ICCAT-GBYP ACTIVITIES FOR IMPROVING KNOWLEDGE ON BLUEFIN TUNA BIOLOGICAL AND BEHAVIOURAL ASPECTS (ICCAT-GBYP PHASES 1 TO 3)

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SUMMARY

The Atlantic-wide research programme on bluefin tuna, conventionally GBYP, among several objectives, has the duty to improve the knowledge of bluefin tuna biology, ecology and ethology, with a particular attention to the identification of sub-populations. The results of the first three Phases were able to provide several new data about the behavior (by using electronic tags), the growth rates (by conventional tags), the genetic structure, the possible origin (by microchemistry analyses), the age-length correlations (by reading hard structures as otoliths and spines) and the maturity. The aerial survey were able to provide some first data about the distribution of spawners aggregations in some areas and their apparent abundance, while additional data sets (SST and waves) provided environmental parameters for developing a preliminary prediction model. These preliminary results will be possibly strengthened by the activities in following GBYP Phases.

RÉSUMÉ

Le Programme de recherche sur le thon rouge englobant tout l'Atlantique, dénommé conventionnellement « GBYP », a parmi plusieurs objectifs la mission d'améliorer les connaissances sur la biologie, l'écologie et l'éthologie du thon rouge, en accordant une attention particulière à l'identification des sous-populations. Les résultats des trois premières phases ont pu fournir plusieurs données nouvelles sur le comportement (à l'aide des marques électroniques), les taux de croissance (au moyen des marques conventionnelles), la structure génétique, l'origine éventuelle (par le biais des analyses de microchimie), les corrélations âge-longueur (par la lecture des structures osseuses comme les otolithes et les épines) et sur la maturité. Les prospections aériennes ont pu fournir les premières données sur la répartition des concentrations de reproducteurs dans certaines zones et leur abondance apparente, tandis que des jeux de données supplémentaires (SST et vagues) ont fourni des paramètres environnementaux pour l'élaboration d'un modèle de prédiction préliminaire. Ces résultats préliminaires seront éventuellement renforcés par les activités prévues dans les phases suivantes du GBYP.

RESUMEN

El Programa de investigación de atún rojo para todo el Atlántico, denominado GBYP, entre otros objetivos, tiene la tarea de mejorar los conocimientos de la biología, la ecología y la etología del atún rojo, prestando especial atención a la identificación de las subpoblaciones. Los resultados de las tres primeras fases pudieron proporcionar distintos y nuevos datos acerca del comportamiento (usando marcas electrónicas), las tasas de crecimiento (usando marcas convencionales), la estructura genética, el posible origen (mediante análisis de microquímica), las correlaciones edad-talla (leyendo las partes duras como otolitos y espinas) y la madurez. Las prospecciones aéreas pudieron proporcionar algunos de los primeros datos acerca de la distribución de las concentraciones de reproductores en algunas zonas y su aparente abundancia, mientras que otros conjuntos de datos (SST y olas) proporcionaron parámetros medioambientales para desarrollar un modelo de predicción preliminar. Estos resultados preliminares se verán probablemente reforzados por las actividades que se llevarán a cabo en las siguientes fases del GBYP.

KEYWORDS

Bluefin tuna, Large pelagic species, ICCAT, Biological analyses, Tagging, Genetics, Maturity, Microchemistry, Mediterranean Sea, Atlantic Ocean

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1. Introduction

The Atlantic-wide research programme for bluefin tuna was officially adopted by SCRS and the ICCAT Commission in 2008, after a long process. In 2003, as an input of the Working Group established by Rec. 02-11, SCRS presented the Commission with a research plan to improve knowledge on bluefin tuna, with a special focus on mixing between the two stocks (ICCAT, 2004, Col. Vol. Sci. Pap. ICCAT, 56(3): 987-1003). The various research elements included in this first proposal are still pertinent today, even if some other activities have been included in the following years. During the Marrakech Commission meeting (2008), the SCRS chair met with all the scientists present at the meeting and a detailed proposal was forwarded to the Commission. The proposal was adopted by the Commission in plenary (ICCAT Report 2008-2009 (I), 1: 40) and resulted in a first official document, Res.08-06, which covered only the 2004 SCRS proposal but under a broader title. At the same time, the Commission approved the STACFAD Report (ICCAT Report 2008-2009 (I), 1: 42), which included the agreement to endorse the Atlantic-wide research programme (ICCAT Report 2008-2009, (I), 1, Appendix 10 to Annex 9: 284-287), establishing three priorities in 2009 (Coordinator, data mining and Aerial surveys), other action to be further discussed by SCRS in 2009 and the provision for the programme to be adjusted in the following years taking into account the evolution of its implementation and research needs. The total budget of the programme was estimated at about 19 million Euros in 6 years. The same document reports the engagement of the European Community and some other Contracting Parties to contribute to this programme in 2009 and in the following years.

The SCRS, in 2009, reviewed the updated research proposal submitted by SCRS chair, as it was discussed and presented to the Commission at its meeting in 2008 (ICCAT Report 2008-2009 (II), 1: 224 and ICCAT Report 2008-2009 (II), 2: 223-224). The SCRS indicated the priorities identified in the 2008 document, as follows:

a) Improve basic data collection through mining (including information from traps, observers, and VMS), developing methods to estimate sizes of fish caged, elaborating accurate CPUE indices for Mediterranean purse seine fleets, development of fisheries-independent information surveys and implementing a large scale well planned conventional and genetic tagging experiment;
b) Improve understanding of key biological and ecological processes through electronic tagging experiments to determine habitat and migration routes, broad scale biological sampling of live fish to be tagged and dead fish landed (e.g. gonads, liver, otoliths, spines, etc.), histological analyses to determine bluefin tuna reproductive state and potential, and biological and genetics analyses to investigate mixing and population structure; ecological processes, including predator-prey relationships;
c) Improve assessment models and provision of scientific advice on stock status trough 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.

A number of Contracting Parties expressed a willingness to make extra-budgetary contributions to such a programme with a view towards initiation of activities in 2009; the Commission, in 2009, set a very clear list of priorities for the GBYP: programme coordination, data mining, aerial surveys, and tagging design studies, with additional research activities to be undertaken in the following years.

The first phase costs were set at 750,000 Euro and voluntary contributions sufficient to initiate the year 1 activities were jointly committed by the European Community, United States, Japan, Canada, Norway, Croatia, Turkey and Chinese Taipei, while Morocco indicated its interest in future contributions. The provision to accept additional contributions from various entities and private institutions or companies was also agreed. In the same document, it was recommended to form a Steering Committee comprised by the SCRS Chair, the ICCAT Executive Secretary or his/her Assistant, bluefin tuna rapporteurs, and an outside expert with substantial experience in similar research undertakings for other tuna RFMOs, to guide and refine the Programme as necessary.

The first phase, officially initiated on October 22, 2009 for 12 months, had a prorogation of 2 months for completing the works already planned. The prorogation of the EC Grant agreement SI2.542789 was provided after a specific request by the GBYP Steering Committee thought an amendment to the agreement provided by the European Commission on October 10, 2010; the termination of GBYP-Phase 1 was set on December 12, 2010.

Originally, the costs of GBYP Phase 2 were 3,390,000 Euro (ICCAT Commission, 2008), then 5,845,000 euro (ICCAT Commission and STACFAD, 2009) and finally 3,476,075 Euro (GBYP Steering Committee, 2010). The final budget reduction, due to the availability of funding by the various CPCs, induced the cancellation of some research activities (i.e.: eggs and larval survey) and the limitation of other research activities (i.e.: tagging and biological sampling). Several ICCAT CPCs confirmed their engagement for funding the GBYP, either with financial contributions or in-kind, but the SCRS recommendation to provide a dedicated quota for improving the financing of the programme was set aside, because it was not studied enough to be adopted by Panel 2 (ICCAT Report 2010-2011, vol. 1, page 267). The costs of the second Phase were then finally set at 2,502,000 Euro.

The second phase (12 months) officially initiated on December 22, 2010, after the signature of the Grant agreement for co-financing the GBYP Phase 2 (SI2.585616) by the European Commission. Phase 2 had two prorogations, the first up to April 22, 2012, and the second up to May 22, 2012. The co-funding for GBYP Phase 2 was committed by United States, Turkey, Libya, Japan, Morocco, Canada, Norway, Croatia, Chinese Taipei and the ICCAT Secretariat. The provision to accept additional contributions from various entities and private institutions or companies was also confirmed and additional funds were provided[2], mostly in kind or specifically devoted to individual activities.

The budget for GBYP Phase 3 in the original research plan approved by the Commission in 2008 (confirmed also by ICCAT Commission and STACFAD in 2009) was set at 5,845,000 Euro, then increased at 6,183,776 Euro by the GBYP Steering Committee in 2010 and revised at 4,417,980 Euro by the SCRS in 2011. Again, all tentative for putting in place a different and more stable funding structure for the programme were unsuccessful and finally the available budget for GBYP Phase 3 was set at 1,925,000 Euro, with a serious reduction of the field activities and the suspension of some of them.

Due to the extension of Phase 2, the third phase (7 months) officially initiated on June 20, 2012, after the signature of the Grant agreement for co-financing the GBYP Phase 3 (SI2.625691) by the European Commission. The proposal to extend Phase 3 by 1-month for operative needs was not endorsed by the GBYP Steering Committee and then Phase 3 officially ended on January 19, 2013. In addition to the EU Contribution, the co-funding for GBYP Phase 3 was committed by United States, Turkey, Libya, Japan, Morocco, Canada, Norway, Croatia, Chinese Taipei and the ICCAT Secretariat. The provision to accept additional contributions from various entities and private institutions or companies was also confirmed[3].

For the first time, the GBYP used the provisions of Rec.11-06 concerning the Research Mortality Allowance (RMA). This RMA was essential for carrying out both tagging and biological sampling activities. In total, only 5,039.5 kg of BFT were used (equal to 662 BFT individuals) over a total of a maximum of 20,000 kg (Deliverable A). The RMA was followed in real time by the GBYP staff and all forms were closely checked and immediately registered.

In conformity with the Atlantic-Wide Bluefin Research Programme (GBYP) adopted by the SCRS and the Commission for Phase 3, the following research initiatives have been conducted or initiated, in addition to the data recovery and data mining.

2. Aerial survey on bluefin tuna spawning aggregations

The aerial survey on bluefin tuna spawning aggregation was suspended by the GBYP Steering Committee in Phase 3.

A SWOT analyses was carried out by the GBYP Coordination for assessing two alternatives (aerial survey on juveniles versus spawners), because a study was recommended by the GBYP Steering Committee for Phase 3, but there was no budget availability. The results were presented to the SCRS in 2012 (SCRS/2012/140). The analyses resulted in higher opportunities and strengths for the aerial survey on spawners, confirming the motivation of the choice made by both the SCRS and the ICCAT Commission when the GBYP was adopted.

[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) and, in kind, by Balfegó Grup (SP), IEO–Fuengirola (SP); INRH –Tangier (MO), Maromadraba SARL and Es Sahel (Fuentes Group)(MO), Roberto Mielgo Bregazzi (SP) and WWF Mediterranean Programme.

[3] Additional contributions in kind to GBYP were provided by INRH –Tangier (MO), Maromadraba SARL and Es Sahel (Fuentes Group)(MO), Roberto Mielgo Bregazzi (SP), WWF Mediterranean Programme and by Dr. Antonio Di Natale.

