Report of the 2023 Swordfish Species Group Meeting (including MSE)
(22-26 May, hybrid St. Andrews, New Brunswick, Canada)

The results, conclusions and recommendations contained in this Report only reflect the view of the Swordfish Species Group. Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission reviews them at its annual meeting. Accordingly, ICCAT reserves the right to comment on, to object to and/or to endorse this report, until it is finally adopted by the Commission.

1. Opening, adoption of the agenda and meeting arrangements

The meeting was held in hybrid format from 22-26 May 2023. Kyle Gillespie, the Species Group rapporteur and meeting chair, opened the meeting and welcomed participants. Dr. Miguel Santos, the assistant ICCAT Executive Secretary, also welcomed participants. The meeting agenda was adopted and is provided in **Appendix 1**. The List of participants is attached as **Appendix 2.** The List of presentations and papers is contained in **Appendix 3**. The authors' abstracts of all SCRS documents and presentations are included in **Appendix 4.** Rapporteurs were assigned as follows:

Section	*Rapporteur*
Item 1.	N.G. Taylor, M. Santos
Item 2.	C. Palma, C. Mayor, J. García
Item 3.	A. Hank, D. Rosa, S. Miller, D. Busawon
Item 4.	D. Rosa, D. Macias, G. Gioachini, R. Coelho
Item 5.	M. Lauretta, A. Hordyk, N. Fisch, N. Duprey, S. Miller
Item 6.	N.G. Taylor, B. Mourato
Item 7.	K. Gillespie
Item 8.	K. Gillespie, M. Santos
Item 9.	M. Santos.

2. Review of fishery statistics and tagging information

The ICCAT Secretariat presented to the Group the most up-to-date fishery statistics information available in the ICCAT database system (ICCAT-DB) in relation to swordfish (*Xiphias gladius*, SWO) for the three stocks (SWO-N: North Atlantic; SWO-S: South Atlantic; SWO-M: Mediterranean Sea). The datasets reviewed include Task 1 nominal catches (T1NC), Task 2 catch and effort (T2CE), Task 2 size frequencies (T2SZ), Task 2 catch-at-size estimated/reported by CPCs (T2CS), and the most recent CATDIS estimations (T1NC catches distributed by quarter and 5x5 squares, between 1950 and 2021). Existing conventional and electronic tagging information regarding swordfish was also presented and reviewed by the Group.

2.1 Task 1 (catch) data

Following the several comprehensive revisions of the full T1NC series (1950-2021) for the three swordfish stocks (reduced unclassified gears, gap completion, reclassified erroneous gears, corrections to sampling areas and stocks, etc.) completed by this Group over the last decade, no major corrections were made afterwards. The ICCAT Secretariat noted that the T1NC of SWO-M is overall less complete than for the two Atlantic stocks.

Total swordfish catches (landings and dead discards) by stock, major gear, catch type, and year are presented in **Table 1**. The live releases catch component of T1NC is summarised in **Table 2**. The total swordfish catches of each stock by gear and year are presented graphically in **Figure 1** (SWO-N)**, Figure 2** (SWO-S) and **Figure 3** (SWO-M). A dashboard to explore and dynamically browse through all the T1NC information with swordfish data was also made available by the ICCAT Secretariat to the Group.

The ICCAT Secretariat informed the Group that, despite great improvements over the last decade, the swordfish catch series of the three stocks are still incomplete, particularly the swordfish dead/live discards components. No major progress was made on reporting swordfish discards of any kind (DD: discarded dead; DL: discarded live) in T1NC datasets by ICCAT CPCs (only a few cases). The Group acknowledged the inherent complexity of obtaining accurate swordfish estimates of dead/live discards. Therefore, it reiterated the need to improve this methodology as the first step towards allowing ICCAT CPCs to provide estimations of both dead and alive swordfish discards to ICCAT. After evaluating the most recent T1NC information, the Group adopted these swordfish catch series as the most complete T1NC available without any major modifications. It also restated that the ongoing T1NC data improvement work should continue with more involvement from ICCAT CPC statistical correspondents.

The Group also discussed the practicality of including the "DL" component in the SCRS executive summary tables with Task 1 nominal catches, together with the "L" (Landings) and "DD" components. After a fruitful discussion, it was agreed that this subject, which may imply changes to the tables (structures, arrangements, interpretations of grouped elements, etc.) and to the ICCAT Secretariat's existing code that handles this information, should be better addressed and planned by the Sub-Committee on Statistics (SC-STAT) at its next annual meeting. The ICCAT Secretariat committed to contact the SC-STAT chair and other "key" ICCAT scientists who have historically been involved in these matters (also to be followed by the SCRS Chair), to jointly study potential formats and associated implementation costs (resources involved to update the source code: SQL, JAVA, etc.), in order to have a feasibility study ready to be presented at the SC-STAT annual meeting.

The ICCAT Secretariat also informed the Group about the most recent update made to CATDIS with swordfish estimates (derived T1NC information with catches distributed by quarter and in 5x5 squares, reflecting the existing catch and effort space-time distribution series provided to ICCAT). The swordfish maps with catches by decade (1990s to 2000s) and gear are presented in **Figure 4**. The new CATDIS was also published in the ICCAT Statistical Bulletin Vol. 48 and reflects the swordfish T1NC information received until January 2023.

