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

(Activity report for the last part of Phase 8 and the first part of Phase 9 (2018-2019))

1. Introduction

The ICCAT Atlantic-wide Research Programme for Bluefin Tuna (GBYP) was officially adopted by the SCRS and the ICCAT Commission in 2008, and it started officially at the end of 2009, with the objectives of improving a) basic data collection, including fishery independent data; b) understanding of key biological and ecological processes and c) assessment models and provision of scientific advice on stock status. It was initially envisaged as a 6 year programme, but in 2014 the Commission, acknowledging the importance of the programme for bluefin tuna management, endorsed the GBYP Steering Committee (2015) and the SCRS recommendations (Report of Special Research Programmes – GBYP contained in the *Report for Biennial Period 2014-15, Part I (2014) - Vol. 2*) for extending the GBYP activities up to 2021. Consequently, the donors have maintained their budgetary support (EU 80%, other donors 20%) since then, allowing for the continuity of the programme. The general information about GBYP activities and its results, as well on budgetary and other administrative issues of the GBYP programme, from the very beginning of the programme till today, are available on the GBYP webpage. All the relevant documents related to the programme development, including final reports of every activity and derived scientific papers, Annual Reports to the SCRS and European Union, GBYP workshops or Steering Committee meetings reports, are also readily available on the GBYP webpage.

The eight phase of the GBYP officially started on 21 February 2018 following the signature of the Grant Agreement for the co-financing of the GBYP Phase 8 (SI2.777629) by the European Commission and should have ended on 20 February 2019. However, in order to better address new research needs, and make optimal use of Phase 8 funds, the GBYP Phase 8 Grant Agreement was amended, extending Phase 8 till 20 September 2019. The activities carried out during the first six months of Phase 8 and their preliminary results were presented to the SCRS and the Commission in 2018 (SCRS/2018/171) and approved. The ninth phase of the GBYP officially started, following an EU request, on 1 January 2019, after the signature of the Grant Agreement for co-financing of Phase 9 (SI2.777629) by the European Commission with a planned duration of one year. This implies that, for the first time, two GBYP phases have been developed in parallel, making a bit more complex the GBYP program management, but this has not caused any major problem since each phase has a different and well defined work-plan and budget, and every cost can be assigned unequivocally to the activities detailed in the respective Grant Agreements.

In general, in spite of some technical problems affecting a couple of specific activities within field surveys, all the activities planned within both phases have been or are being implemented successfully. The activities in both phases have continued to be structured considering the same main lines of research established since the beginning of the programme, i.e. data recovery, biological studies, tagging, aerial surveys and modelling, but this does not mean that the workplans of these last two phases mimic those of the previous ones. Thus, in line with the new strategic approach resulting from the global internal review of project performance carried out at the beginning of the GBYP Phase 8 and presented to and approved by the SCRS at the 2018 SCRS meeting, new actions aiming mainly at improving and standardising the methodologies applied for generating data which are crucial for proper stock assessment have been developed during the extension of Phase 8 and the first months of Phase 9. Specifically, in order to reach the widest consensus among SCRS specialists on some controversial issues, three workshops involving representatives from most research teams working on the respective topics have been organized within this reporting period, one on BFT reproductive biology, another on BFT ageing and the last one on electronic tagging methodologies. In addition, several new actions focused on increasing the reliability of aerial survey indices, such as calibration exercises among spotters, feasibility studies for the application of acoustic techniques to the validation of aerial surveys and future development of new fishery independent indices, development of optimized sighting strategies and protocols and reanalysis of the whole aerial survey indices time series to correct some detected bias, have been implemented. It is also worth pointing out the broad study on BFT growth in farms that have been designed and implementation started during this last year by the GBYP in five different areas in order to address the ICCAT Rec. 18-02, paragraph 28.

Both these new scientific activities and those initiated in previous phases carried out throughout the GBYP Phase 8 and those launched during the first part of Phase 9, as well their final or preliminary results and the related coordination activities, are described and summarised in this report. Moreover, it also includes a proposal of activities to be carried out within Phase 10, for consideration and eventual support of the SCRS.

