

REPORT OF THE 2023 ICCAT GBYP WORKSHOP ON ATLANTIC BLUEFIN TUNA ELECTRONIC TAGGING

(hybrid/Madrid, 4-6 July 2023)

Anonymous

SUMMARY

The GBYP Workshop on Atlantic bluefin tuna electronic tagging was organized with the goal of reaching a broad consensus on the strategic planning of future electronic tagging and the best use of available tagging data. The state-of-the-art in Atlantic bluefin tuna telemetry was revised and multiple subjects related to e-tagging, from methodological issues to knowledge gaps, were discussed. A new ICCAT information system to manage archival tags data, aiming to facilitate future joint studies, was presented. Finally, a strategic plan for further tagging to fill in identified gaps and improve stock assessment was drafted, including a list of priorities for future tagging campaigns.

RÉSUMÉ

L'atelier du GBYP sur le marquage électronique du thon rouge de l'Atlantique a été tenu avec pour objectif de dégager un vaste consensus sur la planification stratégique du futur marquage électronique et la meilleure utilisation des données de marquage disponibles. L'état de l'art en matière de télémétrie pour le thon rouge de l'Atlantique a été révisé et de multiples questions en lien avec le marquage électronique ont été discutées, allant de questions méthodologiques jusqu'aux lacunes dans les connaissances. Un nouveau système d'information de l'ICCAT destiné à gérer les données des marques archives et visant à faciliter les futures études conjointes, a été présenté. Finalement, un plan stratégique pour la poursuite du marquage afin de combler les lacunes identifiées et d'améliorer l'évaluation des stocks a été rédigé, incluant une liste de priorités pour les futures campagnes de marquage.

RESUMEN

El GBYP organizó un taller sobre marcado electrónico de atún rojo del Atlántico, con el objetivo de alcanzar un amplio consenso sobre la planificación estratégica del futuro marcado electrónico y el mejor uso de los datos de marcado disponibles. Se revisó el estado actual de la telemetría del atún rojo del Atlántico y se debatieron múltiples temas relacionados con el marcado electrónico, desde cuestiones metodológicas hasta lagunas en los conocimientos. Se presentó un nuevo sistema de información de ICCAT para gestionar los datos de las marcas archivo, con el objetivo de facilitar futuros estudios conjuntos. Por último, se elaboró un plan estratégico de marcado para colmar las lagunas identificadas y mejorar la evaluación de los stocks, incluida una lista de prioridades para futuras campañas de marcado.

KEYWORDS

Bluefin Tuna, electronic tagging, database

1. Workshop overview and objectives

Data from electronic tagging has greatly increased the knowledge of bluefin movements and life history, which has been used for management purposes within the framework of the recently adopted management procedure for Atlantic bluefin tuna (based on the Management Strategy Evaluation (MSE) process). In recent years, the quantity and quality of data from electronic tagging has increased significantly. However, some important knowledge gaps remain regarding spatial patterns and population structure of bluefin tuna stocks, and broad joint analyses of all available data sets are still pending. Therefore, the field of bluefin tuna science stands to gain from finding ways to collaborate to jointly analyze these compiled datasets and to strengthen the coordination among different initiatives to better fill knowledge gaps.

To address these needs, GBYP organized this workshop with the goal of reaching a broad consensus on the strategic planning of future electronic tagging and the best use of available tagging data.

The specific objectives of the workshop included:

- i) Identification of remaining knowledge gaps in movement transitions, life history traits and population structure;
- ii) Drafting of a strategic plan to fill these gaps;
- iii) Discussion of the development of a new ICCAT database (ETAGS DB), that will integrate information from e-tagging activities;
- iv) Discussions regarding the access and use of the data contained in the ETAGS DB in light of the recently adopted Rules and Procedures for the protection, access to, and dissemination of data compiled by ICCAT;
- v) Elaboration of a workplan for conducting joint analyses of the combined tagging datasets.

2. Opening, adoption of agenda and meeting arrangements

The meeting was held in a hybrid format, presential and online, at the ICCAT Secretariat in Madrid, Spain from 4-6 July 2023. The ICCAT Executive Secretary welcomed the participants to ICCAT, emphasizing the importance of collaboration between groups, and wished everyone a fruitful meeting. Dr. Enrique Rodríguez-Marín (EU-Spain) and Dr. Francisco Alemany (GBYP), the Rapporteur for the eastern Atlantic and Mediterranean, and the GBYP Coordinator, respectively, opened the meeting and served as Co-Chairs. They described the objectives of the workshop as outlined above. The co-chairs reviewed the agenda, which was adopted without changes (Appendix 1). Dr. Erin McClelland from the GBYP staff served as the rapporteur of the workshop report. The List of Participants is included as Appendix 2.

3. Overview of ICCAT e-tagging programs and information systems. GBYP Coordinator (Francisco Alemany)

Abstract: GBYP coordinator presented an overview of the status of the ICCAT main tagging programs, GBYP and AOTTP, bluefin tuna and tropical tunas respectively, highlighting the problems they have faced during its implementation. Following, the current information systems implemented to manage the information from these programs were described, showing its weaknesses, which justify the need of developing a more comprehensive Information System integrating the metadata on tagging operations and the data from the deployed tags into a single centralized database to facilitate the analyses of broad datasets. Next, the explicit mandate from SCRS to design and implement such etagging DB was remembered. Finally, the specific objectives of this GBYP etagging workshop and the new activities planned to be carried out in the short term within the GBYP etagging program were listed.

Discussion: It was suggested that it would be convenient to revise similar initiatives on etags information systems developed by other ORPs and that the possibility of resuming the electronic tagging with internal archival tags providing multiannual data should be explored.

4. Keynote talks

Electronic Tagging Informs the Spatial Distributions of Atlantic Bluefin Tuna Stocks. Barbara Block (United States/Stanford University)

Abstract: Atlantic Bluefin tuna (ABT), *Thunnus thynnus*, have been exploited by international fisheries throughout their range. ICCAT currently manages the ABT as two populations separated by the 45° W meridian with major spawning areas recognized in the Gulf of Mexico (GOM) and the Mediterranean Sea (MED). A third spawning zone, the Slope Sea (SS), has been discovered in the western North Atlantic and the origin of ABT populations spawning in this location remains challenging to assess. In the past two decades, our teams have utilized biologging to advance our understanding of the spatial distributions, life history and population structure of ABT. Our TAG A Giant (TAG) tagging campaign has enabled large scale study of the movement ecology of the species since 1996 in the west and east Atlantic. To date, approximately 2000 archival, acoustic and satellite tags have been deployed in the Atlantic on ABT by our US team and collaborators in many nations. Electronic tag (e-tag) tracks can be used to understand life history, natural mortality, and spatial overlap of the ABT populations. Stanford, TAG, and ICCAT, along with academic and national labs from the United State, Canada, Ireland, England, Norway, Spain, and Israel have collaborated together to make the ABT fishery the most intensively studied with e-tags in the world. Our 27-year time series of e-tag data is potentially the longest in any commercial fishery and has enormous value as climate change impacts the Atlantic Ocean and stock mixing becomes increasingly complex. Here we describe the movements of more than 600 western and eastern tagged bluefin to better understand the spatial dynamics of the sub-adults and spawning populations to better understand their mixing. Our TAG collaborative efforts have focused on sharing tagging techniques, data analyses and comparative track analyses to inform ICCAT management models. Together we are improving modeling efforts, providing inputs to management models that enable assignment of catches to putative stocks and inform quota allocations. Fin clip and muscle biopsies taken for e-tagged fish also offer the potential to measure ABT stock origin, age and sex using genomic techniques. ICCAT models incorporating the tag spatial data with stock-of-origin will improve our understanding of Atlantic bluefin tuna mixing.

Discussion: A question was raised about fish tagged in the Mediterranean near Israel as to whether these fish were spawners. While they were tagged in warm water and were of a size that could spawn, there was no evidence that they had spawned.

Tagging Bluefin Tuna from the French fisheries. Tristan Rouyer (EU-France)/IFREMER

Abstract: Electronic tagging of Bluefin Tuna (BFT) is an important tool to understand the ecology and dynamics of the species in a context of climate change, but it also provides data feeding models that include explicit spatial dynamics. France is a major country for BFT exploitation, with active fisheries in the Mediterranean and in the Atlantic. France has a large purse seiner fishery operating in the Mediterranean spawning grounds, which is the dominant exploitation segment for BFT. Here we describe French tagging operations that target the different national exploitation components in the Gulf of Lion, the Mediterranean spawning grounds, and in the Bay of Biscay. We present recent results and perspectives.

Discussion: The question was raised as to whether there is a size constraint with this method. The author noted that there is no size limit *per se* but when they are operating in particularly warm waters they have to be very quick so the fish don't run out of oxygen and it is more difficult to operate on larger fish. However, fish up to 250kg can be tagged in 10-15 minutes. Longline boats tend to be a little easier as they have more space on deck and expertise with handling the fish. With the longline, they set for no more than 6 hours and there is a time limit so that the fish are not too tired.

It was noted that some groups use a tow cage but there may be some logistical difficulties (i.e., with registration) to using a cage in this area.

