Collect. Vol. Sci. Pap. ICCAT, 81(5), SCRS/2024/132: 1-21 (2024)

ICCAT ATLANTIC-WIDE RESEARCH PROGRAMME FOR BLUEFIN TUNA (GBYP) ACTIVITY REPORT FOR PHASE 13 AND THE FIRST PART OF PHASE 14 (2023-2024)

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SUMMARY

Phase 13 of the ICCAT Atlantic-Wide Research Programme for Bluefin Tuna (GBYP) was implemented between 1 May 2023 and 31 July 2024. Phase 14 was initiated on 1 February 2024, with a planned duration of almost two years, therefore temporarily overlapping with Phase 13. As in previous years, the GBYP programme has promoted and funded several activities in the following lines: (a) data recovery and management, (b) biological studies, (c) stock indices: aerial survey on spawning aggregations, (d) tagging, including awareness and reward programmes and (e) further steps of the modelling approaches. The present report summarizes the final results of the activities carried out in Phase 13 and describes the activities initiated in Phase 14, as well as their preliminary results, if available, corresponding to the reporting period September 2023-August 2024.

RÉSUMÉ

La phase 13 du Programme de recherche sur le thon rouge englobant tout l'Atlantique (GBYP) a été mise en œuvre entre le 1er mai 2023 et le 31 juillet 2024. La phase 14 a été lancée le 1er février 2024, avec une durée prévue de près de deux ans, chevauchant donc temporairement la phase 13. À l'instar des années précédentes, le Programme GBYP a encouragé et financé plusieurs activités dans les domaines suivants : (a) récupération et gestion des données, (b) études biologiques, (c) indices des stocks : prospection aérienne des concentrations de reproducteurs, (d) marquage, y compris campagne de sensibilisation et de récompense et (e) nouvelles étapes des approches de modélisation. Le présent rapport résume les résultats finaux des activités menées au cours de la phase 13 et décrit les activités entamées au cours de la phase 14, ainsi que leurs résultats préliminaires, s'ils sont disponibles, correspondant à la période de référence septembre 2023-août 2024.

RESUMEN

La fase 13 del Programa de Investigación de Programa de investigación sobre atún rojo para todo el Atlántico (GBYP) de ICCAT se desarrolló entre el 1 de mayo de 2023 y el 31 de julio de 2024. La fase 14 se inició el 1 de febrero de 2024, con una duración prevista de casi dos años, por lo que se solapa temporalmente con la fase 13. Como en años anteriores, el El GBYP ha fomentado y financiado diversas actividades, en la siguiente línea: (a) recuperación y gestión de datos, (b) estudios biológicos, (c) índices del stock: prospección aérea de concentraciones de reproductores, (d) marcado, lo que incluye una campaña de concienciación y recompensas y (e) más avances en los enfoques de modelación. El presente informe resume los resultados finales de las actividades realizadas en la fase 13 y describe las actividades iniciadas en la fase 14, así como sus resultados preliminares, si se dispone de ellos, correspondientes al periodo de referencia septiembre de 2023-agosto de 2024.

KEYWORDS

Bluefin tuna; ICCAT; databases; biological analyses; tagging, genetics; CKMR; aerial survey; modelling; Mediterranean Sea; Atlantic Ocean

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1. Introduction

1.1 Historical background

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 recovery, understanding of key biological and ecological processes, and improvement of assessment models to provide 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 recovery, 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. Given that budgetary contributions would be made annually the Programme has 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 and the SCRS (documents SCRS/2014/194 and SCI 005/2014) recommended extending the GBYP activities up to 2021 and this proposal was endorsed by the Commission during its November 2014 meeting, 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 its continuity. In its report for the biennial period 2020-2021, Part 2 (2021), adopted in the 27th regular meeting of the Commission, the SCRS explicitly requested further funding of the GBYP for the period 2022-2026.

From 2015 GBYP is being complemented by a twin programme, the BTRP, funded by NOAA-NMFS and addressed to USA research teams, which focuses their research activities on the western Atlantic Ocean.

1.2 Objectives

At the beginning of the programme the GBYP Steering Committee defined 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 strategic objective, a series of general objectives was set considering the priorities initially stated by SCRS (data collection, understanding of key biological and ecological processes and assessment improvement). These broad objectives have been maintained throughout the program, but along the successive phases they have been adapted to the evolution of the "state of the art" as regards scientific knowledge on bluefin tuna, in order to better match SRCS research needs and Commission recommendations. In addition to these initial objectives, some new ones, aiming not only at generating new knowledge but also to consolidate and make the best use of available data, have been set along the last GBYP Phases.

Therefore, the current general objectives of GBYP program are:

- Improve basic data collection.
- Improve understanding of key biological and ecological processes.
- Improve assessment models and provision of scientific advice on stock status.
- Enhance the coordination between GBYP activities and the monitoring and research activities on BFT carried out by other institutions, both at national and international level.
- Contribute to the implementation within ICCAT Secretariat of new BFT information management systems.

In relation to each of these broad objectives, the specific objectives set for GBYP Phases 13 and 14 were:

- Contribute to the optimization of BFT biological sampling programs, ensuring that sampling activities carried out by CPCs and those funded by GBYP are complementary and collect representative biological samples.

- Ensure the collection of the biological samples necessary to develop the studies designed to address the SCRS research priorities.
- Enhance the information available on BFT spatial distribution and mixing, by promoting and supporting electronic tagging campaigns, and continuing the support to CPCs conventional tagging activities.
- Provide SCRS with updated and reliable data on biological parameters and stock structure.
- Develop a feasibility analysis and planning for the implementation of the Close Kin Mark Recapture methodology to BFT Eastern stock, exploring the possibilities for integrating West and East BFT stocks CKMR studies and, if recommended by SCRS and adopted by the Commission, initiate the implementation of a BFT CKMR study.
- Update and improve the fishery independent aerial survey index of abundance.
- Support the further development and implementation of BFT Management Strategy Evaluation (MSE).
- Support the external review of the ongoing ICCAT MSE processes.
- Contribute to the implementation of an internationally coordinated and optimized BFT sampling system.
- Promote the integration of data generated by CPCs research institutions into the ICCAT electronic tags DB, as well as its joint analysis by relevant research teams.
- Contribute to the design and implementation, in close coordination with ICCAT Secretariat Research and Statistics department, of an Information System on biological data, which will integrate in a relational database all relevant information on BFT available at ICCAT Secretariat, generated by GBYP program or within CPCs research programs.
- Contribute to the design and implementation, in close coordination with ICCAT Secretariat Research and Statistics department, of an Information System on electronic tags data, integrating etags data sets from ICCAT and CPCs e-tagging programs.

1.3 Programme management and financial aspects

The GBYP programme development is supervised by a Steering Committee, which has the role to guide its implementation. It is composed of the SCRS chair, W-BFT rapporteur, E-BFT rapporteur, one external member and the ICCAT Executive Secretary, which can be substituted by his deputy. The 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 and propose the follow-up of the Programme, and adopt the budget.

The GBYP coordination team carries out the day to day tasks related to the implementation of the project, including the elaboration of the calls for subcontracting different types of activities and for Expressions of Interest to collaborate with some of the GBYP lines of research, the drafting of contract and Memorandum of Understanding proposals, supervising the reports received from contractors or collaborating institutions, organizing GBYP related meetings and workshops, taking care of the regular reporting on the GBYP activities to the SCRS relevant groups and the elaboration of the final annual global and executive reports presented to the SCRS Plenary and to the main donor, the EU.

Furthermore, the GBYP coordination team participates, or provides scientific support whenever requested, in national or international initiatives which are potentially able to increase the effectiveness of the GBYP and the achievement of its objectives. For example, since 2010 the GBYP coordinator has been part of the Evaluation Committee of the NOAA BTRP and has participated regularly in the meetings of the EU Regional Coordination Group on Large Pelagic.

