INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS

COMMISSION INTERNATIONALE POUR LA CONSERVATION DES THONIDES DE L'ATLANTIQUE

COMISION INTERNACIONAL PARA LA CONSERVACION DEL ATUN ATLANTICO

ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA

(ICCAT GBYP)

PHASE 8

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

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

PHASE 8

FINAL REPORT

Table of Contents

1. Introduction

The Atlantic-Wide Research Programme for Bluefin Tuna was officially adopted by the ICCAT Commission in 2008, endorsing the SCRS Chair's report on Bluefin Tuna Research Priorities and Potential costs. In 2009 the SCRS advised the Commission that, in order to substantially improve the scientific advice, such program would focus on the improvement of basic data collection through data mining, understanding of key biological and ecological processes and assessment models and provision of scientific advice on stock status.

During the Commission Meeting in 2009, a number of Contracting Parties expressed a willingness to make extra-budgetary contributions to such a Programme with a view towards initiation of activities related to different priorities: Programme coordination, data mining, aerial surveys and tagging design studies, with additional research activities to be undertaken in the following years. The provision to accept additional contributions from various entities and private institutions or companies was also agreed.

GBYP (Grand Bluefin Tuna Year Programme) was then adopted as official acronym of the research programme. Given that budgetary contributions would be provided annually the Programme have been implemented by annual Phases. To facilitate its coordination and management a post of Programme Coordinator was created and a Steering Committee (SC) was set.

It was initially envisaged as a 6 year programme, but 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. A new plan for the GBYP activities to be done during these additional years was approved along with the extension. Consequently, the donors maintained their contributions, allowing the continuity of the programme.

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

The general information about GBYP activities and its results from the very beginning of the programme till nowadays, as well on budgetary and other administrative issues of GBYP programme, is available from ICCAT GBYP webpage (https://www.iccat.int/GBYP/en/). All the relevant documents related to the programme development, including final reports of every activity and derived scientific papers, annual reports to SCRC and European Union, as well GBYP workshops or Steering Committee meetings reports, are also easily available therefrom.

1.1. Objectives

Considering the priorities stated initially by SCRS, the Steering Committee set as the main objective of the GBYP the improvement of the knowledge and understanding of the Atlantic bluefin tuna (*Thunnus thynnus*) stocks and populations. Aiming at the achievement of this general objective, the following specific objectives were set:

a) Improving basic data collection through data mining developing methods to elaborate these data and to estimate sizes of fish caged, development of fisheries-independent information surveys and implementing a large-scale scientific tagging programme.

b) Improving understanding of key biological and ecological processes through electronic tagging experiments to determine habitat and migration routes, broad scale biological sampling of live fish and dead fish landed (e.g. gonads, liver, otoliths, spines, etc.), histological analyses to determine bluefin tuna reproductive state, biological and genetics analyses to investigate mixing and population structure; and ecological processes, including predator-prey relationships;

c) Improving 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 among areas, and developing and use of biologically realistic operating models for more rigorous management option testing.

1.2. Project management

The GBYP Steering Committee has the role to guide and refine the Programme. It is composed by the SCRS chair, W-BFT rapporteur, E-BFT rapporteur, the external member and the ICCAT Executive Secretary or his deputy. It should be pointed out that the changes in the SC members, which are logical according to the current institutional components, sometimes created different views for some GBYP activities.

Steering Committee is regularly informed and consulted by the GBYP Coordinator for all relevant issues. The Steering Committee meets not less than once a year, to verify the activities done, refine the Programme, propose follow-up of the Programme and adopt the budget.

The GBYP coordination team is nowadays composed by the Program Coordinator, an Assistant Coordinator and a Database Specialist. The team carries out the day to day tasks related to the implementation of the project, including the elaboration of the calls for different types of contracts, the reports on the different GBYP meetings and the annual and executive reports.

Furthermore, the GBYP coordination provides 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 has been part of the Evaluation Committee for the Bluefin tuna programmes of the NOAA.

1.3. Annual budget

The GBYP is funded by voluntary contributions of CPCs and other entities, as Chinese Taipei and ICCAT Secretariat. Among CPCs, EU provides 80% of total budget. In addition, several private or public entities also provided few additional funds or in-kind support. The budget is set annually, by phase. The evolution of the total budget along the Programme, by type of activity, has been as follows (in euro):

	Phase 1	Phase 2	Phase 3	Phase 4	Phase5	Phase 6	Phase 7
Coordination	210,000	453,000	225,000	600,245	342,000	383,000	415,745
Data Recovery	200,000	149,000	30,000	40,250	20,000	165,000	25,000
Aerial Survey	300,000	465,000		518,426	519,500		405,000
Biological Studies		505,000	430,000	364,000	363,000	556,000	580,000
Tagging	40,000	890,000	1,175,000	1,229,979	669,500	844,000	262,000
Modelling		40,000	65,000	122,100	211,000	177,000	121,240
FINAL	**750,000**	**2,502,000**	**1,925,000**	**2,875,000**	**2,125,000**	**2,125,000**	**1,808,985**

It must be pointed out that this annual and variable funding scheme, instead of a multi-year and more stable funding system, is one of the major problems for GBYP, because this fact makes

difficult a mid and long term planning of the activities, which would be for sure more efficient. 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 for a given Phase is confirmed only at the very end of the previous one. This fact implies a continuous attention to the effective budget availability at each step of the programme by the Coordination team and Steering Committee and the impossibility to operate with multi-year contracts for multi-year activities.

It should be mentioned that the total budget of the programme officially approved by the ICCAT Commission in 2008 was 19,075,000 Euro in six years, with the engagement of the European Union and some other ICCAT Contracting Parties to contribute to this programme in 2009 and in the following years. The overall GBYP operating budget for the first seven Phases, covering eight years (a total of 14,110,985 Euros) is only about 74% of what it was supposed to be for just six years only. These budget reductions had an impact on all activities carried out so far.

1.4. Programme review

For the purpose of independently reviewing the work carried out to date within the scope of ICCAT GBYP and evaluating the effectiveness of this complex research programme, in 2013 a mid-term review of the Programme was carried out by the team of independent scientist. Other large comprehensive review of the first five Phases of ICCAT GBYP was carried out at the beginning of the Phase 6 and the results were presented to the SCRS 2016 Plenary (document SCRS/2016/192) and to the Commission at its 2016 Special Meeting.

1.5. Research mortality allowance

The enforcement of the ICCAT Rec. 11-06, which allows for a “research mortality allowance” (RMA) of 20 tons/year 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, enabled GBYP to carry out both tagging and biological sampling activities. The ICCAT Secretariat issues a circular letter establishing the rules and the details for the enforcement of the Rec.11-06, including the official form for reporting RMA and the list of authorized institutions. The list is updated at least once a year or when necessary. All information received through RMA forms is regularly entered in the database specially designed for that purpose, which is maintained by GBYP and the quantities of used RMA are yearly reported to the SCRS.

2. Budget in Phase 8

The eight Phase of the ICCAT GBYP officially started on 21 February 2018 following the signature of the Grant agreement for the co-financing of the ICCAT GBYP Phase 8 (SI2.777629) by the European Commission and should have ended on 20th February 2019.

However, new important research needs were identified by the GBYP Steering Committee taking into account the recommendations from 2018 SCRS and Commission meetings. Among the latter, the main one was the request to GBYP of initiating as soon as possible a wide and detailed study on maximum growth rates within BFT farming operations (paragraph 28 of Rec. 18-02). In addition, the internal analysis of GBYP performance carried out along the implementation of Phase 8 by the GBYP Coordination team and the GBYP Steering Committee allowed to detect

some further actions that are crucial for improving the reliability and accuracy of the GBYP outputs, and for speeding up the full achievement of GBYP general objectives.

Consequently, following the recommendation from GBYP SC and with the objective of better addressing the current research needs and making an optimal use of the funds available for GBYP Phase 8, an amendment of the GBYP Phase 8 Grant agreement, including some new activities and modifications of the amounts associated to some of the previously listed activities, as well as a proposal for a six-months extension of the GBYP Phase 8, was elaborated by GBYP Coordination tea, which was submitted to the EU and finally signed on 14 February 2019. This six-months extension is necessary because some of the new activities imply field work that can only be carried out during the BFT spawning period, peaking in June. Therefore, the eight Phase officially ended on 20 September 2019.

It is worth to mention that the GBYP Phase 9 started, following EU requirements, on 1st January 2019, with a planned duration of one year. Therefore, it has overlapped with Phase 8 for almost nine months. It has made a bit more complex the GBYP program management, but it has been possible to develop in parallel both phases without major problems, since each phase has a different and well defined work-plan and budget, and hence every cost can be assigned univocally to the activities detailed in the respective Grant Agreements.

A first report of the GBYP activities in Phase 8 up to September 2018 was provided to the SCRS (Annex 1b, document no. 1 presented as SCRS/2018/171) and the Commission, which was approved (Annex 1a, document no. 25, Annex 1b, document no. 3). The final report of Phase 8 activities has been submitted to SCRS and at the Commission in their respective meetings in 2019.

In Phase 8, the budget had the following funders (in order of contribution already received or committed):

European Union	1,400,000.00 €
Kingdom of Morocco	66,898.53 €
Japan	59,139.54 €
Tunisia	49,050.13 €
Libya	46,942.83 €
USA	32,220.77 €
Turkey	31,692.99 €
Norway	19,000.00 €
Canada	18,976.53 €
ICCAT Secretariat	10,000.00 €
Egypt	4,696.91 €
Korea	4,151.96 €
Chinese Taipei	3,000.00 €
Iceland	2,179.78 €
Popular Republic of China	2,050.03 €
TOTAL BUDGET	**1,750,000.00 €**

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. Additional eventual residuals from the amounts provided in Phase 8 will be used for the following Phases of GBYP. It should be noted that some contributions for the current and previous GBYP Phases are still pending from several ICCAT CPCs.

3. Programme Coordination in Phase 8

3.1. Steering Committee

The Steering Committee in the Phase 8 was composed by the SCRS chair (Dr. Gary Melvin, who took over from Dr. David Die in September 2018), Western BFT rapporteur (Dr. John Walter, who took over from Dr. Gary Melvin in June 2018), Eastern BFT rapporteur (Dr. Ana Gordoa), external expert (Dr. Ivan Katavic) and ICCAT Executive Secretary (Mr. Camille Jean Pierre Manel, who took over from Mr. Driss Meski in July 2018). The contract for the external member of the Steering Committee was signed on March 2018 with Dr. Ivan Katavic, professor at the Croatian Institute for Oceanography and Fisheries.

During the Phase 8, three SC meeting have been held. The first meeting (18-19 April 2018) was focused on the closure of Phase 7 and refining the activities of the Phase 8, including also a lot of issues the SC needed to take decision about. The second meeting (24 September 2018) was held back to back to other SCRS meeting and therefore was brief, focusing on the most important ongoing tasks. The third meeting (17-19 December 2018) was more extensive, treating mostly about the activities in Phase 8 planned in the initial proposal which were still pending, the elaboration of the amendment proposal for Phase 8 Grant Agreement, to adapt it to the latest recommendations from SCRS and Commission, and to the refinement of the work-plan for the planned activities in Phase 9. The reports from these meetings are attached in Annex 1a (document no. 17-19).

3.2. Coordination Team

In the Phase 8 the Coordination Team was composed by the GBYP Coordinator (Dr. Francisco Alemany), the Assistant Coordinator (Mrs. Stasa Tensek) and the Database specialist (Mr. Alfonso Pagá). It should be pointed out that the ICCAT Secretariat provided the technical and administrative support for all GBYP activities on a daily basis.

3.3. Project management activities

During Phase 8, a total of 5 calls for tenders and 10 official invitations were released, which resulted in a total of 21 contracts awarded to various entities (Annex 2). A total of 33 reports were produced in the framework of ICCAT GBYP in Phase 8 (Annex 1a). A total of 41 scientific papers have been produced in Phase 8 (list in Annex 1b), while others will be published in the following months. So far, the GBYP produced in total, over the first 8 Phases, 343 activity reports and 283 scientific papers.

Other routine project management activities have been the actions related to GBYP Research Mortality Allowance, the Tag awareness and reward program, the regular communication with the Steering Committee members and the updating of the GBYP web page.

Regarding RMA, during 2018 the Research Mortality Allowance was used for covering the incidental death of 128 specimens of bluefin tuna, majority of which occurred during tagging campaigns, which equals to a total of 709.08 kg. These were reported through 18 RMA forms.

The regular communication system with the SC have been improved by developing a new template for reporting on a monthly basis the progress of each specific activity.

As regards the updating of the web page, in GBYP Phase 8, within the framework of the ICCAT web page improvement process carried out along the last year, the GBYP web page

(https://www.iccat.int/GBYP/en/index.asp) have been also deeply restructured. It is worth mentioning that a search tool (https://www.iccat.int/GBYP/en/search.asp) has been incorporated to facilitate the identification and downloading of GBYP documents.

In addition to the coordination tasks related to activities developed under these contracts or agreements and other day to day communication tasks with different stakeholders, the GBYP coordination team participated in all ICCAT meetings focused on bluefin tuna.

On the other hand, the GBYP coordination team has carried out several types of activities in line with the new strategic approach resulting from the global internal review of project's performance carried out at the beginning of GBYP Phase 8 and presented to and approved by the SCRS in the 2018 SCRS meeting (Annex 1b, document no. 3), aiming at, for example, increasing the coordination between SCRS and GBYP, involving more directly SCRS scientist in the planning of GBYP research, and improving synergies between CPCs research and monitoring activities and those organized by GBYP. Thus, GBYP coordination team has organized two important workshops within this Phase: the Workshop on Atlantic bluefin tuna reproductive biology, attended by more than 30 international experts in the field, and the Workshop on bluefin tuna growth attended by more than 20 international experts, as well as the Training Course for all crews participating in the GBYP Aerial surveys.

The GBYP coordinator participated also in the training course for ROP observers, giving a talk to stress the importance of ICCAT observers for the Biological Studies and Tagging GBYP activities.

In addition, to improve the communication and coordination with different stakeholders, looking for potential synergies, the GBYP Coordinator has participated, as invited key speaker or attendant, in several international forum or scientific workshops, as the Oceanography and Marine Resources Conference within 1st Alboran Sea Forum, the FAO Fish Forum 2018, the EUCAW (European Users Conference on Argos Wildlife) and the EU Regional Coordination Group on Large Pelagics.

Moreover, with the same objectives and to get first-hand information on logistic capabilities of private and public organisms relevant for future GBYP research activities, the GBYP coordinator visited the logistic base of Grup Airmed at Reus airport and the IEO-ICRA, a large scale research facility for the controlled reproduction of Bluefin tuna, in this latter case accompanied by the ICCAT Executive and Assistant Secretaries.

Finally, the GBYP coordinator participated, accompanied by ICCAT Secretariat staff members (ICCAT Executive Secretary and Assistant Executive Secretary, and/or GBYP Steering Committee members, in various bilateral meetings (in Spain, Malta, Portugal, Croatia and Turkey) with local stakeholders (fishing authorities, local scientists and representatives of BFT farming industry) focused on the planning of the broad study of BFT growth in farms requested by the Commission through the Rec. 02/18).

The more relevant among these activities and their results are described in following chapters.

4. Activities in Phase 8

4.1. Data Recovery

The objective of GBYP 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 catch or catch by size data, which causes a large amount of substitutions in the assessment process, increasing uncertainties. Such activities can include also the recovery of old or recent rough data on BFT ecology or biological parameters, relevant for BFT evaluation and management, which had not been made available for BFT evaluation purposes. In general, they will allow for a better understanding of the long-time catch series by gear, improving the data available for the assessments.

Three data recovery activities have been carried out within GBYP Phase 8: a) recovery of old data on BFT catches in several Italian traps data, b) recovery of data on tuna catches from ICES reports and c) obtainment of electronic tags datasets deployed by Stanford University and the ones deployed by Tag A Tiny. The amount of ancient data recovered in Phase 8 is shown in **Table 1.**

4.1.1. Recovery of catch data

Table 1. Catch data recovered in Phase 8.