2. Coordination activities and general issues of GBYP programme management

The GBYP SC in Phases 8 and 9 has been composed of the SCRS Chair, the Western Bluefin Tuna Rapporteur, the Eastern Bluefin Tuna Rapporteur, the ICCAT Executive Secretary and one external expert, who was contracted for the purpose at the beginning of Phase 8, and such contract has been renewed in Phase 9. Within this reporting period, the GBYP Coordination Team has been composed of the GBYP Coordinator, the Assistant Coordinator and the Database Specialist. The ICCAT Secretariat has provided technical and administrative support for all GBYP activities on a daily basis.

Three GBYP SC meetings have been held during the last year. The first (24 September 2018) was a short meeting centred on the review of Phase 8 ongoing tasks. The second (17-19 December 2018) was more extensive, focusing on the elaboration of the amendment proposal for the Phase 8 Grant Agreement, to adapt it to the latest recommendations from the SCRS and Commission, and to the refinement of the workplan for the planned activities in Phase 9. The last one, dedicated to the review of the results from the last Phase 8 activities and the Phase 9 ongoing activities, as well to the elaboration of an amendment proposal for the last part of Phase 9 and of the first draft of the Phase 10 workplan, has been held on 23-24 September 2019. The GBYP SC members have been constantly informed by the GBYP Coordination Team about the status of the activities through detailed reports provided on a monthly basis, and they are regularly consulted by e-mail on many issues.

The GBYP Coordination Team, with the advice of the GBYP SC and the direct help of ICCAT Secretariat staff, managed in 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. In Phase 9, an additional 5 calls for tenders have been launched, and a total of 19 contracts have now been signed.

Moreover, within this reporting period, the GBYP Coordination Team has organized three international workshops, and funded and managed the participation of several MSE Technical Groups members in the four MSE related workshops held along the last year.

In addition, to improve the communication and coordination with different stakeholders, looking for potential synergies and to get first-hand information on logistic capabilities of private and public organisms relevant for future GBYP research activities, the GBYP Coordinator has participated in four international workshops and held, accompanied in most cases by ICCAT Secretariat staff and/or GBYP Steering Committee members, eight bilateral meetings. The more relevant among these activities and their results will be described in following chapters.

Other routine project management activities have been the actions related to GBYP Research Mortality Allowance, the Tag Awareness and Rewards Program, and updating of the GBYP web page. Details about the use of RMA and numbers of tags recovered, as well information about the Rewards Program, are available in the document SCRS/2019/197.

2.1 Financial aspects

In Phase 8 the GBYP budget has had the following funders (in order of contribution already received or committed): European Union (Grant Agreement) €1,400,000.00, Kingdom of Morocco (donation according to quota) €66,898.53, Japan (donation according to quota) €59,139.54, Tunisia (donation according to quota) €54,883.78, Libya (donation according to quota) €46,942.83, Turkey (donation according to quota) €36,692.99, United States (donation) €32,220.77, Norway (donation) €19,195.00, Canada (donation) €18,976.53, ICCAT Secretariat €10,000.00, Egypt (donation according to quota) € 4,696.91, Korea(donation according to quota) €4,151.96, Chinese Taipei (donation) €3,000.00, Iceland (donation according to quota) € 2,179.78, China (P.R.) (donation according to quota) €2,050.03. Thus, the total budget has been €1,750,000.00.

In Phase 9 the total budget has been the same, €1,750,000.00, thanks to the contributions from the following donors: European Union (Grant Agreement) €1,400,000.00, United States of America (donation) €165,330.24, Japan (donation according to quota) €56,060.18, Tunisia (donation according to quota) €52,886.96, Turkey (donation according to quota) €41,428.12, Libya (donation according to quota) €34,294.50, ICCAT Secretariat €10,000.00.

Further amounts were residuals of previous GBYP Phases and they were used to better balance the EU contribution and to compensate costs that were not covered by EU funding in various Phases. Additional eventual residuals from the amounts provided in Phase 9 will be used for the following Phases of the GBYP. It should be noted that contributions for the current and previous GBYP Phases are still pending from some ICCAT CPCs.

The approved budget for Phase 8 and Phase 9 is summarised in the **Table 1**.

