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ICCAT ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (GBYP): ACTIVITY REPORT FOR THE LAST PART OF PHASE 5 AND THE FIRST PART OF PHASE 6 (2015-2016)

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

SUMMARY

The Atlantic-wide research programme on bluefin tuna (GBYP) officially begun on October 2009. The Phase 5 was carried out in the period 2015-2016. Phase 6 which began on 21 February 2016 and will be active until 20 February 2017. Activities in the Phase 5 included (a) continuation of data mining, recovery and elaboration, (b) biological studies, (c) tagging, including awareness and rewarding campaign, (d) aerial survey on bluefin spawning aggregations and (e) further steps of the modelling approaches, while in the Phase 6 all the activities continued except the aerial survey, which was suspended by the Steering Committee. The second review of the ICCAT GBYP was held at the beginning of the Phase 6 and the reviewers pointed out that "the GBYP is a success and should be continued." Advances in biological methods to determine spawning grounds origin are identified as particularly successful, as well as advances in MSE and model developments.

RÉSUMÉ

Le Programme de recherche sur le thon rouge englobant tout l'Atlantique (ICCAT-GBYP) a commencé officiellement ses activités en octobre 2009. La phase 5 a été menée au cours de la période 2015-2016. La phase 6, qui a officiellement commencé le 21 février 2016, sera active jusqu'au 20 février 2017. Les activités de la phase 5 comprenaient (a) la poursuite de l'exploration, récupération et élaboration des données ; (b) les études biologiques ; (c) le marquage, y compris les campagnes de sensibilisation et de récompense ; (d) les prospections aériennes des concentrations de reproducteurs de thon rouge et (e) les étapes ultérieures des approches de modélisation, tandis que dans la phase 6 toutes les activités se sont poursuivies, exception faite de la prospection aérienne que le comité directeur a suspendue. Le deuxième examen externe de l'ICCAT-GBYP a eu lieu au début de la phase 6 et les examinateurs ont souligné que l'ICCAT-GBYP était une réussite et devrait se poursuivre. Les progrès accomplis en matière de méthodes biologiques visant à déterminer la zone de frai d'origine sont identifiés comme particulièrement louables, ainsi que les avancées dans la MSE et les développements de modèles.

RESUMEN

El Programa de investigación sobre atún rojo para todo el Atlántico (GBYP) comenzó oficialmente en octubre de 2009. La fase 5 se llevó a cabo en el periodo 2015-2016. La fase 6 empezó el 21 de febrero de 2016 y continuará hasta el 20 de febrero de 2017. Las actividades de la fase 5 incluyeron (a) la continuación de la minería, recuperación y elaboración de datos, (b) estudios biológicos, (c) marcado, incluidas campañas de concienciación y recompensas, (d) prospección aérea de concentraciones de reproductores de atún rojo y (e) más pasos en los enfoques de modelación, mientras que en la fase 6 las actividades han continuado excepto la prospección aérea, que fue suspendida por el Comité directivo. Al inicio de la fase 6 se realizó la segunda revisión del ICCAT GBYP y los revisores señalaron que "el GBYP es un éxito y debe continuar". En particular, se identificaron como un éxito los avances en los métodos biológicos para determinar las zonas de desove de origen, así como los avances en la MSE y en el desarrollo de modelos.

KEYWORDS

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

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

1. Introduction

The 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.

The total budget of the programme was estimated at about 19 million Euros in six years, with the engagement of the European Union and some other Contracting Parties to contribute to this programme in 2009 and in the following years; the budget officially approved by the ICCAT Commission in 2008 was 19,075,000 Euro for 6 years. The initial year had costs for 653,864 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 1,769,364 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 were 2,819,425 Euros. The fifth phase had a total budget of 2,125,000 Euros (against the original approved figure of 3,345,000 Euros) and final costs were 1,995,787 Euros. The sixth phase has a total budget of 2,125,000 Euros (against the original approved figure of 410,000 Euros). The overall ICCAT GBYP operating budget for the first six phases, covering seven years (a total of 11,869,782 Euros) is about 62.23% of what it was supposed to be (the 19,075,000 Euros approved by the Commission). Several private or public entities[2] provided few additional funds or in kind support. These budget reductions had an impact on all activities carried out so far.

Taking into account the above reported figure, in 2014 the GBYP Steering Committee (documents SCRS/2014/194 and SCI 005/2014) and the SCRS recommended extending the GBYP activities up to 2021 and this proposal was endorsed by the Commission during its meeting on November 2014, along with the SCRS report.

Phase 1 and Phase 2 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, Tunisia, Egypt, Iceland and Korea) joined the first funders in the following Phases, while Phase 6 was co-funded by the United States, Japan, Tunisia, Turkey, Libya, Morocco, Norway, Canada, Albania, Korea, Chinese Taipei, Popular Republic of China and Iceland, in order of contribution. Some of CPCs did not paid fully or partly their contribution (sometimes even after the commitment), 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 fifth phase of GBYP officially initiated on February 24, 2015 after the signature of the Grant agreement for co-financing the GBYP Phase 5 (SI2.702514) by the European Commission and ended on 23 February 2016. The partial results were presented to the SCRS and the Commission in 2015 (Di Natale and Tensek, 2015a) and they have been approved. The final report for Phase 5 has been officially approved by the European Union.

The sixth phase of the ICCAT GBYP officially started on 21 February 2016 following the signature of the Grant agreement for the co-financing of the ICCAT GBYP Phase 6 (SI2.727749) by the European Commission and will end on 20 February 2017.

The ICCAT Commission, in its meeting in Genova (Italy) on November 2014 approved the extension of the GBYP up to 2021 as included in the SCRS report, following the recommendations of the GBYP Steering Committee and the SCRS. A new plan for the GBYP activities to be done during these additional years was approved along with the extension.

The 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.

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[2] Additional financial contributions to GBYP were provided by Asociación de Pesca, Comercio y Consumo Responsable de Atún Rojo (SP) and by Grupo Ricardo Fuentes e Hijos s.a. (SP). In kind contributions were provided by Aquastudio Research Institute (IT), Balfegó Grup (SP), Carloforte Tonnare PIAMM (IT), Federcoopesca (IT), Ph.D. Jean Marc Fromentin (France), IEO–Fuengirola (SP); INRH –Tangier (MO), Maromadraba SARL and Es Sahel (Fuentes Group) (MO), Oceanis srl (IT), Ph.D. Molly Lutcavage (US), Mr. Roberto Mielgo Bregazzi (SP), the Stanford University (USA), Unimar (IT), the University of Cagliari (IT), the WWF Mediterranean Programme and the GBYP Coordinator.

2. Coordination activities

2.1 ICCAT GBYP coordination

In the first part of the Programme, the staff was composed by the GBYP Coordinator, the Coordinator assistant (from March 2011 to March 2014) and one contracted technician for data management (from October 2011 to December 2013). In the second part of Phase 4 the staff was reduced to the Coordinator only, while the previous staff level was resumed from May 2015 (see **Table 1**). The ICCAT Secretariat provided always the necessary support for the GBYP activities and this support has been extremely useful.

The GBYP Coordination activity had so far a total cost of 2,082,320 Euro[3], including many components and also all costs for the Steering Committee and the two reviews. This cost represents 17.82% of the total GBYP operative budget for the first 6 Phases.

A total of fourteen calls for tenders were issued in Phase 5, awarding a total of 20 contracts to various entities in that Phase (**Annex 1a**). Eleven additional calls for tenders have been announced to date in the first part of Phase 6 and a total of 18 contracts have been awarded to date to various entities in Phase 6 (**Annex 1b**).

A total of 111 contracts have been awarded under the ICCAT GBYP up to the first part of Phase 6 to 96 entities, located in 24 different countries; many hundreds of researchers and technicians have been involved to date in the various ICCAT GBYP activities. This extensive and open participation in ICCAT GBYP activities is considered to be one of the best results of this research programme.

A total of 43 reports were produced in the framework of Phase 5 of the ICCAT GBYP. Several additional documents and reports have also been issued by the ICCAT GBYP for the needs of Steering Committee meetings; a total of 34 scientific papers were produced in Phase 5, while others will be published later on (**Annex 2a**). A total of 15 reports have been produced in the first part of Phase 6, along with 32 scientific papers (**Annex 2b**). The total number of reports produced by GBYP up the first part of Phase 6 is 212, and 203 scientific papers have been published so far.

The coordination staff participated in 11 meetings in various countries in Phase 5 (5 were already reported in the previous GBYP report), and to 5 meetings in the first part of Phase 6, up to September 2016 (**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 GBYP activities since the beginning of this programme.

A particular coordination effort was necessary for assisting the contractors engaged in the tagging activities and for assisting them for the many permits required, getting directly in touch with the relevant Authorities of the various CPCs concerned. A continuous assistance, 7/7 days 24/24h, was necessary for solving various problems, emergencies and operational difficulties.

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.

In conformity with the Atlantic-Wide Bluefin Research Programme (GBYP) adopted by the SCRS and the Commission for Phase 5 and 6, the following research initiatives have been conducted, completed or initiated (see also **Annex 1**).

2.2 Second Review

The second review of ICCAT GBYP was carried out in the first part of Phase 6. After a selection, the contract was provided to MRAG (UK). The independent reviewers have been Ph.D. Michael Sissenwine and Ph.D. John Pearce; the report was made available to the SCRS and the Commission (SCRS/2016/192).

[3] The cost include 380,950 Euro in the full Phase 6, which might be lower at the end of the Phase.

The reviewers provided an extensive and detailed analysis of the work carried out from 2010 to 2016 and range of proposals for improving the research in the following years.

The reviewers recognized the important improvements in scientific knowledge obtained by the ICCAT GBYP in the first parts of the programme. Specifically, the reviewers pointed out that "The GBYP is a success and should be continued. Advances in biological methods (genetics, otolith microchemistry and shape) to determine spawning ground origin of bluefin tuna are particularly successful." And that "The GBYP has successfully advanced methods for determining the stock origin (eastern or western spawning grounds) of bluefin tuna found throughout the Atlantic Ocean. It has retrieved data that give a historical perspective (including ancient history) on fisheries and improved some time series of data that are used in stock assessments. Model development is going well such that it is reasonable to expect mixed spawning stock BFT fisheries advice in the future (thus addressing need 1 on mixing). Modelling can also be used to guide future research priorities and to quantify data collection priorities. These successes justify the GBYP and the potential for transitioning them into operational data streams to support future scientific advice and management is reason enough for continuing the program".

3. Data mining and data recovery (final part of Phase 5 and first part of Phase 6)

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 previously 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 improving our knowledge about Atlantic bluefin tuna.

The total budget for data mining and data recovery was 600,000 euro for activities in 3 years; so far, the total expenditures have been 538,342 euro for 7 years of activities (89.72 % of the original budget), recovering much more data that it was set at the beginning). The data recovered so far in all ICCAT GBYP Phases are included in **Table 2** and **Table 3**, except those there are still under check. So far, the GBYP objectives set for data recovery and data mining in these first Phases have been largely accomplished.

3.2 Historical trap data recovered in the last part of Phase 5 and Phase 6

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[4] 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.

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

[4] 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.

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 206 different traps for the various countries (Italy, Spain, Portugal, Morocco, Libya, Tunisia and Turkey. The graphs related to the old traps data are shown on **Figure 1**.

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.

Revised trap data recovered by the ICCAT GBYP between Phase 1 and Phase 6 were presented as the SCRS/2016/139 at the SCRS BFT Intersessional Meeting.

3.3 Genetic data mining in the last part of Phase 5

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.

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 Sea and the Levantine Sea are showing partial differences that should be further understood (**Figure 2** and **Figure 3**). This pattern with patched and sporadic differences does not solidly support the existence of temporally persistent subpopulations within the Mediterranean. No genetic erosion has been detected in the samples.

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 have already been presented to the SCRS in 2015, while the final report is available on http://www.iccat.int/GBYP/en/Drecovery.htm.

3.4 Data Recovery in Phase 6

ICCAT GBYP issued one Call for Tenders under this activity in Phase, awarding 3 contracts. One contract was for recovering recent long-line data (by area, vessel, day, effort, catch in kg and number, length and weigh individual frequencies), a second one for additional recent long-line data with the same details and for additional historical trap data, and a third one for trying the recovery of historical catch data in the Canary Islands zone. No proposals have been received from other ICCAT areas.

LL and TRAP bluefin tuna data account for a total of 2,666,971 kg and 13,264 fish, while the data from the Canary Islands concerns a total of 36,877 kg of bluefin tuna, but many data needs a further analysis, because most are related to not-well defined tuna species. All data were provided on the Excel forms, in the format used by the ICCAT Statistical Department.

The data sets recovered from Mediterranean LL for the years 2002-2015 (which are additional data sets not already available in the ICCAT data base) have catches by vessel, area and day, partly with effort data (no. of hooks/day) and are related to a total catch of 11,070 bluefin tunas and a total weight of 112,875 kg. 11,059 bluefin tunas have individual length or weight or both.

The data sets recovered for ancient Italian traps for the period 1823-1922 were extracted from additional documents recently discovered and they fill some temporal gaps in already existing data series, for 13 traps. The data varies from trap to trap, from daily catches by fishing operation ("mattanza" to total year catch). The trap data are related to only 8,463 bluefin tuna in number, and 2,554,096 kg, because in most of the cases, only the total catch in weight was recorded on the original documents. The difficulties for recovering these data was considerable. These data sets for long lines and historical traps are additional to those already recovered in previous GBYP Phases. Data recovered in Phase 6 from longliners (LL) and traps (TRAP) in Italy are shown on **Table 6**.

The data sets recovered in the Canary Islands were extracted from ancient registers of various Spanish factories in Tenerife, La Gomera and Las Palmas, providing various types of data by year, month or even day, sometimes by number of fish and/or weight by specie and by factory. The data recovered are related to various tuna species, to be further analysed in detail, and includes for sure at least a total of 36,877 kg of bluefin tuna catches. A main problem concerns unidentified tuna species related to the number or weight of mixed tuna species which arrived to the salting and canning factories. **Table 7** shows the data for all species in detail. Additionally it was possible to recover information related to the vessels fishing in the Canary area, but was impossible to relate each vessel with their correspondent catch. Catches were possibly obtained by hand lines (HAND) or pelagic trawls (MWT).

An overview of the bluefin tuna data recovery in the Phase 6 is given in the paper SCRS/2016/150, already presented at the SCRS BFT Intersessional meeting.

When this paper was compiled, GBYP discovered that an important Ph.D. thesis was carried out at the University of Tarragona in 2015, on tuna traps in the Realm of Aragon, and many of these traps are not in the ICCAT GBYP historical data sets. This huge thesis and the intense work behind it on many historical archives, will be possible explored in the last part of Phase 6 and surely in the very first part of Phase 7.

3.5 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 that were validated so far, limiting them to those bluefin tunas having RW and GGW individual data and considered reliable, were analised and submitted by GBYP to the SCRS Bluefin tuna Intersessional Meeting in 2016 (SCRS/2016/142) for improving the size frequencies for the EBFT. Weight frequencies of all bluefin tuna from the trade, market and auction files are shown on the **Figure 5**.

In July 2016, the ICCAT GBYP Steering Committee, in line with the comments provided in the external review of the GBYP, recommended analysing market data sets for possibly assessing the total removals by year. The SC recommended awarding an external contract for this purpose. In August, a Call for Tenders was released with the goal to re-analyse market, auction and trade datasets, identify the reliable ones and provide the estimation of the total level of possible catches of Atlantic bluefin tuna that went to the market for each year covered by the data, ideally by stock and under various hypotheses, including the expected CVs by year, for further analyses of the SCRS Bluefin Tuna Species Group. A contract was provided to MRAG (UK) and the results will be available in the last part of Phase 6.

3.6 Electronic tags data recovery

The electronic tagging carried out by ICCAT GBYP in previous Phases showed a very high complexity of the bluefin tuna movements and these data, along with the results obtained from the GBYP biological studies, are also showing mixing in areas where it was not demonstrated before. Since the ICCAT GBYP tagging data alone are obviously not sufficient for describing the complexity of movements and behaviour of BFT in its distribution area, either for the short timeframe of GBYP activities or for the limited number of electronic tags deployed so far, the SCRS recommended to recover all available data set from electronic tags deployed by several institutions in previous years with the objective to have a comprehensive overview of BFT movements. Several data sets have been voluntary provided so far to the two experts in charge of assembling these data in a homogenous manner (i.e. Dr. Matthew Lauretta on behalf of the SCRS BFT Species Group and Dr. Thomas Carruthers on behalf of GBYP Core Modelling MSE Group). These data have been used for “feeding” the MSE process, which is currently under developed.

Being aware of further important e-tags data sets, the ICCAT GBYP Steering Committee recommended to release a formal invitation for providing these data sets to the GBYP, with the objective of incorporating these additional data in an organized system and providing them to the SCRS and to the GBYP Modelling Expert. The contract was awarded to the Stanford University (Prof. Barbara Block), for providing 393 electronic tags datasets. One specialist, Dr. Lutcavage, provided her data to the modelling group in a complimentary way. Another data set was not provided by the scientist owning the data, even if these data were collected with EU funds. All data provided up to date have been transferred to the modelling experts in timely manner.

3.7 Support to Mauritania

In line with the recommendation of the SCRS, which have been endorsed by the Commission, ICCAT GBYP organized a training course in the Islamic Republic of Mauritania in order to improve data and information collection about bluefin tuna in the area. For that purpose, a memorandum of understanding was signed between the ICCAT Secretariat and the Institut Mauritanien de Recherches Océanographiques et des Pêches. The short course was held in Nouadhibou on 13-14 July 2017 and it addressed all the particularities about information and data collection, reporting including SCRS requirements and filling of submission forms, necessary for enforcing the ICCAT Rec. 14-04. All organizational costs, travels and per-diems were covered by the ICCAT GBYP, which also provided dedicated forms and the financial support for the organization of data collection.

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 selected areas have been carried out in GBYP Phase 1 (2010) and Phase 2 (2011). The first one covered entirely 3 areas and partly 3 additional areas, while the second one was limited to 3 areas, due to security and permits problems. The aerial survey activity was suspended in Phase 3 (2012), 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 document SCRS/2012/149, 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. At the end of Phase 3, under the GBYP Modelling budget 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 (a power analysis) for obtaining useful data for operating model purposes, following the views of the GBYP Steering Committee

(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 first extended aerial survey in Phase 4, which was carried out in .

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 with extreme logistics. 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). 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**).

4.2 The ICCAT-GBYP 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, 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.

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, trained by two external experts (Dr. A. Cañadas and Dr. J.A. Vasquez) and by the GBYP Coordinator. The new GBYP Protocol for Aerial Survey for Bluefin Tuna Spawning Aggregation, provided by the two expert, was reviewed by GBYP and officially circulated among all the contractors.

4.3 The ICCAT-GBYP Aerial Survey for Bluefin Tuna Spawning Aggregations in Phase 5

The survey was carried out by three companies, 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). The results of this study are now available on http://www.iccat.int/GBYP/en/asurvey.htm

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.

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 SCRS/2015/154). 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[5], 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 8, 9** and **10** show the results of the aerial survey in total and in both “inside” and “outside” areas.

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.

4.4 The ICCAT-GBYP Aerial Survey 2010-2015 – Overlapping Area Data Analysis

Additional to the 2015 aerial survey data analysis, in the Phase 5, the GBYP requested to include also an analyses on overlapping “inside” areas over the four surveys (**Figure 9**), 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 11**.

The analysis confirmed large inter-annual variability as well as differences in the geographical distribution. 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.

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.

As shown on **table 11**, in general the analysis of overlapping areas showed reduced CVs for all components, except in 2015, when the CV was higher than the previous yeas, due to the different oceanographic conditions in the Mediterranean Sea.

[5] This increase of CV was expected and the SC was informed about this fact before the survey.

In 2015, for the first time, it was checked the possibility to tentatively 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 very 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) 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. A detailed analysis of the additional variance was carried out 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. Even if this result seems critical, on the opposite it helps in understanding the complexity of the bluefin tuna behaviour and the possible features a research should consider for assessing a species in the wild. Furthermore, the statistics behind this first tentative of use the additional variance derived from electronic tags should be further improved.

4.5 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.

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) is the lowest among all recent aerial surveys carried out in the European or Mediterranean area for various marine species (**Table 12**).

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 main 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 also obviously imposed by budget constraints). 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 high (**Figure 10**).

The additional variance has been assessed and it is very high, when considering spatial and temporal variability (see above point 4.3). 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 further 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.

The power analysis report 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. The main recommendation is, thus, to concentrate the survey effort in the inside overlapping areas for future surveys. 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 aerial surveys are still one of the very few available methodologies for providing fishery-independent data; no-one of the fishery independent methodologies is perfect and without biases but, considering the cost of the ICCAT GBYP aerial survey, this approach is not among the most expensive. Several data have been collected in the first four surveys and surely the stop-and-go strategy, induced also by budget unavailability in some years, played a severe role in partly affecting the quality of the data, resulting in a substantial CV. The difficulties in keeping active the same teams in each area were another limit. These problems can be smoothed and possibly reduced to a minimum in a medium- long-term strategy, building on the knowledge already achieved with many efforts.

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."

4.6 Aerial survey in Phase 6

According to the decision of the ICCAT GBYP Steering Committee adopted by e-mail, the aerial survey for the spawning aggregations was suspended in the year 2016. It based the decision on the assumption that the financial resources are not sufficient for carrying out an adequate survey (i.e. in terms of survey effort that would be required to achieve a reasonable CV) again on the entire or most of the area in the Mediterranean Sea where spawners/adults may occur. Additionally, it pointed out large logistical, political and administrative constraints that would more than likely prevent such an extended survey from being adequately implemented, even if very much larger financial resources were available.

Later, the Steering Committee identified the potential alternative to conduct a comprehensive survey restricted to relatively limited areas within the Mediterranean that can be adequately surveyed with the available resources. In order for this approach to provide a useful index of abundance, the proportion of the adult stock within the survey areas during the survey needs to be relatively constant. This is essential so that changes and trends in the actual size of the population can be distinguished from inter-annual variability in the utilization of the areas being surveyed. It also reiterated the request that a sort of calibration will be useful. The SC considered the recommendation that this alternative be adopted and the surveys be restricted to the four core overlapping areas that had been included in all the four previous surveys.

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 up to the first part of the Phase 5 are in document SCRS/2015/149.

5.1 Objectives

The specific objectives of the GBYP tagging activity on the medium term are:

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].
b) Estimate the natural mortality rates (M) of bluefin tuna populations by age or age-groups and/or total mortality (Z).
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.
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 and internal archival 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 and Mediterranean, with a total budget of 9,765,000 euro; the mandatory tag awareness and rewarding campaigns, as well as the tagging design study and protocol, were not included. So far, with only 48.13% of the funds (a total of 4,699,416 euro, including the budget amount set for Phase 6, equal to 431,758 euro), GBYP deployed 84.79% of the conventional tags (25,436) and 105.33% of the electronic tags (316 in total; 258 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.

The updated situation of the tagging activities in Phase 6 is shown on **Table 13**. In total, on 19 September 2016, the total number of bluefin tunas tagged so far in all Phases of GBYP are 17,987, and a total of 25,752 tags of various types have been implanted (**Table 14**). 44.3% of the tagged fish were double tagged.

Figure 11a 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 from Phase 5, due to the cancellation of the conventional tagging. **Figure 11b** shows the percentage distribution of tags implanted in the various geographical areas, up to 19 September 2016.

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.

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

5.3 Tagging activities in last part of the Phase 5

The Steering Committee, in September 2014, adopted a different tagging strategy for Phase 5, keeping the conventional baitboat tagging only in the Bay of Biscay and in the Strait of Gibraltar, while electronic tagging activities were planned in traps for tagging adults (both in Morocco and Sardinia); an experimental tagging with miniPATs was planned in the eastern Mediterranean by purse seine for adults in the Turkish area. In February 2015, the Steering Committee considered that the tag reporting rate for conventional tags was too low and recommended revising the plan for Phase 5, cancelling the conventional tagging, and addressing all activities only to the electronic tagging in the three areas previously identified, increasing the number of tags as much as possible, according to the availability of tags by Wildlife Computers and the budget possibilities.

In Phase 5, a total of 83 electronic pop-up tags were implanted on the adult fish in Sardinia, Turkey, Morocco and in the Tyrrhenian Sea. Complementary conventional tagging was also carried out. All preliminary results of the tagging in the first part of the Phase 5 have already been discussed in the paper SCRS/2015/149. The most important result is the evidence that all previous hypotheses about the lack of movements between the tunas in the eastern Mediterranean and the other Mediterranean and Atlantic areas, which were shown 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, one tuna tagged in the Strait of Gibraltar in 2013 with a conventional tag that was reported in Turkey and one tuna double tagged in Croatia in 2013 that was recovered also in Turkey. This fully new evidence supports the results of the genetic analyses which reported mixing among all areas in the Mediterranean (**Figure 12**). Another important achievement is a possible explanation of the behaviour of the bluefin tuna tagged in the Moroccan traps in 2011, 2012, 2013 and 2015. As discussed in the document SCRS/2015/149, now it seems that a possible explanation might be that some of these fish had a western origin and therefore these “western” fish going to the Moroccan traps had no reason for going into the Mediterranean during the spawning period. On the opposite, if we trust the full separation of the spawning areas for those fish born in a given area, they had good reasons for going back to the western Atlantic areas. This variable presence of western-origin Bluefin tuna in the Moroccan traps 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.Therefore, now it seems that the behaviour of these fish was mostly subject to other factors than the tagging technique and that the different behaviour most possibly inform us about a different natal origin. Of course, any further observation of these data should take into account that we are still missing all details about those Bluefin tuna distributed in the central-southern Atlantic.

