Report of the ICCAT Albacore Year Programme (ALBYP)

Background and programme objectives

Since 2010, the Albacore Species Group (ALB SG) has designed a research programme to address key uncertainties that would allow for the improvement of the scientific advice for management of the species. The research programme has now been developed for both the northern and the southern stocks of Atlantic albacore and has been revised on several occasions according to new knowledge, priorities and cost estimates. The research plan is focused on three main research areas: biology and ecology, monitoring stock status, and Management Strategy Evaluation (MSE) for northern albacore. Funds for this research programme have become available since 2021, and were used to develop some of the key research topics as described below.

2023 activities

Since 2021, the Albacore Species Group has prioritized the following research topics: a reproductive biology study to improve knowledge on maturity and fecundity, an electronic tagging study to better understand the life cycle and habitat use, and MSE to follow the MSE schedule agreed by the Commission. The first two research items are being pursued for both the North and the South Atlantic stocks, while the third one is, for now, specific to the northern stock. The following are the cumulative ALBYP activities conducted up to 2023.

Reproductive biology of North Atlantic albacore

ICCAT funds were used to issue a contract to a consortium to undertake this project to improve knowledge of: (a) the reproduction and maturity for the northern Atlantic albacore stock, (b) sex-specific maturity ogives, (c) spatial and temporal spawning grounds, and (d) L_{50} and size/age related fecundity.

The project consortium is led by Dr Alex Hanke and Dr Dheeraj Busawon (Department of Fisheries and Oceans, DFO, Canada), assisted in the coordination of activities by Dr Victoria Ortiz de Zárate (EU-Spain, Instituto Español de Oceanografía - Consejo Superior de Investigaciones Científicas (IEO-CSIC)). Other scientists involved in the project include: Dr Freddy Arocha (Instituto Oceanográfico de Venezuela (IOV), Universidad de Oriente (UDO), Venezuela), Dr Nan-Jay Su (National Taiwan Ocean University, Chinese Taipei), Dr David Macías (EU-Spain, IEO-CSIC) and Dr Kadra Benhalima (DFO, Canada).

During December 2020 and 2021 the sampling plan was focused on pelagic longline fisheries either targeting albacore (Chinese Taipei fleet) or in which albacore were bycatch (Venezuela and Canada fleets). A subsample of fish were aged using the first dorsal fin ray (samples collected by Venezuela; n=163). Dorsal fin rays were processed and read using the methodology described in Ortiz de Zárate and Babcock (2016). Two readers made independent estimations of age of each sample and final age was determined by agreement. This analysis was completed in the first semester of 2022.

In order to determine maturing stage, gonads were also collected from albacore specimens. A total number of 284 gonads were collected, of which 271 were processed (199 from Venezuela and 72 from Chinese Taipei). Ocytes were classified into one of 6 classes according to their different developmental stages using similar terminology to that of Brown-Peterson *et al*. (2011). To determine the maturity stage and ovarian phase of each female, a microscopic maturity scale was applied to identify the Most Advanced Group of Oocytes (MAGO) in the ovary, the Post Ovulatory Follicles (POF) and Vitellogenic Oocytes development (Farley *et al*., 2013 and 2016; and Schaefer, 2001). To estimate fecundity parameters the following two approaches were used: the Weibel method for fecundity estimates (Weibel and Gómez, 1962; Weibel *et al*., 1966; Weibel, 1969) and a new dissector method (Sterio, 1984). Fecundity parameters were estimated on a reduced number of gonads (n=20) collected in May and June of 2021 and from July to September in 2022 (n=39) in the Central North Atlantic area by Chinese Taipei longline vessels.

In 2022, the collection of samples continued by the Chinese Taipei longline fleet that provided n=72 albacore gonads samples. They were taken in the Central North Atlantic area around 20° North latitude.