3. Summary of Phase 8 and Phase 9 GBYP activities and results by main line of research

3.1 Data recovery

The general objective of GBYP data recovery activities is to fill the many gaps existing in several data series currently present in the ICCAT databases, 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 raw data on BFT ecology or biological parameters.

Three data recovery activities have been carried out during the last year, all of them within the 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) obtaining electronic tags datasets.

a) Ancient traps data recovery

The GBYP was informed that there might be a possibility of recovering some original data on bluefin tuna catches in Italian traps, directly from the owner's registers, and which have not been included in the ICCAT database so far. The recovered set of data consist specifically in daily and or annual catches from five Italian traps, covering different periods between the end of 19th century and the first half of 20 century and, in one case, between 1755 and 1900.

b) Recent catch data from ICES reports

Another potential set of data identified were the data on bluefin tuna catches contained in reports of ICES Bluefin Tuna Species Group, from the 1960s and the 1970s. It was recommended to recover these data at the Data Preparatory Meeting in 2017, because, apparently, they had never been reported to ICCAT. Copies of the reports were found in the ICCAT library, as part of Dr Rodriguez-Roda's personal library, and the GBYP database specialist has taken care in converting the data into electronic format compatible with the ICCAT database. The data set gathered contains information on a large number of bluefin tuna landings by different entities in the 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 provided in the paper SCRS/2018/176.

c) Recovery of electronic tags data

Two electronic tags data sets from different research institutions have been obtained within this period and included in the GBYP electronic tags database through ad hoc contracts. The first, generated by Dr Barbara Block's team and belonging to Stanford University, referred to 41 electronic tags deployed in 2016-2017 off Canada and in 2017 off Ireland, with a mean duration on fish of 190 days and including the raw data on light, temperature and depth, and the processed geolocations. The data have already been provided to the modelling expert, to be used for operating model and MSE purposes. The second data set was provided by Dr Molly Lutcavage (University of Massachusetts). This dataset, referring to 220 electronic tags deployed in the Western Atlantic from 2002 to 2009, had already been provided to the SCRS in aggregated form (number of days each tag spent in a certain MSE statistical area), but this new contract enabled acquiring of detailed processed data (track) and detailed raw sensor data.

3.2 Aerial Survey on Bluefin Tuna Spawning Aggregations

The 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, this activity has not been developed regularly and has not followed homogenous methodologies and sampling strategies throughout the successive GBYP Phases (see previous GBYP annual reports and GBYP aerial surveys final reports). Fortunately, in 2015, 2017 and 2018 (the surveys were cancelled in 2016), GBYP aerial surveys were developed following the same standardized methodology. However, in spite of that, no clear patterns in weight and/or abundance among years and areas have been discerned yet, except maybe in the case of the Balearic Sea area. Moreover, the Coefficient of Variation of the indices remains very high, above the commonly accepted levels. Thus, an in depth internal review of the available reports from the whole time series has been carried out within Phase 8, detecting some potential sources of bias, and concluding that there was still room for further methodological improvements. Thus, in addition to the regular aerial surveys, during the last part of Phase 8 and the ongoing Phase 9, several activities aiming at improving the accuracy of the currently available aerial survey indices time series and optimizing as much as possible the sampling strategy and sighting methodology in the next surveys, have been implemented. Specifically, these actions have consisted in:

a) elaboration of improved aerial survey strategies and sighting protocols
b) design and implementation of an aerial survey professional spotters calibration exercise
c) feasibility study to explore the use of acoustic techniques to validate aerial survey observations
d) re-analysis of the whole aerial survey indices time series

The final reports of all these activities will be available through the GBYP web page, and the results of the calibration exercise have been also presented in the paper SCRS/2019/199.

Regarding the regular aerial surveys, in Phase 8 it was carried out on the same four preferential spawning areas already defined in the previous Phases, using the same design and methodology as in 2017. 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. The results indicate that there was a real increase of bluefin tuna in area A in respect to the previous five years, continuing the increasing trend already observed in 2017, whereas areas C and E were rather similar to previous years. In contrast, in Area G an important decrease was observed of 80% in total weight and 68.5% in abundance compared to the mean for 2010-2017. Detailed results were presented by Vázquez Bonales *et al*. 2018.