A further study concerning the aerial survey was carried out at the end of Phase 3 under the Modelling approaches (see paragraph 6.2.4).

Aerial Survey activities were resumed in Phase 4. The aerial Survey design report, reports from each contractor and final reports can be found in http://www.iccat.int/GBYP/en/asurvey.htm.

3. Sea-Surface Temperature (SST) data and environmental data

The GBYP Steering Committee decided to suspend in Phase 3 the acquisition of detailed SST data initiated in previous Phases, which covered the period 2010 to 2011. These data have been used for elaborating the spatial model of the aerial survey data and can be used for adding reliable environmental data to advanced models in future assessments.

For overcoming the problems caused by this decision, the GBYP Coordination decided to independently collect free data sets, concerning daily SST maps and daily wave maps (**Figure 1**), but no numerical data sets are available. These images were collected daily directly by the GBYP Coordination staff from two very reliable sites (the Mediterranean Ocean Forecasting System and the Mediterranean Wave Forecast), without any impact on the budget. The full collection is available on the GBYP data files.

These data sets are essential for understanding the fishing possibilities for some gears and for confirming the field observations about the presence of spawning tunas in some areas.

4. Elaboration of VMS data

The analyses of VMS data was among the objectives of GBYP data recovery activities. A very preliminary tentative of analysing VMS data was carried out in 2012 and the document SCRS/2012/125 is included among the scientific documents of GBYP Phase 3.

5. Tagging

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 about the tagging activities carried out under the GBYP contract in Phase 3 are available on http://www.iccat.int/GBYP/Documents/TAGGING/PHASE%203/GBYP_TAGGING_FINAL_REPORT_PHASE_3.pdf and are included in Deliverables D1.1 (issued on March 21, 2011), "All Tasks.1" (issued on July 31, 2011), D1.2 (issued on July 31, 2011), D2.1 (issued on October 11, 2011) and D2.2 (issued on June 22, 2012).

For Phase 4, the GBYP Steering Committee recommended to extend conventional tagging to BFT adults in some areas, particularly in north-west African coast (Moroccan traps), in west Mediterranean (Italian traps, Sardinia) and in the Tyrrhenian Sea (Italian Purse seiner), while tagging for BFT juveniles be limited to Bay of Biscay and Strait of Gibraltar (Spanish bait boats). The first set of reports concerning the tagging activities in Phase 4 (up to 15 September 2013) is available in the Phase 4 folder on http://www.iccat.int/GBYP/en/tagging.htm .

5.1 Tagging activities

The tagging activity in Phase 3 was defined by the Steering Committee on 7-8 February 2012 and then refined on 20-21 March 2012, adopting the strategy to use exclusively baitboat vessels and to have a tagging coordinator for following the field activities in real time and maintaining a continuous contact with the GBYP coordination. The Call for tenders was issued on March 26, 2012, anticipating the official beginning of Phase 3 for allowing the field activities to start on time. The contract was awarded on June 21, 2012, to a Spanish Consortium of nine partners (Spain) and 5 sub-contractors, headed by AZTI.

The Consortium encountered several problems for tagging, particularly in the western and central Mediterranean Sea, mostly due to causes of "*force majeure*" (bad weather conditions, accidents and absence of juvenile tunas at the surface when the vessels where on site), but also partly due to some mistakes in the strategy adopted by the taggers. The ICCAT-GBYP tagging activities in Phase 3 are summarized on **Table 1**.

In terms of the Phase 3 tagging objectives by area, the Consortium successfully reached 102 % in Bay of Biscay, while it failed in both Central Mediterranean and Gulf of Lions with 5% and 9%, respectively. In the Strait of Gibraltar it reached barely 46% of the objective.

The Steering Committee, in December 2012, adopted a different tagging strategy for Phase 4, keeping the baitboat tagging only in the Bay of Biscay and in the Strait of Gibraltar, while pilot activities were planned in traps for tagging adults (both in Morocco and Sardinia), with purse seine for adults in the Tyrrhenian Sea and with purse-seine and cages in the Adriatic Sea. The contracts were provided to a Spanish Consortium headed by AZTI for the baitboat-based tagging, to an international consortium headed by INRH with the participation of WWF MedPO for the Moroccan traps, to an Italian consortium headed by COMBIOMA for the Sardinian traps, to an Italian consortium headed by UNIMAR for the purse-seine based tagging in the Tyrrhenian Sea and to a Croatian Company, Kali Tuna, for the purse-seine based tagging in the Adriatic Sea. At the moment of this report several activities are still going on and the most updated date are showed on **Table 2**.

In total, at the moment, the total number of bluefin tunas tagged so far in all Phases of GBYP are 14890, and a total of 21996 tags have been implanted (**Table 3**).

The ICCAT-GBYP electronic tagging with mini-PATs was carried out on juveniles in the Bay of Biscay and in the Strait of Gibraltar in Phases 3 and 4, on juveniles in the Adriatic Sea in Phase 4 only and on adults in the Moroccan Atlantic in Phases 2, 3 and 4. GBYP internal archival tags have been implanted so far in the Bay of Biscay, in the Strait of Gibraltar and in the Adriatic Sea. Most of the results for Phases 2 and 3 have been already provided to SCRS and the Commission in 2012. Further results were provided to the Tenerife Meeting in May 2013, while the most updated ones are included in the present report.

It is important to note that several premature detachments[4] were noticed for mini-PATs since the beginning; 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. The full analyses of these premature detachments will be possibly provided at the end of Phase 4.

The preliminary maps of the mini-PATs deployed by GBYP in the various areas and popped-off in the last part of Phase 3 and in the first part of Phase 4 are on **Figures 2** to **7**. The data from tags which transmitted corrupted data or those staying for less than 10 days at sea are not included in those figures. The most recent data concerning tag pop-off in Phase 4 which have not been processed up to 15 September 2013 are showed on **Figure 8**.

The juvenile tunas electronically tagged in the Bay of Biscay are confirming that their movements in the short period are usually so extended, while one specimen showed extensive movements over a longer period of time. The juveniles electronically tagged in the Gulf of Lion shows a permanence in the Western Mediterranean Sea; only one specimen moved towards the Southern Mediterranean area, possibly for its first spawning.

Those juveniles and young bluefin tuna electronically tagged in the Strait of Gibraltar had many varieties of movements and for this reason it was decided to present two different figures, one for those staying closer to the Strait of Gibraltar (**Figure 4**) and one for those having more extensive movements (**Figure 5**): some of these latters reached well-known spawning areas.

The adult pre-spawners which were tagged in the Moroccan traps showed a general behavior very similar to the one noticed in Phase 2 and Phase 3: a considerable percentage of individuals did not enter into the Mediterranean Sea for spawning during the spawning season and remained in Atlantic areas. The preliminary data analyses of some selected tags presented during the Tenerife meeting showed the relevance of this tagging activity either for confirming spawning behavior evidences or for calculating the time at the surface. This last point is very useful for better calibrating the aerial survey data in future analyses, as it was originally planned.

[4] The full analyses will be carried out in next months, because in some cases it is not clear if the premature detachment was a real one or a catch.

This year, for the first time within the GBYP activities, a first tentative trial of implanting pop-up tags in juveniles in the Adriatic Sea was enforced and the results will be analysed whenever all data will be available.

It will be particularly important to investigate the behavior and the origin of the fish going to Moroccan traps before getting there and particularly in the last part of winter and the first part of spring. Anecdotic information collected by GBYP confirms that bluefin tuna is distributed in several parts of the southern Atlantic Ocean, but scientific data are missing for various reasons.

The analyses of all mini-PATs released up to the date will be available at the end of Phase 4.

5.2 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 13,000 posters of various sizes (A1, A3 and A4) and more than 15,000 stickers were produced so far; all posters are also available on the ICCAT-GBYP web page. A capillary distribution of the tag awareness material was carried out, sending copies to all stakeholders such as: Government Agencies, scientific institutions, tuna scientists, tuna industries, fishers, sport fishery federations and associations and the RFMOs and RACs concerned; the coverage was complete in the ICCAT Convention area, including also non-ICCAT countries and those countries or entities fishing in the area. The map clearly shows the distribution effort (**Figure 9**). The ICCAT-GBYP web page has the full list of contacts http://www.iccat.int/GBYP/en/AwCamp.asp.

GBYP has carried on with the awareness campaign activities in Phases 3 and 4. According to the first data, this activity is a starting to provide better tag reporting results.

5.3 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 is contributing for providing better tag reporting results.

5.4 Tag recovery and tag reporting

This activity is the final result of the activities listed in points 5.3 and 5.4. 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.

The first report of ICCAT-GBYP tag recovery activities is provided on document SCRS/2013/177. While examining the results of the ICCAT-GBYP tag recovery/reporting activities, it is very important to consider that 92.3% of the conventionally tagged fish in Phases 2 and 3 were juveniles (age 0-3); 70.5% 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. Up to the 15th of September 2013, there have been 109 tags recovered (74 deployed by GBYP and 35 deployed by other tagging programmes) **(Table 4)** as follow:

76 Conventional “Spaghetti” tags
19 Conventional “Double/Single barb” tags from double tagged fish
10 External Electronic “mini-PATs” tags
3 Internal Electronic “Archivals” tags
1 Commercial “Trade” bluefin tuna tag.

The tags were recovered by area as follow:

East Atlantic:	53 tags (48.6%): 32 Spaghetti tags, 16 double tags and 5 miniPATs,
Mediterranean Sea:	47 tags (43.1%): 40 Spaghetti, 3 double tags, 3 miniPATs and 1 Archival,

North Atlantic: 4 tags (3.7%): 2 Spaghetti, 1 Archival and 1 Trade,
West Atlantic: 3 tags (2.8%): 2 Spaghetti ones and 1 Archival,
Unknown area: 2 tags (1.8%), all miniPATs[5]

The important tag reporting improvement registered after the beginning of the tagging and tag awareness activities by ICCAT-GBYP is impressive: the average recovery for the period 2005-2010 was only 2 tags per year, while the average of the GBYP tagging activities (2011, 2012 and part of 2013) provides an average of 33 tags per year, with 1550% increase. The year 2012, the first after the tag awareness activity, had a total of 54 tags reported to ICCAT, about 50% of the total over the whole period. It is possible that 2013 recoveries will be at a similar level at the end of the year. This is the clear evidence that GBYP tag awareness campaign is producing positive effects.

6. Biological and Genetic Sampling and Analyses

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_Sampling_Plan_GBYP_2011.pdf. Some of the activities concerning the biological sampling and analyses have been already preliminary presented to SCRS and the Commission in 2012. This report includes the final results of Phase 3 activities.

6.1 Activities

Phase 3 activity was clearly able to accomplish its objective (**Table 5**). Of course, the activities in following Phases of GBYP are set for completing and improving the preliminary results and for better defining some issues, such as mixing between the two current stocks and the sub-population hypothesis, which may require several years of data and many analyses, depending on the available budget.

The biological activities for Phase 3, carried out by an international Consortium headed by AZTI including 12 institutions and 5 subcontractors was reported in detail Deliverable D (issued on February 17, 2013). All activities for the biological studies in Phase 3 (final report) are now available on http://www.iccat.int/GBYP/Documents/BIOLOGICAL%20STUDIES/PHASE%203/Bio_Consortium_FinalReport_GBYP_Phase3.pdf.