Tagging of Atlantic bluefin tuna (*Thunnus thynnus*) with pop-up satellite archival tags (PSAT) in Norway. Keno Ferter (Norway/IMR)

Abstract: Atlantic bluefin tuna (ABFT; *Thunnus thynnus*) is a highly migratory species. While highly abundant in the middle of the last century, major stock declines led to its disappearance from the productive feeding grounds in the Norwegian Sea for several decades. This disappearance also corresponded with a steep decline in the Eastern ABFT stock. However, in recent years, management regulations based on a comprehensive rebuilding program instituted by ICCAT starting in 2007 led to an unprecedented increase in this stock's size and distribution.

Furthermore, ABFT have reappeared in increasing numbers along the Norwegian coast during the last decade. To learn more about this assemblage, we deployed pop-up satellite archival tags (PSATs) on 14 large ABFT (Curved Fork Length: 242-292 cm) near the northern limit of their distribution (i.e., north of 60°N) to study their annual migrations and spawning stock affiliation. Eleven tags yielded useful data, and for 8 individuals a full-year migration cycle was obtained. These fish underwent significant migrations stretching from 65°N to 20°N and 53°W to 19°E covering water depths from 0 m to greater than 1100 m, and temperatures from 2°C to 28°C. The Nordic waters, Newfoundland Basin, and Canary Islands were identified as key foraging habitats. The majority entered the Mediterranean Sea before returning to Norwegian waters, indicating strong fidelity to the tagging location. Our results confirm the historical comeback and re-establishment of giant ABFT at its northernmost distribution following effective stock rebuilding measures.

Discussion: It was noted that they did see some mortality with no obvious cause and that perhaps this was due to a heart attack.

It was noted that both recreational and commercial fisherman along the west coast of France report that fish are larger and older every year and that younger fish do not seem to be recruiting to the area. The same trend has been seen in Norway, however, in the last year some smaller fish have been observed in the water although this is not yet reflected in the data. The majority tagged are really big fish (240kg on average in 2020, and 275kg in 2023). The researchers are considering the issue of whether they need to change fishing methods to target those smaller fish.

The question was raised as to whether it would be possible to release fish headfirst (to reduce mortality/stress). This had been considered but given the difficulty in turning the fish around in a relatively small deck space this was not considered to be beneficial.

The model used for determining tag tracking routes was discussed.

Scandinavian Bluefin Marathon – several hundred fish later. Kim Aarestrup (EU-Denmark/DTU)

Abstract: Scandinavian Bluefin Marathon (SBM) has been tagging Giant ABFT since 2017. The operation is a joint collaboration between DTU Aqua in Denmark and SLU VFM in Sweden. We use local experienced big game anglers to catch the GBFT in good condition and subsequently tag them onboard dedicated tagging boats. Over the years, we have expanded tagging to include a broad suite of electronic tags including pop-up satellite tags, accelerometer tags, data storage tags and acoustic tags to gain knowledge of ABFT behaviour and survival. Additionally, all ABFT are tagged with a Floy tag from the ICCAT series. The tag suite is designed to give information of different temporal scales of ABFT behaviour. Accelerometer tags give information on the first few days after release including detailed information about behaviour after release. Pop up satellite tags inform about the overall migration routes over a yearly scale including spawning. Data storage tags, acoustic tags and Floy tags provide information on migration up to a decadal scale, including survival and repeatability. Most fish are tagged with multiple types of tags making it possible to integrate results over different temporal scales of the individual with the goal of improving modelling. The overall goal of SBM is to inform management to ensure sustainable practices and help secure ABFT visiting Scandinavian waters in the decades to come. The first results indicate diverse migration behaviours in ABFT with the majority spending time in the greater North Atlantic area and entering the Mediterranean during spawning. In this talk the authors showed examples from the results, including a more detailed focus on the pros and cons of acoustic tags.

Discussion: Some discussion of a cost/benefit analysis regarding the information gained from different components (i.e., purchase of tag, activities to maintain data, logistics of implementation etc.) would be useful and important for taking advantage of limited resources.

It was noted that regulations of commercial products might impose some restriction on the use of some internal tags and the question was raised as to ways to identify fish with internal tags. PIT tags which can be detected onboard industrial trawlers, was suggested as a possible solution. PIT tags can be placed in parts of the fish that are not consumed to avoid any concern about the quality of the fish for market. Floy tags are also used as an external identification method. Internal tags have some advantages because for long lasting external tags, it is often the attachment point that fails rather than the tag. No external tags have been recovered after 6 years of deployment. However, survivorship may be better with external tags and internal implantation is difficult, particularly for large fish.

It was noted that acoustic tagging has shown that fish move very quickly and could go through the potential area of detection of the receivers without being detected, limiting the amount of information that can be gathered from acoustic tags. The author pointed out that with the global system of loggers and certainly with the right setup it is possible to estimate detection efficiency of receiver arrays, hence making survival estimates possible. In the pipeline is also a change in the transmission method in acoustic tags, reducing code transmission time 0,1 s (typically from 3 – 6 s today) significantly increasing number of detection possible when in range of a receiver. It was noted that acoustic tags can provide estimates of natural mortality, which are otherwise very difficult to determine. Therefore, it might be worth designing experiments specifically to get this information.

Six years of tagging giant BFT in Skagerrak – fishing and tagging practices. Gustav Hellstrom (EU-Sweden/SLU)

Abstract: Since the return of ABFT to Scandinavian waters, SLU VFM in Sweden and DTU Aqua in Denmark have been tagging these fish under the joint collaborative project Scandinavian Bluefin Marathon (SBM). In one of the largest citizen science fishing efforts in Northern Europe, up to 150 fishing teams and thousands of volunteers have been engaged every year since 2017 in helping the project tag over 600 large ABFT with electronic tags. This presentation summarizes the experience gained over the years regarding project organization and logistics, as well as the development of tagging protocol and sampling routines.

Discussion: There was some discussion about the best way to get the fish on deck, tagged and released while minimizing stress to the fish. With fight times that are too short, the fish is not tired when it is brought on deck and thus is harder to handle. The recommendation was made to release the fish belly down, although it was noted that this can be difficult if the fish is very large.

Tagging of Atlantic Bluefin Tuna off Ireland Reveals Use of Distinct Oceanographic Hotspots. Hugo Maxwell (EU-Ireland/MI) & Camille Pagniello (USA/Stanford University)

Abstract: Electronic tagging of Atlantic bluefin tuna (ABT; *Thunnus thynnus*) has provided a wealth of data that has shaped our understanding of their movements and migrations throughout the Atlantic basin. In this study, we used pop-up satellite archival tagging data to examine the movements of ABT tagged off the coast of Ireland. When combined with satellite oceanographic data, we found that ABT utilize the warm North Atlantic Current as a corridor for migration to access foraging areas in the North Atlantic Ocean. We identified four potential foraging regions: (1) off the coast of Ireland, (2) the Bay of Biscay, (3) the Newfoundland Basin, and (4) the West European Basin. In addition, many ABT migrated in mid-May to their spawning grounds in the Mediterranean Sea, where they remained until early-July. In all five regions, anticyclonic ocean features (i.e., quasi-permanent eddies or recirculation) were present. These features often co-occurred with areas where the daily maximum diving depth of tuna exceeded 400 m and/or tuna spent extended time diving to mesopelagic depths (i.e., greater than 200 m). We hypothesize that ABT exploit anticyclonic structures to forage on the abundant mesopelagic fish communities. Additionally, our results suggest that ABT are travelling across the North Atlantic Ocean in a directed migration to the Newfoundland Basin to reach what may be the best mesopelagic feeding ground in the world for large pelagic predators. Incorporating oceanographic preferences into tuna spatial distribution models can allow managers to identify areas likely to have high Atlantic bluefin tuna bycatch and potentially adjust catch predictions based on local conditions.

Discussion: There were no comments following this presentation.

Tagging and tracking of Atlantic bluefin tuna from UK waters- a summary of the Thunnus UK programme 2018-2022. David Righton (UK/ CEFAS & Exeter University)

Abstract: Sightings of and encounters with Atlantic bluefin tuna (BFT) have been increasing in UK waters since 2014. The ‘Thunnus UK’ programme began in 2017, with the aim to increase understanding of the spatial dynamics and ecology of BFT around the UK. Using established techniques, more than 80 BFT have been tagged with pop-up satellite archival tags (Wildlife Computers MiniPAT) and released in the western Channel/ Manche and in the Celtic Sea. To date, more than 60 datasets have been recovered from tags, of which 27 are full archives that have been downloaded from tags recovered at sea or after washing ashore. Mapping of migrations revealed a utilisation distribution encompassing the north-east Atlantic Ocean and the Mediterranean Sea, built up from three main phases over the course of the annual migratory cycle. Between August and November, individuals were found at centres of density in the Bay of Biscay and western Channel, before a second phase between December and April when individuals dispersed across more westerly and southerly latitudes. In May and June, individuals either moved to putative spawning sites in the Mediterranean Sea or remained in the Atlantic. As they began the

next annual cycle, individuals typically returned to the foraging areas where they were tagged the year before. We discuss the refinements to tagging and analytical methods made during the programme and discuss the findings in relation to future GBYP research priorities.