The aerial surveys in Phase 9 were carried out also on the same 4 preferential spawning areas already defined in the previous Phases, from 28 May to 29 June 2019, using the same design and methodology as in 2017, except for the change in the delimitation of Area A introduced for getting a better match between spawners distribution and surveyed area, as well as for optimizing observation time and hence reducing costs. In general, the surveys were successful, although there were some minor problems due to unfavorable weather conditions and also an unexpected restriction of the air space applied by Malta, which for the first time did not give permission to carry out the scientific aerial survey within the 25 nautical miles of the fishing protection area. In spite of the fact that the new protocols were not yet available, during the training course special attention was paid to prevent potential sources of bias, introducing some of the improvements that will be introduced in the new protocols, such as making clear distinctions between juveniles and adult schools, correct use of declinometers and maximum time to dedicate to the recording of non-target species. For the first time the data analysis for the calculation of the aerial survey index, which is still ongoing, has been carried out filtering out the sightings of juvenile fish. However, to allow a more complete comparative analysis between the currently available time series and that resulting from the ongoing re-analysis, such analysis has been also carried out including all the sightings. Final results will be available shortly through the GBYP webpage, and also reported to the next relevant BFT SCRS meetings.

3.3 Tagging activity

This line of research has faced two important problems from the very beginning of the GBYP tagging program in Phase 2, which have prevented or limited the full achievement of the main objectives, it is the estimation of the natural mortality rates (M) of bluefin tuna populations by age or age-groups and the evaluation of habitat utilization and large-scale movement patterns (spatio-temporal,), including estimates of mixing rates between stock units by area and time strata, of both juveniles and spawners.

One is the very low recovery rate of conventional tags, which impeded the use of these data to estimate reliable mortality rates. Due to this, the GBYP SC decided to cancel the conventional tagging programme in Phase 4 and focus on electronic tagging instead, maintaining only complementary conventional tagging activities by providing tags and tagging equipment to different institutions or organizations, as well as maintaining the awareness and reward campaigns and the database, integrating all the results from recovered tags. The second major problem has been the relatively short time that most of the electronic pop up tags have remained on fish. The premature releases are attributable to different factors, such 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 which are not fully adequate for bluefin tuna.

These potential problems have been addressed in Phases 8 and 9 by improving the equipment, using a new model of MiniPat satellite tag designed to minimize "pin broke" problems, and reinforced tethers, similar to those currently used by the Stanford University BFT tagging team. Moreover, an ad hoc workshop focused on e-tagging methodologies, including practical tagging sessions in the field, has been held in July 2019, which was attended by 25 experts representing all the teams that have been involved in GBYP electronic tagging activities in the past. The final report of the workshop, including a new GBYP tagging protocol agreed among the participants and an in depth analysis of the performance of different e-tags deployment methods, based on a data base which is currently being elaborated from detailed data provided by the participants, will soon be available through the GBYP web page and the main results reported to the next relevant SCRS meetings.

Regarding electronic tags deployment, in both Phase 8 and 9 the main specific objective of GBYP tagging programme was, considering the current needs of the MSE modelling process, to improve the estimations of the degree of mixing of western and eastern bluefin tuna stocks in the different statistical areas and throughout the year. To this end, the Steering Committee decided to concentrate tagging activities in the North Sea and/or Celtic Sea and in Southern Portugal area. Thus, in Phase 8 one contract was awarded to TUNIPEX for deploying 30 satellite tags in Portuguese traps, a second contract was awarded to the Marine Institute of Ireland for deploying 10 satellite tags in the Celtic area and, finally, a Memorandum of Understanding was signed between ICCAT GBYP and the Institute of Marine Research of Norway, for deploying 20 tags in the Norwegian Sea.