As requested by the Bluefin tuna Species Group, the SCRS and the GBYP Steering Committee, an SCRS meeting was organized in May 2013 in Tenerife for reviewing the bluefin tuna biological parameters and the report is available on http://www.iccat.int/Documents/Meetings/Docs/2013-BFT_BIO_ENG.pdf. The results are also on documents SCRS/2013/080, SCRS/2013/089, SCRS/2013/94, all presented at the Tenerife meeting.

The total number of samples was higher than the target (141%); an achievement made possible thanks to the ICCAT Rec.11-06, which allowed collecting samples even outside the fishing season. Additional 150 biological samples collected by the Libyan scientists are not included in the official report provided by the contractor. GBYP was informed by one member of the Consortium that these Libyan samples were moved to Malta and stocked there in the last part of 2012. They will become available for the analyses in Phase 4 and officially included in the biological data base. The late beginning of the activity had particularly affected the gonads sampling of mature gonads, because the spawning period was already initiated when the activity was conducted. Additional technical and logistic problems were noticed by the Consortium, particularly for sampling juveniles in Malta and for exporting the samples from Turkey.

Among the most relevant results, the genetic analyses are clearly showing and confirming the genetic characteristics and difference between the specimens from the Western Atlantic and the Eastern Atlantic. After the studies carried out in 2011, the additional results obtained in 2012 seem able to better identify at least two sub-populations inside the Mediterranean (**Figure 10**): one temporarily called “Western Mediterranean” (which includes tunas from the western and central Mediterranean, including the Adriatic Sea) and the other temporarily called “Eastern Mediterranean” (which is possibly generated by the ancient sub-population of bluefin tuna which inhabited the Black Sea and the Marmara Sea up to the ‘70s and which possibly displaced in the Eastern Mediterranean after the ecological crisis of the Black Sea). The analyses showed a problem among age 0 fish from the Eastern Mediterranean, because there was a Western Mediterranean component, which created a discrepancy with the full Eastern Mediterranean identification of the bluefin tuna larvae.

[5] These are tags reported after a long fishing campaign, and the recovery location was not available. The location will be defined when the manufacturer will be able to recover the data stored inside the tags.

In this case, the broader view of GBYP is able to provide a possible justification, thanks to the aerial survey carried out in 2011 and the environmental data collected daily in the same period. According to these field observations, an anomalous oceanographic condition, coupled with strong winds south of Malta, caused the presence of a large area of stable hot waters in the western part of the Eastern Mediterranean, between Cyrenaica and the southern part of Italy and the western part of Greece. In this area, the stable conditions of hot surface waters allowed for a deep surface thermocline; this fact induced a considerable number of bluefin tuna spawners, usually spawning in the central Mediterranean, to move eastward and possibly spawn in this large area north of Cyrenaica. This opportunity possibly caused the presence of some "western Mediterranean" age 0 fish in 2012 in areas where "Eastern Mediterranean" tunas were usually distributed (the right food chain is anyway available for juvenile bluefin tuna even in that area, where there is traditionally a high availability of small pelagic species).

Even if further analyses are necessary for confirming and more precisely define the various sub-populations, it is clear that the availability of information from many different sources (aerial survey, environmental data, genetics, microchemistry, etc.) may sometimes contribute in increasing our understanding of the results of sophisticated analyses.

The microchemistry analyses, carried out on 897 otoliths (600 from Phase 2 and 297 from Phase 3), also provided again very useful and interesting results, further discriminating the two main bluefin tuna populations according to the individual origin of each fish: western and eastern Atlantic Ocean. During GBYP Phase3, the baseline historically used to estimate mixing proportions was updated and improved, and both Phase 2 (n=600) and Phase 3 (n=400) samples were re-analyzed using the new baseline. Of the 400 otoliths analysed in Phase3, 297 correspond to mixed areas and the rest (103) correspond to the baseline estimates. The results are given as percentages (**Figure 11**).

It is very interesting to further define the results according to the scientific knowledge on the distribution, biology and ethology of Atlantic bluefin tuna. As a matter of fact, the results from the Central-North Atlantic confirm the current knowledge, which shows a partial mixing of the Western and Eastern bluefin tuna. The data of the Bay of Biscay show an almost total presence of juveniles from the Eastern Atlantic stock, with very marginal components of Western Atlantic migrants. The samples collected in Moroccan traps (East Atlantic-West African coast) are extremely interesting, because they show a major Western Atlantic component which is not well known in terms of migration; adding to these data the results of the electronic tagging and the doubts about the bluefin tuna living in South Atlantic, it is very clear that this area needs much more attention in future years and the sampling should be strongly improved, aiming at improving our understanding of the various components. The results from the various areas of the Mediterranean Sea show a total component of East Atlantic bluefin tuna, except, in 2012, for a marginal component of Western Atlantic tuna in the inner part of the Mediterranean, the Turkish area. Even if it is difficult to clearly identify the reason for this presence, looking at the historical distribution of the tuna traps, it is evident that, at the beginning of the XX century, there were some traps in East Libya and in Egypt fishing for bluefin tuna coming at least from the Western Mediterranean and these tunas, in the traps of Tripolitania, had also an undefined component coming from the Atlantic through the Strait of Gibraltar. Then, it is not impossible that a tuna from the Western Atlantic may reach from time to time even the extreme Eastern Mediterranean. Of course, it will be necessary in next years to increase both sampling and tagging, for better defining also this situation and the possible mixing rate.

The ageing analyses provided a second GBYP data set for age-length key (ALK), in addition to the set obtained in 2011, which can be used in future assessments, together with all other available ALK data. The ageing analysis in 2012 was carried out on 315 samples (more than the target of 250): 157 age determinations were carried out by using otoliths and 158 by using spines. Many additional samples (a total of 1789 otoliths and 1443 spines) have been collected and those not used for the analyses in 2012 were stocked together with previous samples collected in 2011 for future analyses. The target objective for sampling 10 specimens by 10 cm length range was nearly achieved, but not for all age classes. **Figure 12a** shows the ALK obtained from otoliths, while **Figure 12b** shows the ALK from spines. **Figure 13** provides the comparison between ALK from otoliths and spines.

The gonads analyses were carried out on 158 samples, from the 351 ovaries and testes collected which represent more than the target and almost the double of the samples collected in 2011, but only a portion of these samples were collected just before, during or just after the usual spawning period. Sampling in some traps provided biased results, because the tunas were kept inside the trap for several weeks, due to quota issue. The results obtained in 2012 are confirming again most of the current knowledge about the spawning season of the eastern Atlantic stock. In future years, sampling well outside the usual spawning season should be avoided. A continuous sampling immediately before, during and after the main spawning season in various areas may

confirm extended or non-typical spawning seasons in some years, when the oceanographic conditions show this possibility.

The closing administrative procedures for Phase 3 biological studies have been extremely delayed by some members of the Consortium, creating many problems for releasing the contract for Phase 4. Samplings and analyses are continuing in Phase 4, carried out by all institutions already engaged in tagging activities in the various areas. A Call for tenders for both sampling and analyses was issued in 6 March 2013, receiving one offer from a large Consortium of 13 entities and 7 sub-contracted entities, belonging to 13 countries.

7. Modelling approaches

The ICCAT-GBYP activity on Modelling Approaches in the last part of Phase 3 and the first part of Phase 4 strictly followed the course recommended by the GBYP Steering Committee, endorsed by ICCAT-SCRS and approved by the ICCAT Commission.

Four contracts have been awarded under the Modelling Programme in support of BFT Stock Assessment: I) Qualitative & Quantitative Risk Assessment, II) Statistical conversion of catch-at-size to catch-at-age, III) Auto-regressive imputation of catch-at-age data and IV) Statistically-based stock assessment methods to be used for raising reported catch data. No bids were submitted for the Call for tenders concerning the Development of biological hypotheses for the use of MSE (Management Strategy Evaluation).

In addition to these three contacts, one more contract was awarded to an external expert after the GBYP Steering Committee meeting in December 2012: Assessment of the feasibility of a large-scale aerial survey of BFT spawning aggregations in all the Mediterranean Sea for obtaining useful fishery-independent indices for the purpose of Operating Models.

The reports are included in Deliverables E.1 (presented to SCRS in 2012), E.2 (received on January 8, 2013), E.3 (received on January 21, 2013), E.4 (received on January 18, 2013) and E.5 (received on January 15, 2013).

In Phase 4, two meetings were held on modeling approaches: a first one in May 2013 in Tenerife for preparing a first discussion draft document (see: http://www.iccat.int/GBYP/Documents/MODELLING/PHASE%204/tenerife_Modelling.pdf, and http://www.iccat.int/GBYP/Documents/MODELLING/PHASE%204/Tenerife_gbyp-modelling_draft_proposal.pdf) and a second in July in Gloucester, where a detailed planning of bluefin tuna modeling activities have been agreed for the submission to SCRS (see the report on http://www.iccat.int/Documents/Meetings/Docs/2013_BFT_METHODS_REP_ENG.pdf .

7.1 Phases 3 and 4 activities for modelling in support of BFT stock assessment

All reports concerning Modelling approaches in Phase 3 are already available on http://www.iccat.int/GBYP/en/modelling.htm .

7.1.1 Risk analysis

The objectives of this work package are to identify the main sources of uncertainty related to stock assessment and management. The risk analysis conducted under Phase 2 identified the main sources of uncertainties of concern to members of the SCRS. Under Phase 3 this work was extended to managers.

For Phase 4 the risk analysis will be quantitatively modeled using the initial qualitative work carried out during Phase 3. The development of such a quantitative risk analysis is to evaluate the relative importance of the different sources of uncertainty. In particular in helping to design scenarios used in the management strategy evaluation of the alternative management procedures with respect to meeting management objectives.

7.1.2 Catch data

Three non-parametric stochastic imputation approaches that provide a means of imputing Atlantic bluefin tuna length frequency data are described and tested by cross-validation.

The multivariate normal 'distance' model that randomly imputes data using a multinomial probability function, offered the best predictive capacity by some margin. All imputation methods operate most successfully when nearby (in time and space) length observations are imputed preferentially.

The multivariate normal imputation approach described offers a basis for quantifying uncertainty from data processing by means of repeated-imputation inference (running multiple stock assessments from multiple imputed data sets).

By imputing data that are specific to time and region, the approach offers the basis for applying multiple growth curves (for cohort slicing for example) where applicable. Additionally, uncertainty from aging may be simultaneously incorporated into the same repeated-imputation inference framework. A number of patterns in the data provide evidence of possible errors in the Task II dataset for Atlantic bluefin tuna, for example, identical length samples replicated in adjacent areas and times.

While the imputation approach appears to perform reasonably well (assuming the data are reported correctly) future improvements could include the incorporation of greater variability among imputations and further optimization of code to improve computation time (by extending the code to be compatible with parallel processing packages, for example).

7.1.3 Conversion of size to age

This contract reviewed the available methods for estimating catch-at-age data from catch-at-size information. Two main groups of methods were considered, i.e. those based on the classic Age-Length Key (ALK) method, for which the ALKs produced can only be applied to the same population from which the catch-at-size samples were drawn, and those based on the inverse ALK method, which don't have this restriction.

A total of 7 methods were considered, and are described on the paper that accompanies the report. The methods will be used during the next BFT SCRS data meeting in May 2013 to evaluate the benefits of different stock assessment methods and biological sampling programmes.