The GBYP is funded by voluntary contributions of CPCs and other entities, as Chinese Taipei. Among CPCs, EU provides 80% of total budget. In addition, several private or public entities also provide few additional funds or in-kind support. Up to Phase 13 the budget has been set annually, by phases that were initially planned for 12 months periods, even they have been usually extended for some months to allow to complete some specific studies. The Phase 14 has been set initially for a duration of 23 months, from 1st February 2024 to 31st December 2025. However, the total budget has been split in two budgets, one for 2024 and another for 2025, aiming to match with the amounts by line of research approved for each annual period by the Commission. Moreover, from Phase 14 onwards, the timing of the successive Phases will match exactly with the calendar year, to better adapt the calendar of research activities to the annual budgets approved by the Commission.

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, 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.

2. Budget

The thirteenth Phase of the ICCAT GBYP officially started on 1st May 2023, following the signature of the Grant agreement for the co-financing of the ICCAT GBYP Phase 13 (101133291) by the European Commission. Initial duration of the Phase was one year, but it was extended for 3 months, thus officially ending on 31st July 2024. The main motivation for extending the Phase 13 was the need to finish the study developed by the University of Stanford based on the whole DNA sequencing, which started later than planned due to unexpected delays in the negotiation of the contract with Stanford administrative services and was afterwards further delayed due to retaining of samples in Spanish customs. Moreover, extending the Phase 13 allowed carrying out the tagging campaign in the Levantine Sea, considered as a high priority activity, within this phase. In addition, some modelling tasks identified during the SCRS BFT Group intersessional meeting held in April 2024 related to the Close-Kin Mark-Recapture methodology, which were necessary to complete the feasibility study on the implementation of CKMR approach to East BFT stock that was going to be presented to the consideration of SCRS, were also incorporated to the Phase 13 work plan.

Consequently, GBYP Phase 13 has overlapped with Phase 14, which necessarily had to start in February 2024 to allow the organization and development in time of the 2024 GBYP aerial surveys, which had to be funded under Phase 14 budget. It has made a bit more complex the GBYP programme management, but it has been possible to develop in parallel the different phases without major problems, since each phase has a well-defined work-plan and budget, and hence every cost can be assigned univocally to the activities detailed in the respective Grant Agreements. **Tables 1 and 2** show the amounts provided as voluntary contributions to Phases 13 and 14. In the latter case, the amounts only represent the contributions for the year 2024, which in some cases have been committed but not yet received.

3. Programme Coordination

3.1 Steering Committee

The GBYP Steering Committee along this reporting period has been composed by the SCRS chair (Dr. Craig Brown), the Western BFT rapporteur (Dr. John Walter), the Eastern BFT rapporteur (Dr. Enrique Rodríguez Marín), the ICCAT Executive Secretary (Mr. Camille Jean Pierre Manel) and the external expert (Dra. Ana Parma, researcher at the Centre for the Study of Marine Systems -CONICET-). The contract for the external member of the Steering Committee was signed, following the decision of its *ex officio* members, considering her expertise in lines currently crucial for the SCRS BFT group, as MSE processes and CKMR studies.

One formal SC meeting was held in January 2024. Other consultancies and decisions have been taken via email, following the regular correspondence held between the GBYP Coordinator and GBYP SC members for all relevant issues, or taking advantage of the attendance of SC members to SCRS meetings, as the SCRS BFT Group meeting held in April 2024 in Malta.

3.2 Coordination Team

The Coordination Team has been composed by the GBYP Coordinator (Dr. Francisco Alemany), the Assistant Coordinator (Mrs. Stasa Tensek) and the Database Specialist (Mr. Alfonso Pagá). In January 2024, the Assistant Coordinator left the GBYP program and was incorporated into the Secretariat staff, but she continued providing support to GBYP program, besides her new obligations.

3.3 Project management activities

During Phase 13, a total of 5 calls for tenders and 1 official invitation were released, which resulted in a total of 8 contracts awarded to various entities. In addition, one call for Expression of Interest in collaborating with GBYP electronic tagging program was published, which resulted in 12 Memorandums of Understanding signed.

Other routine project management activities have been the actions related to GBYP Research Mortality Allowance, the maintenance of 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 2023 the Research Mortality Allowance was used for covering the incidental death of 47 specimens of bluefin tuna, which equals to a total of 2414 kg, reported through 11 RMA forms. Considering the number of specimens, most of these correspond to sampling activities, while considering the weight, the most correspond to incidental deaths due to electronic tagging activities.

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 has participated in all SCRS meetings focused on bluefin tuna, it is:

- Bluefin tuna Species Group Meeting (Madrid, 18-22 September 2023).
- Standing Committee on Research and Statistics (SCRS) meeting (Madrid, 25-29 September 2023).
- 28th Regular Commission meeting (Cairo, 13-20 November 2023), during which the GBYP Coordinator, within a side even organized by GBYP, presented to ICCAT commissioners a series of fact sheets on GBYP Programme, focusing on its main activities, outputs and future challenges.
- Intersessional Meeting of Bluefin Tuna Species Group (Malta, 15-18 April 2024).

In addition, the GBYP Coordinator or the GBYP DB specialist participated, in person or online, in the following meetings, also focused or related to BFT and GBYP program management:

- SCRS Subcommittee on Statistics (Madrid, 22-23 September 2023).
- Collaborative Workshop to evaluate the incidental capture of Sea Turtles in the ICCAT fleets in the Mediterranean Sea (Fuengirola, 2-4 October 2023).
- Coordination Meeting ICCAT/DGMare (Brussels, 16-17 October 2024).
- SCRS Officers meeting (Madrid, 6 February 2024).
- Meeting of the online reporting technology Group (WG-ORT) (Online, 7-8 February 2024).
- Panel 2 intersessional meeting (Madrid, 5-8 March 2024).
- SCRS Workshop (Madrid, 18-20 March 2024).
- Intersessional SCRS BFT Group meeting (Malta, 15-18 April 2024).
- Regional Coordination Group Large pelagics meeting (Olhao, 24-26 June 2024).
- Ad hoc Working Group on coordination of tagging information (Madrid, 5 July 2024).

4. Activities

The activities carried out during this reporting period, adapted to the current SCRS research needs and Commission requests, were structured considering the main lines of research established since the beginning of the programme, i.e. data recovery and management, biological studies, tagging, stock indices (aerial surveys) and modelling, All activities carried out throughout the GBYP Phase 13, as well their final results, as well the first activities developed up to August 2024 within Phase 14, are summarized in this report.

4.1 Data recovery and management

Most of the efforts along the last year have been directed to the development of information systems allowing the proper storage of the data from GBYP funded research activities along the successive phases of the program, or other data provided by CPCs research programs relevant for BFT management not yet included in the current ICCAT databases.

Regarding the biological data information system, in addition to advances in the design of the whole DB structure, templates to standardize the biological data collection for all ICCAT species have been produced in close collaboration with the ICCAT Secretariat Statistics department. This in-house activity started in previous phases and has not been completed yet. Once terminated and functional, this relational database will integrate all available information relevant for BFT biological data, provided by GBYP or by CPC national research teams. It will also allow to develop broad collaborative studies to estimate more reliable biological parameters and to optimize sampling programs, ensuring that they are complementary.

Another in-house activity carried out has been further development of ETAGS database. Testing of already installed datasets revealed various issues which will have to be addressed in the future phases, along with the further optimization of the database function and its fine tuning. This database is meant to integrate electronic tagging datasets from ICCAT and CPCs e-tagging programs. Once relevant datasets are incorporated and compiled, the ETAGS DB will allow performing of joint analyses of broad datasets, which will contribute to improving knowledge on BFT population structure and spatial patterns.

The outputs from these databases will be directly used to improve the parameterization of assessment models (input data) and therefore the management of BFT stocks as well.

4.2 Fishery independent stock abundance indices (Aerial Surveys)

Two main activities have been undertaken in relation to GBYP Aerial Surveys this last year: the updating of the index time series incorporating the results from 2023 campaign and the development of new campaigns in summer 2024.

The contract for aerial survey data analysis was provided, as in previous phases, to the CREEM team of the University of St. Andrews, which are the original developers of the DISTANCE methodology applied for the GBYP aerial surveys data analyses. This work comprised the analysis of the 2023 aerial survey data and updating the estimates from the previous surveys conducted in 2017-2023. Abundance and biomass in the surveyed blocks were estimated using line transect distance sampling methods. The tuna indices were updated in two ways: actualization of the whole time series (Task 1), and strict update of the index for 2023 (Task 2). To provide a strict update, the detection function from last year was used, i.e. the same variables and same parameters.