In order to get precise information on the performance of different tagging methods the tagging operations in Southern Portugal traps were carried out using two methods, underwater tagging by experienced divers directly underwater using a long pole (10 fish) and onboard a vessel by IPMA scientific staff (20 fish). Preliminary results show that all the tags deployed by scuba divers popped off shortly after tagging, and that most of those deployed on board also popped off soon after, but some tags remained for longer times, suggesting that underwater tagging on free swimming fishes is not a good method for deploying e-tags on BFT, and that on board tagging does not guarantee by itself tagging success. Within the tagging campaigns in the Celtic Seas 24 tags were deployed (10 provided by GBYP and 14 by the Marine Institute). In this case, all fish were captured using angling methods and tagged on board a vessel equipped with transom doors, and the miniPATs were attached using titanium darts and tethers similar to those used by Stanford University within the Tag a Giant program, as well as retention loops. The results have been very good, since most of these tags have remained on the fish for long times, even some of them are still on the fish and probably will pop off when programmed, after one complete year cycle, which had only happened twice in the GBYP tagging programme, suggesting that the use of adequate equipment is also a key factor for the success of e-tagging operations. Because of bad weather only 2 bluefin tuna were tagged in Norway, and the remaining 18 tags were returned to the GBYP.

The GBYP e-tagging surveys in Phase 9 have been developed taking into account the results from phase 8 and the conclusions of the aforementioned workshop. Therefore, all the tags have been equipped with reinforced tethers and titanium darts manufactured by Dr Barbara Block's team and tagged on board using retention loops. Ten tags were deployed on fishes from TUNIPEX trap in Southern Portugal, during the practical sessions within the workshop, and another 30 tags have been successfully deployed by the Marine Institute from Ireland (15) and the Technical University of Denmark (DTU) (15), in the Celtic Sea and Skagerrak, respectively.

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 (SLU, CEFAS, Exeter University, WWF), 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, with the condition that relevant info obtained from these tags will be shared with GBYP.

Other activity within this line of study in Phase 8 was the development of a new Shiny application for visualization of multiple tracks on the interactive map, including filtering and grouping according to several criteria. More details on this activity were presented in the scientific paper SCRS/2018/174. In addition, a preliminary analysis of bluefin tuna depth and temperature preferences revealed by electronic tags was also carried out (presented in paper SCRS/2018/173).

As regards conventional tagging, the GBYP programme has been maintained as a complementary activity, providing logistical support to several institutions. In Phase 8, a total of 945 tags were deployed on 904 bluefin tuna individuals. Detailed information about these deployments is available in the paper SCRS/2019/180.

The GBYP tag awareness and reward policy has also been maintained as in previous phases. As a result, the impressive improvement in the recovery rates detected from the beginning of the GBYP programme (from 0.88 tags per year to an average of 88.21 tags per year) has been maintained. Thus, in the years 2018 and 2019 (up to 1 September) a total of 76 and 50 tags were recovered respectively. These are slightly fewer than in previous years, but this can probably be attributed to the fact that, on recommendation of the Steering Committee, from 2014 onwards the GBYP massive conventional tagging programme was cancelled, and hence the number of deployed conventional tags has decreased. 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 the GBYP, this is the clear evidence that GBYP tag awareness campaign is producing positive effects.

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 it seems that both types of tags (single barb and double barb) are more or less equally resistant, with slightly better resilience for double barb.

3.4 Biological studies

The GBYP biological sampling and analysis programme covering the main bluefin fisheries and including a series of studies based on the analysis of the available samples, as ageing studies and microchemical and genetics analyses to investigate mixing and population structure, aiming at guaranteeing the availability of key information for BFT stock assessment, has been maintained along this reporting period. 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 at https://aztigps.shinyapps.io/bluefin/. Moreover, given that in spite of the huge research efforts dedicated to determine some crucial biological parameters, such as those related with reproductive biology and growth, some controversies remain, making it difficult to decide on the set of biological parameters that must be used for stock assessment. The GBYP has organized two ad hoc workshops on these issues, aiming at improving and standardizing the methodologies used for determining such parameters and to reach wider consensus about the values that should be considered for stock assessment. In addition, as a result of ICCAT Rec. 18-02, paragraph 28, the GBYP has designed and started to implement a broad study on BFT growth in farms.