It is important to note that several premature detachments[7] have been noticed for mini-PATs since the beginning of the Programme; 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 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, 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 and it was impossible extracting it 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 later infection in the wound, which might result is weakening the skin itself around the wound in few weeks. As discussed later, it is to be noted that most of the “premature detachments” happened in areas and times where several fishing vessels were operating.

5.4 Tagging activities in the Phase 6

In the Phase 6, the ICCAT GBYP Steering Committee decided to proceed with the electronic tagging activities, keeping conventional tagging only as a complimentary activity. It was decided to focus the attention for the first part of the tagging on the eastern Mediterranean Sea, where recent tagging activities were not carried out, in the Moroccan traps, where all recent tagging activities showed variable behaviour of the bluefin tuna passing in this area and in the Sardinian area where electronic tagging was carried out in 2015 at the beginning of the spawning seasons.

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

For the first part of the tagging activity in 2016, a call for tenders was published in April and the contracts were awarded to a consortium led by COMBIOMA for tagging in Sardinian traps, a consortium led by INRH for tagging in Moroccan traps and to Istanbul University which in collaboration with UNIMAR carried out tagging in the Levantine Sea. In the first part of the tagging activities, a total of 53 electronic pop up tags were implanted on adult bluefin tunas in these areas.

The second part of the tagging activities was intended to be carried out in the Strait of Messina (central Mediterranean Sea), where tagging activities on "resident tunas" have not yet been carried out, in the Portuguese traps, where bluefin tuna moving into the Atlantic after spawning can be tagged and the sea off Ireland, where some tagging was carried out in the past. After releasing the call for tenders two contract were provided, to UNIMAR for tagging in the Strait of Messina and to TUNIPEX for tagging in Portuguese trap, while the contract for tagging off Ireland was suspended by the Steering Committee. A total of 24 tags was implanted in Portugal and another 21 are planned to be implanted in the Strait of Messina starting from the last half of September 2016. It is important to stress that 6 of the PSATs plus additional 2 brand-new experimental electronic satellite tags that will be deployed in the Strait of Messina, were kindly donated by the WWF and the tagging data results will be shared.

The preliminary results of the tagging activities in Phase 6 show the important number of premature detachments. The reason for this probably lies in the high fishing pressure, the same problem that we faced in the Phase 5, as already discussed in the paper SCRS/2016/138. Additionally, this year the PSAT tags supplied by Wildlife Computers, which were used for the ICCAT GBYP tagging, were technically modified in terms of adding the automatic release device situated in the tag tether. As recognized by the manufacturer, a great deal of the premature detachments was due to the broken pin, which was more sensible than it should have been according to the technical specifications. As a matter of fact, out of 73 tags deployed in Phase 6 that have already popped-up (as of 22 September 2016), 25 detached because of the broken pin. The negotiation process with the producer has been initiated and the producer in August recalled and replaced the malfunctioning tags that hadn't been deployed yet and provided more robust ones. Additionally, the producer provided the guarantee that all tags already implanted, that have released before their scheduled pop-off date due to this technical failure mode, will be replaced free of charge.

The first results of the Tagging programme 2016 are available for the tags deployed in Levantine Sea, Sardinia, Portugal and Morocco. The tracks of 67 PSATs that have already popped off and the estimated tracks of which were processed by CLS are shown on **Figure 13**. According to the first results, it seems that this year all tunas tagged in Morocco entered immediately to the Mediterranean Sea for spawning. This is different from the tagging results of previous years showing only a proportion of tagged tunas entering the Mediterranean, while the others stayed in the Atlantic Sea. The previous results are consistent with the results providing from the GBYP Biological Studies, showing each year different proportion of tunas in Morocco belonging to the eastern and western stock; therefore, we suspect that all tunas tagged in Morocco in Phase 6 should be EBFT, but the confirmation from the GBYP Biological Studies will be provided in the last part of Phase 6.

The tunas tagged in Portugal showed a different pattern, heading towards the North Atlantic. These were expected results, having in mind that these tunas were tagged after the spawning season; it is important to notice that one of the bluefin tuna tagged there showed a different displacement from the others, moving toward the Azores.

The bluefin tunas tagged in Sardinia stayed in the western Mediterranean, which is a behaviour similar to what have been already observed in 2015 when none of the tunas tagged in Sardinia had left the Mediterranean Sea. There is still one tuna tagged in the Sardinian traps with the tag on, and the pop-off is set for July 2017.

Regarding the bluefin tunas tagged in the Levantine Sea, the observed behaviour is the same as the last year. Although the majority of tags detached in a short period of time which didn't let us the chance to record the displacements of these tunas after spawning, it seems that the majority were heading west, and some tunas reached western Mediterranean areas before their tag popped off. There are still three tunas tagged in the Turkish area with the tags on, and the pop-off is set for all of them on June 2017.

5.5 External review and cost-benefits analysis of the ICCAT GBYP Tagging Programme

It the last part of Phase 5, a call for tenders was issued for the external cost-benefit analysis for the ICCAT GBYP tagging programme, 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 and future phases, as recommended by the Steering Committee. For that purpose, a short term contract was awarded 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 on http://www.iccat.int/GBYP/Documents/TAGGING/PHASE%205/TAGGING_PHASE5_REVIEW.pdf.

The independent review and 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[8]), comparing the current GBYP cost levels with the only available comprehensive estimate for all EU tagging projects[9] (page 19 of the report), was about 63% for the conventional tags and 24% for the electronic tags, pointing out the low cost level obtained by GBYP and its management strategy.

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 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".

5.6 The analysis of the PSAT tags data

A summary of all ICCAT GBYP PSAT tags that were deployed between 2011 and 2015 (Phase 6 was not included) was provided by SCRS/2016/138. The analysis was carried out in-home, by the GBYP team. Out of 193 tags implanted, the full datasets were recovered from 173 tags. The longest received dataset was recovered from the tag which stayed 337 days attached to the fish. A brief discussion was provided on how the real tag dataset duration

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

is in most cases shorter than the period between the deployments and the pop-up, because the tag detachment may happens few days before the tag starts transmitting to the satellite. It is very important that in all future PSAT tags data analysis this fact is taken into account in order to remove the data between the detachment and the pop off, for avoiding a bias in an integrated analysis. A brief analysis of the potential cause of the tag detachment was discussed in detail and the method was established for determining various possible causes, concentrating to the specific behavior of the tuna when they are caught by different fishing gear. The results indicated a huge number of detachments possibly due to the fishing activities (75%). For the first time, now the detailed specifications for trying to attribute a premature detachment to a specific fishing gear type are now available and this new information was appreciated by the SCRS BFT Intersessional meeting.

The analysis of tag reporting performance was also performed and it indicated a slight technological improvements over the time. Tag trajectories revealed many interesting moving patterns for bluefin tunas, some of which were previously unknown and present a great contribution of the GBYP programme to the science. The analysis of the time the bluefin tuna spends close to the surface in the Mediterranean was also analysed and it was found that there is a significant difference in its behaviour during the spawning and non-spawning season (**Figure 14**). During spawning season (in the Mediterranean from May to August) bluefin tuna spend more time in the upper water column, which was expected result having in mind that spawning occurs at the surface.

All data sets from electronic tags deployed by the GBYP in all Phases were provided to Ph.D. Matt Lauretta (in charge of collecting and analysing all satellite tags data sets on behalf of the SCRS BFT Species Group) and to Tom Carruthers (the modelling expert in charge of developing the technical aspects on behalf of the ICCAT GBYP Core Modelling MSE Group).

It has to be noted that GBYP is only one of the entities providing PSAT data to the two experts. Although if recently there has been a great progress in a quantity of data these experts received, there are still some entities that didn't provide their electronic tags data. GBYP in the Phase 6 awarded a contract to Prof. Barbara Block, for recovering the data from Tag-A-Giant research programme of the Stanford University. A datasets of 393 electronic tags will be provided in the framework of this contract, half of the data have been already provided before this report and are now available to the two experts for modelling purposes.

5.7 The analysis of displacements of tagged BFT

As concerns the displacement data provided by the conventional tags, the basic analysis for those fish that have both release and recovery position was carried out and the results are presented in the paper SCRS/2016/143. A set of maps was elaborated for better representing the current situation and for showing the various movements of the bluefin tunas using tag release/tag recovery data. As a matter of fact, over 5,962 fish having both data, 5,434 fish (equal to 91.14%) had position data that have been validated. For plotting the displacements data by decade, it was decided to use the recovery date as reference. The maps of bluefin tuna displacements using conventional tags data are shown on **Figure 15.** A separate plot was extracted for the conventional tags deployed by ICCAT GBYP, as shown on **Figure 16.**

Regarding the displacement of bluefin tuna obtained via electronic tags, 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 17**), where the second tag (conventional spaghetti) was recovered and reported to GBYP.

As concerns the electronic tags (minPATs) deployed within the framework of the GBYP in the period 2011-2015, a summary of all daily geolocation estimates are shown in the **Figure 18** and their basic analysis is already provided on the paper SCRS/2016/138. Tag trajectories revealed some very interesting bluefin tuna movements and migration paths. A tuna that was tagged in May 2012 in Morocco entered the Mediterranean and went to Tyrrhenian Sea in June where it probably spawned, exited the Mediterranean afterwards and headed north towards Norway, where its tag finally popped up after 93 days (**Figure 19**). The other bluefin that was tagged in Morocco in May 2013 also entered into the Mediterranean Sea going to the southern Tyrrhenian Sea in June, but after exiting the Mediterranean headed east, towards Newfoundland (**Figure 20**). In the 2015, we were able to recover data from 2 tags deployed on the very end of May on adults in Eastern Mediterranean (Levantine Sea), that stayed attached long enough to witness these tuna entering the Atlantic at the beginning of July and heading northwards. One tuna got it tag detached after 50 days off Galicia (**Figure 21**) and the other reached the Faroe Islands and then after 82 days its tag pin broke (**Figure 22**).

The independent review of the GBYP tagging programme carried out in the Phase 5 recognises the recovery of about 180 datasets from electronic tags as one of the GBYP tagging programme key achievements, because that provide evidence of the complexity and diversity of bluefin movements and behaviour within the Mediterranean and eastern Atlantic.

5.8 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 RACs concerned; the coverage was complete in the ICCAT Convention area, including also non-ICCAT countries and entities fishing in the area. The map clearly shows the distribution effort (**Figure 23**). 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 (except in 2016 because it was not authorised) to the training of ICCAT ROPs, with a specific focus on tag awareness and tag recovery, but also for having reports of any natural tag in bluefin tuna harvested in farms.

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.

In the Phase 6, a call for tenders was released for producing a short video propaganda on ICCAT GBYP tagging activities, specially focusing on its contribution to the scientific knowledge, the sustainability of fisheries and the available rewards. The contract was awarded to the audio-visual producer company MALVALANDA from Spain, for developing a short 5 minutes documentary and a shorter 50 seconds video spot. The videos will be presented a the SCRS meeting in September 2016. It is envisaged to develop the ICCAT GBYP bluefin tuna tagging visibility campaign and use these video materials for this purpose, by distributing them to main TV stations and other media in Mediterranean CPCs. The videos will be translated in all main languages.

5.9 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 new strategy includes the following rewards: spaghetti tag 50€/ or a T-shirt; electronic tag 1000 €; annual ICCAT GBYP lottery (September): 1000 € for the first tag drawn and 500 € each for the 2nd and 3rd tag drawn.

According to the first data, this policy (along with the strong tag awareness activity) was very useful for considerably improving the tag reporting compared to previous times.

5.10 Tag recovery and tag reporting

This activity is the final result of the activities listed in previous points. 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 ROPs.

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 nil, because fishermen sold their quota to other fisheries. Furthermore, the institutional GBYP conventional tagging campaign was suspended in Phase 5 and 6.

Since the first year of the GBYP and up to September 19, 2016, there have been 447 tags recovered by GBYP. The GBYP recoveries are summarized as follow:

- 275 Conventional “Spaghetti” tags (61.5% of the total)
- 133 Conventional “Double-barb” (two types) tags (29.8% of the total)
- 23 External Electronic “mini-PATs” tags (5.1% of the total)
- 11 Internal Electronic “Archivals” tags (2.5% of the total)
- 1 Acoustic tag (0.2% of the total)
- 4 Commercial “Trade” bluefin tuna tag (0.9% of the total)

The distribution of tag recovered by area and fishery[10] is shown on **Table 15** and **Table 16**.

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 70 tags, of various types (52 single-barb spaghetti, 13 double-barb spaghetti, 4 internal and 1 acoustic), while 22 were recovered from purse-seiners (14 single-barb spaghetti, 6 double-barb spaghetti, 1 PSAT and 1 internal). Even considering that most of the last conventional tagging activities were targeting juveniles, the recovery and reporting rate is unrealistically too low (15.66% of the total reported tags for the farms and 4.92% for the purse-seiners). The same conclusions can be stated for the traps, because they have reported only 8 tags to ICCAT within the period taken into account (4 single-barb spaghetti, 2 double-barb spaghetti, 2 internal archival). Even in this case, the recovery and reporting rate (1.79% 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 (37 tags in total, 24 single-barb spaghetti, 11 double-barb spaghetti and 2 internal, equal to 8.28% 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).

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 24**): 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 68.8 tags per year. 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. In the year 2016, up to the September 19, 53 tags have been recovered. 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 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.

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 1.74%, 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.

[10] 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).

Interesting information is slowly coming from the double tagged tunas (**Table 18**): up to September 19, 2016, tags were recovered from 126 double tagged fish and both tags have been recovered from 88 fish (69.84% of the double tagged fish recoveries). 20 fish had only the billfish (double-barb) tag on, while other 18 fish had only the single barb spaghetti on. According to these first data, it seems that both types of tags (single barb and double barb) are more or less equally resistant. The tag recovery rate for all double tagged fish by GBYP is currently 1.38%.

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.

5.11 Close-kin genetic 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 (Close Kin Mark Recapture, CKMR). It is a new approach to estimate SSB abundance and other important population parameters that is currently applied for some fish species (including sharks), some marine mammals species, for the southern Bluefin tuna and that will be applied also for the Pacific Bluefin tuna. CKMR uses information on the frequency and distribution in space and time of closely genetically related individuals in samples of tissue from live or dead animals.

The application of CKMR model to the southern Bluefin tuna was relatively simple, given the fact that it is a single population with only one known spawning ground and one main area for the distribution of juveniles. On the contrary, possible application of the method to the Atlantic bluefin tuna is rather challenging, given the variable rate of mixing of the east and west population throughout the Atlantic Ocean, a series of uncertainties regarding bluefin biological background and a complex logistic/operational environment. One of the main assumptions for the application of this method is to have enough number of high quality samples of both spawning adults and juveniles, obtained from strategically distributed sampling locations and surely from the main spawning areas.

For the purpose of obtaining the advice on close-kin tagging and a feasibility study, at the last part of the Phase 5, a call for tenders was released and the contract was awarded to The Commonwealth Scientific and Industrial Research Organisation (CSIRO) from Australia. Due to the important delay linked to 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 of the feasibility study to be done during Phase 5 and, depending to the availability of funds, the possible follow up which would be done in Phase 6. Given the fact that CSIRO provided its report with considerable delay and with some problems in the contents, the Steering Committee decided to refine the report and organize a workshop for specialist in genetics in Phase 6, before going on with the second part of the CKMR feasibility study in Phase 7.

The report made by CSIRO considers 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 within 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.

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 (from a maximum CV 0.29 for 4,000 samples per year for 3 years to a minimum CV 0.05 for 20,000 samples per year for 5 years). 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 (considering 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 that we based the calculations on, and from (ii) other assumptions (e.g. about mixing proportions) that will needed to be made in order to explore possible designs. Sample sizes can be adjusted as the study goes on and knowledge accumulates, 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).

The costs, estimated on the current cost levels for SBT, were assessed by the study at about 200,000 to 300,000 euro/year, but these costs are considered too much optimistic by GBYP, given the current level of costs just for the sampling. Given that it was not possible for the contractor to provide a realistic costing for the CKMR study at this primary stage, the GBYP Steering Committee decided to start collecting the necessary samples for practically testing the feasibility and real costs for carrying out a CKMR study for EBFT. An enhanced sampling was done within the Biological studies for both juveniles and adults in major spawning areas[11], also for testing the problems and not only the real costs. These activities are described in detail under point 6 of this paper. Additionally, for the purpose of interchange of the knowledge and technics on BFT genetics, especially having in mind recent discoveries in the field which might somehow reduce the costs of samples analyses, a workshop on CKMR is going to be held in Madrid in February 2017. It is planned that it will be attended by the experts in genetics who have previous experience in analysing BFT samples within the GBYP and the ones that have experience on analysing genetic for the purpose of southern bluefin CKMR.

6. Biological and Genetic Sampling and Analyses

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 47.73% of funding (2,076,261 euro), the ICCAT GBYP collected samples from 9183 fish up to Phase 5, while additional 2,676 fish should be sampled in Phase 6, bringing the total to 11,859 fish, equal to 98.8% of the initial target; furthermore the GBYP carried out aging, aging calibration, 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 the first part of Phase 5 concerning the biological sampling and analyses have been already preliminary presented to SCRS and the Commission in 2015.

6.1 Objectives

The main objective of this task was originally 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. In particular, objective was pursuing the work to better 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 explore any sub-population hypothesis, which may require several years of data and many analyses, depending on the available budget.

GBYP activities in Phase 5 were 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, 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 now is 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 Calls for tenders. A first contract was awarded to a large Consortium headed by AZTI (SP), including 14 entities and 7 subcontractors, belonging to 8 different countries, for both sampling and

[11] The current real costs for sampling 2,575 bluefin tuna (both spawners and YOY) in 2016 is 292,560 euro.

biological studies, while the second contract, limited to sampling in two areas, was awarded to Necton Soc. Coop. a r.l. (IT). Unfortunately, it was not possible to contract a new aging calibration in Phase 5, because the bid was considered not satisfactory. The samples collected during Phase 5 are shown on the **Table 19**. Phase 5 reports are available on http://www.iccat.int/GBYP/en/biostu.htm

In the Phase 6, according to the decisions of the Steering Committee, biological studies were planned mainly as the continuation of the activities already started in earlier phases. Sampling was extended to areas and fisheries not covered or poorly covered in previous Phases, according to the ICCAT GBYP sampling design. A particular attention was devoted to the collection of otoliths and to aging studies with the objective of developing an updated ALK and otolith collection was made mandatory in all contracts. Furthermore, a specific activity was dedicated to compare, for the first time, single nucleotide polymorphisms (SNPs) analyses and microsatellites analyses, using the same samples. At the same time, funds were devoted for carrying out a larger number of analyses and use most of the samples already collected in previous Phases. A contract for biological studies in Phase 6 was awarded to the Consortium headed by AZTI (SP), having 14 partners and 4 subcontractors, belonging to 11 different countries. Given a delay in rewarding the contract and start of work, the results of biological studies will be presented in latter stages of Phase 6.

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 on 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; several samples cannot be assigned to any of the two stock in a variable proportion depending on area and year and this should find additional explanations (**Figure 25**). 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.

In addition, 1,371 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 26**). 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 depending on the year), 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.

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 27** 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.

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 28**).

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.

The trace element analysis was carried out on Li, Mg, Mn, Fe, Cu, Zn, Sr and Ba (**Figure 29**). 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 30** and **Figure 31**.

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, if the analyses are related to a sufficient number of samples balanced among the various areas, 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 any genetic structuring within the Mediterranean (**Figure 32**). The result is consistent whatever set of parameters is used (M=2/n=3 or M=4/n=6) and they are in agreement with the analyses carried out in previous GBYP Phases. Interestingly, when removing PCR clones, the differences between the Mediterranean and the North-West Atlantic are not as obvious in the structure plots (**Figure 33**), 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. 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 Sea.

[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.

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.

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 the Strait of 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 their 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 contradiction indicates that otolith shape is more influenced by the environmental history than the 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 only. 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.

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 the 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 both the proposals 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 34** and **Figure 35**. Likewise an ALK by calcified structure was built (**Table 24**) and the average size and its variation by age were examined (**Figure 36**).

In Phase 6, the Steering Committee recommended an additional aging effort for 2,000 otoliths already collected in previous GBYP Phases, under the condition to use these otoliths preserving them for additional micro-chemical studies. The results of these additional age readings should have been available for the SCRS Bluefin Tuna Species Group at the Bluefin Data Preparatory meeting in 2017. A Call for tenders was issued in August 2016, but no bids were submitted. It is possible that a more limited additional aging will be proposed on a complimentary basis in the last part of Phase 6 by the Canadian institution.

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 updated strata that were provided by the ICCAT GBYP Steering Committee, were not used as requested 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 it is continously being updated. Analysis of the integrated database revealed that overall the 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), mostly when otolith shape is used as discriminant. 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 for ensuring the collection of otoliths and tissues from the same fish and representatives 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, while the fact that the Black Sea is excluded as a spawning area simplified some other 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 Sampling for adult in the spawning areas

In GBYP Phase 5, the Steering Committee recommended to initiate the feasibility study for the close-kin genetic tagging, a new methodology that can be useful for a fishery-independent assessment of bluefin tuna population. One of the key points for going on with this approach is assessing the feasibility of a large sampling for both adults and young-of-the-year bluefin tunas. While YOY were sufficiently sampled in some areas in previous ICCAT GBYP Phases, sampling of bluefin tuna adults were always much more problematic for various reasons. This fact also prevented the development of an annual ALK. Furthermore, the close-kin genetic tagging needs a large amounts of samples collected from bluefin tuna fished during the spawning season in the main spawning areas; in the Mediterranean Sea, these fish are currently going to farms for fattening in the last years.

Therefore, as recommended by the Steering Committee, it was necessary to assess the feasibility of carrying out the sampling activity for adults fished in the main spawning areas during the spawning season, when they are harvested in farms. This activity can be carried out only by the same farms, with a dedicated in-home organization which will follow the same GBYP protocols adopted in the Biological Studies. After a series of preliminary contacts with all bluefin tuna farms in the Mediterranean Sea, ICCAT GBYP received several good-will availability for initiating this work.

An invitation for submitting a proposal for carrying out the sampling of adult bluefin tuna was sent to the entities managing bluefin tuna farms in Spain, Malta and Turkey and there was a positive response from Spain and Malta while no offers were received from Turkey for carrying out sampling in the Levantine Sea, even if the invitation was send also to the Turkish authorities as request. Three contracts were issued for this additional sampling: for the Balearic Sea, the contracts were provided to Balfegó & Balfegó S.L. (SP) and to a Consortium headed by Taxon Estudios Ambientales S.L. (SP), while a contract was provided to a Consortium headed by Aquabiotech

Ltd. (ML) for the southern Tyrrhenian Sea and the central-southern Mediterranean Sea; a minimum of 300 adult fish will be sampled by area (otoliths, spines and muscle). As concerns the Levantine Sea, the sampling for both adults and juveniles was included in the general contract for Biological Studies, within the Consortium's activities.

6.4 Larval studies

Larval surveys were included in the preliminary list of GBYP research activities recommended by the SCRS at the early beginning of the GBYP approval process, even if with a low priority. Later on, the Commission excluded any larval survey from the programme, even if the first discussion on the budget included the larval studies for three years. The exclusion was shared also by the GBYP Steering Committee.

Studies carried out during past years on early life stages of top predators species, as tunas, have been shown to be useful in understanding the population dynamics of harvested stocks. This reflects the hypothesis that early life dynamics is one of the main drivers influencing population fluctuations.

This information has been incorporated in stock assessment, particularly as relative abundance indices of the spawning stock. There is the potential for scientists to contribute additional indices and data streams that could contribute to stock assessments, such as larval survival index; spawning and larval habitat quality predictions; population genetic structure, abundance estimates and stock mixing (through kinship analysis).

Under the context of ecosystem-based fisheries management, early life history studies can provide understanding of the structure and trophodynamics of plankton assemblages and sources of environmental variability that can feed into ecosystem models. They can also provide indicators of the plankton assemblages that are relevant for ecosystem-based fisheries management and the effects of climate change, if sufficient data about all main components can be provided.

Pursuant to the recommendation of the Steering Committee and the ICCAT SCRS in 2015, GBYP in the Phase 6 organized a dedicated Workshop on larval studies and surveys. The workshop was held in ICCAT headquarters in Madrid, on 12-14 September 2016 and was attended by around 20 eminent scientists in bluefin tuna larval biology from EU, USA and Japan.

