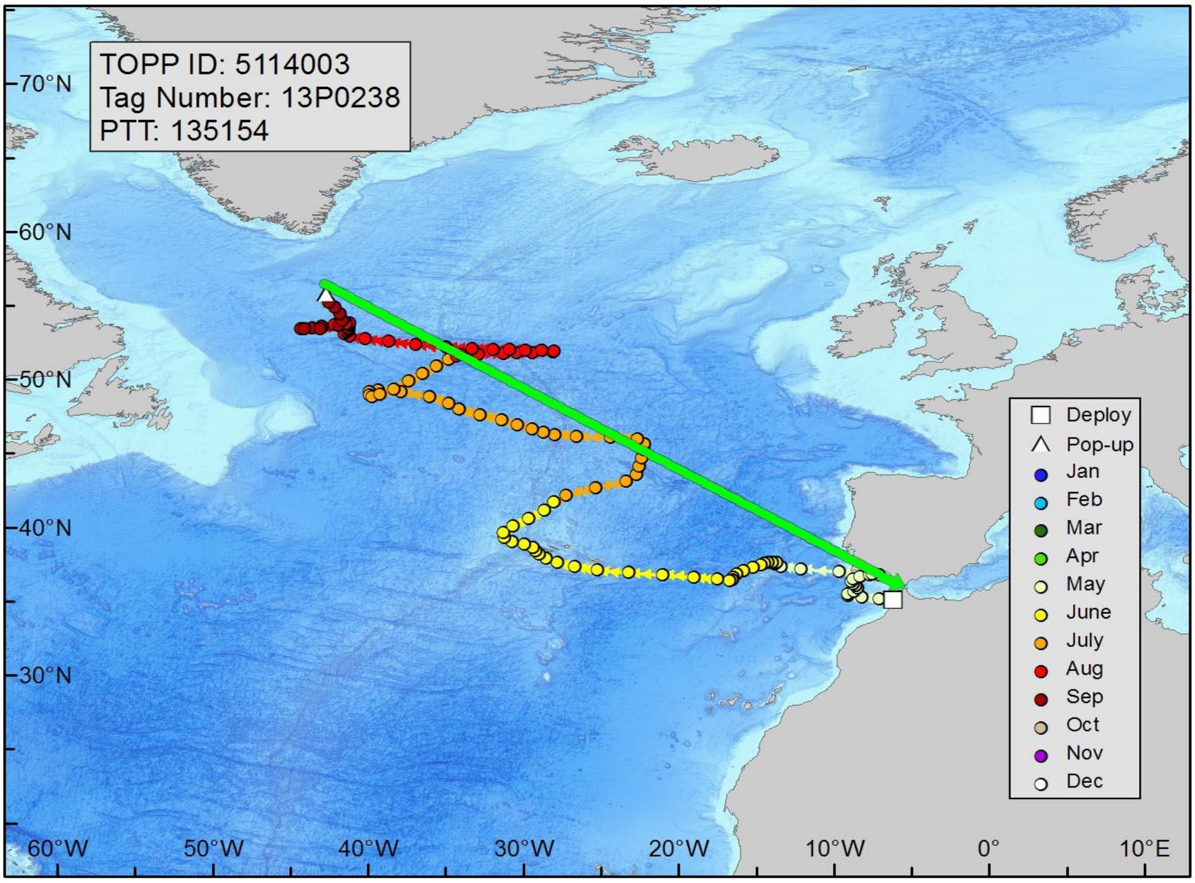


Figure 22. Estimated track of a bluefin tuna tagged in Larache (Morocco) on 13 May 2014 (bullets in color), which went to Greenland in the same year (pop-off on 12 September 2014). This tuna was fished in the Strait of Gibraltar on 25 June 2015 (straight line). (image courtesy: Prof. Barbara Block, Stanford University, USA).

The displacement of conventional tags limited to fish tagged by GBYP activities, for which tags were reported to ICCAT, are showed in **Figure 19**, while **Figure 20** shows the selection of only those tags implanted by GBYP on juveniles. **Figure 21** shows the displacement of juveniles tunas when tags were recovered and reported within the first year after tagging. All figures derived from conventional tags shows trans-Atlantic movements and other interesting features.

A particularly interesting case concerns a male bluefin tuna that was double tagged by the team of the Stanford University in cooperation with the GBYP in the tuna trap of Larache (Morocco) on 13 May 2014, which went to Greenland in the same year (the track of the electronic tag shows a pop-off on 12 September 2014), without entering into the Mediterranean Sea during the 2014 spawning season and therefore moved somewhere in the Atlantic Ocean. It was finally fished in the Strait of Gibraltar on 25 June 2015 (**Figure 22**), where the second tag was recovered and reported to GBYP.

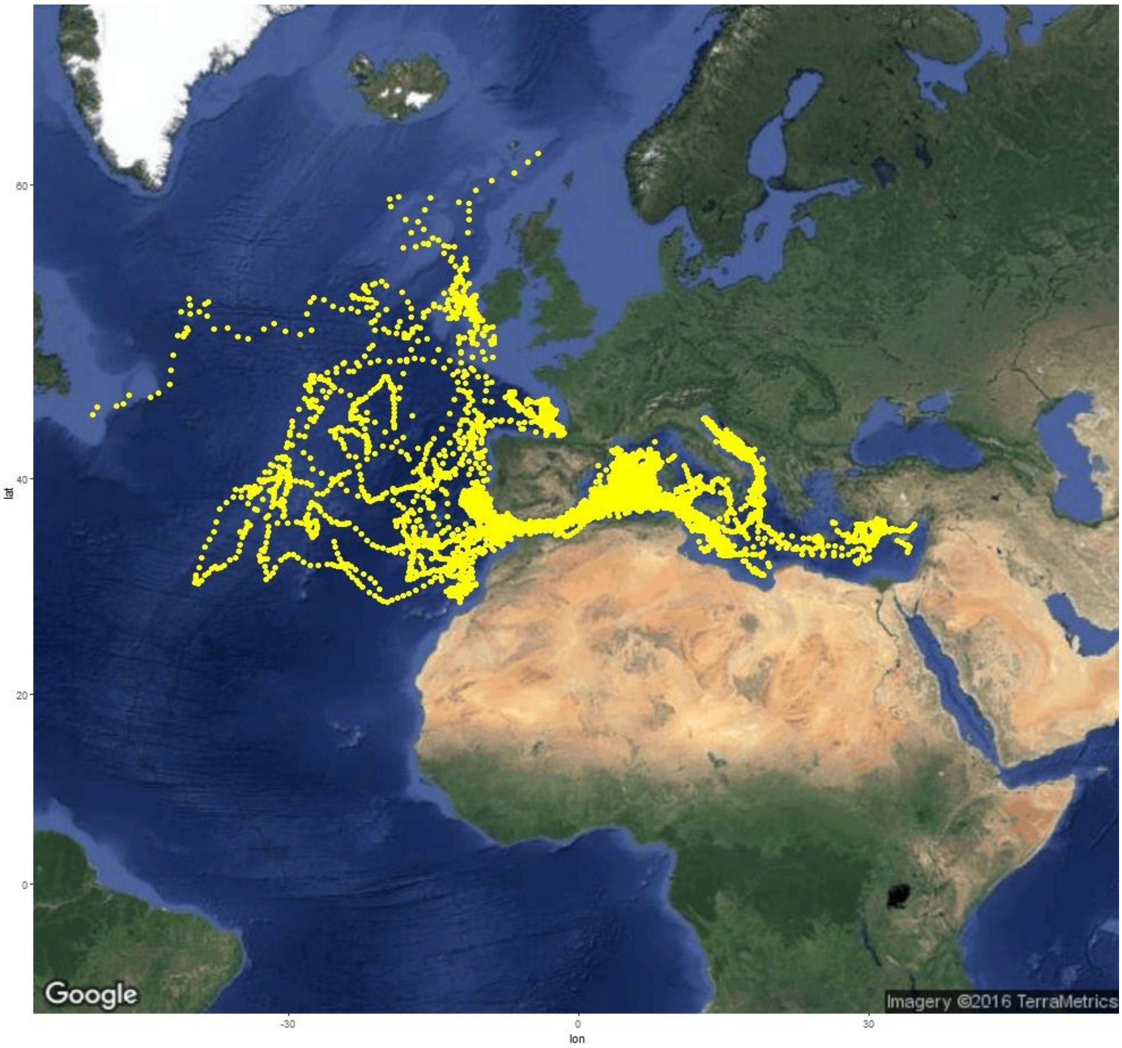


Figure 23. Cumulative tracks of all satellite data received so far from all PSATs deployed in the various Phases by ICCAT GBYP in Eastern Atlantic and in the Mediterranean.

As concerns the electronic tags (miniPATs) deployed in Phase 5, for the first time all data were recovered before the end of this Phase. The full analysis of these data taking into account the individual behaviour and the environmental data will require time but, even if GBYP has not been specifically requested to do so, it was already initiated.

All tracks (81 in total) are now fully available and they are much more than those included in SCRS/2015/149 (**Annex 1b, document no. 21**); therefore, and for duly reporting this activity, a dedicated technical report was attached in the annexes (**Annex 1a, document no. 27**). The full cumulative tracks of all PSATs deployed in all GBYP phases are showed on **Figure 23**, while those from PSATs deployed in Phase 5 only are showed on **Figure 24**. The trajectories of all PSATs deployed in Phase 5 are showed on **Figure 25**.

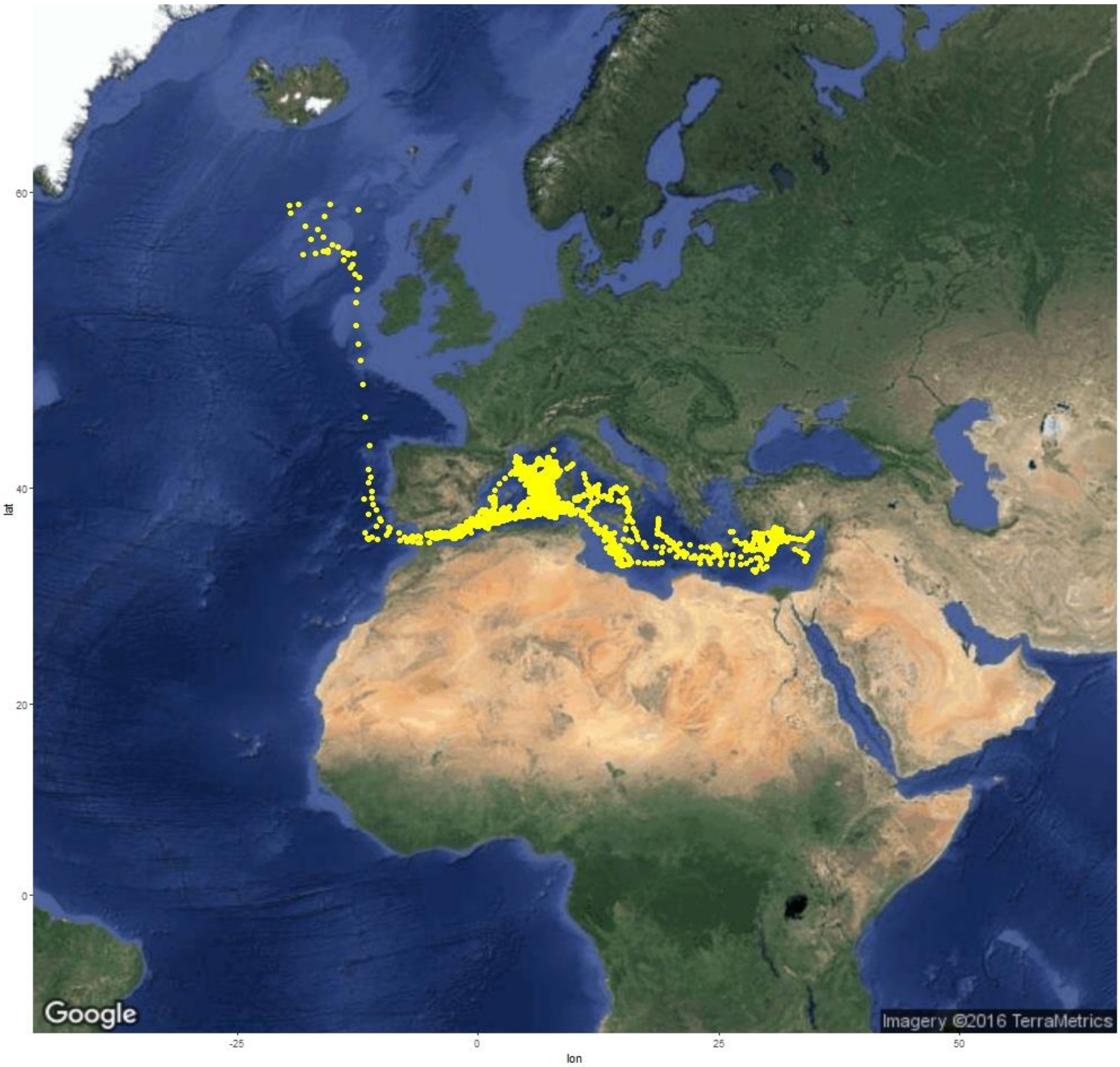


Figure 24. Cumulative tracks of satellite data from all PSATs deployed in Phase 5 by ICCAT GBYP in Eastern Atlantic and in the Mediterranean.

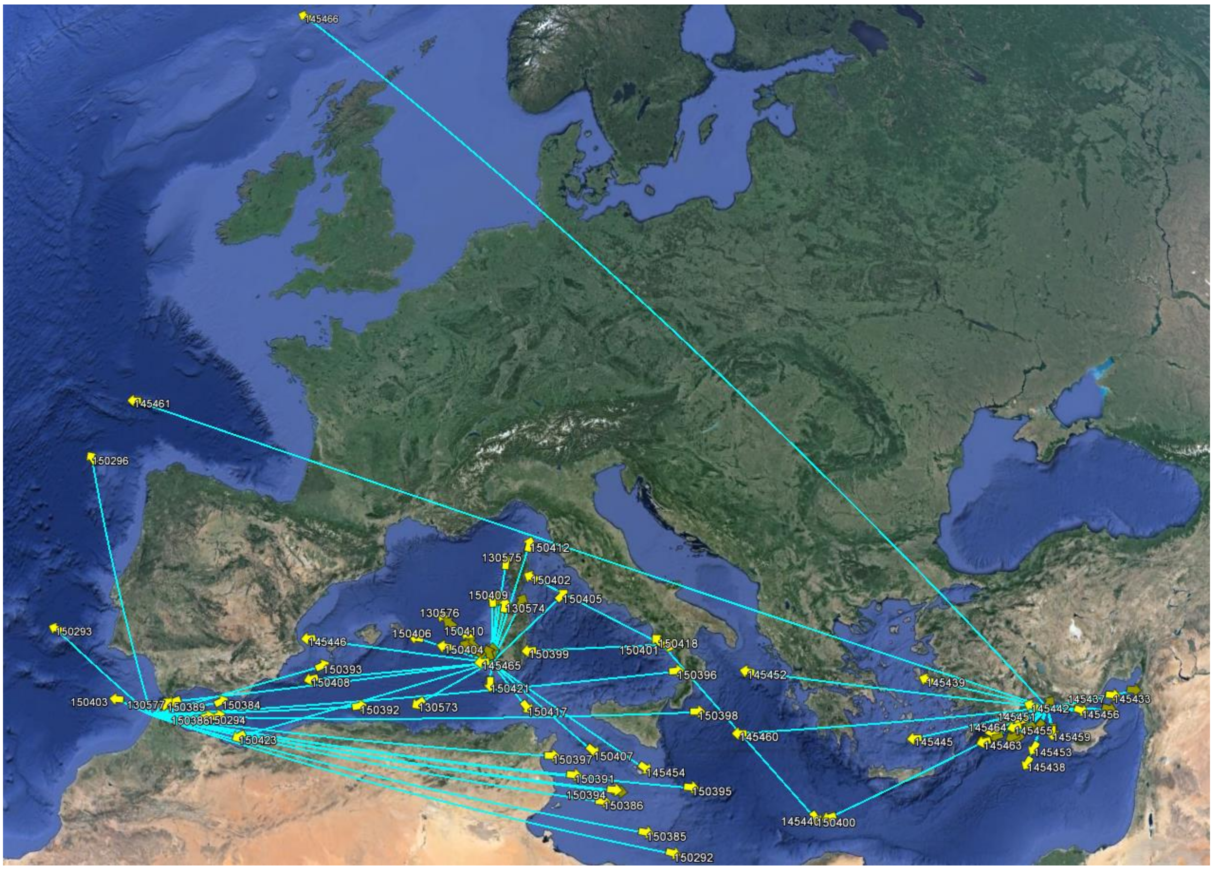


Figure 25. Tag release-tag pop-up vectors of adult bluefin tunas tagged with miniPATs in the Moroccan and Sardinian traps, in Turkish purse-seine and in an Italian cage in GBYP Phase 5.

For better showing the results of the PSATs deployed in each location in Phase 5, here there are specific figures. **Figure 26** shows the tracks of the tags deployed in the tuna trap of Larache (Morocco), showing that some of those tunas entered into at least three of the main spawning areas (Balearic Sea, southern Tyrrhenian Sea and southern-central Mediterranean Sea).

Figure 27 shows the remarkable displacements of some of the tunas tagged in Turkish purse-seiners (showing also the number of tags that popped-off because these tunas where fished within two weeks from tagging), **Figure 28** shows the "resident" behaviour of the medium-size tunas tagged in the Sardinian traps. **Figure 29** shows similar behaviours of the few tunas tagged in the southern Tyrrhenian Sea quite late in the season.