Discussion: In response to a question from the group, the author clarified that if at least 30% of the data is not transmitted (based on modeled expectations) then they drop the fish from the data set in order to ensure that they are only including robust data. With less than 30% transmission there might still be valuable information that could be looked at, but it would be important to use this data carefully. They are also happy to make recommendations to other projects about quality assurance methods.

Evidence of bluefin tuna (*Thunnus thynnus*) spawning in the Slope Sea region of the Northwest Atlantic from electronic tags. Emil Aalto (USA/Stanford University)

Abstract: Atlantic bluefin tuna (ABT) are large, wide-ranging pelagic predators which typically migrate between foraging regions in the North Atlantic and two principal spawning regions, the Gulf of Mexico and the Mediterranean Sea. A new spawning area has been described in the Slope Sea (SS) region off New England; however, the relationship between ABT that spawn in the SS and ABT using the principal spawning regions remains poorly understood. We used electronic tags to examine the location, temperature, and diving behavior of ABT in the SS, and identified 24 individuals that were present during the spawning season (June-August) with tag data showing temperatures and behavior consistent with spawning ABT. In general, the SS spawners had similar spatial ranges to Mediterranean-spawning ABT; however, some individuals displayed distinct behaviours that were identified first in Gulf of Mexico spawners. Using monthly spatial distributions, we estimated that the SS spawners have high exposure to fishing pressure relative to other ABT and may represent a disproportionate share of the West Atlantic catch. This analysis provides the first description of the behavior of ABT frequenting this spawning ground, creating a foundation for integrating this region into multi-stock management and, potentially, conserving an important source of genetic diversity.

Discussion: A question was raised regarding the number of spawning days or spawning events that have been detected in the Slope Sea. The author responded that 12 days would be typical for spawning, but this needs to be confirmed.

It was also noted that in the Slope Sea there is a shallow thermocline (similar to the situation in the Mediterranean, but different from the Gulf of Mexico), so fish do not have to dive very deep for thermal relief.

A question was raised regarding the challenges in identifying spawning from non-recovered pop-up tag data sets. The author noted that they were able to use light signals and body temperature as a proxy for spawning. Recovered data from PSAT have been shown to detect spawning behaviour. Archival tags, with body temperature data, are valuable for identifying spawning dates but use of diel behaviour is also a good proxy. It was suggested that oceanographic proxies might also be useful for detecting spawning.

Acoustic tagging of Atlantic Bluefin in the Gulf of St. Lawrence, Canada, determines their fidelity, survivorship, distribution and migration timing. Michael Stokesbury (Canada/Acadia University & DFO)

Abstract: Atlantic Bluefin Tuna, *Thunnus thynnus*, are the largest tuna of the genus *Thunnus*, and utilize a spatial range throughout the North Atlantic and adjacent seas. In the Tag-A-Giant program run by Stanford University over 2000 electronic tags have been deployed on bluefin including archival, pop-up satellite archival and acoustic tags. Acoustic tags were first deployed in 2009 and over fifteen years have logged >115,000 detections on 1500 receivers in North American and European waters. Receiver infrastructure is primarily provided by the Ocean Tracking Network, as well as independent receivers from collaborators along the North American coastline and in Europe. This research provides the highest spatial detection rates in the Canadian Maritime Provinces where large acoustic lines are present spanning the entrance to the Gulf of St. Lawrence. The spatial and arrival and departure data provides precise information on how and where bluefin enter and exit the Gulf of St. Lawrence and specific information on movements on the Scotian Shelf and the eastern seaboard of the US. Receiver arrays provide detection information from the migratory paths of the bluefin as they move between spawning and feeding grounds. Time series of detections, over multiple years, provides information on spawning and feeding site fidelity, natural survivorship, and stock structure that informs management models.

Discussion: There were no comments or questions regarding this presentation.

Why we tag tuna. Molly Lutcavage (United States/Univ. Massachusetts (Tag a Tiny program))

Abstract: Our Center's eTagging program began in 1997 with popup satellite tag deployments on "giant" Atlantic bluefin tuna (ABFT) released from the US commercial fishery. In 2006, we released smaller tags (PSATs) on juvenile bluefin from the recreational fishery. To date, we've deployed >650 PSATs and 156 archival tags in the NW Atlantic, and made tracks available to the SCRS for assessment purposes. The main objective of our bluefin research followed that of earlier researchers: to document life history and movements with field studies and best scientific tools available. These methods still include exploratory fishing, bio-sampling and conventional ID tagging, including the 2006 start of Tag a Tiny™ program.

While recognizing the incredible value of large eTag datasets, including those LPRC contributed for MSE and mixing modeling, historic studies were not data dense. Nonetheless they provided reliable, often prescient information, as illustrated in Mather et al's. comprehensive Historic Document. In 1962, Mather reported "The indications are that the bluefin spawn over wide areas and a considerable period of time in the western Atlantic. The giants evidently spawn in the southern areas in April and May, while the medium-sized ones apparently spawn north of the Gulf Stream somewhat later". P.C. Wilson, Chief Scientist for the first US exploratory longline cruises, concluded the same. Through more recent investigations, we and our collaborators elaborated upon their findings—namely, that sexual maturity is consistent across the Atlantic and that ABFT spawn along the Slope Sea. A corollary is that large, older ABFT reproducing in the Gulf of Mexico would have spawned elsewhere at smaller size and younger age. In addition, the complexity of some one-year migration records exhibited by fish present in two potential spawning areas argues for more biological studies to understand the basis of movements that will soon be subsumed in mixing models and MSE.

While eTags offer unique insights on behavior, they cannot take the place of basic biological research. For example, inferences from eTag results alone, concluding that skipped spawning has occurred, would be an extraordinary finding that contradicts reproductive traits and tuna life history. Spawning, or lack of it, requires biological evidence in time and place, necessary work that should accompany eTag programs, especially in regions where surveys are sparse or nonexistent. The potential for ABFT spawning in the East Atlantic and island arcs hypothesized by earlier researchers needs attention and resolution, and small size classes are not well represented in e-data holdings to date.

Etag programs have delivered an exceptional body of spatial and temporal information since their first applications. Assimilation into stock assessment is a major advance, and will be essential for monitoring bluefin dynamics as the Atlantic warms. ICCAT's focus on stock assessment, MSE and genomics approaches, along with eTag information, should not leave biological research behind.

Discussion: The comment was made that it continues to be important to study basic tuna biology. Reconditioning of the [stock assessment] model in 2027 will provide an opportunity to incorporate new information about biological parameters.

The use of electronic tagging data in the Atlantic bluefin tuna MSE. Matt Lauretta (USA/NOAA)

Abstract: A review of electronic tagging data availability and use in the Atlantic bluefin tuna MSE was presented. Topics to be discussed include a detailed description of the tagging data used in the current MSE operating models, the statistical methods used to summarize bluefin migration rates, and a summary of additional data that have been collected since MSE development that can be considered for inclusion during MSE reconditioning, scheduled to occur in 2027-28. Lastly, a summary of information gaps in Atlantic bluefin tuna migrations were discussed.

Discussion: It was noted that this presentation was important in terms of thinking about priorities for coming years.

It was noted that the MSE model tends to show a high biomass in the South Atlantic. This could have to do with short term transitions of fish through that area but could also occur if there isn't sufficient data for the South Atlantic because the model can assign fish to that area in a way that distorts the reality as an artifact of the modeling process. Some adjustments were made in the biological rules, such as not allowing fish to remain in certain areas past a certain data, but there are as yet no systematic fixes to this issue.

Long-term tracks in this region may improve performance. However, there is also a concern that the model is strongly influenced by the number of parameters generated by catch series and that this swamps any movement data. Just adding longer tracks might not balance out the lack of catch data. One thing to look at would be seasonality of biomass presence in case it corresponds to times of low fisheries data. Overall, it was pointed out that there is now more information coming in from all the different teams where before there was only limited data so there may be some changes in the operating model in the future.

It was also pointed out that there is a lack of focus on small fish in the North Atlantic. There is an incredible availability of small fish in Gulf of Maine and mid-Atlantic but no tagging campaigns for small fish have been carried out in these regions since the early 2000s. It would be useful to think about the different methods that can be used to assign fish to stock of origin so that it would be possible to use older tag tracks. It would also be useful to tag more juvenile fish for which stock of origin can be simultaneously assigned.

It was noted that there are 122 ICCAT datasets generated since 2018 that haven't been used in the MSE. The MSE reconditioning is scheduled for 2027, so if there is data that the group would like to see modeled that is a date to keep in mind.

From 2008 to 2023, involving recreational anglers in the conservation of an iconic species in the Western Mediterranean. Pablo Cermeño (EU-Spain/Acuarium Barcelona)

Abstract: The involvement of recreational anglers in scientific data collection has gained traction in recent years, offering a unique opportunity to tap into their local knowledge, enthusiasm, and extensive fishing experience. Through partnerships between researchers, conservation organizations, and recreational fishing associations, numerous tagging expeditions have been conducted in the Western Mediterranean, utilizing recreational anglers as citizen scientists. These initiatives have led to a healthy collaboration that goes beyond the benefits of data collections. In conclusion, the potential of recreational anglers as partners in bluefin tuna tagging expeditions in the Mediterranean has proven to be a valuable approach for data collection, conservation, and public engagement.