Table 3 summarizes the sightings for the 2023 survey. Like previous years, most sightings in 2023 occurred in block A. For the distance sampling analysis, only on-effort sightings and sightings of non-juveniles' schools were considered. Sightings described as 100% small (individuals <25 kg) have, therefore, been excluded. However, the remaining sightings may still include some schools that contain small individuals amongst larger fish. The school sizes observed in 2023 were, on average, larger than in the previous years. This was also reflected in the larger average observed biomass, second only to the year 2021.

The largest search effort per block was conducted in block A and lowest in block C. Apart from block E, which was only surveyed partially, the effort and area covered in each block was comparable to these in the previous years. Most sightings were made in block A, resulting in the highest estimated encounter rates and with lowest CVs. Encounter rate estimates were lowest in block C with highest CVs.

Regarding Task 1, the biomass estimates are presented in **Table 4** and **Figure 1**. The estimates for the previous years based on the newest detection function are comparable with the estimates from the previous reports. There is no increase in biomass in block A in 2023 despite the increase in abundance from 2022. There is a sharp decrease in biomass in block E and a sharp increase in block C following these trends in abundance.

In relation to the strict update of the index, the biomass results, detailed in **Table 5** and **Figure 2**, are very similar to the pattern in the abundance estimates for all three blocks and to estimates from Task 1. The largest discrepancies in the estimates between Tasks 1 and 2 are for blocks A and E, but both are well within the confidence intervals.

The analysis presented in Task 1 revealed that there is little difference between the abundance and biomass estimates between analysis based on all four blocks (A, C, E and G) and just three blocks (A, C, E) and both estimates are well within the confidence intervals of each other. One would expect the uncertainties around the estimate probability of detection to decrease the larger the number of detections. There was, however, no change in the estimated uncertainties. Keeping the detection function based on all four blocks is, however, consistent with the biomass and abundance estimates of the ICCAT GBYP programme and useful in case block G is surveyed again in the future.

The actualization of the tuna indices for 2023 showed an increase in BFT abundance in blocks A and E and decrease in block C. The estimates for block E are associated with large confidence intervals most likely since only part of the block was surveyed. This resulted in a lower number of sightings in this block in comparison to previous years. The expected school size in this block is also much higher in 2023 than in 2022, hence increase in abundance and larger uncertainties. The encounter rate in block A was higher in 2023 than 2022 but lower in 2023 than 2022 in the two other blocks, which is reflected in the above-mentioned trend in abundance.

The probability of detection in block A in 2023 was much lower than in the previous surveyed year, 2022 (0.32 and 0.60 respectively), but comparable in the remaining two blocks (0.35 and 0.40 in block C and 0.38 and 0.28 in block E respectively) between the last two years (2022 and 2023).

While adding new data (here, new surveyed year) and calculating a new detection function based on updated data, standard error and confidence intervals for the previous years can be updated and, frequently, reduced. The approach used in Task 2 does not allow for such updates as the calculation is based on detection function on a reduced data set (i.e. not including sightings from 2023). CREEM recommended to continue using the approach from Task 1 including 4 survey blocks instead of Task 2, especially that the best detection function contains the same covariates (here company) each year of the analysis. For further details, see the report by Chudzinska *et al.* in https://www.iccat.int/GBYP/en/asurvey.asp (Documents section, Phase 13).

Regarding the 2024 GBYP aerial surveys, they covered four replicates in each area from the end of May to the beginning of July, following the same design and sighting methodology as in 2023.

Before the mission, on 30 May 2024 an on-line training course was held with the participations of all members of the crews (pilot, professional spotters, 2 scientific spotters), to provide them with the detailed instructions on the methodology and the way to fill the sighting forms.

The survey in Area A (Balearic Sea) was carried out with a Cessna 337 plane, from 4-24 June 2024. To cover the entire 4 replicas (30 transects in total), 16 flights were made in 14 days. During five days weather conditions were worse than allowed by the field protocol – wind stronger than 10 knots or high chance of low clouds. Some transects could not be flown completely. That was mainly because they cross the airspaces of commercial airports with high traffic. However, the number of nautical miles that were not flown was low, and this did not have significant impact on the completed effort. Thanks to the intervention of ICCAT, the regulated zone of the Park Cabrera National Park could be flown over. Fortunately, military dangerous area D 26 was always free at the time of the eight flights that required penetration of this area. In total, during the time on effort, 12 observations of bluefin were recorded, which summed to more than 1,935 individuals with a total weight of 403 t. Of these, there were 7 observations of small groups ranging from 10 to 30 individuals which ranged from small to medium category of fish. The other 5 observations were schools of tuna ranging from 100 to 1000 individuals, made up mainly of fish in the medium to giant category. The majority of BFT observations were located in the western part of the block and mostly in the southwestern part around Ibiza and between Mallorca and Ibiza, as shown in **Figure 3**.

The survey in the Southern-Tyrrhenian Sea (area C) was carried out by a plane Partenavia/Vulcanair P68 B model during the period from 4 June to 6 July. There were a total of 13 survey flights. During other days, the survey had to be cancelled due to weather conditions or unforeseen events. A total of 3 bluefin sightings were realized, of medium-large schools, which summed up to 3,000 individuals with a total weight of more than 460 t. Although the importance of this area for bluefin spawning could be confirmed once again this year, there were less sightings than before. According to the professional spotters' opinions, part of the BFT schools could be deeper and less visible, probably due to high surface sea temperatures. The distribution of sightings is shown in **Figure 4**.

The survey in Area E: Central-Southern Mediterranean Sea (Sicily Channel) was carried out from 7 June to 1 July. The survey was carried out by a plane Partenavia/Vulcanair P68 B model through 20 survey flights. Unfortunately, due to the extension of the area and bad weather condition, it was it was not possible to carry out the fourth replica over the entire area. In total, 14 bluefin tuna schools were recorded, which represents a similar number as in previous years. 6 of these were composed by small individuals in feeding activities so only 8 were composed by medium and large fish. In total, there were 10,690 individuals observed with a total weight of 1,060 t. The distribution of sightings is shown in **Figure 5**. For further details, see the reports on 2024 aerial surveys in https://www.iccat.int/GBYP/en/asurvey.asp (Documents section, Phase 14).

4.3 Tagging

This line of research has faced several problems from the beginning of the program, as low recovery rates, premature release of electronic tags due to inadequate tagging methodologies or technical problems of the tag itself, as pin-broke. These problems have been minimized along the previous GBYP phases through awareness actions and methodological improvements, increasing significantly the time spent on fish and the percentage of recovered tags during the last years. Unfortunately, an additional technical problem affecting the performance of the satellite tags used within GBYP program, which has resulted in bad or null data transmission of tags deployed along the last years, mainly in those campaigns developed in warm waters, started to occur in 2018, and affected very negatively some surveys carried out in 2021 and 2022. An intensive work has been done along the last year, in close collaboration with the tags manufacturing company, to prevent and minimize the negative effects of this potential problems, as design and application of stricter tags maintenance and testing protocols, have been implemented, besides tagware improvements carried out by the manufacturer.

4.3.1 Tagging campaigns

As in previous phases, the GBYP tagging program in 2023 and 2024 has been carried out along with electronic tagging programs developed at national level, which has allowed to strengthen collaboration with national teams, taking advantage of the synergies between the different tagging programs, increasing its efficiency. A Call for expressions of interest was published in July 2023 (ICCAT Circular #G- G-0869/2023), for deployment of a total of 75 pop-up satellite tags by experienced tagging teams in the Mediterranean and/or North Atlantic Ocean, targeting eastern stock individuals. As a result, ad hoc MoUs were signed with the following institutions:

- Acadia University, in collaboration with DFO (Fisheries and Ocean Canada) and Stanford University - 8 PSAT tags to be deployed in Canadian waters.