2.2 Task 2 (catch-effort and size samples) data

The swordfish standard SCRS catalogues (T1NC and T2CE/SZ/CS availability, ranked by importance in the total swordfish stock production within the 1993-2022 period) were updated and presented to the Group (SWO-N in **Table 3**, SWO-S in **Table 4**, and SWO-M in **Table 5**). The SCRS catalogue is an instrument that provides a combined view of Task 1 catch and Task 2 dataset availability for each major fleet. Information for 2022 is partial and incomplete.

Task 2 catch and effort (T2CE)

T2CE datasets are identified in the SCRS catalogues with the character "a". The ICCAT Secretariat reminded the Group that these catalogues no longer show T2CE datasets with poor time-area resolution (e.g., datasets aggregated by year and/or datasets with 10x20/20x20 geographical grid aggregation levels) that are available in the ICCAT-DB but not usually used in any scientific work. A detailed catalogue of T2CE with important metadata was also provided to the Group for querying information related to highly grouped T2CE datasets. In line with other species, the rationale behind the above approach is to encourage ICCAT CPCs to report improved datasets to ICCAT with a view to replacing those identified as having low time-area resolution.

The ICCAT Secretariat informed the Group that very minor improvements were made to T2CE having swordfish catches in the three stocks. The Group recommended that CPC scientists use the standard SCRS catalogues as a tool to identify any missing data.

Task 2 size frequencies

The swordfish standard SCRS catalogues show the availability of both T2SZ (character "b") and T2CS (character "c"). As for T2CE, these catalogues do not show T2SZ/CS datasets with poor quality (poor time-area detail, size/weight bins larger than 5 cm/kg) that are available in the ICCAT-DB but not usually used in scientific work.

Overall, the tendency to report higher resolution T2SZ/CS datasets has been maintained over the last decade. Some important datasets are lacking for all three stocks in various years.

The Group considers that the ICCAT Secretariat's ongoing (since 2010) Task 2 data recovery/improvement work should continue with active participation of CPC scientists.

Presentation SCRS/P/2023/094 explores the consequences of the 10-cm increase of the Minimum Landing Size (MLS), following *Recommendation by ICCAT Replacing the Recommendation 13-04 and Establishing a Multi-Annual Recovery Plan for Mediterranean Swordfish* (Rec. 16-05). It uses observer data (2017-2021) and total reported landings to estimate the number of kilos discarded by the surface longline fleet targeting swordfish in the Spanish Mediterranean for each month that the fleet is active (April to December) for the fraction of fish measuring from 90 to 100 cm straight lower jaw fork length (LJFL). This estimation of the monthly number of discarded fish is added to the total amount of reported landings for each month of the year (from 2017 to 2021) to explore when the TAC is reached if this fraction of fish is included in the total catch. In addition, a preliminary analysis on the carbon footprint of the fleet was conducted. The results show that reducing the MLS to 90 cm would cause the TAC to be reached earlier in the year, which would reduce the duration of the fishing season and consequently the carbon footprint of the fleet.

The Group acknowledged this important preliminary work, particularly on aspects related to improvements of the methodology used to estimate both dead and live discards, and recommended that it be continued. The Group discussed the impact that lowering the minimum size threshold by 10 cm may have on stock status (see Item 7. Recommendations). As an alternative, the Group discussed the potential effect of a spatial/temporal closure. The Group suggested that this analysis should be extended to examining the effects of changing the minimum size threshold from the current size limit to no size limit.

2.3 Tagging data

The ICCAT Secretariat presented a summary of updated swordfish conventional tagging data. **Table 6** shows releases and recoveries per year and **Table 7** shows the number of recoveries grouped by number of years at liberty. Three additional figures geographically summarise the SWO conventional tagging data available in ICCAT: the density of releases in 5x5 squares (**Figure 5**), the density of recoveries in 5x5 squares (**Figure 6**) and apparent swordfish movement (arrows from release to recovery locations) (**Figure 7)**.

In addition, the ICCAT Secretariat presented two SWO dashboards to dynamically and interactively examine the tagging data. The first one (**Figure 8**) is related to conventional tags, showing a summary of released and recovered tags. The second one (**Figure 9**) is related to electronic tags, showing a summary with data extracted from the meta-database held in ICCAT. The creation of dashboards for conventional tagging and electronics tag metadata for all species is under heavy development and will soon be published on the ICCAT website. The ICCAT Secretariat thanked scientists for their support in the production of the dashboards presented.

The ICCAT Secretariat informed the Group of the current difficulties encountered in incorporating conventional tagging data reported by the U.S. between 2009 and 2019 (all species including SWO) due to various reasons. Aiming to solve this situation in the mid-term, collaborative work has begun involving the ICCAT Secretariat and the U.S. tagging correspondents to work on the full cross-validation of both conventional and electronic tagging databases, with the main objective of correcting all the discrepancies and missing information across all species. The ICCAT Secretariat will update the ICCAT tagging databases as the revision proceeds.

Improvements in conventional tagging information will continue and run in parallel with the maintenance and improvement of the conventional tagging database (CTAG), and the development of the new electronic tagging database (ETAG). The ETAG project's main goal is to integrate all the information obtained from electronic tags and the associated metadata into a centralized relational database system (PostgreSQL). The Group discussed creating a standardized methodology for estimating tag tracks (see Item 7. Recommendations).