All the female albacore samples collected in the tropical area by Venezuela longliners were mature specimens, but exhibited no sign of spawning in 2021. These female albacores were classified as being in a resting stage and therefore were not used when estimating fecundity parameters.

The new findings on the reproductive biology of North Atlantic albacore obtained from the analysis of the 2020-2021 samples were presented at the Albacore Species Group meeting in September 2022. In 2023 the collection of albacore samples (gonads and spines) by the longline Chinese Taipei fleet continued in the Central North Atlantic area around 20° North latitude in central and western zones following the fishing activities of commercial fleet. The observers onboard have collected gonadas (n=281) and spines (n=231) from February to August. These samples will be analysed when the ChineseTaipei longline fleet ends the fishing season and will be shipped to the laboratory in charge.

Reproductive biology of South Atlantic albacore

Dr Paulo Travassos, a national scientist from Brazil, is the project leader for this short-term contract, with research activities being conducted with the participation and support of scientists from Brazil (Dr Mariana Rego, Dr Maria Lúcia Araújo, Dr Joaquim Evêncio Neto and Dr Luis Gustavo Cardoso), Uruguay (Dr Andrés Domingo and Dr Rodrigo Forselledo), South Africa (Dr Denham Parker, Dr Sven Kerwath), Namibia (Charmaine Jagger) and Chinese Taipei (Dr Nan-Jay Su).

Important gaps in scientific knowledge remain for albacore in the South Atlantic Ocean that need to be filled in. Thus, the objective of this research is to determine the spawning areas, spawning season, the age-size at maturity, and the fecundity of the southern Atlantic albacore, using samples/measurements provided by participating CPCs. This work is expected to generate vital information for the conservation of the species and the management of fisheries in the South Atlantic.

To achieve these objectives, biological sampling is being carried out in the three main areas in the South Atlantic (oceanic areas off Brazil/Uruguay and Namibia/South Africa). From September 2021 to date, samples have been collected in a joint effort by the partner countries with the aim of sampling on the largest possible space-time scale. However, only samples collected by the Brazilian (145 gonads) and the Chinese Taipei tuna fleets (180 gonads) have been included in the study so far. About 176 gonads of males (n=100) and females (n=76) have been histologically processed and analyzed to estimate L50.

Samples were collected from three different areas along de Brazilian coast: one located in the North (around 4°-6°S Recife fleet), with samples taken between September and November 2021, as well as from February 2022 to April 2023. The second area is located in the South (around 33°-34°S, Rio Grande fleet), with samples collected in February and July 2021. The third area is located around 22°-27°S with samples collected during November-December 2021 (Chinese Taipei fleet). Upon examining the frequency distribution of albacore caught by the three fleets, it was observed that there was a gradient in length composition based on latitude. The Recife fleet, operating at lower latitudes, caught the largest fork length sizes ranging from 91-125 cm. The Chinese Taipei fleet caught sizes ranging from 99-111 cm, while the Rio Grande fleet caught sizes ranging from 81-111 cm.

Based on histological criteria, it was found that 80% of female and 59.8% of male samples analyzed had reproductive activity. In males, the following maturation stages were observed: immature (4.7%), developing (35.5%), spawning capable (35.5%), active (16.8%), and regressing (7.5%). In females, the maturation stages were immature (3.3%), developing (16.7%), spawning capable (13.3%), active (55%), and regressing (11.7%). Based on the data generated for fish classified as capable of spawning and active, the spawning area of the species in the South Atlantic is probably located between latitudes 10°S and 25°S, where many active females are caught in the southernmost part of this area.

The study indicated that both male and female southern Atlantic albacore are mature at larger sizes than previously assumed. Specifically, the L_{50} values were 102.3 cm FL and 96.3 cm FL for males and females, respectively. However, these are preliminary findings, since the sample size and geographic range analyzed were limited. To gain a more precise understanding of the species' maturation sizes along its migratory path, further research with larger and more diverse samples is needed. The range of batch fecundity was found to be between 0.14 - 1.7 million oocytes based on a sample size of only six gonads. Thus, the analysis is yet preliminary. Nevertheless, there appears to be a correlation between ovarian weight and batch fecundity.