- Fundación AZTI - 6 PSAT tags to be deployed in the Bay of Biscay.
- Technical University of Denmark (DTU) - 8 PSAT tags to be deployed in North Eastern Atlantic water (Eastern North Sea, Skagerrak, Kattegat and Øresund).
- University of Exeter in collaboration with Cefas and the Government of Jersey - 4 PSAT tags to be deployed in Jersey territorial waters.
- University of Exeter -4 PSAT tags to be deployed in southwest England.
- Institute of Marine Research (IMR) of Norway - 8 PSAT tags to be deployed in Norwegian waters.
- The Marine Institute - 8 PSAT tags to be deployed in the coastal waters off Ireland.
- Swedish University of Agricultural Sciences - 8 PSAT tags to be deployed in Skagerrak, Kattegat and Öresund.
- Stanford University in collaboration with Barcelona ZOO and AZTI - 8 PSAT tags to be deployed off Canary Islands.
- Stanford University - 8 PSAT tags to be deployed in the waters off North Carolina.
- University of Genova - 5 PSAT tags to be deployed in the Ligurian Sea.
- Ifremer - 10 PSAT tags to be deployed in the Western and Central Mediterranean.
- Stanford University, in collaboration with Mediterranean Fisheries Research, Production and Training Institute (MEDFRI), Akua Group Fisheries, General Directorate of Fisheries and Aquaculture (GDFA).
- Republic of Türkiye and Cukurova University - 13 PSAT tags to be deployed in the Levantine Sea.

Most of these MoU have been implemented successfully along the last year. So, Stanford University and Acadia University deployed the 8 awarded tags in the Gulf of Saint Lawrence (Canada) in fall 2023 on large bluefin tuna (268-290 cm CFL). Technical University of Denmark (DTU) deployed, within the framework of the Swedish and Danish collaboration "Scandinavian Bluefin Marathon", a variety of electronic and conventional tags on 134 ABFT (CFL ranging between 217 to 290 cm) in Skagerrak, Kattegat and Øresund over the course of 17 tagging days between 19 August and 1 October 2023. All the individuals were tagged with a conventional tag, and most were also tagged with an acoustic tag (Thelma Biotel). 23 ABFT were also tagged with PSATs, of which 8 were provided by ICCAT GBYP and 6 were tagged with biologgers. Given the ongoing deployment of acoustic infrastructure in the Strait of Gibraltar and Danish Straits (under the guise of the EU-funded STRAITS project) the data from the deployed acoustic tags will contribute greatly to the broader understanding of bluefin tuna movements and population dynamics. The Marine Institute successfully carried out tagging of bluefin tuna in Donegal Bay (North-West Ireland) over two consecutive days, between the 30 September-1 October 2023 with all 8 individuals tagged and released with GBYP owned PSATs and numbered floy tags. The Marine Institute tagged a further 9 tuna in the period 1-17 October 2023 in Donegal Bay (N.W. Ireland) with Wildlife Computers PSATs. All 9 individuals were also tagged with ICCAT issued floy tags. The Institute of Marine Research continued its tagging program of BFT along the coast of Norway between the 6 September and 22 October 2023. In total, eleven BFT ranging from 231 - 292 cm CFL were tagged with PSATs -8 belonging to GBYP- and conventional tags. In North Carolina, Stanford University successfully deployed 4 GBYP PSATs over the period 19 February-1 March 2024, on bluefin tuna ranging 190-234 cm CFL. The other 4 awarded tags failed battery transmission tests and were returned to Wildlife Computers for warranty replacement. Swedish University of Agricultural Sciences (SLU) deployed a variety of electronic and conventional tags on 41 large (> 229 cm CFL) bluefin tuna captured by volunteer rod-reel anglers in Skagerrak between 19 August and 3 September, and in Öresund between 23-27 September 2023. A total of 20 PSATs were deployed, out of which 8 of which were provided by ICCAT. The University of Exeter, in collaboration with Cefas and the Government of Jersey deployed 28 PSATs, including 8 provided by ICCAT GBYP, besides 6 accelerometers, 5 PATs and 19 acoustic tags, on bluefin tuna ranging 136-230cm CFL off southwest England and the Channel Islands, in September and November 2023. In Levantine Sea tagging was performed by Turkish team (MEDFRI, T.R. GDFA, Akua Group Fisheries and Çukurova University) and Stanford University on 8 June 2024. One Stanford University Expert was contracted to assist in tagging deployment, while a second one was provided in kind by the same institution. In addition to providing expertise, Stanford University also provided additional tags to be deployed. The Akua Group Fisheries Company captured 32 fish bluefin tuna during purse seine operations conducted between 2-4 June in Antalya Bay. Of these, 17 were tagged with a pop-up tag only, 13 were tagged with an acoustic tag only, and two were double tagged. The CFL of ABT individuals ranged from 120 to 273 cm. IFREMER carried out tagging operations in the Central and Western Med, specifically in Malta, SE Spanish coasts and Balearic Sea. Unfortunately, the tagging operation on board purse seiners south of Malta should be cancelled, since after 3 weeks onboard the PS, the boats still hadn't caught any tuna. It was therefore decided to move away from this operation so that effort could be put into the other operations. The second operation was developed in Santa Pola (SE Spanish coasts), taking advantage of a sport fishing event. It was very successful, allowing the deployment of 6 GBYP tags. Finally, the third operation was developed on board French longliners operating in the Balearic sea after the purse seine fishing season. It was difficult, since it was plagued with a week-long period of low-catch, but allowed to deploy the two last GBYP tags available. Summing up, a total of 14 pop-up tags, including the 8 GBYP tags, were deployed on fish between 156cm and 275cm (CFL).

Stanford University tagging team, in collaboration with the Barcelona Zoo and AZTI, deployed GBYP pop up tags in the Canary islands targeting giant tuna. The initial plan was to deploy a total of 9 GBYP tags around La Gomera and south Tenerife, but due to rough weather, a minimum of force 4 winds in Beaufort scale along the whole survey, developed between the 28th of April to the 5th of May 2024, the survey was moved to Lanzarote, looking for better conditions. Thanks to that and to the use of a larger than usual sport fishing vessel, 7 large fish, between 247 and 272 cm CFL, could be tagged. Two remaining tags were reassigned to the tagging survey in the Levantine Sea. From the six GBYP miniPAT tags awarded to AZTI to tag and sample medium-large sized ABFT in the Bay of Biscay, four of those tags were successfully deployed in Atlantic bluefin tuna ranging from 156 to 250 cm CFL, during spring and summer in fish, both tagging from sportfishing vessels and professional fishing vessels. Due to logistic limitations to handle the fish on board in some of the vessels, it was developed a tagging procedure to tag large fish inside the water with two anchors, without having to lift them onboard when no big boats are available to do so).The two remaining ones, which could not be deployed due to the lack of fish, even after having tried to do it within extra surveys in summer 2024, will be reused, after testing, in the fall 2024 campaigns. Only one of the MoUs, the one signed with University of Genoa to deploy 5 tags in the Ligurian sea, could not be implemented due to force majeure reasons, and these tags will be reused, after testing, in future campaigns.

In addition, for the first time within GBYP program, direct support was provided to develop an acoustic tagging campaign in a Portuguese trap located in Algarve coasts, targeting fishes migrating from the Atlantic to Mediterranean for spawning aiming primarily at testing the efficiency of the new acoustic receivers array recently deployed within the framework of the EU project STRAITS, which has significantly reinforced in recent years the European Tracking Network (ETN). So, 18 acoustic tags provided by IFAPA (EU-Spain) were deployed by ICCAT Secretariat staff with the logistic support from IPMA (EU-Portugal) and the TUNIPEX tuna trap (EU-Portugal). For further details, see reports on tagging campaigns available in https://www.iccat.int/GBYP/en/tagging.asp (Documents section, Phase 13).

Within Phase 14 a new Call for EoI was launched in July 2024. As a result, 10 new MoUs have been recently signed, to deploy, between September 2024 and May 2025, a total of 109 GBYP owned electronic tags, including not only pop-up satellite tags, but also internal archival tags and acoustic transmitters. The number and type of tags awarded by team, is summarized in **Table 6**.

As regards conventional tags, within the reporting period associated to Phase 13, 1750 “spaghetti” tags, along with applicators and the tagging protocols and forms to report tagging operations, were delivered to various institutions (**Table 7**). During this reporting period, a total of 630 fish were tagged (**Table 8**).