Phase one has been completed with the ETAG data inventory, the creation of the loading files (special format files with all the electronic tagging files), and the installation of the entire ETAG system (database, front-end applications, validation tools, etc.). The second phase will work on consolidating the metadata and uploading the electronic tagging data into the ETAG system.

3. Swordfish Year Program (SWOYP)

3.1 Life History Project

SCRS/2023/016 provided a final report for Phase 4 of the ICCAT short-term contract to collect swordfish biological samples for growth, reproduction, and genetics studies.

The Group recognized that the Swordfish Year program (SWOYP) is one of the most ambitious projects in ICCAT. It involves about 20 teams and over the past 4 years it has been extremely successful in collecting samples that will help reduce uncertainty in stock assessments and Management Strategy Evaluation (MSE) models. The Group considered the gaps in the samples that remain and questioned whether approaching fleets that fish in the gap areas may be a more effective strategy than a general call for filling those gaps. It was mentioned that the general call approach has resulted in too few samples in the most recent phases and, consequently, surplus funds were returned to the funders. Recognizing that it was not helpful to the funders, the Group suggested increasing regional coordination to increase the sample collection rate.

The Group suggested filling gaps using the raw data that was used in previous age and growth studies or using parameter estimates from previous age and growth studies as informative priors. Raw age and size data is available for the West Atlantic, along with a database of supporting images; however, some consideration must be given to how the images were recorded before attempting to re-age them. Alternatively, the Group discussed using targeted surveys to gather samples and was reminded that the Commission will hold a regular meeting this year where they will discuss the budgets for the next 2 years. When requesting funds for the 2-year research plan, it is critical to describe how the work will improve management advice.

SCRS/P/2023/073 described research plans for Phase 5 of the ICCAT short-term contract to collect swordfish biological samples for growth, reproduction, and genetics studies. The plan includes focused sampling in areas which have not yielded any samples to date and, given the large spatial and temporal gaps in areas where sampling has been successful, it was questioned how it would be possible to achieve a more complete sampling in Phase 5. It was requested to show quarterly and perhaps monthly views of the data by area and to relate these gaps to project objectives to address the most impactful gaps first.

The Group also discussed the issue of curating the samples collected under the SWOYP, noting that AZTI is currently under contract to perform this function for the Grand Bluefin Tuna Year Programme (GBYP) and that this represents a significant cost to the GBYP. The Group noted the ICCAT Secretariat's efforts to develop a Task 4 database for the biological data. This database could hold information on the disposition of the samples and responsible parties. Such a database would allow the curation to be a collaborative effort among several facilities. The Group was cautioned to be mindful of facilities' storage constraints in terms of freezer costs, maintenance schedules, and facilities management. These constraints may impact the long-term quality of the samples for future analysis.

Finally, the Group was informed that the new grant agreement with the EU, which will fund most of Phase 5 of the SWOYP, has not been signed yet. Nevertheless, the teams were encouraged to continue working on project deliverables since the Phase 4 project end date is September 2023. The Group was reminded that 2022 funds are being used to fund Phase 5 up to October 2023 and that 2023 funds will be available to support the Group's work from November 2023 to March 2024. Consequently, the Group was encouraged to temper any new requests for research funds for use in 2024 given the carry forward of unspent funding approved in previous years.

3.1.1 Ageing and Growth

SCRS/P/2023/62 covered the outcomes and recommendations of the ageing workshop held in Olhão, Portugal in February 2023.

There was a question concerning the timing of the next ageing workshop as more work is required to standardize ageing protocols. The ICCAT Secretariat mentioned that EU funding would start in mid-June and be available until March 2024. The Chair commented that it was informative to have had various Species Groups at the workshop, but suggested that a dedicated swordfish workshop would be more beneficial to further ageing and maturity work. It was suggested that the next workshop be held in early 2024 in accordance with the current workplan.

SCRS/P/2023/060 reviewed spine and otolith collection by the SWOYP and future work related to reading standardization, daily ageing of otoliths and age validation using otoliths through bomb radiocarbon techniques.

Discussion focused on the imbalance in sampling and the lack of paired spine-otolith samples from larger, likely older, individuals and the impact on analyses and project objectives. The Group inquired if the data gaps represent an issue for validation/growth work and if the gaps were reflected in the Terms of Reference (TOR) for Phase 5. The Chair and presenter agreed that this is an issue, but that Canada (its longline and harpoon fleets) and the U.S. (the University of Maine and the Gulf of Maine Research Institute) are making efforts to collect otoliths and spines from larger individuals which will hopefully address this gap. Other CPCs were encouraged to continue sampling for these spine-otolith pairs. It was noted that once the initial age-length key/growth curves are produced, the sampling programme would switch to minimal sampling requirements to monitor any growth changes.

The Group noted that tagging work in the northwest Atlantic primarily shows North and South movements and few West-East movements. In addition, recent genetic studies suggest that the North and South Atlantic stocks co-occur in the northeast Atlantic and that this may affect the direction of future sampling if there are differences in growth and biological characteristics of the stocks. The Group asked if it is reasonable to use samples from across the stocks to address sampling gaps when conducting the analyses. Consideration will be given to the stock of origin of the samples and the effect of combining samples across stocks.