Out of the seventy-nine first dorsal fin spines collected, 25.3 have been cut and read, 31.6 have been embedded, and 43.0 have not yet been processed. The range of the number of rings in the analyzed spine sections was 7 to 8 rings, but the number of years is likely higher as the initial rings are not visible due to the vascularization zone of the spine.

Movements and habitat use of North Atlantic albacore

This project is led by Dr Haritz Arrizabalaga (AZTI, EU-Spain), in collaboration with scientists from EU-Spain (AZTI and IEO), and additional support from scientists from different CPCs involved in communication of tagging recoveries and rewards (EU-France, EU-Ireland, EU-Portugal, Japan and Chinese Taipei).

ICCAT funds are used mainly to purchase tags and to cover some of the deployment and satellite transmission costs, while other costs (additional tags, personnel, travel, etc.) are provided as in-kind contributions by participating institutions involved in tagging and analyses activities.

Since 2019, several tagging surveys have been conducted off the Canary Islands and in the Bay of Biscay. The surveys off the Canary Islands were conducted onboard baitboats and charter vessels targeting large individuals during the winter/spring. So far, 29 MiniPATs have been implanted (5 in 2019, 10 in 2020 and 14 in 2022). In the Bay of Biscay, surveys were conducted onboard baitboats used for the bluefin tuna acoustic survey, as well as on recreational and charter vessels using trolling gear, targeting small to medium size individuals during summer and autumn. So far, 108 internal archival tags (Lotek LAT 2810L) and 2 PSATS have been implanted in 2020-2023.

In order to increase the chances of recovering internal archival tags, posters announcing €1,000 rewards were produced in Spanish, French, English, Portuguese, Japanese and Mandarin Chinese and distributed through collaborating ALB SG participants from different CPCs. To date, we have collected data from 26 of the PSATs deployed, which account for an accumulated 1448 tracking days. Of the internal archival tags, 9 tags were recovered, eight of them with times at liberty above one full year. Unfortunately, two of them were recovered with the antenna broken, but the other six provided full year tracks. These recoveries, to our best knowledge, the longest recoveries for an albacore tuna in the Atlantic Ocean. These track cover more than a year in the life of a juvenile albacore that visited shallow waters of the Bay of Biscay in subsequent summers, while inhabiting deeper waters in the central and western Atlantic during the winter, as well as travelling south to the Canary Islands before returning to the Bay of Biscay. Updates of the results obtained thus far were presented to the Albacore Species Group during the Species Group meetings held in September 2022, the North Atlantic Albacore Data Preparatory Meeting (including MSE) (20-23 March 2023) (Anon., 2023a) and the Atlantic Albacore Stock Assessment Meeting (including MSE) (26-29 June 2023) (Anon., 2023h) (Cabello de los Cobos, 2023). In the near future, we will continue deploying the remaining purchased tags.

Movements and habitat use of South Atlantic albacore

The project leaders for this study are Dr Paulo Travassos and Dr Andrés Domingo, national scientists from Brazil and Uruguay, respectively. The main purpose of this study is to provide information about movement patterns and habitat use of albacore in the South Atlantic Ocean, to contribute to the assessment and management of the southern stock of the species.

Initially, a total of 6 miniPAT (WildLife Computers) tags have been made available by ICCAT. These tags arrived in Brazil in February 2022 and since then attempts have been made to tag some specimens off the Northeast coast of Brazil. Taking the opportunity of an expedition to tag yellowfin tuna around the Fernando de Noronha archipelago (Protuna Project, national research supported by the Brazilian government; CNPq

Process No. 445810/2015-7), an attempt to tag albacore in this area was conducted from 23-27 May 2022. However, no albacore were caught during this cruise and thus no fish were tagged. This region of the Fernando de Noronha archipelago does not have a high abundance of albacore and, furthermore, the time of year was not the most suitable for the presence of the species off the Northeast coast of Brazil. The greatest abundance of albacore occurs during the austral spring-summer periods, when the species seeks warm tropical waters for reproductive activity.