Discussion: A question was raised about how the electronic tags are deployed. The www.scientificangler.es platform helps coordinate research efforts by linking interested anglers with researchers. The platform provides information to anglers on where/when to fish based on the structure of the research study provided by the researchers. The research team provides tags and is responsible for obtaining all correct permits etc. (in this case from the Spanish government) needed to conduct the research. The anglers provide the boats and personnel.

The Past, Present, and Future of the Gibraltar Strait Curtain: A Turning Point in BFT Monitoring. Miguel Cabanellas-Reboredo (EU-Spain/IEO)

Abstract: More than a decade ago, a team formed by The Ocean Tracking Network, the University of Barcelona and the Spanish Institute of Oceanography (IEO) researchers demonstrated the feasibility of deploying an acoustic curtain across the Strait of Gibraltar for the monitoring of bluefin tuna and other large-migratory species. Unfortunately, due to political and economic barriers, the deployment of this key-monitoring infrastructure was ultimately abandoned. Currently, under the umbrella of the European Tracking Network, the IEO has taken up this promising challenge and has successfully demonstrated not only its feasibility but also its applicability using bluefin tuna monitoring as a case-study. Past and present efforts have culminated in the HORIZON-INFRA-EU project STRAITS, which aims to acoustically equip four of the most important corners of Europe for tracking aquatic life, with a focus on better understanding their biology and ecology. The 4-year project will provide the financial support necessary to achieve the desired deployment of the Gibraltar acoustic receivers curtain, with the final goal being to establish a useful and effective infrastructure for the long-term monitoring of large migratory species across one of the most valuable natural gateways in the world. Once implemented, this acoustic barrier holds the potential to address the key knowledge gaps in Bluefin Tuna Ecology, greatly enhancing the estimation of essential life-history parameters crucial for assessing this highly valued marine resource.

Discussion: It was noted that the European Tracking Network is not only deploying receivers in the Strait of Gibraltar but also around the European coasts.

A question was raised about the possibility of putting a second curtain in place in order to collect information on the direction of movement of the fish. The author noted that for the moment, the curtain is being placed in Spanish waters because it any political issues with countries that are not onboard the project. They would like to place a 2nd curtain, but they must deal with both the political and technological issues around placement, which should be negotiated with Moroccan authorities. For the moment, they will keep this long-term goal in mind but remain focused on deploying the first curtain.

Questions were raised about the testing done for the receivers and specifically about the cone of reception in rough waters and how to deal with detecting fish at different depths. Preliminary surveys were done with the transmitters attached to a rosetta and different profiles were tested. Trigonometry included depth and distance; concluding that with 800 m of separation between receivers the whole strait can be covered. Originally, in the deeper areas (around 900 m depth) the plan was to place receivers at 750m depth (200 m over the bottom), but range testing suggested

that such deeper receivers should be placed around 500m to better address potential surface detections. For fish moving at deeper depths, they may have to attach another receiver in the opposite direction, being one possibility that could be tested during this proof-of-concept phase.

It was noted that some receivers are deployed on tuna traps in collaboration with fishers and they will maintain these receivers as part of the coverage for the whole area.

Update on internal archival tags (IAT) for long term insights into BFT movements. Iñigo Onandia (EU-Spain/AZTI)

Abstract: Since 2005, AZTI has been tagging Bluefin tuna with conventional and electronic (both PSATs and IATs) tags in the Bay of Biscay, which is one of the main juvenile feeding grounds in the Atlantic and to which the species shows strong fidelity. The tagging effort has focused mainly on internal archival tags, with the goal of providing high resolution data on the migration patterns of these juveniles throughout their lifecycle. To date, 249 internal tags have been implanted, of which 65% were placed on age 1+ juveniles. Overall, 12 have been recovered, with times at liberty ranging between 1 to 14 years. Lately, the recovery rates are increasing thanks to ICCAT ROPs on farms. The 12 archival tags recorded 26.5 years of information out of the 90 years at liberty and showed signals of poor performance of some sensors. The results show animal residency in the Atlantic until at least age 5 and migrations into the Mediterranean between age 6 and 8-11. Recently, Rouyer et al., 2022 observed that only large fish migrate out of the Mediterranean. These observations are consistent with the hypothesis that the Mediterranean bluefin that live in the Atlantic have a delayed maturity schedule (compared to the resident ones), which would be similar to the one for the western stock. In order to validate this important hypothesis, it is necessary to deploy more tags (PSAT and IAT) in fish of age 3-6 (25-60kg), both in the Atlantic and Mediterranean, as well as to keep tagging juveniles to inform about first maturity and spawning fraction, as well as to understand resident versus migrant behaviours. Moreover, as the European Tracking Network's (ETN) STRAITS project is about to deploy an array of acoustic receivers across the Strait of Gibraltar, the team could start double tagging these fish with acoustic tags to validate entries to the Med.

Discussion: A question was raised about the effect of temperature on geolocation. The researchers were using tags from Wildlife Computers, but they are no longer producing archival tags so they will move to LOTEK instead. The archival tags record both internal and external temperature.

It was noted that LOTEK isn't currently making archival tags because of a shortage of parts. It might be helpful for ICCAT to indicate an interest in the use of archival tags and to encourage them to continue production.

A question was also raised about mortality rates. This is currently unknown since the fish are not double tagged with technology that could provide this information (e.g., with pop-up tags). Recovery rates of fish are between 10-20%, which is similar to conventional tagging. They have seen a strong tagger effect with some having 0% recovery rates and others over 20%. Big fish seem to be more easily recovered than smaller fish.

It was noted that the use of a different color of external tag to indicate the presence of an internal tag would be useful. The group from AZTI currently uses red conventional tags, instead of yellow, to indicate the presence of the internal tag. They make posters and send information to the different fleets informing them what to look for. It was further noted that ICCAT and other collaborators should work together to educate farms and processors about the different types of tags and the best strategies to recover information, particularly from internal/archival tags.

The size of tagged fish was discussed. LOTEK 28-10 tags can be deployed on 3-4kg fish. There may be smaller tags that could be used for smaller fish but data recovery might be difficult. It was noted that it would be nice to use this technology to examine the connection between the Bay of Biscay and Balearic Islands, among other questions.

Bluefin Tuna Migration and Residency Behavior in the Eastern Mediterranean: Preliminary Results and Future Plans. Sinan Mavruk (Türkiye/Univ. Cukurova)

Abstract: The Northern Levant Sea serves as a significant spawning ground for Atlantic Bluefin Tuna (ABT), emphasizing the importance of understanding the species' population structure and migration patterns in this region. Despite previous efforts aimed at investigating these aspects, a considerable knowledge gap remains, highlighting the urgent need to gain insight into the migration-residence behavior of ABT for the development of more effective management strategies. This study presents preliminary results from ongoing research efforts that

aim to understand the migratory-residency behaviors of ABT in the northeastern Mediterranean. Additionally, it provides information about future plans. In June 2022, as part of the ICCAT Grand Bluefin Tuna Year Program (GBYP) research activities, conventional and satellite pop-up tags were deployed on ABT individuals in Türkiye waters. In collaboration with the Republic of Türkiye, Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policy, General Directorate of Fisheries and Aquaculture, and General Directorate of Agricultural Research and Policy, the ABT specimens were donated by Akua group Group Fishing Company. These specimens were captured using a commercial purse seine vessel and caged in the Antalya-Kemer region situated on the northern coast of the Levantine Sea. The tagging operation adhered to ICCAT protocols and took place on June 7, 2022. ICCAT GBYP provided 20 satellite pop-up tags, of which 13 were successfully deployed on ABT individuals ranging in size from 120 to 149 cm in curved fork length. Following the tagging operations, one tag prematurely detached within Antalya Bay, the location where the tagging took place. After 140 days, another tag resurfaced off the southern coasts of Cyprus. Unfortunately, technical issues prevented the acquisition of data from the remaining tags deployed during this campaign. All stakeholders involved in ABT fisheries demonstrate a strong commitment to continuing research on the migratory behavior of tunas in the Eastern Mediterranean. There is a collective motivation to further expand studies in this field, and endeavors in this regard are anticipated to persist in the upcoming years.

Discussion: A question was raised about the size structure of the catch as it was noted that tagged fish tended to be small. The presenter responded that although tagged fish are caught in a purse seiner, which is not selective gear, it is hard to tag larger fish. Once the fish are in the purse seine some are placed in a smaller area of the net and then caught by hand by divers. It is very difficult for the divers to handle the larger fish and it was determined that excessive handling necessary for larger fish was too stressful for the animals. In the future they would like to tag larger fish as they continue to develop their methodology.

It was noted that in other tagging campaigns, specifically an example from Portugal, increased mortality was observed up to one month after tagging so that condition following release is not necessarily a good indicator of expected outcomes for the fish.

It was noted that tuna are sighted in the Black Sea (a handful per year) and some may be very large.

They currently only tag fish during the spawning period but it might be possible to tag outside the spawning period in the future.