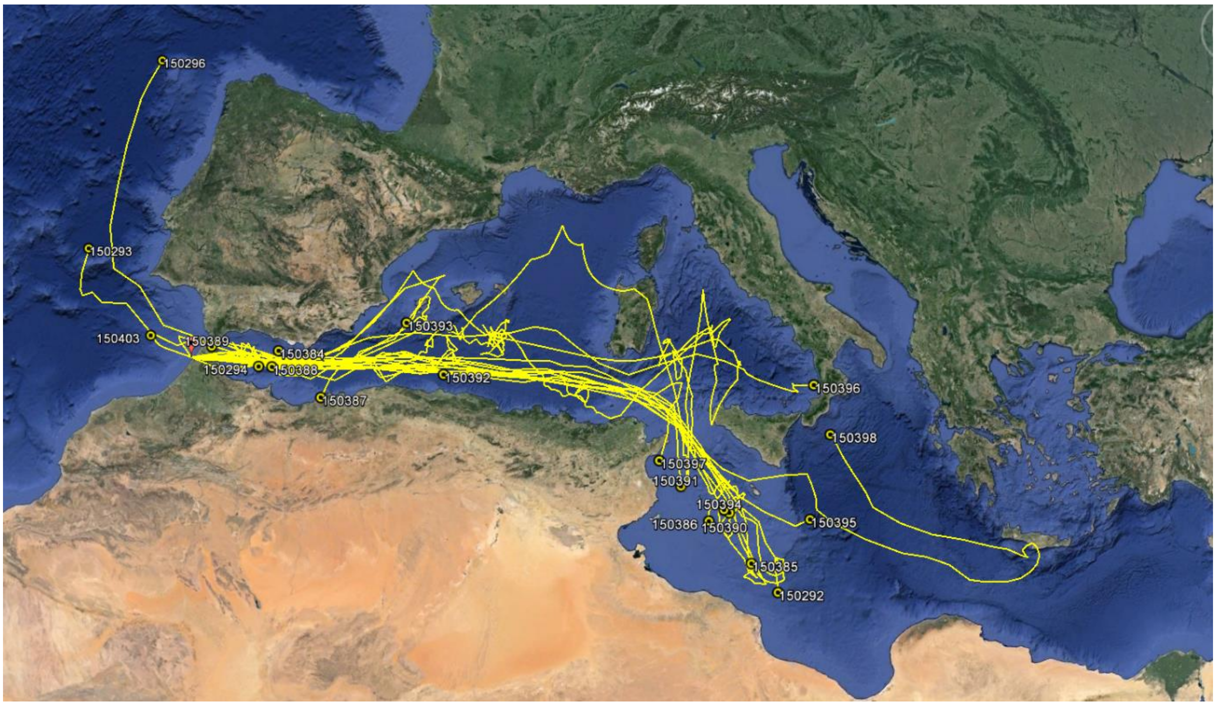


Figure 26. Cumulative tracks from all PSATs deployed in Phase 5 by ICCAT GBYP in Larache (Morocco)

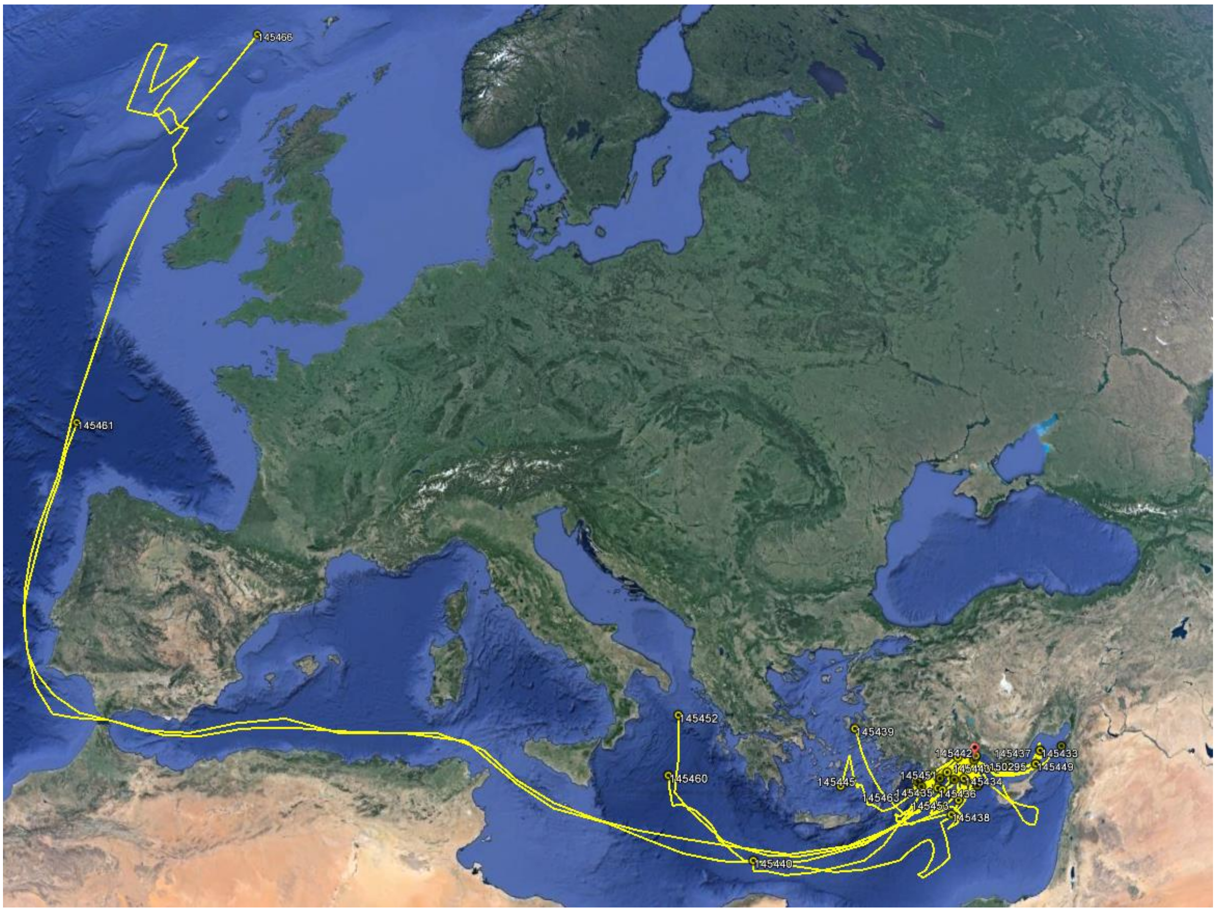


Figure 27. Cumulative tracks from all PSATs deployed in Phase 5 by ICCAT GBYP in Turkey.

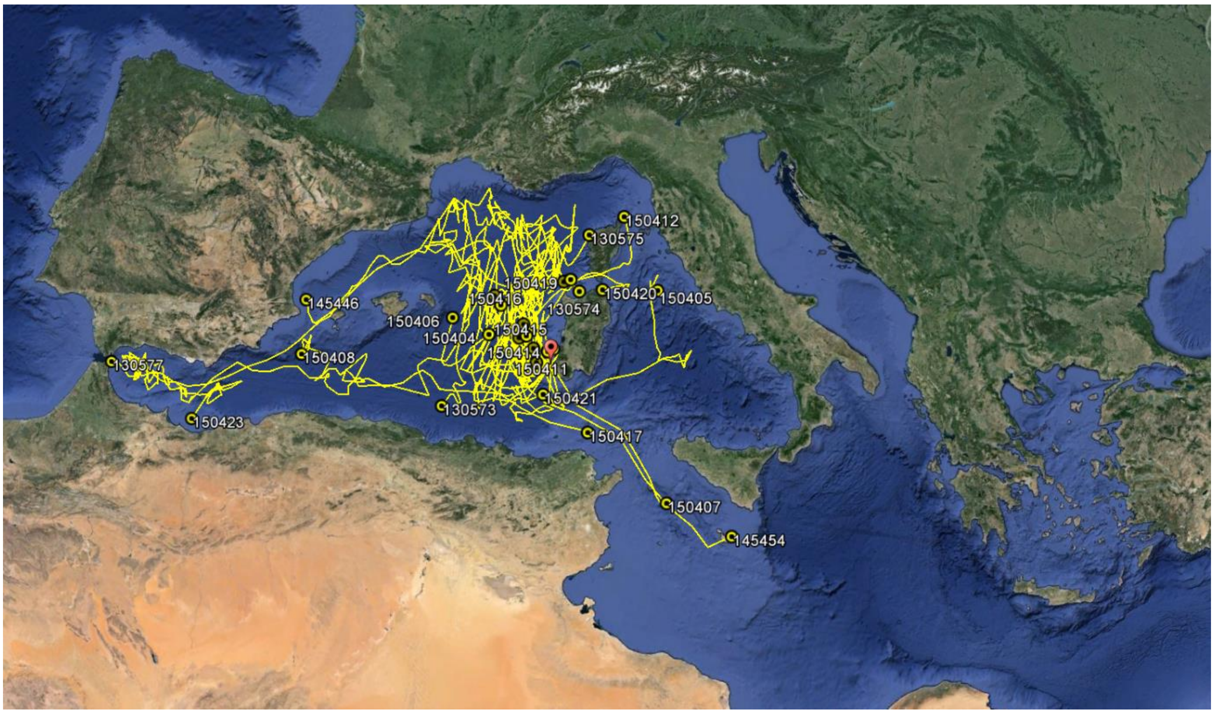


Figure 28. Cumulative tracks from all PSATs deployed in Phase 5 by ICCAT GBYP in Sardinia.

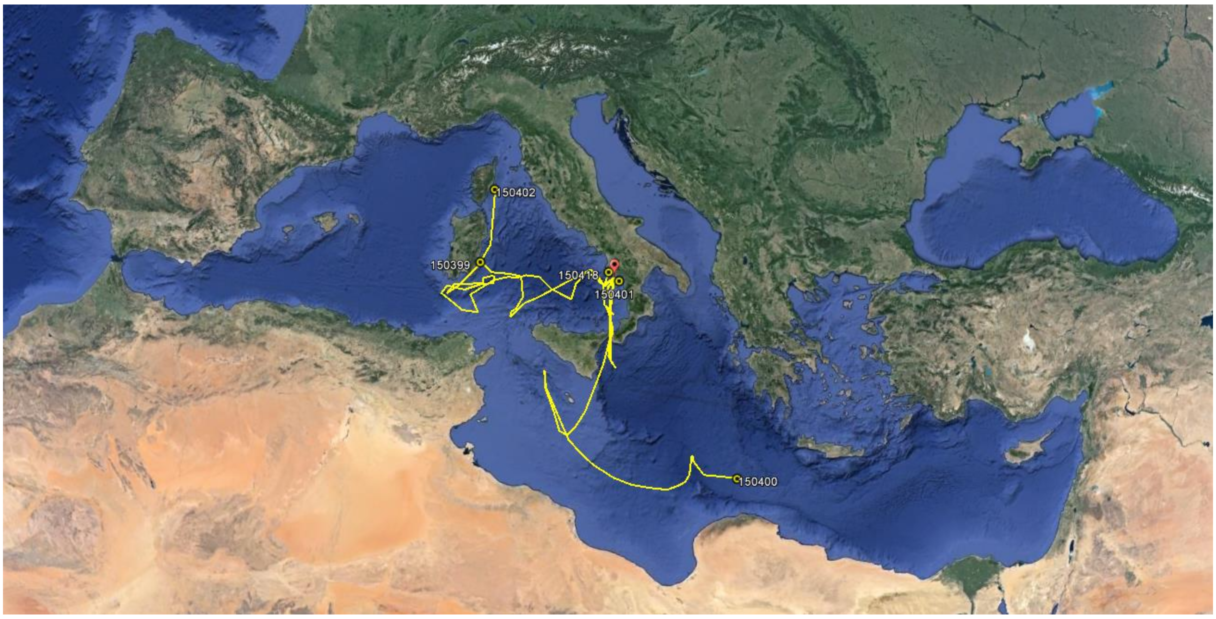


Figure 29. Cumulative tracks from all PSATs deployed in Phase 5 by ICCAT GBYP in Sardinia.

During the SCRS BFT Data Preparatory Meeting, all data sets from electronic tags deployed by the GBYP in all Phases were provided to PhD Matt Lauretta (in charge of collecting all satellite tags data sets on behalf of the SCRS BFT Species Group) and to Tom Carruthers (the expert in charge of developing the technical aspects on behalf of the ICCAT GBYP Core Modelling MSE Group), and these data were used for two papers

(SCRS/20015/170 and SCRS/2015/180), plus a presentation at the BFT Data Preparatory Meeting (SCRS/P/2015/008) (**Annex 1b, documents 7, 23** and **28**). PSATs data sets which arrived in the following months have been provided to the two experts as well and the results were showed during the last meeting of the ICCAT GBYP Core Modelling MSE Group in Monterey (January 2016).

Unfortunately, GBYP was one of the few entities providing the data from PSATs to the two experts and this is a clear limitation because partial data might create a biased image of the BFT situation. Some important data sets are still sitting in some laboratories and the following recommendation from the SCRS BFT Data Preparatory Meeting (May 2014) "Given the substantial number of tags that have been deployed on Atlantic Bluefin tuna, much of which has not been made available through ICCAT, the Group recommended that all electronic tagging data be submitted to ICCAT in the format approved by the Ad Hoc SCRS working group on tagging to be made available for analyses by April, 2015. In this regard, the Group supports the previous recommendation from the Biological Parameters Meeting (2013, Tenerife)" is still only partially enforced.

5.7 Cost-benefit analysis for the tagging programme

As recommended by the Steering Committee, then by the SCRS and as it was endorsed by the Commission, the cost-benefit analysis for the ICCAT GBYP tagging programme was done in the Phase 5, in order to have a more focused overview of the activities carried out so far and have further details for adopting the best research strategy in Phase 6.

The detailed terms of references were set by the GBYP Steering Committee and, after the Call for Tenders, a short-term contract was provided to Centre for Environment, Fisheries and Aquaculture Science - CEFAS, from United Kingdom.

The full report of the cost/benefit analysis for the ICCAT GBYP Tagging activities is provided in the annexes (**Annex 1a, document no. 28**) and it is also available on http://www.iccat.int/GBYP/Documents/TAGGING/PHASE%205/TAGGING_PHASE5_REVIEW.pdf .

5.7.1 Results of the analysis and recommendations

Independent cost-benefit analysis of the tagging programme affirmed that the ICCAT GBYP is known globally as a significant scientific endeavor that has very high value in raising public awareness. The analysis also acknowledged the efforts made by the GBYP Coordination in all Phases.

The analysis was quite comprehensive and took into account all data available up to the end of January, which were not the full data sets that were available later. At the same time, the report revised all results so far and the costs.

The final cost per tag (considering the full costs for the material, the deployment and all side costs and taking into account the number of tags recovered so far[9]), comparing the current GBYP cost levels with the only available comprehensive estimate for all EU tagging projects[10] (page 19 of the report), was about 63% for the conventional tags and 24% for the electronic tags.

As key achievements of the tagging programme between 2010 and 2015 the reviewers stated the followings:

- A comprehensive tagging programme that has succeeded in deploying nearly 25,000 tags on more than 16,000 ABFT across a broad area of the Mediterranean and eastern Atlantic, despite significant logistic constraints, and at lower than expected cost;
- Development of an ABFT tuna tagging manual and incremental improvement of tagging techniques (both conventional tags and electronic tags) that provide confidence in the GBYP tag deployments;
- Coordination of a tag awareness and return programme that has resulted in nearly 400 tags being returned over five years, representing a near doubling of the data available on eastern Atlantic and Mediterranean tuna from the previous 30 years. These returns help to validate the current paradigm of eastern and western stock components;
- Recovery of ~180 datasets from electronic tags that provide evidence of the complexity and diversity of bluefin movements and behaviour within the Mediterranean and eastern Atlantic.
- Development of modelling and assessment frameworks in readiness for use of the tagging data. The uptake of tagging data into the assessments will help to identify the strengths and weaknesses of the tagging data, and to further refine the tagging programme in the future.

Based on the assessment of the achievements and benefits of the tagging programme so far, a number of recommendations was made, based on the long-term achievement of the high-level objectives:
R1: Undertake a comprehensive and systematic analysis of all tagging data returned to date;
R2: Long-term planning for the next stage of the GBYP;
R3: Modify the GBYP tagging and sampling design and move, largely, to fishery independent data retrieval;
R4: Improve awareness of tagging programme though coordinated campaign of peer-review, popular articles, and social media.

Fulfilment of these recommendations would help contribute towards the current SCRS strategic goals of communication (goal 4: improve communication of data to the scientific community), research (goal 2: acquire

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[9] For the electronic tags, it was considered the number of tags which transmitted the data to the satellite.

[10] STECF 2008, STECF, (2008). Report of the Working Group on Research Needs (SGRN-08-02). 6. Bluefin tuna and swordfish tagging activities in the period 2005-2007: summary of actions undertaken by MS and evaluation. JRC Scientific and Technical reports, EUR 23631: 115-123.

the necessary biological knowledge in tuna) and data collection (goal 3: other biological data).

The reviewers also stated the following (page 19): “Given the financial resources invested (only ~1/3rd of expected funding for the GBYP tagging programme was realised) and the range of logistic issues experienced during the tagging programme it is clear that, despite falling short of the original targets, the achievements have generally exceeded expectations”.

The results of this cost-benefit analysis for the tagging programme will represent one of the key elements of the second GBYP review and will be an essential step prior to making any important decision or possibly changing a work plan.

5.8 Close-kin tagging

As a possible alternative to the conventional tagging or as additional tagging approach, the ICCAT GBYP Steering Committee recommended to explore and evaluate the close-kin genetic tagging. The close-kin approaches is a method that uses the frequency of closely related individuals (e.g. parent-offspring, siblings) in a sample to estimate abundance and other vital rates of populations. The close-kin method provides an estimate of the absolute biomass and/or the trend in biomass, which can be directly used in a stock assessment or harvest control rule. As with other genetic methods, the cost-effectiveness depends on the availability of suitable samples, the costs of developing appropriate markers and sufficient understanding of the life-history of the species. The method was tested and used in southern bluefin tuna and performed very well and is now being considered as a method for routine long-term monitoring of the spawning stock. Therefore, an expert advice for the ICCAT GBYP on this subject was asked for, including a detailed overview of the close-kin genetic tagging carried out so far on tuna species, the recent scientific developments and an evaluation of possible costs for properly implementing a close-kin genetic tagging program for the Atlantic bluefin tuna in its distribution range.

For the purpose of obtaining the advice on close-kin tagging, two Calls for tenders were unsuccessfully released, resulting in receiving one inadequate bid on the first attempt, and no bids on the second attempt. As a consequence, after the opinion of the Steering Committee, it was decided to proceed by releasing a direct invitation to the institutions knowing to have direct experience with the method. This approach proven to be more successful, because two bids were received. Due to the important delay caused by the first two Calls, and the time constraints for the conclusion of Phase 5, the original terms of reference were split in two parts by the Steering Committee: a first part to be done during the Phase 5 and, depending to the availability of funds, the possible follow up which would be done in Phase 6.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) from Australia was awarded and contracted, for providing a report with the following parts:

a) Describe in a clear and synthetic way the close-kin genetic tagging and its uses for assessment purposes, including the MSE;

b) Overview of the close-kin genetic tagging activities carried out on tuna species in various areas;
c) An evaluation of the potential to apply close-kin genetic tagging method for obtaining estimates of the size of the spawning population for Eastern Atlantic Bluefin including sample size for various level of precision ranging from cv's of 10-30%;
d) A detailed experimental design including the steps and timeframe for the implementation such a program including realistic sampling options and strategies;
e) A comprehensive consideration of the assumption involved and how they might be tested and dealt with to ensure that robust estimates are obtained (e.g. stock structure; skipped spawning and relative spawning potential;
f) The feasibility and benefits of combining a close-kin genetic tagging for Eastern and Western Atlantic Bluefin;
g) Potential risks and strategies for minimizing them.

Depending on the positive completion of the first part of the study, the contractor may be granted an extension of the contract in Phase 6, for the second part of the study, including these tasks:

1. Review of the genetic sequencing work conducted on Atlantic bluefin tuna to date
2. Definition of genetic markers for the Atlantic Bluefin Tuna.
3. Estimate a possible budget including a breakdown for the various components (e.g. sampling; genetic analyses, statistical analyses) for carrying out a reasonable close-kin genetic tagging for the Atlantic bluefin tuna in its distribution range within the ICCAT Convention area.
4. An evaluation of the potential to combine a close-kin genetic tagging program with a mark-recapture genetic program for juveniles including sample sizes, sampling strategies and additional cost.

5.8.1 The first part of the close-kin genetic tagging feasibility study

The CSIRO provided this first report with a considerable delay. The report includes a comprehensive overview of the close kin genetic tagging studies carried out so far, with more detailed overview of the activities carried out on tunas and particularly on southern Bluefin tuna. Furthermore, the studies on pelagic sharks have been included.

The study (**Annex Ia, document no. 29**) includes many details on the scientific approach in terms of demographic probability of kinship and the data required for carrying out a reliable close-kin genetic tagging study.