7.1.4 Use of aerial survey data for operating models

According to a specific request of the GBYP Steering Committee, this contract assessed the feasibility of a large-scale survey on bluefin tuna spawning aggregations in all the Mediterranean Sea for obtaining useful data for operating modeling purposes.

A key assumption is the relationship between effort and CV. If there is no over-dispersion, CV = sqrt(n)/n, where n is proportional to effort. The study assumed that variance of n is 2 x n to account for some over dispersion but this is simply a scalar here. Therefore, CV is proportional sqrt(effort)/effort. This relationship should be explored more fully and empirically using re-sampling methods by first combining the data from the original replicates and then re-calculating the variances.

There are factors that influence additional variance (e.g. due to variability in availability due to proportion of schools at the surface) and among them some will be related to environmental conditions and other factors that will vary spatially and temporally.

Another problem with the choice of scenario is that the analysis assumes that there is perfect knowledge already of the density outside the area. This is not the case. A better procedure would have been to calculate CVs for each survey design based on the different scenario, i.e. the CV that would be expected if the scenario on which that design was based was wrong but one of the other scenario was right, i.e. the risk of a specific design with the wrong scenario. This resulted in a matrix of CV's. This also means that using an adaptive survey design may be useful since after a few years the densities outside the areas will be better known, factors affecting the CVs due to school size and sighting should be better understood, and the population structure hypotheses developed, all of which will influence the optimal design.

Also for operational reasons the survey design is likely to change from that used in the report. While this would not be expected to change the general conclusions it will require the analysis to be re-conducted prior to a survey going ahead.

In this study it is assumed that the survey will be used as an index of abundance independently of a stock assessment model. However, the GBYP will hopefully develop new stock assessment methods which would use the index as an input in which case the power to detect trends may be improved.

The study provided the necessary inputs and scenarios to the GBYP Steering Committee (on the basis of the best available data and assumptions) for adopting the recommendation for Phase 4 activities.

7.2 Further actions on modeling

A Call for tenders was issued in Phase 4, including three activities: a) quantitative risk assessment, b) a study on statistically based stock assessment methods and, c) development of biological hypotheses for the use within MSE. Two contracts were awarded and the results should be available at the end of Phase 4.

An outlining of future modelling activities is being developed (in the form of a EU FP7 Framework Project Document), in which objectives, milestones and deliverables are presented. In this document the work in subdivided into work packages with clear responsibilities for the GBYP, SCRS and the ICCAT Secretariat. The main work to be done in Phase 4 is to develop an Operating Model (OM) for use as part of Management Strategy Evaluation (MSE). The plan was recommended by the Gloucester meeting (see document http://www.iccat.int/Documents/Meetings/Docs/2013_BFT_METHODS_REP_ENG.pdf) and will be discussed by SCRS.

8. Legal framework

The rules set by ICCAT Rec. 11-06, which allows for a "research mortality allowance" (RMA) of 20 t for GBYP and for the use of any fishing gear in any month of the year within the ICCAT Convention area for GBYP research purposes and the further provisions set by the ICCAT Secretariat (Circular #2296 on May 22, 2012 and Circular #2779 on May 28, 2013) are now helping the ICCAT-GBYP in a substantial manner.

9. Recommendations

The various GBYP operational meetings, GBYP Steering Committee and the SCRS provided a list of recommendations on various issues; several of them are essential for fulfilling the duties.

In addition, GBYP considers essential better defining the following points:

a) Evolution of the Atlantic-Wide Research Programme for Bluefin Tuna: according to the current situation, which demonstrated the impossibility to reach the funding level approved by the ICCAT Commission in 2009 for the various years of the GBYP and, as a consequence, the impossibility to carry out the various activities as originally planned, a programme revision is then necessary, finding the right balance among funding possibilities, research needs and duration. The funding system shall be better defined and improved.
b) Aerial survey: the suspension caused by the impossibility for budget shortage to carry out this activity (but covering the full Mediterranean, as requested by the GBYP Steering Committee) contemporary with other activities in 2012, questioned also the objective, the strategy and the time frame; GBYP presented a SWOT analyses to the SCRS in 2012, but it had no follow-up; the study conducted in the last part of Phase 3 showed different possible scenarios. The Steering Committee is still requesting a Mediterranean comprehensive survey in 2013 and the final decision will be taken according to the availability of permits. The previously surveyed areas represent the zones where spawners mostly aggregate in the last decades and 12% of the total potential spawning area in the Mediterranean Sea.
c) Tagging: the first year (Phase 2) can be regarded as a complex large scale experiment; the strategy adopted for Phase 3 was used for testing a different strategy and approach, which resulted in a further revision of the field approaches. Tagging in Phase 4 will be conducted according to the recommendations provided by the GBYP Steering Committee, on fourth major issues. It would be necessary to possibly extend the tagging activities to other areas (such as the Eastern Mediterranean Sea), always considering the budget constraints and the permits issue. The electronic tag activities should be improved, particularly in Eastern Mediterranean, the Atlantic Moroccan coast and possibly even in South Atlantic). The tag awareness activity shall be firmly continued, improving media communication.

d) Biological and genetic sampling and analyses: according to the current situation, it is clear that it was impossible to analyse all samples which have been collected (due to budget limits), while it is also clear that it will be necessary to apply all possible efforts for getting samples from areas not sampled so far (mostly the North African Mediterranean area, the SE Mediterranean area and the Central-South Atlantic) even if not always easy. The number of analyses shall be strongly increased in Phase 4. A medium term strategy is needed.
e) Modelling: new additional efforts should be devoted for finding the best approaches for using fishery independent data and innovative approaches for better quantify uncertainties. The meeting in Phase 4 should possibly better define opportunities and limits.

10. Acknowledgments

The GBYP would like to warmly acknowledge the very supporting efforts made by all the colleagues of the ICCAT Secretariat staff for allowing the Atlantic-Wide Research Programme for Bluefin Tuna to stay on schedule, besides of the few time available for carrying out all the necessary duties, sometimes under a very short notice. In particular, the GBYP caused a considerable increase of workload to the ICCAT Administration and the translators and we would like to officially acknowledge the continuous, professional and generous support we are still having. The GBYP also acknowledges the strong collaboration of the GBYP Steering Committee, who responded very often in real time, particularly on very difficult scientific and practical issues.

Annex 1

List of deliverables and scientific papers produced by ICCAT-GBYP in Phase 3

List of internal deliverables:

A. Report on the use and enforcement of GBYP Research Mortality Allowance in Phase 3: 1-9.

B.1a Report on the ICCAT-GBYP Data Mining & Recovery Plan, Phase 3: Exploratory trials on Ottoman and other Turkish Archives (by A. F. Örenç, M. Ünver and L. Akgünlü, January 8, 2013) : 1- 15 + 1-25 (fig.).

B.2a Questionnaire and survey on GBYP data recovery perspectives: Independent Opinion *Pro-Veritate* (presented by GBYP Coordination to the GBYP Steering Committee on December 12, 2012): 1-12.

C.1a1 Report on the ICCAT-GBYP Phase 3 Tagging Programme (by the Consortium for Tagging, January 20, 2013): 1-34 + 1-16 (Annexes).

C.1a2 Summary of the electronic tagging activities carried out in cooperation with WWF-MedPO: 1-4.

C.3 Summary Table on the ICCAT-GBYP Tag Recovery Activity (February 20, 2013): 1.

D. Report on the GBYP Biological and Genetic Sampling and Analyses in 2012 (by the Consortium for Biogenetic Activities, February 5, 2013, and partly revised afterwards): 1-99 + 1-17 (Appendix).

E.1. Reports on ICCAT-GBYP Technical meeting on Modelling Approaches: 3 SCRS documents:

SCRS/2012/029: A catch curve analysis for East Atlantic Mediterranean Bluefin Tuna: 1-8.

SCRS/2012/030: A length-based indicator for East Atlantic Mediterranean Bluefin Tuna: 1-9.

SCRS/2012/186: Projections for East Atlantic Mediterranean Bluefin Tuna: 1-10.

E.2. Report on the ICCAT-GBYP Modelling Approaches: Risk Assessment – Eliciting uncertainties in GBYP (by A.W. Leach, P. Levontin, J. Holt and J.D. Mumford, January 8, 2013): 1-24.

E.3. Report on the ICCAT-GBYP Modelling Approaches in Support to Bluefin tuna Stock Assessment: Non-parametric stochastic imputation of length composition data for Atlantic Bluefin tuna; Description and cross-validation of imputation methods (by T. Carruthers, January 21, 2013) : 1- 14.

E.4. Report on the ICCAT-GBYP Modelling Approaches in Support to Bluefin tuna Stock Assessment. ALKr: a R package of methods based on age-length keys to estimate the age structure of fish populations (by A.G. Murta, J.F. Loff, M. Neves and L. Wise, January 18, 2013): 1- 25.

E.5 Report on the ICCAT-GBYP Contract for assessing the feasibility of a large-scale aerial survey on bluefin tuna spawning aggregations in all the Mediterranean Sea for obtaining useful data for operating modeling purposes (by A. Cañadas and J.A. Vázquez, January 15, 2013): 1-18 + 5 tables.

ICCAT-GBYP Steering Committee Reports in Phase 3:

Report of the *Ad horas* meeting of the GBYP Steering Committee; Madrid - September 07, 2012: 1-3;

Report of the GBYP Steering Committee meeting; Sète – December 12-14, 2012: 1-24.

List of Scientific Papers – Phase 3

SCRS/2012/029 A catch curve analysis for East Atlantic Mediterranean Bluefin Tuna. Kell L.T., Bonhommeau S., Fromentin J.M., Ortiz M., 8 p.

SCRS/2012/030 A length-based indicator for East Atlantic Mediterranean Bluefin Tuna. Kell L.T., Bonhommeau S., Fromentin J.M., Palma C., 9 p.

SCRS/2012/116 Review and preliminary analysis of size frequency samples of bluefin tuna (Thunnus thynnus) 1952-2010. Justel Rubio A., Ortiz M., 22 p.

SCRS/2012/125 Preliminary analyses of the ICCAT VMS data 2010-2011. Justel Rubio A., Parrilla A., Ortiz M., 19 p.

SCRS/2012/139 ICCAT-GBYP Atlantic-wide Research Programme for Bluefin Tuna 2012. GBYP Coordination detailed activity report on Phase 2 (last part) and Phase 3 (first part). ICCAT Secretariat (Di Natale A., Idrissi M.), 54 p.

SCRS/2012/140 ICCAT-GBYP Aerial Survey: juveniles versus spawners. A SWOT analysis for both perspectives. ICCAT Secretariat (Di Natale A., Idrissi M.), 11 p.

SCRS/2012/141 BFT catch and size historical data recovered under the ICCAT Atlantic-wide Research Programme for Bluefin Tuna (Phases 1 and 2). ICCAT Secretariat (Di Natale A., Idrissi M., Justel Rubio A.), 34 p.

SCRS/2012/142 The mystery of Bluefin tuna (Thunnus thynnus) presence and behavior in the central southern Atlantic in recent years. Di Natale A., 12 p.

SCRS/2012/143 Preliminary information on GBYP pop-up tagging activities in Morocco in 2012. Quílez-Badia G., Cermeño P, Sainz Trápaga S., Tudela S., Di Natale A., Idrissi M., Abid N., 9 p.

SCRS/2012/149 Eastern Bluefin Tuna (Thunnus thynnus, L.): Reproduction and Reproductive Areas and Season. Piccinetti C., Di Natale A., Arena P., 20 p.