5. ICCAT Etags Database: presentation, demonstration and discussion

5.1 Etags Presentation

This section began with a presentation on the newly developed ICCAT Etags Database.

Adopting a “life cycle” approach to electronic tagging data management: ICCAT Etags DB. Tim Lam (USA/ Big Fish Intelligence) & Jesus Garcia (ICCAT)

This presentation showcased an end-to-end approach to electronic tag management, which covers the full life cycle of electronic tags from programming, field deployment, data recovery and analysis to potential physical tag recovery. Multiple, persistent challenges faced by the tagging community over the past twenty years were identified, including non-standardized output formats, inconsistent, poorly defined file headers and an evolving geolocation analysis that further complicate management and usage of these data. As a possible solution, the team demonstrated “eTUFF” as a universal, simple, self-described file format with detailed metadata that can harmonize outputs from various manufacturers. The team also presented on a comprehensive relational data model and associated open-source data management system (Tagbase-server) being implemented at ICCAT as their Etags database. Consistent with ICCAT electronic tagging program data management needs, the database system is capable of supporting popup and archival tag data across the range of electronic tag manufacturers and is also designed to be both flexible and scalable to account also for future technological advancements in tagging hardware.

5.2 Database demonstration

The presentation described in section 5.1 was followed by a practical demonstration of how data is imported in the database using representative examples of Wildlife Computer satellite data returns, Lotek and Microwave telemetry data. The live demo run by ICCAT staff (Garcia) successfully illustrated multi-manufacturer support via the eTUFF format, automated bulk ingestion, support for multiple tracks, and downstream integration of the database with ICCAT reporting dashboards.

5.3 Discussion of Etags Database implementation

By way of background, it was noted that this database project was requested by the SCRS and the Commission. The intention was to create a flexible platform that could be used to store and manage tagging data collections from across ICCAT projects in a standard format and to facilitate data requests from different users. One goal is to provide the tools and ability to disseminate information in a format that can then be taken into different platforms such as R or web-based tools for further analysis. To this end, the database is fully open source, and available freely on Github.

Several questions were raised regarding the type of data and metadata being stored. ICCAT receives the raw data from the tag companies; this data can then be used to generate geolocations and tag tracks using the model of choice (or multiple models). Tag manufacturers have a default geolocation model that can be applied, or a different method can be used. The availability of raw data is important for future use of that tag data in case the tag manufacturer may no longer be in business. Detailed metadata on all aspects of tagging and data returned are stored together with the measurement data within the same database. This allows for the provenance and the evolution of data and metadata over the tagging dataset lifecycle to be fully captured. For example, if a tag uploads from the satellite but is later recovered so data can be downloaded directly, the database will store both iterations of the data and associated metadata, including identification of the data source and other descriptive information critical for correct querying, interpretation and usage of the data. The database also facilitates interfacing of tagging data other relevant data (i.e., oceanographic data) and tools. Only datasets generated by ICCAT's initiatives are currently considered for inclusion in the newly developed ICCAT Etags database.

Overall support was expressed for ICCAT's efforts to implement the Etags database to better manage their electronic tagging data holdings consistent with their institutional mandates and policies. There was, however, considerable discussion about how the ICCAT Etags database would be used by other institutions and what data could be made available (for further discussion about the data policy see section 5.4). It was noted that other institutions already maintain their own databases and that data processing happens at different points and different locations. Some groups may have more customized data collection, holding and analysis methods which could make it easier for them to integrate ICCAT data into their systems rather than ICCAT trying to assimilate their data. It was suggested that ICCAT focus only on having a robust database and not worry about modelling the data for generating tracks. ICCAT personnel made it clear that the database is an open-source tool that could be used by other groups if helpful and they choose to do so, but that there is no requirement for other groups to adopt it. In the future, ICCAT would like to think about ways to better facilitate data sharing with other groups, but for now the focus is to provide a database to store and manage ICCAT electronic tagging data exclusively. The group suggested that it would be helpful to see a roadmap from ICCAT regarding database development, data handling and data dissemination so that they have a clearer picture of ICCAT's plans regarding data management and data sharing.

It was mentioned that a future workshop to discuss some of the technological issues around data handling and storage would be helpful. Examples of relevant topics include: manufacturers could provide data outputs in a specific format; tag sensor outputs often need to be corrected if calibration has drifted, data is sometimes altered before being entered in the database.

It was also noted that ICCAT will need additional funds to support the cost of additional cloud computing resources. The current Rackspace server is quite small and more processing power (estimated at an extra 200 euros per month) will be required to store more data and to support access by multiple users concurrently. Some concern was expressed about funds being allocated to database development vs. other projects.

The session concluded with a brief presentation showing how the data within the database, once it is organized in a standardized way, can easily be interfaced with external visualization tools, enabling for example tag tracks and measurements to be overlaid with ecological, satellite oceanographic or other habitat data and interactively explored.

5.4 Use of ICCAT database in light of the new ICCAT data policy

The new ICCAT data policy was made available to the group. Entities requesting access to information must submit a request to the secretariat explaining what they want and for what purpose. Data is sent only for those specific proposals, which are reviewed and approved by the Secretariat; data is not available for free use. ICCAT is the owner of the information from the tags purchased by the ICCAT but if the tags have been deployed by a research team, that team has priority for the scientific use of the data. If that data is provided to 3rd parties, that entity must get permission for use from the group that deployed the tags. It is not currently clear how long this embargo on 3rd party use should be imposed. Questions, concerns and recommendations were solicited from the group albeit with the reminder that this is a workshop not an official proceeding so recommendations may be brought forward to the species group meetings but would not necessarily be adopted. It was further noted that the data policy applies to ICCAT in general, and there cannot be a different policy for individual groups (i.e., GBYP). All contracts that are now in place must adhere to the new data policy.

The question was raised as to the amount of time before making the data available (1) to ICCAT and (2) to 3rd parties. It was noted that for ICCAT, it is helpful to have the data sooner to facilitate better management of the stock. In this case it would be species groups not individual researchers that are requesting use of the data. However, researchers need time to download and process data and make sure that quality tracks are being submitted to ICCAT. In addition, a concern was raised about how data would be tracked through the database to ensure that the embargo would remain in place on use of those data for peer reviewed publications. A further point was raised that since ICCAT uses movement data for reconditioning operating models and other management procedures, and that reconditioning of the BFT model is not scheduled until 2027, there doesn't seem to be a rush to provide data immediately at this date. In regard to providing data to 3rd parties, it was noted that researchers need the opportunity to use data for peer reviewed publications before making it widely available. It was noted that as per the ICCAT data policy, confidential data is available only for SCRS use and ICCAT will provide that data to the species groups only at the level of detail necessary for their work. CPCs can also specify the level of confidentiality that they want for the data. Once ICCAT has the data, the teams who provided it have first priority for publication. ICCAT should be informed at once of any violations of this policy so they can take appropriate action.

It was noted that the Ocean Tracking Network has a complete data policy, which includes a 2-year embargo on publication of work generated by 3rd parties, which could be looked to for some guidance.

There was some discussion about the funding structure for tagging research. Many of the research groups that interact with ICCAT do so through an MOU and bear most of the cost of the research. For these groups in particular, the ability to publish that data first is crucial. Several participants expressed their desire to provide ICCAT with tagging data from all tags, not just those provided to the teams by ICCAT, as long as they had first priority for publishing.

There was some discussion about funding for tagging research and a desire for more investment by the fishery in science. The point was made that it is important to demonstrate to the Commission that more investment in science is required to answer the management questions they are concerned with. ICCAT is increasing the science budget but it will take time to grow, and in the future funds may be allocated differently between the species groups depending on management priorities. Researchers were encouraged to participate in the SCRS species group meetings. Some participants suggested that participation in the process is limited depending on how much your country is involved in the BFT fishery.

6. Knowledge gaps for MSE and stock assessments

The lack of tagging in general in the Mediterranean Sea was commented on, being these waters where most of the catches of this species come from. Several regions were identified as places of particular interest:

- Marmaris Sea/Levantine basin/Dardanelles/Bosporus: Some projects have been started in this area by researchers from Türkiye. Tagging has also been undertaken in the eastern Mediterranean by Barbara Block's group and researchers from Israel.
- Slope Sea: Some multiyear archival tags have proven to be very informative, but more work is needed to understand the dynamics in this region.
- Canary Island/South Atlantic: Observations of BFT migrations to this area have been increasing in recent years.

- UK/Ireland/Northern Europe: BFT seem to be re-emerging in places where they existed historically but have not been observed from some time. Is this a shift in range or a re-expansion into the historical range? Drivers of this change are currently not well understood.
- Gulf of Mexico: Recent tagging here has been limited yet there appears to be a reduction in fish from this region observed in sampling surveys. Climate change could be driving changing dynamics in this region.

Another gap that was identified was the connections between regions. For example, it would be useful to tag juveniles with archival tags in the Bay of Biscay and the central Mediterranean (some tagging is already occurring in fish farms in Croatia) to better understand the linkages between these sites. Tagging juveniles in northern European waters could also help inform researchers about the connections between these sites and the Mediterranean or other parts of the Atlantic.