4.3.2 Tag recoveries

The ICCAT GBYP tag recovery activities, supported by awareness and reward programs, has continued as usual along the last year. The current strategy includes the following rewards: 50€/ or a T-shirt for each conventional tag; 100€ for acoustic tags, 1000 € for each archival electronic tag, and the annual ICCAT GBYP lottery (September): 1000 € for the first tag drawn and 500 € each for the 2nd and 3rd tag drawn. This rewards policy, along with the strong tag awareness activity, including along the last years meetings with ICCAT ROPs representatives, have demonstrated to be very useful for improving the tag recoveries. So, in the year 2023, a total of 201 tags were recovered, including e-tags, as can be seen in **Figure 6**. It is worth highlighting the exponential increase over the last three years, coinciding with the specific awareness actions directed to ICCAT observers, in the recovery of electronics tags, as shown in **Figure 7**.

4.4 Biological studies

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

4.4.1 Biological sampling and analyses

As done in previous GBYP phases, a call for tenders was issued 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. A contract was provided to the Consortium headed by AZTI.
During Phase 13, the Consortium sampled a total of 573 Atlantic bluefin tuna (135 YOY, 1 juvenile fish, 24 medium sized fish and 413 large fish) from different regions (148 from the Balearic Sea, 30 from Canary Islands, 85 from the Bay of Biscay, 131 from the Norwegian Sea and 149 from the Central Atlantic). In total, 986 biological samples (286 otolith samples, 127 fin spines and 573 genetic samples) were collected by the Consortium and

incorporated into the tissue bank. The Consortium also received samples apart from those agreed in the contract. In total, the Consortium handled 1384 biological samples (405 otolith samples, 256 fin spines and 723 genetic samples) from 732 individuals (**Table 9**). All these samples have been catalogued and stored together within the biological tissue bank.

Following the Commitment to the EU to increase dissemination of the data, the Consortium developed a detailed and updated catalogue of samples stored in the GBYP Tissue Bank. The catalogue is available through a link to a persistent and reliable public web repository http://aztidata.local/BioTuna. This user-friendly interface has been developed within a Shiny app (**Figure 8**) and offers an integrated and interactive data visualization tool. This tool enables compiling data from multiple databases and data sources providing a superior overview. Results are visualized with maps, graphs and diagrams.

Another activity included sorting and identifying ABFT larvae from surveys conducted in the Balearic Sea spawning ground for potential close-kin analyses. In total, 2923 individuals from 25 samples collected during 2023 were identified. Bluefin tuna larvae were found in 21 out of the 25 samples analysed. The sorted individuals were preserved in 100% ethanol in different 4 ml jars and kept in the freezer for perfect conservation.

On the genetic analysis, based on whole genome sequencing analysis a set of candidate gene variants were identified, potentially affecting Atlantic bluefin tuna fitness originated from a past introgression event from the albacore tuna, which was confirmed to have occurred in the Mediterranean Sea. The observed introgression signal in ABFT, stronger from Mediterranean albacore than from Atlantic albacore, confirms that the introgression of albacore alleles into ABFT originated from individuals of both species co-occurring in the Mediterranean. The confirmed origin of albacore alleles introgressing into Atlantic bluefin tuna from the Mediterranean, along with the observed introgression among Slope Sea larvae and young-of-the-year (YOY), validates the connectivity between the Mediterranean and Slope Sea spawning areas. Regarding the adaptive potential of albacore origin, it was found that the preservation of specific genomic regions with strong signal of introgression in the genome and the location of protein coding genes within them suggests that a past introgression event of albacore tuna alleles could confer adaptive potential to the Atlantic bluefin tuna.

Genetic variants affecting fitness at earliest life stages of Atlantic bluefin tuna was also studied. The filtered genotype table contained 624 larvae (n=490) and YOY (n=134) captured in the Mediterranean Sea during the years 2018 to 2023 and 5975 neutral SNPs. The PCA showed weak genetic differentiation between larvae and YOY based on these 63 SNPs (**Figure 9**). The finding of candidate genomic variants for affecting survivorship during the earliest life-stages of the Atlantic bluefin tuna in the Mediterranean Sea means an advance on the understanding of the genomic basis of adaptive capacity of the species to changing environmental conditions.

The Consortium also briefly studied the suitability of the larvae for kinship analysis required for CKMR model implementation in the Eastern Atlantic bluefin tuna. The obtained results suggest that adult individuals may spawn at different locations in the Westen Mediterranean during the same spawning season. Spatial and temporal connectivity between spawning sites in the Mediterranean Sea needs further study and increased sampling size to determine Atlantic bluefin tuna spawning site fidelity. Moreover, kinship analysis can be used to explore spawning site fidelity at a fine scale within the Mediterranean Sea.

The genetic origin of previously unassigned individuals was also explored, in order to understand the mixing patterns and monitor the migratory behavior with the aim to anticipate potential changes in stock distribution. It was found that the genetic origin assignments based on the 96 SNP panel could overestimate the proportion of Gulf of Mexico individuals and the mixing of both components at both sides of the North Atlantic Ocean, highlighting the need for a more comprehensive and powerful tool, such as the ABFT SNP Array, for Atlantic bluefin tuna monitoring to provide with more accurate information about the genetic origin of Atlantic bluefin tuna, mixing dynamics and behavior. **Figure 10** shows the difference in genetic assignments between the two methods. In conclusion, using ABFT SNP Array tool, the Consortium identified a set of candidate genomic variants potentially affecting survivorship during earliest life-stages that require further analysis, and performed kinship analysis which suggested the participation of the same individual in multiple spawning events at different locations within the same spawning season, expanding our knowledge on the demographic connectivity of the species.

The study on the genetic profile of bluefin tuna captured in the Bay of Biscay in different season showed that individuals of Mediterranean and Gulf of Mexico origin can be found in the Bay of Biscay at different proportions across different years, seasons and age classes, suggesting dynamic migratory behavior of the species. Unusual increased catches of Atlantic bluefin tuna in the Bay of Biscay during the winter over the last three years are composed by individuals of Mediterranean origin, although higher samples sizes are needed to infer more robust conclusions.

Another activity included evaluating the sex assignment power of genetic markers included in the SNP array with the objective to pose hypothesis of sex-biased migration. The results showed an assignment rate of the 92.6%. In conclusion, the correct sex assignation of the ABFT samples using the genetic markers for sex determination included in the ABFT SNP array will allow the reliable automated sex identification of ABFT individuals genotyped using the ABFT SNP array required for kinship analysis needed for the implementation of CKMR models without increasing costs. For further details see the report from Fraile *et al*., available at https://www.iccat.int/GBYP/en/biostu.asp (Document section, Phase 13).

4.4.2 Investigating Adaptive Divergence in Atlantic Bluefin Tuna using Whole Genome Sequencing

In Phase 13 a specific study has been performed using the whole genome sequencing of Atlantic bluefin tuna DNA with the objective to allow better characterization of the population structure and mechanisms driving evolutionary divergence between bluefin tuna spawning populations. Due to the long duration of the procedures to agree on all the terms of the contract between Stanford University and ICCAT, it was signed in February 2024, much later than expected considering that the work had been awarded in August 2023. Therefore, the effective analytical work started also later than planned. Moreover, the initial attempts to extract DNA from larvae sampled between 2010 and 2016 in the Central Mediterranean shown that it was challenging to get high enough quality DNA for full genomic sequencing, and hence it was necessary to use analytical approach different to those initially planned, which has caused a further delay in the development of the study. Because of that the complete set of analytical results will be presented within the SCRS BFT Group meeting in September 2024. After that However, the first WGS results, based on 331 samples representing Atlantic bluefin tuna populations in the western, eastern Atlantic, and Mediterranean Sea, are summarized below.

The mean percentage of reads mapped to the Atlantic bluefin tuna reference genome was 99.44% and the mean genome coverage across the 92 retained individuals was 10.24x. After filtering, we obtained 13,241,151 single nucleotide polymorphisms (SNPs) for subsequent analyses.

Principal component analysis (PCA) revealed subtle, but significant genome-wide differentiation between GOM and Med samples for both the full and neutral dataset (**Figure 11**). Results from ADMIXTURE on the neutral dataset supported K=1 as the best supported cluster by cross-validation errors, and we did not see any population structuring in the visualization of ancestry proportions for higher values of K. There were no differences in heterozygosity between GOM (mean ± SD = 0.21± 0.03) and Med (0.20 ± 0.03).