Close-kin Mark Recapture (CKMR) is a new approach to estimating abundance and other important population parameters with demonstrated applicability to the highly migratory southern bluefin tuna fishery. Close-Kin Mark-Recapture uses information on the frequency, and distribution in space and time, of closely related individuals in samples of tissue from live or dead animals. The first large-scale application was for southern bluefin tuna (SBT), where it was developed as an absolute abundance estimator independent of commercial catch per unit effort

(CPUE) and total catch data. The SBT application was relatively simple, in that: SBT is a single population with one know spawning ground; much of the population biology is well documented; and existing monitoring systems were in place that facilitated the provision of high quality length, age and tissue samples of known spawning adults and juveniles. An application to EBFT poses a number of challenges, including: east-west population structure across the Atlantic and possible structure within the Mediterranean, which require more complex sampling designs and estimation models; less biological background knowledge; and substantially more complex logistics/operational environment.

The review of previous applications of CKMR highlights two central considerations for EBFT. First, it has been extended and generalised beyond the Parent-Offspring-Pairs (POP) used in the SBT case, to include more distant kin (e.g. Half-Sibling-Pairs), which reduce the sample size requirement (because for a given sample size, the total number of kin-pairs found will be larger), and reduce the need for untestable assumptions and/or extra biological information, e.g. about fecundity-at-age. Second, a "naive" carbon-copy of the SBT approach to a species that (unlike SBT) may have substantial within-population structure (i.e. spawning-ground fidelity of some kind), could lead to badly biased estimates. However, the report assumes that a more sophisticated version of CKMR, using POPs and HSPs and sampling in multiple locations, can solve the problem. Specifically, from CKMR it is possible in principle to identify "management relevant" structure in populations, and to estimate the relative contribution of "spawning units" to effective reproductive output of the population as a whole (i.e. the quantity of primary concern to fisheries management). The latter does not require the existence of a genetic marker, in the conventional population genetics sense; rather, the nature of structure and the extent of mixing can, in principle, be estimated from the distribution of POP and HSP among spawning and juvenile grounds (**Figure 30**).

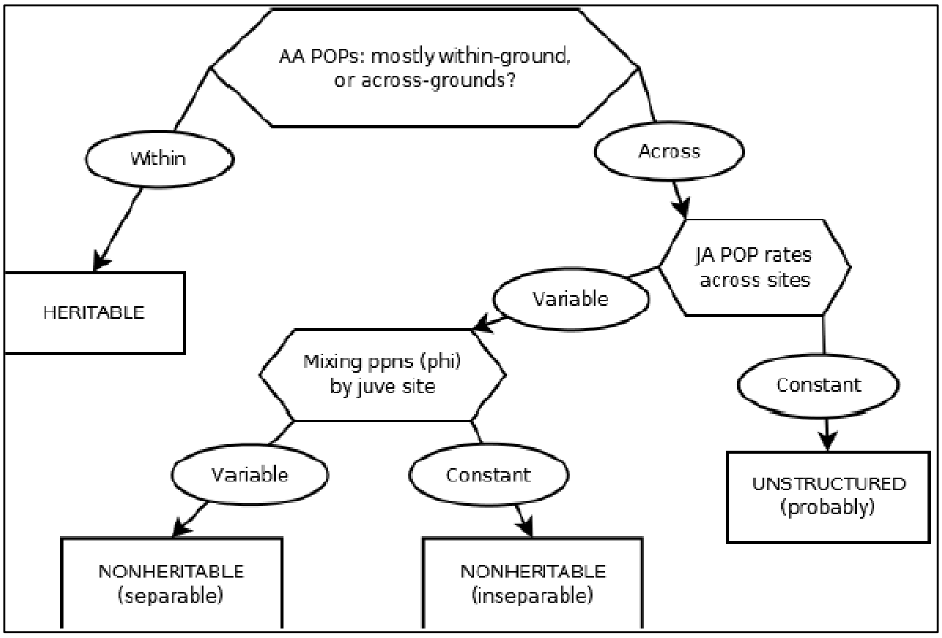

Figure 30. Stock structure decision three. This must exclude Parent Offspring Pairs (POP) comparisons when the adult is caught in the year of juvenile birth and HSP comparisons within the same cohort of juveniles.

Based on a review of the relevant literature, the GBYP sampling programs and communications with ICCAT ABT scientists, the contractor consider that CKMR should be feasible for EBFT, assuming it is possible to: (i) increase the annual sample size of tissue, otolith and length samples obtained from the Mediterranean and eastern/central Atlantic sampling programs; (ii) distinguish between individuals of eastern and western origin with a high probability; and (iii) implement high quality sample, processing and data management programs to minimise the likelihood of genotyping errors. To demonstrate statistical feasibility and to broadly investigate sample size requirements, the contractor developed an age-structured, multiple-population CKMR model and used current estimates of EBFT population parameters consistent with the most recent ICCAT stock assessment for a simple case of 2-spawning grounds by 2-juvenile grounds example. The contractor used this model to explore a range of sampling designs, covering factors such as total sample size, split of samples between adults and juveniles, assumption about age-structure of the adult samples, length of sampling program in years.

Assuming a primary design criterion of a CV of around 15% on the estimated 2014 spawning biomass, it appears that the desired CV might be obtainable for total sample sizes (i.e. adult and juveniles) in the order of ~30,000-40,000 individuals[11]. The total number required should not depend too much on the actual number of spawning and juvenile grounds, but will depend somewhat on the duration of the study (the report considered 3, 4, and 5 year design) and other design details such, e.g. what size of adults to concentrate on genotyping. More importantly, though, the actual number of samples required may well turn out to be considerably different, because the true stock size and other true biological parameters (including the nature of any population structure) may themselves well be quite different from (i) the current stock assessment results the calculations on which the calculation was based, and from (ii) other assumptions (e.g. about mixing proportions) that we had to make in order to explore possible designs. Sample sizes can be adjusted as the study goes on and knowledge accumulates (just as happened for SBT), especially if extra samples are collected (cheap) but not genotyped (less cheap) in the first pass, but are available subsequently for genotyping if sample sizes need to be increased (in order to find enough kin-pairs to make a reliable estimate).

Because of the many uncertainties, it is not possible to provide specific costings for a CKMR study at this stage. However, based on these sample size calculations, the cost of the original SBT application and reductions in the cost of marker development and large-scale genotyping since then, the study would expect the annual cost to be in the order of Euro 620-1300K per annum (411K to 1030K euro/year for sampling and 201K to 240 k for the genetic analyses) for the 5-year period required to provide a first estimate (for a total between 3.1M to 6.5M over 5 years); this estimate does not include the costs for ageing and the sampling/release campaigns for the juveniles.

[11] The total number of bluefin tunas sampled in 2015, joining the efforts of two main contractors. This amount includes fish where it was possible to obtain several types of samples (including otoliths) and fish where only one or more type of samples were collected, because of several sampling constraints.

For specific mathematical reasons (and unlike, say, an annual trawl survey), CKMR is most efficient when used not just as a “one-off” estimator, but rather as part of a time series whereby abundance estimates are updated (e.g. as is now planned for SBT). If a CKMR program for EBFT were to continue after the first few years, it is entirely reasonable to expect sample size requirements to drop and the ongoing annual cost to decline further.

Given this, the report concludes that there is scope for CKMR to significantly improve the data and understanding available to effectively assess the status of ABFT, and EBFT in particular. Assuming there are sufficient resources and institutional commitment to modify and expand the current level of biological sampling completed under the GBYP to the level required to obtain an informative number of close-kin (POPs and HSP) and associated ancillary data, then the study recommends the following activities in order of priority:

1. Determine the most cost-effective form of genotyping that can demonstrably identify HSPs. By cost-effective, we mean the GBS (Genotyping-By-Sequencing) method that can provide the required level of genotyping reliability required to consistently identify HSP for the lowest cost per fish (Note: if the method can do this for HSP, it can necessarily do it for POPs.)
2. Consideration should be given to doing 1 in conjunction with a workshop that includes expertise from a range of other areas that are active in large-scale, high through-put genotyping for applied fisheries and/or natural resource management purposes (e.g. Pacific Salmon, the FishPopTrace Consortium, GBYP Biological Program Consortium, CSIRO) to learn from their experience and share the cost involved in evaluating alternative GBS platforms in a very rapidly developing and technically complex field.
3. In consultation with GBYP Biological Program and BFT WG, select juvenile and adult sampling locations for “initial round of CKMR sampling”, which are consistent with current understanding of spawning units and juvenile grounds, and initiate sample collection as soon as possible. These samples can, in the short-term, be archived and, or, used to develop genotyping and data processing work-flows and quality control procedures for identifying kin; genotyping itself can happen later.
4. Commence an inclusive, expertise-based process to review and identify candidate markers (genetic and/or microchemical) for assigning samples to eastern and western populations. While it may be appealing to include “within Med” markers as part of this exercise, it is not necessary for the purposes of CKMR, and there is no virtue in waiting for the (uncertain) outcome of a within-Med marker search before starting CKMR. As noted in the report (section 6), the CKMR data will reveal any population structure in the Mediterranean, as long as the sampling of spawning grounds and juvenile areas is sufficiently comprehensive. The final E-W candidate(s) markers, including assignment probabilities, should be decided based on validation study conducted with known origin fish of sufficient sample sizes to provide statistically reliable estimates of assignment probabilities.
5. Finally, it is important to recognise that design and implementation of CKMR requires a combination of both broad (fisheries biology, field and laboratory logistics, statistics, mark-recapture theory, population dynamics, population genetics and genomics, applied stock assessment) and deep knowledge and expertise (in this case, in

ABFT population biology and fisheries, CKMR design and implementation). CKMR data will not fit into a VPA. Hence it will be important to establish close linkages with the development of new assessment methods and the MSE work program of the GBYP and broader ICCAT assessment process to ensure the greatest benefit is obtained from the data and information that would be provided by such a program. There is a very substantial process of statistical and programming development required for both the stand alone CKMR assessment model and the incorporation of the CKMR results into an integrated stock assessment (see Hillary *et al*., 2012, 2013). CKMR itself is quite new, and the extension to population-structured settings like EBFT is completely new; in these (relatively) early stages of the development and implementation, it will be important to consider the best mechanism (contracting and institutional) to establish and maintain a suitable experienced and qualified team for design and implementation to deliver high quality and robust results in the short-term and, if successful, the development of the necessary capability to maintain an ongoing program into the future.

The operating model being developed for MSE, as part of the GBYP Modeling and MSE work program (Carruthers et al., 2014; Butterworth et al., 2016), would be able to accommodate the CKMR data. It is likely that these data would be extremely informative and valuable for this purpose, if and when they become available; and, particularly, if they can be obtained for both the east and western populations.

6. Biological Studies

The initial, short-term ICCAT GBYP objective approved by the Commission in 2008 was to collect samples from 12,000 fish (including western Atlantic and the Japanese catches and markets) and carry out ageing and genetic studies, and micro-constituent analyses in three years in the eastern Atlantic and Mediterranean, with a total budget of 4,350,000 Euros. So far, with only 34.04% of funding (a total of 1,480,787 Euros, including the budget amount set for Phase 5, equal to 342,496 Euros), the ICCAT GBYP collected samples from 9183 fish (76.53% of the target) and carried out ageing, genetic and micro-constituent analyses; furthermore, the sampling design and protocols, and the otolith shape analyses were included in the activity carried out so far. It is very clear that the general objectives sets for the biological studies in these first Phases were largely accomplished so far, taking into account the proportion of the available budget.

The GBYP biological sampling design was the one provided by the Institut National de Recherche Haulieutique (INRH - Morocco) on March 2011. The final approved version is available on the ICCAT-GBYP web site: http://www.iccat.int/GBYP/Documents/BIOLOGICAL%20STUDIES/PHASE%202/Rapport%20final%20design%20echantillonnage%20biologique%20ICCAT-GBYP.pdf

All the activities carried out in previous Phases and in the first part of Phase 5 concerning the biological sampling and analyses have been already preliminary presented to SCRS and the Commission (SCRS/2015/0144, **Annex 1b, document no. 16**).

6.1 Objectives

The main objective of this task was to improve understanding of key biological and ecological processes through broad scale biological sampling of live fish to be tagged and dead fish landed (e.g. gonads, muscles, otoliths, spines, etc.), histological analyses to determine bluefin tuna reproductive state and potential, and biological and genetics analyses to investigate mixing and population structure, namely to define the population structure of Atlantic bluefin tuna (*Thunnus thynnus*), with a particular attention to the age structure and the probable sub-populations identification.

6.2 Activities

The activities in previous GBYP Phases have been clearly able to accomplish their objectives. Of course, the activities in following Phases of GBYP are set for completing and improving the preliminary results and for better defining some issues, such as mixing between the two current stocks and the sub-population hypothesis, which may require several years of data and many analyses, depending on the available budget.

Following the recommendations of the Steering Committee and the SCRS, the GBYP plan for **Phase 5** was set as a continuation of Phase 4, going on with all activities and repeating the ageing calibration. Furthermore, it was planned to have a recompilation of previous analytical data according to well-established areas that shall be constant over the years. The GBYP coordination, working together with the Steering Committee and the BFT Species Group, revisited the list of strata and areas for the sampling, according to the improvements that were not available at the moment of the sampling design. This table is now the reference table for all ICCAT GBYP biological studies, because its details allow for any type of aggregation when elaborating the data. As such, it was made mandatory attaching it to the Call for tenders (no. 02341/2015) that was released on 29 April 2015. Unfortunately, the three bids received by ICCAT were not considered adequate. Therefore, and after few modifications of the ToRs, ICCAT released a new Call for tenders (no. 03587/2015) on June 6, 2015. After the selection of the four bids received, two bids were awarded. The first was to a large Consortium headed by AZTI, including 14 entities and 7 subcontractors, belonging to 8 different countries, while the second contract, limited to sampling in two areas, was awarded to Necton Marine Research Society. Unfortunately, it was not possible to contract a new ageing calibration in Phase 5, because the bid was not satisfactory. Phase 5 reports are available on on http://www.iccat.int/GBYP/en/biostu.htm and the document are in the attachments (**Annex 1a, documents no. 19** and **20**)

Table 19. Detail of samples collected by size and area by the Consortium. Additional 224 samples were collected by Necton in the Tyrrhenian Sea (25 age 0, 19 juveniles, 50 medium, 30 large) and in the eastern Ionian Sea (50 medium and 50 large)(central Mediterranean), bringing the total samples to 1,730 tunas in 2015.

	Larvae	Age 0	Juvenile	Medium	Large	TOTAL	Target	%wrt target
Eastern Mediterranean		18		8	45	71	100	71%
Central Mediterranean		100		51	36	187	200	94%
Western Mediterranean	80	63	3	66	9	221	175	126%
Strait of Gibraltar		15				15	0	>100%
East Atlantic - West African coast					73	73	100	73%
Northeast Atlantic			2	3	43	48	40	120%
North Sea					26	26	0	>100%
Central North Atlantic				14	593	607	50	1214%
North-Western Atlantic					30	30	0	>100%
Gulf of Mexico	47				181	228	0	>100%
TOTAL	127	196	5	142	1036	1506	665	226%
Target	0	225	0	50	390	665		
% wrt target	>100%	87%	>100%	284%	266%	226%		

The main report of biological studies was provided by the Consortium on time, after amending the contract, but then it was revised six times and it was finalised with a considerable delay. Some activities were well over than the target, while others were below for various reasons. The Consortium provided a detailed table for all the samples analised so far, with individual coordinates (with this allowing for any possible aggregation by strata), but it was not able to re-elaborate within the time frame of the contract the tables from previous reports according to the new strata as it was planned. The detail on new samples collected in Phase 5 is on **Table 19**.

6.2.1 Micro-chemical analyses

Otoliths of Atlantic bluefin tuna have proven to be highly effective tools to study population structure and migratory pathways. Over fish's life, otoliths grow by accumulating new material in concentric layers around a central nucleus. Examining the chemical composition of different portions of otoliths informs about where fish have been at various life-stages; the initial nucleus of the otolith can inform about the natal origin of each fish.

Based on stable isotopic composition, mixed stock proportions of eastern and western population can be estimated throughout the North Atlantic Ocean. New carbon and oxygen stable isotope analyses were carried out in 286 otoliths of Atlantic bluefin tuna captured in east and west parts of Atlantic Ocean in order to determine their nursery area. $\delta^{13}C$ and $\delta^{18}O$ values measured in otolith cores indicated substantial mixing in Morocco and the central Atlantic Ocean, especially west of 45ºW. Nevertheless, based on previous and current results, the majority of bluefin tunas captured west of 45°W are of western origin, whereas catches east of 45ºW are primarily from the eastern Atlantic population (**Figure 31**). Although the mixing rates in both central and western North Atlantic Ocean are considerable, they seem very variable over the years (**Table 20**). Results of the current and previous analyses suggest that there is a significant interannual variation in the spatial distribution of bluefin tuna in the North Atlantic Ocean, with considerable variable mixing rates.

Table 20. Maximum-likelihood predictions of the origin of large (>100 kg) bluefin tuna analyzed under the current contract. Estimates are given as percentages and the mixed-stock analysis (HISEA program) was run under bootstrap mode with 1000 runs to obtain standard deviations around estimated percentages (± %).

			Predicted Origin		
Region	Year	N	% East	% West	% SD
Bay of Biscay	2012	52	99.7	0.03	± 1.3
Portugal	2012	30	90.8	9.2	±13.7
Central North Atlantic (west of 45°W)	2013	53	36.7	63.3	± 9.7
Central North Atlantic (east of 45°W)	2013	65	51	49	± 11.2
Morocco	2014	49	29.7	70.3	± 11.9
Canary Islands	2014	38	100	0	+ 0

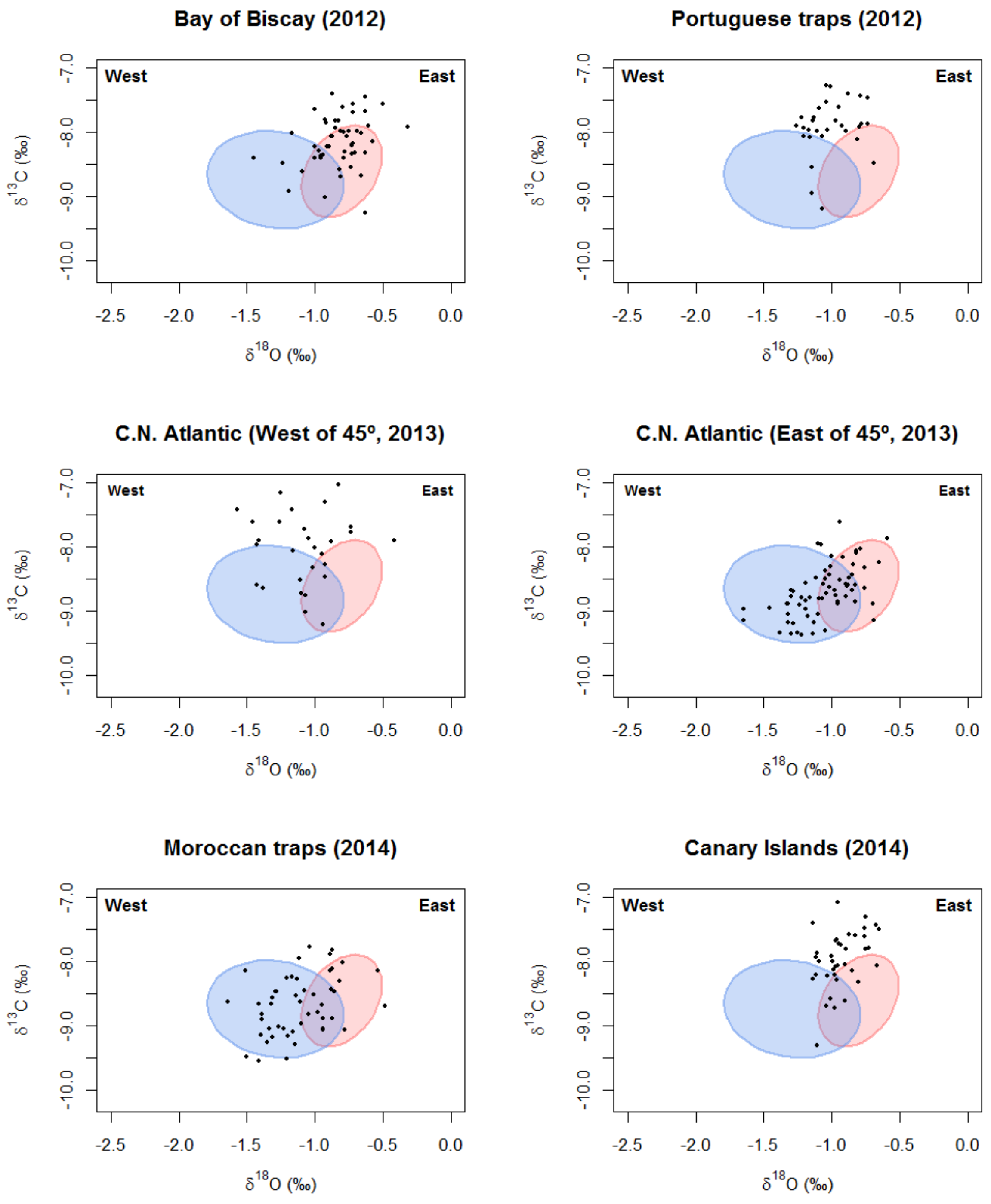

Figure 31. Confidence ellipses (1 SD or ca. 68% of sample) for otolith δ13C and δ18O values of yearling bluefin tuna from the east (red) and west (blue) along with the isotopic values (black dots) for otolith cores of bluefin tuna collected from the Bay of Biscay, Portuguese coast, central North Atlantic Ocean (namely west of 45ºW), central North Atlantic ocean (east of 45ºW), Atlantic Moroccan coast and Canary Islands (from Consortium Report, 2016).