After that, no tagging cruise was carried out and then the six tags had to be sent to the manufacturer (WildLife Computers) to change tagware and battery. At the end of May 2023 another six miniPAT tags were delivered to restart the tagging work, with first tagging cruise expected in July/August 2023. In addition, three more miniPATs were sent to South Africa in July 2023. Unfortunately, attempts to deploy MiniPATs have not yet been successful. The teams will continue to deploy tags and an update of the results will be presented in 2024.

Management strategy evaluation (MSE) of North Atlantic albacore

ICCAT funds were used for a short-term contract to AZTI, coordinated by Dr Gorka Merino and Dr Agurtzane Urtizberea, to accomplish the technical tasks required to follow the MSE schedule adopted by the Commission in 2021. According to this schedule, after adoption of the first ICCAT Management Procedure (MP) in 2021 (following adoption of a harvest control rule in 2017), the existence of Exceptional Circumstances must be evaluated on a yearly basis (indicators depending on the year). In addition, a new benchmark stock assessment using SS3 was developed in 2023, which will serve as a basis for conditioning new operating models for the second round of the MSE framework. This new MSE is expected to be delivered in 2026 to allow the Commission to revise the MP if they wish to do so. Moreover, the *Recommendation by ICCAT on conservation and management measures, including a Management Procedure and Exceptional Circumstances Protocol, for North Atlantic albacore* (Rec. 21-04) requires testing alternatives to the adopted MP.

With regards to the OM development in the new MSE model framework for North Atlantic albacore, interested members of the ALB SG worked together with the ICCAT Secretariat and the contractors on the new model structure since 2021. The definition of the fleets, catch, CPUE and size data for the SS3 model was adopted at the 2023 Albacore Data Preparatory Meeting. In 2022, the contractors developed initial SS3 runs, and the results were presented at the September 2022 ALB SG meeting (Urtizberea and Merino, 2022). In 2023, the SS3 model was further developed and discussed at the Albacore Data Preparatory Meeting (Urtizberea *et al.*, 2023a) and the Albacore Stock Assessment Meeting (Urtizberea *et al.*, 2023b). At the 2023 Albacore Species Group meeting, the refined model (Urtizberea *et al.*, 2023c) was presented together with a set of model diagnostics, incorporating the suggestions by the ALB SG. This model produced very similar results to the model used to provide stock status in the 2023 stock assessment but showed a better performance with regards to diagnostics performance. The ALB SG accepted this model as a reference case to structure the OMs for the new MSE.

With regards to the MSE developed to support the adoption of Recommendations 17-04 and 21-04, the performance of MP variants requested in Rec. 21-04, was evaluated by the contractors in 2022 and 2023. These variants consisted of varying levels of target fishing mortality and biomass thresholds, as well as the effect of using only some of the CPUE series on MP performance (Merino *et al.*, 2022). They also performed initial tests with varying levels of underreporting and updated the analyses regarding the effect of the carry over provision, implementation error, and alternative stability clauses. They also produced the necessary plots for the ALB SG to discuss the detection of Exceptional Circumstances (Merino *et al.*, 2023a), as requested by the Exceptional Circumstances Protocol contained in Rec. 21-04. In 2023, additional robustness tests were developed for the newly adopted natural mortality vector (Merino *et al.,* 2023b).

Expenditures in 2022 and 2023

The total budget within ALBYP in 2018, 2019, 2020 and 2021 amounted to €94,375, €85,000, €130,000 and €100,000, respectively. The effective expenditures for that period were €41,832, €42,788, €163,644 and €133,988.58, respectively.