Questions still remain about BFT population structure, including whether the Slope Sea represents a unique population and whether there is a resident population that does not leave the Mediterranean.

A question was raised about fish that seem to mature late and that enter the Mediterranean to spawn at age 6 when BFT are generally thought to be mature at age 4. However, mentioned that just because fish don't enter the MED by age 6 or 7 doesn't mean they don't reach maturity. It was further pointed out that there may be spawning in the Bay of Biscay since some larvae have been found in that region and gonads have been recovered from smaller fish that look like they are post spawning. It was cautioned that BFT reproduction has been extensively studied and is extremely well understood. Evidence from tagging data that suggests late spawning or skip spawning needs to be corroborated by biological evidence.

Some data issues related directly to the MSE procedure were discussed. Emil Aalto presentation on this topic was used as a reference to identify some problems and gaps, as:

- Complications in the use of movement data – catch trends between east and west are really important for outcomes of model. Catch series will swamp subtleties of movement.
- Composition and proportions of stocks in east and west. Otolith and genetic proportions show more western stock in the east than is suggested by tags leading tagging data to be underutilized.
- Assignment to stock of origin. All tracks that do not have assigned stocks are removed from the model so genetic stock ID is very important.
- Regional and quarterly gaps in data. If there is a lot of data within one time period then getting more tagging data for those time periods is not that helpful in comparison to having data from underrepresented quarters. The movement transition matrix drives the model.
- Bias in west to east movement because there is more tagging in the west.
- The model doesn't have enough data to look at shifts in movements across years.

The impact of the installation of windfarms in the north Atlantic is unknown. Many of these farms are being placed in areas that are likely part of the BFT migration route and in Skagerrak even in a main feeding area.

The repeatability of fish movement patterns is largely unknown. Use of acoustic tags would be helpful as these can be deployed for up to 10 years. There should be more investment in acoustic receiver arrays. Archival tags can provide long term data but are only retrieved when fish are caught so they do not provide data about fish that don't enter the fishery. Individual variation in movement patterns is expected.

7. Methodological issues

7.1 *Pop-up tagging and impact of national animal welfare rules*

Most groups are using similar protocols for deploying pop-up tags. Deep insertion of the tags is important to avoid early detachments. It was noted that for some experienced teams a single insertion point might be OK.

For publications, any impact on the welfare of the fish must be justified. It was suggested that ICCAT provide some rules or guidelines to ensure animal welfare. For example, in the UK protocols include an assessment of the physical appearance of the fish both before and after tagging. David Righton can share this protocol with the group. If others have protocols to share, the group could work towards a common set of best-practices guidelines.

It was noted that some fish appear fine upon release but die within a month of tagging. Use of ICG monitors can be used to measure heart activity to make sure fish don't die while under anesthesia. Accelerometers could be used to get some idea of the impact of tagging and capture on individuals. It was suggested that for tags that only need a single point of attachment, the procedure could be done in the water; however, this would probably only be possible for very experienced crews and also make some sampling difficult (e.g. blood, feces). For less experienced taggers or for more complicated procedures, it is better to bring the fish on board to reduce errors.

There was some discussion about the optimal time to fight the fish or handle it in the water to ensure it is tired enough when brought on board so that it doesn't struggle but that it will still be able to swim upon release. If the fish is brought on board too soon then cortisol levels are very high, while if fish are fought for a longer time there is less cortisol but higher lactic acid. Examples were given of fighting times that ranged from 1.5 hours to 6 hours, but still with successful tagging. It was noted that there will be variation in how individual fish respond so that teams should be flexible with how much time they take recovering a fish prior to release, for example, gills can ventilate for longer, fish can be towed near the boat etc.

7.2 Hardware problems

Wildlife Computers has acknowledged that they have a problem with battery passivation. They have switched to a new battery and nose cone this year, but it has not been tested in the field. Passivation arises when a tag is kept unused prior to deployment, and this results in problems with battery life in the field; this problem is exacerbated in warm water. ICCAT realized there was a systemic problem after a year in which there were no transmissions. Other groups had the same issue. Thus far, there have not been problems with passivation in the new tags for those groups who are using them. It was suggested that groups all share data on failed tags to give a more complete picture of tag failures and to facilitate negotiations on tag replacements with Wildlife Computers. There was a lengthy discussion about how best to interact with the tag company on this issue. ICCAT, together with the CPCs, should have enough bargaining power to pressure Wildlife Computers to offer 100% replacement for failed tags that are the fault of the company. A replacement/compensation clause should be added to the contract when purchasing tags. It was suggested that ICCAT reach out to other RFMOs involved in tagging efforts to find out if/when they also have problems with tag failures; this should include groups that are tagging other ICCAT species, not just BFT. Currently, individual research groups negotiate for tag replacements on a tag-by-tag basis. If there is a batch issue, it would be more efficient to approach the company for compensation/replacements as a group.

There was also some discussion about the best storage conditions for tags. There was no consensus, and it was further noted that Wildlife Computers gives conflicting information about storage. Some groups test the voltage weekly. Some keep tags in the refrigerator (5deg) while others store them in the freezer (-20deg). It was generally agreed that voltage and transmission need to be checked prior to deployment. Tags purchased in bulk may be kept in storage for up to a year, so it is very important to test before using.

Previous discussion focused on issues with Wildlife Computers tags. However, there are 3 tag companies (Microwave, Wildlife Computers and Lotek). It was noted that it might be helpful for ICCAT to get some tags from other companies to test. ICCAT should also think about diversifying in the future and working with other companies to facilitate development of the types of tags they would like to use. Other teams have been testing Lotek tags with varied success. These tags are still in development and the company is working closely with researchers to address problems. They have offered a 100% replacement guarantee for any failed tags. It was noted that in general Wildlife Computers does have a good product but that the best way to have even better products is to work with the companies on tag development.

It was suggested that ICCAT could keep track of information regarding tag failures as well as recommendations as to which tags to use for different goals. In general, users would like to be more informed about tagging issues, solutions and best practices. It was suggested that ICCAT put together a report on different tags. This type of information could be placed on the ICCAT webpage for ease of access.

It was also noted that researchers from other countries not currently engaged in tagging efforts would like to contribute, but they do not have access to the same prices that this group does. The question also arose as to whether ICCAT would be able to supply other types of tags (i.e., acoustic tags) in addition to pop-up satellite tags.

7.3 Multiple tagging

Different tags are used to address different questions; however, combinations of tags could also be put to good use to address various questions. It was noted that resources are being underutilized by not placing multiple tags on a fish. It was suggested that for large fish there is not really a limit on how many tags could be used but for smaller fish it will be important to think about which tags are most complementary. For example, use of pop-up satellite and acoustic tags together could improve geolocation estimates.

It was suggested that asking companies to develop tags with multiple capabilities would also be very helpful. In the meantime, archival and acoustic tags could be inserted together into the ventral cavity.

It was noted that some research suggests that predators can detect acoustic tags, thus facilitating predation, particularly on smaller tuna. Another study did not find much effect of acoustic tags on predation depending on the number of fish in the area and the size of the fish. More tests on this issue might be warranted before deciding to deploy acoustic tags on all tagged fish.

A question was raised as to the best placement of external, double insertion, acoustic tags on small fish, given the assumption that these tags might last up to 10 years and that the fish will grow considerably during this time. Possible ways to alleviate the problem could be placement of the tag be in areas that are less affected by growth or that implantation.

7.4. Multiannual tags

Multiannual tags are the only way to address some questions about BFT life history and movement. Pop-up tags may have a 2-year life, but comes with the loss of resolution of transmitted data, while acoustic and archival tags are multiyear tags.

It was noted that Wildlife Computers is no longer building archival tags and Lotek is not currently making one but could in the future if the community was asking for it. Internal archival tags do have some issues with failing sensors and with the percentage of tags recovered so it is important to consider the probability of recovery when deciding to deploy them. Recovery will depend on the population size of the year class. It was suggested that recovery seems to be better for slightly larger fish. It is also important to make sure fish are clearly marked with an external tag to indicate the presence of an internal tag in case that fish enters the fishery. Most archival tagging in the past has come from the USA so future experiments in the Mediterranean or other temperate areas would be very informative. ICCAT doesn't currently have the funds to provide archival tags but could look into it for the future.

7.5 Relationships with manufactures: adapting products to user's needs

The following suggestions were made of things the group would like to see from the manufacturers:

- Tags with multiple capability's (i.e., acoustic/pop-up satellite; archival/acoustic; acoustic tags with more sensors). Several sensors are already available for acoustic tags and more is in development.
- Solve the battery passivation problem
- Improve battery life for satellite tags (2 years or more)
- Prolong battery life for archival tags (6 years or more)
- Reduce drift/calibration and failure problems for sensors. (It was noted that it is possible to correct for any drift in the sensors)
- Implement an open protocol
- Compatibility between platforms

It was noted that tag models will need to continually adapt over time to meet user needs.

7.6 Accuracy of tracking models

There are 6 working track models that are regularly used. They tend to agree with each other, but sometimes they return very different results. Where they differ tends to be where there are peninsulas of land or small straits. Bathymetric data can be used to resolve these differences. It was further noted that how tags are programmed influences the data you get back and problems with tag transmission can also affect both quality and quantity of data. While multiple models could be run, ultimately it is necessary to delineate only one track.