SCRS/2012/186 Projections for East Atlantic Mediterranean Bluefin Tuna. Kell L.T., Bonhommeau S., Fromentin J.M., Ortiz M., Walter J., 10 p.

SCI/2012/036 ICCAT-GBYP Operational Meeting on tagging, biological and genetic sampling and analyses (Madrid, April 17-18, 2012), 25 p.

In press: The ICCAT-GBYP Tagging Programme for Bluefin Tuna. Di Natale A., 35 p. (presented to the IOTC Indian Ocean Tagging Symposium and in press on: Fisheries Research):

Table 1. Details on the number of Bluefin tuna tagged with various types of tags in Phase 3 and on the number of the various types of tags implanted in the various areas.

	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.
Bay of Biscay	3413	1987	0	3	0	0	1399	11	0	0	13	0	0
Morocco	0	0	0	0	0	0	0	0	0	0	0	0	0
Strait of Gibraltar	1489	244	9	0	0	0	1190	16	5	0	23	2	0
West Mediterranean	313	210	11	0	0	0	87	5	0	0	0	0	0
Central Mediterranean	97	97	0	0	0	0	0	0	0	0	0	0	0
		2538	**20**	**3**	**0**	**0**	**2676**	**32**	**5**	**0**	**36**	**2**	**0**
GRAND TOTAL	**5312**	**SUBTOTAL = 2561**					**SUBTOTAL = 2751**						

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Bay of Biscay	4836	3410	1399	14	13	0
Morocco	0	0	0	0	0	0
Strait of Gibraltar	2732	1459	1227	21	25	0
West Mediterranean	405	298	102	5	0	0
Central Mediterranean	97	97	0	0	0	0
	8070	**5264**	**2728**	**40**	**38**	**0**

Table 2. Details on the number of Bluefin tuna tagged with various types of tags in Phase 4 (up to September 21, 2013) and on the number of the various types of tags implanted in the various areas.

	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.
Bay of Biscay	3000	1382	0	0	0	0	1611	7	0	0	0	0	0
Morocco*	265	129	0	7	0	0	121	0	0	7	0	0	1
Strait of Gibraltar	1262	303	5	0	0	0	954	0	0	0	0	0	
West Mediterranean**	219	11	201	0	0	0	7	0	0	0	0	0	0
Central Mediterranean	1239	671	71	0	0	0	478	7	0	0	12	0	0
		2496	**277**	**7**	**0**	**0**	**3171**	**14**	**0**	**7**	**12**		**1**
GRAND TOTAL	**5985**	**SUBTOTAL = 2780**					**SUBTOTAL = 3205**						

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Bay of Biscay	4618	3000	1611	7	0	0
Morocco*	401	258	121	14	0	8
Strait of Gibraltar	2216	1257	959	0	0	0
West Mediterranean**	215	0	215	0	0	0
Central Mediterranean	1736	1149	568	7	12	0
	9186	**5664**	**3474**	**28**	**12**	**8**

Table 3. Details on the number of Bluefin tuna tagged with various types of tags in all Phases of GBYP (up to September 21, 2013) and on the number of the various types of tags implanted in the various areas.

	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.
Bay of Biscay	7692	4152	1	3	0	0	3505	18	0	0	13	0	0
Morocco*	275	129	0	12	0	0	121	5	0	7	0	0	1
Strait of Gibraltar	4142	1306	42	0	0	0	2748	16	5	0	23	2	0
West Mediterranean**	1445	872	216	0	0	0	352	5	0	0	0	0	0
Central Mediterranean	1336	768	71	0	0	0	478	7	0	0	12	0	0
		7227	**330**	**15**	**0**	**0**	**7204**	**51**	**5**	**7**	**48**	**2**	**1**
GRAND TOTAL	**14890**	**SUBTOTAL = 7572**					**SUBTOTAL = 7318**						

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Bay of Biscay	11228	7688	3506	21	13	0
Morocco*	416	258	126	24	0	8
Strait of Gibraltar	6729	4079	2604	21	25	0
West Mediterranean**	1790	1207	578	5	0	0
Central Mediterranean	1833	1246	568	7	12	0
	21996	**14478**	**7382**	**78**	**50**	**8**

Table 4. Details of tag recovery by fishery, in numbers and percent

Fishery -Gear / Tags	Spaghetti Tags	Single/Doube Barb Tags	External Elec. Tags	Internal Elec. Tags	Commercial Tag	Grand Total	%ge
Bait Boat	22	11	0	0	0	33	30,3%
Farms	15	1	1	0	0	17	15,6%
Non-fishermen	5	0	8	1	1	15	13,8%
UNCL	14	0	1	0	0	15	13,8%
Long line	8	3	0	1	0	12	11,0%
TROL	4	2	0	0	0	6	5,5%
Sport & Recr.	3	0	0	0	0	3	2,8%
Purse seine	2	1	0	0	0	3	2,8%
Trammel	1	1	0	0	0	2	1,8%
Trap	1	0	0	1	0	2	1,8%
Rod & Reel	1	0	0	0	0	1	0,9%
Grand Total	**76**	**19**	**10**	**3**	**1**	**109**	**100%**

Table 5. Samples collected and analyses carried out by the Consortium in GBYP Phase 3, with the target and percentages of achievement.

item	*Target no.*	*Achievement no.*	*% of achievement*	*% considering 10% tolerance*
Bluefin tuna individuals sampled (1)	1750	2843	162.45	n.a.
Biological & Genetic Sampling (2):				
Genetic samples (muscle/fin)	1550	2763	178.25	n.a.
Ootoliths	1450	1789	123.38	n.a.
Spines	1250	1443	115.44	n.a.
Gonads	250	351	140.4	n.a.
Biological & Genetic Analyses (3):				
Genetic analyses	1000	1152	115.2	n.a.
Microchemical analyses	400	400	100.00	n.a.
Age readings (otoliths)	130	157	120.77	n.a.
Age readings (spines)	120	158	131.67	n.a.
Histological analyses	60	158	263.33	n.a.
TOTAL (2+3)	**6210**	**8371**	**134.79**	**n.a.**
Total Biological & Genetic Sampling	4500	6346	141.02	n.a.
Total Biological & Genetic Analyses	1710	2025	118.42	n.a.

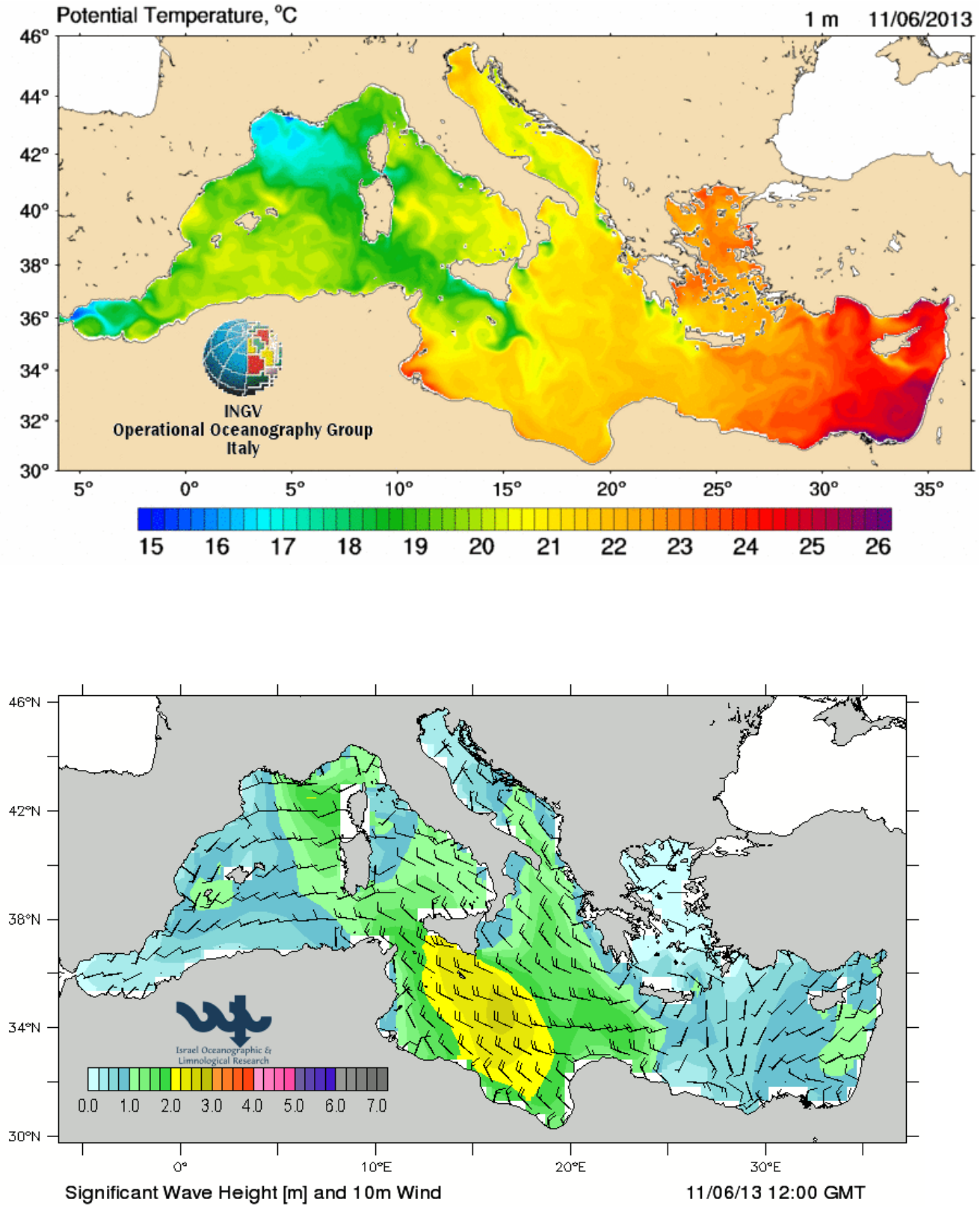

Figure 1. An example of the daily maps for sea surface temperatures (left) and waves (right) daily collected by GBYP in 2013.