Fishing period	Gear	Fishing area/Trap Name	ICCAT CPC	BFT total catch (n)	BFT total catch (tons)	individual fish data (size or weight)
1880-1965	TRAP	Secco	EU.ITA	42.699	5.071	
1918	TRAP	Magazzinazzi	EU.ITA	2.175	369	
1918	TRAP	Scopello	EU.ITA	1.184	249	
1755-1900	TRAP	Flumentorgiu	EU.ITA	54.766	9.310	
1879-1921	TRAP	Baratti	EU.ITA	1.504	35	
1974, 1976	TRAP	Northwest Atlantic	CAN	578	190	578
1964	TRAP	Central Mediterranean	LBY	14.912	9	14.912
1971-1972, 1974-1976	PS	Northwest Atlantic	CAN	11.018	8,3	11.018
1968-1978	RR	Northwest Atlantic	CAN	5.678	246,7	5.678
1964	MWT	North Sea	EU.DEN	112	9	112
1976-1978	MWT	North Sea	EU.DEN-EU.SWE	31	10,1	31
1973, 1975-1977	HAND	Northwest Atlantic	USA	1.919		1.919
1973, 1975	HARP	Northwest Atlantic	USA	225		225
1962-1964, 1966-1970, 1974-1978	PS	Northwest Atlantic	USA	116.923	44	116.923
1973, 1975, 1977-1978	RR	Northwest Atlantic	USA	4.470	2,8	4.470
1975, 1978	UNCL	Northwest Atlantic	USA	2.327	70,1	2.327
total Phase 8				**260.521**	**15.624**	

a) Ancient traps data recovery

Already in Phase 7, GBYP was informed that there might be a possibility of recuperation of some original data on bluefin tuna catches in Italian traps, directly from the owner's registers, that haven't been included in the ICCAT database so far. For that purpose, in Phase 8, GBYP started investigating the real content on the available data, especially in terms of trap locations and years for which the catch series were available. Once it was confirmed that this data would cover several holes in the database and would correct some of the estimates already included in the ICCAT DB and, given that the price for their recovery was reasonable, the Steering Committee recommended initiating the activity. For that purpose, a contract invitation was submitted to Ph.D. Antonia Mangano.

The activity was carried out along summer 2018. Finally, data on daily or annual catches from 5 Italian tuna traps were transcribed from original handwritten registers and transferred to ICCAT DB forms. The recovered set of data consist specifically in:
-Daily catch data of tuna trap "Tonnara del Secco", near San Vito Lo Capo (Trapani, Sicily), from twenty years between 1912 and 1965. Data are referred to all species captured by the trap, which operated for many years as a mixed trap between a "Tonnara" and a "Tonnarella", targeting also smaller tuna species.
-Annual catches of tuna trap "Tonnara del Secco" between 1880 and 1979, with few missing years.
-Daily catch data of tuna traps located in Magazzinazzi and Scopello for the year 1918.
-Annual catches of tuna trap Flumentorgiu (Sardinia), for 35 years between 1755 and 1900.
-Annual catches of tuna trap Baratti (Tuscany), for the periods 1879-1893; 1901-1905 and 1912-1921, including by catches of other species

Some of these data were available, but had been obtained from other, less reliable sources, and are currently under review. The final report is available in Annex 1a, document no. 20.

b) Recent catch data from NOAA archives

Another potential set of data identified within Phase 7 were the data on bluefin tuna caches contained in reports of ICES Bluefin Tuna Species Group, from 1960s and 1970s. It was recommended to recover these data at the Data Preparatory Meeting in 2017, because, apparently, they have never been reported to ICCAT. The use of these data had been restricted by ICES until 2017 when ICCAT finally obtained the permission for their use. Copies of the reports were found in ICCAT library, as part of the Dr. Rodriguez-Roda personal library. The GBYP database specialist have taken care of converting the data into electronic format compatible with ICCAT database. The gathered data set contain information on a large number of bluefin tuna landings by different entities in Atlantic and Mediterranean, from 1962 to 1978, including the details on flag, geographical location, fishing gear and biological data (length and/or weight), by year, month or even week. More details are given in the paper SCRS/2018/176 (Annex 1b, document no. 29).

4.1.2. Recovery of electronic tags data

a) Datasets from Barbara Block

GBYP also received a direct offer for providing datasets on electronic tags from Ph.D. Barbara Block, who had already provided a similar service, under an ad hoc contract, in Phase 6. These new data set refers to 41 electronic tags deployed in 2016-2017 off Canada and in 2017 off Ireland, with a mean duration on fish of 190 days (much higher than the mean of satellite tags within GBYP database). Considering the great value these datasets have for the purpose of determining the level of mixing between Eastern and Western bluefin tuna stocks and the fact they are directly used by the MSE operating model, the Steering Committee recommended getting the data, under the similar conditions (unit price) as in 2016. For that purpose, a contract with Stanford University was signed.

In February 2019, the complete datasets were received, including the raw data on light, temperature and depth, and the processed geolocations i.e. track. The data have already been provided to modelling expert, to be used for operating model and MSE purposes.

b) Datasets from Molly Lutcavage

In order to recover all available datasets from electronic tags deployed on BFT by other institutions, with the objective of taking advantage of the synergies derived from the global analysis of the available information, at the end of Phase 8, another contract was also signed with Ph.D. Molly Lutcavage, Tag a Tiny Project, through Social and Environmental Entrepreneurs, for providing electronic tags datasets. These datasets had already been provided to SCRS in aggregated form (number of days each tag spent in certain MSE statistical area), but this contract enabled acquiring of detailed processed data (track) and detailed raw sensor data. The datasets refer to 220 electronic tags deployed in Western Atlantic from 2002 to 2009.

4.2. Aerial Survey

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. However, due to different reasons, as budget and logistic limitations, different opinions about the best sampling strategies, and even about the reliability and usefulness of the results from these aerial surveys, among SCRS and GBYP SC members, this activity has unfortunately not been developed regularly and has not followed homogenous methodologies and sampling strategies along the successive GBYP Phases (see previous GBYP annual reports and GBYP aerial surveys final reports). Summing up, aerial surveys on selected spawning areas were carried out in Phase 1 and 2, and then the activity was suspended in Phase 3. An extended aerial survey, covering 90% of the Mediterranean Sea surface was realized in 2013, at the beginning of Phase 4, but due to budget constrains the aerial survey was suspended again in 2014, during the extension period of Phase 4. An extended survey, similar to that carried out in 2013, was developed in 2015, within Phase 5, revealing 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), 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.

In the last part of Phase 5, a power analysis and a cost benefit analysis for the aerial survey on spawning aggregations was done in order to have a more focused overview of the works carried out up to that point within the GBYP and getting further details for adopting the best research strategy in Phase 6. The main recommendation coming out from the power analysis was that a reduction of the coefficients of variations, at several levels (encounter rates, school size, detection function and additional variances) is required to be able to detect trends in population abundance within an acceptable time frame. Furthermore, increased coverage in terms of length of tracks (which means several replicates) on effort was deemed necessary. The ICCAT GBYP Steering Committee suspended again the aerial survey in the year 2016, basing the decision on the assumption that the financial resources were 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 in 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 a potential alternative, which was to conduct a comprehensive survey restricted to relatively limited areas within the Mediterranean that can be adequately surveyed with the available resources. A basic assumption of this approach is

that, to provide a useful index of abundance, the proportion of the adult stock within the survey areas during 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 was also reiterated a sort of calibration should be necessary. The SC recommended alternative be adopted, and the surveys be restricted to the four core overlapping areas that have been included in all the four previous surveys, which would provide standardised results and short series possibly usable both for the assessment and the MSE process.

Therefore, in Phase 5, a reanalysis of all data up to that point was carried out, taking into reference only four overlapped areas (the Balearic Sea, the Tyrrhenian Sea, the Southern-Eastern Mediterranean and the Levantine Sea) and making some further corrections, thus producing standardized 4 years series of fisheries independent index.
Consequently, the aerial survey activity was resumed in Phase 7, on four overlapped areas only, using the same methodology already established in Phase 5, producing one more year of standardized index.

4.2.1. Aerial survey campaign 2018

The aerial survey in Phase 8 was carried out on the same 4 preferential spawning areas already defined in the previous Phases (**Figure 1**), using the same design and methodology than in 2017 in order to get standardized results comparable with previous series. For a purpose of data elaboration, a call for tenders was issued and the contract was awarded to the only entity that submitted the offer, Alnilam, which has participated in all previous GBYP aerial surveys as well. In addition to data elaboration, the contractor also provided updated versions of the Protocol and Forms for this year aerial survey. Moreover, the contractor provided materials and acted as tutor at the training course that was organized for members of the aerial survey crews. Some further details about 2018 GBYP aerial survey results are included in the publication SCRS/2018/175 (Annex 1b, document no. 38).

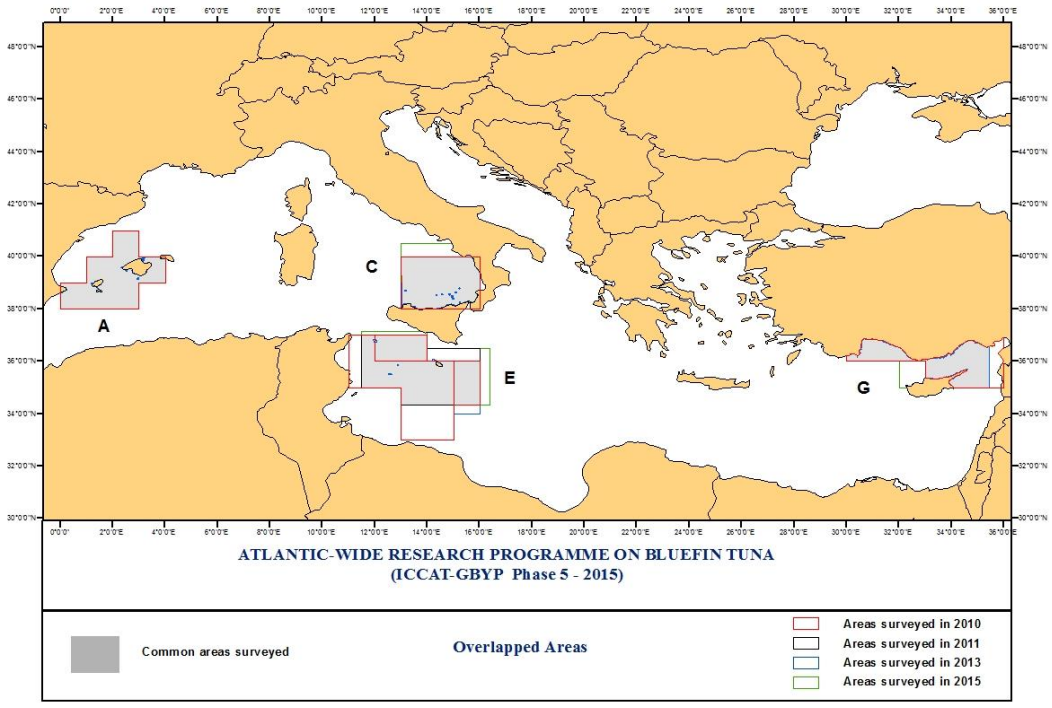

Figure 1. Overlapped areas for four GBYP aerial surveys (2010-2015). The same areas were surveyed in 2017 and 2018.

a) Activity and training course

The training survey was held in the ICCAT headquarters on 16 May 2018, with the participation of all the contracted pilots, professional spotters and scientific observers. A total of 17 participants attended the course. The list of participants is available in Annex 1a, document no. 6. As in the previous years, the members of the crews were instructed in detail on methodology for performing an aerial survey, they were given details on previous surveys and they were trained on how to follow the protocol (available in Annex 1a, document no. 1) and fill out the forms (available in Annex 1a, document no. 2), including practical examples. The presentation exposed during the Course are available in Annex 1a, documents no. 3-5.

Three companies were awarded for carrying out the aerial surveys in 2018, which were the ones that submitted their offers following the call for tenders. All these companies had previous experience in GBYP aerial surveys and were familiar with the particularities and possible problems of each area of the survey. The survey in Area A (Balearic Sea) was done by Spanish company "Grup Air Med", while the surveys in Areas C (southern Tyrrhenian) and Area E (central-southern Tyrrhenian Sea) was done by Italian companies Unimar and Aerial Banners. As concerns Area G, it was done by French company "Action Air Environnement". Similarly to previous years, the Turkish government requested the inclusion of a national observer as a member of the crew on board. The Turkish observer, with previous experience of performing GBYP aerial survey in the area, acted as a scientific observer.

The surveys were carried out within the period from 27 May to 28 June 2018, on the 4 areas simultaneously, although the actual number of effective days and days on standby depended on weather conditions in each area. This year, as in previous two ones, data were delivered from each area on a weekly basis, and they were immediately checked for any potential problem or error in order to solve it in a real time. In general, the survey was successful, although there were some minor problems due to unfavourable weather conditions and delays in obtaining the flight permits and restricted air space.

b) Data analysis

The overall analysis has shown that the survey design generally worked very well, and homogeneous coverage was achieved in all areas, despite the aforementioned temporal disruptions or delays due to restriction on flight over some zones because of military/political/rescue operations reasons. Data collection worked much better than in previous surveys and it seems to be improving each year. Final results are shown in **Table 2**.

In 2018 there were a total of 87 sightings of bluefin tuna, from which 79 could be used for fitting the detection function and 67 that were used later for determining the abundance. As in previous years, data were analysed using Distance software. Overall, a total of 47,361 (CV = 33.8%) tonnes and 361,995 (CV = 28.6%) individuals of Bluefin tuna were estimated in all the spawning sub-areas together. In Area A there was 7% less effort in 2018 than the mean effort of 2010 to 2017. However, there was 53% more sightings on effort this year than the mean of the previous 5 years and this was the year with most sightings in Area A so far. All encounter rates, total weight and total number of animals were much higher in 2018 than in the mean of the previous years (except encounter rate in 2017), showing an increase up to 85%. The fact that the encounter rates and final estimates are much higher than the previous years when at the same time there was similar effort in 2018 than the rest of the years, indicates that there was a real increase of BFT in area A in 2018 in respect to the previous 5 years. In this area there was already an important increase in 2017 in comparison to the previous years, but the increment is much larger in 2018.

In area C, there was approximately half the amount of effort than in 2010 and 2011, but double than in 2013 and 2015 and similar than in 2017. However, the number of sightings of BFT was similar to the mean of the previous years but much less than in 2017 (for similar amount of effort). The encounter rate of groups, total abundance and total weight are similar to the mean of 2010-2017, but much lower than in 2017 and 2013 taken individually.

Area E had a much smaller number of sightings of BFT in 2015, 2017 and 2018 with respect to 2010, 2011 and 2013, not corresponding exactly to the variations of effort. For example, in 2011 there were only 125 km more of effort than in 2018 but there were 75% more sightings; or in 2018 there was 51% more effort than in 2013 but there were 45% more sightings in 2013. Overall, 2015 was the year with the lowest encounter rate, total weight and total abundance, and 2011 the year with much larger abundance and total weight. 2018 is similar to 2013 in terms of final total abundance but also similar to 2017 in terms of total weight.

Area G was not surveyed in 2011, and mean school size was not recorded in 2010, so comparisons are more limited than for the other areas. In 2018 there was 13% less effort and 51% less sightings than in 2017. Overall, there was 29% more effort in 2018 than the mean for 2010-2017, but the same number of sightings, and much smaller mean weight and school size, resulting in 80% smaller total weight and 68.5% lower abundance than the mean for 2010-2017.