In terms of sampling, it was noted that a large proportion of the sampled fish in the northeast are of sub-legal size. This could be because observers are not allowed access to legal size fish due to potential damage from sampling. This bias in sampling could have impacts on ageing as ease of interpretation could be size-related (e.g., spines/otoliths from younger fish could be harder to interpret). Furthermore, sampling could be impacted if this minimum size is ever removed.

3.1.2 Reproduction and maturity

SCRS/P/2023/068 shared the preliminary results of an ongoing study contracted by ICCAT on swordfish reproduction. The work entails processing gonad samples to examine maturity by size, season, and area. The results are being used to assess the size at first maturity (L_{50}) and construct maturity ogives for the three populations. Staging of ovaries (Stage I through Va,b) is carried out according to the criteria in the ICCAT Manual.

The study's preliminary results indicate maturity ogives slightly to the left of those currently used in assessments. For example, the preliminary Mediterranean L_{50} is 131 cm LJFL, compared to 144 cm in the assessment. Similarly, the preliminary L_{50} for the North Atlantic in this study is 164 cm, compared to 179 cm in the assessment.

The Group had an extended discussion about sampling distribution and needs. It was noted that mature ovaries can weigh up to 15kg, and samples must be stored in a fixative soon after collection to be viable for analysis. Furthermore, food safety concerns associated with the use of fixatives onboard commercial vessels complicate

gonad collection. Therefore, although there are several historical samples, most of those results cannot be combined in analyses with more recent samples since the older studies used a different method to assign maturity stage (i.e., oocyte distribution).

Priority regions for gonad collection were identified as the Sargasso Sea in the North Atlantic, the quadrant areas and Gulf of Guinea in the South Atlantic, and the eastern Mediterranean Sea. A number of samples collected primarily in the equatorial area in October-November, including some samples from Chinese Taipei currently at the ICCAT Secretariat, will soon be analysed. Due to the challenges in sampling mature gonads, the Group agreed that a dedicated survey would be useful, particularly in the Sargasso Sea since there is very little fishing effort in that region. Because gonad weight is critical for evaluating fecundity, a survey might be the best sampling approach for reproductive studies. Samples are also sought from the Gulf of Mexico, an important swordfish nursery area but a region where few swordfish larvae have been found. It was noted that Gulf spawners may be limited to younger, newly mature fish. The Chair suggested that increased compensation could be paid for gonad samples, and the SCRS Chair emphasized that sampling requests to scientific observers must include clear collection protocols. Protocols for sampling have been developed during the 2019 Biology Workshop, see Appendix 1 of Gillespie *et al*. (2020).

The Group also discussed the prevalence of parasites in swordfish gonads but noted no evidence of inter-sex swordfish possessing both testes and ovaries, despite this anomaly being found in other fish species.

3.1.3 Genetics and stock boundaries

SCRS/P/2023/071 presented the results of a study on the genetic structure and diversity, fitness, evolutionary potential and distribution of Atlantic and Mediterranean swordfish stocks. The research consisted of four main parts: sequencing and analysis of the Mediterranean swordfish genome, double-digest restriction site DNA (ddRAD) sequencing, whole genome sequencing, and epigenetic ageing.

The Mediterranean swordfish genome sequencing and annotation and comparative analysis found that 3.5% of the swordfish genome is unique to the species, with 52.3% shared with other species. The expanded genes are related to immune and pollution response, while the contracted gene families are mostly related to metabolism, the nervous system, and heart development. The Group noted that the species' increased investment in immune response originated thousands of years ago.

A genetic population analysis was conducted on samples from the North Atlantic, South Atlantic, and Mediterranean Sea using ddRAD sequencing. The results found strong stock differentiation between the Atlantic and Mediterranean Sea, but only weak differentiation between the North and South Atlantic. The Group discussed how that lack of North/South signal may be a function of sampling bias since most of the South Atlantic samples were from the equatorial area, with a few additional samples from southern Brazil. It was also noted that while the cluster analysis showed some differentiation between swordfish in the northeast and northwest Atlantic, the sampling was not sufficient to fully analyse potential differences between the two areas, despite tagging data that suggests little mixing between the two sides of the Atlantic. The Sargasso Sea, northeast Atlantic mixing area, East Mediterranean, and waters off Namibia and South Africa (including on the Indian Ocean side of the Cape of Good Hope) were highlighted as critical areas for increased DNA sampling. Due to the critical need for more usable samples, the Group stressed that tissue samples should be stored in ethanol and shipping should be coordinated with the ICCAT Secretariat to avoid customs delays.

The Group also explored the threshold for defining separate stocks based on genetics. It was noted that stock boundaries are not necessarily stationary and could be different both historically and in the future, especially in the context of climate change.

Whole genome sequencing was carried out for ten samples from each stock and was able to successfully distinguish between swordfish from the Mediterranean Sea and North and South Atlantic. Structural (rather than functional) changes to chromosome 5 allowed for the best differentiation between SWO-N and SWO-S. Although whole genome sequencing is more costly than ddRAD, ddRAD returns a very large number of markers so processing and statistical analysis requires a lot of time. Furthermore, now that whole genome sequencing

has identified chromosome 5 as a way to distinguish between SWO-N and SWO-S, the co-authors are working to locate a few markers on chromosome 5 that can be used to differentiate between North and South using ddRAD. In this way, sequencing is fundamental to understand population structure.