Genome-wide FST estimates between GOM and Med suggest moderate levels of divergence (mean FST = 0.0032), with 158 SNPs having elevated FST values greater than four standard deviations above the mean (**Figure 3**). The 158 outlier SNPs overlapped with 468 elevated windows, which mapped to 305 unique gene IDs. Several of these had functions related to development of the vasculature (angiogenesis) and calcium signaling in ion channels (**Table 10**).

Summing up, GOM – Med whole genome comparisons performed up to now describe subtle, but significant, genomic variation using both adaptive and neutral markers. The most differentiating markers across the entire genome that may aid future efforts in assigning individuals of unknown origin to the western or eastern stock have been identified. The analysis of the additional Med larvae from different sites, as well as the adults tagged in Norway, will allow to investigate the possibility of population structure within the Mediterranean Sea. The addition of Slope Sea spawners will help to better understand their origin and contribution to overall bluefin tuna biodiversity.

Within Phase 14, a new Call for tenders for the maintenance of the GBYP Tissue Bank and to develop further biological studies related to CKMR feasibility studies was launched in July 2024. These studies will focus in determining the frequency of the different Atlantic bluefin tuna mitochondrial haplotypes, aiming at identifying haplotypes whose low frequency would allow to use them to know if two individuals share the same mother and in evaluating the sibship among BFT larvae sampled within the Balearic Sea EU DCF ichthyoplankton survey. For further details see the report from Mikles and Block, available at https://www.iccat.int/GBYP/en/biostu.asp (Document section, Phase 13).

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, further developing stock assessment models including mixing between various areas and developing and use of biologically realistic operating models for more rigorous management option testing".

In previous GBYP Phases, modelling tasks were mostly focused on the development of MSE related models. Given that the BFT Management strategy evaluation (MSE) modelling tasks have already been completed within Phase 12, in this phase 13 GBYP modelling efforts focused on CKMR issues.

So, regarding MSE, within Phase 13 GBYP provided only indirect support to further development and implementation of the process. New MSE modelling related tasks related to MSE OM reconditioning will be addressed again in GBYP Phase 14. In addition, GBYP continued providing its support to BFT MSE Technical Group by covering the travel expenses, whenever needed, for participating in MSE related meetings of the members of the previous MSE Core Modelling Group. In Phase 13 GBYP supported the travel of the MSE Coordinator (Dr Doug Butterworth) and the MSE modelling expert (Dr. Tom Carruthers) to BFT Species Group meeting in September 2023. Modelling tasks related to CKMR development are detailed below.

4.5.1 Close-Kin Mark-Recapture modelling

Due to the new SCRS research priorities identified during Phase 13, additional tasks related to the CKMR development were carried out within the extension of Phase 13. So, to address the need for developing mathematical and statistical modelling to assess the probabilities of BFT population dynamics parameters required for CKMR analysis and creating potential alternative sampling designs a contract was awarded to experienced CKMR modelers to produce an initial model to be presented and discussed within the SCRS BFT group intersessional meeting held in April 2024. Specifically, this model consisted in a spatially-explicit Close-Kin Mark-Recapture (CKMR) model suitable for Eastern Bluefin Tuna (EBFT), which was used to investigate some sampling options (e.g., sample sizes by fishery, number of years, whether to preferentially subsample bigger or smaller fish, etc), to check what kind of precision might be achievable for quantities-of-interest (mainly, total abundance of adult EBFT) and by when. This contract was extended until July 2024 once GBYP Phase 13 amendment was approved, to explore alternative options for potential sampling designs suitable for EBFT CKMR, as recommended by the SCRS BFT Group during April 2024 meeting. So, seven designs were considered, that differed in terms of total sample size and in the breakdown of samples across fisheries. The effect of using genetic samples collected in the Atlantic and Mediterranean in recent years, was also investigated.

The main conclusion of this modelling work was that given sampling levels that seem quite feasible logistically, from a small number of selected fisheries (and a larval survey), then by 2030 it could be expected a very good precision on adult abundance (~10% CVs) and on Z (in effect on M) – under reasonable working assumptions about spatial structure and current abundance. There should also be enough kin-pairs of particular types to check assumptions about spatial structure, e.g. extent of spawning site fidelity. Useful CVs on aggregate abundance might even be achieved in time for SCRS 2027, but there will not be enough kin-pairs to check most spatial structure assumptions. For details, see the report from Bravington and Fernandez, available at https://www.iccat.int/GBYP/en/modelling.asp (Documents section, Phase 13).

Table 1. Amounts provided to GBYP Phase 13 by CPC.

European Union	900,000.00 €
Morocco	66,280.30 €
Japan	55,782.93 €
Tunisie	47,258.00 €
Türkiye	46,575.34 €
Libya	45,643.84 €
Algerie	36,239.20 €
Canada	20,529.68 €
Norway	19,000.00 €
Albania	4,719.17 €
Iceland	4,012.64 €
Korea	3,958.90 €
TOTAL	*1,250,000.00 €*

Table 2. Amounts committed for the first year of GBYP Phase 14 by CPC.

European Union	400,000.00 €
Remanent funds	308,000.00 €
Canada	45,118.93 €
Morocco	35,176.46 €
Japan	29,039.94 €
Türkiye	24,246.58 €
Norway	19,000.00 €
Algerie	18,865.70 €
Albania	2,446.96 €
Korea	2,060.96 €
China	1,044.47 €
TOTAL	*885,000.00 €*

Table 3. Summaries of BFT sightings in 2023. The Final number indicates the number of sightings which are on-effort and represent adult schools. In brackets are given numbers after truncation to 1,500 m.

Year	*Block*	*All sightings*	*On effort*	*Non juveniles*	*Final number*
2023	A	24	22	22	21 (14)
	C	5	5	4	4 (3)
	E	11	11	8	8 (8)

Table 4. Estimated biomass (B, in tonnes) per block (block and year) with standard errors (SE) and lower (LCL) and upper (UCL) confidence levels. Coefficient of variation (CV) is also provided for the results from this analysis. The orange values apply to estimates reported last year (2023), and the grey values from the year before (2022). All estimates are based on sightings from all blocks: A, C, E and G.

Label	B	SE	CV	LCI	UCI	N	CV	LCI	UCI	N	CV	LCI	UCI
	This report					Paxton et al. 2023				Chudzinska et al. 2022			
A-2017	8726	3817	0.44	3774	20177	7949	0.44	3426	18444	8001	0.45	3436	18634
A-2018	14603	4480	0.31	8034	26544	13251	0.31	7225	24304	13345	0.31	7352	24222
A-2019	12948	5139	0.40	6015	27871	11808	0.40	5469	25495	11548	0.38	5619	23734
A-2021	5183	2747	0.53	1905	14105	4955	0.53	1831	13410	4714	0.53	1750	12696
A-2022	10640	4849	0.46	4441	25493	9433	0.49	3723	23899				
A-2023	10970	5364	0.49	4289	28056								
C-2017	6994	2824	0.40	3167	15442	6715	0.40	3060	14733	6749	0.43	2981	15280
C-2018	5238	3032	0.58	1740	15767	5042	0.58	1680	15129	5069	0.54	1846	13920
C-2019	3186	1857	0.58	1047	9696	3057	0.58	1008	9275	3072	0.62	977	9652
C-2022	10770	4610	0.43	4677	24804	9965	0.44	4237	23436				
C-2023	4054	2764	0.68	1140	14412								
E-2017	6393	3726	0.58	2147	19040	5822	0.58	1951	17372	5884	0.6	1981	17483
E-2018	3865	2205	0.57	1335	11189	3702	0.57	1283	10682	3735	0.47	1538	9067
E-2019	2096	994	0.47	848	5176	1956	0.46	804	4760	2023	0.5	797	5188
E-2022	2110	1599	0.76	537	8284	2092	0.77	528	8293				
E-2023	14954	6592	0.44	6299	35500								

Table 5. Estimated biomass (B, in tonnes) per block (block and year) with standard errors (SE) and lower (LCL) and upper (UCL) confidence levels based on the parameter estimates from analysis up to the 2022 data inclusive. Coefficient of variation (CV) is also provided for the results from this analysis. All estimates are based on sightings from all blocks: A, C, E and G.