Overall, there has been similar amount of effort in 2018 as in the five previous surveys (only 9% more than the mean), and 10% more sightings. The mean weight is 25% smaller than the mean for 2010-2017 (113) and the mean school size is 73% smaller than the mean (1018). The total weight in 2018 is 47% larger than the mean 2010-2017, and the total abundance is 31% larger than the mean for the 5 previous years. However, the total abundance estimate for 2018 (361,995) is very similar to 2017 (346,272), so total abundance has not really changed overall from last year to this one, although distribution has. For example, in 2018 abundance in area A has been much higher than in previous years, but contrastingly in area E has been much lower than in 2017. Therefore, it can be hypothesized that the distribution pattern may have changed due to environmental conditions that may have affected the timing and spatial patterns of the genetic migration. The final report is available in Annex 1a (document no. 10).

Table 2. Results for all aerial surveys in all areas combined

Year	**2010**	**2011**	**2013**	**2015**	**2017**	**2018**	**Total (sum)**	**Total (mean)**
Survey area (km^2)	265,627	209,416	265,627	265,627	265,627	257,135		265,627
Transect length (km)	31,532	26,856	16,060	10,272	21,178	23,308	129,206	21,534
Effective strip width x2 (km)	2.96	1.36	3.00	3.9	2.9	1.4		2.6
Area searched (km^2)	93,442	36,525	48,127	39,904	61,096	33,365	334,307	52.08
% coverage	35.2	17.4	18.1	15.0	23.0	13.0		20.3
Number of schools ON effort	76	65	52	14	91	67	365	60.8
Abundance of schools	250	388	338	78	387	568		335
%CV abundance of schools	22.8	19.9	21.5	38.9	20.2	22.5		
Encounter rate of schools	0.0024	0.0024	0.0032	0.0014	0.0043	0.0029		0.0028
%CV encounter rate				20.2	11.6	13.6		
Density of schools (1000 km^{-2})	0.942	1.852	1.274	0.295	1.457	2.208		1.261
%CV density of schools	22.8	19.9	21.5	38.9	23.4	22.5		
Mean weight (t)	87.9	101.1	22.6	272.2	82.3	84.5		**108.420**
%CV weight	16.8	27.5	51.0	41.4	19.2	24.4		

Mean cluster size (animals)	791	1,275	582	1,548	895	643	**956**
%CV abundance	18.6	37.3	18.5	40.5	17.0	18.5	
Density of animals (km^{-2})		**2.7388**	**0.702**	**0.234**	**1.304**	1.420	**1.161**
%CV density of animals		29.9	29.4	39.1	25.9	28.4	
Total weight (t)	**23,371**	**44,139**	**16,866**	**8,690**	**31,855**	**47,946**	**28,811**
%CV total weight	25.6	28.7	30.3	35.3	26.7	33.4	
L 95% CI total weight	14,243	25,315	9,343	4,398	19,018	25,283	
U 95% CI total weight	38,347	76,964	30,447	17,169	53,355	90,921	
Total abundance (animals)		**573,543**	**186,505**	**62,284**	**346,272**	**365,091**	**269,528**
%CV total abundance		29.9	29.4	39.1	25.9	28.4	
L 95% CI total abundance		321,620	105,320	28,766	209,816	211,128	
U 95% CI total abundance		1,022,800	330,270	134,860	571,473	631,334	

4.2.2. Improvement of the GBYP aerial survey methodology

In spite that six aerial GBYP aerial surveys have been carried out up to now, including Phase 8 one, and that significant advances in the standardization of the survey strategies and methodologies have occurred in recent years, no clear patterns in weight and/or abundance among years and areas have been discerned yet, except maybe in the case of Balearic Sea area. Moreover, the Coefficient of Variation of the indices remains very high, above the commonly accepted levels. Given the strong inter-annual and spatial variability in the different components of aerial survey (encounter rate of groups, mean weight and mean school size), it was partly expectable, and probably longer time series should be necessary to get clear trends. In addition, it is known that environmental variability adds a new level of complexity, and hence a deeper knowledge about the influence of environmental variables on BFT spawning schools distribution across years and areas, might provide better understanding of the variability in observed distribution and abundance. Consequently, the development of habitat models was one of the actions planned to be realized within GBYP Phase 8 to improve in the following Phase 9 the accuracy of the indices from aerial surveys, by identifying relevant environmental variables that should be taken into account when producing the indices.

However, aiming at detecting, and consequently prevent or minimize any potential source of bias that could affect the accuracy of the results, an exhaustive analysis of the methodologies applied and results obtained in previous surveys was carried out by the GBYP Coordination team. From this exercise, some potential sources of bias were detected, as the notable differences in the observation patterns among professional and scientific spotters or the inclusion in the calculation of the indices of sightings of individual that could be juveniles and hence should be not incorporated in an index related to spawning stock biomass. To complete this review and look for ways to minimize as much as possible any source of bias, on August 2018 the representatives of Alnilam, the company which have been in charge of the design, technical supervision and data analysis of GBYP aerial surveys from the beginning of the time series were called to hold a meeting at ICCAT Secretariat. From the analysis and discussion held within this meeting it was concluded that some type of calibration exercises should also be designed and carried out to improve the reliability of GBYP aerial surveys outputs. Moreover, it was also agreed that other methodological questions should be addressed to optimize the surveys and overcome some of the detected problems, as improving the shape of Area A, making it more convenient from the logistical and biological point of view, and also improving the structure and working methodology of the observer's teams, which would permit reducing the potential sources of bias.

The GBYP SC was informed about these conclusions and, consequently, in the December 2018 GBYP SC meeting, decided that some actions should be carried out to improve the precision and accuracy of aerial surveys in a future and also the reliability of the results from previous surveys, as development of calibration exercises among spotters, further refining the current survey protocols to minimize the potential sources of bias as much as possible, to develop methods to consider environmental influence on the aerial index estimations, to reanalyze the available time series of data from aerial surveys taking into account the new potential sources of bias detected and, finally, to explore the possibility of carrying out validation exercises for aerial surveys. In fact, a need for calibration exercise for spotters with the objective to standardize their sightings had been previously identified on various occasions (SCRS/2011/011, SCRS/2015/143, SCRS/2014/194), and even it was planned to carry out such action in Phase 5, but finally was not done due to logistic constrains (SCRS/2015/143).

Consequently, it was decided that some of these actions would be carried out within the extension of Phase 8 (design of spotters calibration exercise, development of improved sighting protocols, feasibility studies for the application of acoustic techniques to aerial surveys validation and development of habitat models to develop correction factors to standardize the aerial survey indices by taking into account environmental influence on spawners distribution, whereas others, as the implementation of the calibration exercise, the reanalysis of the aerial surveys data time series and the incorporation of environmental variables to aerial survey indices estimation, would be realized in Phase 9. Later, considering new inputs from specialists in habitat modelling consulted to this end, it was decided that the activities aiming at considering the influence of environment on aerial survey index estimation would be merged in a single activity to be developed in Phase 9. Thus, the actions carried out within Phase 8 are described below:

a) Design of improved aerial survey sighting protocols and of spotter's calibration survey

For the purpose of improving the reliability of results of aerial surveys, in Phase 8 a direct contract for improved aerial survey sighting protocols and of spotter's calibration survey was issued to company Alnilam, due to their proven theoretical skills and experience in bluefin tuna aerial surveys.

The Contractor provided a design for an aerial survey calibration/validation exercise, which was carried out in the Balearic sea at the end of the 2019 GBYP aerial survey, within Phase 9, with the main objective to calibrate the sightings of the professional spotters who have already participated in GBYP aerial surveys. This will allow to calculate "correction factors" useful for smoothing the additional variance when elaborating the aerial survey data. The Contractor also provided the improved aerial survey sighting protocol, addressing all the potential sources of bias identified from the in-depth analysis of the previous GBYP aerial surveys results, especially focused on the standardization of methodologies for calculating declination angle, the potential loose of effective observation time due to the time dedicated to the register of previous sightings and the differences in the observation patterns between professional and scientific spotters. In addition, the contractor provided a list of alternative methods to get more accurate estimates of total number of animals, average weight of individuals and total weight of the group. Finally, the contractor provided a strategic plan to guarantee in a future the availability of spotters able to strictly apply the sighting protocols required by the distance transect methodology, considering the potential lack of professional spotters. The calibration design and a strategic plan are available in Annex 1a, document no. 32.

b) Acoustic survey feasibility study to explore the use of these techniques to validate aerial survey observations

In 2019 there was an opportunity to carry out a feasibility study on the use of acoustic techniques to validate aerial observations at a relatively low cost, taking advantage of the presence in the Balearic Sea, and during the BFT spawning peak, of an IEO research vessel carrying out an ichthyoplankton survey targeting BFT tuna larvae (the one providing the currently used BFT larval index) equipped with a scientific sonar MS70, able to characterize BFT spawners schools. Given the spatial and temporal overlap between this survey and the calibration exercise described in the previous point, both surveys were carried out in a coordinated way, trying to increase the possibility of getting acoustic data from the same schools observed during the aerial survey calibration exercise.

Thus, it was decided to carry out an acoustic survey in parallel to the ichthyoplankton survey making use of multi-beam sonars and echo-sounders of the research vessel with two objectives: first, taking advantage of the sampling strategy during the first phase of the ichthyoplankton survey, in which most of Balearic sea is sampled in a systematic way visiting sequentially stations located every 10 miles on a regular quadrangular grid, to get an estimation of the encounter rate with tuna schools making use of a scientific sonar following this sampling strategy and, secondly, to characterize in detail BFT spawning schools, in the case they be detected.

For that purpose, an agreement was made with Spanish Institute of Oceanography for using the sonar systems of their research vessel Angeles Alvariño, taking advantage of its presence in the Balearic Sea area due to bluefin tuna larval campaign. In addition, two contracts were issued, for the advice on the use of the aforementioned sonar system (MS70 multi-beam sonar and EK-80 echo-sounder).

One contract was signed with Dr. Victor Espinosa Roselló, senior professor of the University of Valencia (UPV), seeking his advice on the use of the equipment for mapping the BFT distribution and their potential trophic resources in the Balearic Sea, and for collaborating in the detailed characterization of BFT spawning schools by means of the MS70 sonar. The other contract was issued with the Institute of Marine Research (Norway) for getting the advice of a group of IMR scientiss which are recognized specialists in this field, in the use of the MS70 sonar (Drs. Maria Tenningen, Rolf Korneliusen, Egil Ona and Hector Peña). Dr. Maria Tenningen participated directly in the survey, being the main responsible for the use of the sonar and also for processing the all the data generated by MS70 sonar within the aforementioned survey.

The acoustic survey was carried out in the Balearic Sea, in June/July 2019 during the bluefin spawning peak, coinciding with the period in which the aerial survey calibration exercise. The aircraft did not detect BFT schools near the research vessel and consequently no detailed measurements of free-swimming BFT could be made. Nevertheless, an agreement was made with a BFT cage transport vessel to approach and make sonar measurements of the BFT in the cage. The tuna in the cage may not be representative of a free-swimming tuna school, where fish may be organized in a different way and less densely packed. Still, the data provide highly useful first measurements of BFT with the MS70 sonar.

The few measurements of BFT in and near the transport cage indicate that the MS70 sonar is suitable for characterizing BFT schools. The 3D matrix of beams and high resolution of the sonar provides detailed information about the schools. However, for accurate estimates of school biomass and abundance more information is needed about the acoustic properties of BFT, its schooling behaviour and how it may affect the acoustic measurements. It is also important to validate estimates made acoustically.

To monitor and measure the schools it is necessary to be at relatively close range (<300 m) and keep the whole school in the acoustic beams for some time to obtain good data. As no free-swimming schools were detected it remains uncertain how feasible this is. It will depend on the swimming speed of the BFT and how reactive they are to the research vessel, which again may depend on the current activity of the BFT.

The final report is available in Annex 1a, document no. 33.

4.3. 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.

This line of research has faced two important problems which have prevented or limited the fully achievement of these initial objectives. One is the very low recovery rate of conventional tags, which impede the use of these data to estimate reliable mortality rates. Because of that GBYP SC, decided to cancel the conventional tagging program in Phase 4, maintaining only complementary conventional tagging activities by providing tags and tagging equipment to different institutions or organizations which ask for this support, as well as maintaining the awareness and rewards campaigns and the data base integrating all the results from recovered tags. The second major problem has been the relatively short time on fish of most of the electronic pop up tags, which limits the usefulness of the recorded data to achieve the stated objectives. The premature releases are attributable to different factors, as technological problems of the tags, fishing activities, death of the fish after tagging and, in general, probably the use of equipment and tagging methodologies not fully adequate for BFT. These potential problems have been addressed through different ways, as the use in Phase 8 on a new reinforced model of MiniPAT satellite tag designed to minimize “pin broke” problems, selection of tagging areas with lower fishing pressure and exploring and applying whenever possible improved tagging methodologies.

4.3.1. Tagging campaigns in 2018

As recommended by the Steering Committee, the tagging activities carried out under contract on specific agreements in the Phase 8 were limited again to the deployment of electronic tags, keeping the deployment of conventional tags only as a complimentary activity. In addition to 22 electronic tags that have already been purchased in the previous Phase 7 and that could not be deployed due to “force majeure” reasons and were on stock, , in 2018 GBYP acquired additional 25 tags (7 of them were both with 50% discount due to the physical return of recovered tags). The producer also added 13 warranty replacement tags for pin broke. Given that the purchase order was done commonly with other order from the Secretariat and therefore included high number of the tags, a special quality discount from the manufacturer of $200 per tag was obtained. All tags were of type MiniPAT made by Wildlife Computers.

The specific objective of GBYP tagging programme in Phase 8 was improving the estimations of the degree of mixing of western and eastern bluefin tuna stocks along the different statistical areas and throughout the year, specifically considering the current needs of the MSE modelling process. To this end, the Steering Committee decided to concentrate tagging activities in the North Sea and/or Celtic Sea and in Southern Portugal area. After publishing the call for tenders,

4 offers were received, but, due to the budget constraints, only 2 from them have been awarded. The contract for tagging in Portuguese traps was awarded to Tunipex, the same company that has already carried out GBYP tagging activities in previous phases of the Programme. The other contract was awarded to the Marine Institute of Ireland for deploying tags in the Celtic area. It has to be noted that Marine Institute met the costs of staff for this activity, including reporting and data management. In addition to the two contracts, a Memorandum of Understanding was signed between ICCAT GBYP and the Institute of Marine Research of Norway, for deploying 20 tags in western Norway. According to the MOU, while the costs of the tag deployment would be covered by the IMR, ICCAT would provide the electronic tags and assume the cost of satellite transmission, while the resulting data would be shared between the two institutions.

Tagging operations in Southern Portugal traps were carried out successfully in August 2018 and it was possible to successfully deploy 30 mini-PAT tags. The bluefin tuna were tagged by experienced divers directly underwater using a long pole (10 fish) and on-board the Tunipex ship by IPMA scientific staff (20 fish). All mini-PATs attached onboard were secured with an intra-muscular double attachment. The final report is available in Annex 1a, document no. 30.

The tagging campaigns in the Celtic Seas area were successfully carried out in October/November and 24 bluefin individuals were tagged. Out of these tags, 10 were provided by GBYP while 14 were made available by the Marine Institute and the data were shared with GBYP. One vessel was used during the tagging period, which was equipped with transom doors to bring fish on board. All fish were captured using angling methods. All mini-PATs were attached using the titanium tag dart or Domeier dart with retention loop. The final report is available in Annex 1a, document no. 29.

Tagging along the western coast of Norway was carried out between August and September, using the vessels used belonged to the voluntary angling teams. Although it was planned to tag 20 individuals, due to adverse weather conditions, namely strong winds, fewer fishing days than planned were performed and consequently only 2 bluefin tuna were tagged. One of these individuals died shortly after the release and the other had its tag detached after only 33 days. The remaining 18 tags have been returned to GBYP and deployed under the framework of Phase 9 tagging activities in 2019. Available tracks from electronic tags deployed in 2018 are shown in **Figure 2**.