During the workshop, a review of the available knowledge on the bluefin tuna early stages was presented, for both Mediterranean Sea and the Gulf of Mexico, along with the results from the latest studies. Current and recent research project were presented and the sampling methodologies that were followed during each study were discussed in detail, as well as common problems that were encountered. A special attention was put on the spawning and larval habitat, as well as environmental dependencies. The difficulties for morphologically identifying bluefin tuna larvae were deeply discussed, even if some doubts are still to be solved according to some scientists, while there are no doubts when it is possible to have a genetic analysis. The progress and limits in using the larval index was also discussed, as well as its potential use as an abundance index for the purpose of the bluefin tuna stock assessment. The GBYP presented an overview of potential research needs and opportunities for the larval surveys (see document SCRS/2016/176).

The participants also discussed the possibilities for carrying out a joint larval study, with standardised methodology on all spawning grounds in the Mediterranean. It might also provide information on early stages of ICCAT species other than bluefin tuna and therefore contribute to the assessment of different stocks. Terms of reference of the future larval survey working group was drafted, identifying the goals and initial work plan, with the intention for it to be presented in the SCRS meeting and therefore available to different species working groups. The report is available on SCRS/2016/206.

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 88.1% of the funds (a total of 528,853 Euros, including the budget amount set for Phase 6, equal to 194,000 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

In the Phase 6, a follow up contract was released to the Expert MSE Technical Assistant only, while the contract for the modelling coordinator was suspended.

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 obviously included in GBYP Phase 5 activities and the report is available on http://www.iccat.int/GBYP/Documents/MODELLING/PHASE%205/MODELLING_GROUP_PHASE5_SECOND_MEETING_REPORT.pdf .

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 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 Group on May 2015. A modelling MSE report was discussed at the SCRS Bluefin tuna Species Group in 2015. 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. All the reports concerning the ICCAT GBYP Modelling and MSE activities are available on http://www.iccat.int/GBYP/en/modelling.htm

In the Phase 6, a contract for the MSE Coordinator was suspended by the Steering Committee.

7.2.2 Modelling 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 modelers.

Several papers and documents have been produced by the MSE technical assistance in Phase 5, along with three interim reports. Most of the papers are concerning the use of data and the operating data development. All documents are available on the ICCAT GBYP web pages. 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 have already been provided.

7.3 Phase 6 activities for modelling in support of BFT stock assessment

Activities in the beginning of the Phase 6 were mainly continuation of the work already started in the previous phases. A follow up contract for the MSE technical assistant was provided to the Dr. Tom Carruthers, the same expert who initiated the work, for developing the Operating Model and MSE framework and related code. According to the recommendation of the Steering Committee, a contract for the MSE coordinator was suspended, given its low priority in this Phase.

An ICCAT GBYP multi-annual modelling work plan was proposed at the Monterey CMG meeting, based on the conclusions of the Gloucester meeting. A main objective of MSE is to provide advice that is robust to uncertainty, and requires a number of steps:

1. Identification of management objectives and mapping these into statistical indicators of performance or utility functions;
2. Selection of hypotheses for considering in the Operating Model (OM) that represents the simulated versions of reality;
3. Conditioning of the OM based on data and knowledge, and weighting of model hypotheses depending on their plausibility;
4. Identifying candidate management strategies and coding these as Management Plans;
5. Projecting the OM forward in time using the MPs as a feedback control in order to simulate the long-term impact of management (Ramaprasad, 1983); and
6. Identifying the Management Plan that robustly meet management objectives.

These steps require the engagement of stakeholders to evaluate alternative management actions and the risks of not meeting management objectives. An OM (a mathematical simulation model) has to be coded up to allow the consequences of the improvement of knowledge, collection of data and implementation of management measures to be evaluated.

This requires the OM to be implemented in software. Therefore under previous phases of the GBYP M3 a prototype OM has been implemented and is available in the software repository https://github.com/ICCAT/abft-mse. This will allow multiple developers to collaborate on its development. In addition a manual has been provided which will form the basis of a Software Development Plan (SDP) for future development.

The next stage in the development of the OM requires test units to be developed to ensure that the code is fit for use. In particular, to ensure that resource dynamics in the OM are implemented as agreed by Bluefin WG and the Core Modelling Group (CMG). This requires that the individual source code procedures and modules together with associated control data, usage procedures, and operating procedures, can be tested. This will also help to avoid errors when the code is revised, and when collaboration involves multiple developers.

The objectives for the activities in GBYP Phase 6 are the following:
1. Continue the development of the Operational Model (OM) based on the Management Strategy Evaluation (MSE) trial specifications document.
2. Develop a test unit to validate the age-based movement model.
3. Work with third parties to add Management Plans (MPs) to the MSE framework including empirical control rules and simple stock assessment methods
4. Run the MSE in collaboration with BFT Species group.
5. Collaborate with SCRS to develop interactive graphics (i.e. Shiny apps) to communicate MSE results to stakeholders based on the performance metrics of the trial specifications document.
6. Work with others to update and maintain the meta database of the available bluefin data and knowledge https://github.com/ICCAT/GBYP-MetaDB
7. Work with SCRS to help develop 3 prototype examples.

During the BFT Data Preparatory Meeting in July 2016, the progress of simulation testing a multi-stock model with age-based movement was presented as a paper SCRS/2016/144. The issues arising from the preliminary conditioning of operating models for BFT were presented as well, and are available as SCRS/2016/145.

7.3.1 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) in the last three years, taking into account the two GBYP Core Modelling and MSE Coordinators, the new SCRS Chair and the new WBFT rapporteur. The Group in Phase 6 has the following members: Tom Carruthers (expert and MSE Technical Assistant), Polina Levontin, Richard Hillary, Toshihide Kitakado, Haritz Arrizabalaga, Doug Butterworth and *ex-oficio* members: David Die (SCRS Chair), Clay Porch (ABFT Chair), Gary Melvin (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).

A third meeting of the ICCAT GBYP Core Modelling and MSE Group is planned in the second part of GBYP Phase 6, possibly in Madrid and back-to-back with the Tuna RFMOs Meting on MSE.

8. Discussion about the fishery-independent indices and estimates

Following the various activities carried out so far in the 6 Phases of the GBYP, it seems necessary that the following Phases it be more focused in finally get one or more bluefin tuna fishery-independent indices (relative SSB or larval) and/or a fishery-independent estimate of the SSB (CKMR).

The selection made in Phase 1 for the main bluefin tuna spawning areas in the Mediterranean Sea, that was immediately used for defining the main areas for the first GBYP aerial survey for spawners, was based on the accumulated scientific knowledge over the last decades and the more recent strategies adopted by the tuna purse-seiners fishing for spawners derived from the accurate analysis of the VMS data in the three previous years.

This selection of areas is now further confirmed by the results obtained during the four GBYP aerial surveys (**Figure 37** and **Figure 38**), where a substantial majority of the cumulative sightings are concentrated exactly in these four areas, while sightings outside these areas are very few. Even taking into account the different coverage of the areas, this is a clear confirmation of the validity of the initial spawning area identification. Furthermore, after the analyses of the data obtained from the miniPATs deployed by GBYP in the last years, it was possibly to select the cumulative tracks related to the bluefin tuna in the months of May, June and July, when spawning usually and mainly occur. The tracks (**Figure 39**) confirm the relevance of the four main spawning areas. These tracks also reveal minor bluefin tuna displacements in other areas outside the Mediterranean Sea during the spawning period. These areas are those in the Atlantic part of the Strait of Gibraltar, in the area between SW Morocco and the Canary Islands, in the northern part of the Madeira Islands and around the Azores, already put into evidence by Mather *et al*. (1995), by Piccinetti *et al.* (2013) and by GBYP as additional and opportunistic spawning areas, but for which evidences are still not fully available.

The consistency of the four main spawning areas in the Mediterranean Sea provides a solid background for planning future activities for getting fishery-independent indices or SSB estimates.

At the moment, there are three potential candidates, the aerial survey for spawning aggregations (for minimum relative SSB trends), larval surveys (for larval indices) and CKMR (for SSB estimate), which could be possible alternatives, carrying out one and not the others or that could be tested in parallel (i.e.: Aerial survey and CKMR or larval survey and CKMR or even aerial survey and larval survey).

Being this a very important issue for the future steps of GBYP and considering the original choice made by the Commission (also confirmed in 2013), it would be necessary to get the SCRS opinion about the possible choice, because the choice will imply different level of costs and partly even different time needs. Of course the choice for the most adequate fishery-independent index (aerial survey or larval survey) or estimate (CKMR) would be mostly based on scientific motivations.

GBYP suppose that it is useful to provide a summary table of the main components for each fishery-independent product which might be helpful for taking a decision (**Table 25**).

9. 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, finally 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. The third circular (no. 2180/2014) was issued on 23 April 2014, with a list of 36 authorised entities. The forth circular (no. 3203/2015) was issued on 26 May 2015, with a list of 32 entities. The sixth circular (G-0745/2016) was issued on 10 June 2016, with the list of 20 entities and another circular will be issued for covering all activities in the second part of GBYP Phase 6.

A total of 231 ICCAT GBYP RMA certificates have been issued from 2012 to September 2016, using 11,087.79 kg of bluefin tuna (equal to 1368 fish). 64 RMA certificates were issues in Phase 5, using a total of 343.56 kg corresponding to 328 fish and 2 certificates have been issued in Phase 6, corresponding to 424.2 kg and 3 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 (see document SCRS/2015/145 and the GBYP summary presentation to the SCRS Subcomstat in 2016).

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.

10. Cooperation with the 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 regularly participating to the ICCAT ROP observers training courses up to 2015, 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.

11. Steering Committee Meetings

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. Gary Melvin (who replaced Ph.D. Youkio Takeuchi from April 2016), 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.

The changes in the SC members, which are logical according to the current institutional components, sometimes created different views for some GBYP activities and some problems in its effectiveness were noticed. 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 three last Steering Committee meetings reports.

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 is regularly 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 Steering Committee held a meeting after the SCRS Bluefin Tuna Species Group (26 September 2015) with the objective, among others, to propose a plan for Phase 6. The first meeting in the Phase 6 was held on 30-31 July 2016, discussing various aspects of the programme, providing guidance and opinions and deeply revising the activity for Phase 6. All finalised reports of the GBYP Steering Committee meetings are available on http://www.iccat.int/GBYP/en/scommittee.htm .

12. 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 six Phases, GBYP received and used only 62.22% of the funds originally approved for the same time period (11,869,782 euro[13] against 19,075,000 euro).

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

European Union (grant agreement)	Euro	1,620,430.32
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

In Phase 6, the budget had the following funders (in order of contribution already received):

European Union (grant agreement)[14]	Euro	1,190,000.00
United States of America (donation)	Euro	111,348.65
Japan (donation)	Euro	62,860.40

[13] For Phase 6, due on-going activities, the amount is based on the budget.
[14] The amount represents the anticipation received, over a total EU contribution of 1,700,000 euro.

Tunisia (donation according to quota)	Euro	58,336.51
Turkey (donation according to quota)	Euro	57,138.43
Libya (donation according to quota)	Euro	54,068.52
Kingdom of Morocco (donation)	Euro	53,324.00
Norway (donation)	Euro	20,000.00
Canada (service agreement)*	Euro	18,894.52
Albania (donation according to quota)	Euro	5,143.59
Korea (donation according to quota)	Euro	4.442.65
Chinese Taipei (donation)	Euro	3,000.00
Popular Republic of China (donation according to quota)	Euro	2,106.80
Iceland (donation according to quota)	Euro	1,708.54

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 the various Phases. 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 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[15]), 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).

[15] 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.

- ✓ 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).
- ✓ 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.
- ✓ 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).
- ✓ 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, and 4).
- ✓ 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).
- ✓ Lutcavage Molly, Ph.D.,Scool of Environment, University of Massachusetts (USA), donation of data from 697 e-tags; estimated value not defined (for GBYP Modelling in Phase 6).
- ✓ 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).
- ✓ UNIMAR, Rome (IT), donation of data sets from 9 e-tags (for GBYP Modelling in Phase 5).
- ✓ 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). Donation in kind of 6 miniPATs and 2 experimental e-tags; estimated value 40,000 euro (for tagging in the Strait of Messina in Phase 6).
- ✓ GBYP Coordinator, donation of many thousands of old catch data; estimated value not defined (Phases 3, 4 and 5).

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

13. GBYP web page

The ICCAT-GBYP web page, which was created in the last part of Phase 1, 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 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.

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

GBYP STAFF		2010	2011	2012	2013	2014	2015	2016
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 M A M J J A S O N D
Antonio DI NATALE	coordinator							
M'Hamed IDRISSI	assistant							
Ana JUSTEL RUBIO	data expert							
Stasa TENSEK	assistant							
Alfonso PAGÁ GARCÍA	data expert							

Table 2. Total data recovered by GBYP from Phase 1 to Phase 5. The additional data provided in Phase 6 are still to be checked and were not included.

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).

TOTAL PHASES 1 to 5																			
DATA TYPE	Year / source	<1500	1500	1600	1700	1800	1900	1910	1920	1930	1950	1960	1970	1980	1990	2000	2010	TBFA	DTBV
# 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.

Table 4. Additional trap data recovered in the last part of Phase 4, which were checked in Phase 5 and 6 and finally incorporated in the ICCAT BFT data base in Phase 6. 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	*First year*	*Last year*
Italy	1595	1997
Morocco	1916	1973
Portugal	1797	1933
Spain	1525	1980
Tunisia	1863	1997

Table 6. Data recovered in Phase 6 from Italian longliners (LL) and traps (TRAP).

Fishing period	*Gear*	*Fishing area*	*BFT total catch n*	*BFT total catch kg*	*BFT Samples (FL and/or weight)*	*No. of vessels*
2002-2015	LL	Adriatic Sea	1952	92310.4	1952	3
2002-2015	LL	Strait of Sicily	2417	112875	2417	22
2002-2015	LL	Tyrrhenian Sea	6690	340964.5	6690	6
2013-2015	LL	Sardinia	11	1097.1		1
1823-1836	TRAP	Marzamemi	1638	44099		
1918-1922	TRAP	Scopello		366220		
1918-1922	TRAP	Castellammare del Golfo		195700		
1918-1922	TRAP	Magazzinazzi		626900		
1920-1922	TRAP	Orsa	556	10700		
1922	TRAP	Isola delle Femmine		21900		
1922	TRAP	Mondello		64300		
1920-1922	TRAP	Vergine Maria		7077		
1918-1922	TRAP	S. Elia		267900		
1918-1922	TRAP	Solanto		463600		
1918-1922	TRAP	S. Nicolò		173500		
1918-1922	TRAP	Trabia		297700		
1920-1922	TRAP	Torre Caldura		14500		

Table 7. Data recovered in Phase 6 in salting and cannery factories from handliners (HAND) and mid-water pelagic trawl (MWT) in the Canary Islands.

Factory Name	Fishing Period	Indeterminated Species (n)	Indeterminated Species (kg)	BFT kg	ALB kg	YFT kg	BET kg	SKJ kg
Casanova	1926-1939	1778	545512					95227
Gran Canaria	1966-1984			5773	263995	720522	9030082	5245444
La Rajita	1926-1984	3873	4766308	20995	1408811	171557	6964369	6380551
Novaro	1931-1934	2204	106748					15366
Santiago	1927-1983	5089	1438805	4878	333435	2875	2302941	2035091
Tenerife	1949-1984		339161	5231	62765	391559	2431410	3869455
Trujillo	1927-1934	1485	269698					70110
TOTAL	1926-1984	**14429**	**7466232**	**36877**	**2069006**	**1286513**	**20728802**	**17711244**

Table 8. 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 9. Mean school size, density and total weight and abundance of bluefin tuna for each "inside" sub-area in 2015.

		Sub-area				
		A	C	E	G	TOTAL
Survey area (km^2)		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 (km^2)		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 (km^2)	**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 km^2)	**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	

Table 10. Mean school size, density and total weight and abundance of bluefin tuna for each “outside” sub-area in 2015.

		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	

Table 11. New assessment of bluefin tuna spawning aggregations in the four main areas (“inside”) for four years, 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

Table 12. 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

Table 13. Details on the number of bluefin tuna tagged with various types of tags in Phase 6 and on the number of the various types of tags implanted in the various areas (updated on 19 September 2016).

Phase 6

	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	3	0	3	0	0	0	0	0	0	0	0	0	0
Bay of Biscay (a)	0	0	0	0	0	0	0	0	0	0	0	0	0
Morocco*	38	0	24	13	0	0	0	1	0	0	0	0	0
Portugal	139	0	28	24	0	0	87	0	0	0	0	0	0
Strait of Gibraltar***	0	0	0	0	0	0	0	0	0	0	0	0	0
West Med. **	0	0	0	0	0	0	0	0	0	0	0	0	0
Central Med. ****	374	0	354	20	0	0	0	0	0	0	0	0	0
East Med.	20	0	0	20	0	0	0	0	0	0	0	0	0
		0	409	77	0	0	87	1	0	0	0	0	0
GRAND TOTAL	574	SUBTOTAL = 486					SUBTOTAL = 88						

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Canada	3	0	3	0	0	0
Bay of Biscay (a)	0	0	0	0	0	0
Morocco*	38	0	24	14	0	0
Portugal	226	0	202	24	0	0
Strait of Gibraltar	0	0	0	0	0	0
West Med. **	0	0	0	0	0	0
Central Med.	374	0	354	20	0	0
East Med.	20	0	0	20	0	0
	661	0	583	78	0	0

Table 14. Details on the number of bluefin tuna tagged with various types of tags in all Phases of GBYP and on the number of the various types of tags implanted in the various areas (updated on 19 September 2016).

All GBYP Phases (2, 3, 4, 5 & 6) (up to 19/09/2016)

	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	298	0	293	0	0	0	0	5	0	0	0	0	0	1,7%
Bay of Biscay (a)	7701	4173	1	3	0	0	3493	18	0	0	13	0	0	42,8%
Morocco*	365	129	48	45	0	0	121	14	0	7	0	0	1	2,0%
Portugal	255	17	213	24	0	0	88	0	0	0	0	0	0	1,4%
Strait of Gibraltar***	5561	2254	43	0	0	0	3212	22	5	0	23	2	0	30,9%
West Med. **	1675	932	358	28	0	0	352	5	0	0	0	0	0	9,3%
Central Med.	2082	773	787	25	0	0	479	7	0	0	12	0	0	11,6%
East Med.	50	0	0	50	0	0	0	0	0	0	0	0	0	0,3%
		8278	1743	175	0	0	7745	71	5	7	48	2	1	
GRAND TOTAL	17987	SUBTOTAL = 10196					SUBTOTAL = 7879							100,0%

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED					
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic	% by area
Canada	303	0	298	5	0	0	1,2%
Bay of Biscay	11225	7697	3494	21	13	0	43,6%
Morocco*	514	258	182	66	0	8	2,0%
Portugal	430	139	267	24	0	0	1,7%
Strait of Gibraltar***	8618	5491	3075	27	25	0	33,5%
West Med. **	2031	1285	713	33	0	0	7,9%
Central Med.	2581	1252	1285	32	12	0	10,0%
East Med.	50	0	0	50	0	0	0,2%
TOTAL	25752	16122	9314	258	50	8	100,0%
%	100%	62,6%	36,2%	1,0%	0,2%	0,0%	

Table 15. Details of tag recovery by area in numbers and percent (updated on 19 September 2016).

Fishing Area / Tags	Spaghetti Tags	Double BarbTags	External Elec. Tags	Internal Elec. Tags	Acoustic Tags	Commercial Tags	Grand Total	%
East Atl	58	31	11	1		1	102	22,82
Med	206	89	8	9	1		313	70,02
North Atl	4	1				2	7	1,57
West Atl	7	12		1		1	21	4,70
Unknown			4				4	0,89
Grand Total	275	133	23	11	1	4	447	100
%ge	61,5%	29,8%	5,1%	2,5%	0,2%	0,9%	100,0%	

Table 16. Details of tag recovery by fishery, in numbers and percent up to 19 September 2016.

Fishery -Gear / Tags	Spaghetti Tags	Double BarbTags	External Elec. Tags	Internal Elec. Tags	Acoustic Tags	Commercial Tags	Grand Total	%
BB	124	67					191	42,73
FARM	52	13		4	1		70	15,66
HAND	12	9	1				22	4,92
LL	24	11		2			37	8,28
LLHB	2	2					4	0,89
NF			13			4	17	3,80
PS	14	6	1	1			22	4,92
RR	8	17		2			27	6,04
SPOR	11	1					12	2,68
TN	1	1					2	0,45
TRAP	4	2		2			8	1,79
TROL	10	3					13	2,91
UNCL	13	1	8				22	4,92
Grand Total	275	133	23	11	1	4	447	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	0,67
2011	8		1				9	2,01
2012	36	7	6	1		1	51	11,41
2013	60	28	9	2		1	100	22,37
2014	72	30	1	3		2	108	24,16
2015	68	46	3	3	1		121	27,07
2016	28	22	1	2			53	11,86
Undefined (2012 or 2013)			2				2	0,45
Grand Total	275	133	23	11	1	4	447	100

Table 18. Detail of the recoveries from double tagged bluefin tunas (GBYP only) (updated on 19 September 2015).

Release	Spaghetti tag only	Double Barb Tag only	Both	TOTAL FISH	TOTAL TAGS	
2011	0	4	5	9	14	
2012	9	7	36	52	88	
2013	9	9	47	65	112	
Total	18	20	88	126	**214**	
%	14,29	15,87	69,84	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	2	35
2013		6	15	17	9	47
2014				1	0	1
TOTAL	6	24	27	20	11	88
%	6,82	27,27	30,68	22,73	12,50	100,00

Table 19. Samples collected and analyses carried out by the Consortium headed by AZTI in GBYP Phase 5, with the target and percentages of achievement. Additional 224 BFTs were sampled under the contract with Necton Soc.Coop. a r.l.

item	*Target no.*	*Achievement no.*	*% of achievement*	*No. considering 10% tolerance*
Bluefin tuna individuals sampled (1)	965	1634	169%	n.a.
Biological & Genetic Sampling (2):				
Genetic samples (muscle/fin)	965	1403	145%	n.a.
Otoliths	965	913	95%	868
Spines	865	615	71%	778
Total biological and genetic samples	*2795*	*2931*	105%	n.a.
Biological & Genetic Analyses (3):				
Otolith chemistry (stable isotopes)	200	286	143%	n.a.
Otolith chemistry - (stable isotopes) - individual	1000	1371	137%	n.a.
Otolith chemistry (trace elements)	120	127	106%	n.a.
Otolith chemistry (combination isotopes-trace elements)	280	229	82%	252
Genetic analyses (RAD-seq)	240	240	100%	n.a.
Genetic analyses (Genotyping SNPs)	192	192	100%	n.a.
Genetic analyses (SNPs panel)	192	0	0%	172
Otolith shape	100	324	324%	n.a.
Age readings (intercalibration)(3 x each)	300	359	120%	n.a.
Total biological and genetic analyses	*2624*	*3128*	119%	n.a.
TOTAL (1+2+3)	6384	7693	121%	n.a.

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

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%

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

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

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			

Table 25. Summary overview of the various options for fishery independent products for EBFT.