3.4.1. Biological sampling and analysis

As done in previous GBYP phases, both in Phase 8 and Phase 9, calls for tenders have been issued for maintenance and management of the ICCAT GBYP Tissue Bank, collecting tissue samples and otoliths and performing analyses - both microchemistry analyses of otoliths and genetic analyses of tissue samples. Two contracts were awarded for carrying out the biological studies in Phase 8, one with the Consortium led by AZTI for both sampling and biological analysis, including microchemical and genetic ones, and the other

contract was signed with the University of Bologna - BiGeA- for sampling in Italian waters, whereas in Phase 9 only one proposal was awarded, which was submitted by the Consortium led by AZTI.

These sampling and analyses have aimed primarily at contributing to knowledge on population structure and mixing, aiming to provide accurate information and clear alternative hypotheses to the MSE process. In this line, in Phase 9 one of the most important uncertainties to resolve is related to the understanding of the implications of the new spawning grounds in the Atlantic Ocean (Slope Sea, Bay of Biscay).

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 the future "close kin" studies, call for tenders to carry out sampling of adults in BFT farms have been launched both in Phase 8 and 9. The awarded companies have been the same in both years, AquaBioTech, from Malta, for providing samples from the Southern Tyrrhenian Sea and the Central/Southern Mediterranean Sea, and Taxon, from Spain, for providing samples from specimens fished in the Balearic Sea. Further biological samples have been provided to the GBYP tissue bank from ROP and tagging teams.

It must be pointed out that the GBYP sampling has been done independently from other routine sampling activities for fisheries and fishery resources monitoring (e.g. the Data Collection Framework), according to the GBYP Biological sampling protocol and following the GBYP sampling strata. However, looking for synergies and to prevent any duplication of efforts between the GBYP and EU DFC sampling, and hence to optimize available resources, in Phase 9, a close collaboration with the EU Regional Coordination Group on Large Pelagics has started, including as a first step the sharing of detailed information about the respective sampling schemes.

In relation to ageing analysis, the Australian company Fish Ageing Services, has been awarded with a contract to prepare (Phase 8) and proceed with the reading (Phase 9) of a set of 2000 otoliths from the GBYP tissue bank.

The main specific activities carried out over the last year in relation to biological sampling and analysis of biological samples are detailed in the paper SCRS/2019/180. The most relevant results are summarized below:

a) Biological sampling

In Phase 8 the Consortium headed by AZTI obtained young of the year and large fish from potential mixing areas in the Atlantic, whereas UNIBO provided juvenile and adult samples from Italian waters. The sampling in farms completed the sampling of adults in the Western and Central Mediterranean. Including the samples from ROP and tagging operations, a total of samples from 2706 individuals (1826 pairs of otoliths, 495 spines and 2694 muscle/fin samples for genetics) were submitted to AZTI to be included in the GBYP tissue bank. In Phase 9 the sampling activity is following the same general scheme as in Phase 8, focusing on sampling in mixing areas. A task to gather biological material (BFT larvae from the Balearics) that can be used in future close-kin analyses has also been included. As regards sampling large individuals for constructing the age length key, which was one of the priorities identified by the Bluefin Species Group, it was decided to focus the effort of the Consortium on collecting hard parts from the individuals from the Atlantic Ocean, while the sampling of individuals in the Mediterranean will be carried out mainly through the contracts for sampling adults in the farms. It should be mentioned that these sampling tasks in the future should be mostly achieved through national sampling programs, such as the EU Data Collection Framework.

b) Biological analyses

In Phase 8, new carbon and oxygen stable isotope analyses that were carried out on 256 otoliths of Atlantic bluefin tuna captured in the Central North Atlantic, 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.

Previous genetic analyses supported the presence of two populations of Atlantic bluefin tuna, but a new study suggested the presence of a third spawning ground within the Slope Sea and controversy existed about the origin of the larvae and young of the year found in this area. The presence of a new spawning ground

called 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, the Slope Sea and the Mediterranean, and have determined genetic origin of over 1,000 individuals from feeding aggregates based on 96 SNPs that discriminate between the Gulf of Mexico and the 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. A specific objective was to conduct age and genetic analyses on the Norwegian bluefin tuna. Thus, a total of 446 individuals were genetically analysed, showing that they are predominantly from Mediterranean origin.