The final report is available in Annex 1a, document no. 31.

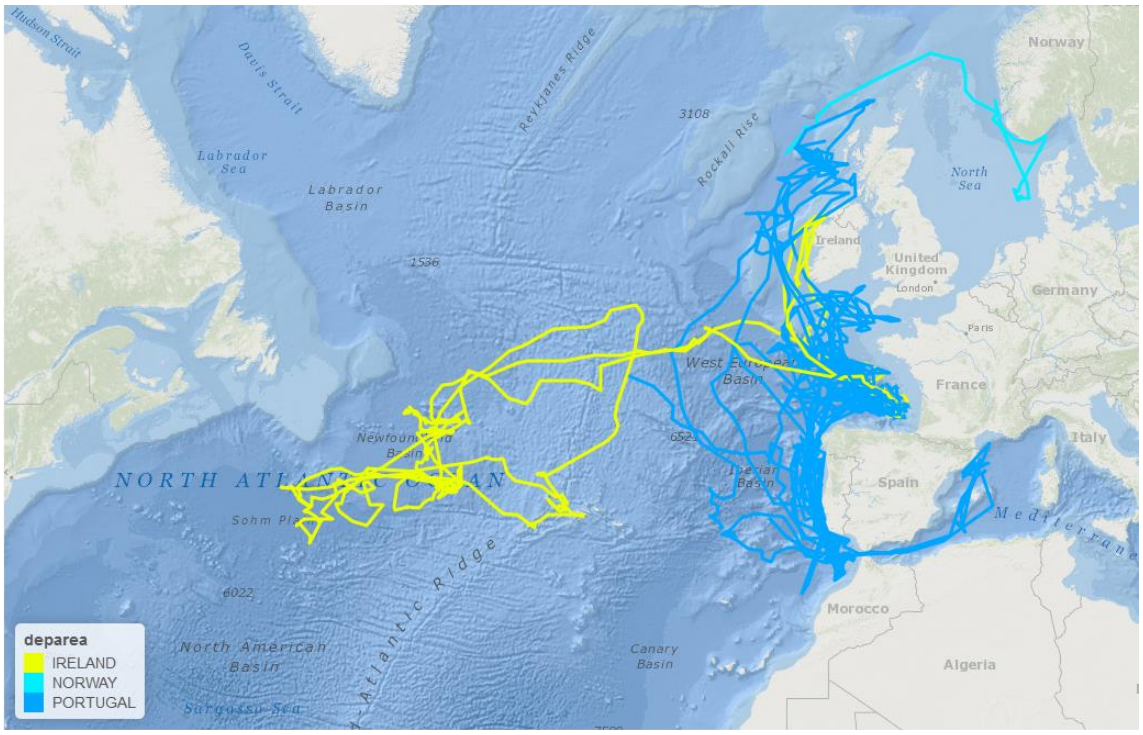

Figure 2. Available tracks from electronic tags deployed in 2018

It is worth mentioning that besides these activities carried out under formal GBYP contracts or agreements, GBYP has supported e-tagging activities carried out independently by other institutions, by allowing the use of GBYP RMA in case of BFT casualties during tagging operations and the use of GBYP Argos system account for data transmission. Specifically, National Institute for Aquatic Resources (DTU Aqua) of Denmark and the Italian branch of WWF Mediterranean Marine Initiative have been included in the 2018 GBYP list of institutions that can make use of RMA. WWF has recently deployed several satellite tags in the Western Mediterranean which are associated to GBYP Argos system account, so the resulting data will be directly integrated in GBYP database. DTU Aqua has already agreed to share the resulting information with GBYP.

As regards conventional tags, within Phase 8 “spaghetti” tags, along with applicators and the tagging protocols and forms to report tagging operations were delivered to various institutions (**Table 3**). In addition, conventional tags and related equipment was also delivered to the teams in charge of satellite tags deployment, since in this phase they have been asked to carry out a double tagging whenever possible, implanting conventional tags besides the satellite tags.

Table 3. Number of conventional tags and other tagging equipment and material sent to different collaborators in Phase 8 (until and including February 2019).

Country	Institution	Conventional tags	Applicators		Awareness		
			Conventional	Electronic	Posters	T-Shirts	Stickers
TUNISIA	National Institute of Marines Sciences and Technologies (INSTM)	200	8		31	20	30
USA	The University of Maine/Gulf of Maine Research Institute	50	2				
EU.DENMARK	Technical University of Denmark	250	4				
NORWAY	Institute of Marine Research	50	5				
EU.IRELAND	Marine Institute	50	5	3			
CANADA	Goverment of Canada (Fisheries and Oceans)	1000	25				
KOREA	National Institute of Fisheries Science	25					
EU.ITALY	WWF Mediterranean Marine Initiative	150	10	3	54	20	50
EU.ESPAÑA	Associacio Catalana per a una Pesca Responsable (ACPR)	150	20		40	62	30
EU.ITALY	The Italian Federation Sport Fishing (FIPSAS)	1000					
TOTAL		**2925**	**79**	**6**	**125**	**102**	**110**

In Phase 8, a total of 945 tags were deployed on 904 bluefin tuna individuals (**Table 4** and **5**). The level of tagging was similar to Phases 5, 6 and 7, since the conventional tagging was cancelled by the Steering Committee in Phase 4, keeping it only as a complementary activity. In total, from the beginning of the Programme up to 1 September 2019, more than 20 thousand bluefin tuna individuals were tagged, using more than 28 thousand tags of different types (**Table 6** and **7**).

Table 4. Number fish tagged during Phase 8 (until and including February 2019)

	ALL FISH TAGGED	FISH SINGLE TAGGED			FISH DOUBLE TAGGED		
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Double Tags - Conventional	Mini-PATS + Conv.	Mini-PATS + 2Conv.
Canada	573	0	573	0	0	0	0
Bay of Biscay	0	0	0	0	0	0	0
Morocco	0	0	0	0	0	0	0
Portugal	60	30	0	30	0	0	0
Strait of Gibraltar	0	0	0	0	0	0	0
West Med.	27	27	0	0	0	0	0
Central Med.	59	54	5	0	0	0	0
East Med.	49	49	0	0	0	0	0
North and Celtic Seas	136	94	10	1	20	1	10
TOTAL	**904**	**254**	**588**	**31**	**20**	**1**	**10**
		SUBTOTAL = 873			**SUBTOTAL = 31**		

Table 5. Number of tags implanted during Phase 8 (until and including February 2019)

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED		
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs
Canada	573	0	573	0
Portugal	60	30	0	30
West Med.	27	27	0	0
Central Med.	59	54	5	0
East Med.	49	49	0	0
North and Celtic Seas	177	125	40	12
TOTAL	**945**	**285**	**618**	**42**

Table 6. Number of fish tagged since the beginning of GBYP (up to 1 September 2019)

	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	1,826	0	1,821	0	0	0	0	5	0	0	0	0	0
Bay of Biscay	7,701	4,173	1	3	0	0	3,493	18	0	0	13	0	0
Morocco	365	129	48	45	0	0	121	14	0	7	0	0	1
Portugal	347	53	39	94	0	0	154	7	0	0	0	0	0
Strait of Gibraltar	5,561	2,254	43	0	0	0	3,212	22	5	0	23	2	0
West Med.	1,763	1,001	377	28	0	0	352	5	0	0	0	0	0
Central Med.	2,709	1,051	1,120	32	0	0	479	15	0	0	12	0	0
East Med.	99	49	0	50	0	0	0	0	0	0	0	0	0
North and Celtic Seas	166	96	10	4	0	0	30	16	10	0	0	0	0
GRAND TOTAL	**20,537**	8,806	3,459	256	0	0	7,841	102	15	7	48	2	1
		SUBTOTAL = 12,521					**SUBTOTAL = 8,016**						

Table 7. Number of tags implanted since the beginning of GBYP (up to 1 September 2019)

	TOTAL NUMBER OF TAGS	TAGS IMPLANTED				
		FT-1-94	FIM-96 or BFIM-96	Mini-PATs	Archivals	Acoustic
Canada	1,831	0	1,826	5	0	0
Bay of Biscay	11,225	7,697	3,494	21	13	0
Morocco	515	258	183	66	0	8
Portugal	508	182	225	101	0	0
Strait of Gibraltar	8,618	5,491	3,075	27	25	0
West Med.	2,119	1,354	732	33	0	0
Central Med.	3,215	1,530	1,626	47	12	0
East Med.	99	49	0	50	0	0
North and Celtic Seas	232	142	60	30	0	0
TOTAL	**28,362**	**16,703**	**11,221**	**380**	**50**	**8**

Other activities within this line of study include a new Shiny application which was developed in for visualization of multiple tracks on the interactive map, including filtering and grouping according to several criteria. More details on this activity are presented in the scientific paper SCRS/2018/174 (Annex 1b, document no. 36). In addition, a preliminary analysis of bluefin tuna depth and temperature preferences revealed by electronic tags was also carried out (available in Annex 1b, document no. 37, presented as SCRS/2018/173).

4.3.2. Tag recoveries

a) Tag awareness and reward policy

This activity is considered essential for improving the 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. Several thousands of posters of various sizes (A1, A3 and A4) and stickers were produced so far and distributed to all major stakeholders, such as Government Agencies, scientific institutions, tuna scientists, tuna industries, fishers, sport fishery federations and associations in the area. In addition, in 2016 two short propaganda videos on ICCAT GBYP tagging activities were produced, which are available in 8 languages through YouTube.

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

For further improving the results, meetings with ICCAT ROPs have been organized periodically, further informing them about the ICCAT GBYP tag recovery activity and asking them to pay the maximum attention to tags when observing harvesting in cages or any fishing activity at sea.

b) Tag recovery and reporting

The important tag reporting improvement registered after the beginning of the tagging and tag awareness activities by ICCAT GBYP is impressive: the average ICCAT recovery for the period 2002-2009 was only 0.88 tags per year (7 tags reported in 8 years), while during GBYP tag recovery activities the average was 88.21 tags per year (860 tags in 9 ¾ year). The first significant increase in the rate of the tag recoveries was recorded from 2012. 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 2018, a total of 76 tags were recovered, less than in two previous years (**Figure 3**). This decrease can probably be attributed to the fact that, due to recommendation of the Steering Committee, from 2014 onward, conventional tagging was limited to the complimentary tagging only. It should be stressed that, in last couple of years, 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.

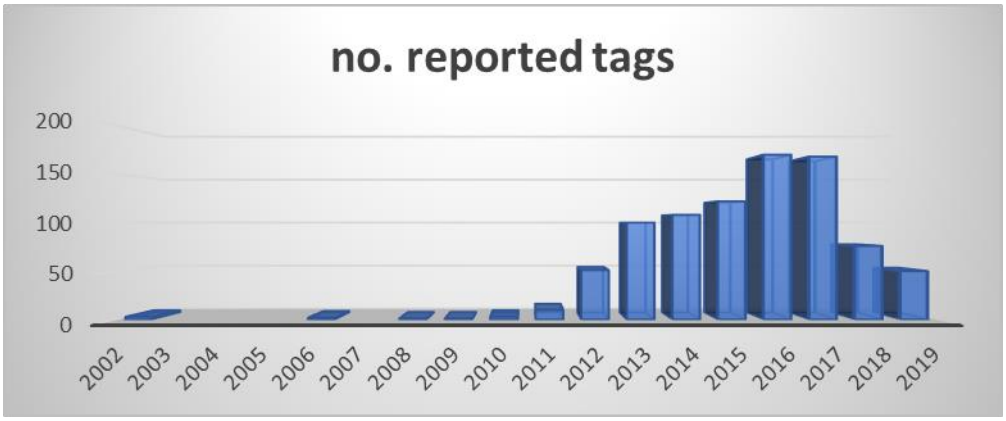

Figure 3. Annual trend of bluefin tuna tag recoveries reported to ICCAT since 2002 (up to 1 September 2019)

As for the study of conventional tags shedding rate, tags were recovered from 254 double tagged fish (up to 1 September 2019). According to the results (**Table 8**), it seems that both types of tags (single barb and double barb) are more or less equally resistant, with the slight better resilience for the double barb.

Table 8. Tag recoveries from double tagged fish by type

Release	Spaghetti tag only	Double Barb Tag only	Both	TOTAL FISH	TOTAL TAGS
2011	4	6	6	16	22
2012	13	18	46	77	123
2013	32	20	72	124	196
2016	1	2	1	4	5
2017	6	12	15	33	48
Total N	56	58	140	254	394
Total percent	22%	23%	55%		

4.4. Biological Studies

One of the core activities of ICCAT GBYP are so-called Biological Studies, which ICCAT GBYP started in 2011, maintaining a biological sampling programme covering the main bluefin fisheries and funding a series of studies based on the analysis of these samples, as microchemical and genetics analyses to investigate mixing and population structure, with a particular attention to the age structure and the probable sub-populations identification.

Bluefin tuna biological samples are stored in the GBYP Tissue Bank, which is maintained by AZTI. The information on available samples can be obtained through an interactive web application, especially designed for that purpose on https://aztigps.shinyapps.io/bluefin/.

The objectives of the Biological Studies initially stated for Phase 8 were keeping an ICCAT GBYP tissue bank able to provide the samples required to carry out the studies necessary for improving the understanding of key biological and ecological processes affecting BFT, providing updated, representative and reliable ALKs useful for BFT stocks assessment and providing accurate and reliable estimations of mixing rates between BFT Western and Eastern stocks. Apart from those, GBYP in Phase 8 focused also on getting improved knowledge on growth and reproductive parameters of bluefin tuna, since in spite a lot of research have been carried out on these topics

from decades ago some controversies remain, which make difficult to decide on the set of biological parameters that must be used for stock assessment. In addition, given that as a result of the Commission Rec. 18-02, paragraph 28, GBYP was committed to carry out urgently a broad study to determine BFT growth in farms in all the areas where these farming activities are developed, in the GBYP work-plan amendment proposal presented in January 2019 the concrete design of such study was included as new Phase 8 objective.

In order to achieve these objectives, three main types of activities have been developed within GBYP Phase 8: Biological sampling and analysis, organization of ad hoc workshops on key biological parameters and tasks aiming at improve the design and facilitate the implementation of the broad study of growth in farms, whose core activities will be developed mainly under GBYP phase 9.

4.4.1. Biological sampling and analyses

As done in previous GBYP phases, a call for tenders was issued in May 2018 for maintenance and management of ICCAT GBYP Tissue Bank, collecting tissue samples and otoliths and performing analyses – both microchemistry analyses of otoliths and genetic analyses of tissue samples. The Call also asked for elaboration of comprehensive study on results of stock assignment analyses already conducted within the GBYP in order to provide a complete set of plausible hypotheses about stock structure consistent with the data for the MSE operational model. Sampling activities were rather reduced this year and concentrated on samples from potential mixing areas in Atlantic and some additional ones from the Mediterranean Sea.

Two contracts were awarded for carrying out the biological studies in Phase 8. One was signed with the Consortium led by AZTI for both sampling and biological analysis, including microchemical and genetic ones. Under this contract, the task of maintaining the GBYP Tissue Bank was again entrusted to AZTI, that has been managing it since the beginning of the Programme. The second contract was signed with the University of Bologna – BiGeA- for sampling only. It must be pointed out that the University of Bologna could not fulfil the sampling objectives fixed in the contract within the envisaged period. Thus, they asked for an extension in order to complete the sampling scheme. Such extension was approved, allowing them to take samples during the 2019 fishing season, taking advantage of the extension already approved for the whole Phase 8. The final reports of these activities are available in Annex 1a, documents no. 13-14.