There is a tagging group within ICCAT, which is not currently very active. It was recommended that the Secretariat reactivate this group; this can be discussed at the species group meetings and with the SCRS. This group would address tagging issues for all species not just BFT.

It was suggested that this working group could develop a protocol to determine consensus tracks to be used for management decision making. It would be helpful to have a suite of tools to determine the most accurate tracks.

It was noted that there will always be newer models and people will always have to determine whether to move to a new method or not. As more groups use the different methods and contribute more data, the methods will improve. Newer models are very transparent about how they work, which is important for determining some sort of confidence level in the estimates. GBYP currently uses GP3 tracks. However, it is a good idea to optimize other programs as well.

It was suggested that validation of the models could be done as part of a study. Experimental deployments using a glider could be used for a geolocation validation study, for example, to differentiate between the Bay of Biscay/Gulf of Cadiz/Strait of Gibraltar. AZTI is currently planning to deploy a glider with a Lotek tag in the near future within the Bay of Biscay, but it is possible that the study area could be expanded.

7.7 Genetic analyses for stock of origin determination

As noted above, many tag tracks are not currently used in the MSE process because stock origin is unknown. All groups currently take genetic samples when tagging but more funding needs to be made available for genetic analysis. The funding question is something that should be put before the species groups. It was suggested that salmon be used as a model in how researchers arrived at a standardized methodology for stock identification. To this end, a technical workshop of relevant genetics groups could be organized to compare techniques and come to some consensus on methodology (i.e., use of microsatellites vs SNPs vs genomic data)

7.8 Tag programming

It was discussed that tag programming depends on the study and that there aren't really any general recommendations for programming. It was suggested that the ICCAT tagging working group could develop some longer-term plans and identify what information they need to best manage the resource. This information would then be used to determine what tags are needed and what protocol should be used. The group noted the importance of distinguishing between research objectives targeting biological questions and those targeting management priorities when identifying the type of tags needed and the study design. It was also pointed out that tag recovery of some tags is dependent on the fishery, with some exceptions when tags have washed up on the coast, which is also important to consider in study design.

It was noted that careful programming of the tags can help conserve power and battery life. For example, not all the sensors on the tag need to be activated if a research objective only requires track data.

7.9 Impact of anthropogenic structures in tuna spatial patterns-migrations

7.9.1 Tuna cages

Aggregations of wild tuna around farms has increased over last few years in the south of Spain near aquaculture facilities so that now they have wild tuna around pens throughout the year. Other aquaculture groups have raised concerns with the Spanish government regarding these aggregations. There was a question as to whether these aggregating fish are those that would normally stay in the Mediterranean or if this is a disruption in the migration patterns. Typically, wild tuna aggregate around tuna farms in autumn but leave in January; but normally these fish would be expected to leave the Mediterranean in June/July. The Mediterranean Institute of Advanced Studies (with Pablo Arechavala) currently has a research project underway to tag tuna with acoustic tags to examine movement into and out of the area. The group raised the question of whether the fish aggregating around the farms originated from within the Mediterranean or entered the area from the Atlantic. There was a further question as to whether the effect of larvae that are produced during spawning in the net pens could contribute to the fish that prefer to remain close to shore.

7.9.2 Wind farms

Norway, Sweden and Denmark is planning the development of several large offshore windfarms in the North Sea and Skagerrak Sea, which will lie in the migration route of BFT. While no official experiments are underway, it was noted that current tagging efforts will result in an ad hoc before/after study, with current tagging constituting the before sample, so impacts can be assessed in the future. It was suggested that ICCAT make a formal request for an environmental impact study to consider migratory tuna prior to windfarm construction. The acoustic tagging in Skagerrak may offer a potential to gather data before any infrastructure is put in place, but study has to be set up quickly.

Smaller windfarms are under development along the west coast of Portugal. The developers inquired about the impact on tuna but there was no literature that could be used to provide information. However, given the size and placement of the farms they are not expected to have an impact on migration.

One of the concerns about windfarms is that vibrations from the cables which support the windmill column produce acoustic deterrents to fish from entering the area.

It was noted that ICES has a working group on offshore wind development.

It was suggested that this issue should be raised with the SCRS, who could then bring it to the Commission. There will be conflicts and opportunities around this development which the SCRS should be made aware of. It was suggested that a short paper be written to inform the SCRS about this topic, which should include any available information about where offshore wind development is currently being installed or is planned to it is possible to assess the extent of possible impacts.

8. Draft design of strategic plan for further tagging to fill in identified gaps and improving stock assessment

The group generated a list of questions and suggestions that could be used to drive future strategic planning for tagging studies. These questions were then grouped into short-term and long-term goals. It was noted that these suggestions are not intended to be a detailed research plan nor an exhaustive list, but rather a list of ideas to guide future planning based around key research questions for BFT as identified by the current group. Note that some research priorities fell into both short-term and long-term goals.

8.1 Short-term

- *Determine number of populations*
 - Can the potential Slope Sea and Eastern Mediterranean populations be described sufficiently to include in future management models (i.e., genetics stockidentification, stock-specific movement, abundance indices, residency, etc.)?
- Describe the ontogenetic shift of each stock (how much they move across ICCAT boxes/management units in a lifetime)
 - In particular, what proportion of the Eastern stock crosses the Atlantic for each age group?
 - Recent influx of long Eastern Atlantic tracks may alter current mixing assumptions, lessening the driving force of the high Eastern stock biomass in model outputs
 - Ontogeny of maturation size: when do tuna enter known spawning grounds?
- Issues specific to the Mediterranean
 - Test if there is a residential Mediterranean population, e.g. one could tag 1000 fish with acoustic/archival tags at 2-5 years of age
 - Determine what proportion of tagged fish (as suggested above) by age leave the Mediterranean?
 - Nb: Gibraltar is a feeding area so it is more relevant to look at if fish move from the Atlantic to spawning areas
 - Analyze movement of fish tagged in the Mediterranean outside of the fishing season vs those tagged during the spawning season.
 - Does every tagged fish that enters the Mediterranean also leave the Mediterranean?
 - What is the mixing of different stocks in the Mediterranean?
- Issues specific to the Gulf of Mexico
 - Where are the adults?
 - What does the relative decline in GOM tracks in the Gulf of Saint Lawrence represent?
 - Did they shift with climate? Are they swamped by Eastern fish? Are they just less abundant?
 - Is it possible to develop a fishery-independent GOM stock abundance index?
 - What are the stock specific mortality rates.
 - Where are the young GOM Fish?
 - Where can we tag them?
- Issues specific to the Slope Sea
 - Assess spawning activity. Do smaller fish spawn in the Slope Sea and then spawn in the Gulf of Mexico or the Mediterranean in subsequent years? Is there long-term site fidelity?
 - Tag young Slope Sea fish
 - Use pop-up satellite tags for ages 4+ or acoustic/archival tags for age 3-4.
- Mortality
 - Do the data support the presence of stock-specific natural mortality?

- Can acoustic tags be used to address this question?
 - Can Eastern stock fish be tagged in the Gulf of Saint Lawrence to look at trans-Atlantic mortality?
- Look at trends over time. Is climate change affecting ABFT mortality?
- Impact of anthropogenic structures
 - What is the impact of cages on migratory behavior of tunas? Experiment: set acoustic receivers around traps and cages; 100 fish tagged could test the residency over 10 years.
 - What is the impact of Windmill placement in BFT migration routes. It may be possible to use acoustically tagged BFT in a before and after study.
- Northward expansion and/or reappearance
 - BFT are returning to Northern areas (UK, Norway, Denmark, etc.) where they once existed but have not been observed for some time.
 - “Atlantification” of the Arctic is occurring and there is evidence of BFT movement to the north
 - Use and maintain long term data sets to track this movement
- Model validation for determining tag tracks
 - Buoyancy Glider experiments to recover experimental tag tracks to validate model tracks; north/south delineation, around peninsulas and through straits
 - New models are in development that will incorporate all data sources
 - Validate models with double tagged animals
- Area specific local aggregations
 - Can presence of local aggregations be tested acoustically? Use 1-2 receivers or local curtain and 100 archival/acoustic tag experiments
 - Use combined archival tags and acoustic tags for some fish
 - Note the opportunity to target juveniles at fish farms in Croatia
- Genetic/Genomic studies
 - Genetic/genomic studies go hand-in-hand with tagging studies. Tagging gives an idea of the mechanism behind genetic patterns.
 - Genetic teams should come up with advice/agreement on techniques
 - Teams continue to collect genetic samples
 - Archiving tissue is also important for future analysis as technologies continue to improve, be aware that changing ethanol over time might be necessary to maintain sample quality