In addition, 1371 individual bluefin were assigned to their natal origin on individual basis, using different classification techniques. Based on QDFA and SVM methods, 226 individuals were identified as western migrants with a probability > 70%, whereas NB and RF identified 207 and 206 individuals respectively. Given the similarity of the methods, results from the QDFA were used in subsequent analyses (**Figure 32**). For this purpose, otoliths that have already been analysed for stable isotopes composition in previous phases of the GBYP were used. Knowing the origin of individual fish will enable the construction of stock-age-length-keys, and the comparison/improvement of individual assignments based on different types of markers (i.e. genetic, otolith shape and stable isotopes). Moreover, it will allow to table the results according to any stratification that might be used during the stock assessment or MSE process. Overall, all classification methods used in this analysis lead to very similar results, indicating that individual classifications are robust and in agreement with mixed stock proportions found in the previous GBYP Phases using maximum likelihood estimates. Interannual variability in mixing between west and east population seem to be high (mostly in central North Atlantic, where EBFT are usually dominant, and in the Ibero-Moroccan area, where there is a huge variability between EBFT and WBFT), which implicates that, for the purpose of stock assessment and management, the monitoring of mixing proportion needs to be carried out on a yearly basis.

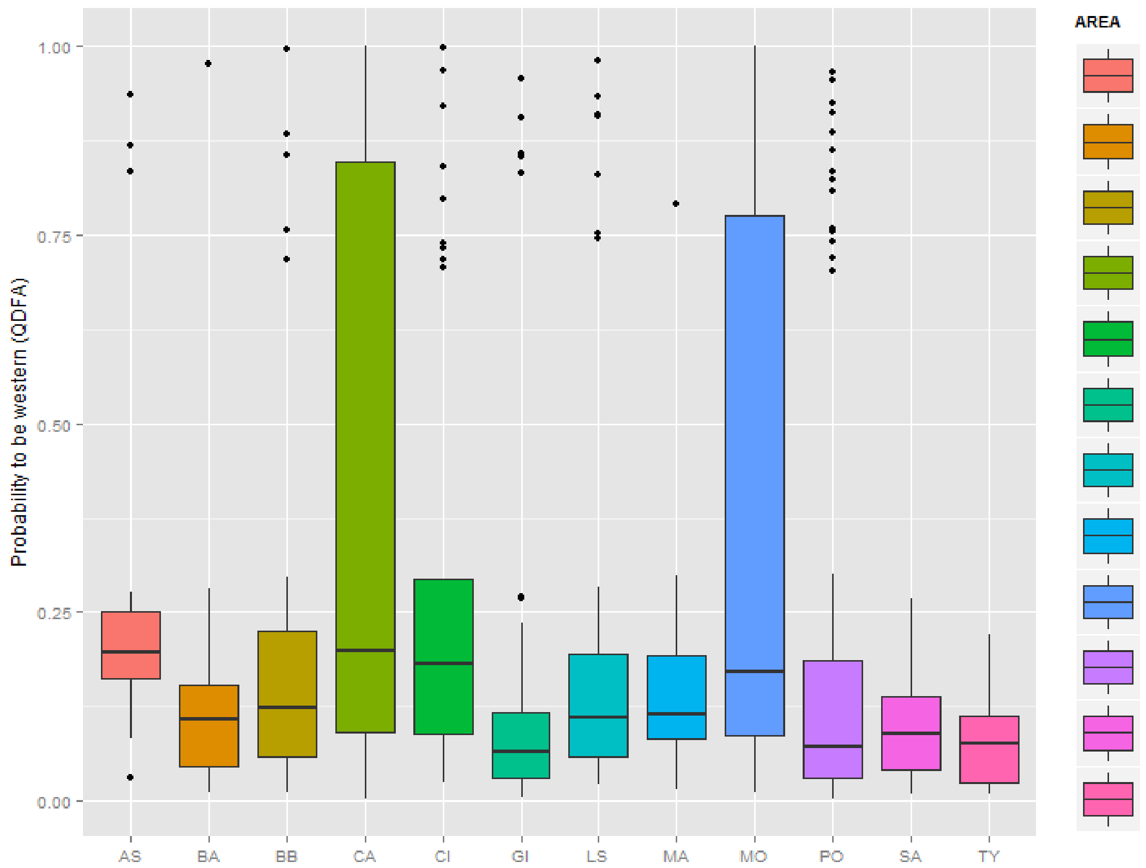

Figure 32. Boxplot of the probabilities of western origin estimated by QDFA (excluding probabilities between 30-70%). Areas: Adriatic Sea (AS), Balearic Sea (BA), Bay of Biscay (BB), Central Atlantic Ocean (CA), Canary Islands (CI), Strait of Gibraltar (GI), Levantine Sea (LS), Malta (MA), Atlantic Morocco (MO), south Portugal (PO), Sardinia (SA) and Tyrrhenian Sea (TY).

Regarding tracking habitat usage through different life stages by trace element composition, during GBYP Phase 4 otoliths from Mediterranean Sea and open Atlantic Ocean were already analysed by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) with the aim of developing a new marker that allows tracking bluefin tuna movement between the Mediterranean Sea and Atlantic Ocean. In the Phase 5 additional otoliths were analysed for the purpose of extending the dataset by including samples from the western Atlantic Ocean. Although the assessment of the utility of otolith trace element chemistry along the growth axis of the otolith to reconstruct the spatial movements of adult bluefin tuna over their lifetimes is still ongoing (**Figure 33** shows the variability of three elements along the otolith axis of a BFT sampled in Malta), it already suggests that discrimination among water masses is possible if sufficient gradient in temperature and salinity exist among locations.

Figure 33. Example of trace element (Mg, Sr and Ba) chemical analysis along the growth axis of an otolith of adult Atlantic bluefin tuna captured in Malta. Analyses performed from the core to the edge. Last 40µm of the time series are used to represent capture location.

Finally, a combined analysis of the trace element and stable isotope composition in young-of-the-year (YOY) from different nurseries was carried out. This research was guided by the hypothesis that if YOY signatures prove to be distinct among nurseries within the Mediterranean, then adult bluefin tuna that are caught in the fishery can be assigned back to their regions of origin, and each nursery's contribution to the adult population can be quantified. Stable isotopes analyses were carried out on 153 otoliths collected in 2011 and 2012; the results show areas of overlapping among different Mediterranean areas, but at the same time that BFT from the Levantine Sea could be discriminated from the other areas (**Figure 34**).

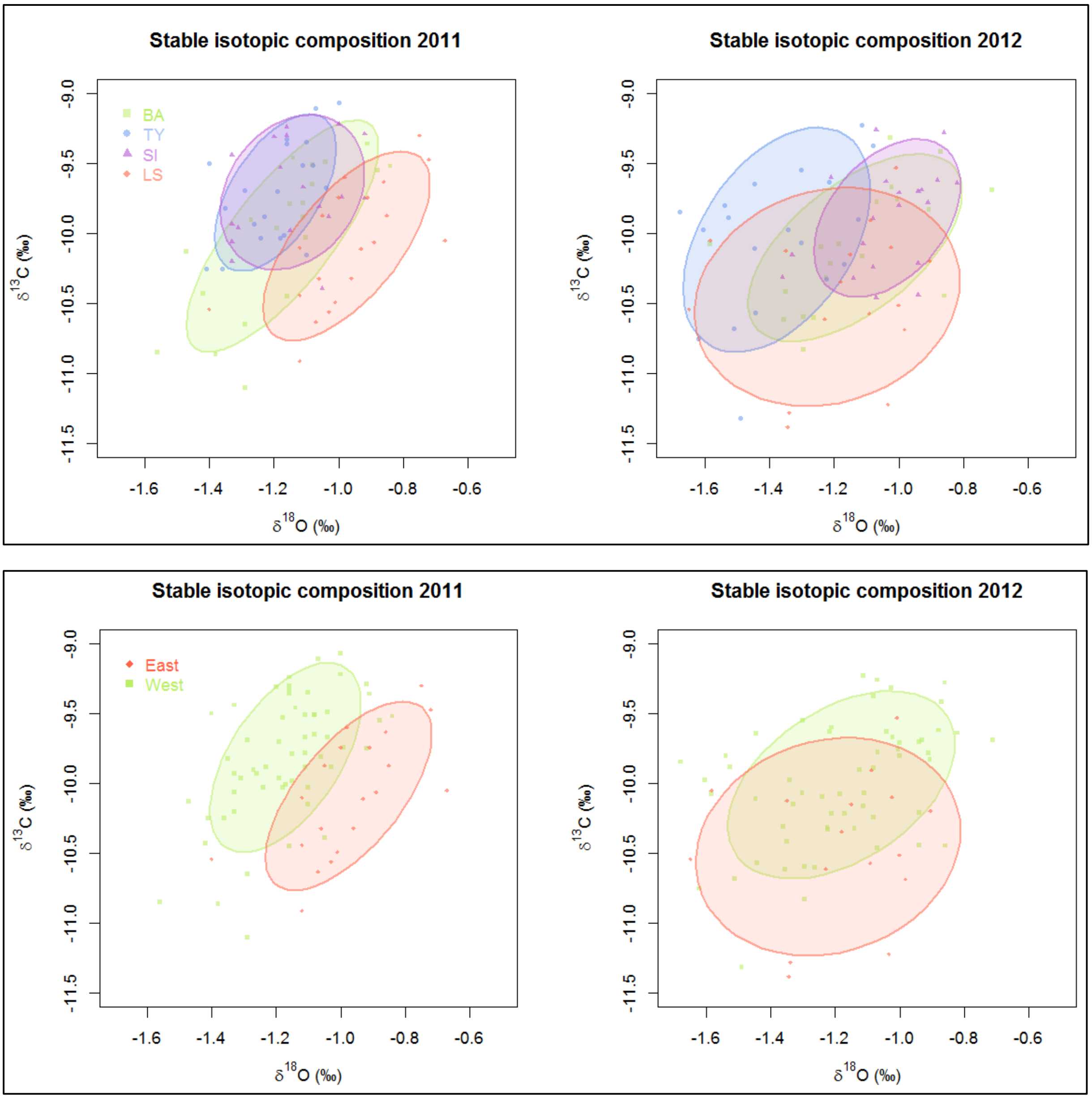

Figure 34. Discrimination of nursery areas within the Mediterranean Sea by trace element and stable isotope composition in young-of-the-year bluefin tuna. **Upper figures**: Confidence ellipses (1 SD or ca. 68% of sample) for otolith δ13C and δ18O values of young-of-the-year bluefin tuna from the Balearic Sea (green), southern Tyrrhenian Sea (blue), eastern Sicily (purple) and Levantine Sea (red) collected during 2011 and 2012. **Lower figures**: Confidence ellipses (1 SD or ca. 68% of sample) for otolith δ13C and δ18O values of young-of-the-year bluefin tuna from the eastern (Levantine Sea) and western-central (Balearic Sea, southern Tyrrhenian Sea and eastern Sicily) Mediterranean basins.

The results from QDFA indicated a good classification success for YOY from western-central vs. eastern Mediterranean basin (86% in 2011 and 78% in 2012) (**Table 21**). These results reflect the potential strength of this approach as a tool to differentiate bluefin tuna originated in the Levantine Sea with those from other spawning grounds in the Mediterranean Sea.

Table 21. Best element(s) and classification accuracy (estimated by QDFA) using stable isotopic composition of young-of-the-year bluefin tuna otoliths for 2011 and 2012 cohorts. Area codes correspond to Levantine Sea (LS), southern Tyrrhenian Sea (TY), eastern Sicily (SI) and Balearic Sea (BA).

Group division	Year	Best element(s)	Classification accuracy
BA / TY / SI / LS	2011	$\delta^{18}O + \delta^{13}C$	40%
BA / TY / SI / LS	2012	$\delta^{18}O + \delta^{13}C$	44%
East (LS) / West-Centr. (BA, TY, SI)	2011	$\delta^{18}O + \delta^{13}C$	86%
East (LS) / West-Centr. (BA, TY, SI)	2012	$\delta^{13}C$	78%

The trace element analysis was carried out on Li, Mg, Mn, Fe, Cu, Zn, Sr and Ba (**Figure 35**). The optimal classification accuracy (based on QDFA) was attained when using only the combination of Ba, Fe, Li and Mg. Discrimination between the samples collected from the Levantine Sea and those collected from other parts of the Mediterranean Sea are showed on **Figure 36** and **Figure 37**.

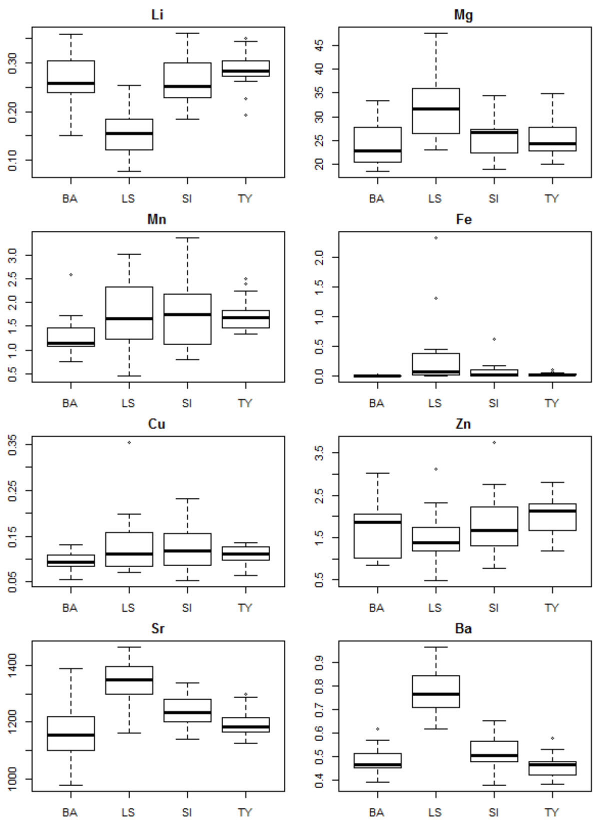

Figure 35. Trace element concentration (ppm) in post-larval portion of otoliths from young-of-the-year Atlantic bluefin tuna (*Thunnus thynnus*) collected in the Balearic Sea (BA), Levantine Sea (LS), eastern Sicily (SI) and southern Tyrrhenian Sea (TY) from August to October 2011.

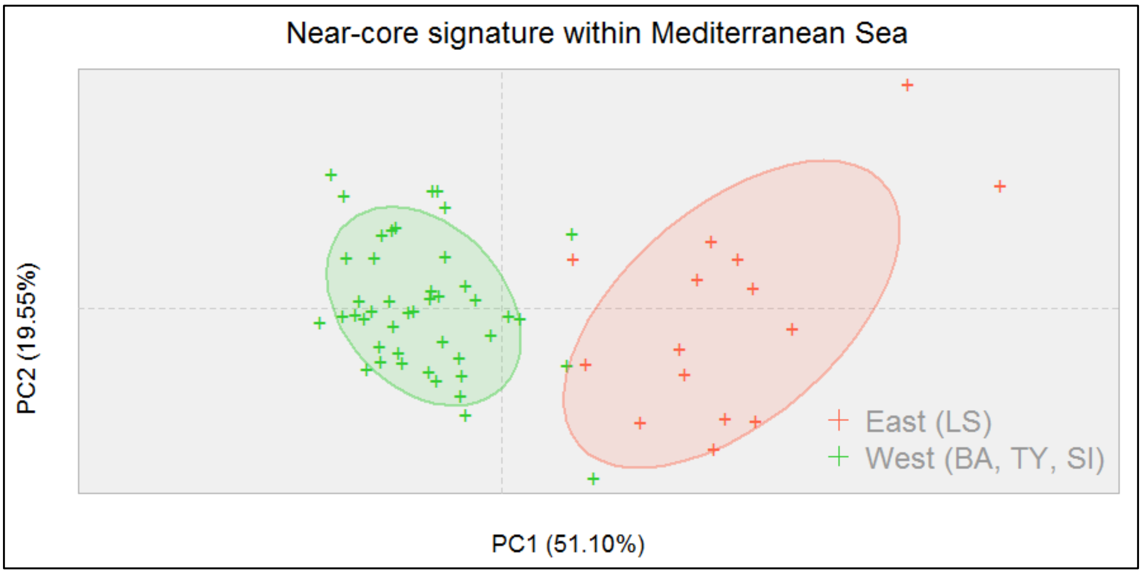

Figure 36. Elemental fingerprints for young-of-the-year bluefin tuna (*Thunnus thynnus*) otoliths from the eastern (Levantine Sea, in red) and western-central (Balearic Sea, southern Tyrrhenian Sea and eastern Sicily, in green) Mediterranean basins, based on the first two axis of the Principal Component Analysis including Li, Mg, Fe, Sr and Ba concentrations.