In addition, to ensure the availability of biological samples from adult bluefin tuna representative of the whole population, enough to elaborate reliable ALK or carry out in a future “close kin” studies, a complementary sampling has also been performed, as in previous phases 6 and 7, in BFT farms. After a call for tenders to this end was launched in April 2018, Contracts for that purpose were awarded to two enterprises. One was AquaBioTech, from Malta, for providing samples from at least 300 specimens from the Southern Tyrrhenian Sea and at least 300 specimens from the Central/Southern Mediterranean Sea. The other one was Taxon, from Spain, for providing samples for at least 300 specimens fished in the Balearic Sea. Additional samples were also provided by ICCAT ROPs and by tagging teams. The final reports of these activities are available in Annex 1a, documents no. 15-16.

Regarding ageing related activities, the Phase 8 initial proposal included specific budgets for carrying out the reading of 2000 otoliths by Fish Ageing Services (FAS), as well as a calibrations exercise between FAS and SCRS specialist on BFT growth to guarantee that both the BFT otoliths readings carried out by FAS under GBYP contract in Phase 7 and the new of new readings that

was planned to carry out in Phase 8 were totally comparable. However, at the beginning of Phase 8 the GBYP Coordinator was informed that some researchers, including the specialists that have been providing to SCRS the BFT ALKs along the last years, had already launched a wide international calibration exercise, focused mainly on assessing the observed discrepancies between age readings from spines and otoliths, especially in young specimens.

Therefore, to ensure that the ALKs provided by GBYP were elaborated following the best standard methodologies approved by the SCRS, it was decided to postpone both activities till the ongoing exercise had been finished and new protocols be available. Finally, the results of the aforementioned international calibration exercise were presented at 2018 SCRS BFT species Group meeting, as paper SCRS/2018/127 (Annex 1b, document no. 32). This exercise also provided an improved protocol for BFT otoliths interpretation (available in Annex 1b, document no. 33 presented as SCRS/2018/126).

Nevertheless, the SCRS BFT ageing specialists group involved in this calibration exercise recognized that age estimations for younger ages remain still uncertain due to the frequent appearance of numerous sub-annual bands, and recommended to held an ad hoc meeting to agree on methods to minimize bias in age estimations of young BFT using otoliths, which was endorsed by SCRS. Thus, within the GBYP SC meeting held on December 2018, it was decided to change the initial plan regarding ageing issues, organizing the required ad hoc workshop and limiting the FAS activities to the otoliths cutting and mounting, postponing the readings to Phase 9. These changes were included in the Phase 8 amendment proposal. Finally, a contract to prepare the selected set of 2000 for reading following the protocols agreed within the GBYP workshop on BFT ageing, which was held on February 2018, was signed in March 2018

In addition to these activities dealing with annual growth, the GBYP SC member Ana Gordoa offered to perform the daily ageing of 50 otoliths free of charge, in order to continue the study initiated in Phase 7 in greater depth and obtain more conclusive results. Pursuant to her offer, GBYP SC decided to provide her with the required samples (52 YOYs of 2016).

The development of genetic test for BFT sex assignment was also initially planned to be done in the Phase 8, taking advantage of the first works in that line carried out within Phase 7. Nevertheless, in spite that the Steering Committee recognized the study would be useful, it postponed the activity subject to availability of funds and finally it was cancelled.

The main specific activities carried out in relation to biological sampling and analysis of biological samples and their more relevant results are summarized below:

a) Biological sampling

The biological sampling conducted in Phase 8 aimed primarily at contributing to knowledge on population structure and mixing. As such, it was done independently from other routine sampling activities for fisheries and fishery resources monitoring (e.g. the Data Collection Framework). The sampling was carried out according to the GBYP Biological sampling protocol (Annex 1a, document no. 11), following the GBYP sampling strata (Annex 1a, document no. 12).

The Consortium headed by AZTI was in charge of obtaining samples from potentially mixing areas in Atlantic. By size class, the consortium planned to sample only two size classes, namely young of the year and large fish. The sampling objectives for these two size classes were met at 224% and 91%, respectively, and additional samples were obtained for the medium size class. The number of YOY individuals caught in Atlantic side of the Strait of Gibraltar was larger than expected, which will provide additional insights into the origin of these YOY found in the Atlantic

(although very close to the Mediterranean). Regarding large fish, the sampling in the central Atlantic and Canarias went as expected, while in Norway the number of samples was below the target, due to bad weather conditions that limited fishing activity in that area.

This was complemented by the sampling in Mediterranean made by UNIBO, which provided samples from the Central and Western Mediterranean. In addition, the sampling was performed on farms, targeting large individuals from Southern Tyrrhenian Sea, the Central/Southern Mediterranean Sea and the Balearic Sea. Additional samples were also provided by ICCAT ROPs and by tagging teams. The large majority of samples from outside the consortium came from the Balearics, Tyrrhenian and Malta. Total number of samples collected is shown in **Table 9** and **10**.

Table 9. Sampling performed in Phase 8: number of BFT sampled by area and size group

		Age 0	**Juveniles**	**Medium**	**Large**	**Total**
		<3 kg	**3-25 kg**	**25-100 kg**	**>100 kg**	
Central Mediterranean	Adriatic Sea			50		**50**
	Malta			5	499	**504**
	Sicily (East Sicily and Ionian Sea)		50	50	19	**119**
Western Mediterranean	Tyrrhenian Sea		45	99	466	**610**
	Sardinia			5		**5**
	Gulf of Lion, Catalan				125	**125**
	Balearic			3	849	**852**
Gibraltar	Gibraltar	112		7	51	**170**
Northeast Atlantic	Portugal				34	**34**
East Atlantic	Madeira, Canary Islands				57	**57**
North Sea	Norway				80	**80**
Central North Atlantic	Central and North Atlantic				100	**100**
	TOTAL	**112**	**95**	**219**	**2280**	**2706**

Table 10. Sampling performed in Phase 8: number of samples by tissue type and area

		Otolith	**Spine**	**Muscle/Fin**	**Total**
Central Mediterranean	Adriatic Sea	49	50	50	149
	Malta	400	0	503	903
	Sicily (East Sicily and Ionian Sea)	135	119	119	373
Western Mediterranean	Sardinia	3	0	5	8
	Tyrrhenian Sea	617	153	599	1369
	Gulf of Lion, Catalan	0	0	125	125
	Balearic	306	0	852	1158
Gibraltar	Gibraltar	112	81	170	363
Northeast Atlantic	Portugal	30	32	34	96
East Atlantic	Madeira, Canary Islands	51	0	57	108
North Sea	Norway	23	60	80	163
Central North Atlantic	Central and North Atlantic	100	0	100	200
	TOTAL	**1826**	**495**	**2694**	**5015**

b) Biological analyses

The analyses carried out within Phase 8 have already started to provide important information that is relevant for Atlantic bluefin tuna management. As such, project results have continued to feed the bluefin tuna stock assessment and Management Strategy Evaluation (MSE) process. The stock composition percentages in the geographical boxes used in the MSE have been compared using different alternative methods and discussed in relation to the main mixing hypotheses considered in the MSE framework. The most relevant results from each type of analysis are summarized below:

Otolith microchemistry

The results from previous phases suggested that western origin contributions were negligible in the Mediterranean Sea, Bay of Biscay and Strait of Gibraltar, but mixing rates could be considerable, in some years, in the central North Atlantic, Canary Islands and western coast of Morocco. In Phase 8, new carbon and oxygen stable isotope analyses were carried out in 256 otoliths of Atlantic bluefin tuna captured in the Central North Atlantic in 2014 and 2015, to determine their nursery area. δ13C and δ18O values measured in otolith cores indicated that these samples were dominated by eastern origin individuals. The comparative analysis with previous Phases suggests that important interannual variations in the mixing proportions can be observed in this area, which warrants year to year monitoring (**Figure 4**).

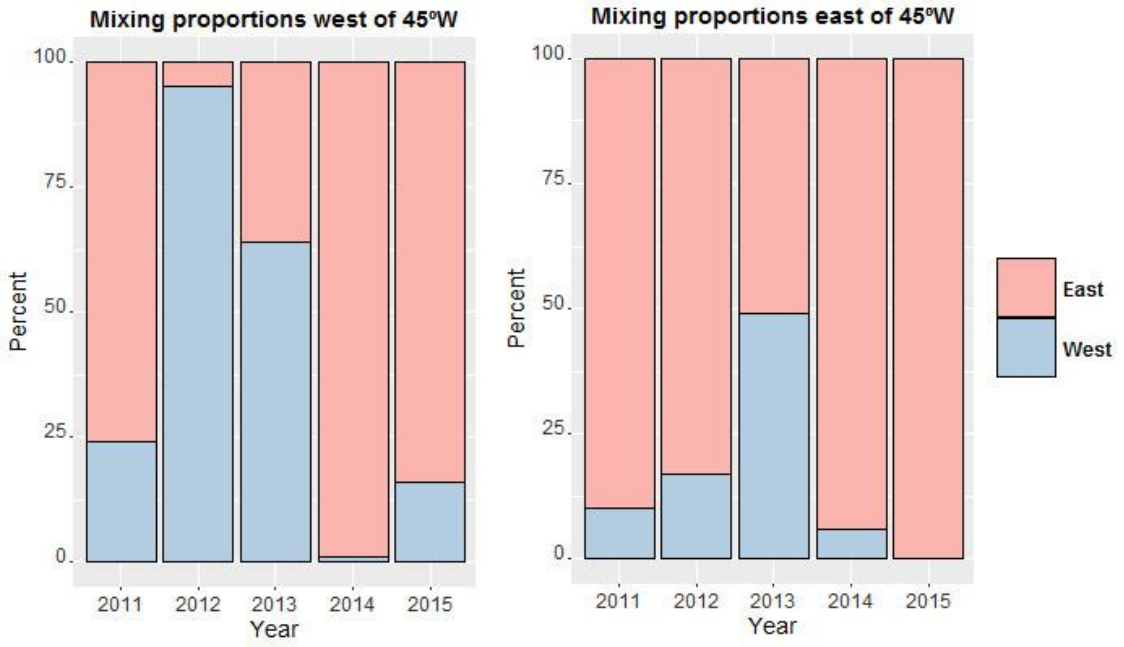

Figure 4. Interannual variation of the mixing proportions east and west of the 45ºW boundary estimated by Maximum Likelihood Estimator (HISEA program).

Genetic analyses

Previous results supported the presence of two populations of Atlantic Bluefin Tuna, which, despite the trans-Atlantic migrations of individuals from this species, is maintained through a natal homing behaviour to the two main spawning grounds, the Mediterranean and the Gulf of Mexico. This allowed the development of a traceability SNP panel that assigns individuals to their stock of origin and which is very relevant for ABFT management. Yet, since these analyses were performed, a new study suggested the presence of a third spawning ground within the Slope Sea and controversy exists about the origin of the larvae and young of the year found in

this area. The presence of a new spawning ground not only requires more in-depth analyses about the reproductive behaviour of ABFT, but might also call for the development of a new traceability panel taking a potential “third stock” into account.

Therefore, in Phase 8, population genetic analyses were performed based on about 10,000 SNPs and 400 reference samples from the Gulf of Mexico, Slope Sea and Mediterranean, and have determined genetic origin of above 1,000 individuals from feeding aggregates based on 96 SNPs that discriminate between Gulf of Mexico and Mediterranean Sea. These analyses confirmed the genetic differentiation of the Gulf of Mexico and Mediterranean Sea; yet, they also showed that Mediterranean-like individuals are found in the Gulf of Mexico and that the Slope Sea constitutes a genetically intermediate population. This demonstrates that Atlantic bluefin tuna presents more complex population dynamics than previously thought and calls for additional analyses to determine how genetic differentiation between the two components is maintained and how the “intermediary” population in the Slope Sea is originated. Concerning the origin of the feeding aggregates, the analyses confirmed that samples collected at eastern locations are mostly of Mediterranean origin, and also suggested a larger proportion of Mediterranean origin fish in western locations (**Figure 5**, **6** and **7**).

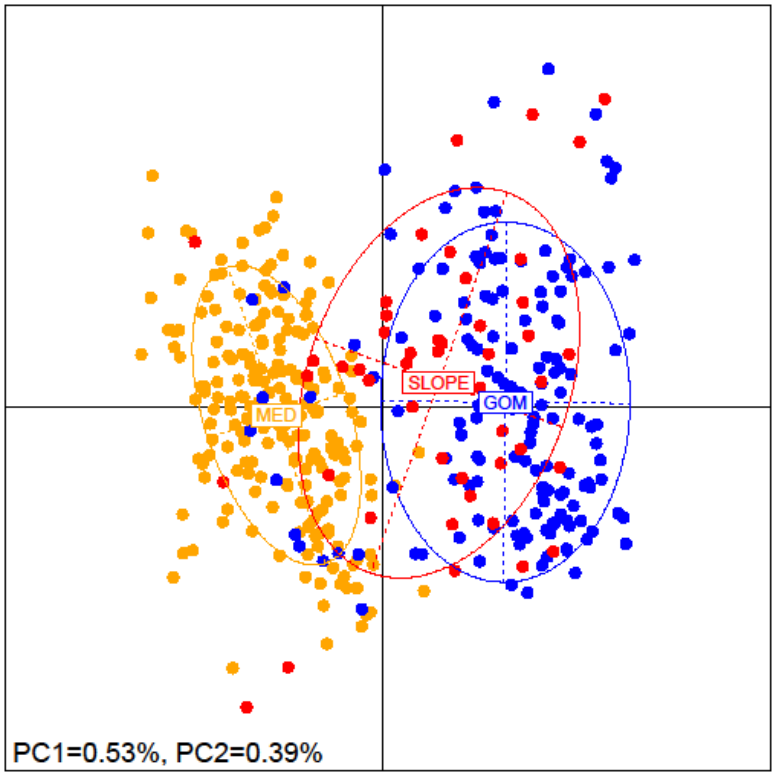

Figure 5. Principal Component Analysis of the Atlantic Bluefin tuna RAD-seq derived genotype markers. Each dot represents one sample and colors represent different locations. The Principal Components 1 and 2 explained 0.53% and 0.39% of the variation of the data.

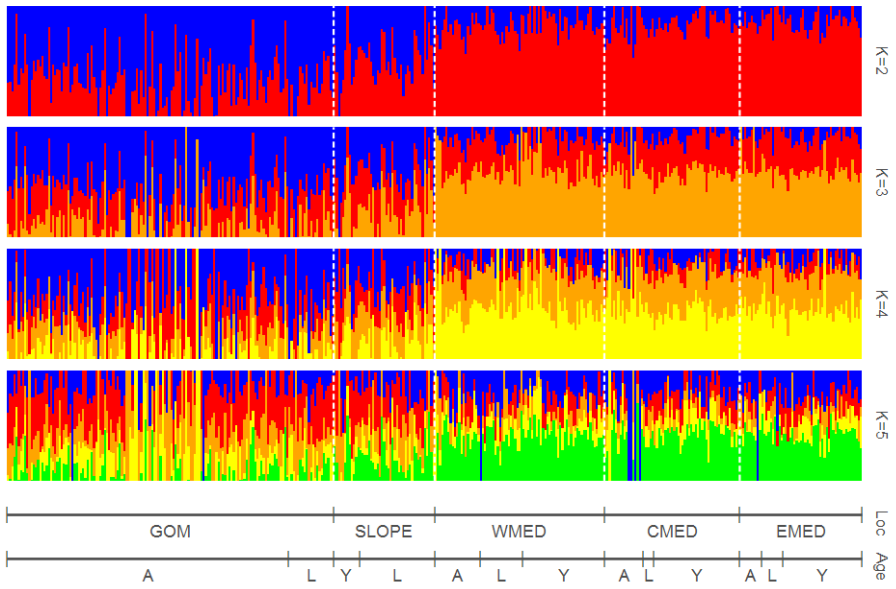

Figure 6. Individual ancestral proportions of Atlantic Bluefin tuna inferred using ADMIXTURE. Each color represents one ancestral population. Groups of individuals are identified in the x axis labels divided by location (GOM stands for Gulf of Mexico, SLOPE for Slope Sea and WMED, CMED and EMED for West, Central and East Mediterranean Sea locations respectively) and age group (A, L and Y stand for adult, larvae and young of the year respectively).