OVERVIEW OF FISHERY-INDEPENDENT PRODUCTS OPPORTUNITIES FOR EBFT			
	AERIAL SURVEY FOR SPAWNERS	**LARVAL SURVEY**	**CKMR**
possible output	minimum SSB relative values/trends over the years	larval abundance index over the years	single absolute estimate of stock size
no. years available	4 (2 main, 2 ext.)	8 in three groups	1
min. no. years needed	6 to 10	unknown, maybe 6 to 10	3 to 5 for the first assessment
current coverage	265,626 km^2 and max 1,558,224 km2 for the extended	± 57,700 km2	all spawning areas (spawners and juveniles), 2,325 samples
min. coverage need	265,626 km^2	265,626 km^2	10,000 samples/y
ext. coverage need	more than 1,753,493 km2 (currently 1,558,224 km^2 almost feasible)	more than 1,753,493 km2 (currently 1,558,224 km^2 almost feasible)	10,000 samples/y (30/40,000 in total) min 3 years
current CV	0.33 or 0.55ext	1.4 tot or 0.56 last 3 years for Balearic only	n.a.
expected CV	0.38 min	unknown	from 0.29 (4,000 samples/y for 3 years) to 0.05 (20,000 samples/y for 5 years)
current cost	about 315,000€/y or 499,000/y ext	350,000€/y Balearic	about 293,000€/y only for the sampling, no analysis
expected cost	between 300,000 and 400,000 €/y	1,505,000 €/y	about 2,740,000€/y at the current costfor 10,000 samples/y including analyses; possibly about 780,000€/y with analyses on routine methods but without otoliths and aging
constraints	•impossibility to access some areas for the extended survey; •yearly plan to be adopted max at the end of February; •permits for accessing the airspaces to be required 3 months in advance; •need to use 4 aircrafts (7 for the extended); •impossibility of a full calibration	•impossibility to access some areas for the extended survey; •yearly plan to be adopted max at the end of February; •permits for accessing national waters to be required 3 months in advance; •need to use 4 vessels (tbd for the extended)•calibration?	•impossibility to access some areas for juveniles; •permits to be required 3 months in advance for YOY; •unknown if CKMR can work with 4 spawning areas; •if there are additional opportunistic spawning areas outside the Med this will be an unknown constraint; •calibration?
feasibility	yes for the main areas (already proved), possibly with a very limited calibration if it has any sense; limited extended survey from time to time already tested	possibly yes for the main areas but after a good planning and preliminary agreements with CPCs; limited extended survey from time to time already tested	possibly yes for the main areas but the total minimum number of samples seems very difficult to achieve; getting a reliable ALK it is possible to avoid the otolith sampling and strongly decrease the cost

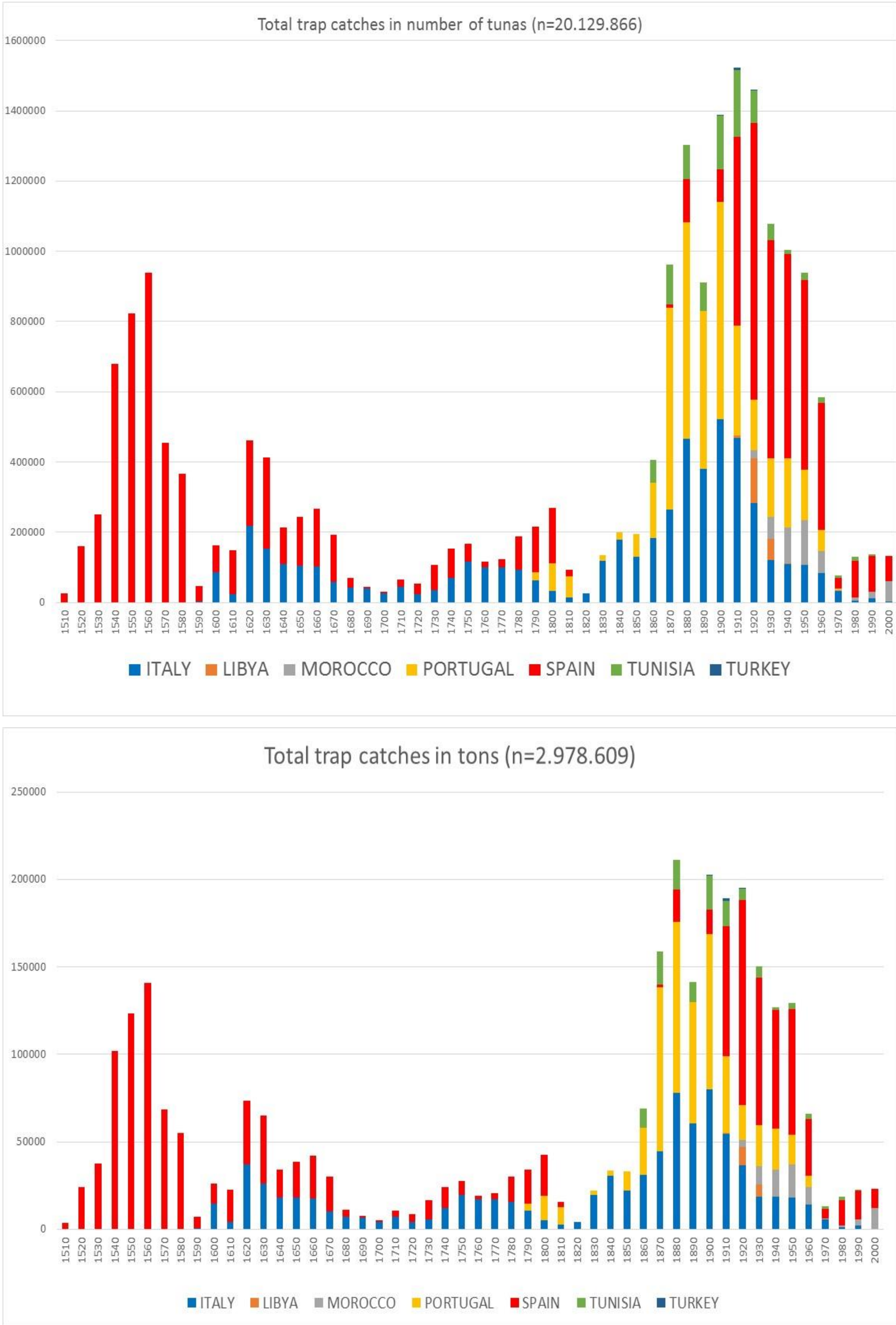

Figure 1. Cumulative bluefin tuna catch data by decade, in number of fish (top) and in weight (tons) (bottom) for the all traps included in the ICCAT GBYP files.

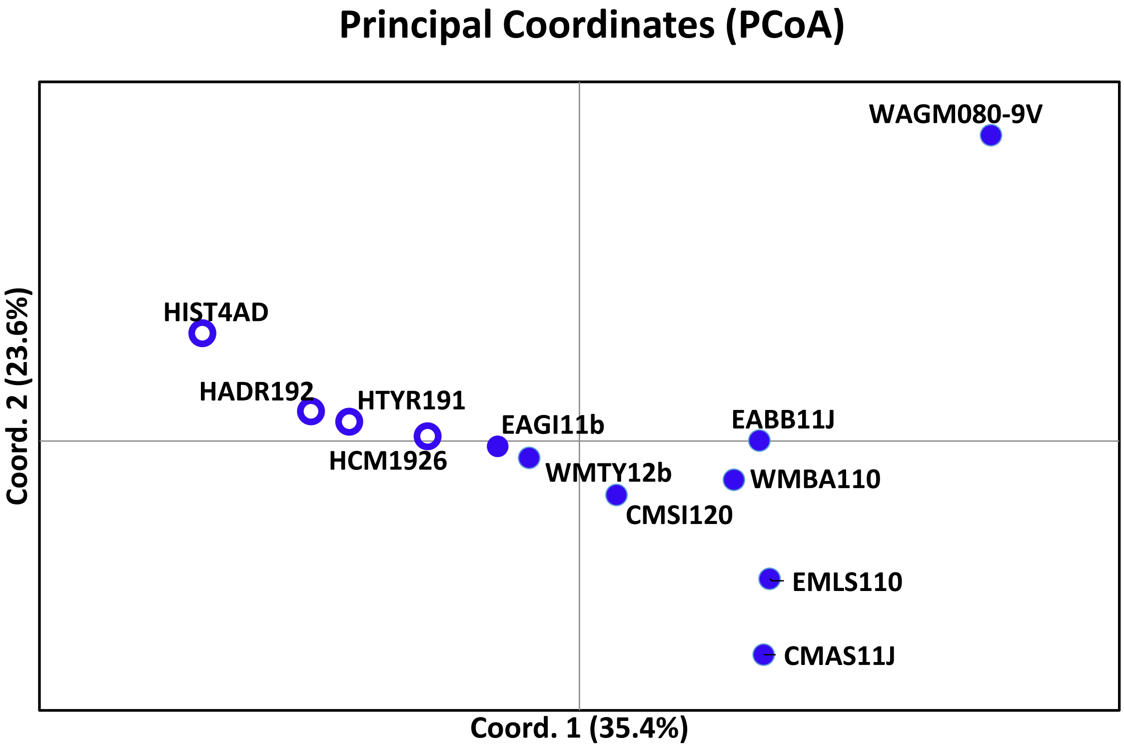

Figure 2. Principal coordinates analysis (PCoA) showing clustering of historical samples and isolation of samples from the Gulf of Mexico and the Levantine and Adriatic Seas.

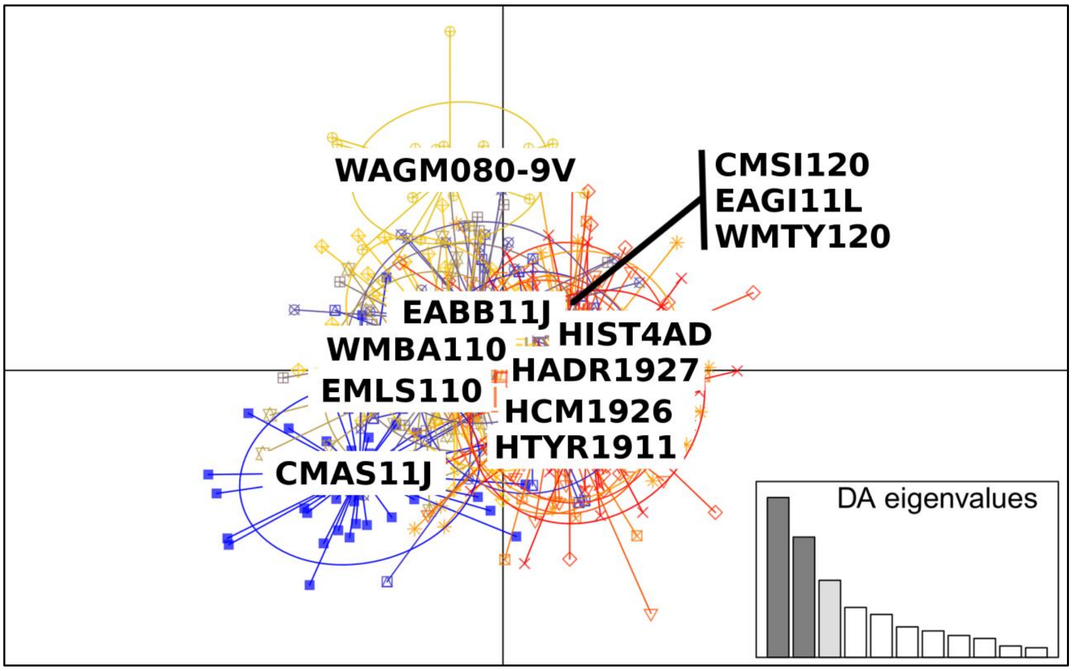

Figure 3. Discriminant analysis showing clustering of historical samples and isolation of samples from the Gulf of Mexico and the Levantine and Adriatic Seas.

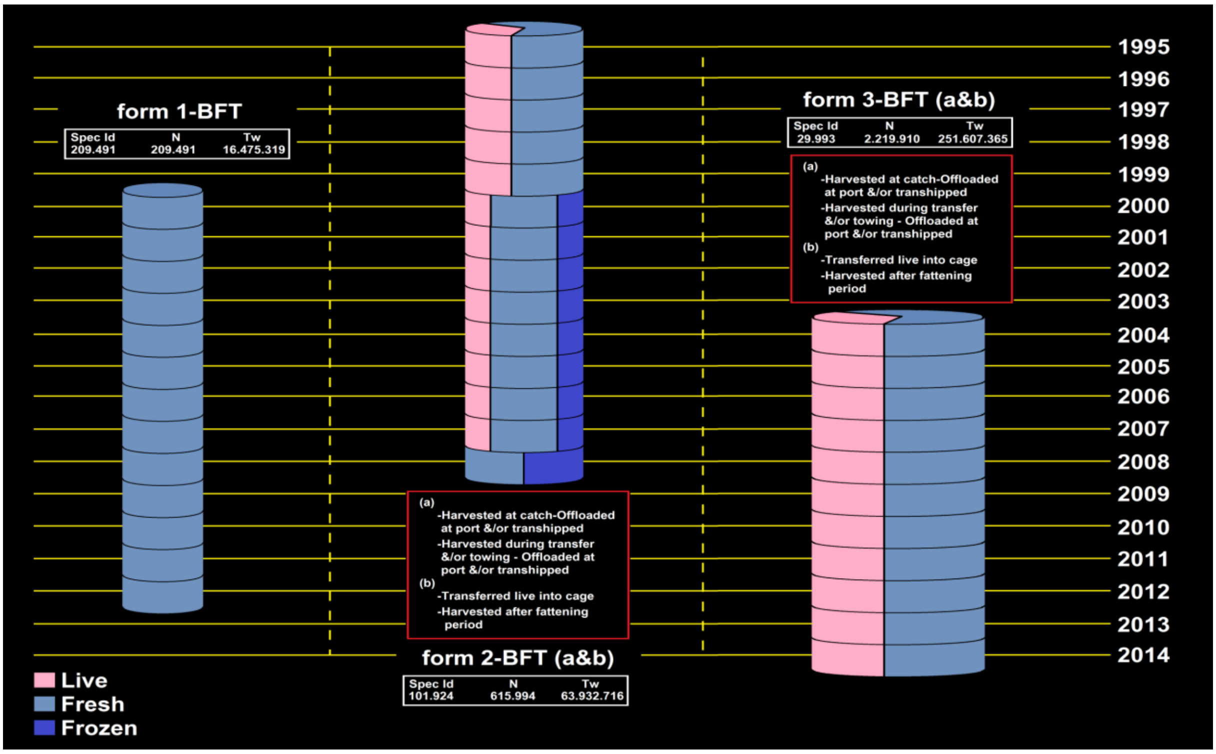

Figure 4. Chronology and structure of trade, auction and marked data (form1, form2 and form3) recovered by GBYP for the period 1995 to 2014. The data that were validated by the SCRS were included in form 1 and 2, but it was decided to use only data coming from fish under certain physical conditions (RW or GGW).

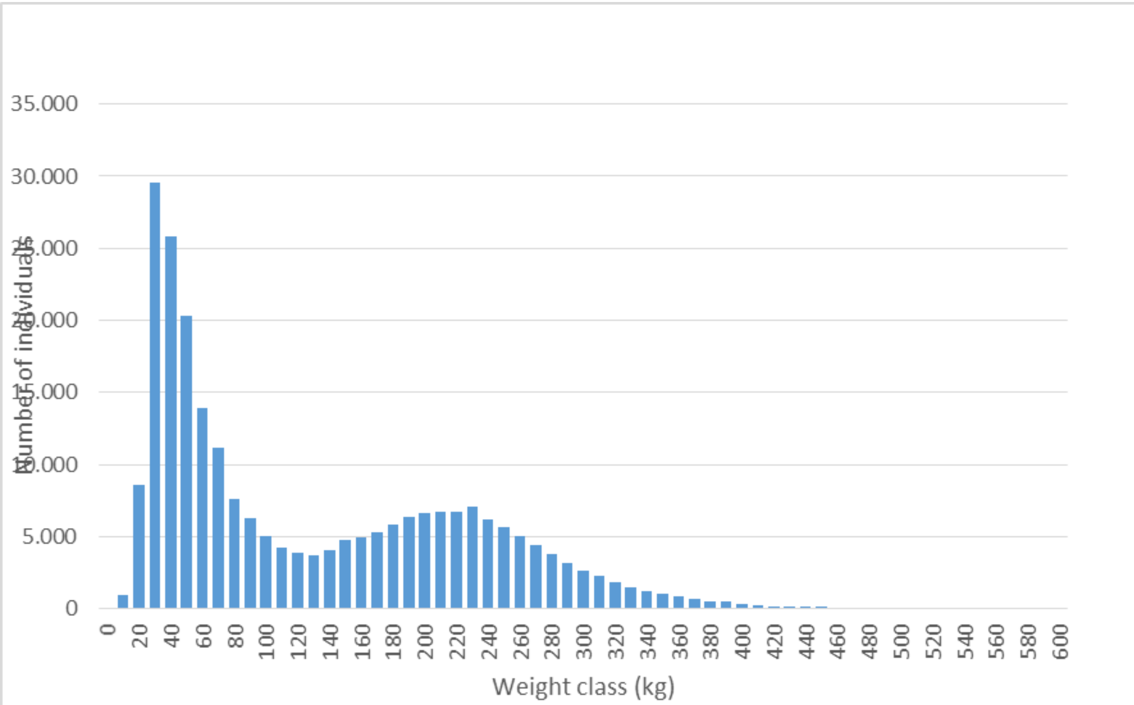

Figure 5. Weight frequencies (total individuals) of both wild and farmed bluefin tuna caught in the Atlantic and in the Mediterranean in the period 1995-2012, from the trade, market and auction files.

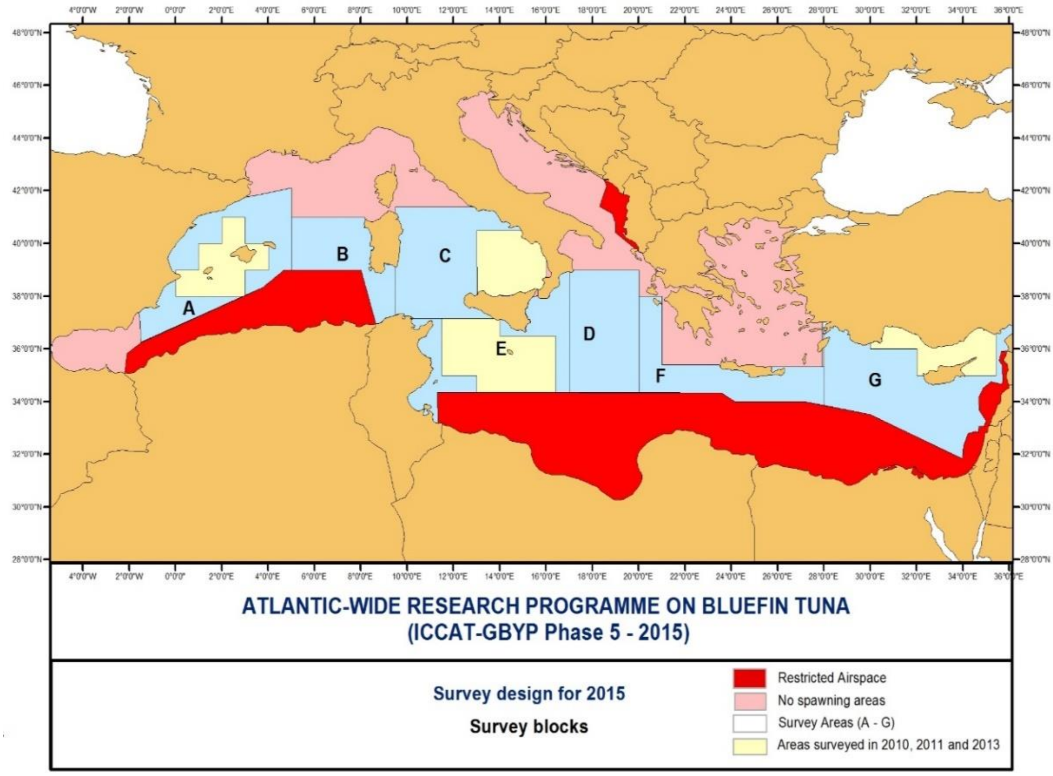

Figure 6. Area blocks identified through the aerial survey design for the purpose of 2015 GBYP aerial survey on spawning aggregations.

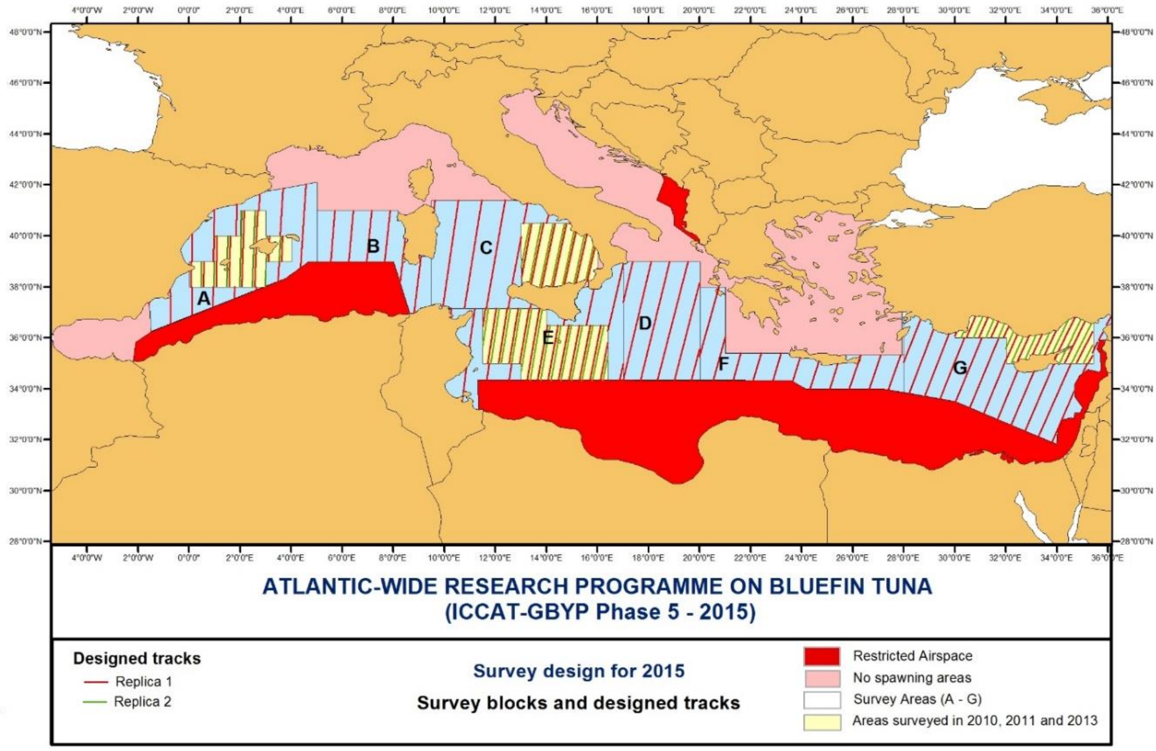

Figure 7. Designed transects for ICCAT GBYP aerial survey in 2015.

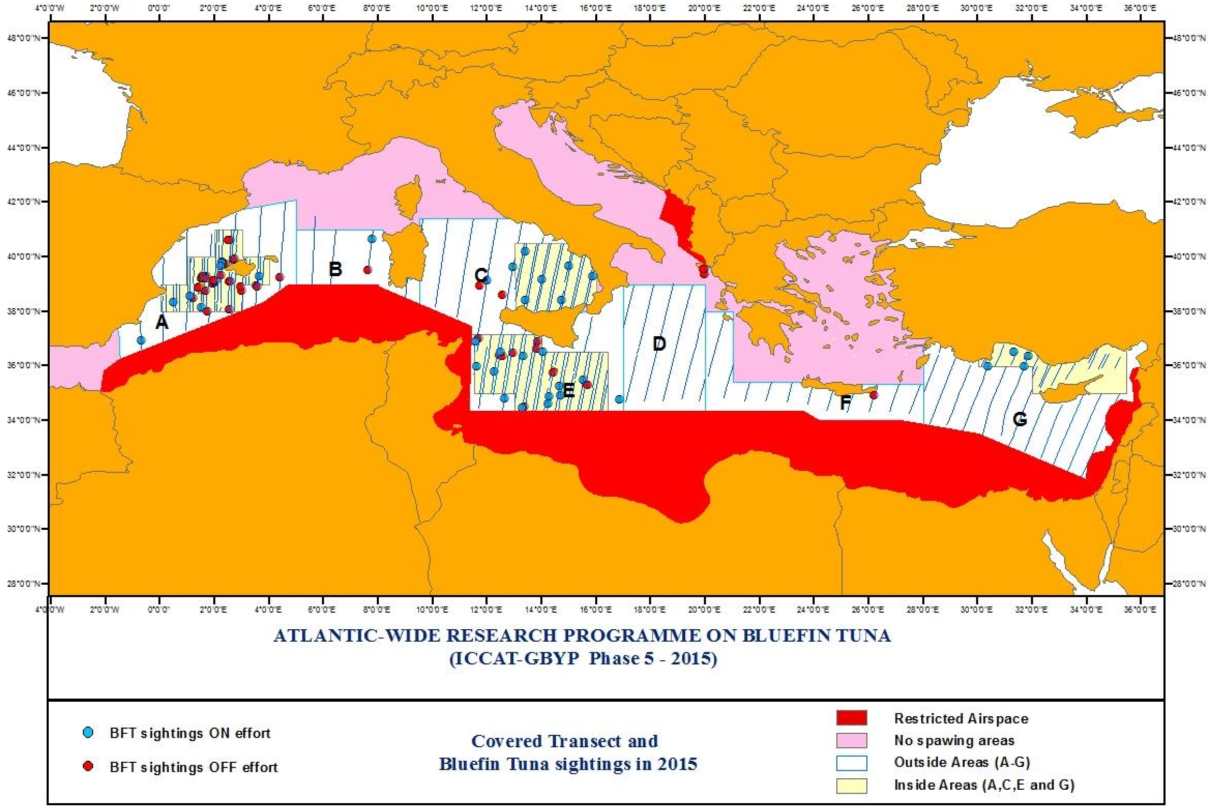

Figure 8. Transects flown on effort and sightings of bluefin tuna on and off effort.