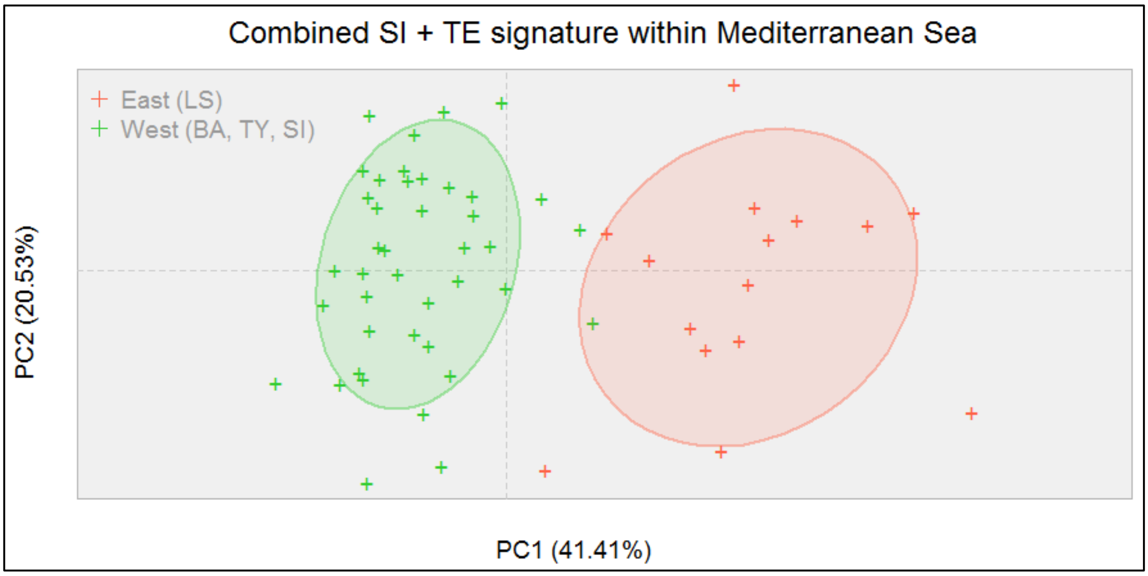

Figure 37. Elemental and isotopic fingerprints for young-of-the-year bluefin tuna (*Thunnus thynnus*) otoliths from the eastern (Levantine Sea) and western-central (Balearic Sea, southern Tyrrhenian Sea and eastern Sicily) Mediterranean basins, based on the first two axis of the Principal Component Analysis including Li, Mg, Fe, Sr, Ba concentration together with δ13C and δ18O values.

Results from QDFA indicated that YOY bluefin tuna from the Levantine Sea can be discriminated from the western-central Mediterranean basins with 98% accuracy. Additionally, this technic may allow determining if some spawning locations have greater contributions to the adult stock than others. Nevertheless, since the interannual variability is huge, the prior year-class sample matching is necessary to approve accuracy when applying this methodology, as well as building a multiyear baseline for elemental signature when using trace element chemistry for classification of several year-classes.

6.2.2 Genetic analyses

The RADSeq analyses have already been initiated in previous phases of the GBYP project, and they have been completed this year with additional 75 reference samples (larvae and young-of-the-year), for which DNA was extracted. Using a total of 188 samples (plus 4 as negative controls), 8 genotype datasets were generated containing PCR clones. Results of the structure analyses based on these genotypes show clear structure and support genetic differentiation between the Northwest Atlantic and the Mediterranean, but doesn't show any evidence of genetic structuring within the Mediterranean.

Furthermore, a set of 192 RAD-seq derived SNPs has been selected and is currently in the validation process[12], for assessing the conversion rate of genotyping assay and the consistency of the genotypes obtained with those inferred from RADSeq data and for evaluation of the reliability of these markers for assignments of samples of the known origin. This set will be combined with the best SNPs derived from the GBS panel (Phase 4) and with other SNPs obtained from the literature in order to build a "final, best available SNP panel". Once this panel will be validated (technical and biologically), it will be ready to be used for assigning of genetic origin to individuals of unknown origin in the mixing regions.

The genetics analyses carried out in Phase 5 were carried out on a total of 240 samples analysed with RAD-seq; after the quality and genotype filters, only 221 were retained. When using the dataset containing PCR clones, Structure analyses based on the eight genotype datasets show a clear structure between the Northwest Atlantic and the Mediterranean but no evidences of genetic structuring within the Mediterranean (**Figure 38**). The result is consistent whatever set of parameters is used (M=2/n=3 or M=4/n=6). Interestingly, when removing PCR clones, the differences between the Mediterranean and the North-West Atlantic are not as obvious in the structure plots (**Figure 39**), although still visible particularly for m=3.

Principal Component Analyses are congruent with the Structure results and show clear differences between the Mediterranean and North-West Atlantic samples, both when PCR clones are included or not (Figures 5.4 and 5.5). Again, no differences among Mediterranean samples can be observed. In summary, the analyses support genetic differentiation between North-West Atlantic and Mediterranean samples, but do not show evidences of any substructure within the Mediterranean.

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[12] This work was initially included into GBYP Phase 5, but then the Consortium had unexpected technical problems when selecting the SNPs suitable for genotyping.

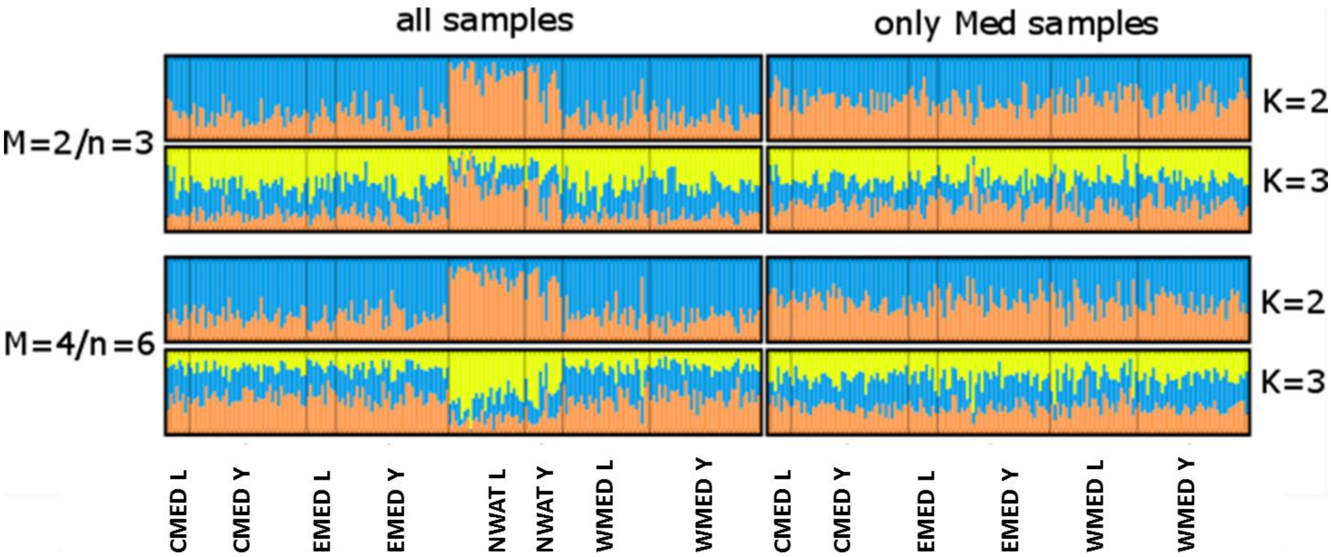


Figure 38. Graphical representation of individual ancestry using Structure software for the four genotype datasets including PCR clones. Each bar represents one individual and each color, its degree of belonging to each inferred group. Results of 2 or 3 (K) potential ancestral populations are shown.

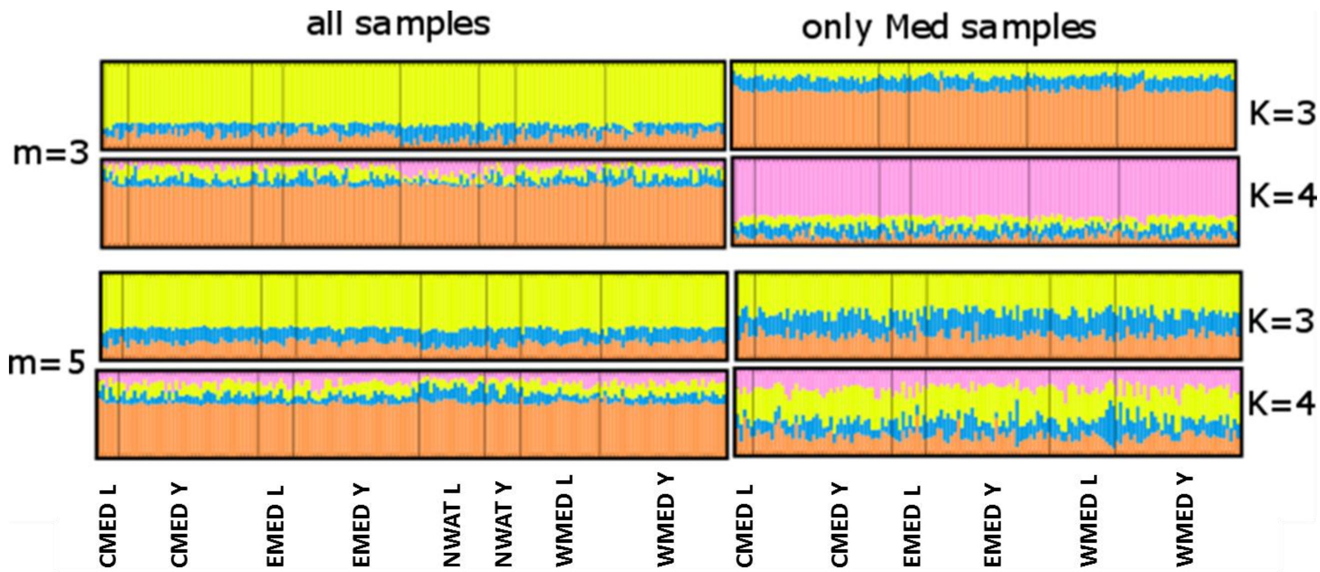


Figure 39. Graphical representation of individual ancestry using Structure software for the four genotype datasets not including PCR clones. Each bar represents one individual and each color, its degree of belonging to each inferred group. Results of 3 or 4 (K) potential ancestral populations are shown.

6.2.3 Otolith shape analysis

Regarding otolith shape analyses, otoliths of bluefin from the Gulf of Mexico were used to improve the characterisation of the western stock of bluefin tuna using otolith shape. Only otoliths from large adult spawners

(>170 cm FL) were used for the analyses, but all samples were from specimens collected in Phase 4, while 2015 samples were set aside for future analyses.

Baseline analyses:

In all, 27 elliptical Fourier coefficients and one shape index showed significant variation between the East and West Atlantic (GLM P<0.05) and were not significantly correlated with length (in some cases after standardisation). Seven shape descriptors (B6, B10, C8, C9, D2, D3, D5, circ) were retained in the DFA by stepwise selection producing one canonical function that distinguished between otoliths from east Atlantic and west Atlantic fish (P<0.0001). The canonical function distinguished between fish of eastern and western origin with a mean jack-knife classification success rate of 80% (**Table 22**). The classification success was comparable but marginally lower than that achieved in the previous analysis. This may reflect the fact that the refined western baseline includes fish with more diverse environmental histories and hence more variable otolith shape than the Canadian samples that were previously used as the baseline. The future inclusion of the Mediterranean spawners from the 2015 sampling season will allow this to be examined in more detail.

Table 22. Jack-knife classification matrix from the discriminant function analysis, using seven otolith shape descriptors (B6, B10, C8, C9, D2, D3, D5, circ) to discriminate between adult bluefin tuna (>170cm FL) from the Gulf of Mexico (West) and the Mediterranean (East).

	Estimated origin		
True origin	**East**	**West**	**%correct**
East	83	21	80
West	22	89	80
Total	104	88	80

Mixed analysis:

The results of the Bayesian stock mixture analysis are summarised in **Table 23**. Consistent with the previous analysis, samples from the central Atlantic and Gibraltar were predominantly of eastern origin. The Canadian samples which were treated as the western baseline in the previous analysis were estimated to be predominantly of western origin, justifying there use as the western baseline in the previous analysis. The Canadian samples which were estimated to have a >80% probability of being from the eastern stock (HPE) based on their otolith stable isotope signatures were classified as largely of western origin based on otolith shape. This indicates that otolith shape is more influenced by environmental history than natal origin. Nonetheless, the GLM analyses revealed small but significant differences between the HPE and HPW fish in four of the otolith shape descriptors (P<0.05). The estimated % of eastern origin fish was actually higher in the HPW samples (23%) than in the HPE (9%). However, there was a large margin of error associated with these estimates, particularly for the HPW fish and the difference was not statistically significant. Overall, the performance of the classification model was relatively poor for the HPW and HPE fish compared to the original Canadian samples (previous baseline). This may reflect the fact that the HPW and HPE samples were collected over three sampling years while the original Canadian samples were all collected in 2013. Inter-annual variability could also account for the large % error associated with the mixed samples from Morocco and Portugal. However, the baseline samples were also collected across multiple years, and the shape variables used in the classification function did not vary between years.

Table 23. Mean predicted percentages (±1 s.d.) and 95% Bayesian credible intervals (CI) for eastern and western origin fish in samples of Atlantic bluefin tuna collected from different locations in the central and west Atlantic based on conditional Bayesian estimation (mixFish program)

Location	n	% eastern origin	95% Bayesian CI	% western origin	95% Bayesian CI	% error (± SD)
Central Atlantic (CA)	31	91	53.6-100	9	0.01-46.3	12.5
Canada (CD), original baseline	50	8.1%	0.01-33.5	91.9	66.6-100	9.5
Canada (CD), high probability eastern origin	54	9.1	0.01-43.2	90.9	56.8-100	12.0
Canada, high probability western origin	48	23.4	0.04-88.5	76.6	15.2-100	25.0
Gibraltar (GI)	37	91.6	55.4-100	8.4	0.01-44.6	11.9
Morocco	52	66.8	0.59-100	33.2	0.04-99.4	33.1
Portugal	52	66.8	0.59-100	33.2	0.04-99.4	33.1

6.2.4 Age determination analyses

In the 2015 bluefin data preparatory meeting it was recommended to extend the age analysis by including samples from major fisheries in the Mediterranean, covering the months of higher catches and especially the purse seine fishery. Moreover, it was recalled the importance of carrying out a comprehensive analysis by specimen, with the aim of obtaining information on stock structure coupled with information on age. The GBYP Steering Committee requested also a new calibration, but it was not possible to have this included in the proposal from the Consortium.

In Phase 5, age has been interpreted from 359 calcified structures, 261 otoliths and 98 spines, of which 49 paired structures were obtained from the same specimen; 10 otoliths and 4 spines were discarded due to damages. 93% of the samples were collected in 2011 and 2012; the ageing analysis of these samples was added to the analyses carried out in previous GBYP Phases, reaching a total of 780 otoliths and 633 spines. The CV obtained by the readers is low: 6.5% for otoliths and 3.1% for spines.

The sample selection aimed to improve the sampling coverage of summer months, the Mediterranean area and some fisheries (purse seine, longline and trap). Diagnosis of paired age agreement was evaluated by precision indices through Average Percent Error (APE) and Coefficient of Variation (CV), tests of symmetry and age-bias plots. It was not built an age length key (ALK) for this fifth phase of the project because of the biased selection of samples. Thus, these age readings were combined with previous ones. The annual, monthly, geographical and by gear stratification of the aged samples was explored for phase 5 and for all phases of the project. The results of the ageing results for multi-year analyses are showed on **Figure 40** and **Figure 41**. Likewise an ALK by calcified structure was built (**Table 24**) and the average size and its variation by age were examined (**Figure 42**).

Otoliths	Estimated age																			
SFL (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total n
20-24	100																			6
25-29	100																			4
30-34	100																			6
35-39	100																			4
40-44	100																			5
45-49		100																		1
50-54		100																		1
55-59		100																		14
60-64		100																		10
65-69		100																		1
70-74		50	50																	4
75-79		47	53																	17
80-84		22	65	13																23
85-89			67	33																3
90-94			100																	2
95-99			53	33	13															15
100-104			21	50	29															14
105-109			15	38	15	31														13
110-114				9	47	25	19													32
115-119				9	30	48	13													23
120-124				9	18	55	18													11
125-129					13	60	20	7												15
130-134				10	25	25	30	10												20
135-139					17	25	33	8	17											12
140-144					18	18	18	35	12											17
145-149						31	54	15												13
150-154						21	21	29	21	7										14
155-159						7	36	43	14											14
160-164						9	18	27	36	9										11
165-169							7	50	43											14
170-174								17	33	50										6
175-179								42	33	8	17									12
180-184							6	35	41	18										17
185-189								13	27	20	33	7								15
190-194								8	42	33	17									12
195-199								10	31	24	10	14	7	3						29
200-204								18	18	23	10	10	5	13	3					39
205-209								8	24	29	20	14	2	2						49
210-214								7	20	37	13	15	2	4	2					46
215-219								8	15	25	26	17	8	2						53
220-224									11	30	22	22	5	8			3			37
225-229								10	10	10	25	25	10		5	5				20
230-234									14	14	32	19	16	5						37
235-239									12	12	24	12	6	18	12		6			17
240-244									4	13	13	26	26		9		4	4		23
245-249										22	22	11	22			11		11		9
250-254									17		17	17	17	17	17					6
255-259											20		40	20		20				5
260-264												25		25	25				25	4
265-269													100							1
270-274															100					1
275-279																	100			1
280-284															50		50			2
Total %	3.2	5.4	5.5	3.7	5.6	7.4	5.9	9.0	12.9	12.9	10.5	8.1	4.2	2.7	1.4	0.4	0.6	0.3	0.1	780

0-20%
20-50%
50-100%

Otoliths	Adjusted age																			
SFL (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total n
20-24	100																			6
25-29	100																			4
30-34	100																			6
35-39	100																			4
40-44	100																			5
45-49		100																		1
50-54			100																	1
55-59		93	7																	14
60-64		90	10																	10
65-69		100																		1
70-74		50	50																	4
75-79		24	41	35																17
80-84		22	57	22																23
85-89			67	33																3
90-94				100																2
95-99				73	27															15
100-104			7	57	36															14
105-109			15	31	23	31														13
110-114				6	47	28	19													32
115-119				4	22	61	9	4												23
120-124					27	55	9	9												11
125-129					7	53	33	7												15
130-134				10	20	25	30	15												20
135-139					17	25	33	8	17											12
140-144					12	24	12	41	12											17
145-149						15	62	23												13
150-154						21	21	29	21	7										14
155-159						7	36	43	7	7										14
160-164						9	18	27	36	9										11
165-169							7	50	43											14
170-174									33	67										6
175-179								42	33	8	17									12
180-184							6	35	41	18										17
185-189								13	27	20	20	20								15
190-194									50	33	17									12
195-199								7	31	24	14	14	7	3						29
200-204								18	15	21	13	13	3	13	5					39
205-209								6	22	24	22	20	2	2						49
210-214								7	15	35	11	20	7	4		2				46
215-219								6	13	15	32	21	6	8						53
220-224									8	22	32	22	5	8			3			37
225-229									20	5	15	30	20			10				20
230-234									8	16	24	27	11	8	5					37
235-239									12	12	24	6	12	12	6	12	6			17
240-244									4	13	9	13	39	4	9		4	4		23
245-249										22	22		22	11			11		11	9
250-254									17		17	17		33	17					6
255-259											20		40	20		20				5
260-264												25			50				25	4
265-269													100							1
270-274																100				1
275-279																	100			1
280-284															50			50		2
Total %	3.2	4.5	3.8	5.4	5.6	7.7	5.9	8.7	12.2	11.7	10.6	9.2	4.6	3.3	1.4	0.9	0.6	0.3	0.3	780

0-20%
20-50%
50-100%

Figure 40. Multi-year otolith-based age length key for bluefin tunas caught in the eastern Atlantic and Mediterranean stock, built up with estimated age from opaque bands counting (**left**) and with adjusted ages (**right**). Numbers represent percent by number by 5 cm length class (SFL).