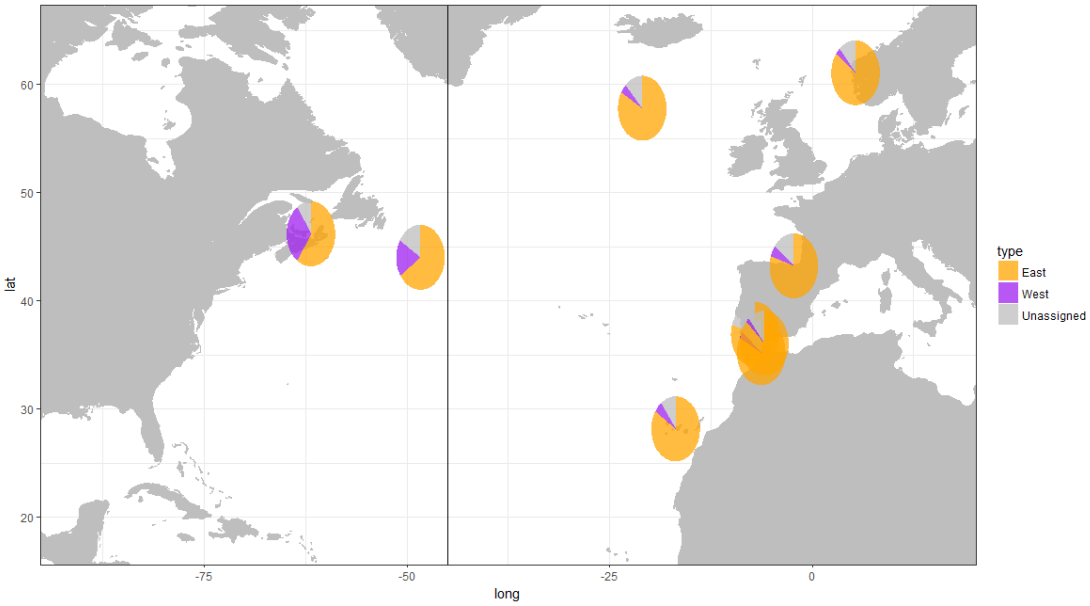

Figure 7. Proportion of samples per location assigned to Gulf of Mexico (purple) and Mediterranean Sea (orange). Black line indicates -45º meridian.

In relation to genetic analysis, it is worth to point out that given the notable success of the close kin study applied on Western bluefin tuna and some new methodological improvements in this field, the GBYP SC reviewed the new information available on this topic within the meeting held in December 2018. The main conclusion was that it would be recommendable to re-evaluate in –depth the possibility of resuming the studies in the Eastern part as well. The initial CKMR

simulations indicated a target number of adult-juvenile comparison of 25,000 fish (which would provide around 25 POPs). One of the key recent improvement is the possibility of using larvae instead of juveniles, which drastically reduces the costs of sampling. It was explained that, for obtaining a CKMR estimate of spawners abundance, a great number of samples has to be collected and analysed, but that with fewer samples this method may provide some other intermediate products such as spawning fraction at age and fishing mortality rate, which would present valuable inputs for the stock assessment/MSE. It was acknowledged that the initial analyses will be more expensive, because they will be dedicated to the identification of the genetic markers to be used for identifying parent-offspring pairs. It was also recommended to strive for developing a common genetic analysis method, which would serve both for CKMR and stock assignment. Although the GBYP CKMR study has not started yet, since an ad hoc workshop involving recognized specialists in the field should be held before to provide advice on the most adequate sampling design, in Phase 8 some preparatory work has been initiated. Thus, one of the objectives of maintaining the massive sampling of adults in farms, activity that was initiated in phase 6 mainly to provide samples to carry out a Close Kin study that was later cancelled, is to gather samples that could allow to apply these genetic techniques in a near future, since large numbers or BFT larvae samples are also available from ichthyoplankton surveys carried out at national level in different spawning areas.

Integrated genetic/microchemical analysis

Additional analyses were focused on the integrated approach to stock discrimination. The integrated stock discrimination model developed in GBYP phase 6 combined genotypic (SNPs) and phenotypic (otolith core stable isotopes δ13C and δ18O) markers of stock origin to discriminate between bluefin tuna from the Gulf of Mexico and Mediterranean spawning populations. In Phase 8, the existing adult baseline was extended to include fish from the western Mediterranean (Balearic Islands). Stable isotope signatures were compared between the adult baseline and the yearling baseline. The resolving power of the integrated model was re-evaluated and compared with single marker approaches. The integrated model was used to assign Bluefin from potential mixing zones in the Atlantic (N=306) to their population of origin and the results were compared with single marker assignments (**Figure 8**, **Table 11**).

Otolith core stable isotope signatures of the extended adult baseline remained more distinct than those of the yearlings. Adult bluefin from the Gulf of Mexico and Mediterranean were classified to their population origin with a mean accuracy of 95.3% compared to a classification accuracy of 82.3% for the yearling baseline. The classification accuracy of the integrated model (97.3%) exceeded that reported in this or previous studies using stable isotopes or genetics, particularly for the Gulf of Mexico population. However, the integrated model did not perform as well when used to assign individuals from the mixing area to their population of origin; 27% of these fish were assigned to the Mediterranean population using genetics and to the Gulf of Mexico population using stable isotopes baseline, and so these individuals could not be assigned to either population using the integrated model. When taken together, the genetic and stable isotope profile of these fish did not match that of the fish in either spawning area. They may represent a third spawning component or a migratory contingent within the Mediterranean population.

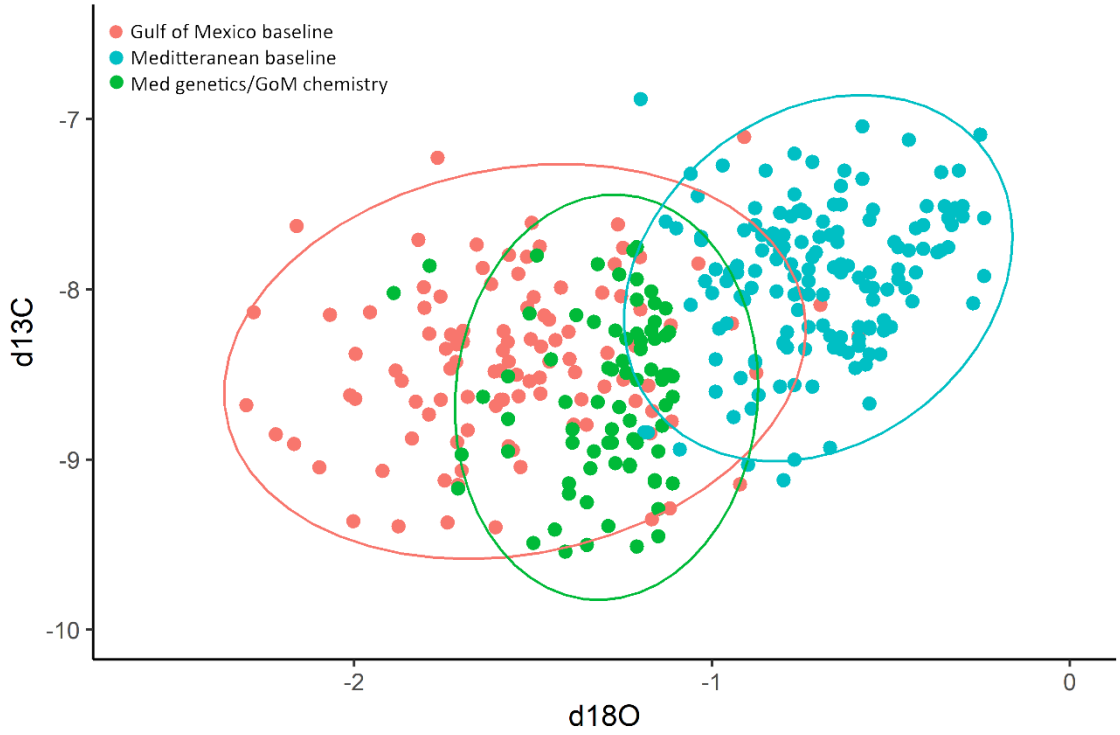

Figure 8. Otolith core values of δ13C and δ18O for 83 bluefin that were assigned to the Mediterranean population based on their genetics and to the Gulf of Mexico population based on the isotope composition of their otolith cores plotted alongside isotope values for the Gulf of Mexico and Mediterranean adult baselines that were used for the assignment.

Table 11. Confusion matrix from the random forest analysis, using a) δ13C and δ18O isotope measurements b) three SNP genetic markers (Rad213, Rad26 and Rad35) and c) a combination of otolith chemistry and genetics (δ13C, δ18O, Rad213, Rad26) to discriminate between adult bluefin tuna (>170cm FL) from spawning populations in the Gulf of Mexico and the Mediterranean. Classifications are based on 150 fish (45 from Gulf of Mexico and 105 from the Mediterranean) which had been analyzed using both methods.

Isotopes – adult baseline				**Genetics – adult baseline**				**Isotopes and genetics – adult baseline**			
	Estimated origin				*Estimated origin*				*Estimated origin*		
True origin	**GoM**	**Med**	**%correct**	*True origin*	**GoM**	**Med**	**%correct**	*True origin*	**GoM**	**Med**	**%correct**
GoM	41	4	91.1	**GoM**	34	10	77.3	**GoM**	43	2	96.6
Med	3	102	97.1	**Med**	3	100	97.1	**Med**	2	103	98.1
Total	44	106	95.3	**Total**	37	110	91.1	**Total**	45	105	97.3

A specific objective was to conduct age and genetic analyses on the Norwegian bluefin tuna, to know more about the Norwegian catch composition in terms of cohorts and origin. In total, 446 individuals collected between 2013 and 2017 were genetically analyzed and the probability to belong to the Mediterranean Sea and Gulf of Mexico populations was estimated (**Figure 9**). Fin spines of 417 individuals from 2016 and 2017 were used for age reading. Results suggest that the large bluefin tuna individuals that feed in Norwegian waters in summer are predominantly of Mediterranean origin, and similar age classes were observed in 2016 and 2017, ranging between 6 and 14 years old, but mostly of 9 and 10 years old.

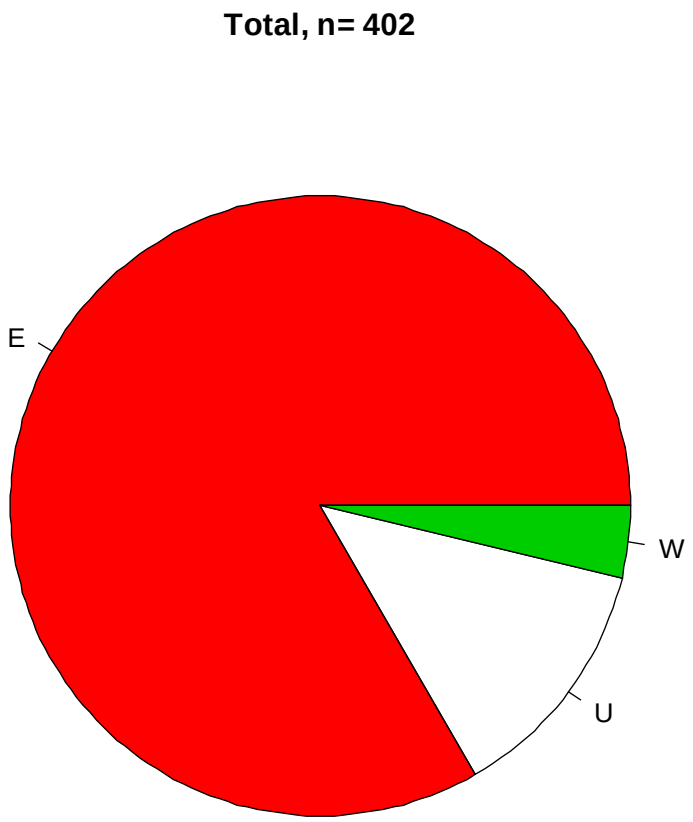

Figure 9. Proportion of Norwegian bluefin tuna assigned to the eastern population (red), western population (green) and unassigned (white).

Ageing related analysis

Fish Ageing Services successfully finished the preparation for reading of a set of 2000 otoliths following the revised protocol, consisting in embedding otoliths and cutting 2 sections per otolith for samples greater than 2 years and only one section for those 2 years old or less. Cutting 2 sections allows that one is used for the purposes of ageing, while the other one can be used for microchemical analyses.

4.4.2. Workshops on biological parameters

a) BFT ageing workshop

Pursuant to the conclusions that arose during the Juvenile Atlantic bluefin tuna otoliths exchange carried out by several SCRS experts on BFT growth along 2018 and in order to solve a series of identified issues, it was recommended to conduct an ageing workshop. Therefore, ICCAT GBYP finally organized the international Worksop on ABTF Growth that had been already planned to be carried out in 2018, but that had been postponed till the SCRS calibration exercise was finished. The workshop was held on 4-8 February 2019 in Santander, Spain. The main reason behind the organization is that, when during the 2017 Atlantic bluefin tuna assessment an age-length database coming from direct ageing was presented, for the first time, it was observed that otolith age estimates for fish younger than 8 years old had a smaller size at age compared to spine (first dorsal fin radius) age estimates. This difference, although small, was enough to misallocate the year class. This misallocation was initially partly solved when introducing a bias vector to correct the aging of the otoliths based on paired otolith-spine samples, produced

within the framework of the calibration exercise developed by SCRS specialists in 2018. However, it was still necessary to identify the causes of the divergences between spine and otoliths reading, possibly attributable to errors in the interpretation of the otoliths of young fishes. Thus, the GBYP workshop focused on identifying the possible sources of bias and, once detected, produce improved otolith interpretation criteria to prevent such bias. Thus, two possible causes for over-estimating age in the otolith age-length data were identified: the current age adjustment criterion (to convert the bands counting into ages) and a reading bias in age estimations from some laboratories. During the workshop, otolith preparation and reading protocols were also reviewed. The analysis showed that the formation of opaque zones seems to occur primarily between December through to June, contrary to what was thought until now, for which a new criterion for age adjustment was proposed. In addition, a series of conclusions and recommendations for future studies were proposed. The results of the Workshop are presented as SCRS/2019/132 (Annex 1b, document no. 41).

b) Workshop on BFT reproductive biology

Pursuant to the conclusions of the Preparatory Workshop on bluefin reproductive biology held in Phase 7 and the recommendations of Steering Committee, a special review of current assumptions on reproductive parameters of Eastern and Western bluefin tuna stock was requested, with the special focus on discrepancies between the assumed ages of first maturity and identification of feasible methods for determining spawning fraction. For this purpose, two independent reviewers have been contracted: Dr. Jessica Farley (CSIRO, Australia) and Dr. Seiji Ohshimo (Seikai National Fisheries Research Institute, Japan). As required by the contract, the experts prepared a detailed report on BFT reproductive biology, which was presented as scientific paper SCRS/2018/172 (Annex 1b, document no. 17.) and included review and insights into the differences in reproductive parameter estimates between Eastern and Western stock.
The report was presented during a special workshop dedicated to BFT reproductive biology that was organized by GBYP. The Workshop was held in Madrid, 26-28 November 2018 and it included participation of numerous experts in the field who gave presentations and discussed on various topics including discrepancies in eastern/western reproductive parameters, reproductive physiology, reproduction in captivity, larval ecology, spawning habitat modelling, life history, effects of fisheries practices on sampling and implication on MSE and assessment. The report of the Workshop is available in Annex 1b, document no. 40, presented as SCRS/2019/180. Individual presentations exposed during the Workshop are also available from the Annex 1b.