8.2 Long-term

- Determine number of populations
 - Can the potential Slope Sea and Eastern Mediterranean populations be described sufficiently to include in future management models (i.e., Genetic identification, stock-specific movement, abundance indices, residency, etc.)?
- Describe the ontogenetic shift of each stock (how much they move across ICCAT boxes/management units in a lifetime)
 - In particular, what proportion of the Eastern stock crosses the Atlantic for each age group?
 - Recent influx of long Eastern Atlantic tracks may alter current mixing assumptions, lessening the driving force of the high Eastern stock biomass in model outputs
 - Ontogeny of maturation size: when do tuna enter known spawning grounds?
- Issues specific to the Gulf of Mexico
 - Where are the adults?
 - What does the relative decline in GOM tracks in the Gulf of Saint Lawrence represent?
 - Did they shift with climate? Are they swamped by Eastern fish? Are they just less abundant?
 - Is it possible to develop a fishery-independent GOM stock abundance index?
 - What are the stock specific mortality rates.
 - Where are the young GOM Fish?
 - Consider tagging with acoustic tags (make sure they are an open code set, so they will be detected in Europe as well)
- Regional/Seasonal transitions
 - Are certain regional/seasonal transitions under-represented in the dataset?
 - Data exists but needs to be conditioned to go into the model, then it can be determined if more tagging is needed to fill gaps
 - Could possibly use summaries/aggregated data rather than detailed data that is needed for peer-reviewed papers

- Long-term trends
 - o Have migration patterns changed over the decades? Is there a component driven by climate change? Use long data sets to examine migration patterns between the Gulf of Saint Lawrence and the Gulf of Mexico, the Carolinas to the Mediterranean, and the North Sea to the Mediterranean.
 - o Do the data support fitting 2 or more different movement matrices? For all age groups and stocks, or only a subset?
- Mortality
 - o Do the data support the presence of stock-specific natural mortality?
 - Can acoustic tags be used to address this question?
 - Can Eastern stock fish be tagged in the Gulf of Saint Lawrence to look at trans-Atlantic mortality?
 - o Look at trends over time. Is climate change affecting ABFT mortality?
- Use of anthropogenic structures
 - o Examine impacts of windfarm lease/platforms and other physical structures
 - Opportunity for research because there will be monitoring required of these facilities. Tagging can be a key component.
 - o Consider placing acoustic receivers on offshore platforms or on cages
 - Consider who would manage data from acoustic tags deployed on farms/structures (The obvious choice would be ETN and OTN)
 - Consider who would maintain receivers (i.e., downloading/uploading data, replacing batteries etc.). This is typically done by an institutional level.
- Northward expansion and/or reappearance
 - o BFT are returning to Northern areas (UK, Norway, Denmark, etc.) where they once existed but have not been observed for some time.
 - o “Atlantification” of the Arctic is occurring and there is evidence of BFT movement to the north
 - o Use and maintain long term data sets to track this movement
- Fidelity experiments to examine ontogenetic changes
 - o How repeatable are the behaviors/migrations that we observe?
 - o Will patterns change in the face of climate change?
 - o Can new spawning or rearing areas be identified?
- Genetic/Genomic studies
 - o Genetic/genomic studies go hand-in-hand with tagging studies. Tagging gives an idea of the mechanism behind genetic patterns.
 - o Genetic teams should come up with advice/agreement on techniques
 - o Archiving tissue is important for future analysis as technologies continue to improve.

9. Planning for joint analyses

Ways to facilitate future collaboration were discussed. The suggestion was made to create a list of what people are currently working on and of the papers generated by each lab (students, postdocs etc.) that are currently in press or in revision. This will facilitate identification of points of collaboration for future work. A further suggestion was made to summarize the work that has already been done and to identify national data sets, ICCAT data sets and university data sets.

There was also some discussion about standardizing techniques and in particular how to standardize external tags (e.g., to indicate presence of internal tags). It was further mentioned that the tag reward system and ICCAT informational posters regarding tag recovery could be updated. It was noted that more pressure could be put on farm owners to ensure that observers and farm workers have time to correctly collect tags. Observers are there primarily for compliance and not so much for science. However, researchers are losing opportunities to recover data. Scientists can work through their delegation to change the recommendations for observer activities. If the SCRS thinks this is an issue that is hampering research, they can make that clear to the Commission and they can be asked to improve data collection through additional requirements or incentives.

Further validation of models was also identified as an important point for collaboration.

10. Proposals for consolidating a SCRS BFT species group tagging subgroup

This agenda point was addressed in point 7.6.

GBYP E-tagging workshop
(Madrid, Spain, hybrid, 4-6 July 2023)

Agenda

Day 1:

08:30/09:00- Registering (ICCAT headquarters, 6th floor)

09:00/09:10- Welcome of participants by ICCAT Executive Secretary

09:10/09:30- Meeting arrangements: Nomination of rapporteurs, adoption of Agenda

09:30/10:00- Introductory talk: “Overview of ICCAT e-tagging programs and information systems”. GBYP Coordinator.

10:00/10:30- Keynote talk: “Electronic Tagging Informs the Spatial Distributions of Atlantic Bluefin Tuna Stocks” Barbara Block

10:30/10:45- Coffee break

10:45/11:15- Keynote talk: “Tagging Bluefin Tuna from the French fisheries” Tristan Rouyer

11:15/11:45- Keynote talk: “Tagging of Atlantic bluefin tuna (*Thunnus thynnus*) with pop-up satellite archival tags (PSAT) in Norway” Keno Ferter

11:45/12:15- Keynote talk: “Scandinavian Bluefin Marathon – several hundred fish later” Kim Aarestrup

12:15/12:45- Keynote talk: “Six years of tagging giant BFT in Skagerrak – fishing and tagging practices” Gustav Hellstrom

12:45/13:15- Keynote talk: “Tagging of Atlantic Bluefin Tuna off Ireland Reveals Use of Distinct Oceanographic Hotspots” Hugo Maxwell & Camille Pagniello

13:15/14:45- Lunch

14:45/15:15- Keynote talk: "Tagging and tracking of Atlantic bluefin tuna from UK waters- a summary of the Thunnus UK programme 2018-2022" David Righton

15:15/15:45- Keynote talk: "Evidence of bluefin tuna (*Thunnus thynnus*) spawning in the Slope Sea region of the Northwest Atlantic from electronic tags" Emil Aalto

15:45/16:15- Keynote talk: Acoustic tagging of Atlantic Bluefin in the Gulf of St. Lawrence, Canada, determines their fidelity, survivorship, distribution and migration timing” Michael Stokesbury

16:15/16:30- Coffee break”

16:30/17:00- Keynote talk: “Summary of Tag a Tiny program” (temptative title) Molly Lutcavage

17:00/17:30- Keynote talk: "The use of electronic tagging data in the Atlantic bluefin tuna MSE” Matt Lauretta

17:30/18:00- Keynote talk: “From 2008 to 2023, involving recreational anglers in the conservation of an iconic species in the Western Mediterranean.” Pablo Cermeño

Day 2:

09:00/09:30- Keynote talk: “The Past, Present, and Future of the Gibraltar Strait Curtain: A Turning Point in BFT Monitoring” Miguel Cabanellas-Reboredo

09:30/10:00- Keynote talk: “Update on internal archival tags (IAT) for long term insights into BFT movements” Iñigo Onaandia

10:00/10:15- Short talk: “Bluefin Tuna Migration and Residency Behavior in the Eastern Mediterranean: Preliminary Results and Future Plans” Sinan Mavruk

10:15/10:30- Coffee break

10:30/11:00- “Adopting a “life cycle” approach to electronic tagging data management: ICCAT Etags DB” – Tim Lam & Jesus Garcia

11:00/12:00- Practical demo sessions Etags DB

12:00/13:00- Discussion on ICCAT e-tags DB implementation:
– Suggestions for DB design improvement

13:00/14:30 Lunch

14:30/15:30- Discussion on ICCAT e-tags DB implementation (cont.):
– Potential contributions from CPCs
– Rules for the use of the DB, in the light of the new ICCAT data policy.

15:30/16:00- Knowledge gaps analyses
– gaps in knowledge on movement transitions in the current MSE mixing models

16:00/16:15- Coffee break

16:15/17:00- Knowledge gaps analyses
– gaps in knowledge of life history traits
– gaps in knowledge of population structure

17:00/18:00- Analysis of data needs for improving stock assessments

Day 3

09:00/10:30- Methodological issues

- 9 Pop up tagging methodologies and impact of animal welfare national rules
- 10 Hardware problems (pin broke, battery issues, tag maintenance...)
- 11 Multiple tagging
- 12 Multiannual tags
- 13 Relationships with manufactures: adapting products to user’s needs
- 14 Accuracy of tracking models
- 15 Genetic analyses for stock of origin determination
- 16 Other

10:30/10:45- Coffee break

10:45/13:00- Draft design of strategic plan for further tagging to fill in identified gaps and improving stock assessment:
– Priority questions to be addressed, specific objectives

13:00/14:30- Lunch

14:30/16:00- Draft design of strategic plan for further tagging to fill in identified gaps and improve stock assessment:
– Priorities for e-tagging: what tags, where, when, whom

16:00/16:15- Coffee break

16:15/17:30- Planning for joint analyses

17:30/18:00- Proposals for consolidating a SCRS BFT species group tagging subgroup

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Mayor, Carlos

Aleman, Francisco

McClelland, Erin

Pagá, Alfonso

Tensek, Stasa

García, Jesús