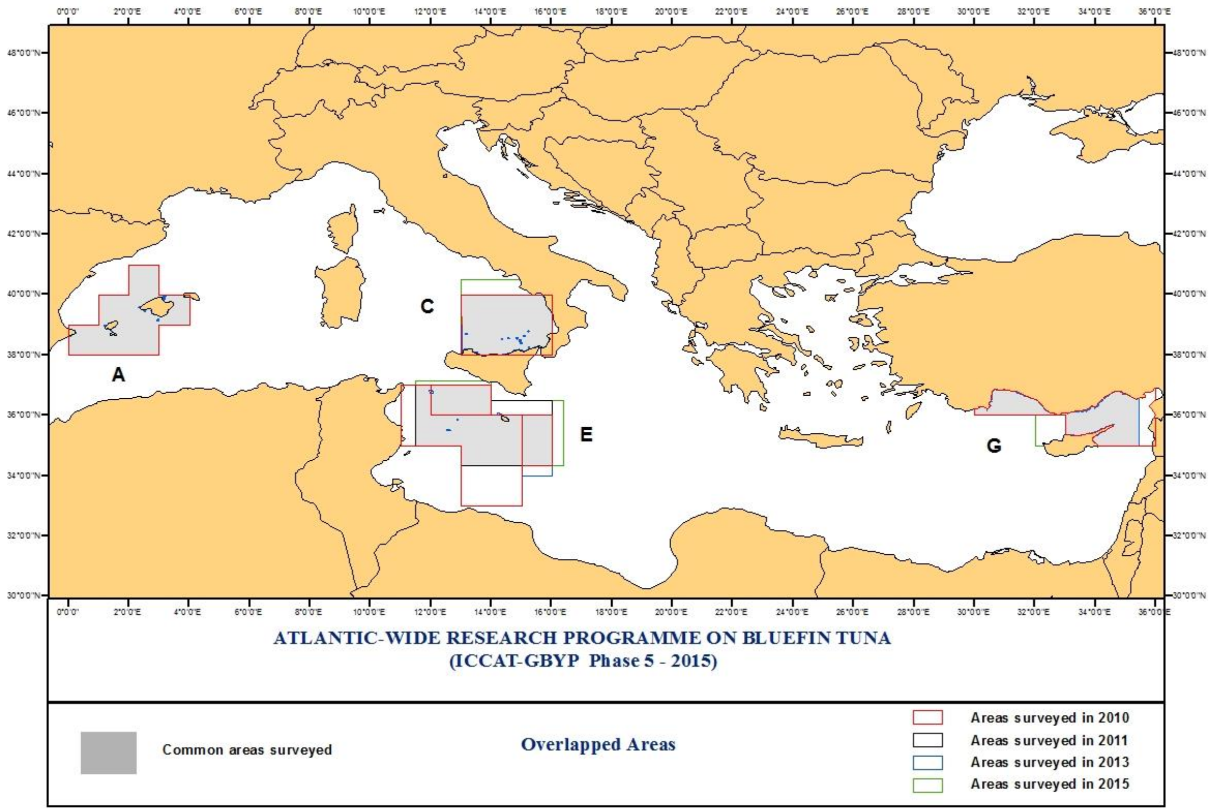

Figure 9. Overlapped Survey blocks for the four GBYP aerial surveys.

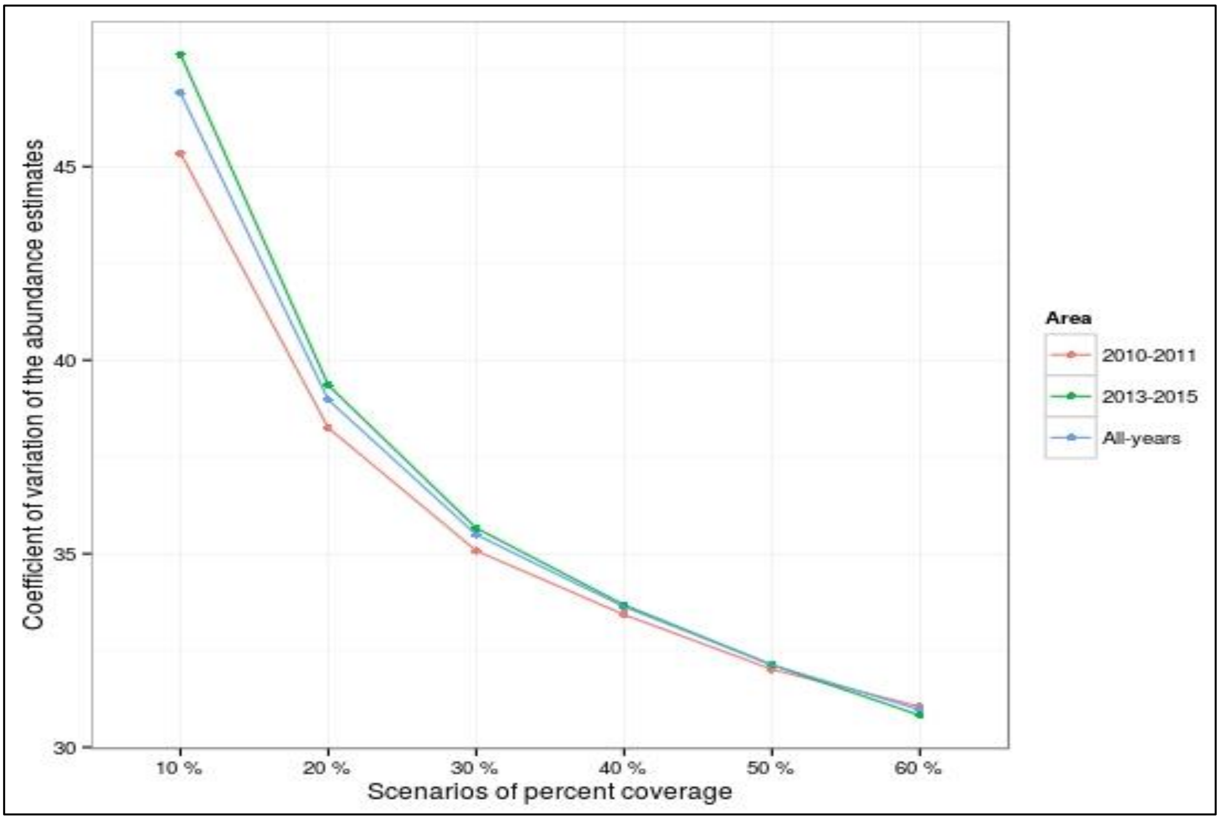

Figure 10. Trend of the CVs of abundance under various scenarios of area coverage in the overlap areas, based on the CVs of 2010-2011 (surveying only the inside areas), 2013-2015 (surveying both inside and outside areas), and the whole period; the graph does not include the associated costs, which are very different according to the survey strategy (the "extended" strategy has costs 71.83% higher than the original one).

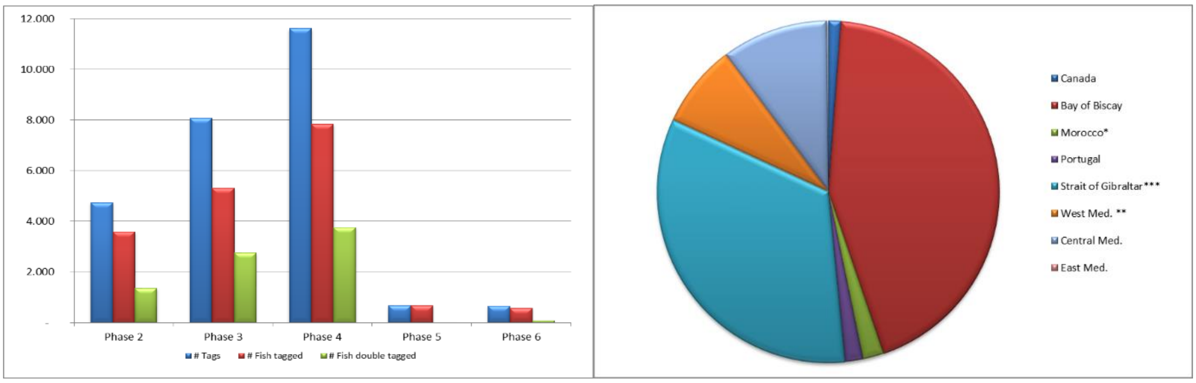

Figure 11a (left). Progression of the ICCAT GBYP tagging activities in the various Phases. **Figure 11b (right)**. Percentage distribution of tags implanted in the various geographical areas by GBYP, up to 19 September 2016.

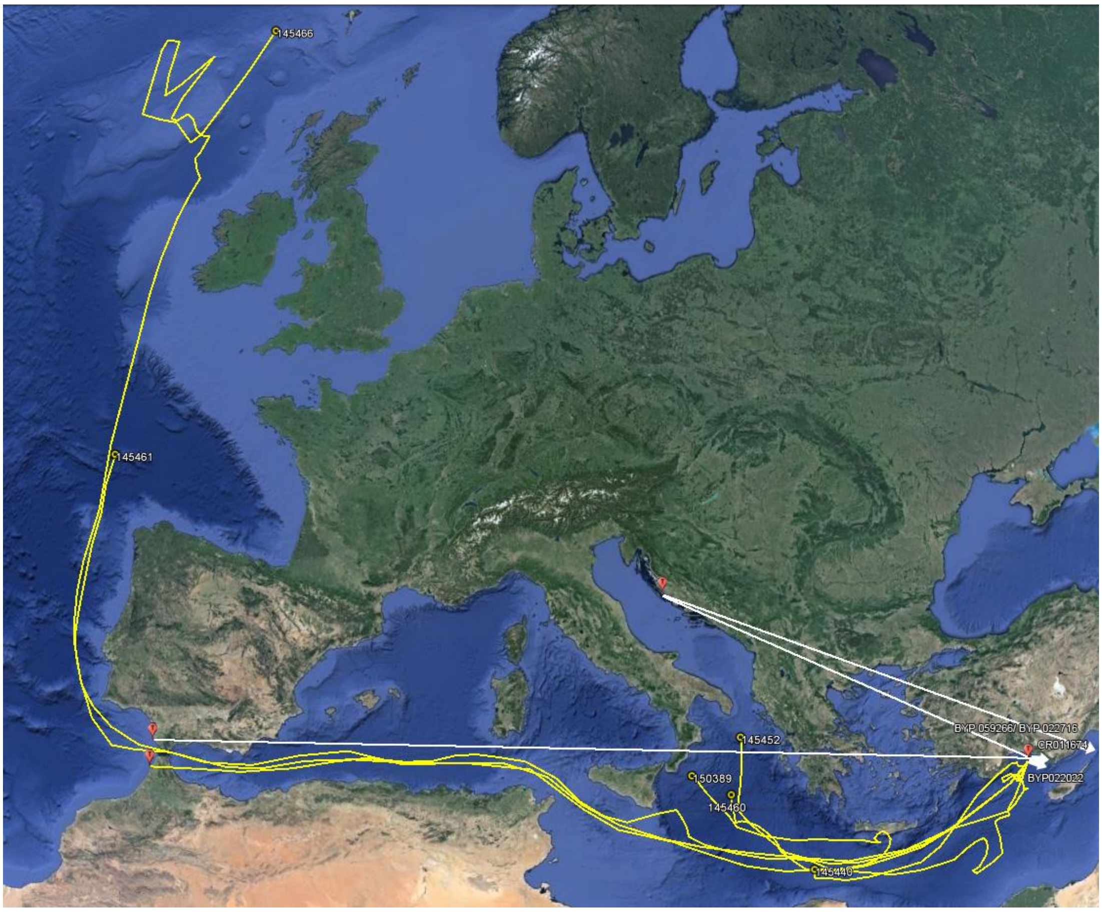

Figure 12. Tracks (in yellow) of 5 miniPATs deployed in Turkey in 2015, moving westwards from the eastern Mediterranean, of one miniPAT deployed in a Moroccan trap in 2015 which reached the eastern Mediterranean, and trajectories (in white) of three bluefin tunas conventionally tagged, one in 2011 (in the Strait of Gibraltar) and two in 2013 (one single tagged and one double tagged in Croatia), which were recovered in Turkey.

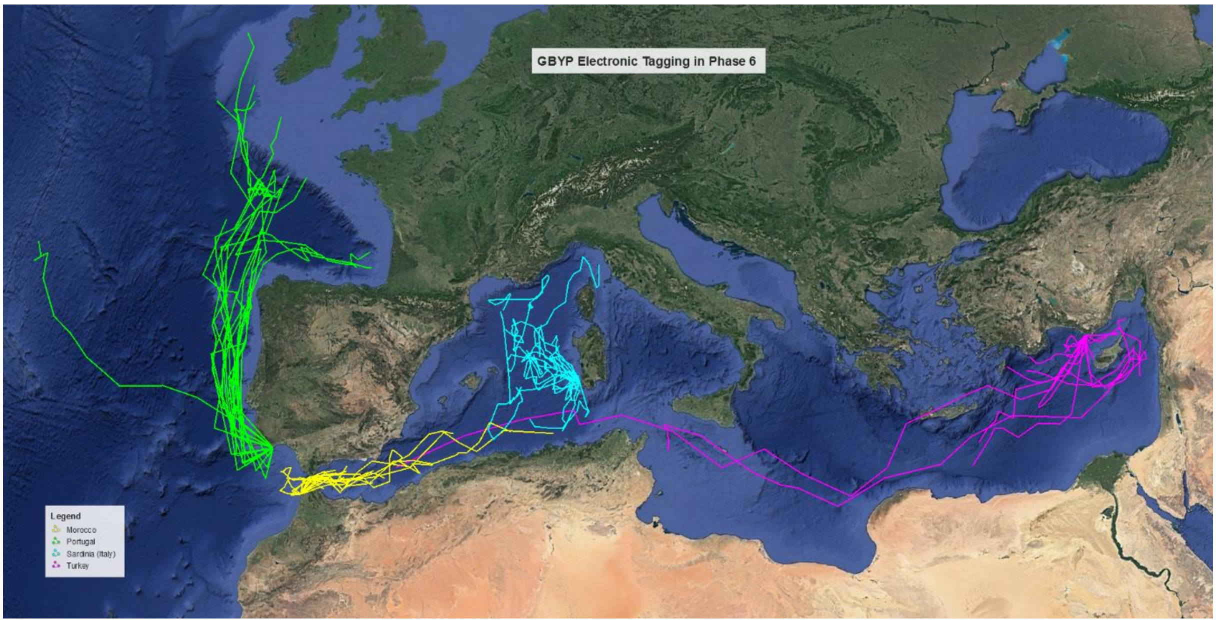

Figure 13. Tracks of 67 miniPATs deployed during Phase 6, whose estimated track was available before 22/09/2016.

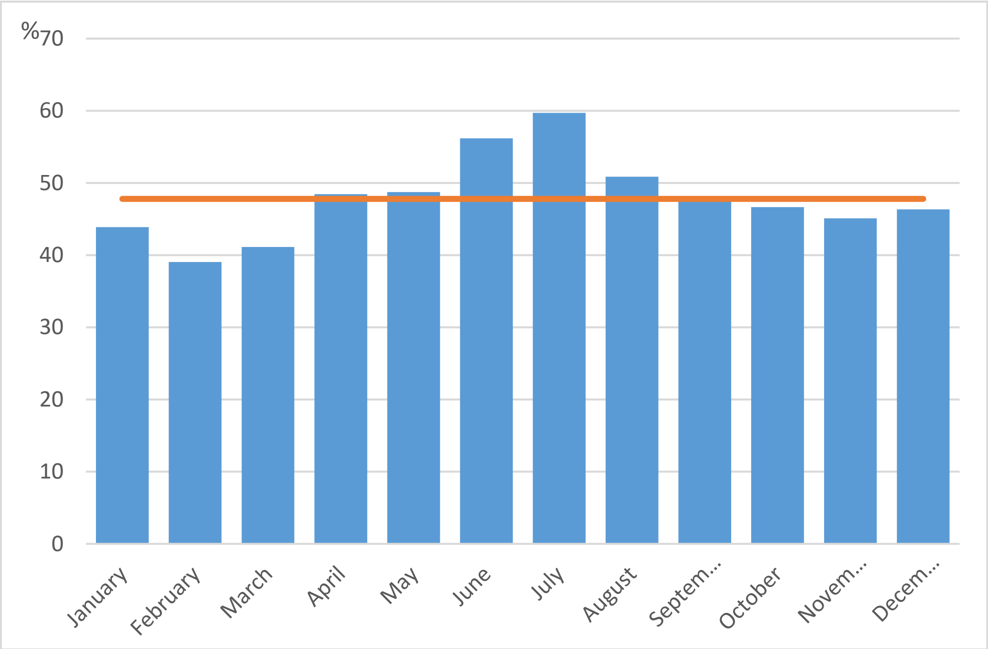

Figure 14. Mean percentage of time bluefin tuna spent on the surface (0-10 m) by months, according to the data provided by electronic pop up tags deployed by ICCAT GBYP (2011-2015). Orange line represents the mean percentage of time spent on the surface (1-10 m) throughout the year.

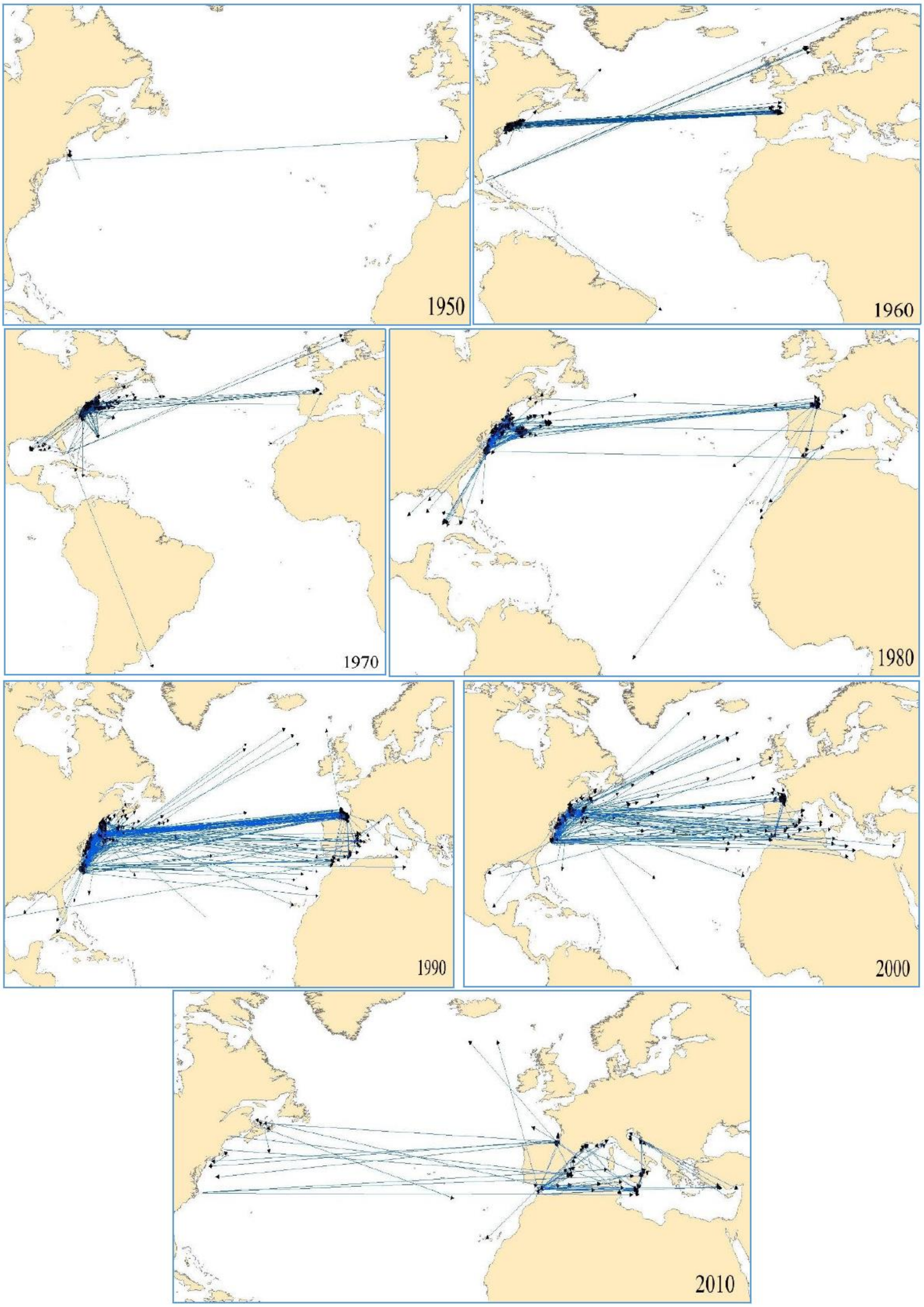

Figure 15. Bluefin displacements detected using validated conventional tag data plotted by decade recoveries.

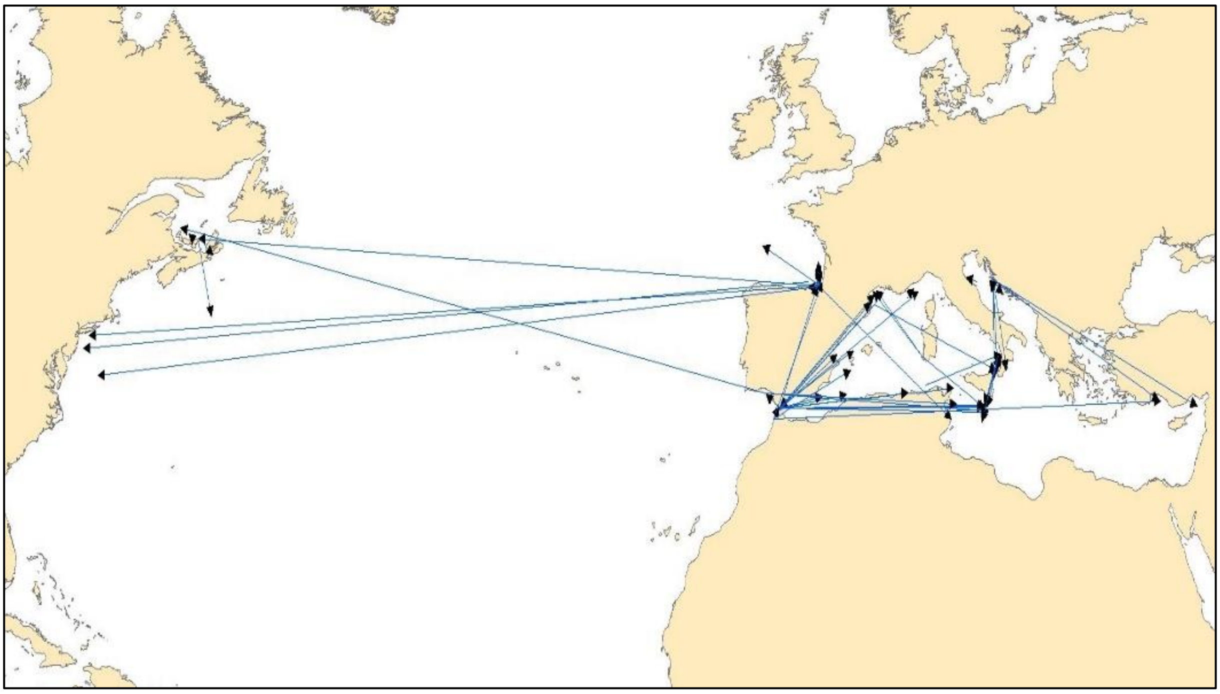

Figure 16. Bluefin tuna displacements for all individuals tagged and recovered under the GBYP (2011-2016) with geo-data validated.

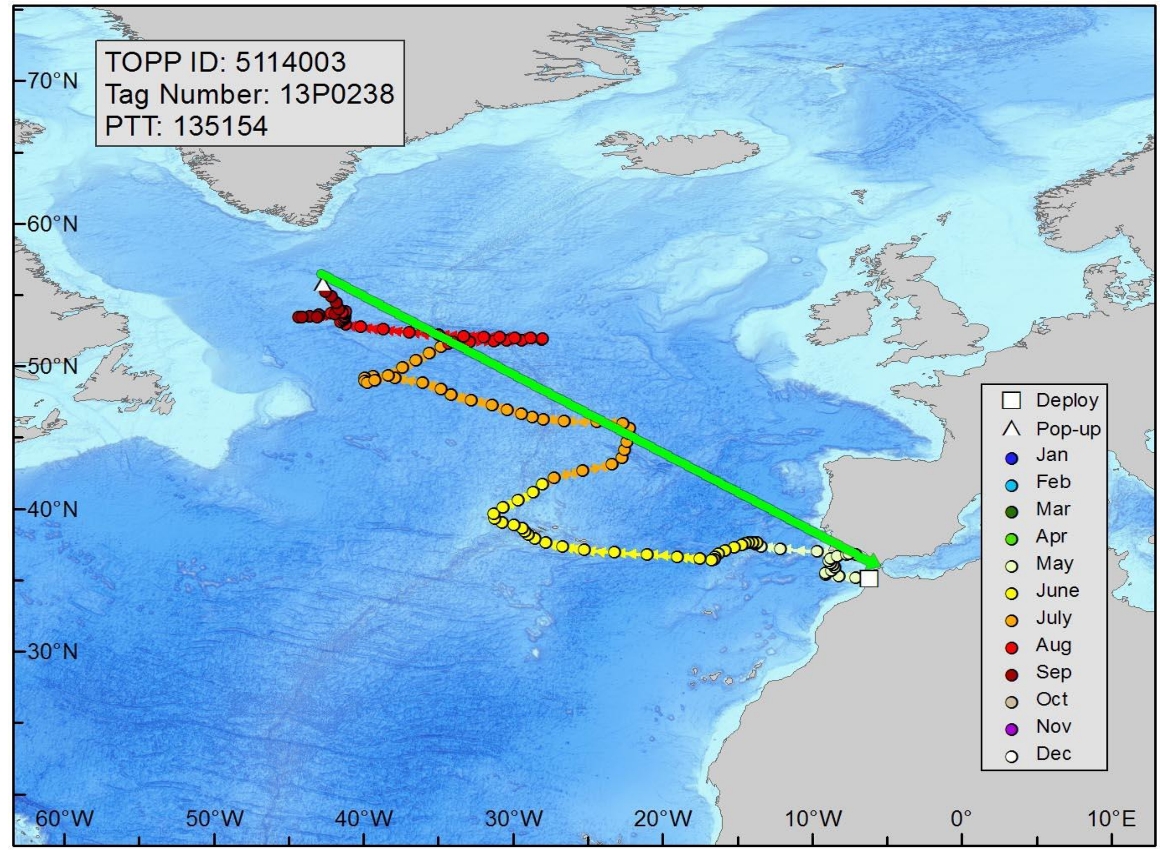

Figure 17. Estimated track of a bluefin tuna tagged in Larache (Morocco) on 13 May 2014 (bullets in color), which went to Greenland in the same year (pop-off on 12 September 2014). This tuna was fished in the Strait of Gibraltar on 25 June 2015 (straight line) (image courtesy: Prof. Barbara Block, Stanford University, USA).