4.4.3. Study on BFT growth in farms

During the last 21st Special Meeting of the Commission, the SCRS was asked to provide an update on the potential growth rates of Bluefin tuna in farming/fattening facilities, with the aim of improving the coherence within the growth rates derived from eBCD, as stipulated in the paragraph 28 of Rec. 18-02. Consequently, GBYP was committed to carry out a broad study on this topic, involving ad hoc experiments in selected farms along the eastern Atlantic and Mediterranean.

As a first step for the planning of such study, the GBYP Steering Committee decided to prepare and distribute a questionnaire that all the companies involved in bluefin tuna farming/fattening activities were invited to complete. The immediate objective of this questionnaire was to gather detailed information on tuna farms characteristics and farming/fattening strategies, allowing to determine the different strata in which the study should be structured. This information will also help to interpret properly the obtained results, since it will allow to identify the different co-

variables influencing growth rates, and to evaluate the representativeness of the farms where the *ad hoc* field studies will be developed.

In addition, the Steering Committee identified 5 areas where the study will be carried out: Portugal, Spain, Malta, Croatia and Turkey. During Phase 8, all these areas were visited by GBYP Coordinator and other ICCAT Secretariat representatives, accompanied in some cases by SC members. Visits included holding various meetings with BFT farms representatives, local scientists and national authorities. The purposes of these visits were:

- to explore the willingness of farm owners to collaborate in the proposed study
- to get first-hand information about the logistic capabilities of the farms to carry out the envisaged activities, specially tagging and stereo-cameras image recording
- to present the questionnaire prepared by GBYP to get detailed information about farming procedures, to clarify any doubt and ask for feedback to improve it
- to inform about the context, objectives and general methodological approach of the proposed study
- to ask for rough cost per unit estimations by type of activity

The visits were successful and they allowed to understand that, in spite that the BFT farms do not show striking differences in rearing procedures, each of them has special characteristics, referring both to logistic capabilities and the initial length distributions of the reared fish, which conditions the harvesting strategies to a great extent. This results in a variety of scenarios, and such heterogeneity makes it difficult to apply a unique methodological approach.

All the preparatory work was successfully finished in Phase 8 and the studies will be initiated in Phase 9 on 5 farms: Tunipex in Portugal, Balfegó in Spain, AquaBioTech in Malta, Pelagos Net Farma in Croatia and Akua Group in Turkey.

4.5. Modelling

The modelling programme addresses the GBYP general objective 3, which is to "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".

Initially, it was planned that GBYP start with carrying out operational modelling studies only from the year 4, but following the recommendation of Steering Committee and SCRS, the modelling activities already started from the year 2. It became evident that this line of study has greater importance than perceived in the moment when GBYP was conceived and that the amount of effort for this activity is much larger than initially considered. In addition, the MSE process being embarked upon by ICCAT has been an important initiative which represents a significant investment of time and resources by the Commission, CPCs and scientists involved.

4.5.1. MSE development expert

In Phase 8 the contract for modelling approaches was again awarded to Dr. Tom Carruthers (Blue Matter Science, Canada), for providing support to bluefin tuna stock assessment, who initiated the work on MSE and modelling in 2014. The main objectives for this year were ensuring the OM scenarios agreed by the ICCAT GBYP Core Modelling and MSE Group can be run, that third parties can use the operating model to evaluate candidate management procedures of their own specifications and to provide a set of agreed summary statistics that can be used by decision makers to identify the management procedures, including data and knowledge requirements, that robustly meet the management objectives.

It is important for the BFT Species Group and the Commission to gain experience in conducting MSE. Major interactions with decision makers and stakeholders will best be conducted using results from stocks of interest to illustrate trade-offs, so that they can choose between tangible option on the basis of actual projections rather than abstract concepts. The initial MP design and performance statistics, however, should be few, informative and based on axes such as stock status, safety, stability and yield.

The specific tasks defined in the Phase 8 were the following:

1. Refine the software package following feedback from users at the 2018 ICCAT Bluefin Tuna and North Atlantic Swordfish MSE Meeting.
2. Maintain the meta-database of operating model data inputs.
3. Continue to develop help-documentation and tutorials to assist stakeholders in CMP development.
4. Work with stakeholders to assist them to develop CMPs, and also the Contractor himself is to develop a CMP.
5. Produce MSE visualization tools such as a revised Shiny App and Bayesian Belief Network.
6. Produce a scientific manuscript on a multi-stock management procedure to be presented as scientific communication to ICCAT SCRS Species Groups 2018 meeting.
7. Produce a scientific manuscript on 'Strategies and Tactics in the Campaign for Sustainability of Atlantic Bluefin Tuna to be presented as scientific communication to ICCAT SCRS Species Groups 2018 meeting.

8. Assist in documenting the deliberations of meetings taking this MSE process forward in a manner that records developments in some detail.

In the scope of Phase 8, the operating models have been updated considerably to include, for example, multiple phases of recruitment estimation and time-varying future movement, the meta data-base was updated to a new version, a dedicated CMP developers guide was made, more than 30 CMPs were integrated into the R package and the Trial Specification document has expanded considerably in scope to include comprehensive detail on all operating model aspects and now includes version numbering to record the evolution of decisions regarding operating model structure and assumptions. Also developed were new standardized operating model reports, operating model comparison reports and a preliminary MSE results report (essentially standardizing CMP developer results). In addition, a range of other research products and tasks were completed following requests from working group meetings and informal ad-hoc discussions over email. A mixture modelling approach was developed to more accurately process stock-of-origin data such as otolith microchemistry and genetics data, a full account of ABT-MSE operating models was submitted, following the identification of missing age-0 catches in the Mediterranean, a post-hoc analysis of impact on the Eastern VPA was conducted, a meta analytic evaluation of bluefin tuna life-history assumptions was made and an automatic report was built in the ABTMSE R package that standardizes MSE results.

The outputs from GBYP MSE modelling activities, as mixture model interpretation of stock of origin data and an updated summary of conditioned operating models have been presented within BFT SCRS Species Group session as scientific papers SCRS/2018/133 (Annex 1b, document no. 8) and SCRS/2018/134 (Annex 1b, document no. 9).

At the end of Phase 8, the MSE framework has been completed, although not all components downstream of the Management Procedures and the Management Objectives have been finalized yet (**Figure 10**). The final report is available in Annex 1a, document no. 28.

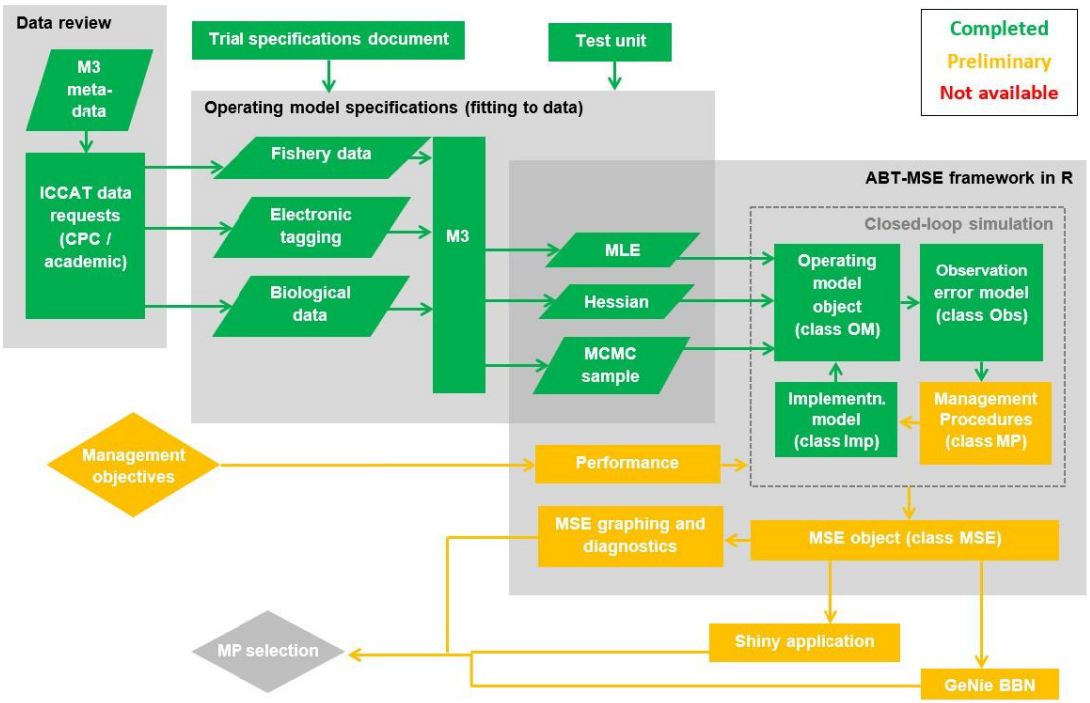

Figure 10. Status of the components of the ABT MSE framework, as of February 2019, showing the preliminary nature of Management Procedures and Management Objectives (and hence all components downstream)

4.5.2. BFT MSE Technical Group

In order to support the important and complex MSE development by an effective coordinating body with the requisite technical expertise and appreciation of needs of the SCRS and Commission, in 2014 the GBYP Core Modelling and MSE Group was created. The Steering Committee provided its terms of reference and recommended the membership of the Group. The Group was intended to provide technical oversight and advice on the MSE process and review technical contributions and outputs of the work program. From December 2014 to 2017 the Group held 6 meetings.

BFT Species Group held the MSE intersessional meeting on 16-20 April 2018, partly together with Swordfish Species Group. During the meeting, the Bluefin tuna Core Modelling Group presented its work and obtained feedback from the SCRS focusing on adjustments to the bluefin tuna operating models. The MSE trial specification document was updated and several initial candidate management procedures were proposed and tested on preliminary basis. The Group shared the experiences with the coding package and discussed its possible amendments and associated trials. Several other topics were discussed and the further CMP refinement schedule was drafted, as well as priority actions identified including closer consideration of stock mixing, BMSY calculations, future recruitment scenarios, abundance indices, and definition of key uncertainties. The report is available in Annex 1a, document no. 21. GBYP supported the attendance to this meeting of the GBYP CMG coordinator, Dr. Doug Butterworth, and the CMG expert Dr. Carmen Fernández.

The Standing Working Group on Dialogue between Scientists and Managers hold a meeting on 21-23 May 2018, including an agenda item specific to bluefin tuna MSE. The objective of this meeting was to initiate input from stakeholders to assist in future refinement of candidate management procedures. It was recognized that the original road map adopted by the Commission was too ambitious, because the Bluefin tuna Species Group, whose involvement is crucial at this stage, will have to meet several times to advance their work, given the complexity of MSE. The estimated delay in the timeline for bluefin tuna is at least six months, which should allow ICCAT to remain on track to consider candidate MPs for possible adoption in 2020. The report is available in Annex 1a, document no. 22. GBYP supported the attendance to this meeting of the GBYP CMG coordinator, Dr. Doug Butterworth.

In April 2018, during the MSE intersessional meeting of the BFT Species Group, it was decided to formalize the creation of the BFT MSE Technical Group, which, unlike Core Modelling Group, would be open to all interested ICCAT scientist, without restriction to participation. Therefore, GBYP Core Modelling Group was dissolved and it was succeeded by the BFT MSE Technical Group. Nevertheless, although this Group was not formally constituted within the framework of Programme, GBYP continued to provide its support, by covering the travel expenses, when needed, for participating to the meeting of the following experts:

- Doug Butterworth
- Tom Carruthers
- Carmen Fernandez
- Shuya Nakatsuka
- SCRS Chair
- E-BFT Rapporteur
- W-BFT Rapporteur

5. Overall GBYP use of data and results

One of the principal objectives of the GBYP is to improve the basic data for their use in the various assessment and modelling approaches. Several types of data obtained by GBYP have been specially formatted and subsequently incorporated in the databases maintained by the ICCAT Secretariat. Other data, that could not be incorporated due to inexistence of a specific database, have been maintained and analysed separately and the final results have been provided directly to SCRS. The data provided by GBYP have been used for the bluefin tuna stock assessment in both 2014 and 2017 and are currently used for the purpose of MSE.

Here below are listed some of the greatest achievements and contribution of the Programme, by line of investigation:

Data mining

- Size data
- LL CPUE
- Historical trap data
- BB data
- Non-GBYP electronic tag data recovered by GBYP
- Historical maturity data
- Historical genetic data

Aerial survey on BFT spawning aggregation

- A 6 years long series of fisheries independent index for adult BFT in 4 spawning areas in the Mediterranean

Tagging

- Conventional and electronic tag data
- Growth data from conventional tags
- Mixing determination (MSE areas movement matrices)
- BFT temperature and depth preferences revealed by electronic tags
- Recoveries of tags deployed by other teams on BFT
- Development of tagging protocols

Biological studies

- Length/weight correlation
- Reproductive characteristics
- Age length key
- Population structure
- Genetic and microchemical studies for stock assignment
- Mixing determination (MSE areas)
- Development of stock of origin assignment methods
- BFT tissue bank with on-line accessible inventory
- Workshop on BFT reproductive biology
- Workshop on BFT larval studies
- Development of sampling protocols
- Development of otolith reading protocols
- Development of otolith cutting protocols

Modelling and MSE

- Development of ABT-MSE analysis software
- OM development
- SAM application
- VPA training course

- Financial support for organization of BFT MSE technical group meetings, including participations of modelling coordinator and several experts

It is also worth mentioning that so far GBYP has awarded 149 contracts to 98 entities, localized in 24 different countries, involving therefore a work of many hundreds of researchers and technicians. This large and open participation to ICCAT GBYP activities is also considered an important achievement of this research programme.

Annex 1. List of reports and scientific papers in Phase 8

a) List of deliverables and reports produced within the framework of GBYP contracts and activities

1. Aerial Survey – 15 May 2018: Short term contract for aerial survey training course, real-time monitoring of the data and real-time survey data analysis (ICCAT GBYP 02/2018), Aerial survey protocol. Alnilam Research and Conservation Ltd: 1-17.
2. Aerial Survey – 15 May 2018: Short term contract for aerial survey training course, real-time monitoring of the data and real-time survey data analysis (ICCAT GBYP 02/2018), Aerial survey forms. Alnilam Research and Conservation Ltd: 1-3.
3. Aerial Survey – 16 May 2018: ICCAT GBYP Administrative rules for the Aerial survey, Presentation for the Training Course. ICCAT GBYP Coordination: 1-14.
4. Aerial Survey – 16 May 2018: ICCAT GBYP Aerial Survey objectives and approach, Presentation for the Training Course. ICCAT GBYP Coordination: 1-14.
5. Aerial Survey – 16 May 2018: Short term contract for aerial survey training course, real-time monitoring of the data and real-time survey data analysis (ICCAT GBYP 02/2018), Power Point presentation for the Aerial Survey Training Course 2018. Alnilam Research and Conservation Ltd: 1-89.
6. Aerial Survey – 16 May 2018: Training Course for the ICCAT GBYP Aerial survey for bluefin spawning aggregations, List of participants. ICCAT GBYP Coordination: 1-2.
7. Aerial survey- 13 July 2018. Short term contract for the aerial survey for bluefin spawning aggregations (ICCAT GBYP 03/2018-b) – Final report for Areas C and E. Unimar and Aerial Banners: 1-31.
8. Aerial survey- 14 June 2018. Short term contract for the aerial survey for bluefin spawning aggregations (ICCAT GBYP 03/2018-c) – Final report for Area G. Action Air Environnement: 1-35.
9. Aerial survey-7 July 2018, Short term contract for the aerial survey for bluefin spawning aggregations (ICCAT GBYP 03/2018-a) – Final report for Area A. Grup Air Med: 1-35.
10. Aerial Survey – 30 August 2018: Short term contract for aerial survey training course, real-time monitoring of the data and real-time survey data analysis (ICCAT GBYP 02/2018), Final report. Alnilam Research and Conservation Ltd: 1-25.
11. Biological studies – 18 July 2018. Short term contract for biological studies (ICCAT GBYP 06/2018-a). Sampling protocol for GBYP biological sampling. Consortium led by AZTI: 1-19.
12. Biological studies – May 2018. Sampling strata and needs for Biological studies in Phase 8. GBYP Coordination: 1-2.
13. Biological studies – 10 February 2019. Short term contract for biological studies (ICCAT GBYP 06/2018-a). Final report. Consortium led by AZTI: 1-76.
14. Biological studies – 8 August 2019. Short term contract for biological studies (ICCAT GBYP 06/2018-b). Final report. Consortium led by UNIBO: 1-4.
15. Biological studies – 7 February 2019. Short term contract for biological studies –sampling of adults (ICCAT GBYP 04/2018-b). Final report. AquaBioTech: 9.
16. Biological studies – 7 February 2019. Short term contract for biological studies –sampling of adults (ICCAT GBYP 04/2018-a). Final report. Taxon: 1-30
17. Coordination –19 April 2018: ICCAT GBYP Steering Committee Meeting, Report, Anon: 1-8.
18. Coordination –24 September 2018: ICCAT GBYP Steering Committee Meeting, Report, Anon: 1-3.
19. Coordination –19 December 2018: ICCAT GBYP Steering Committee Meeting, Report, Anon: 1-8.
20. Data recovery – 20 August 2018. Short term contract for the data recovery plan (ICCAT GBYP 08/2018) – Final report. Antonia Mangano: 1-3.