The fourth component of the project will be explored during Phase 5 of the project and involves conducting age estimation of swordfish using epigenetics. Methylation of DNA at the CpG loci decreases with age, so DNA analysis is now being used to age individual fish. With the development of a reference epigenetic clock for swordfish by comparing epigenetic analyses to "known" ages, non-invasive DNA sampling will enable the ageing of swordfish in the future. In coordination with the ageing component, the first tissue samples for epigenetics will be chosen from the samples for which ages are being validated through bomb radiocarbon. The Group agreed to reach out to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for guidance on the study design, given the organisation's expertise in swordfish epigenetics in the Pacific Ocean. For example, it might be desirable to build the first clock using samples of one sex from one stock to avoid confounding variables.

3.2 Size/sex distribution study

SCRS/P/2023/062 provided an update on the swordfish size and sex ratio study, with detailed size and sex data compiled for both hemispheres and the Mediterranean. Exploratory analysis showed the differences in sizes between the different ICCAT areas and possibly different sex ratios across latitudes.

The Group noted that in the 1990s it was recognized that females grew faster than males and attained larger sizes. At the time, ICCAT developed a key of sex ratios at size that changed over latitudes and seasons, and those would be characteristic of spawning or feeding areas depending on the shape of those sex ratio at size curves. The Group suggested pursuing an update to that analysis, as we now have a much larger dataset covering wider Atlantic areas. This can have implications for the sampling areas, that in the future could be more based on biological aspects and not on the geographical sampling areas as they are defined now.

The Group noted that there are uncertainties as regards the swordfish stock assessment and asked if differences in sex and sex ratios across areas and seasons are accounted for in the assessment models. For the North Atlantic, it was noted that the current SS3 model uses specific size data for males and females separately, as well as sex-specific growth curves. There are other ways of further incorporating sex-related differences in the future if needed, such as using sex specific natural mortality and allowing for sex-specific selectivity.

Given the current MSE timelines, the Group asked what could be done at this stage with additional specific length data from observer programmes. The Group decided not to include these new length data in Operating Model (OM) reconditioning due to observer coverage gaps, the need to combine these data with existing Task 2 length data, and the short timelines available to perform this work. These data will be kept and can be prepared for future iterations of the stock assessment and MSE models when those are to be updated in the future.

3.3 Pop-up satellite archival tag project

Presentation SCRS/P/2023/062 provided an update of the study on habitat use for swordfish, developed within SWOYP. So far, 35 Wildlife miniPATs and 5 Microwave X-Tags have been deployed. The preliminary results showed that swordfish moved in several directions, travelling considerable distances in both the North and South stocks, while having shorter displacements in the Mediterranean. Efforts are ongoing to include historical tags deployed by Fisheries and Oceans Canada (DFO) and the National Oceanic and Atmospheric Administration (NOAA) to obtain a wider perspective on the horizontal and vertical habitat use of swordfish in the Atlanti

The Group noted it was very useful to include the previous raw data from West Atlantic DFO and NOAA tags, as they complement more recent efforts in the northeast and equatorial areas.

The Group noted the recurring problems with Wildlife Computer tags. They have suffered various malfunctioning issues over the years, including tether issues and battery problems. These problems have hopefully been resolved in new tags that are now being manufactured and refurbished tags.

The Group also noted that some Microwave Telemetry tags were acquired in the past and they have been recently deployed. Unlike the software provided by Wildlife Computers, Microwave Telemetry does not provide software that will estimate most-likely tracks. Accordingly, the tag's geo-location data needs to be analysed by the user. This is not necessarily a problem, as in this case analysts have more control of the analysis that is generating the tracks. There are now several models, some using R libraries, that use various covariates (e.g., SST, temperature-at-depth, ocean heat content, depth) to better estimate the most likely tracks, and those models are being explored in this study.

It was also noted that the more recent tags generally have better sensors, including light sensors, that can better detect light even at deeper depths. Therefore, those newer tags should provide better estimates of the tracks, and it is still important to deploy more recent tags even in areas where tagging efforts were done in the past.

The Group reflected on the possible outputs of those data and what work could be done to enhance the advice that the SCRS provides to the ICCAT Commission. One first output, that was in essence the main reason for the initial tagging efforts within the SWOYP, is to better define stock boundaries because they affect future assessments. Tagging data can be complemented with genetics and life-history data that is also being collected within the SWOYP. They also make it possible to better understand the species' vertical habitat use and how it overlaps with fishing gears; they can also, for example, be used to investigate if the gears have different impacts on different population size classes. Tagging data can also be used in multistock management cases, as we now start to have multiple species with good tagging coverage. It is therefore possible to better understand the impacts that fishing gears and/or spatial restrictions could have on various target and bycatch species. Finally, the Group noted that tagging data can also be used to improve tools like the longline simulator, which can incorporate this type of data to better quantify the species habitat distribution.