Label	N	SE	CV	LCI	UCI
A-2023	7513.3	5624.2	0.75	2007.3	28122.5
C-2023	3793.5	2601	0.69	1063.5	13531.4
E-2023	14026.2	6352	0.45	5810	33861.1

Table 6. Number and type of GBYP owned etags awarded within the GBYP Phase 14 first Call for EOI to collaborate with GBYP e-tagging program.

	Type of tag		
Institution	*PSAT*	*Internal*	*Acoustic*
Marine Institute	4		8
DTU	6		8
Acadia Univ.	5		
AZTI	4	8	
Stanford (Canaries)	6		5
Zoo Barcelona	3	4	8
Stanford (Slope Sea)	8	6	
Exeter Univ	4		3
IMR	5		
SLU	6		8

Table 7. Number of conventional tags sent to different collaborators in Phase 13 (from March 2023 until March 2024).

Country	*Institution*	*Conventional tags (number)*
Canada	St. Andrews Biological Station	1000
United Kingdom	Centre for Environment Fisheries and Aquaculture Science	500
Italy	Federazione Italiana Pesca Sportiva e Attività Subacquee	50
Sweden	Swedish University of Agricultural Sciences. Department of Aquatic Resources (SLU Aqua)	100
Denmark	Technical University of Denmark	100

Table 8. Number of fish tagged during Phase 13 (from March 2023 until March 2024).

	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	8	0	0	0	0	8	0
West Med.	8	0	0	8	0	0	0
North and Celtic Seas	574	0	534	0	0	40	0
Bay of Biscay	4	0	0	0	0	4	0
Canary Islands	0	0	0	7	0	0	0
Northwest Atlantic	4	0	0	4	0	0	0
East Med.	32	0	20	0	0	12	0
GRAND TOTAL	630	0	554	19	0	64	0
		SUBTOTAL = 573			SUBTOTAL = 64		

Table 9. Total number of otoliths, dorsal fin spines and muscle/fin tissue samples collected in Phase 13, per area.

ICCAT MSE Region	*Area*	*Tissue sampled*			*Total*
		otoliths	*spine*	*muscle/fin*	
MED	Balearic Sea	12	12	166	190
	Strait of Sicily		5		5
	Tyrrhenian Sea	118	124	122	364
	Adriatic Sea			40	40
SATL	Gibraltar Strait			30	0
	Canary Islands	30		30	60
EATL	Bay of Biscay			31	31
				54	54
NATL	Norway	95	115	131	341
	Skagerrak	1			1
WATL	Central and North Atlantic	149		149	298
TOTAL		405	256	723	1384

Table 10. Selection of candidate genes and their putative roles from FST outlier peak on Chromosome 21.

Chrom	Gene name	Description
21	a2ml	Liver development
21	plekhg5 b	Angiogenesis, blood vessel endothelial cell migration
21	rcbtb1	Retinal vasculature and blood vessel development
21	MLNR	Calcium-mediated signaling
21	pgr	Ovulation; LH signaling
21	trpc6a	Calcium channel activity

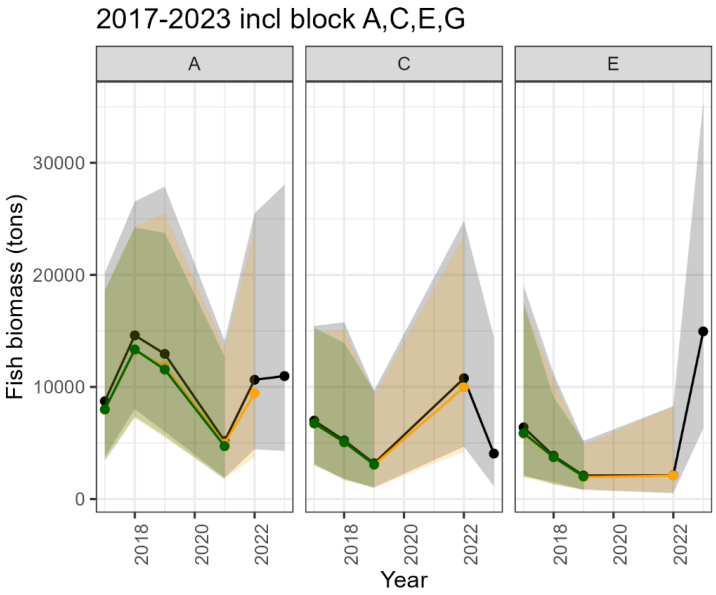

Figure 1. Estimated biomass (in tonnes) of BFT for surveyed years and blocks. Black colours show estimates from this study: dots show mean values and ribbon show upper and lower confidence limits of the 95% confidence interval. Orange colour shows estimates from the last year (2023) and green the year before (2022).

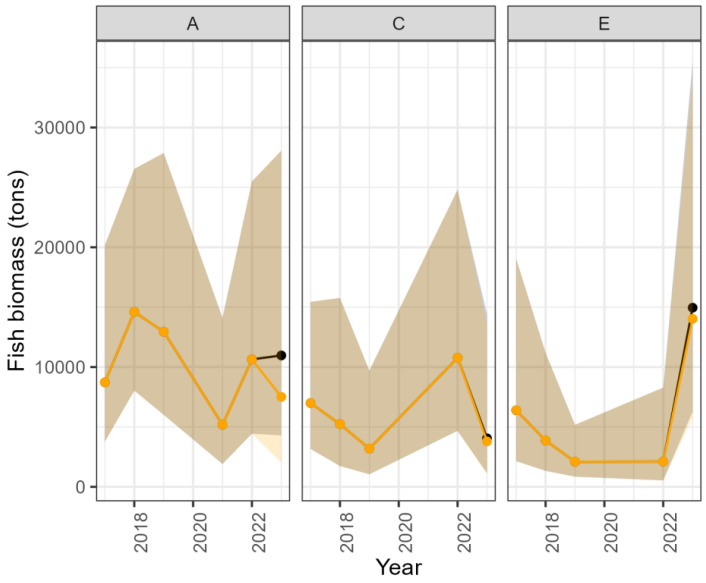

Figure 2. Estimated biomass (in tonnes) of BFT for surveyed years and blocks. Black colours show estimates based on all four blocks (A, C, E and G) for Task 1: dots show mean values and ribbon show upper and lower confidence limits of the 95% confidence interval. Orange colour shows estimates based in Task 2.

Figure 3. Bluefin tuna observations in the Balearic Sea area 2024.

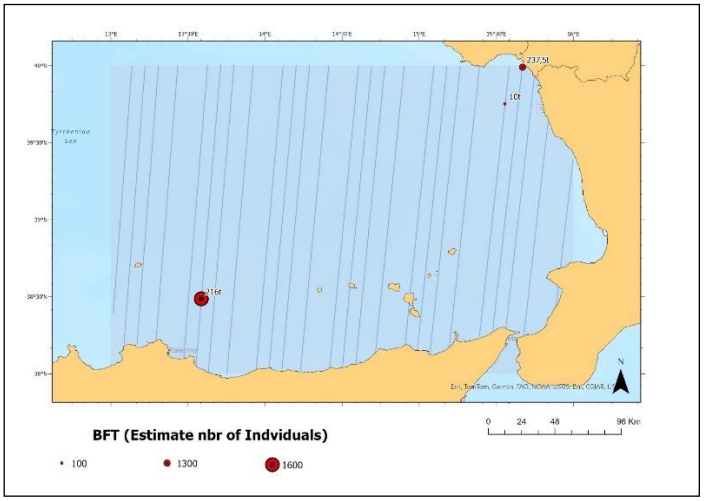

Figure 4. Bluefin tuna observations in the Southern Tyrrhenian Sea area 2024.