Spines	Age																			
SFL (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total n
20-24	100																			3
25-29	100																			4
30-34	100																			6
35-39	100																			4
40-44	100																			5
45-49	100																			1
50-54		100																		1
55-59	11	89																		9
60-64		89	11																	9
65-69		100																		2
70-74		33	67																	3
75-79			97	3																29
80-84			93	7																30
85-89			67	33																9
90-94			40	40	20															5
95-99				93	7															15
100-104				100																11
105-109				15	69	15														13
110-114				19	65	16														31
115-119				6	68	26														34
120-124				4	44	52														25
125-129					20	75	5													20
130-134				3	3	74	19													31
135-139					7	60	33													15
140-144						58	42													24
145-149					14	23	45	14	5											22
150-154						36	57	7												14
155-159						16	58	21	5											19
160-164						15	23	54		8										13
165-169							25	50	25											8
170-174							50	25	25											4
175-179							17		67	17										6
180-184							12	29	53	6										17
185-189								20	40	40										10
190-194								25	25	42	8									12
195-199								13	47	27	13									15
200-204								15	10	50	20	5								20
205-209									35	40	10	15								20
210-214								10		60	10	10	10							10
215-219								5	5	20	60	5		5						20
220-224								13	7	20	33	20		7						15
225-229										23	38	31		8						13
230-234									5	10	33	38	10	5						21
235-239									11	11	11	44	22							9
240-244										10	20	40	20	10						10
245-249												67		33						3
250-254											40	20	20				20			5
255-259												67	33							3
260-264													33	33		33				3
265-269													100							1
270-274																				0
275-279																				0
280-284																	100			1
Total %	3.8	3.2	10.6	7.1	11.7	16.6	9.6	6.2	7.1	8.5	7.0	5.4	1.7	1.1		0.2	0.3			633

0-20%
20-50%
50-100%

Figure 41. Multi-year spine-based age length key for bluefin tunas caught in the eastern Atlantic and Mediterranean stock. Numbers represent percent by number by 5 cm length class (SFL).

Table 24. Mean length at age by calcified structure from multi-year age length keys.

	Multi-year otolith ALK			Multi-year spine ALK		
Age	Mean length (cm, SFL)	Stand. Deviat.	Number	Mean length (cm, SFL)	Stand. Deviat.	Number
0	31.7	7.1	25	34.5	8.2	24
1	65.6	9.8	35	60.6	5.1	20
2	80.3	11.9	30	80.3	4.6	67
3	96.9	13.7	42	101.2	10.6	45
4	114.9	11.9	44	116.8	9.3	74
5	125.4	13.7	60	132.1	12.2	105
6	138.7	16.4	46	149.7	12.9	61
7	170.7	26.5	68	177.4	21.3	39
8	195.1	25.0	95	191.1	17.6	45
9	207.7	19.4	91	206.1	15.3	54
10	216.9	16.2	83	220.7	13.6	44
11	217.5	14.7	72	230.9	13.6	34
12	230.5	17.1	36	243.1	15.4	11
13	223.1	18.0	26	234.8	15.8	7
14	240.5	24.0	11	260.0		1
15	238.2	20.8	7			
16	246.2	19.7	5	267.5	23.3	2
17	260.5	29.0	2			
18	256.1	9.7	2			

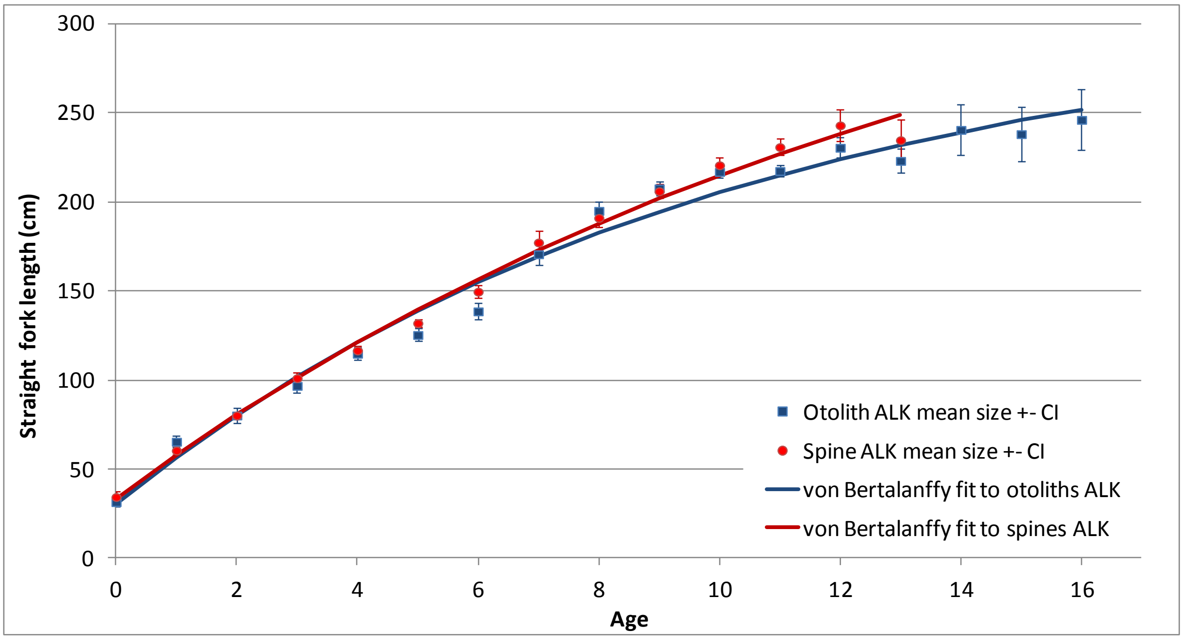


Figure 42. Length at age from multi-year ALKs and 95% confidence intervals for otoliths (blue dots and CI error bars), and spines (red dots and CI error bars). ALKs von Bertalanffy growth model curves fitted to observed length at age data for otoliths (blue line) and spines (red line).

6.2.5 Integrated approach to stock discrimination

The integrated approach to stock discrimination has been only partly carried out in Phase 5, claiming for the late release of the contract. As a matter of fact, the update strata that were provided by the ICCAT GBYP Steering Committee, were not used in this first integrated approach, even if the detailed data in the Excel file attached to the report allow for any type of future analysis and aggregation.

Regarding the integrated approach to stock discrimination, an integrated stock identification database has been established and is continually being updated. Analysis of the integrated database revealed that overall, rates of agreement between methods were reasonably good given the compounding influence of classification error associated with each method. Rates of agreement were lowest for fish of potential western origin (according to at least one method) collected in the Mediterranean and northeast Atlantic and fish of potential eastern origin collected in the western Atlantic (Canadian samples). This may reflect the influence of environmental history on phenotypic markers (otolith shape and chemistry). Otolith shape data, otolith stable isotope data and tissues from adult bluefin tunas from the Gulf of Mexico has been obtained through collaboration with NOAA and will facilitate the characterisation of the western stock using multiple markers. During the 2015 sampling season a coordinated approach was adopted which ensured the collection of otoliths and tissues from the same fish and representative of the Mediterranean spawning population. Future analysis of this material will facilitate the characterisation of the eastern stock using multiple markers. The database, together with the material and data sourced through this task will enable an integrated stock discrimination analysis of Atlantic bluefin tuna.

The main stock structure hypotheses provided by the SCRS BFT WG in Tenerife (May 2013) have been discussed in the report. The mixing discovered by GBYP in some areas added further complexity to the previous hypotheses. The results provided so far by the GBYP biological studies do not allow for any discrimination of any subpopulation or contingency, out of the two stocks (WBFT and EBFT), but further studies about natal homing would be necessary, including the results of electronic tagging in the integrated approach.

6.3 Cost-benefit analysis for the ICCAT GBYP biological studies programme

As requested by the Steering Committee, and endorsed by the SCRS and Commission, the cost-benefit analysis for the ICCAT GBYP biological studies programme was programmed in the last part of Phase 5, in order to have a more focused overview of the works carried out so far and have further details for adopting the best research strategy in Phase 6. The terms of reference were the followings:

1. Review how the activities conducted in previous phases (including the sampling design adopted for ageing, genetics, micro-chemistry and otolith-shape analysis) have achieved the objectives, taking into account costs and logistic constraints;
2. Review the potential improvements in knowledge about bluefin tuna biology, population structure and natal origin and their possible use for other GBYP research activity (i.e. tagging, modelling);
3. In particular, evaluate the precision and bias of alternative age-stock keys given uncertainty, i.e. the ability to assign samples of fish to a cohort and stock, i.e. under a variety of hypotheses about growth and population structure;
4. Propose and evaluate alternative sampling schemes using an appropriate methodology. In particular, strategies for being able to obtain annual age-length keys and estimates of the stock mixing proportions captured by the different fisheries.

A Call for Tenders was released, but no offers were received for this item. Due to the time constraints, any possible reopening the call for tenders for this item was not feasible and therefore this additional component was not done. Nevertheless, a comprehensive review of the first five Phases of ICCAT GBYP is envisaged in Phase 6, including all components.

7. Modelling approaches

The initial, short-term ICCAT GBYP objective which was approved by the Commission in 2008 was to carry out operating modelling studies from year 4, with a total budget of 600,000 Euros. So far, with only 62.98% of the funds (a total of 377,895 Euros, including the budget amount set for Phase 5, equal to 194,670 Euros), the ICCAT GBYP carried out many modelling activities since Phase 2, following the recommendations of the Steering Committee and the SCRS. It is very clear that the general objectives set for the modelling studies in these first Phases were largely accomplished so far, taking into account the proportion of the available budget. Furthermore, the modelling plan was fully revised and now it has been extended up to 2021 as recommended by the SCRS, and as it was endorsed by the Commission.

The ICCAT-GBYP Modelling activities in the Phase 5 strictly followed those recommended by the GBYP Steering Committee, then endorsed and further recommended by ICCAT SCRS and approved by the ICCAT Commission. Two contracts were awarded in Phase 5 under the Modelling Programme in support of BFT Stock Assessment: one for a new Modelling MSE coordinator as recommended by the GBYP Steering Committee (Ph.D. Joseph Powers) and the other one for the Expert MSE Technical Assistant (Thomas Carruthers, who continued the job).

The final reports of the two contracts were presented at the SCRS BFT Species Group meeting and are already available on the ICCAT GBYP web pages http://www.iccat.int/GBYP/en/modelling.htm .

7.1 Objectives

Under the GBYP the modelling programme addresses objective 3:

- Improve assessment models and provision of scientific advice on stock status through improved modelling of key biological processes (including growth and stock-recruitment), further developing stock assessment models including mixing between various areas, and developing and use of biologically realistic operating models for more rigorous management option testing.

In addition, in 2012 the Commission requested the SCRS (Doc. No. PA2-617A/2012 COM) to conduct a stock assessment in 2015 and to:

a) Develop a new assessment model allowing the inclusion of the last updated knowledge on the biology and ecology of bluefin tuna, in particular life-history parameters, migration patterns, and aiming at identifying and quantifying uncertainties and their consequences on the assessment results and projections.

b) Release a stock status advice and management recommendations, supported by a full stock assessment exercise, based on the new model, additional information and statistical protocols mentioned in points above and on which basis all actions may be adopted and updated by the Commission through the management plan to further support the recovery.

The GBYP activities in the first Phases were consistent with the objectives, within the timeframe set by the Modelling MSE Core Group.

7.2 Phase 5 activities for modelling in support of BFT stock assessment

A modelling coordinator and a modelling technical assistant were contracted in Phase 4, according to the decision taken by the bluefin tuna species group, the ICCAT GBYP Steering Committee and the SCRS. An ICCAT GBYP Core Modelling and MSE Group was also established. The modelling coordinator was replaced in Phase 5, based on a recommendation of the Steering Committee, while the modelling technical assistant got a renewed contract up to the end of Phase 5. There were institutional replacements in the membership of the ICCAT GBYP Core Modelling and MSE Group. The work necessary for developing new modelling approaches will take anyway several years.

The GBYP Modelling Coordinator, together with the GBYP Coordinator and the ICCAT Secretariat, organised the ICCAT GBYP Core Modelling Group meeting in Monterey (California, USA) on 21-23 January 2016, just after the Symposium on Bluefin Tuna Future and taking advantage of the contemporary presence of many bluefin tuna specialists. This meeting was already included in GBYP Phase 5.

Basic concepts, stock structure and basic dynamics were discussed in detail by the Group in order to come up with the unified definition and methodology which will be followed in all future GBYP modelling and MSE activities. Furthermore, comprehensive Specifications for MSE Trials for Bluefin Tuna in the Northern Atlantic were developed. This meeting was an important additional step for specifying the structure of the BFT MSE. Additional steps were designed for the future, with this schedule:

- 2016 - Completion of specifications and initiation of simulation trials together with review of those trials. It is expected that although these activities will not be completed during 2016, a great deal of progress will be made. Additionally, a dialog needs to be established with the Commission on issues and decisions that the Commission will need to address.
- 2017 – A review of the trials and their conditioning, with and possibly necessary modifications made in the light of those results. The meeting was planned for early 2017 for the purpose of development of a suite of meaningful scenarios to be used to initiate stakeholder involvement. A progress on the bluefin assessment will be presented to the Commission, although it needs to be noted that while the MSE effort will be ongoing, the MSE process will not be complete at that time. The modeling package will be completed by the end of the Phase 6 by GBYP MSE Modeler and distributed to volunteers to run trials.
- 2018 – A complete proposal with MSE options will be presented to the SCRS in September with the goal of communicating that to the Commission at their annual meeting.

7.2.1 The ICCAT GBYP Core Modelling and MSE Group

The role of the ICCAT GBYP Core Modelling and MSE Group is defined as follows:

a) Provide technical oversight and advice on the MSE process to the SCRS

b) Provide annual review of progress against work plan and report to SCRS and Commission

c) Review technical contributions and outputs to the work program and advise the secretariat on satisfactory completion of tendered contracts.

d) Advise the secretariat and GBYP Steering Committee on out-of-session revisions to work program, where necessary and appropriate.

There were institutional replacements in the membership of the ICCAT GBYP Core Modelling and MSE Group (ex ICCAT GBYP Core Modelling Group). At the last meeting, the Group included the Modelling and MSE coordinator (Joseph E. Powers), who was also acting as a chair on the meeting, Thomas Carruthers (expert and MSE Technical Assistant), the members (Polina Levontin, Richard Hillary, Toshihide Kitakado, Haritz Arrizabalaga, Doug Butterworth) and the *ex-oficio* members: David Die (SCRS Chair), Yukio Takeuchi (WBFT Rapporteur), Sylvain Bonhommeau (EBFT Rapporteur), Laurie Kell (ICCAT Population Dynamics Specialist), Paul De Bruyn (ICCAT Research and Statistics Coordinator), Antonio Di Natale (ICCAT GBYP Coordinator) and Miguel Neves dos Santos (ICCAT Scientific Coordinator).

7.2.2 Modelling and MSE Coordinator

In Phase 4 the Modelling Coordination was entrusted to Ph.D. Campbell Davies (CSIRO), who initiated the work and proposed the first set of members for the ICCAT GBYP Core Modelling Group. Due to the initial delays and the heavy workload of the coordinator, it was not possible to fully comply with the objectives provided by the work plan.

The ICCAT GBYP Steering Committee, on its meeting on February 2015, identified the need for an urgent follow up with the MSE modelling work and decided to substitute the former modelling coordinator. After contacting few selected candidates, a contract was provided to Ph.D. Joseph E. Powers.

Some of the roles of MSE and modelling coordinator were to review the previous meeting report and provide, in collaboration with the ICCAT GBYP Core Modelling MSE Group, an updated “detailed multi-annual work plan” (with clearly identified objectives, deliverables, milestones and deadlines, along with setting responsibilities and associated budget); furthermore, the Coordinator had to provide proposals for updating the members of the Group and establish electronic tools for collaboration and communication. A dedicated Github website was set for providing the necessary data and documents for the meeting of the Group.

The GBYP Modelling MSE Coordinator proposed a revised workplan that was delivered to the Core on May 2015 (**Annex 1a, document no. 29**). A modelling MSE report was discussed at the SCRS Bluefin tuna Species Group in 2015 (**Annex Ib, document no. 31**). The final report of the Modelling and MSE coordinator included all deliverables, a report of the 2nd meeting of the ICCAT GBYP Core Modelling and MSE Group, an agreed revised table of all ICCAT GBYP Modelling activities up to 2018 and the budget that was considered necessary by the Group for fulfilling all necessary activities (**Annex 1a, documents no. 40, 41** and **42**). All the reports concerning the ICCAT GBYP Modelling and MSE activities are available on http://www.iccat.int/GBYP/en/modelling.htm

7.2.3 MSE Technical Assistant

The contract for the MSE Technical Assistant in the Phase 5 was provided to the same expert from Canada (Dr. Thomas Carruthers), who initiated the work on the Operating Model and MSE framework and related code in Phase 4, to continue this task in GBYP Phase 5, working directly with the Modelling Coordinator and in consultation with the ICCAT Secretariat, the ICCAT GBYP Core Modelling and MSE Group, the SCRS Bluefin Tuna species Group and MP modellers.

Several papers and documents have been produced by the MSE technical assistance in Phase 5, along with three interim reports (**Annex Ia**, **documents no. 30** to **32**). Most of the papers are concerning the use of data and the the operating data development (**Annex Ia**, **documents no. 33** to **36,** and **Annex Ib, documents no. 27, 28** and **34**). The GBYP transmitted all electronic tag data and the results of biological studies to the expert, in real time. The electronic tags data are fully incorporated in the data sets that are currently used by the expert for the OM and the MSE trials.

During the Phase 5, a spatial, multi-stock statistical catch-at-length operating model (M3) was developed in the software ADMB and already presented to the SCRS BFT Species Group and to the ICCAT GBYP Core Modelling MSE Group. Moreover, a metadata summary was constructed to identify all sources of data that could be used to fit operating models for Atlantic bluefin tuna, and was already presented to the SCRS as well. The M3 operating model was simulation tested and then conditioned on preliminary data to reveal possible model mis-specification and future data processing needs. The model was further updated in line with the conclusions of the Core Modelling and MSE Group meeting, especially in the part of estimation of age-specific movement rates. Following the Trial Specifications Document, which was as well developed in line with the conclusions of the meeting, framing a prospective MSE, 192 operating models were described. A new management procedure (MP) based on the harvest control rule of Cooke (2012) was coded into the MSE framework and, along with 9 other MPs, was applied in a preliminary MSE, using the 192 operating models derived from the Trial Specifications document. The results of the preliminary MSE were used to develop an R Shiny application for investigating MSE results and performance metrics. A first part of the ME software specifications is provided in **Annex Ia**, **document no. 40**.

The plan for the MSE Technical Expert is to continue this part of the modelling work in the next GBYP Phase, with these short-term priorities:

1. Obtaining new spatial, age-structured data (stock of origin by age class, electronic tagging by age class, a joint standardized CPUE index, an inverse age-length key, finalized indices of spawning stock biomass by stock and analyses to identify the correct fleet disaggregation (time and gear type)
2. Simulation test M3 operating model v1.17 to identify coding errors, possible biases and correct weighting of various data sources
3. Fitting the M3 model to data

4. Finalizing Trial Specifications and carrying out alternative M3 model fits
5. Updating online tools (R Shiny Application)
6. Assisting in experimental design of data collection programs (for instance, estimation of stock biomass using close-kin genetic tagging).

The above priorities will be revised by the GBYP Steering Committee in the first part of Phase 6.

8. Legal framework

The enforcement of the ICCAT Rec. 11-06, which allows for a “research mortality allowance” of 20 tons for GBYP and for the use of any fishing gear in any month of the year in the ICCAT Convention area for GBYP research purposes, helped GBYP in carrying out both tagging and biological sampling activities.