In relation to genetic analysis, it is worth pointing out that given the success of the close kin study on western bluefin tuna and some new methodological improvements in this field, the GBYP SC reviewed the new information available on this topic at 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. Thus, in Phase 8 some preparatory work has been initiated, such as the intensive sampling of adults and larvae in the Mediterranean Sea, which would allow such studies to be carried out in the near future.

Integrated genetic/microchemical analysis analyses were also carried out to assign bluefin from potential mixing zones in the Atlantic (N=306). The classification accuracy of the integrated model (97.3%) exceeded that reported in this or previous studies using stable isotopes or genetics.

In Phase 9, both genetic and microchemical analyses are being carrying out on the same sample in order to improve the mixing proportions accuracy. Also, a specific study on YOY in the Mediterranean will continue in order to discriminate their nursery areas, by means of analysis of trace elements and stable isotopes. It is also planned to perform the genetic analysis (RAD-seq) of more than 500 bluefin tuna individuals captured in the Slope Sea, including larvae, in order to determine the contribution of the Mediterranean and Gulf of Mexico population to the Slope Sea population. In addition, high resolution stable isotope analysis will be performed in order to identify resident and migratory contingents within the Mediterranean population.

Regarding ageing related activities, to ensure that the ALKs provided by the GBYP were elaborated following the best standard methodologies approved by the SCRS, they were postponed till the calibration exercise carried out by SCRS experts in 2018 would be concluded. Finally, the results of the aforementioned international calibration exercise were presented at 2018 SCRS BFT species Group meeting, as paper SCRS/2018/127. This exercise also provided an improved protocol for BFT otoliths interpretation (presented in paper 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 and recommended to hold an ad hoc workshop, whose results are summarized in the next point. Finally, two contracts were signed with FAS, the first under Phase 8 to prepare the selected set of 2000 otoliths and the second one under Phase 9 to proceed with the interpretation of these otoliths, following in both cases the protocols agreed within the aforementioned workshop. In addition, in Phase 9 it is envisaged to realize a calibration of the 2000 otolith age estimates provided by Fish Ageing Services (FAS) in Phase 7 and create an otolith reference collection. As a result of all these activities, GBYP will provide for the next BFT stock assessment a new ALK based on the reading of 4000 otoliths from the eastern stock sampled along the last years.

3.4.2 Workshops on biological parameters

In order to address some controversies about key biological parameters and aiming to build up wide consensus among specialists in each field on the most reliable methodologies and set of parameters to be used in BFT stock assessments, the GBYP has organized and funded two workshops on BFT biological issues, one on reproductive biology and another on ageing methodologies based on otolith analysis. The first was held in November 2018, involving 7 experts who gave presentations and discussed 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 implications for MSE and assessment. The report of this workshop is included in the paper SCRS/2019/180. In order to elaborate a reference document for guiding the discussions during the workshop, two independent experts, Dr Jessica Farley (CSIRO, Australia) and Dr Seiji Ohshimo (Seikai National Fisheries Research Institute, Japan) were contracted in Phase 8. Such report was presented in the 2018 SCRS meeting (SCRS/2018/172). The BFT ageing workshop was held in February 2019 with the participation of 14 SCRS experts in Atlantic BFT growth and representatives of the Australian company FAS. The results of the workshop, which can be considered highly satisfactory since new improved protocols both for otoliths mounting and interpretation were agreed among participants, who in addition agreed to carry out further calibration exercises and elaborate a reference otolith collection, are presented as SCRS/2019/115.

3.4.3 Study on BFT growth in farms

During the 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 coherence within the growth rates derived from eBCD, as stipulated in 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. Such broad study have been planned within Phase 8, including several preparatory task as elaboration and distribution of a detailed questionnaire submitted to all the operative BFT farms and meetings with farm owners, local authorities and scientists in the five areas where the study will be developed. The implementation of the study has started in Phase 9, including tagging experiments to determine individual growth trajectories, intensive monitoring of representative cages, including the record of relevant environmental variables and food provided to caged fishes and seasonal measurements of their growth by means of stereo-cameras measurements, as well the elaboration and analysis of a database including data on initial length distributions from stereo-cameras and data on final sizes and weight at the end of farming period obtained during harvesting operations. A detailed report describing all the actions carried out up to now in relation to this study are presented in the paper SCRS/2019/198.