In 2022 and 2023, to implement the main activities planned in the framework of ALBYP, the yearly budgets provided by ICCAT amounted to €110,000 and €95,000, respectively. The detailed funding allocations and total expenditures for ALBYP as of 11 September 2023 are shown in the **Table 1** below.

Table 1. Details of funds available for ALBYP during 2022 and 2023 and respective expenditures as of 11 September 2023.

Year	*2022*		*2023*	
Component	*Budget (€)*	*Expenditure (€)*	*Budget (€)*	*Expenditure (€)*
Tagging	40,000	39,550.57	40,000	6,000
Reproductive	35,000	14,126	10,000	-
Age and growth	10,000	6,360	10,000	-
Sample collection and shipping	5,000	12,370.44	5,000	-
MSE	20,000	19,800	30,000	-
TOTAL	**110,000**	**92,207.01**	**95,000**	**6,000**

2024-2025 Plan and activities

Reproductive biology and aging of North Atlantic albacore

In view of the inherent difficulties in collecting mature albacore and the need for additional gonads samples to better cover the spatio/temporal strata of maturity and fecundity estimates in the North Atlantic sampling, additional sampling of gonads, spines and otoliths is planned through the end of the autumn and winter 2023 onboard longliners from Venezuela. Sampling activities will continue in 2024 to achieve a number of samples that will resume a comprehensive study on reproductive biology of northern albacore. When new samples are provided to the IEO laboratories involved, the analyses will be done using the same methods as previously used to estimate maturity stage and fecundity. The corresponding spine samples will be aged to determine the age of fish sampled for the reproductive staging and fecundity study.

In order to estimate the maximum age of albacore tuna to inform hypotheses about natural mortality, additional samples for aging (spines and otoliths) of large individuals (>100 cm SFL) are required (100-200 individuals per stock). A sample of spines, already aged, is available, and additional samples are and will be available to complete this study.

Reproductive biology and aging of South Atlantic albacore

Given that only samples collected by the Brazilian and Chinese Taipei tuna fleets have thus far been analyzed, priority will be given to collecting samples from the other partner countries (mainly Namibia and South Africa). Samples will be shipped to Brazil for analysis. It is anticipated that these samples will provide information about different spatial and temporal strata. This sampling effort should continue during 2024-2025.

Paired (otolith and spine) samples of large albacore will also be collected in order to verify natural mortality assumptions based on maximum age.

Movements and habitat use of North Atlantic albacore

During the rest of 2023 and 2024-2025, we plan to continue deploying additional tags using different tagging opportunities (commercial, research, charter and recreational vessels) with the intention to better characterize the life cycle of North Atlantic albacore and consider stock structure assumptions. Following the experience of recent years, deployments are planned by AZTI scientists in the Bay of Biscay and the Canary Islands but may be expanded to other areas if opportunities arise, especially in the western Atlantic if suitable tagging platforms are identified.

Movements and habitat use of South Atlantic albacore

Tagging activities will restart in the second half of 2023, and throughout the years 2024-2025, depending on availability of tags. The intention is to tag albacore caught by baitboats that target skipjack tuna off the Southeast coast of Brazil; albacore is caught in small proportions in this fishery. The advantage of this approach is that the tagged fish will be in good condition due to the characteristics of this fishing method. New attempts to tag the species will also be made in the Northeast region of Brazil from September to October, when the spawning season begins, thus increasing availability of adult fish. Additional tagging efforts will be conducted in South Africa.

Management strategy evaluation of North Atlantic albacore

In 2024 a new set of Reference and Robustness OMs will be structured using the reference case developed in 2023. A key development expected for this MSE is the simulation of the observed errors in abundance indices, which can be configured with a random error function or reproducing the statistical properties of the indices to the SS3 models. In 2024 and 2025, empirical and model-based MPs will be developed and evaluated. At least one of the MPs considered should the one adopted in Rec. 21-04.