The Swordfish tagging coordinator (Dr Rui Coelho, EU-Portugal) presented a new line of research to be considered within the tagging project. This was the possibility of having dedicated trips to tag swordfish using longliners. In commercial longliners, swordfish suffer high at-vessel mortality, as well as a high post-release mortality. In those dedicated trips (or dedicated days within regular fishing trips), there would be fewer hooks per set to keep the soaking time minimal, and therefore increasing the chance of capturing swordfish in good conditions to be tagged. It was suggested that the first stage be conducted in the area between mainland Portugal, Madeira and the Canary Islands, west of the entrance to the Strait of Gibraltar as it is a mixing zone of the 3 stocks. The priority of such trips would be to tag swordfish in good condition, but full samples would also be collected from any animals captured dead; this could allow for the collection of samples from larger animals in this area that are not collected. Additionally, on those trips it might also be possible to tag other species of interest, such as sharks and billfishes. It was noted that although that would be ideal, it might not be possible in practice because the species of interest for the different groups may not co-occur in the same spatial-temporal areas. The Group agreed that this would be an interesting approach, and that a detailed budget and proposal should be prepared by September for the Species Group meeting.

It was noted that there are also plans to request funding for dedicated trips to areas with gaps in biological sampling, such as the Sargasso Sea, which is likely a spawning area for swordfish in the Atlantic, and the eastern Mediterranean. In those cases, the priorities would more likely be sample collection (i.e., spines, otoliths, genetic tissue, and gonads), but it could also be a good opportunity to deploy satellite tags. It was also noted that if it were possible to combine this with other species, this would be a more efficient use of funding.

There was a question regarding the priority areas for future tagging. The Group mentioned that priority areas should continue to be the mixing zones, namely the equatorial area and the mixing area between the Mediterranean and Atlantic stocks, as tagging in those areas could allow for tracking of individuals from feeding to spawning areas. Other areas of interest are zones where fewer tags have been deployed, such as the Mediterranean and the South Atlantic. Additionally, the central North Atlantic would also be important, as well as possibly deploying some of the newer tags in the northwest Atlantic, as there are tagging teams there with

the required experience and possibilities. The Group also showed interest in deploying tags in the mixing area between the Indian and the Atlantic Ocean.

Finally, the Group agreed that there was interest in planning for capacity building workshops for tagging, to try to include other scientists/fleets from other nations that may be interested in participating but do not yet have the knowledge and experience in tagging to do so. This was done recently in southern Brazil, with training provided by Uruguayan scientists, and has been very successful because there are now ongoing tagging activities of sharks and swordfish in southern Brazil. Another important area for the next phase of such training workshops could be the East and North African countries in the Mediterranean.

3.3.1 Project Phase 6 planning

The objectives for Phase 6 and the associated TORs were briefly reviewed. Phase 6 of the programme will involve continuing with work on ageing and growth patterns, reproduction and maturity, and genetic analysis to resolve stock boundaries and mixing. There will be a special emphasis on filling spatial-temporal gaps. In addition, the programme will complete age validation work and explore the use of close kin mark recapture techniques and epigenetic ageing.
It was noted that the funder prefers samples collected within a funding phase to be processed within the same project phase. It was noted this is not always possible due to the sampling and processing times.

The need for a detailed table or summary highlighting sampling gaps was noted. Such a table could be used to identify areas and times where there are too few samples. This analysis should also consider the effort taking place in those areas; if there is no effort, this area/time could be identified as requiring a dedicated sampling survey. If a fleet is identified to be operating in that area/time, it could be directly contacted as regards availability to collect samples.

The Group noted that sampling in some areas can be lacking if observers are not allowed onboard for CPCs where this is voluntary, and also if the observer does not cover the full spatial effort of the fleet. Sampling can also be hampered in cases where the fish will be damaged by the sampling process, as the current compensation scheme does not cover buying the whole fish. Funding is also available in Phase 6 for an analysis to check the feasibility of Close-Kin Mark-Recapture (CKMR) for swordfish, such as analysing the characteristics of stocks and size distribution of catch to inform sampling needs.

4. Northern Swordfish Management Strategy Evaluation

4.1 Overview of progress

The Chair presented a comprehensive overview of the current state of SWO-N MSE development and the next steps, highlighting the needs and decision points identified during the recent meeting with Panel 4 (SCRS/2023/095). The current framework uses the 2022 stock assessment (Stock Synthesis 3) (Anon., 2022) to simulate alternative reference set OMs with two key axes of uncertainty that structure the reference grid natural mortality (M) and steepness (h).

Three additional OMs have been defined as robustness tests, including increased recruitment variability (sigmaR) increased from 0.2 to 0.6, turning off the length composition data (model fit to CPUE only), and increased catchability over time (1%/year). The Group discussed the revised set of performance metrics (**Appendix 5**), limit reference point, and tuning metrics.

The Chair presented the revised timeline and workplan, highlighting the quick timeframe needed to meet the stated goals. The annual work plan included 2 MSE ambassador stakeholder outreach meetings, 3 dialogues with Panel 4, 2 SCRS technical team workshops, and the swordfish Species Group's intersessional and annual meeting. The technical team anticipates presenting the final tuned Candidate Management Procedures (CMPs) to the swordfish Species Group in September, at which time the Group will select a final set of CMPs to present to Panel 4.