The ICCAT Secretariat, on 22 May 2012, issued a first circular (no. 2296/2012), establishing the rules and the details for the enforcement of Rec.11-06, including the official form for reporting the RMA and the first list of authorized institutions (20 entities). Another circular (no. 2279/2013) was issued on 28 May 2013, including 33 authorised entities. A second circular (no. 2180/2014) was issued on 23 April 2014, with a list of 36 authorised entities. A third circular (no. 3203/2015) was issued on 26 May 2015, with a list of 32 entities.

A total of 229 ICCAT GBYP RMA certificates have been issued from 2012 to February 2016, using 10,663.59 kg of bluefin tuna (equal to 1365 fish), while 64 RMA certificates have been issues in Phase 5, using a total of 343.56 kg corresponding to 328 fish. RMA used quantities in previous years (5,039.49 kg in 2012, 4,392.76 kg in 2013 and 887.78 kg in 2014) were officially communicated to ICCAT Statistical Department for the inclusion in the official ICCAT BFT catch table; the details are on SCRS/2015/145 (**Annex 1b, document no. 17**).

The ICCAT CPCs, in general, supported from a practical point of view the GBYP field activities, as established by the Commission. Few exceptions were noticed about the flight permits in some areas and the biological sampling activities in other areas.

9. Cooperation with the ICCAT ROP

The GBYP coordination, together with the ICCAT Secretariat, is maintaining and improving the contacts with the ICCAT ROP observers, for strengthening the cooperation and providing opportunities. The ICCAT ROP observers are engaged for directly checking bluefin tuna at the harvesting for improving the tag recovery and reporting, but also for noticing and reporting any natural mark. Specific forms were provided to ROP. The GBYP Coordinator is regularly participating to the ICCAT ROP observers training courses, specifically training them for the tag recovery and reporting. ICCAT GBYP tag awareness material is regularly provided to ICCAT ROPs.

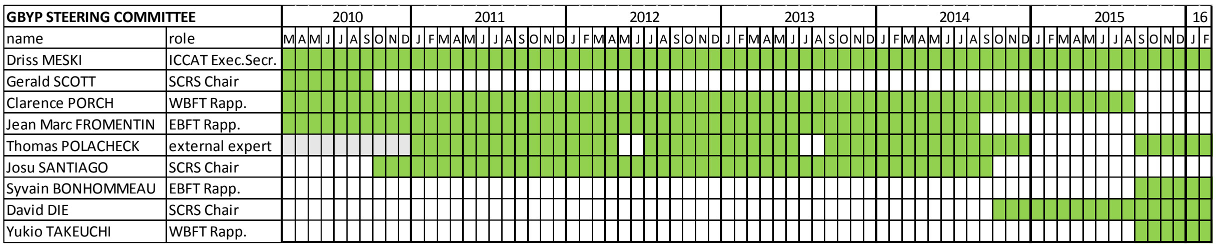
The contacts between ICCAT ROPs and ICCAT GBYP are usually in real time, always through the ICCAT Secretariat, which is duly informed of all contacts and procedures. ICCAT ROPs are also helping for identifying the right persons for providing the rewards for the recovered tags.

ICCAT ROPs are improving their tag reporting year after year and this cooperation could be possibly extended also to genetic sampling, after assessing both their availability and the good-will of the tuna farm owners. This potential opportunity will be studied and assessed in Phase 6.

10. Steering Committee Activities

The GBYP Steering Committee is currently composed by the Chair of SCRS, Ph.D. David Die (who replaced Ph.D. Josu Santiago from December 2014), the BFT-W Rapporteur, Ph.D. Youkio Takeuchi (who replaced Ph.D. Clay Porch from December 2014, but who resigned on at the end of Phase 5), the BFT-E Rapporteur, Ph.D. Sylvain Bonhommeau (who replaced Ph.D. Jean-Marc Fromentin from December 2013), the ICCAT Executive Secretary, Mr. Driss Meski, and the external expert, Ph.D. Tom Polacheck, who was contracted for this duty. **Table 25** shows the different composition of the ICCAT GBYP Steering Committee since the beginning of the programme. The changes in the SC members, which are logical according to the current institutional components, sometimes created different views for some GBYP activities.

Table 25. Composition of the ICCAT GBYP Steering Committee since the beginning of the programme.



The Steering Committee members have been constantly informed by the GBYP about all the initiatives and they are regularly consulted by e-mail on many issues. A monthly report was provided to the Steering Committee by the GBYP Coordinator. The activity of the Steering Committee included continuous and constant e-mail contacts with the GBYP coordination, which provided the necessary information.

In Phase 5 the Steering Committee held one meeting (on 26 September 2015), discussing various aspects of the programme, providing guidance and opinions for setting the plan for Phase 6. The finalised report of the GBYP Steering Committee meeting is available on http://www.iccat.int/GBYP/en/scommittee.htm and attached in the annexes to this report (**Annex 1a, document no 1**).

Some problems in the effectiveness of the Steering Committee were noticed in Phase 5. This was partly due to the rotation of some members and to the fact that some revisions to previously agreed strategies, were requested but they were delayed by the lack of response or agreement by some members. The delay affected also the finalisation of the two last Steering Committee meetings reports.

11. Funding, donations and agreements

The Atlantic-wide Research Programme for Bluefin Tuna, according to the Commission decision in 2009, is voluntary funded by several ICCAT CPCs. The annual budgets are on http://www.iccat.int/GBYP/en/Budget.htm

So far, up to the first four Phases, GBYP received and used only 49.34% of the funds originally approved for the same time period (7,561,541 euro against 15,320,000 euro). The overall GBYP operating budget for the first five phases, covering 6 years (a total of 9,676,542 Euro[13]) is about 50.73% of what was supposed to be (19,075,000 Euro), as it was approved by the Commission..

In Phase 5, the budget had the following funders (in order of contribution):

European Union (grant agreement)	Euro	1,190,000.00
United States of America (donation)	Euro	106,131.41
Japan (donation)	Euro	73,000.00
Tunisia (donation according to quota)	Euro	70,011.98
Kingdom of Morocco (donation)	Euro	62,089.10
Turkey (donation according to quota)	Euro	41,730.49
Canada (service agreement)*	Euro	23,000.00
Norway (donation)	Euro	18,000.00
Algeria (donation according to quota)	Euro	11,919.81
Chinese Taipei (donation)	Euro	5,000.00
Iceland (donation according to quota)	Euro	2,000.00
Popular Republic of China (donation according to quota)	Euro	767.54
Korea (donation according to quota)	Euro	727.16
Egypt (donation according to quota)	Euro	622.51

Further amounts were residuals of previous GBYP Phases and they were used for better balancing the EU contribution and for compensating costs which were not covered by the EU funding in Phase 4. Contributions for previous GBYP Phases are still pending from some ICCAT CPCs.

The lack of a stable and reliable multi-year funding system is one of the major problems for GBYP, because this fact prevents a proper planning of all activities and contracts at the beginning of each Phase. The GBYP Steering Committee and the SCRS several times recommended the adoption of a more stable funding system, but all proposals submitted so far by the ICCAT Secretariat or some CPCs to the Commission (i.e.: scientific quota, contribution proportional to quota, etc.) were discussed but they were never approved. The uncertainties linked to the funding at each Phase are creating operational problems since the beginning of the programme, because it is

[13] For Phase 5, due to the late arrival of some reports and invoices, the amount is currently estimated.

difficult to plan all activities and provide all necessary contracts when the effective funding will be certain and confirmed only at the very end of each Phase. This fact implies a continuous attention to the effective budget availability at each step of the programme by the Coordination.

The Atlantic-wide Research Programme for Bluefin Tuna is a very complex programme and its activities concern all stakeholders; when it was approved by the Commission, the reason was that this programme is necessary for improving the scientific knowledge about this species and this is the difficult work that GBYP is carrying on, following the strategy recommended yearly by the Steering Committee and the SCRS, but also by the Commission. As a consequence, the GBYP needs the cooperation of all stakeholders and all countries to fulfil its duties in the best possible way. This need was perfectly identified by SCRS and the Commission during the preliminary evaluation of the Programme and then reinforced by the mid-term evaluation. Therefore, GBYP is managing to work with all stakeholders, making them aware of the programme and its activities and getting them directly involved when necessary.

A formal agreement of collaboration for research activities to be developed under the GBYP and particularly on tagging was established with the WWF Mediterranean Programme (WWF-MedPO) on 28 April 2011. A formal agreement of collaboration for research activities to be developed under the GBYP and particularly on tagging was established with the Hopkins Marine Station of the Stanford University on 15 May 2013.

GBYP, in these first five phases, continued to work constantly on a diffused network of contacts, always trying to extend and improve it as much as possible, within the rules currently existing. This activity helped the Programme to get donations and practical supports (as it was recommended by the Commission at the beginning of the programme[14]), which sometimes were destined for a precise activity.

Here following is the list of donors to GBYP, in alphabetic order:

- ✓ Aquastudio Research Institute, donation in kind of 1 miniPAT, estimated value 3,500 euro (2014).
- ✓ Asociación de Pesca, Comercio y Consumo Responsable de Atún Rojo (SP): Euro 6,000.00 (for GBYP in Phase 1).
- ✓ Association Marocaine de Madragues, donation in kinds of a social dinner in Tangier; estimated value not defined (for the Symposium on Trap Fishery).
- ✓ Carloforte Tonnare PIAMM, donation in kind of several tunas for biological sampling and tagging; estimated value not defined (Phase 4).
- ✓ COMBIOMA, University of Cagliari, donation in kind for tagging underwater and logistics in Sardinian traps; estimated value not defined (Phase 4).

[14] See: ICCAT Biennial Report 2008-2009, part II (2009), Vol. 1 (COM), page 226, point 7, and ICCAT Biennial Report 2008-2009, part II (2009), Vol. 2 (SCRS), page 224, third paragraph.

- ✓ Departement de la Pêche Maritime, DPMA/DPRH, Rabat (MO), essential administrative and logistic support for tagging in Moroccan traps in Phase 2, 3, 4 and 5.
- ✓ Federcoopesca, Roma, donation in kind, providing 5 extra days of a purse-seiner time for tagging; estimated value not defined (Phase 4, 2013) and donation in kind of the electronic and conventional tagging activity in Phase 5 (estimated value to be defined).
- ✓ Fromentin Jean-Marc, Ph.D., IFREMER: a collection of tuna trap data from 1525 to 2000, estimated value not defined (for Data Recovery and Data Mining, Phase 4).
- ✓ Grup Balfegó (SP), donation in kinds of tuna heads prepared for sampling otoliths; estimated value: Euro 300,00 (for the GBYP Operational Meeting on Biological Sampling in Phase 2).
- ✓ Grupo Ricardo Fuentes e Hijos S.A. (SP): Euro 10,000.00 (for the Symposium on Trap Fishery in Phase 2) and the practical support for tagging in Moroccan traps in Phase 2, 3, 4 and 5.
- ✓ Institute National de Recherche Haulieutique (INRH), Tangier (MO), donation in kinds of logistic support and staff assistance for tagging in Morocco: estimated value to be defined (for GBYP Tagging in Phase 2, 3, 4 and 5).
- ✓ Instituto Español de Oceanografia, Fuengirola, donation in kinds of staff assistance for tagging in Morocco: estimated value not defined (for GBYP Tagging in Phase 2).
- ✓ Maromadraba SARL and Es Sahel (Fuentes Group), donation in kind of divers working time, vessels support and sailors, for tagging in Morocco; estimated value: Euro 6,000.00 (for GBYP Tagging in Phase 2, 3, 4 and 5).
- ✓ Mielgo Bregazzi Roberto (SP), donation in kinds of many thousands of individual tuna data from auctions, estimated value: 50,000.00 Euros (for GBYP Data Recovery in Phase 2) and 300,000 Euros (for GBYP Data Recovery in Phase 3).
- ✓ National Research Institute for Far Seas Fisheries, Shimizu (JP), donation of many hundreds bluefin tuna samples from the central Atlantic fishery: estimated value not defined (for GBYP biological and genetic analyses in Phase 2, 3, 4 and 5).
- ✓ Oceanis srl, donation in kind for tagging underwater and logistics in Maltese cages and Sardinian traps; estimated value not defined (Phase 4).
- ✓ Hopkins Marine Station of the Stanford University, donation in kind of 7 acoustic tags and 8 miniPATs analysis and logistics in Morocco; estimated value not defined (Phase 4, 2013 and 2014).
- ✓ WWF Mediterranean Programme (WW F MedPO), donation in kinds of 24 miniPATs, analysis and logistics in Morocco; estimated value: Euro 80,400.00 (for GBYP Tagging in Phase 2 and 3).
- ✓ GBYP Coordinator, donation of many thousands of old catch data; estimated value not defined (Phases 3 and 4).

The list does not include other entities which provided complimentary tagging activities for conventional tags.

12. GBYP web page

The ICCAT GBYP web page, which was created in the last part of Phase 1 and fully revisited in Phase 4, is usually regularly updated with all documents produced by GBYP; in some cases, due to the huge workload, some set of documents are posted all together. Documents are posted only after their revision and the final approval. The texts of the GBYP pages were revised, improved and updated on February 2016.

The ICCAT Secretariat provided all the necessary support for the ICCAT GBYP web pages.

Annex 1. List of reports and scientific papers in GBYP Phase 5

Annex 1a. List of deliverables produced within the framework of GBYP contracts and activities in Phase 5 (interim reports and software products will not be included in the final copies and they are in yellow evidence; technical interim reports and draft final reports are not listed; interim reports cannot be published):

1. Coordination: Steering Committee – ICCAT GBYP Steering Committee Report, Madrid, 10-12/02/2015, 26. (this document concerns Phase 4, but it was finalized quite later in Phase 5), and ICCAT GBYP Steering Committee Report, Madrid, 28/09/2015: 8 p.
2. Data recovery, data mining and data analyses – Progress Report no. 1, 13/07/2015: Historical genetic samples collected in old times in the Eastern Mediterranean Sea, in the Marmara Sea or in the Black Sea, including the genetic analyses of these samples. University of Bologna, 5 p.
3. Data recovery, data mining and data analyses – Final Report, 31/01/2016: Historical genetic samples collected in old times in the Eastern Mediterranean Sea, in the Marmara Sea or in the Black Sea, including the genetic analyses of these samples. University of Bologna, 28 p.
4. Data recovery – Report of 2015 ICCAT bluefin tuna data preparatory meeting. ICCAT, Madrid, 2-6 March 2015: 1-61.
5. Aerial survey on spawning aggregations – Report, 01/04/2015: Short-term contract for the aerial survey design of the Atlantic-wide Research Programme for Bluefin Tuna (ICCAT-GBYP Phase 5 – 2015). Alnilam S.A., Madrid, 16+23+18 p.
6. Aerial survey on spawning aggregations – 26/05/2015: Report on the 2015 ICCAT GBYP Training course for the aerial survey on Bluefin tuna spawning aggregations (Phase 5). Di Natale A., 1 pag + 3.
7. Aerial survey on spawning aggregations – 28/05/2015: ICCAT GBYP Aerial Survey Protocol 2015, 17 pag.
8. Aerial survey on spawning aggregations – Interim Report, 16/06/2015: ICCAT Bluefin tuna aerial survey on spawning aggregations 03/2015, Intermediate report of surveys carried out in Area A. Grup Air Med (Spain), 16 p. + various annexes.
9. Aerial survey on spawning aggregations – Interim Report, 10/07/2015: Bluefin tuna aerial survey on spawning aggregations 03/2015, Intermediate report of surveys carried out in Areas B, E and G. Action Air SA (France), 18 p.
10. Aerial survey on spawning aggregations – Interim Report, 25/06/2015: Bluefin tuna aerial survey on spawning aggregations 03/2015, Intermediate report of surveys carried out in Areas C, D and F. UNIMAR (Italy), 4 p. + various annexes.
11. Aerial survey on spawning aggregations – Final Report, 24/07/2015: ICCAT Bluefin tuna aerial survey on spawning aggregations 03/2015, Informe final, Area A. Grup Air Med (Spain): 46 p. + various annexes.
12. Aerial survey on spawning aggregations – Final Report, 31/07/2015: Bluefin tuna aerial survey on spawning aggregations 03/2015, Rapport final, zones de prospection B, E and G. Action Air SA (France): 31 p. + various annexes.

13. Aerial survey on spawning aggregations – Final Report, 27/07/2015: Bluefin tuna aerial survey on spawning aggregations 03/2015, Final report of surveys carried out in Areas C, D and F. UNIMAR (Italy): 38 p. + various annexes.
14. Aerial survey on spawning aggregations – Interim Report, 14/09/2015: ICCAT GBYP Phase 5 – 2015. Elaboration of 2015 data from the aerial survey on spawning aggregations: 1-70.
15. Aerial survey on spawning aggregations – Final Report (1st part), 30/10/2015: ICCAT GBYP Phase 5 – 2015. Elaboration of 2015 data from the aerial survey on spawning aggregations: 1-69.
16. Aerial survey on spawning aggregations – Final Report (2nd part, rev.), 26/02/2016: ICCAT GBYP Phase 5 – 2015. Elaboration of 2015 data from the aerial survey on spawning aggregations: 1-66 +15+13.
17. Aerial survey on Bluefin tuna spawning aggregations – Report, 12/02/2016: Power analysis and cost/benefit analysis for the ICCAT GBYP Aerial survey on Bluefin tuna spawning aggregations (ICCAT GBYP 08/2015, item A): 1-31.
18. Biological Studies – 20/08/2015: Short-term contract for the biological studies (ICCAT GBYP 06b/2015-2) (Phase 5). Preliminary report. AZTI on behalf of the Consortium, 10 p.
19. Biological studies – 31/01/2016: Short-term contract for the biological studies (ICCAT GBYP 06b/2015-1) (Phase 5). Necton Marine Research Society, Final report: 1-9.
20. Biological Studies – 23/02/2016: Short-term contract for the biological studies (ICCAT GBYP 06b/2015-2) (Phase 5). Final report. AZTI on behalf of the Consortium: 1-113 + annexes.
21. Tagging programme – Interim Report, 30/06/2015: Marquage électronique de thons rouges adultes dans des madragues situées dans l'Océan Atlantique Est, dans les eaux Marocaines. Programme de marquage 2015 (ICCAT GBYP Phase 5). Rapport Succinct mise a jour. INRH, Maromadraba (Morocco), WWF-MedPO, 14 p. + various annexes.
22. Tagging programme – Interim Report, 09/07/2015: Tagging Programme 2015. Electronic tagging of adult Bluefin tunas by purse-seiners in the eastern Mediterranean (ICCAT GBYP 05/2015, Objective A, as modified by the GBYP Steering Committee). Short Report and 1st update. University of Istanbul (Turkey) and Consorzio Unimar (Italy), 6 p. + various annexes.
23. Tagging programme – Final Report, 21/07/2015: Marquage électronique de thons rouges adultes dans la Madrague « Essahel » située situées dans l'Océan Atlantique Est, dans les eaux Marocaines. Programme de marquage 2015 (ICCAT GBYP Phase 5, 05/2015 objective B). INRH, Maromadraba (Morocco), WWF-MedPO, 28 p. + various annexes.
24. Tagging programme – Final Report, 31/07/2015: Tagging Programme 2015. Electronic tagging of adult Bluefin tunas by purse-seiners in the eastern Mediterranean (ICCAT GBYP 05/2015, Objective A, as modified by the GBYP Steering Committee). University of Istanbul (Turkey) and Consorzio Unimar (Italy): 23 p. + various annexes.
25. Tagging programme – Final Report, 28/07/2015: Electronic tagging of adult Bluefin tunas in Sardinian traps (ICCAT GBYP 05/2015, Objective C, as modified by the GBYP Steering Committee). COMBIOMA, and Carloforte Tonnare PIAM (Italy), 31 p. + various annexes.
26. Tagging programme (complimentary activities) – Final Report, 30/07/2015: Experimental tagging activity of bluefin tuna to be released in the southern Tyrrhenian Sea. Federcoopesca, University of Bologna and Consorzio Unimar (Italy), 1 p. + various annexes.