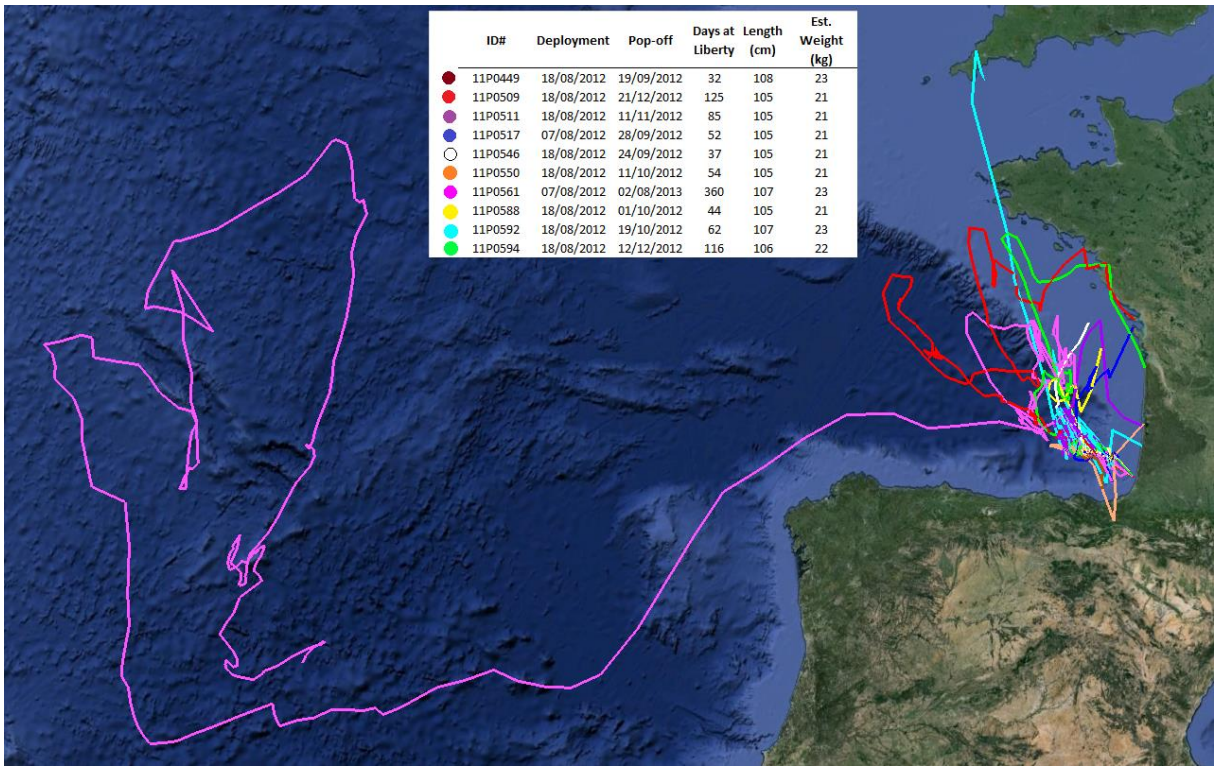

Figure 2. Tracks of juvenile bluefin tunas tagged with mini-PATs in the Bay of Biscay in GBYP Phase 3.

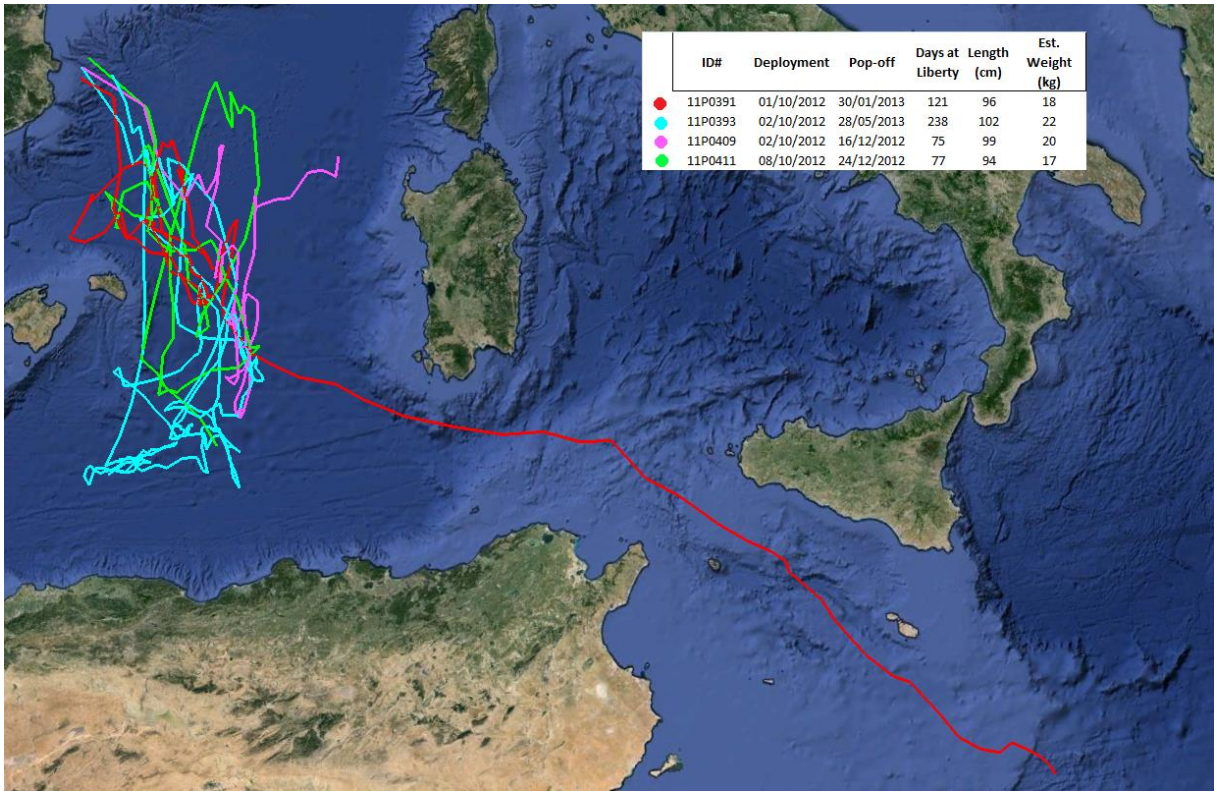

Figure 3. Tracks of juvenile bluefin tunas tagged with mini-PATs in the Gulf of Lion in GBYP Phase 3.

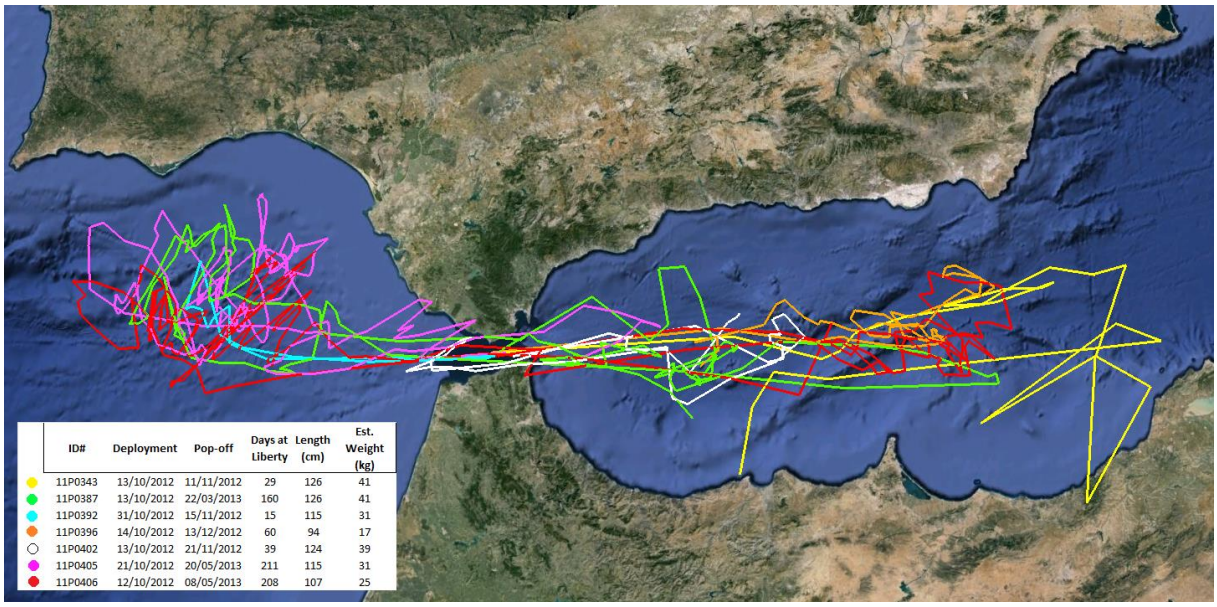

Figure 4. Tracks of juvenile/young bluefin tunas tagged with mini-PATs in the Strait of Gibraltar in GBYP Phase 3, which stayed in the areas close to the Strait over the observed period of time.

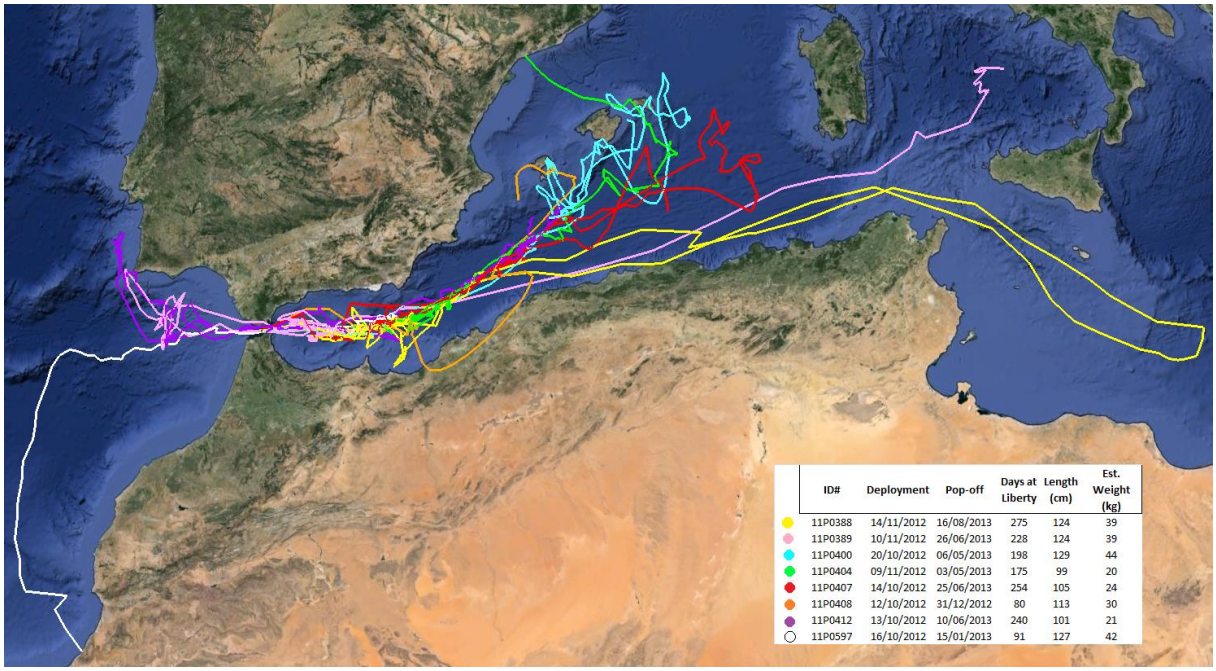

Figure 5. Tracks of juvenile/young bluefin tunas tagged with mini-PATs in the Strait of Gibraltar in GBYP Phase 3, which showed more long-distance movements over the observed period of time.