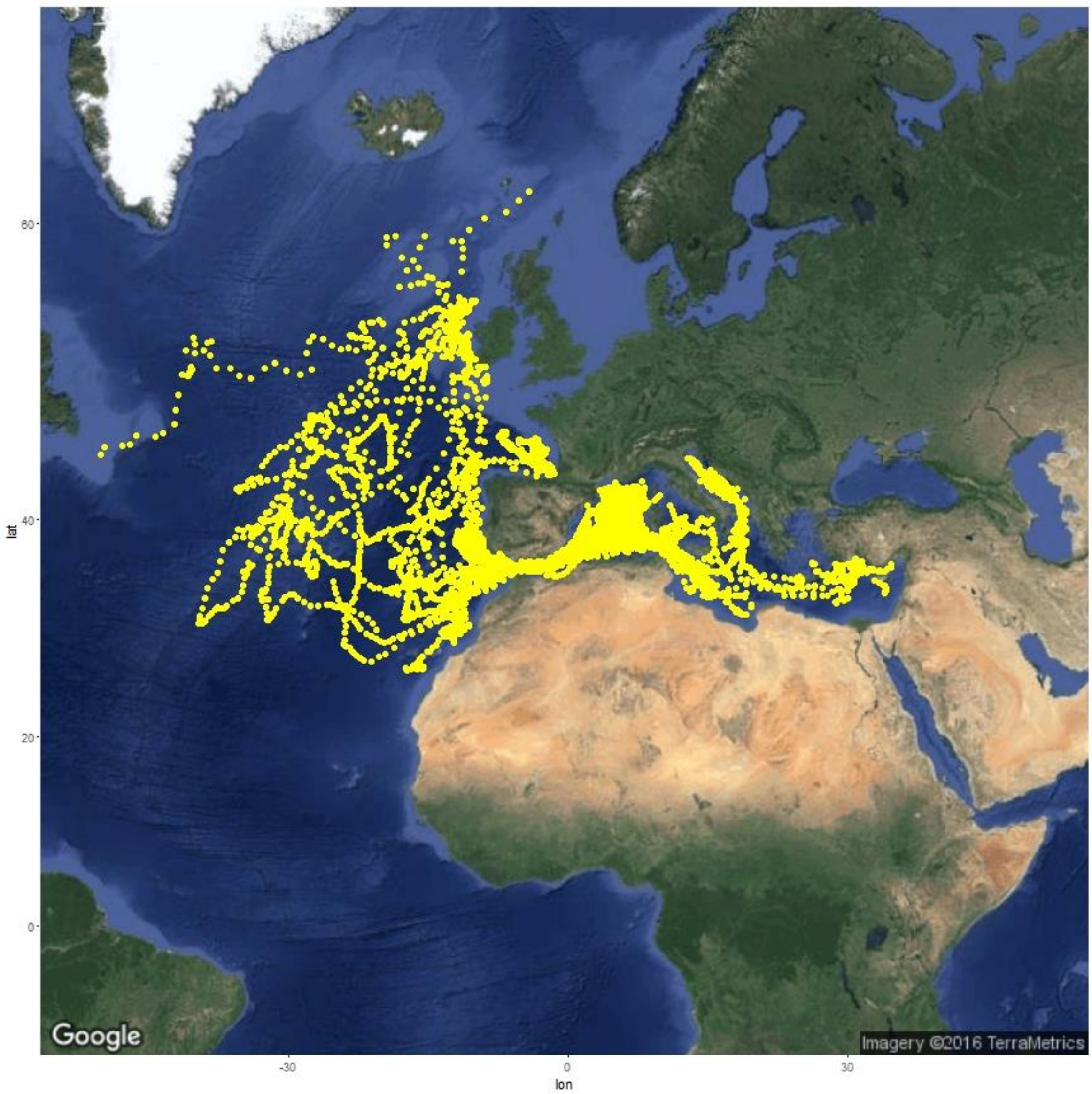

Figure 18. Daily geolocation estimates of 173 bluefin tunas tagged by ICCAT GBYP in the period between 2011 and 2015 pooled together.

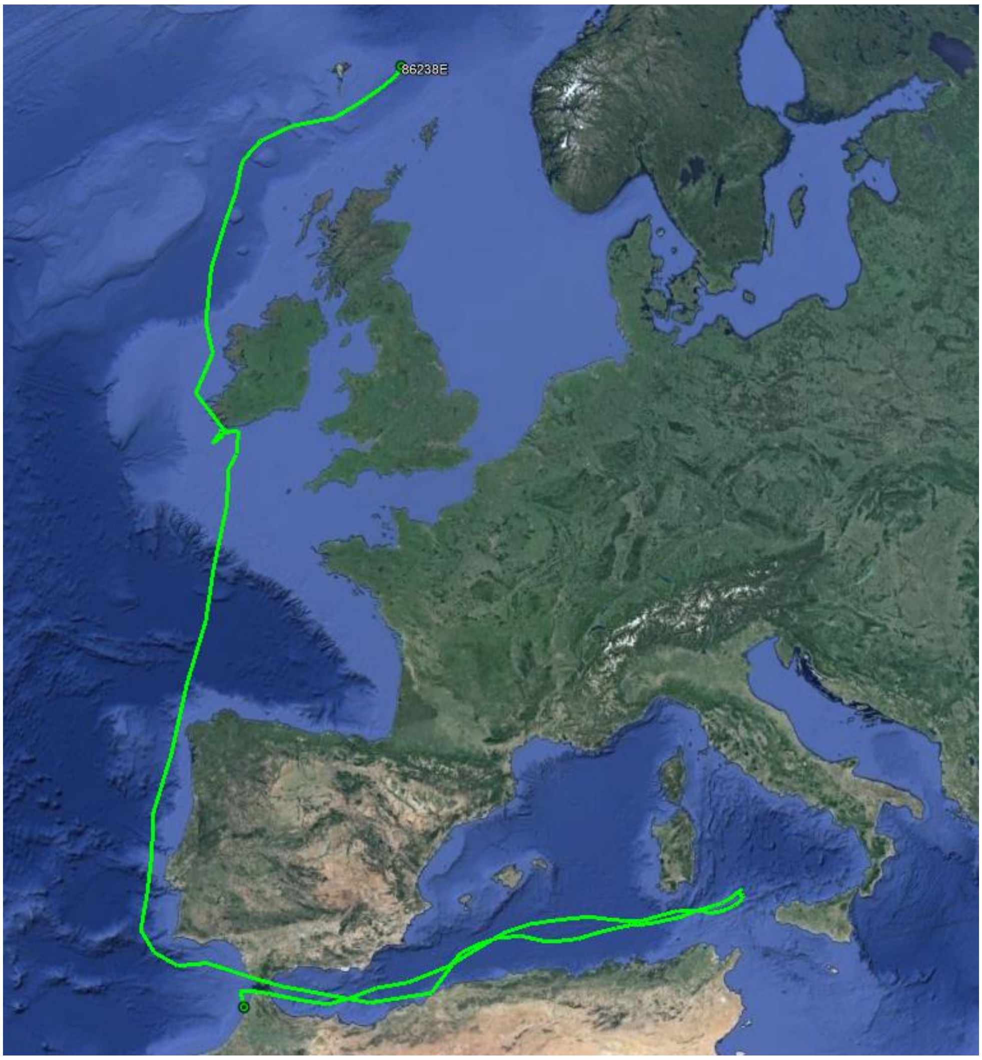

Figure 19. Estimated track of a tag 86238E deployed in Morocco on 14 May 2012 that popped up after 93 days.

Figure 20. Estimated track of a tag 118760 deployed in Morocco on 25 May 2013 that popped up after 142 days.

Figure 21. Estimated track of a tag 145461 deployed in Turkey on 31 May 2015 that popped up after 50 days.

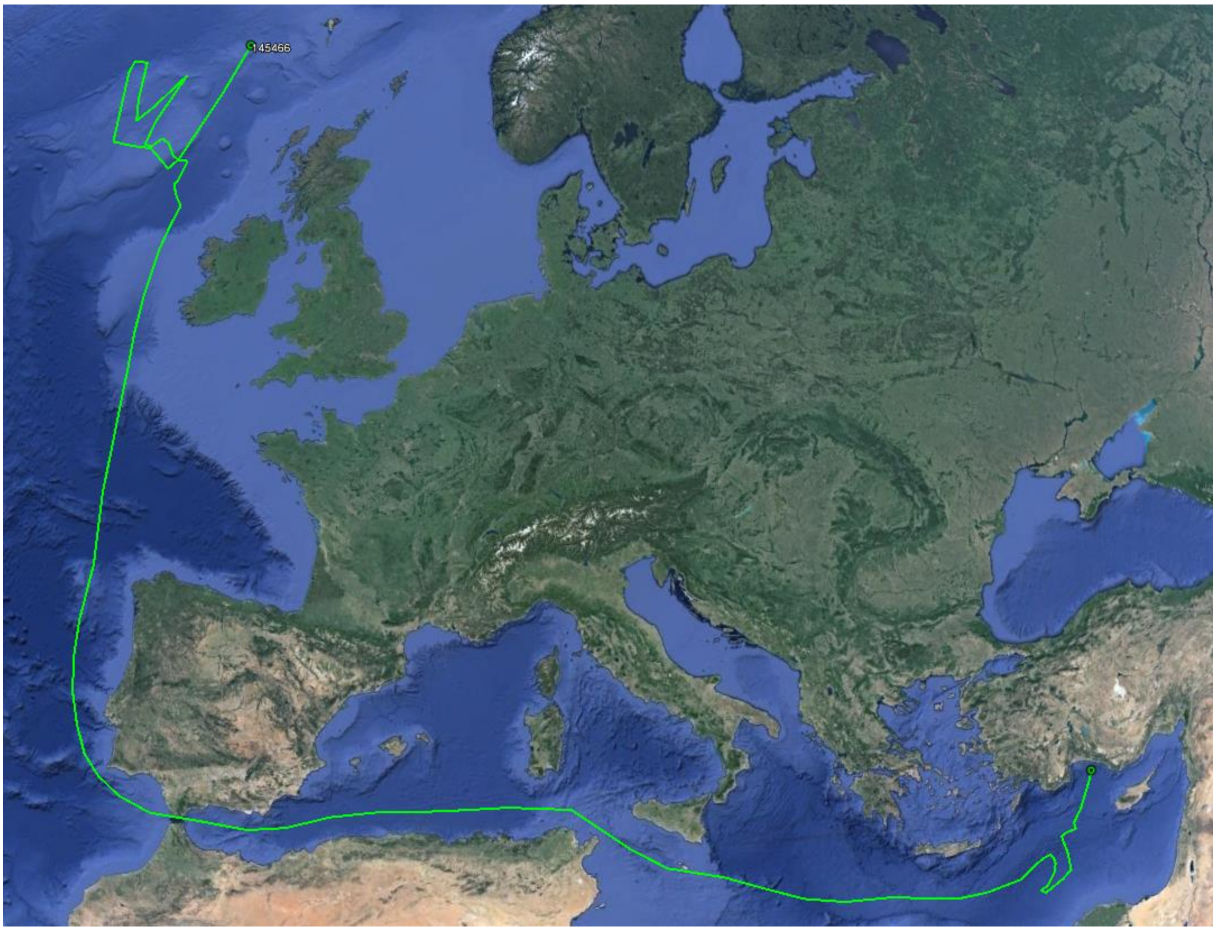

Figure 22. Estimated track of a tag 145466 deployed in Turkey on 31 May 2015 that popped up after 82 days.

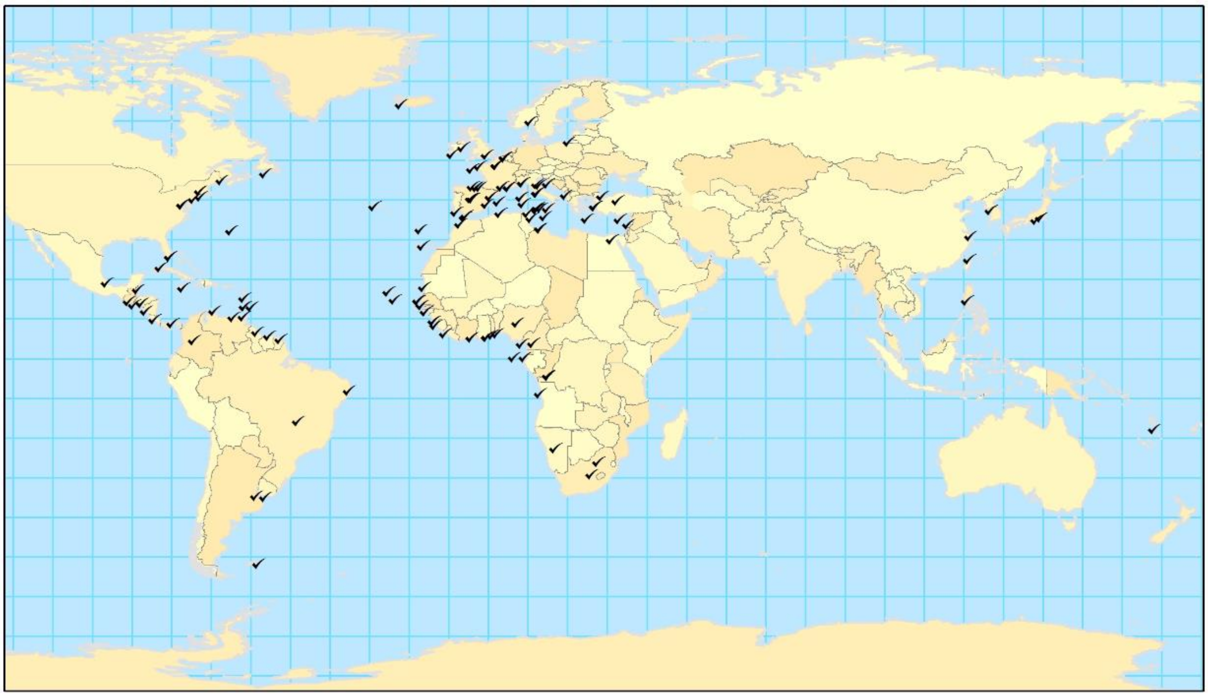

Figure 23. The distribution of the ICCAT GBYP tagging awareness campaign – material distribution areas.

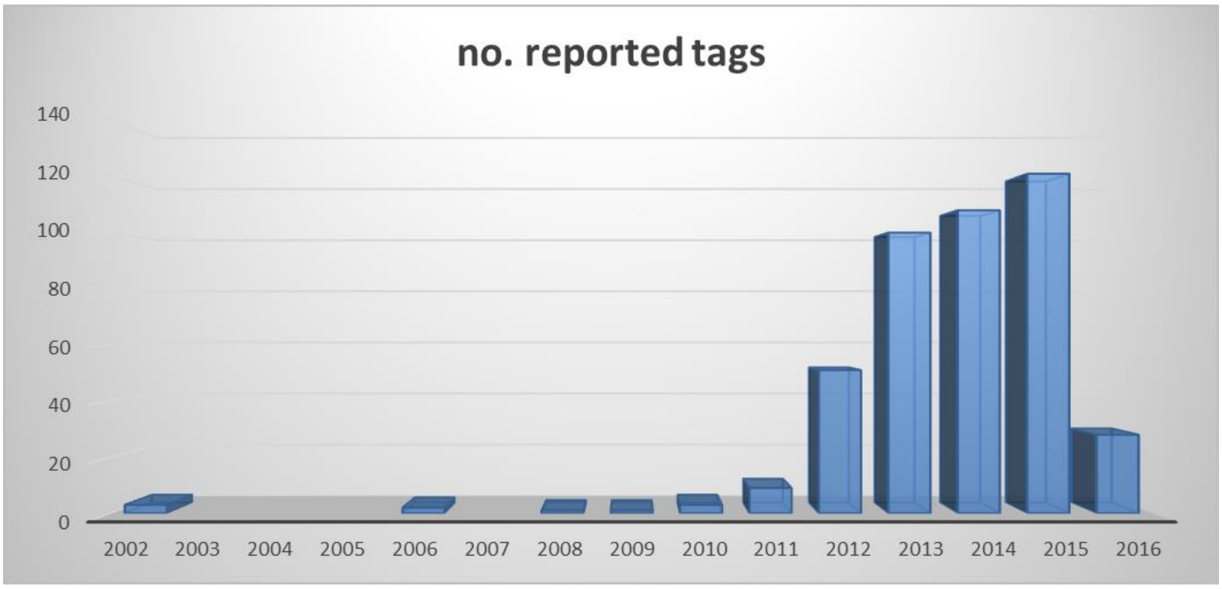

Figure 24. Number of bluefin tuna tags reported to ICCAT by year, up to 19 September 2016.

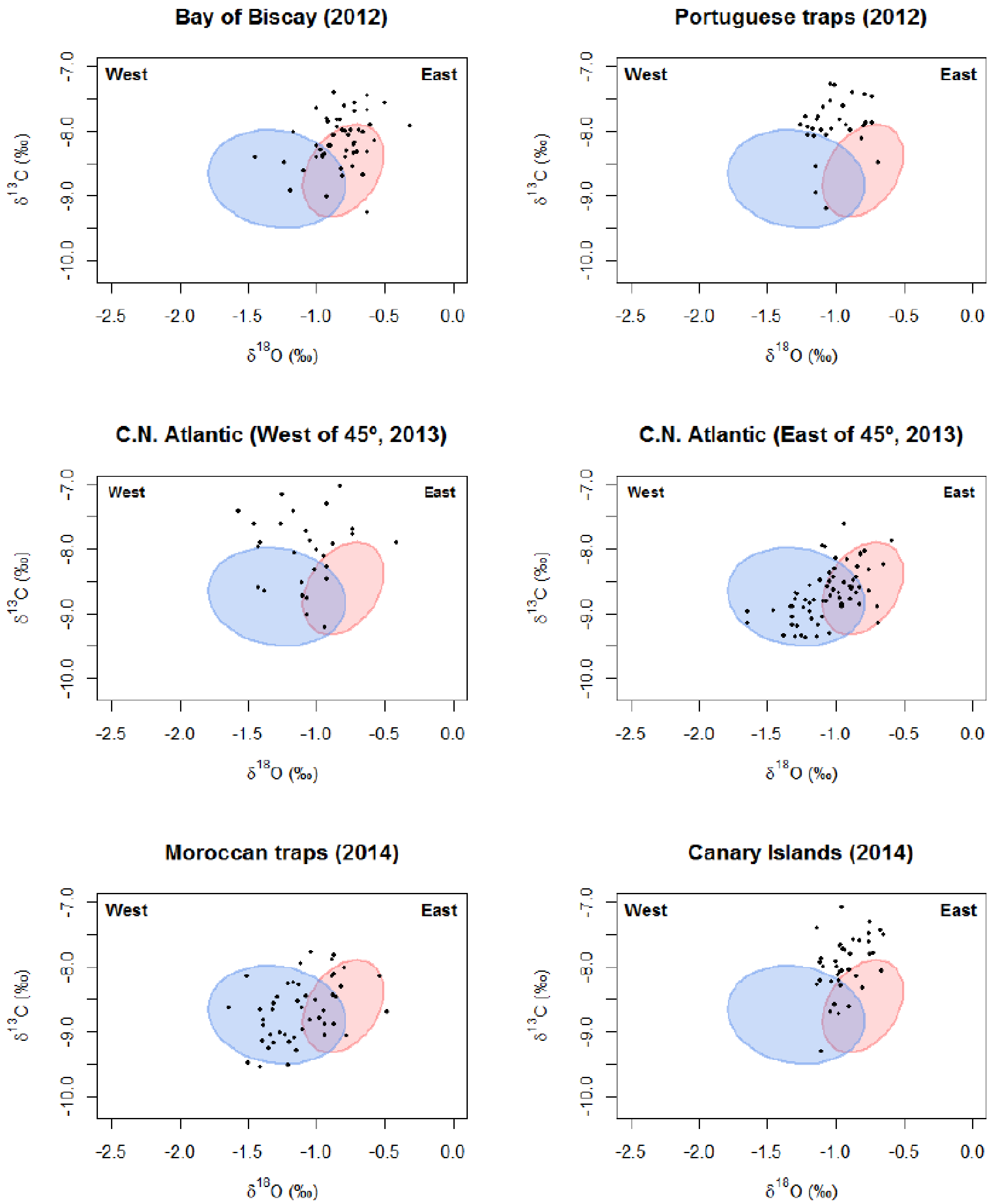

Figure 25. Confidence ellipses (1 SD or ca. 68% of sample) for otolith δ13C and δ18O values of yearling bluefin tuna from the east (red) and west (blue) along with the isotopic values (black dots) for otolith cores of bluefin tuna collected from the Bay of Biscay, Portuguese coast, central North Atlantic Ocean (namely west of 45ºW), central North Atlantic ocean (east of 45ºW), Atlantic Moroccan coast and Canary Islands (from Consortium Report, 2016).

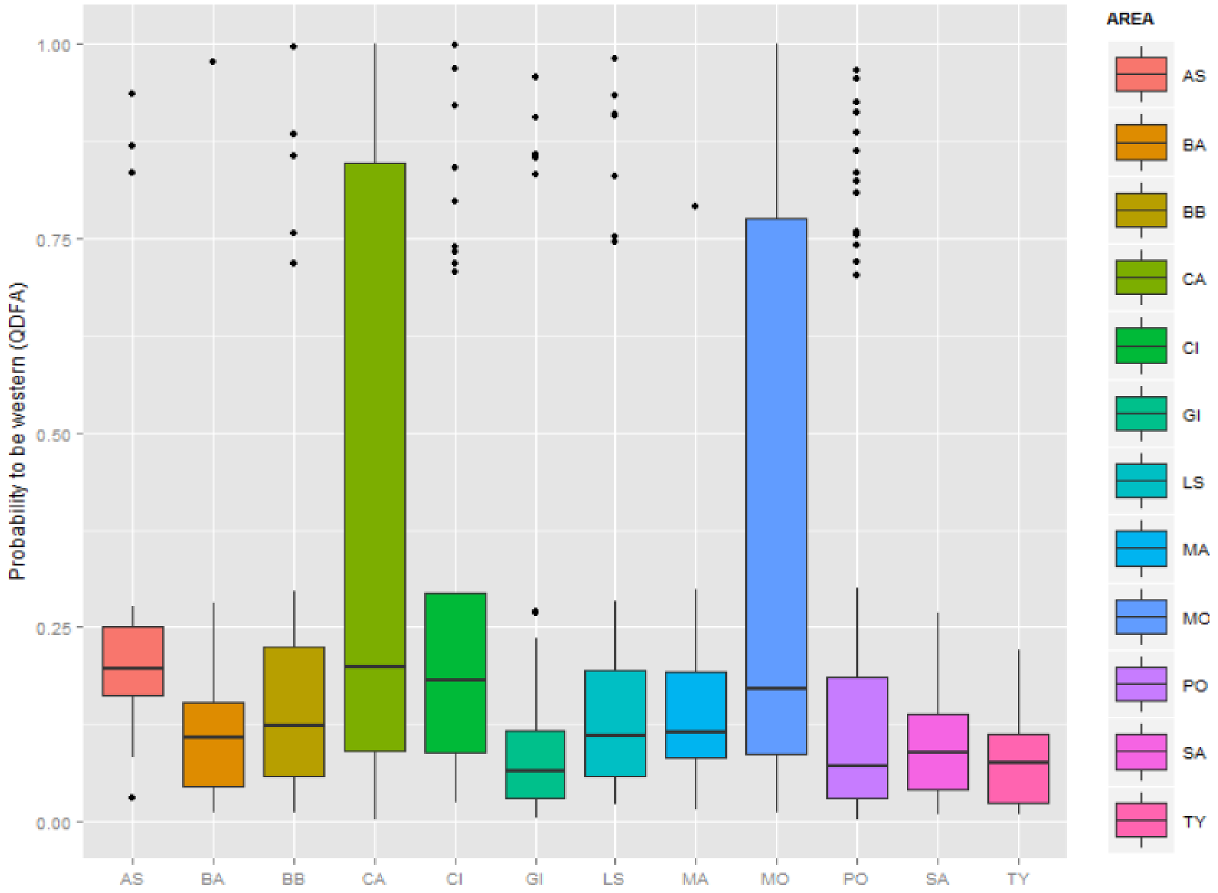

Figure 26. Boxplot of the probabilities of western origin estimated by QDFA (excluding probabilities between 30-70%). Areas: Adriatic Sea (AS), Balearic Sea (BA), Bay of Biscay (BB), Central Atlantic Ocean (CA), Canary Islands (CI), Strait of Gibraltar (GI), Levantine Sea (LS), Malta (MA), Atlantic Morocco (MO), south Portugal (PO), Sardinia (SA) and Tyrrhenian Sea (TY).