4.2 Interactions with Panel 4

After feedback from the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish MSE in March 2023, the SWO MSE technical team made important updates to the MSE (SCRS/2023/P/074). Panel 4 requested several additions to the MSE OM structures. These included:

- A request of Panel 4 was to evaluate climate change scenarios or changing environmental conditions on CMP performance.
    - The Group discussed a proposal to incorporate non-stationarity in recruitment in the MSE projections as a robustness test to address this request. Several scenarios were outlined and discussed. It was agreed that the variable recruitment scenarios are informative for understanding CMP performance under changing productivity scenarios, specifically addressing the potential for higher, lower, or more variable recruitment.
- The Group also discussed the request to evaluate alternative minimum size limits.
    - To address this, the Group recommended a robustness test where the reference set OMs were run with the minimum size limit in place and versions of the reference set OMs where the size limit would be turned off in the projection period.
- The Group also concluded that catch under-reporting scenarios (IUU) could be included in the robustness tests.

The Group encouraged those interested to join the communications team, given the short turnaround time between Species Group and Panel 4 meetings, and the amount and depth of information to be synthesized. The communications team will prepare material in advance of the SCRS Species Group meetings, for review and revision prior to Plenary. It is expected that having draft materials prepared will allow adequate time to incorporate necessary changes in time for Panel 4. The SCRS Chair encouraged all technical experts to review in advance and participate in MSE technical team meetings to address any potential issues well in advance of the September meetings.

4.3 Key MSE Decision Points

The MSE technical expert presented recent revisions to the MSE and current parameterization (SCRS/P/2023/063). The expert highlighted a set of key decision points for the Group about steepness assumptions. The Group reviewed the 2022 assessment's (Anon., 2022) prior distribution of steepness and the posterior likelihood profile presented in Figure 1 of SCRS/2023/095. Key decisions were as follows:

- The Group agreed to moving the steepness = 0.60 scenario from the reference grid to the robustness tests, this decision was made because 0.60 was outside the prior distribution and posterior likelihood profile and therefore was considered by the Group not to be a plausible value.
- The Group also agreed to maintain three steepness scenarios to be included in the reference grid.
- The Group agreed the upper and lower values for steepness to be included in the Reference grid were to be determined from analysis in SCRS/2023/095 (Figure 1) which provided the 2.5th and 97.5th percentile of the prior distribution of steepness used in the 2022 stock assessment (Anon., 2022) (0.69 to 0.88).
- The Group agreed to use the Compensation ratio (Goodyear, 1980) to calculate the middle value between the 2.5th and 97.5th percentiles (h= 0.80).

The technical expert indicated that the nine reference OMs (**Table 8** – list of all nine OMs configurations) would need to be reconditioned using the modified steepness values.

4.4 Data Inputs

The MSE technical expert presented a summary of MSE data inputs, model fits to indices, and index assumptions in the MSE (SCRS/2023/P/064). The expert summarized the statistical properties of OM fits to the overall combined index as well as the individual indices, and described the methods used for projecting indices. The indices of abundance are the primary source of information for all current CMPs, including empirical and model-

based. The expert also provided guidance to CMP developers in selecting/using indices, specifically consideration of index observation error and autocorrelation in selection of CMP inputs.

A key decision point was raised on selection of the historical period in which to calculate the standard deviation and autocorrelation for the "combined index" that will be applied to the predicted values of the index in the projection period. The current methodology uses the entire time series, but the Group discussed truncating the early period prior to 1999, which occurred prior to modern surveys and for which there were fewer data to input into the combined index. The Group decided to model the period between years 1999 and 2020 in defining the index's statistical properties for projection purposes. The Group discussed dealing with this issue for the longer CPUE time series; this was left to the technical team to review and possibly to include something after the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish on MSE in June 2023, when more time is available for considering the approaches.

Several important notes regarding the combined biomass index were highlighted. It was noted that the overall combined index is not fit directly in the OMs, but is informative when plotted in comparison to each OM predicted biomass as a model diagnostic.

4.5 Review of Performance Metrics reports

Presentation SCRS/P/2023/065 gave an overview of performance metrics developed for the North Atlantic Swordfish MSE. These included metrics within the classes of Status, Safety, Yield, and Stability (**Table 9**). For status, the metrics included the probability of being in green zone ($SB>SB_{MSY}$ & $F<F_{MSY}$) of Kobe plot (PGK) for different years in the simulation period, the probability of overfishing ($F>F_{MSY}$) in all years (POF), and the probability of not overfishing (PNOF) ($F<F_{MSY}$) over all years. For safety, metrics included the probability of breaching the limit reference point ($SB<0.4SB_{MSY}$) at any one point for different combinations of years in the simulation period limit reference point (LRP) and the probability of not breaching the LRP ($SB>0.4SB_{MSY}$) (nLRP). For example, if the LRP metric was calculated over the time period 2024-2033 (LRP_short), a simulation would fail if at any point during 2024-2033 the $SB<0.4SB_{MSY}$. For yield, metrics include the Total Allowable Catch (TAC) in the first implementation year (TAC1), the median TAC over years 1-10 (AvTAC10), and median TAC over years 11-30 (AvTAC30). Finally, for stability, metrics included the median variation in TAC (%) between management cycles over all years (VarC) and the maximum variation in TAC (%) between management cycles in all years (MaxVarC).

The Group discussed the optimal formulation of the LRP metrics, specifically whether they should be calculated as a failure if at any point during the projection period the $SB<0.4SB_{MSY}$ or instead if individual years $SB<0.4SB_{MSY}$ would be counted as failures (and conversely years $SB>0.4SB_{MSY}$ would be successes) within a simulation. It was ultimately determined that from the Report of the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE), the requested metric was as described in SCRS/P/2023/065, that if at any point during the projection period the $SB<0.4SB_{MSY}$, that simulation would be counted as a failure for LRP.