3.5 Modelling approaches

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". The modelling activities already started in the Phase 2, and very soon became evident that this line of study had greater importance than perceived in the time when the GBYP was conceived and that the amount of effort for this activity should be 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 the scientists involved. Thus, GBYP have been supporting from the very beginning this strategic initiative.

In Phases 8 and 9 the contract for modelling approaches was again awarded to Dr Tom Carruthers (Blue Matter Science, Canada), who initiated the work on MSE and modelling in 2014. The main objectives for Phase 8 were ensuring the OM scenarios agreed by the ICCAT GBYP Core Modelling Group (CMG) 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, which robustly meet the management objectives. Details about specific activities carried out by the expert in Phases 8 and 9 are presented in the paper SCRS/2019/180.

The outputs from GBYP MSE modelling activities in Phase 8, as mixture model interpretation of stock of origin data and an updated summary of conditioned operating models were presented within BFT SCRS Species Group session as scientific papers SCRS/2018/133 and SCRS/2018/134. 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.

In Phase 9 the contracted expert is continuing to continue his work on bluefin tuna MSE development aiming at ensuring that the OM scenarios agreed by the CMG in 2016 and revised in 2017, 2018 and 2019 by the Technical MSE Group (formerly CMG) and the MSE BFT Group, can be run; that third parties can use the OM to evaluate candidate MPs (CMPs) with their own specifications; and providing a set of agreed summary statistics that can be used by decision makers to identify the MP, including data and knowledge requirements, that robustly meets the management objectives.

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, holding 6 meetings till 2017, funded by the GBYP. During the BFT MSE intersessional meeting held in April 2018, 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 a 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, B_{MSY} calculations, future recruitment scenarios, abundance indices, and definition of key uncertainties. During the meeting, it was also decided to dissolve the MSE CMG and create the BFT MSE Technical Group, which, unlike the CMG, would be open to all interested ICCAT scientists, without restriction on participation. The GBYP has continued to provide its support to this new group, and in general to the whole BFT MSE process, by financing the attendance of some members of the MSE Technical Group (those that belonged to the previous CMG) not only to the successive MSE Technical Group meetings, such as those held in July 2019 (St. Andrews, Canada) and September 2019 (Madrid, Spain), but also to other MSE related meetings. Specifically, the GBYP facilitated the attendance of Dr Doug Butterworth at the Standing Working Group to Enhance Dialogue between Fisheries Scientists and Managers held in May 2018, in Madeira (EU-Portugal) and at the September 2019 SCRS Species Group meeting. The progress in BFT MSE development is summarized in item 15.1 of this report.

4. Outline of GBYP Phase 10 proposal

a) Data recovery: Recovery of data sets relevant for improving BFT management
b) Fishery independent indices: Development of new series of aerial surveys, feasibility study for the application of acoustic surveys to the development and validation of fishery independent indices; development and application of habitat models to standardize fishery independent or dependent indices
c) Tagging: Support to conventional tagging and tag awareness activities; development of electronic tagging campaigns, prioritizing areas according to MSE needs
d) Biological studies: Maintenance of GBYP tissue bank, development of biological sampling and analysis program aiming to ensure availability of samples and generation of basic data to cover research needs derived from SCRS recommendations, implementation of "BFT growth in farms study; implementation, within ICCAT DBs system framework, of relational databases integrating data from GBYP (biological analysis, tagging, data from stereocamera systems and harvesting operations); workshop on close-kin methodologies; support to the coordination and standardization of larval surveys; support to activities aiming at calibrating and improving ageing activities
e) Modelling: Continuous GBYP support to the development of the ICCAT BFT MSE process (funding developers and BFT MSE technical group workshops)

Total envisaged budget €1750000.

Table 1. Approved budget of GBYP Phase 8 and 9.

Item	Phase 8	Phase 9
Coordination	€312,500.00	€285,000.00
Data Recovery	€58,000.00	€20,000.00
Aerial Survey	€494,500.00	€512,000.00
Biological Studies	€583,000.00	€585,000.00
Tagging	€159,000.00	€208,000.00
Modelling	€143,000.00	€140,000.00
Total	**€1,750,000.00**	**€1,750,000.00**