Figure 27. 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.

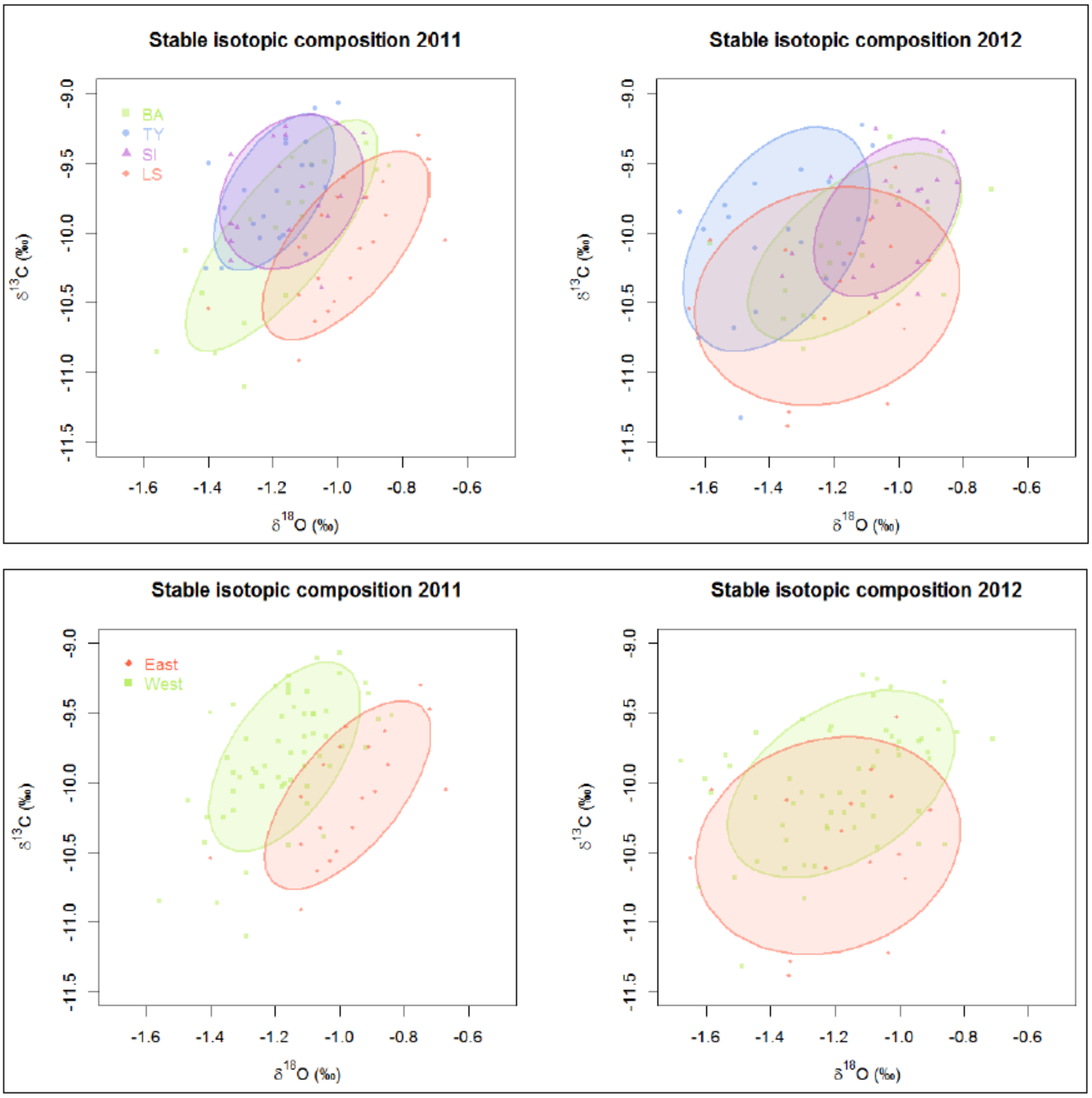

Figure 28. Discrimination of nursery areas within the Mediterranean Sea by trace element and stable isotope composition in young-of-the-year bluefin tuna. **Upper figures**: Confidence ellipses (1 SD or ca. 68% of sample) for otolith δ13C and δ18O values of young-of-the-year bluefin tuna from the Balearic 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.

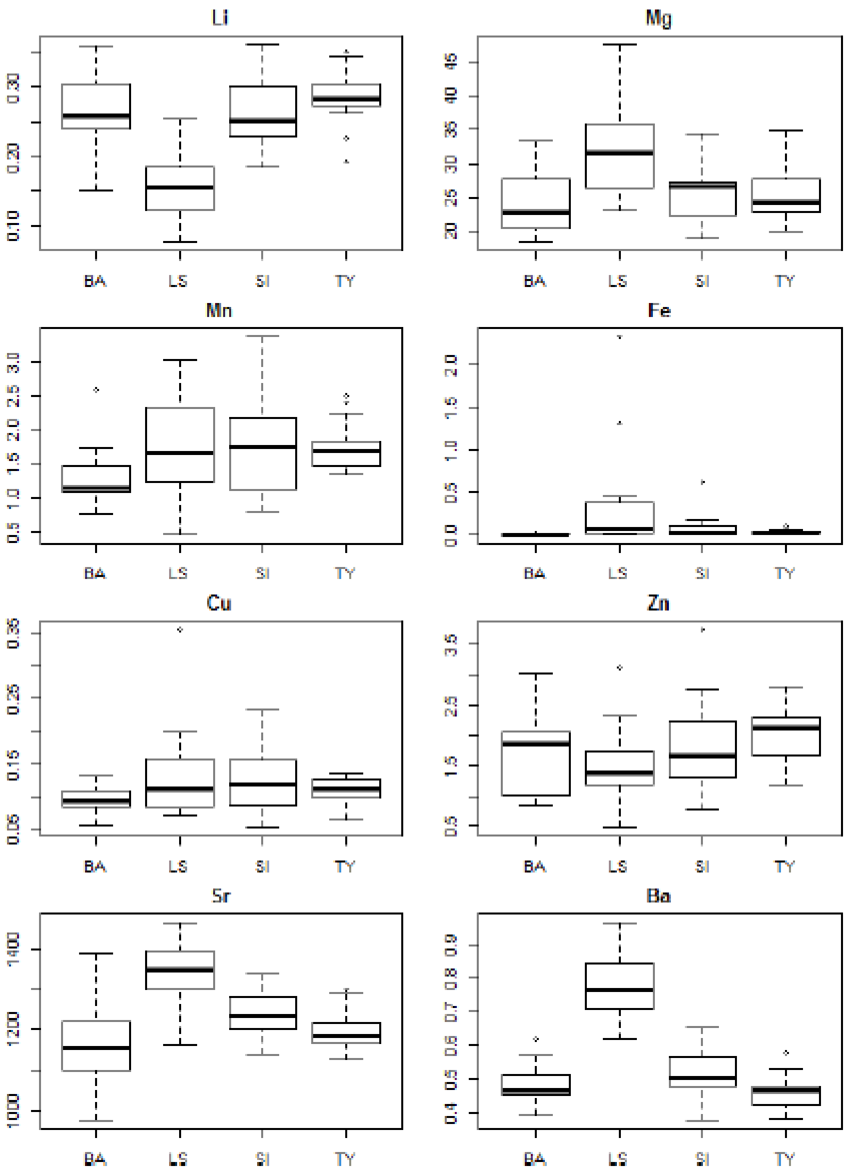

Figure 29. Trace element concentration (ppm) in post-larval portion of otoliths from young-of-the-year Atlantic bluefin tuna (*Thunnus thynnus*) collected in the Balearic Sea (BA), Levantine Sea (LS), eastern Sicily (SI) and southern Tyrrhenian Sea (TY) from August to October 2011.

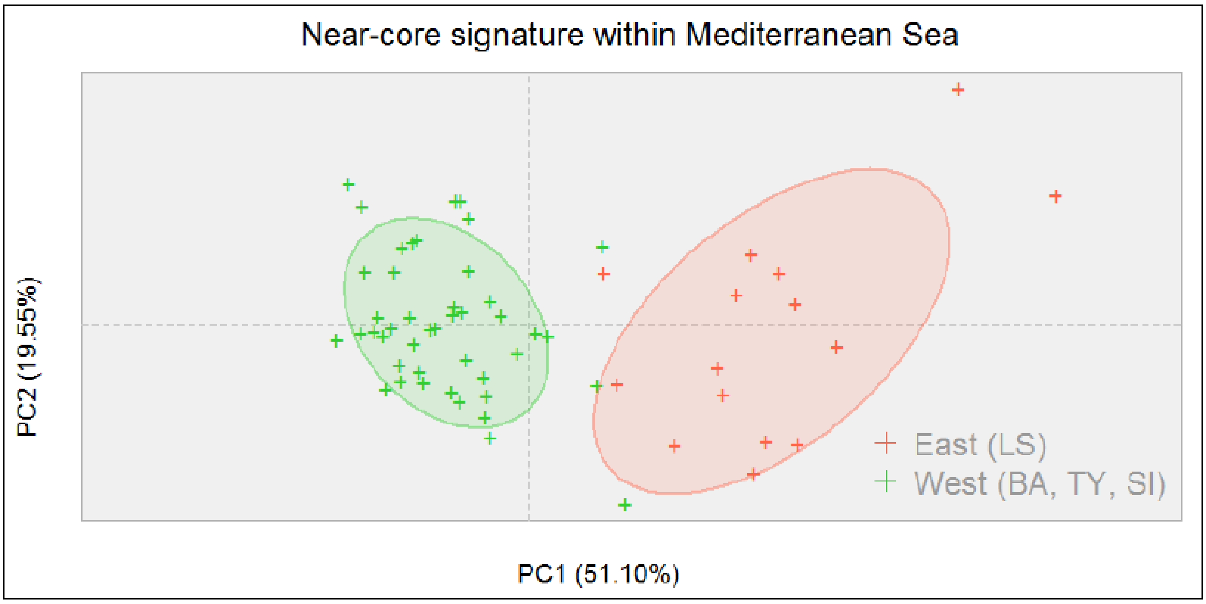

Figure 30. Elemental fingerprints for young-of-the-year bluefin tuna (*Thunnus thynnus*) otoliths from the eastern (Levantine Sea, in red) and western-central (Balearic Sea, southern Tyrrhenian Sea and eastern Sicily, in green) Mediterranean basins, based on the first two axis of the Principal Component Analysis including Li, Mg, Fe, Sr and Ba concentrations.

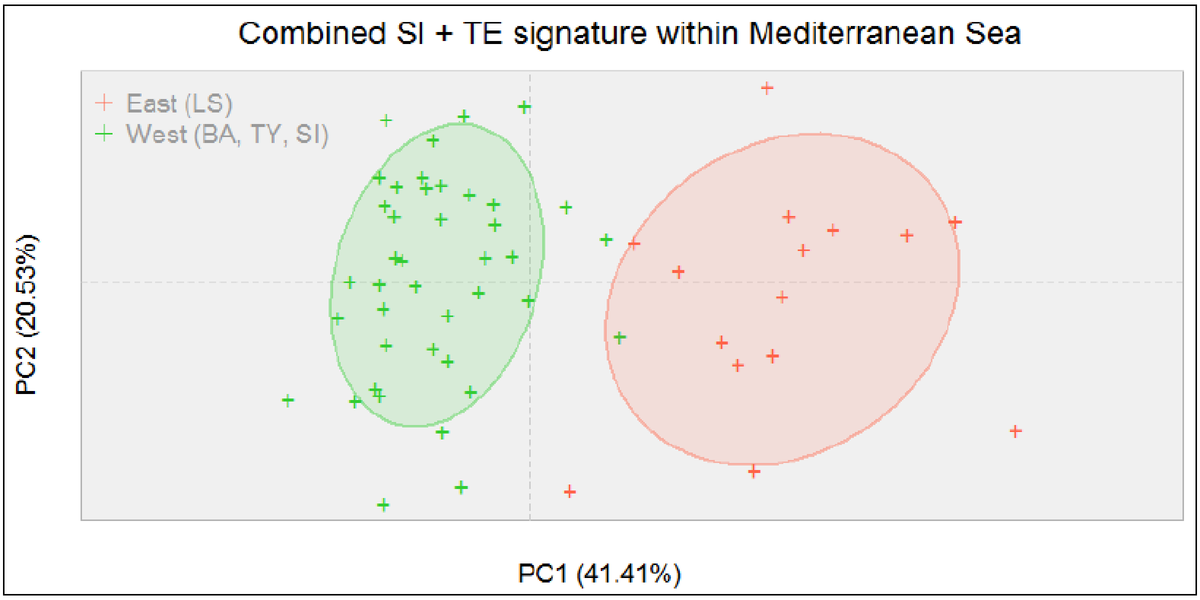

Figure 31. Elemental and isotopic fingerprints for young-of-the-year bluefin tuna (*Thunnus thynnus*) otoliths from the eastern (Levantine Sea) and western-central (Balearic Sea, southern Tyrrhenian Sea and eastern Sicily) Mediterranean basins, based on the first two axis of the Principal Component Analysis including Li, Mg, Fe, Sr, Ba concentration together with δ13C and δ18O values.

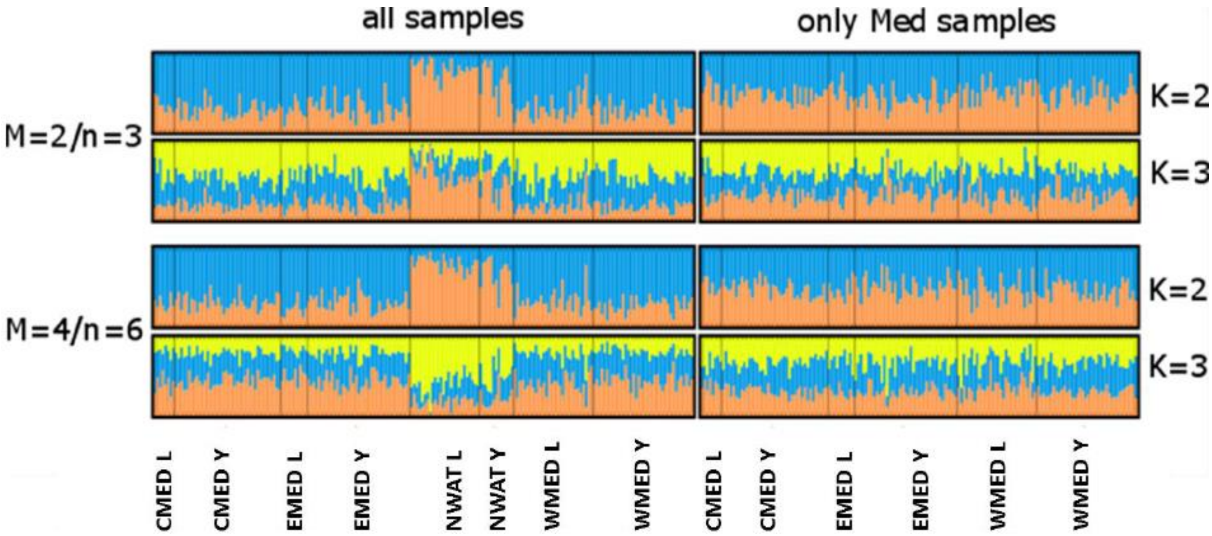

Figure 32. Graphical representation of individual ancestry using Structure software for the four genotype datasets including PCR clones. Each bar represents one individual and each color, its degree of belonging to each inferred group. Results of 2 or 3 (K) potential ancestral populations are shown.

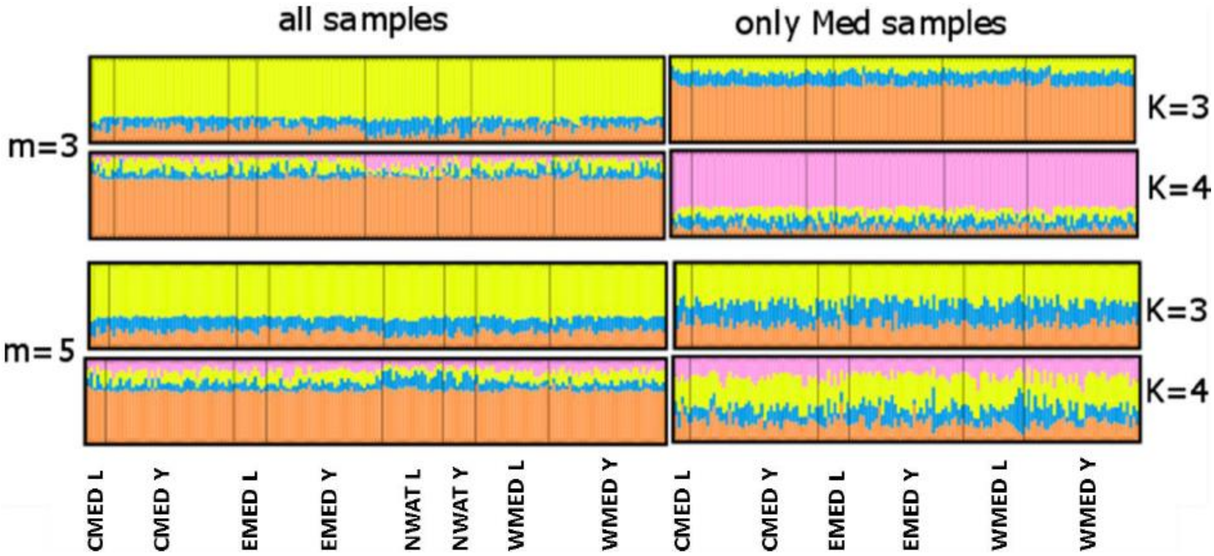

Figure 33. Graphical representation of individual ancestry using Structure software for the four genotype datasets not including PCR clones. Each bar represents one individual and each color, its degree of belonging to each inferred group. Results of 3 or 4 (K) potential ancestral populations are shown.

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 34. 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 35. 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).

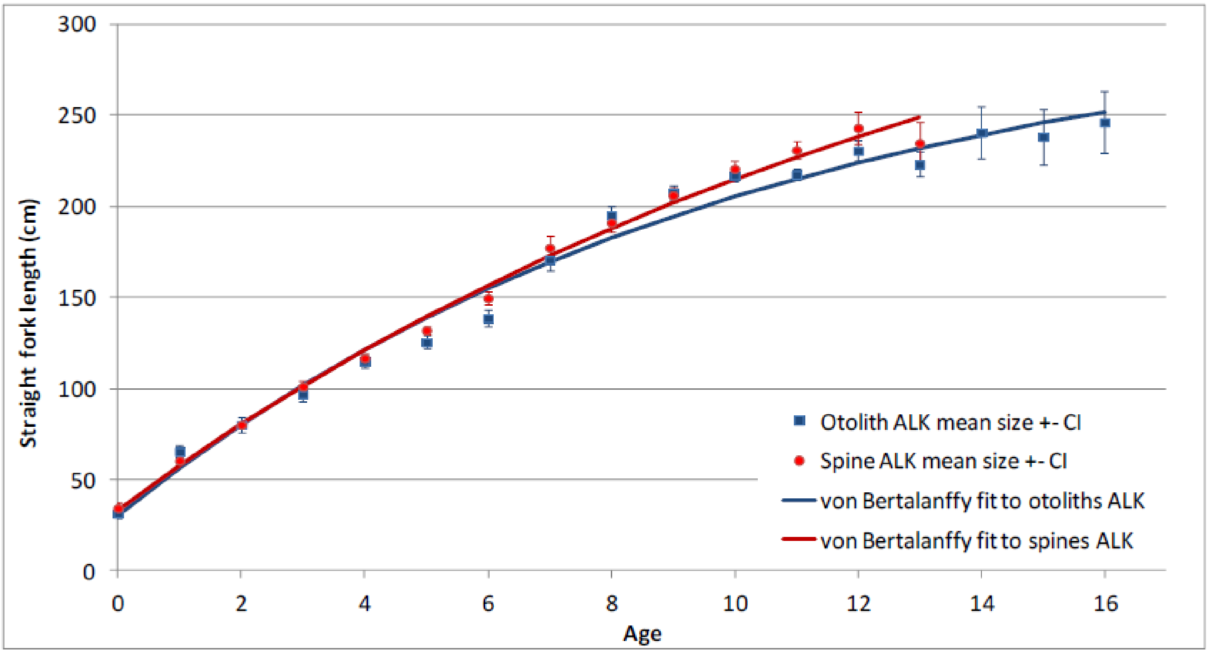

Figure 36. Length at age from multi-year ALKs and 95% confidence intervals for otoliths (blue dots and CI error bars), and spines (red dots and CI error bars). ALKs von Bertalanffy growth model curves fitted to observed length at age data for otoliths (blue line) and spines (red line).

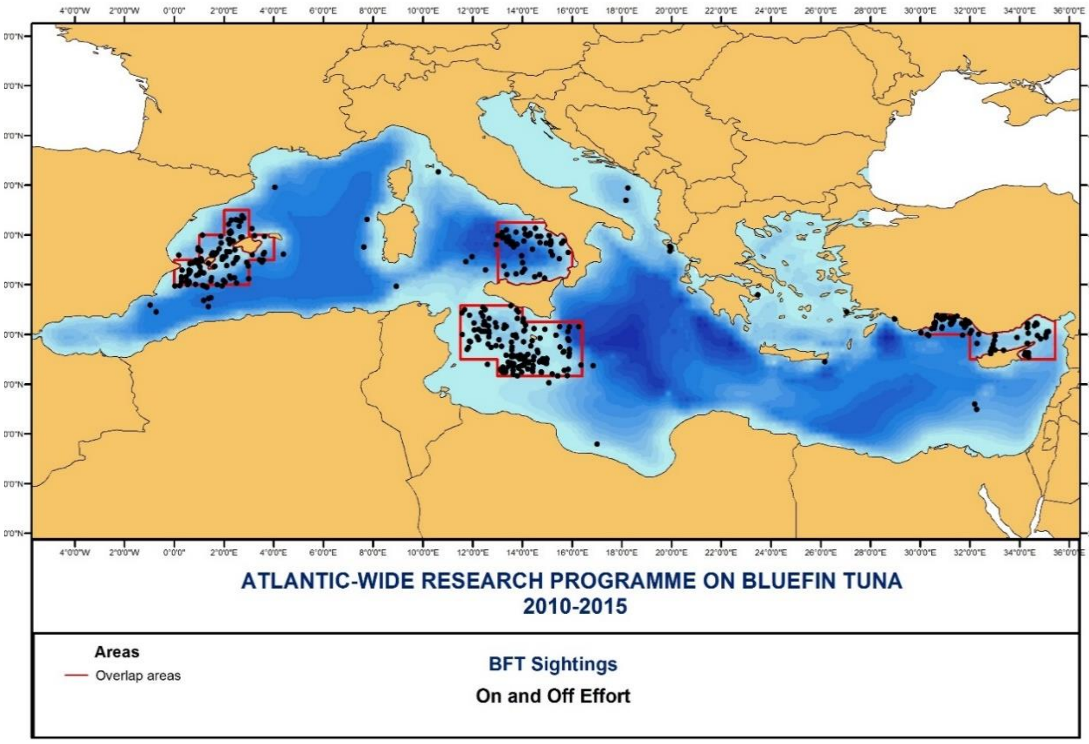

Figure 37. Distribution of BFT spawning aggregations spotted during the four GBYP aerial surveys, on and off effort.