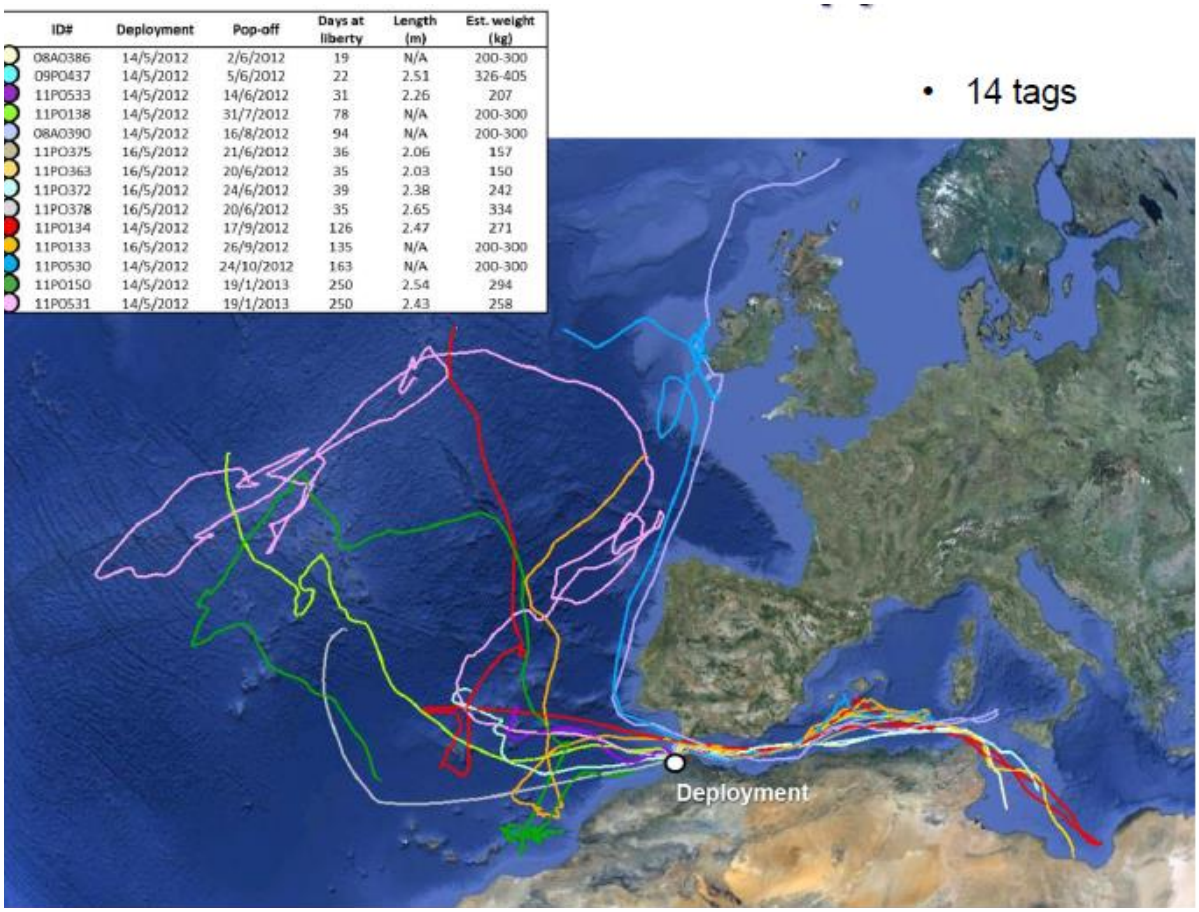

Figure 6. Tracks of adult bluefin tunas tagged with mini-PATs in the Moroccan traps in GBYP Phase 3.

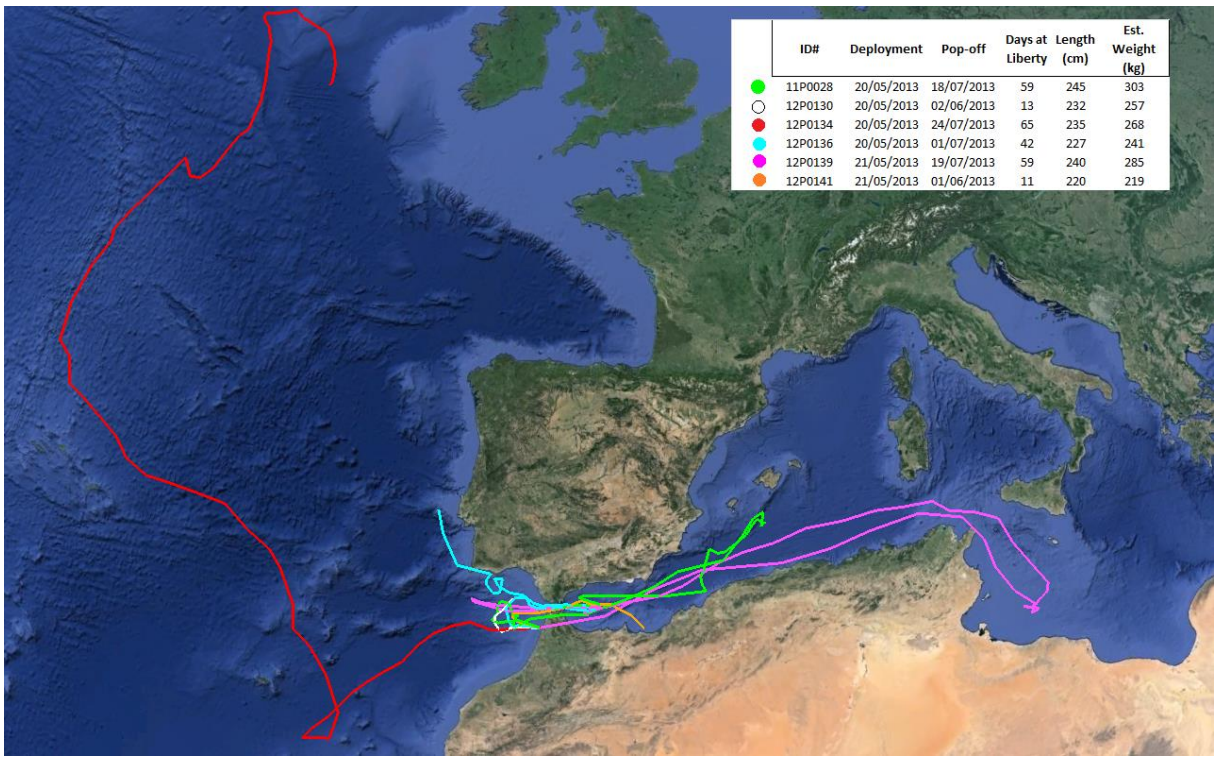

Figure 7. Tracks of adult bluefin tunas tagged with mini-PATs in the Moroccan traps in GBYP Phase 4.

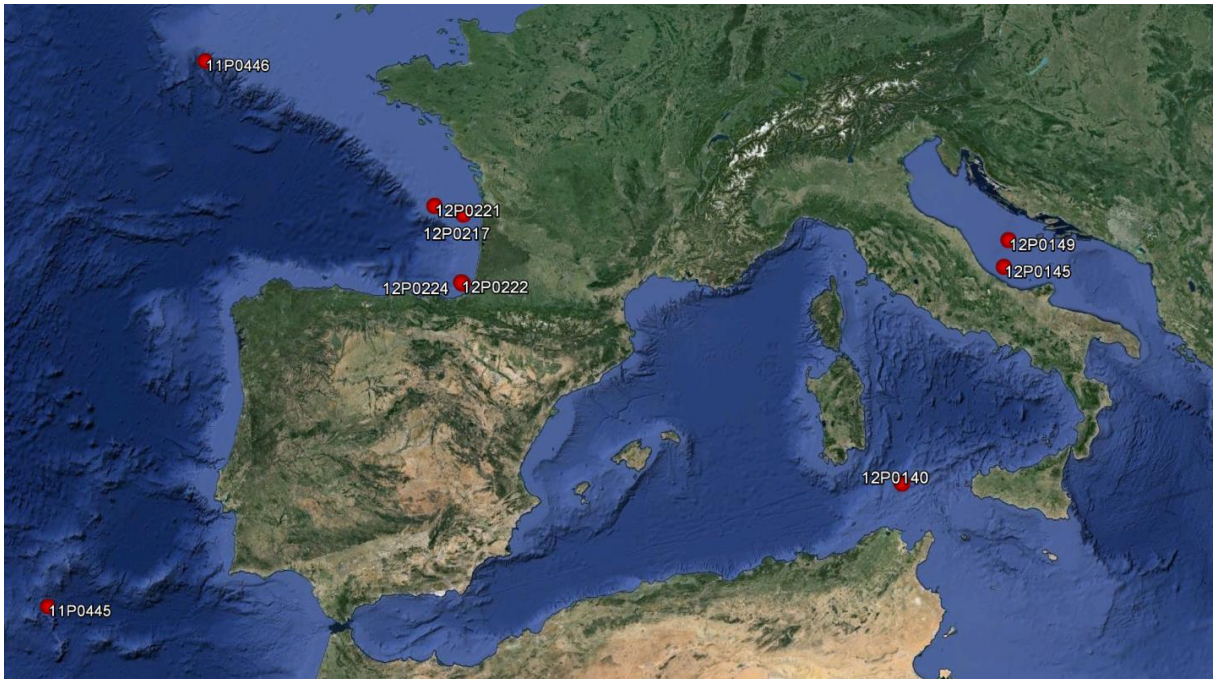

Figure 8. Pop-off location of several mini-PATs deployed by GBYP in Phase 4 in various areas, which were not processed by CLS up to 15 September 2013.

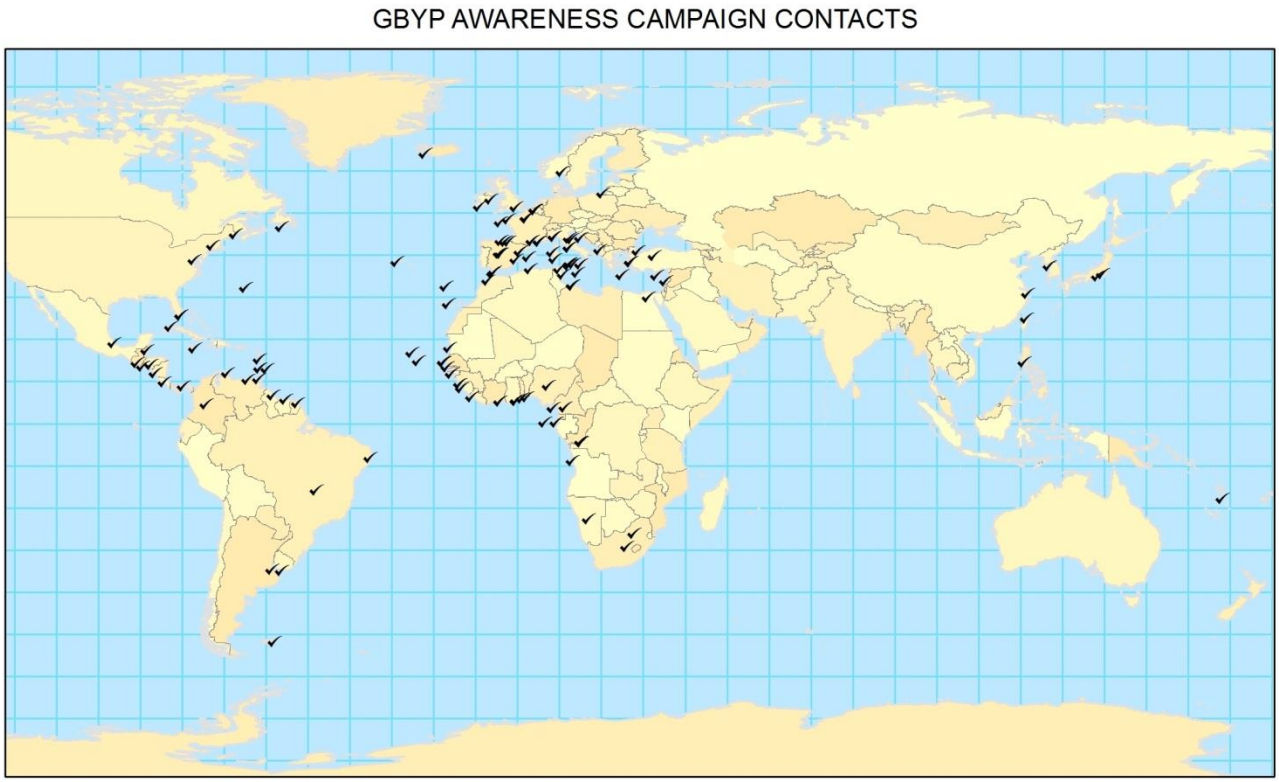

Figure 9. Overview of the localities where the ICCAT-GBYP tag awareness material was distributed so far.