27. Tagging programme – Comprehensive report for all tracks of electronic tags deployed by GBYP in Phase 5 in all areas. 23 February 2016, GBYP: 1-18.
28. Tagging programme – Report, 23/02/2016: Cost/benefit analysis of the ICCAT GBYP Tagging Programme (ICCAT GBYP 08/2015, item B). CEFAS: 1-64.
29. Tagging programme – Final Report: Close-kin tagging feasibility study, 1st part. Advice on Klose-kin Mark-Recapture for estimating abundance of eastern Atlantic Bluefin Tuna: a scoping study. CSIRO, 1-33.
30. Modelling approaches – Interim Report, 19/06/2015. Proposed Multi-annual Workplan for the Development of Management Strategy Evaluations of Atlantic Bluefin Tuna by the International Commission for the Conservation of Atlantic Tunas (ICCAT), Joseph Powers, 7 pag. + 4.
31. Modelling approaches – Draft report, 21/09/2015 - A summary of data to inform management strategy evaluation for Atlantic bluefin tuna. Tom Carruthers.
32. Modelling approaches – Interim report, 21/09/2015. Operating model structure and estimation framework for Atlantic bluefin management strategy evaluation. Tom Carruthers.
33. Modelling approaches – Report 1a, 21/09/2015: Carruthers T., Kimoto A., Powers J., Kell L., Butterworth D., Lauretta M., Kitakado T., 2015, Structure and Estimation Framework for Atlantic Bluefin Tuna Operating Models. SCRS/2015/179 (provided in copy among the scientific papers).
34. Modelling approaches – Report 1b, 21/09/2015: Carruthers T., Powers J., Lauretta M.V., Di Natale A., Kell L., 2015, A summary of data to inform operating models in Management Strategy Evaluation of Atlantic Bluefin tuna. SCRS/2015/180 (provided in copy among the scientific papers).
35. Modelling approaches – Report 2, 21/09/2015: Evaluating Management Strategies for Atlantic Bluefin Tuna. Operating model development and data requirements. Tom Carruthers: 1-31.
36. Modelling approaches – Report 3, 23/02/2016: Evaluating Management Strategies for Atlantic Bluefin Tuna. Fitting operating models to data, MSE trial specifications and interactive visualization. Tom Carruthers: 1-23.
37. Modelling approaches - software product, 19/02/2016: ADMB M3 v0.15 (pre CMG Monterey) and compatible with simulation testing and fitting to preliminary data. Tom Carruthers (available on the GitHub site).
38. Modelling approaches - software product, 19/02/2016: ADMB M3 v0.17 (post CMG Monterey) which estimates age-specific movement etc. Tom Carruthers (available on the GitHub site).
39. Modelling approaches - software product, 19/02/2016: The R Shiny application that allows for interactive exploration of MSE results and performance metrics. Tom Carruthers (available on the GitHub site).
40. Modelling approaches – M3 Software Design Specifications. Tom Carruthers: 1-7.
41. Modelling approaches – Report, 21-23/01/2016: Report of the 2nd Meeting of the ICCAT GBYP Core Modelling and MSE Group, Monterey: 1-50.
42. Modelling approaches – Report, 21/02/2016: Contract report for the MSE Modelling Coordinator (ICCAT GBYP Phase 5). Joseph E. Powers: 1-3.
43. Modelling approaches – Final Report, 23/02/2016: MSE Modelling Coordinator Report, ICCAT GBYP Phase 5. Joseph E. Powers: 1-3.

Annex Ib. List of Scientific Papers – Phase 5

1. Puncher G.N., Arrizabalaga H., Francisco Alemany F., Cariani A., Oray I.K., F. Saadet Karakulak S.F., Basilone G., Cuttitta A., Mazzola S., Tinti F., 2014, Molecular Identification of Atlantic Bluefin Tuna (Thunnus thynnus, Scombridae) Larvae and Development of a DNA Character-Based Identification Key for Mediterranean Scombrids. PLosONE 10(7): e0130407. doi:10.1371/journal.pone.0130407
2. Puncher G.N., 2015, Assessment of the population structure and temporal changes in spatial dynamics and genetic characteristics of the Atlantic bluefin tuna under a fishery independent framework. Ph.D. Thesis, Alma Mater Studiorum and Universiteit Gent: 1-225.
3. Brophy D., Haynes P., Arrizabalaga H., Fraile I., Fromentin J.M., Garibaldi F., Katavic I., Tinti F., Karakulak S., Macías D., Busawon D. , Hanke A., Kimoto A., Sakai O., Deguara S., Abid N., Neves Santos M., 2015, Otolith shape variation in blue fin tuna from different regions of the North Atlantic: a possible marker of stock origin. SCRS/P/2015/004.
4. Arrizabalaga H., I. Fraile, Goñi N., et al., 2015, Biological samples collected within the GBYP program. SCRS/P/2015/005.
5. Fraile I., Rooker J., Arrizabalaga H., et al., 2015, Bluefin Otolith chemistry: what we learnt with the GBYP program. SCRS/P/2015/006.
6. Rodriguez Ezpeleta N., Arrizabalaga H., G.N. Puncher G.N., et al., 2015, Genetic population structure of Atlantic bluefin tuna using RadSEQ. SCRS/P/2015/007.
7. Lauretta M., Goethel D., Walter J., 2015, A summary of available GBYP tagging data for consideration in upcoming benchmark assessments. SCRS/P/2015/008.
8. Cort J.L., Estruch V.D., Neves dos Santos M., Di Natale A., Abid N., de la Serna J..M., 2015, On the variability of the length--weight relationship for Atlantic bluefin tuna, *Thunnus thynnus* (L.). SCRS/2015/026.
9. Cort J.L., Estruch V.D., Neves dos Santos M., Di Natale A., Abid N., de la Serna J..M., 2015, On the variability of the length--weight relationship for Atlantic bluefin tuna, *Thunnus thynnus* (L.). Reviews in Fishery Science and Aquacolture, 23 (1): 23-38.
10. Rodriguez-Marin E., Quelle P., Ruiz M., Luque P.L., 2015, Standardized age-length key for East Atlantic and Mediterranean bluefin tuna based on otoliths readings. SCRS/2015/040.
11. Puncher G.N., Cariani A., Maes G.E., Van Houdt J., Herten K., Albaina A., Estonba A., Cannas R., Rodríguez-Ezpeleta N., Arrizabalaga H., Addis P., Cau A., Goñi N., Fraile I., Laconcha Santamaria U., Tinti F., 2015, Population structure and genetic management unit delineation in the bluefin tuna using a genotyping-by-sequencing approach. SCRS/2015/048.
12. Puncher G.N., Cariani A., Cilli E., Massari F., Martelli P.L., Morales A., Onar V., Toker N.Y., Moens T., Tinti F., 2015, Unlocking the evolutionary history of the mighty bluefin tuna using novel paleogenetic techniques and ancient tuna remains. SCRS/2015/049.
13. Ortiz M., 2015, Update review of bluefin tuna (*Thunnus thynnus*) size and weight measures taken with stereo video cameras at caging operations in the Mediterranean sea 2014. SCRS/2015/050.
14. Di Natale A., Idrissi M., 2015, Review of the ICCAT GBYP tagging activities up to phase 4. SCRS/2015/053
15. Di Natale A., 2015, Tentative SWOT analysis for the calibration of ICCAT GBYP aerial survey. SCRS/2015/143.

16. Di Natale A., Tensek S., 2015, ICCAT Atlantic-wide Research Programme for Bluefin tuna (GBYP). Activity report for the last part of Phase 4 and the first part of Phase 5 (2014-2015). SCRS/2015/144.
17. Di Natale A., Tensek S., Pagá García A., 2015, Report on the use of Research Mortality Allowance by ICCAT GBYP up to September 2015. SCRS/2015/145.
18. Quilez Badia G., Tensek S., Di Natale A., Tensek S., Pagá Garía, Kell L., 2015, An estimate of additional variance for the ICCAT GBYP aerial survey using mini-PATs data. SCRS/2015/146.
19. Di Natale A., Cañadas A., Tensek S., Vázquez Bonales J.A., Pagá García A., 2015, ICCAT GBYP aerial survey for spawning aggregations in 2015. Preliminary report. SCRS/2015/147.
20. Pagá García A., Palma C., Di Natale A., Parrilla A., De Bruyn P., 2015, ICCAT GBYP report on additional ancient trap data recovered in Phase 4 and 5. SCRS/2015/148.
21. Di Natale A., Tensek S., Pagá García A., 2015, Preliminary information about the ICCAT GBYP tagging activities in Phase 5. SCRS/2015/149.
22. Di Natale A., Tensek S., Pagá García A., 2015, 2015: is the Bluefin tuna facing another 2003? SCRS/2015/154.
23. Lauretta M.V., Hanke A., Di Natale A., 2015, Atlantic bluefin tuna electronic tagging data summary. SCRS/2015/170
24. Kimoto A., Takeuchi Y., Itoh T., 2015, Discussion on the area stratification in the North Atlantic for the Bluefin tuna mixing model. SCRS/2015/172
25. Rodriguez-Marin E., Quelle P., Ruiz M., Busawon D., Golet W., 2015, Comparison of age estimates from paired calcified structures from Atlantic bluefin tuna. SCRS/2015/173
26. Hanke A.R., Rodriguez-Marin E., 2015, Atlantic bluefin tuna data base for age and stock identification. SCRS/2015/177.
27. Carruthers T., Kimoto A., Powers J., Kell L., Butterworth D., Lauretta M., Kitakado T., 2015, Structure and Estimation Framework for Atlantic Bluefin Tuna Operating Models. SCRS/2015/179.
28. Carruthers T., Powers J., Lauretta M.V., Di Natale A., Kell L., 2015, A summary of data to inform operating models in Management Strategy Evaluation of Atlantic Bluefin tuna. SCRS/2015/180.
29. Mariani A., Dell'Aquila M., Scardi M., Valastro M., 2015, Electronic tagging of adult bluefin tunas (Thunnus thynnus) in the eastern Mediterranean and Sardinian Sea: improving the precision of tuna size estimates. SCRS/2015/181.
30. Addis P., Secci M., Sabatini A., Palmas F., Cau A., Mariani A., Dell'Aquila M., Valastro M., 2015, Electronic tagging of Bluefin tuna in the trap fishery in Sardinia (W-Mediterranean). SCRS/2015/193
31. Core Modelling Group, 2015, Development of Management Strategy Evaluation for Atlantic Bluefin Tuna. SCRS/2015/208
32. Anonimous, 2015, ICCAT Atlantic-wide research programme for bluefin tuna (GBYP), Activity Report for the last part of Phase 4 and the first part of Phase 5 (2014-2015). SCI-APP.5-2015, 11 p.
33. Brophy D., Haynes P., Arrizabalaga H., Fraile I., Fromentin J.M., Garibaldi F., Katavic I., Tinti F., Karakulak S., Macías D., Busawon D. , Hanke A., Kimoto A., Sakai O., Deguara S., Abid N., Neves Santos M., 2015, Otolith shape provides a marker for North Atlantic Bluefin tuna (Thunnus thynnus). Marine and Freshwater Research http://dx.doi.org/10.1071/MF15086 : A-N.
34. Carruthers T.M., Kell T. L., Butterworth D.D.S., Maunder M.N., Geromont H.F., Walters C., McAllister M.K., Hillary H., Levontin P., Kitakado T., Davies C.R., 2015, Performance review of simple management procedures. ICES Journal of Marine Science, doi:10.1093/icesjms/fsv212, 20 November 2015: 1-19.

Annex 2: GBYP contracts issued in Phase 5[15].

CONTRACT NO	GBYP CALL	CONTRACT NAME	CONTRACTOR	CONTRACT SIGNATURE DATE	CONTRACT TERMINATION DATE	CONTRACT AMOUNT	APPROVED AMOUNT	NOTES	DIFFERENCE amount left	TOTAL APPROVED
AERIAL SURVEY										
1		AERIAL SURVEY DESIGN	ALNILAM INVESTIGACIÓN Y CONSERVACIÓN SL	27/03/2015	01/04/2015	9.000,00 €	9.000,00 €		- €	9.000,00 €
8		AERIAL SURVEY PROTOCOLS AND TRAINING COURSE	ALNILAM INVESTIGACIÓN Y CONSERVACIÓN SL	26/05/2015	28/05/2015	3.200,00 €	3.200,00 €		- €	
16		AERIAL SURVEY TRAINING COURSE	ACTION AIR ENVIRONNEMENT / S.A.S. ACTION COMMUNICATION	26/05/2015	26/05/2015		4.266,67 €		- €	12.602,02 €
17		AERIAL SURVEY TRAINING COURSE	GRUP AIR-MED S.A.	26/05/2015	26/05/2015		838,56 €		- €	
18		AERIAL SURVEY TRAINING COURSE	CONSORZIO UNIMAR Soc. Coop.	26/05/2015	26/05/2015		4.296,79 €		- €	
5	03/2015	AERIAL SURVEY ON SPAWNING AGGREGATIONS (ACTIVITY A, SUB-AREAS B, E, G)	ACTION AIR ENVIRONNEMENT / S.A.S. ACTION COMMUNICATION	26/05/2015	03/08/2015	166.826,00 €	166.826,00 €		- €	
6	03/2015	AERIAL SURVEY ON SPAWNING AGGREGATIONS (ACTIVITY A, SUB-AREA A)	GRUP AIR-MED S.A.	30/06/2015	03/08/2015	107.560,00 €	107.454,36 €		105,64 €	431.319,07 €
7	03/2015	AERIAL SURVEY ON SPAWNING AGGREGATIONS (ACTIVITY A, SUB-AREAS C, D, F)	CONSORZIO UNIMAR Soc. Coop.	17/06/2015	03/08/2015	170.604,00 €	157.038,71 €		13.565,29 €	
16		AERIAL SURVEY DATA ELABORATION	ALNILAM INVESTIGACIÓN Y CONSERVACIÓN SL	17/08/2015	21/02/2016	26.400,00 €	26.400,00 €		- €	26.400,00 €
	08/2015	ITEM A: Power analysis and cost-benefit analysis for the ICCAT GBYP aerial survey	ALNILAM INVESTIGACIÓN Y CONSERVACIÓN SL	08/01/2016	19/02/2016	19.800,00 €	19.800,00 €		- €	
MODELLING										
2	02/2015	MODELLING APPROACHES: SUPPORT TO BLUEFIN TUNA STOCK ASSESSMENT	THE UNIVERSITY OF BRITISH COLUMBIA	19/05/2015	23/02/2016	$ 121.820,00	$ 121.820,00		- €	$ 157.820,00
3	07/2015	MODELLING APPROACHES:	Ph.D. JOSEPH E. POWERS	21/04/2015	22/02/2016	$ 36.000,00	$ 36.000,00		- €	
		travel for coordinator and expert				27.000,00 €	18.349,62 €			
		meeting				25.000,00 €	11.261,95 €			
DATA RECOVERY										
4	04/2015	DATA RECOVERY PLAN	THE DEPARTMENT OF	07/05/2015	31/01/2016	20.000,00 €	20.000,00 €		- €	20.000,00 €
TAGGING										
9	05/2015	TAGGING PROGRAMME ON BLUEFIN TUNA (AREA C)	CENTRO DI COMPETENZA SULLA BIODIVERSITÀ MARINA - Com.Bio.Ma.	08/06/2015	31/07/2015	50.000,00 €	49.992,54 €	27.592,54 Combioma + 22.400,00 Carloforte Tonnare	7,46 €	
10	05/2015	TAGGING PROGRAMME ON BLUEFIN TUNA (AREA B)	INSTITUT NATIONAL DE RECHERECHE HALIEUTIQUE - INRH	03/06/2015	31/07/2015	116.751,00 €	105.679,23 €	7.493,36 WWF + 83.125,00 Maromadraba + 15060,87 INRH	11.071,77 €	245.701,11 €
11	05/2015	TAGGING PROGRAMME 2015 (AREA A)	THE FACULTY OF FISHERIES, UNIVERSITY OF ISTANBUL and CONSORZIO UNIMAR Soc. Coop.	17/06/2015	31/07/2015	91.000,00 €	90.029,34 €	37.679,34 Unimar + 52.350,00 Istanbul	970,66 €	
15	07c/2015	ADVICE ON CLOSE-KIN	CSIRO Marine	08/01/2016	19/02/2016	65.344,00 AUD	65.344,00 AUD		- €	65.344,00 AUD
	08/2015	ITEM B: Cost benefit analysis for the ICCAT GBYP tagging programme	CENTRE FOR ENVIRONMENT, FISHERIES & AQUACULTURE SCIENCE - CEFAS	08/01/2016	19/02/2016	£ 25.000,00	£ 25.000,00		- €	
BIOLOGICAL STUDIES										
13	06b/2015	BIOLOGICAL STUDIES	AZTI Fundación	16/07/2015	31/01/2016	314.496,00 €	314.496,00 €	TBC	- €	
14	06b/2016	BIOLOGICAL STUDIES	NECTON Marine Research Society	05/08/2015	19/02/2016	28.000,00 €	15.741,27 €		12.258,73 €	330.237,27 €

15 The final amount of some contracts is still provisional, because the administrative procedures were not finalised when this scientific report was prepared.

Annex 3: List of meetings and activities attended by GBYP

No.	date	place	Meeting or activity	Motivation
1	02-06/03/2015	Madrid (SP)	ICCAT SCRS Bluefin tuna data preparatory meeting	Review of available data and discussion about their use for MSE; data requested for the next meeting.
2	08/05/2015	Amsterdam (NL)	Meeting organised by WWF NL with various Universities for developing a research plan for the Bluefin tuna in the North Sea.	Overview of GBYP activities and opportunities for cooperation
3	26/05/2015	Madrid (SP)	ICCAT-GBYP Training course on Aerial Survey	Training for pilots, professional spotters and scientific observers working for the GBYP aerial survey.
4	08-09/06/2013	Favignana (IT)	Settimana delle Egadi, Tonni e Tonnare	Historical review of traps activities (nop)
5	07/07/2015	Milano (IT)	EXPO – Conference on marine food and history	Historical and recent importance of traps in providing rich proteins (nop)
6	10-12/09/2015	Isla Cristina (SP)	2015 (XV) Meeting of Tuna Trap Captains	Report about the tuna fishery in the Canary Islands in the early XX century (nop)
7	21-25/09/2015	Madrid (SP)	SCRS BFT Species Group	Overview of the GBYP activities, other BFT subjects
8	26/09/2015	Madrid (SP)	GBYP Steering Committee Meeting	Review of Phase 5 activities and plans for GBYP Phase 6
9	28/09-02/10/2015	Madrid (SP)	SCRS Plenary	Overview of the GBYP activities
10	10-17/11/2015	Malta	24^{th} Regular Meeting of the Commission	Overview of the GBYP activities
11	18-20/01/2016	Monterey (USA)	Bluefin Future Symposium	Report on GBYP activities
12	21-23/01/2016	Monterey (USA)	Meeting of the ICCAT GBYP Core Modelling MSE Group	Participation as member and supervision of the meeting
13	15-19/02/2016	Madrid (SP)	Meeting of the ICCAT Working Group on Stock Assessment Methods	Discussion about MSE approaches

NOTE: nop = non official participation; the meeting was attended on personal behalf and without costs for the programme.