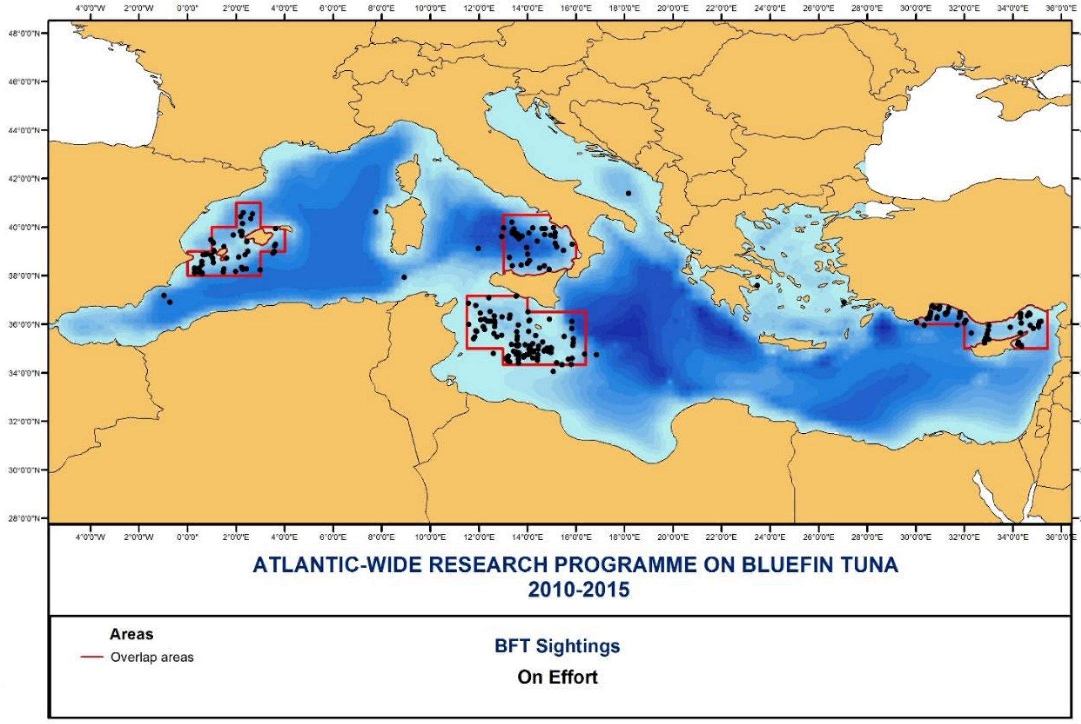

Figure 38. Distribution of BFT spawning aggregations spotted during the four GBYP aerial surveys, on effort only.

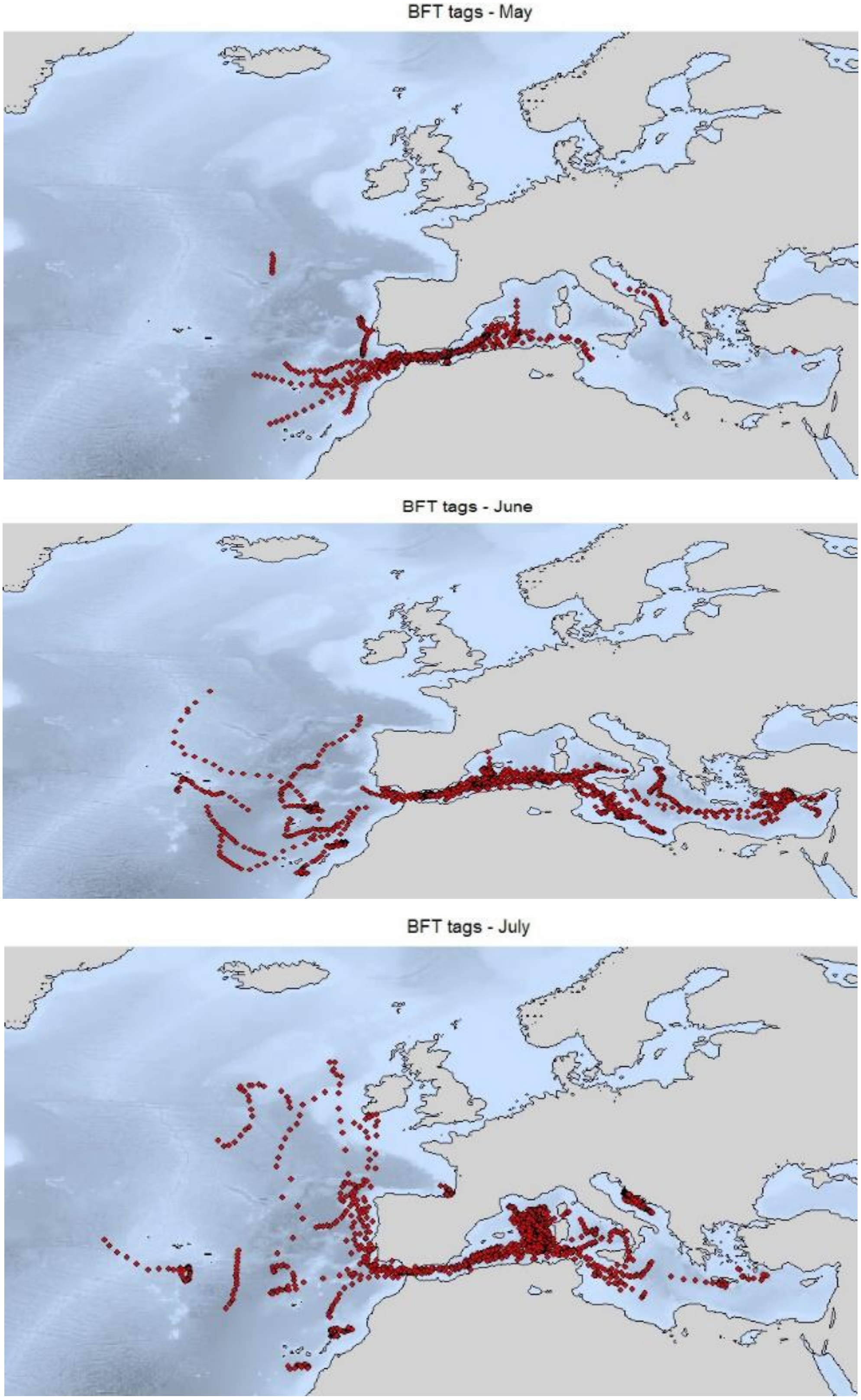

Figure 39. Tracks of BFT tagged with miniPATs by GBYP in the various Phases for the three main months when spawning usually takes place. In May there are pre-spawners and spawners, in June mostly spawners with few post-spawners and in July spawners and several post-spawners. The tracks in the Adriatic Sea are related to immature fish.

Annex 1a

GBYP contracts issued in Phase 5

ICCAT-GBYP CONTRACTS (PHASE 5)								
ICCAT GBYP COORDINATION								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**working schedule initial date**	**working schedule final date**	**COST €**	**NOTES**
5	2015-2016	direct contract	*ICCAT GBYP Steering Committee external member*	Ph.D. Tom Polacheck, e-mail: runningtide.tom@gmail.com	21/06/2015	21/02/2016	15.000,00 €	
ICCAT GBYP DATA RECOVERY								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**initial date**	**final date**	**COST €**	**NOTES**
5	2015-2016	04/2015	*Data Recovery Plan* - University of Bologna, Dept. of Bio., Geo. And Env. Sciences - Italy	Fausto Tinti, e-mail: fausto.tinti@unibo.it	07/05/2015	31/01/2016	20.000,00 €	
ICCAT GBYP AERIAL SURVEY								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**initial date**	**final date**	**COST €**	**NOTES**
5	2015-2016	direct contract	*Aerial Survey Design* - Alnilam Investigación y Conservación SA - Spain	Ana Cañadas, e-mail: anacanadas@alnilam.com.es	27/03/2015	01/04/2015	9.000,00 €	
		direct contract	*Aerial Survey Protocol and Training Course* - Alnilam Investigación y Conservación SA - Spain	Ana Cañadas, e-mail: anacanadas@alnilam.com.es	26/05/2015	28/05/2015	3.200,00 €	
		cost reimburstment	*GBYP Aerial Survey Training Course* - ICCAT	Antonio Di Natale, e-mail: antonio.dinatale@iccat.int	26/05/2015	26/05/2015	9.402,02 €	
		03/2015	*Aerial Survey on Spawning Aggregations (Sub-Area A)* - Grup Air Med, Spain	Javier Hevia, e-mail: javier@grupairmed.com	30/06/2015	03/08/2015	107.454,36 €	
		03/2015	*Aerial Survey on Spawning Aggregations (Sub-Areas B, E and G)* - Action Communication SARL - France (+2 subcontracts to France)	Alexis Giordana, e-mail: agiordana@action-air.net	26/05/2015	03/08/2015	166.826,00 €	
		03/2015	*Aerial Survey on Spawning Aggregations (Sub-Areas C, D and F)* - Consorzio Unimar - Italy (+2 subcontracts to Italy)	Adriano Mariani, e-mail: unimar@unimar.it or mariani.a@unimar.it	17/06/2015	03/08/2015	157.038,71 €	
		direct contract	*Elaboration of Data from Aerial Surveys on Spawning Aggregations* - Alnilam Investigación y Conservación SA - Spain	Ana Cañadas, e-mail: anacanadas@alnilam.com.es	17/08/2015	21/02/2016	26.400,00 €	
		08/2015	*Power analysis and cost-benefit analysis for the ICCAT GBYP aerial survey* - Alnilam Investigación y Conservación SA - Spain	Ana Cañadas, e-mail: anacanadas@alnilam.com.es	08/01/2016	19/02/2016	19.800,00 €	
ICCAT-GBYP TAGGING PROGRAMME								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**initial date**	**final date**	**COST €**	**NOTES**
5	2015-2016	05/2015	*Tagging programme on bluefin tuna (Area C)* - Centro di Competenza Sulla Biodiversita Marina- Italy, as leader of Consortium including one more Italian institution	Dr. Piero Addis, e-mail: addisp@unica.it	08/06/2015	31/07/2015	49.992,54 €	
		05/2015	*Tagging programme on bluefin tuna (Area B)* - Institute National de Recherche Halieutique - Morocco, as a leader of Consortium including one more Moroccan institution and WWF	Dr. Noureddine Abid, e-mail: noureddine.abid65@gmail.com	03/06/2015	31/07/2015	105.679,23 €	
		05/2015	*Tagging programme on bluefin tuna (Area A)* - The Faculty of Fisheries, University of Istanbul -Turkey (+1 subcontract to Turkey) and Conzorsio Unimar Soc. Coop. - Italy	Prof. Saadet Karakulak, e-mail: karakul@istanbul.edu.tr; Dr. Adriano Mariani, e-mail: a.mariani@unimar.it	17/06/2015	31/07/2015	90.029,34 €	
		07c/2015	*Advice on Close-Kin Genetic Tagging Study* - CSIRO - Australia	Ph.D. Campbell Davies, e-mail: campbell.davies@csiro.au	08/01/2016	19/02/2016	43.000,00 €	original cost 65.344,00 AUD
		08/2015	*Cost benefit analysis for the ICCAT GBYP tagging programme* - CEFAS, United Kingdom	Ph.D. David Righton, e-mail: david.righton@cefas.co.uk	08/01/2016	19/02/2016	34.001,50 €	original cost 25.000,00 GBP
ICCAT GBYP BIOLOGICAL SAMPLING AND ANALYSES								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**initial date**	**final date**	**COST €**	**NOTES**
5	2015-2016	06b/2015	*Biological studies* - Fundación AZTI - Spain, as leader of a Consortium including 13 more institutions (1 Spain, 3 Italy, 1 Malta, 1 Morocco, 1 Croatia, 1 Ireland, 1 Turkey, 1 Portugal, 1 France (w/o budget), 1 Japan (w/o budget), 1 USA (w/o budget) (+ 7 subcontracts, 1 Croatia, 1 France, 1 Japan, 1 Italy, 1 Spain, 1 Turkey and 1 USA)	Haritz Arrizabalaga, e-mail: harri@azti.es	16/07/2015	19/02/2016	306.940,76 €	
		06b/2016	*Biological studies* - Necton Soc. Coop. a r.l. - Italy	Antonia Mangano, e-mail: info@necton.it	05/08/2015	31/01/2016	15.741,27 €	
ICCAT GBYP MODELLING APPROACHES								
PHASE	**YEAR**	**CALL FOR TENDERS or ACTIVITY**	**RETAINED PROPOSAL**	**main contact**	**initial date**	**final date**	**COST €**	**NOTES**
5	2015-2016	02/2015	*Modelling Approaches: Support to Bluefin Tuna Stock Assessment* - The University of British Columbia - Canada	Thomas Robert Carruthers, e-mail: t.carruthers@fisheries.ubc.ca	19/05/2015	23/02/2016	112.367,44 €	original cost 121.820,00 USD
		07/2015	*Modelling Approaches: Support to BFT Assessment – MSE-Modelling Coordinator* - Ph.D. Joseph E. Powers - USA	Ph.D. Joseph E. Powers, e-mail: jepowers@lsu.edu	21/04/2015	22/02/2016	32.911,51 €	original cost 36.000,00 USD
		cost reimburstment	*GBYP Core Modelling Group Meeting*	Antonio Di Natale, e-mail: antonio.dinatale@iccat.int	21/01/2016	23/01/2016	11.261,95 €	
		cost reimburstment	*Travel Costs for the Coordinator and the Expert*	Antonio Di Natale, e-mail: antonio.dinatale@iccat.int			18.349,62 €	

Annex 1b

GBYP contracts issued in the first part of Phase 6

ICCAT-GBYP CONTRACTS (PHASE 6 incomplete)

ICCAT GBYP COORDINATION

PHASE	YEAR	CALL FOR TENDERS or ACTIVITY	RETAINED PROPOSAL	main contact	working schedule initial date	final date	COST €	NOTES
6	2016-2017	01/2016	*Second review of the ICCAT GBYP* - MRAG Ltd. - United Kingdom	John Pearce, e-mail: j.pearce@mrag.co.uk	27/04/2016	30/07/2016	49.950,00 €	
		direct contract	*ICCAT GBYP Steering Committee external member - Ph.D. Tom Polacheck*	Tom Polacheck, e-mail: runningtide.tom@gmail.com	31/07/2016	20/02/2017	17.000,00 €	2.000 € for travel

ICCAT GBYP DATA RECOVERY

PHASE	YEAR	CALL FOR TENDERS or ACTIVITY	RETAINED PROPOSAL	main contact	working schedule initial date	final date	COST €	NOTES
6	2016-2017	02/2016	Data recovery plan - Marta Gonzales Herrera - Spain	Marta Gonzales Herrera, email: martaglezher@gmail.com	27/04/2016	08/07/2016	7.500,00 €	
		02/2016	Data recovery plan - Necton Soc.Coop. A r.l. - Italy	Antonio Celona, e-mail: info@necton.it	30/05/2016	08/07/2016	17.100,00 €	
		02/2016	Data recovery plan - Ricerca Mare Pesca s.c.a.r.l. - Italy	Marcello Bascone, e-mail: marcellobascone@libero.it	18/05/2016	08/07/2016	18.280,00 €	
		04/2016	Electronic tag data recovery -Board of Trustees of the Leland Stanford Junior University - USA	Barbara A. Block, e-mail: bblock@stanford.edu	15/07/2016	31/08/2016	50.000,00 €	
		10/2016	BFT Trade, market & auction data analyses - MRAG Ltd - United Kingdom	John Pearce, e-mail: j.pearce@mrag.co.uk		31/01/2017	27.475,00 €	

ICCAT GBYP TAGGING PROGRAMME

PHASE	YEAR	CALL FOR TENDERS or ACTIVITY	RETAINED PROPOSAL	main contact	working schedule initial date	final date	COST €	NOTES
6	2016-2017	03/2016	Tagging programme (Area A) - The Faculty of Fisheries, University of Istanbul - Turkey and Unimar Soc.Coop. - Italy	Saadet Karakulak, e-mail: karakul@istanbul.edu.tr; Adriano Mariani, e-mail: a.mariani@unimar.it	30/05/2016	31/07/2016	55.000,00 €	
		03/2016	Tagging programme (Area B) - Institut National de Recherche Halieutique - Morocco, as leader of consortium including one more Moroccan institution and one Spanish institution	Nouredinne Abid, E-mail: noureddine.abid65@gmail.com	30/06/2016	31/07/2016	116.125,00 €	
		03/2016	Tagging programme (Area C) - Centro di Competenza Sulla Biodiversita Marina- Italy, as leader of Consortium including one more Italian institution	Piero Addis, e-mail: addisp@unica.it	30/05/2016	31/07/2016	140.425,00 €	
		08/2016	Tagging programme (Area A) - Unimar Soc.Coop - Italy	Adriano Mariani, e-mail: a.mariani@unimar.it	15/07/2016	31/12/2016	77.655,00 €	
		08/2016	Tagging programme (Area B) - Tunipex S.A. - Portugal, as leader of consortium including one more Portuguese institution	Alfredo Poço, e-mail:E-mail: alfredo@tunipex.eu	01/08/2016	31/12/2016	27.500,00 €	
		05/2016	Tag awareness activities - Malvalanda SL - Spain	María del Puy Alvarado Landa, e-mail: tamara@malvalanda.com	23/06/2016	23/09/2016	63.000,00 €	

ICCAT GBYP BIOLOGICAL SAMPLING AND ANALYSES

PHASE	YEAR	CALL FOR TENDERS or ACTIVITY	RETAINED PROPOSAL	main contact	working schedule initial date	final date	COST €	NOTES
6	2016-2017	07/2016	Sampling for adults - AquaBioTech Ltd - Malta, as the leader of consortium including three more Maltese institution	Simeon Deguara, e-mail:dsd@aquabt.com	01/08/2016	10/02/2017	96.162,00 €	
		07/2016	Sampling for adults - Balfegó & Balfegó S.L. - Spain	Begonya Mèlich Bonancia, e-mail: bmelich@grupbalfego.com	01/08/2016	10/02/2017	34.898,00 €	
		07/2016	Sampling for adults - Taxon Estudios Ambientales S.L. - Spain, as a leader of consortium including one more Spanish institution	Antonio Belmonte Ríos, e-mail: antonio.belmonte@taxon.es	15/07/2016	10/02/2017	41.100,00 €	
		09/2016	*Biological studies* - Fundación AZTI - Spain, as leader of a Consortium including 13 more institutions (1 Spain, 4 Italy, 1 Malta, 1 Ireland, 1 Turkey, 1 Portugal, 1 Morocco (w/o budget), 1 France (w/o budget), 1 Japan (w/o budget), 1 USA (w/o budget) (+ 5 subcontracts: 1 France, 1 Italy, 1 Spain, 1 Turkey and 1 USA)	Haritz Arrizabalaga, e-mail: harri@azti.es		31/01/2017	404.683,00 €	

ICCAT GBYP MODELLING APPROACHES

PHASE	YEAR	CALL FOR TENDERS or ACTIVITY	RETAINED PROPOSAL	main contact	working schedule initial date	final date	COST €	NOTES
6	2016-2017	06/2016	Modelling Approaches: Support to Bluefin Tuna Stock Assessment - The University of British Columbia - Canada	Thomas Robert Carruthers, e-mail: t.carruthers@fisheries.ubc.ca	30/05/2016	21/02/2017	105.000,00 €	original cost 116.820 USD

Annex 2a

List of reports and scientific papers in GBYP Phase 5

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; 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 à 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 – Draft 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.

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 2b

List of reports and scientific papers in the first part of GBYP Phase 6

List of deliverables produced within the framework of GBYP contracts and activities in the first part of Phase 6 (mid-term reports will not be included in the final copies when the final report is available; interim reports cannot be published):

1. Coordination – August 2016: Second Review of the ICCAT Atlantic-Wide Research Programme on Bluefin Tuna , Final report, MRAG: 1-122
2. Data recovery –July 2016: Short-term contract for the data recovery plan (ICCAT/GBYP 02/2016), Final report. Marta Rodriguez:1-8
3. Data recovery –September 2016: Short-term contract for the data recovery plan (ICCAT/GBYP 02/2016), Final report. Necton: 1-3
4. Data recovery – 22 August 2016: Short-term contract for the data recovery plan (ICCAT/GBYP 02/2016), Final report, Ricerca Mare Pesca: 1-3
5. Biological studies – 4 August 2016: Short-term contract for biological studies – Sampling for adults (ICCAT/GBYP 07/2016-1), Preliminary report. Taxon: 1-5
6. Biological studies – 19 September 2016: Short-term contract for biological studies – Sampling for adults (ICCAT/GBYP 07/2016-2), Short report, AquaBioTech Ltd.:1
7. Biological studies – 16 September: Short-term contract for biological studies – Sampling for adults (ICCAT/GBYP 07/2016-3), Short report, Balfego & Balfego:1-3
8. Modelling approaches – 12 July 2016. Short-term contract for support to BFT assessment (ICCAT GBYP 06/2016), Progress report, Tom Carruthers: 1-6
9. Modelling approaches – August 2016. Simulation Testing A Multi-Stock Model With Age-Based Movement, (provided as SCRS/2016/144), Report. Tom Carruthers: 1-9
10. Modelling approaches – August 2016. Issues Arising From The Preliminary Conditioning Of Operating Models For Atlantic Bluefin Tuna, (provided as SCRS/2016/145), Report. Tom Carruthers: 1-9
11. Tagging – 1 August 2016. Short term contract for the Tagging programme 2016 (ICCAT/GBYP 03/2016 Task C), Final report. COMBIOMA: 1-28
12. Tagging – 15 July 2016. Short term contract for the Tagging programme 2016 (ICCAT/GBYP 03/2016 Area B), Final report. INRH: 1-29
13. Tagging – 29 July 2016. Short term contract for the Tagging programme 2016 (ICCAT/GBYP 03/2016 Area A), Final report, Istanbul University and Unimar: 1-24
14. Tagging – 20 September 2016. Short term contract for the Tagging programme 2016 (ICCAT/GBYP 08/2016, Area B), Final report. Tunipex: 1-21
15. Tagging – 20 September 2016. Short term contract for the Tagging programme 2016 (ICCAT/GBYP 08/2016, Area A), Short report. Unimar: 1-2

List of Scientific Papers – Phase 6

16. Brophy, D., Arrizabalaga, H., Fraile, I., Haynes, P., Kitakado, T., Hanke, A., 2016, Comparative Analysis of Individual Origin Assignments for Bluefin Tuna Sampled Within Gbyp. SCRS/2016/128
17. Quelle, P., Rodriguez-Marin, E., Ruiz, M., Gatt, M., Arrizabalaga, H., 2016, Age-Length Keys Availability For Atlantic Bluefin Tuna Captured in The Eastern Management Area. SCRS/2016/133
18. Rodriguez-Marin, E., Quelle, P., Ruiz, M., Busawon, D., Golet, W., Dalton, A., Hanke, A., 2016. Updated Comparison of Age Estimates from Paired Calcified Structures From Atlantic Bluefin Tuna. SCRS/2016/134
19. Hanke, A., Guénette, S., Lauretta, M., 2016, A Summary of Bluefin Tuna Electronic and Conventional Tagging Data, SCRS 2016/135
20. Tensek, S., Di Natale A., Pagá García, A., 2016, Iccat Gbyp Psat Tagging: The First Five Years. SCRS/2016/138
21. Pagá García, A., Palma, C., Di Natale, A., Tensek, S., Parrilla, A., De Bruyn, P., 2016, Report on Revised Trap Data Recovered by Iccat Gbyp Between Phase 1 To Phase 6. SCRS/2016/139
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Annex 3

List of meetings and activities attended by GBYP Coordination staff or external invited experts in the last part of Phase 5 and in the first part of Phase 6

No.	*date*	*place*	*Meeting or activity*	*Motivation*
1	26/09/2015	Madrid (SP)	GBYP Steering Committee Meeting	Review of Phase 5 activities and plans for GBYP Phase 6
2	28/09-02/10/2015	Madrid (SP)	SCRS Plenary	Overview of the GBYP activities
3	10-17/11/2015	Malta (MT)	24th Regular Meeting of the Commission	Overview of the GBYP activities
4	18-20/01/2016	Monterey (USA)	Bluefin Future Symposium	Report on GBYP activities
5	21-23/01/2016	Monterey (USA)	Meeting of the ICCAT GBYP Core Modelling MSE Group	Participation as member and supervision of the meeting
6	15-19/02/2016	Madrid (SP)	Meeting of the ICCAT Working Group on Stock Assessment Methods	Discussion about MSE approaches
7	25-29/07/2016	Madrid (SP)	Bluefin Species Group Intersessional Meeting	Presentation of GBYP data and analyses
8	30-31/07/2016	Madrid (SP)	GBYP Steering Committee Meeting	Review of Phase 6 activities and plans for GBYP Phase 7
9	8-11/09/2016	Isla Cristina (SP)	2016 (XVI) Meeting of Tuna Trap Captains	Report about the existing and potential bluefin tuna spawning areas for the eastern stock (nop)
10	12-14/09/2016	Madrid (SP)	ICCAT GBYP Workshop on bluefin larval studies and surveys	Discussions about the possibilities provided by larval studies for detecting trends
11	26-30/09/2016	Madrid (SP)	SCRS BFT Species Group	Overview of the GBYP activities, other BFT subjects

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