21. Meetings – 20 April 2018: ICCAT Bluefin Tuna Species Group MSE Intersessional Meeting, Anon: 1-68.
22. Meetings – 23 May 2018, ICCAT Fourth meeting of the Standing Working Group to enhance dialogue between fisheries scientists and managers (SWGSM), Report, Anon: 1-32.
23. Meetings- 28 September 2018, Atlantic Bluefin Tuna Species Group Meeting Summary Report, Anon: 1-7.
24. Meetings – 25 September 2018, Chair and rapporteurs' report of Bluefin MSE Technical Group Meeting, Anon: 1-11.
25. Meetings – 5 October 2018, Report of the Standing Committee on Research and Statistics (SCRS), Anon: 1-469.
26. Meetings – 15 February 2019, Report of the 2019 Intersessional meeting of the ICCAT Bluefin Tuna Species Group, Anon: 1-39.
27. Meetings – 9 February 2019, Report of the 2019 Intersessional Meeting of the ICCAT Bluefin Tuna MSE Technical Group, Anon: 1-15.
28. Modelling – 19 February 2019. Short term contract for modelling approaches (ICCAT GBYP 05/2018) – Final report 9. Blue Matter Science: 1-12.
29. Tagging – 4 December 2018. Short term contract for the Tagging Programme 2018 - Area A (ICCAT GBYP 07/2018). Final report. Marine Institute: 1-27.
30. Tagging- 28 December 2018. Short term contract for the Tagging Programme 2018 - Area B (ICCAT GBYP 07/2018). Final report. Tunipex: 1-25.
31. Tagging – 20 November 2018. Tagging of Atlantic bluefin tuna (Thunnus thynnus) with pop-up satellite archival tags (PSAT) in western Norway during 2018. Final report. Institute of Marine Research: 1-13.
32. Aerial survey – 24 October 2019. Aerial survey calibration exercise design and sighting protocol. Alnilam: 1-44.
33. Acoustic survey – 6 September 2019. Feasibility study on the use of scientific multibeam sonar to characterize the Atlantic bluefin tuna spawning stock. Final report. Norwegian Institute of Marine Research and Polytechnic University of Valencia: 1-23.

b) List of scientific documents produced within the framework of GBYP activities or based on GBYP data

1) Alemany, F., Tensek, S., Pagá García, A., 2018, ICCAT Atlantic-Wide Research Programme for Bluefin Tuna (GBYP) Activity report for the last part of Phase 7 and the first part of the Phase 8. SCRS/2018/171
2) Álvarez-Berastegui, D, Reglero, P, Balbin, R, Mourre, B, Díaz-Barroso, L, Muhling, B, Rassmuson, L, Ingram, GW, Lamkin, J, Tintoré, J, Alemany, F, 2018, Linking bluefin tuna spawning and larval habitats with mesoscale oceanography in Western Mediterranean. Presentation.
3) Anonymous, 2018, Report of the ICCAT Atlantic-Wide Research Programme for Bluefin Tuna (ICCAT GBYP), Activity report for the last part of Phase 7 and the first part of Phase 8 (2017-2018), including a general overview of the activities up to 2018. SCI-036/2018
4) Arrizabalaga, H, Arregui, I, Zudaire, I, Luque, PL, Fraile, I, Murua, H, Nottestad, L, 2018, BFT reproductive biology: an Atlantic perspective. Presentation.
5) Birnie-Gauvin, K., MacKenzie, B.R., Aarestrup, K., 2018, Electronic Tagging of Atlantic Bluefin Tunas in Scandinavian Waters 2018. SCRS/2018/178
6) Block, B, Whitlock, R, Aalto, E, Castleton, M, Schallert, R, Wilson, S, Stokesbury, M, Carlisle, A, Boustany, A, Reeb, C, Horton, T, Witt, M, 2018, Electronic Tags and Genomics Reveal Life History of Bluefin Tunas. Presentation.

7) Boustany, A and Huff, S, 2018, Estimating Spawning Fraction in Pacific Bluefin Tuna, With Application to Atlantic Bluefin. Presentation.

8) Carruthers, T. and Butterworth, D., 2018, A Mixture Model Interpretation of Stock of Origin Data for Atlantic Bluefin Tuna. SCRS/2018/133

9) Carruthers, T. and Butterworth, D., 2018, Updated Summary of Conditioned Operating Models for Atlantic Bluefin Tuna. SCRS/2018/134

10) Carruthers, T. and Hordyk, A., 2018, Are Life-History Parameters for Bluefin Tuna Anomalous? SCRS/2018/156

11) Corriero, A, 2018, First Sexual Maturity in the Atlantic Bluefin Tuna. Presentation.

12) Cort, JL, Di Natale, A, Carranza, J, 2018, Temporal changes in fisheries and manipulation adversely affecting sampling for reproductive studies of Atlantic bluefin tuna. Presentation.

13) Cruz-Castán, RM, Saber, S, Meiners-Mandujano, C, Gómez-Vives, MJ, Galindo-Cortes, G, Curiel-Ramirez, S, Macías, D, 2018, A posible new spawning area for bluefin tuna in southern Golf of Mexico. Presentation.

14) De La Gandara, F and Ortega, A, 2018, Recruits from farmed ABFT in Murcia? Presentation.

15) Di Natale, A, Macías, D, Cort, JL, 2018, ABFT Fisheries (temporal changes in the exploitation pattern, feasibility of sampling, factors that can influence our ability to understand spawning structure/dynamics. Presentation.

16) Di Natale, A., Tensek, S., Pagá García, A., 2018, Is Bluefin Tuna Slowly Returning to the Black Sea? Recent evidences. SCRS/2018/120

17) Farley, J. and Ohshimo, S., 2018, Review and Insights into the Differences in Reproductive Parameter Estimates between Eastern and Western Atlantic Bluefin Tuna Stocks. SCRS/2018/172

18) Heinisch, G, 2018, Sexual maturation in western Atlantic bluefin tuna and other perciforms. Presentation.

19) Katavic, I, Grubisic, L, Segvic-Bubic, T, Males, J, Talijancic, I, Zuzul, I, 2018, New findings on the onset of gonadal maturation of eastern Atlantic bluefin tuna in the Adriatic Sea. Presentation.

20) Lauretta, M, Kimoto, A, Walter, J, 2018, Spawning fraction-at-age effects on the assessment of West Atlantic bluefin tuna. Presentation.

21) Lutcavage, M, Lam, T, Galuardi, B, 2018, Life history of Atlantic bluefin tuna: energy, reproduction and migration. Presentation.

22) Macías, D, Saber, S, Ortiz de Urbina, J, 2018, Assessing Eastern Atlantic bluefin tuna spawning fraction ogive by means of length-converted catch curve analysis. Presentation.

23) MacKenzie, B.R., Aarestrup, K., Birnie-Gauvin, K., Cardinale, M., Casini, M., Harkes, I., Onandia, I., Quilez-Badía, G., Sundelöf, A., 2018, Electronic Tagging of Adult Bluefin Tunas by Sport Fishery in the Skagerrak, 2017. SCRS/2018/164

24) Medina, A, 2018, Reproduction of ABFT in the Mediterranean Sea – Are Eastern and Western stocks so different? Presentation.

25) Merino, G., Arrizabalaga, H., Santiago, J., Gordoa, A., Rouyer, T., 2018, Preliminary Evaluation of a Candidate Management Procedure for Atlantic Bluefin Tuna, SCRS/2018/143

26) Ortega, A, 2018, Reproduction of ABFT in captivity: The role of land-based facilities improving knowledge. Presentation.

27) Oshimo, S, 2018, Comparison on the reproductive parameters of bluefin tuna between Atlantic and Pacific. Presentation.

28) Pacicco, A, Lutcavage, M, Allman, R, Fitzhugh, G, 2018, A histological assessment of bluefin tuna gonads sampled in the Northwest Atlantic from 2007-2017. Presentation.

29) Pagá García, A., Tensek, S., Alemany, F., 2018, Overview of the Bluefin Tuna Data Recovered by GBYP in the First Part of Phase 8. SCRS/2018/176

30) Reglero, P, 2018, How offspring fitness constrains spawning phenology in Atlantic bluefin tuna? Presentation.

31) Richardson, DE, Walsh, H, Marancik, K, Hernandez, C, Llopez, J, Broughton, E, 2018, An update on research on Atlantic bluefin spawning and early life history in the Slope Sea. Presentation.

32) Rodríguez-Marín, E., Quelle, P., Busawon, D., Farley, J., Addis, P., Allman, R., Bellodi, A., Garibaldi, F., Hanke, A., Ishihara, T., Karakukak, S., Koob, E., Lanteri, L., Luque, P.L., Ruiz, M, 2018, Juvenile Atlantic Bluefin Tuna Otoliths Exchange. SCRS/2018/127

33) Rodríguez-Marín, E., Quelle, P., Busawon, D., Hanke, A., 2018, New Protocol to Avoid Bias in Otolith Readings of Atlantic Bluefin Tuna Individuals. SCRS/2018/126

34) Rosenfeld, H, 2018, Timing of puberty in Atlantic bluefin tuna – the endocrine approach. Presentation.

35) Saber, S, Gómez-Vivez, MJ, Ortiz de Urbina, J, Macías, D, 2018, Are the tuna researchers using the same maturity scales? Presentation.

36) Tensek, S., 2018, Shiny Application for Visualisation of Movements of Electronic Tags Deployed Within ICCAT GBYP. SCRS/2018/174

37) Tensek, S., Pagá García, A. and Alemany, F., 2018, Preliminary Analysis of Bluefin Tuna Depth and Temperature Preferences Revealed By ICCAT GBYP Electronic Tags. SCRS/2018/173

38) Vázquez Bonales, J.A., Cañadas A., Alemany F., Tensek S., and Pagá García A., 2018, ICCAT GBYP aerial survey for bluefin tuna spawning aggregations in 2018. SCRS/2018/175

39) Zarrad, R, Alemany, F, Missaoui, H, Balbin, R, Lopez-Jurado, JL, 2018, Evidence of bluefin tuna spawning in the Central Mediterranean. Presentation.

40) Anonymous, 2019, Report of the ICCAT GBYP Workshop on Atlantic Bluefin Tuna Reproductive Biology. SCRS/2019/180

41) Rodríguez-Marín, E, Quelle, P, Addis, P, Alemany, F, Bellodi, A, Busawon, D, Carnevali, O, Cort, JL, Di Natale, A, Farley, J, Garibaldi, F, Karakulak, S, Krusic-Golub, K, Luque, PL, Ruiz, M, 2019, Report of The ICCAT GBYP International Workshop on Atlantic Bluefin Tuna Growth (Santander, Spain, 4-8 February 2019). SCRS/2019/132

Annex 2. GBYP Contracts issued in Phase 8

ICCAT GBYP COORDINATION				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
01/2018	Steering Committee External Expert - Ivan Katavic - Croatia	16/03/2018	20/02/2019	15,000.00 €
ICCAT GBYP DATA RECOVERY				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
08/2018	Data recovery plan - Antonia Mangano - Italy	18/07/2018	01/09/2018	9,800.00 €
09/2018	Electronic tags data recovery - Stanford University, USA	31/08/2018	15/12/2018	8,000.00 €
14/2019	Electronic tags data recovery – Tag a Tiny, USA	26/07/2019	15/09/2019	30,000.00 €
ICCAT GBYP AERIAL SURVEY				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
02/2018	Aerial survey data elaboration - Alnilam - Spain	27/04/2018	06/08/2018	22,275.00 €
03/2018	Aerial Survey - Grup Air-Med - Spain	18/05/2018	18/07/2018	116,690.00 €
03/2018	Aerial Survey - Unimar-Italy and Aerial Banners-Italy	16/05/2018	18/07/2018	187,208.00 €
03/2018	Aerial Survey - Action Air Environnement - France	27/04/2018	18/07/2018	141,414.00 €
cost reimbursement	Aerial Survey Training Course	16/05/2018	16/05/2018	9,545.55 €
08/2019	Design of an aerial survey calibration exercise and an updated aerial survey sighting protocol - Alnilam-Spain	29/04/2019	10/09/2019	8,400.00 €
11/2019	Advice on the application of acoustic techniques to the characterization of Atlantic bluefin spawning Eastern stock - Institute of Marine Research - Norway	27/06/2019	10/09/2019	15,710.00 €
11/2019	Advice on the application of acoustic techniques to the characterization of Atlantic bluefin spawning Eastern stock - Polytechnic University of Valencia - Spain	21/06/2019	10/09/2019	5,000.00 €

ICCAT GBYP TAGGING PROGRAMME				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
07/2018	Tagging programme (Area A) - The Marine Institute - Ireland	30/07/2018	04/12/2018	25,280.00 €
07/2018	Tagging programme (Area B) - Tunipex S.A. - Portugal	03/08/2018	04/12/2018	44,500.00 €
ICCAT GBYP BIOLOGICAL SAMPLING AND ANALYSES				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
04/2018	Sampling for BFT adults - AquaBioTech Ltd - Malta	06/06/2018	10/02/2019	88,300.00 €
04/2018	Sampling for BFT adults - Taxon Estudios Ambientales S.L. - Spain	01/06/2018	10/02/2019	40,000.00 €
06/2018	Biological studies - Fundación AZTI - Spain, as leader of a Consortium including 8 more institutions (2 Italy (1 w/o budget), 2 Spain, 1 USA (w/o budget), 1 Ireland, 1 Japan (w/o budget), 1 France (w/o budget) (+ 4 subcontracts: 1 Norway, 1 Portugal, 1 USA, 1 Spain)	27/06/2018	10/02/2019	217,507.00 €
06/2018	Biological studies - University of Bologna - Italy, as leader of a Consortium including 2 more institutions (1 Italy - w/o budget, 1 Canada-w/o budget)	18/07/2018	31/08/2019	44,000.00 €
10/2018	Bluefin tuna E/W spawning stock differences - CSIRO, Australia	16/08/2018	28/11/2018	6,000.00 €
10/2018	Bluefin tuna E/W spawning stock difference-Seikai-NFRI, Japan	31/08/2018	28/11/2018	6,000.00 €
03/2019	Preparation of otoliths for ageing - Fish Ageing Services, Australia	09/04/2019	01/07/2019	52,388.88 €
ICCAT GBYP MODELLING APPROACHES				
CALL FOR TENDERS or ACTIVITY	**RETAINED PROPOSAL**	**working schedule**		**COST €**
		initial date	**final date**	
05/2018	Modelling Approaches: Support to Bluefin Tuna Stock Assessment - Blue Matter Science - Canada	26/04/2018	20/02/2019	115,000.00 €