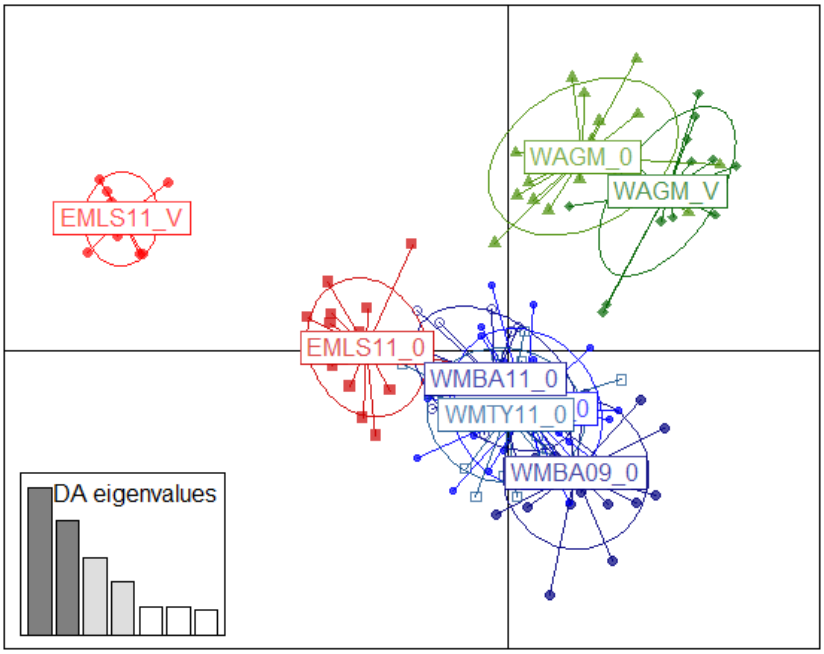

Figure 10. Clustering analysis using DAPC based on the eight reference samples and a restricted subpanel of 96 SNP. Three clusters can be seen, roughly coinciding with the expected spawning groups, with an improved separation of the Eastern Mediterranean Age-0 sample from the Western Mediterranean reference samples, even if yet not clustering with the Eastern Mediterranean Larvae sample.

	C.N.ATLANTIC	BAY OF BISCAY (N.E.ATLANTIC)	E.ATLANTIC (NW.AFRICA)	STRAIT OF GIBRALTAR	BALEARIC (W.MED)	SARDINIA (C.MED)	ADRIATIC (C.MED)	MALTA (S.C.MED)	TURKEY (E.MED)	TOTAL
EAST (%)	70	99	27	100	100	100	100	100	98	
WEST (%)	30	1	73	0	0	0	0	0	2	
Number	177	262	32	190	39	20	47	82	48	897

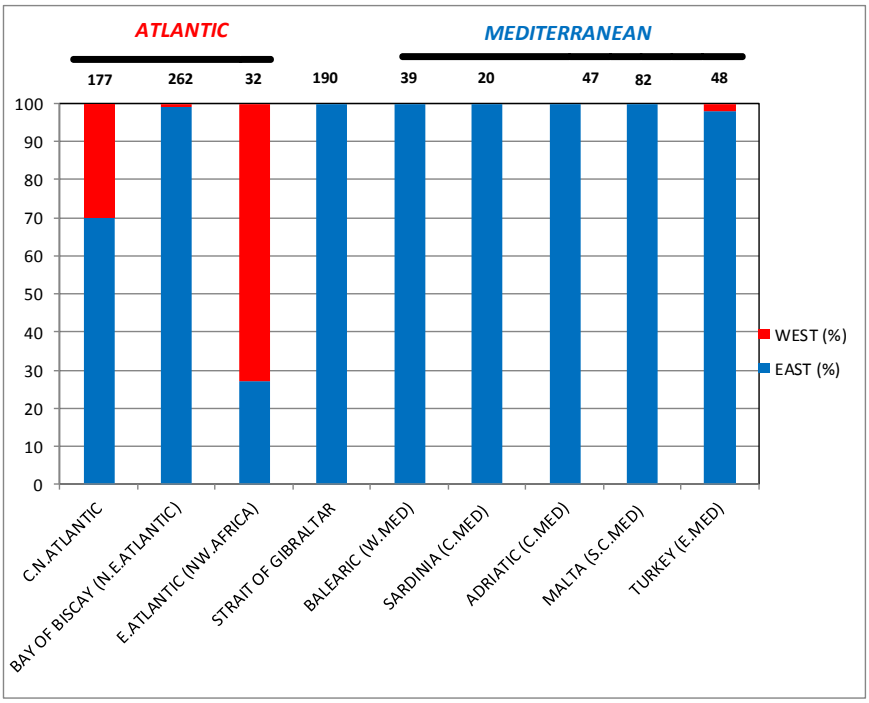

Figure 11. Summary of predicted origin of medium (25-100 kg) and large (>100 kg) bluefin tuna from the Atlantic Ocean and Mediterranean Sea in 2012. Sample size is provided for each area.

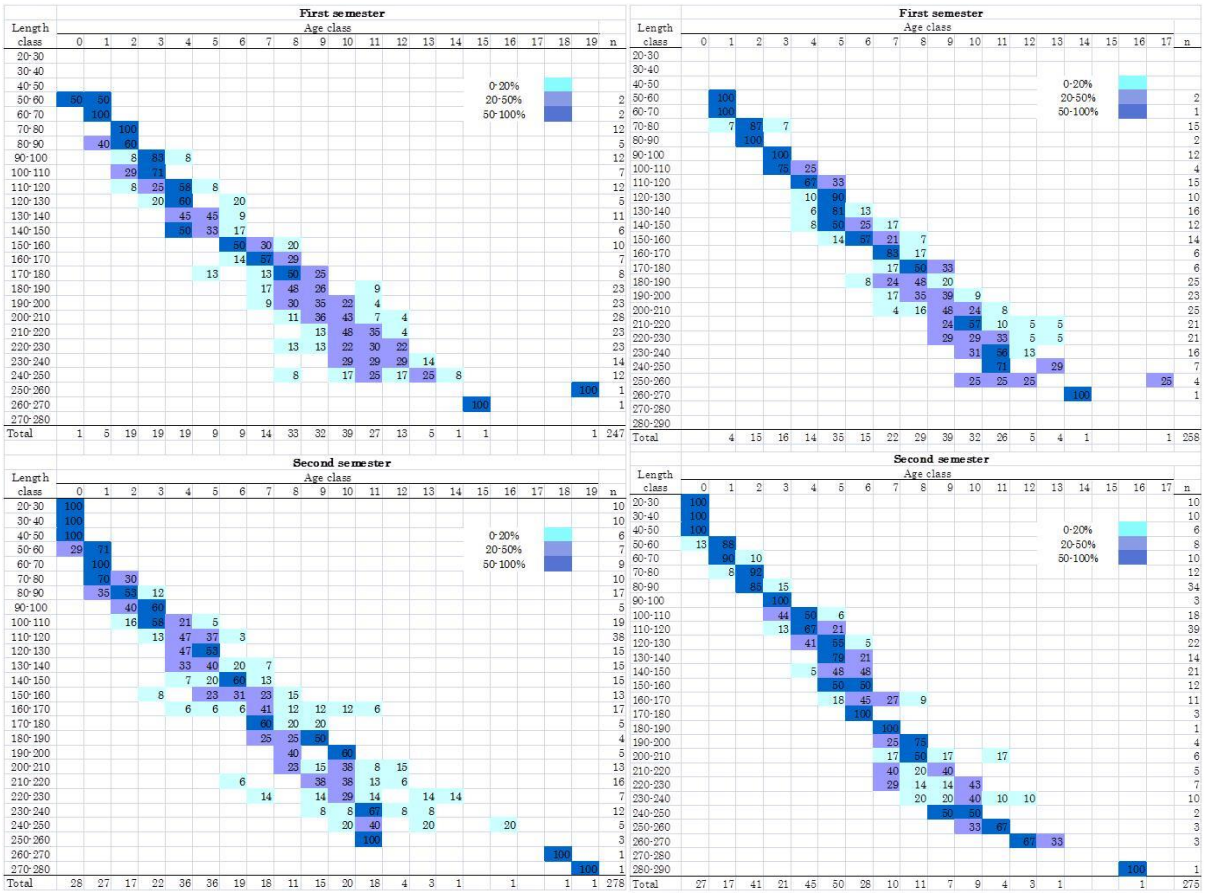

Figure 12. Age-length key based in age interpretation from Atlantic bluefin tuna otoliths (**12a, left**) and spines (**12b, right**) sections, by semester, in 2012. Numbers represent percent by number by length class (SFL, cm).

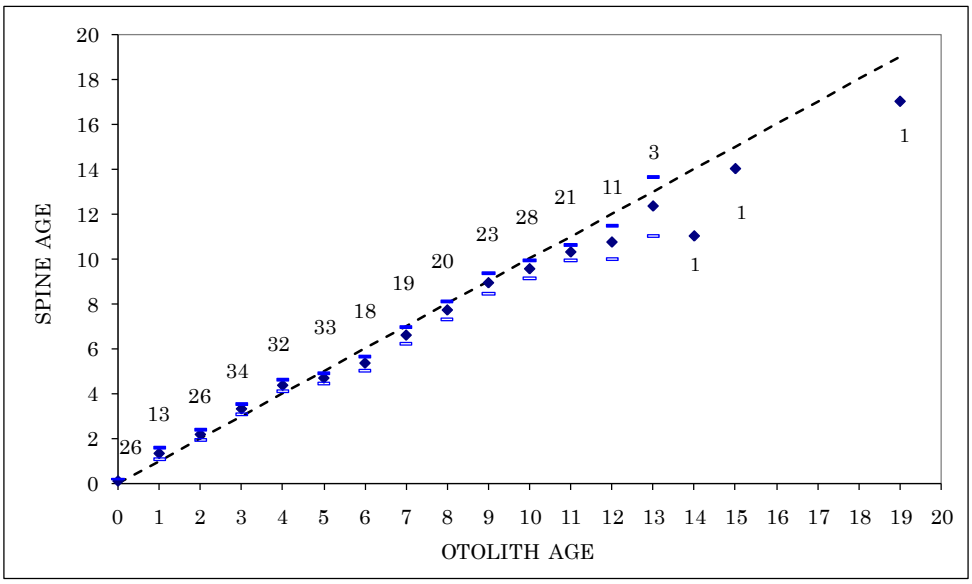

Figure 13. Bias comparison between spines and otoliths age readings in 2012. Spines age readings are presented as the mean age and 95% confidence interval corresponding to otolith age readings (numbers above values represent number of calcified structures used; total number of paired structures: 310).