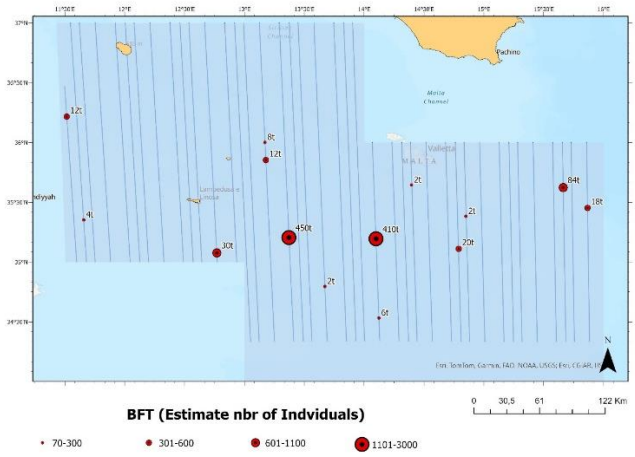

Figure 5. Bluefin tuna observations in the Central-Southern Mediterranean Sea 2024.

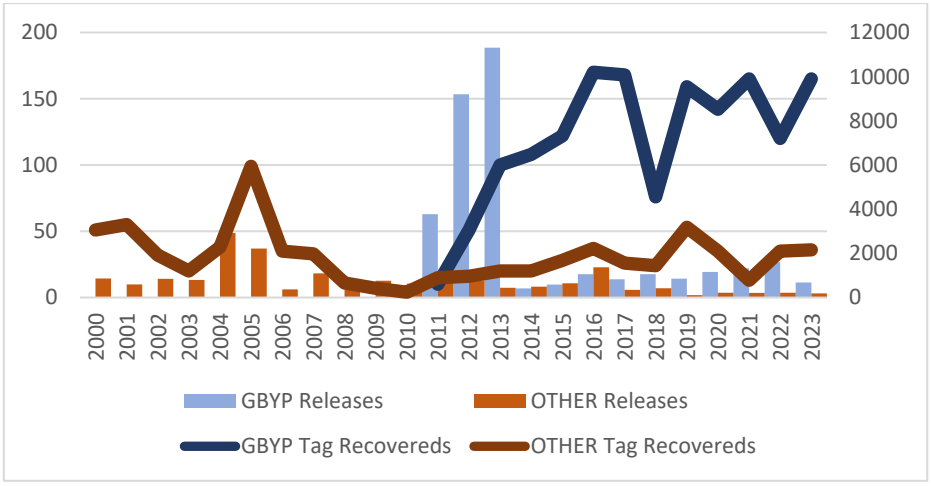

Figure 6. Annual trend of bluefin tuna tag recoveries reported to ICCAT since 2002 (up to 1 March 2024).

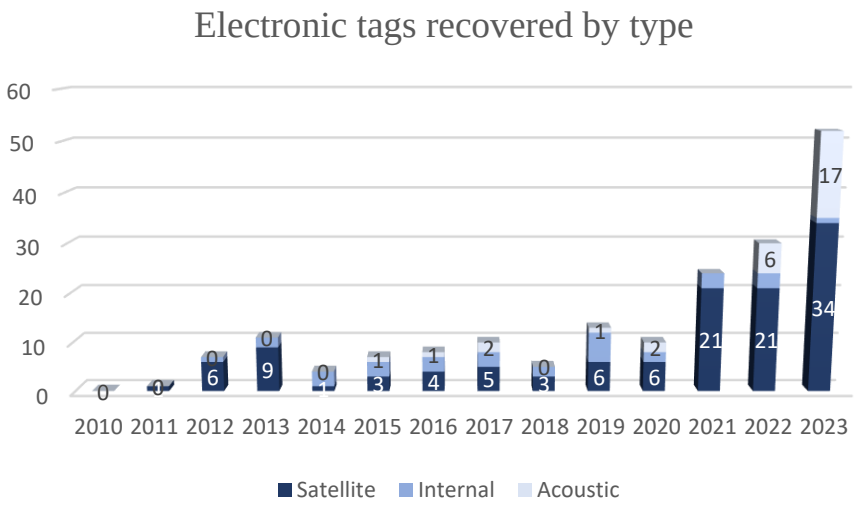

Figure 7. Electronic tags recovered within GBYP program.

Figure 8. BioTuna Shiny application developed by the Consortium including the filter selector and corresponding geographic distribution of data.

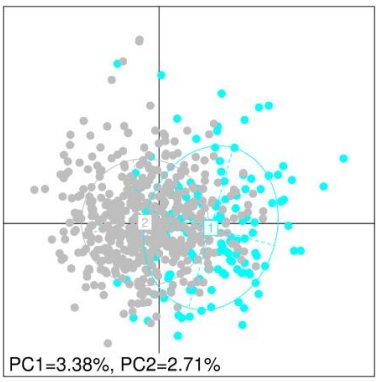

Figure 9. Principal component Analysis performed based on the 63 candidate SNPs affecting fitness in the earliest life-stages of Mediterranean Atlantic bluefin tuna. The analysis included larvae (grey) and YOY (blue) captured in the Mediterranean Sea during the years 2018 to 2023.

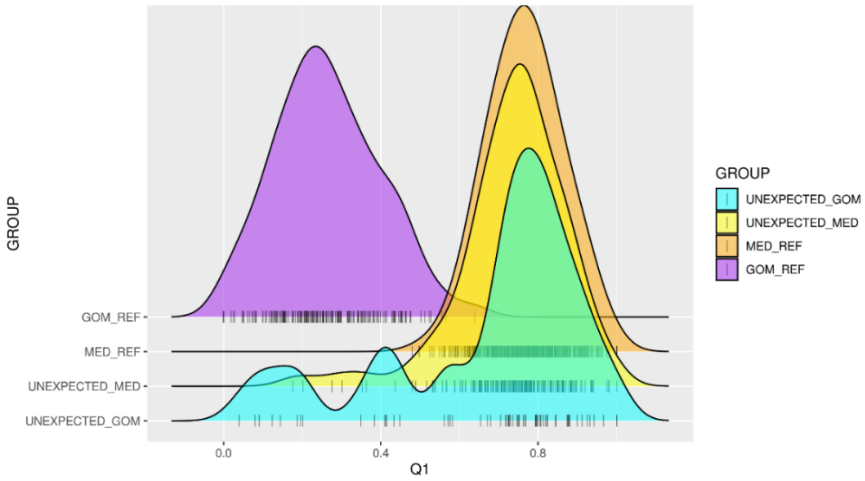

Figure 10. Distributions of individual ancestry proportion (Q1) of the ancestral population which corresponds to the Mediterranean Sea of the reference individuals from the Gulf of Mexico (GOM_REF, in purple) and the Mediterranean Sea (MED_REF, in orange) and individuals that were unexpectedly assigned to the Gulf of Mexico (UNEXPECTED_GOM, in blue) or to the Mediterranean Sea (UNEXPECTED_MED, in yellow) based on results obtained with the 96 SNP panel. Individual ancestry proportions were estimated based on the genotypes at > 6000 neutral SNPs obtained with the ABFT SNP Array.

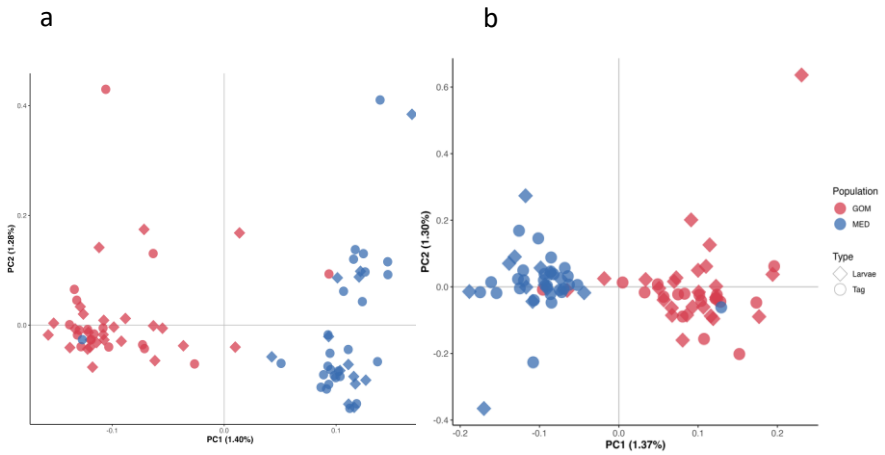

Figure 11. Principal component analysis (PCA) using the full dataset (a) and neutral dataset (b). Points are colored by population, GOM (red) and Med (blue), and shaped by sample type, either larvae (diamonds) or tagged adults (circles).