The Group inquired whether median TAC metrics are calculated using TAC or actual catches. The author clarified this metric is calculated using TAC but could also produce metrics and plots for catches if necessary. The Group also inquired whether the TAC is meant to represent retained catch and if the probability of overfishing is based on both catch and dead discards. The author confirmed that yes, the TAC represents the retained catch allowable, and that the probability of overfishing is based on both catch and dead discards.

The Group noted that the variation in TAC plots would be better represented using violin plots showing the variation in TAC over the time series for a CMP.

The Group inquired whether it would be prudent to consider fixing the 2021 and 2022 indices at their estimated values, which will affect starting TAC. The author noted that this should be done once the data are made available and processed. However, this does not need to be in place before the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE) (30 June 2023) and can be addressed leading up to the September 2023 Species Group meetings.

The Group discussed whether PGK_10 may be omitted. There was some objection to this and it was decided to keep for the time being, at least for the SCRS to examine, however many of the metrics would likely need to be paired down for each category when presenting to Panel 4.

4.6 CMP development and tuning

Presentation SCRS/P/2023/066 was given on the development and tuning of Candidate Management Procedures (CMPs) for the North Atlantic Swordfish MSE. An example tuning procedure was shown for a 6 Operating Model (OM) grid using PGK_6-10 (years 2029-2033) with a target of 0.6 as the tuning metric. This produces a 60% probability of being in the green quadrant of the Kobe matrix across years, simulations, and OMs. Examples of 5 different CMPs that are currently developed were then shown (**Table 10**). These included 2 based on surplus production models (SMPs) (1 Shaefer, 1 Fox), 2 CMPs based on ratios of the combined index (where the TAC is iteratively adjusted in each management cycle based on the ratio of the mean combined index either over the last 2 or 3 years compared to the combined index over the previous 2 or 3 years), and one based on a constant exploitation rate (current rate calculated as the mean of catches from 2016-2020 divided by the mean combined index over the same period).

The Group discussed the timeframes of performance metrics and which years are incorporated in each of the "short", "medium" and "long" term statistics. The results presented at the meeting and tunings were based on the definitions of short, medium and long term used before the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE) (Anon. 2023), (6 March 2023). The panel requested performance metrics for Status, Safety, and Yield was defined as: short = years 1-10, medium = years 11-20, and long = years 21-30. The Group recognizes this request and will include these as performance metrics moving forward.
The Group inquired as to why in some of more productive OMs appeared to have a higher biological risk compared to less productive OMs. The author noted this was likely due to observation error for the combined index being higher in these scenarios (high Autocorrelation (AC) and Standard Deviation (SD) in the index). This was due to the model fitting better to the combined index with lower steepness, thus resulting in less variable residuals and better performance of CMPs that use the index.

It was noted that the CMP shown for the tuning example appeared to pass the safety metric in terms of infrequently breaching $0.4B_{MSY}$. The author commented that it was likely that satisfying PGK is a more limiting factor. The Group commented that if, under the new OMs, tuning to the PGK_6-10 does not satisfy the safety metric, tuning to the LRP metric will be required.

The Group inquired whether the F_{MSY} and B_{MSY} values were recalculated every management cycle for the SPM CMPs and whether the trend in B_{MSY} in the CMP could be provided for comparison with the biomass trend from the OM. The author noted that yes, this was accounted for in the surplus-production based CMPs and that the biomass trend from the CMP could be provided.

The Group inquired as to why, in the index ratio method, does the denominator change for each management cycle? The author noted that this was simply a choice and could also be made relative to some fixed point in the past.

The Group inquired as to what occurs in the empirical CMPs if the stock starts in an overfished state. It was noted that the tuning factor should result in beginning at PGK60 across OMs.

The Group noted that the tuning ratio appeared to change drastically for the 2 versus 3 years index ratio methods (0.79 versus 1.21) and inquired why this change was so large. The author noted that they would look into what was going on in these situations.

The Group noted that in some of the SPM CMPs the TAC seemed to not increase above 14 kt across all simulations, even in simulations where B/B_{MSY} increased above 2.0 and F/F_{MSY} was also well below 1.0. The author noted that they would look into what was going on in these situations.

4.7 Review of preliminary results of CMP performance

SCRS/P/2023/067 presented the preliminary MSE results across the CMPs. Tested CMP are listed in **Table 10**. In general, model based and empirical CMPs provided similar performance. However, SP2_a (surplus production Fox model using the combined index) demonstrated the highest performance across the current OMs. Points for consideration included selection of a single tuning timeframe (i.e., medium (6-10) versus long-term (11-30) PGK) and including asymmetrical increases versus decreases in TAC.

Based on the comparison of performance metrics, it was clear that PGK30 (PGK in year 30) did not meet near or long-term objectives, and therefore the Group recommends removing this scenario from further consideration. Comparison across the years 6-10 versus years 11-30 PGK tuning targets demonstrated that tuning to the years 6-10 also resulted in meeting the long-term objectives but tuning to target years 11-30 failed to meet the medium-term objectives. This pattern was observed across all CMPs. Therefore, the Group recommended tuning to years 6-10 targeting PGK probabilities of 51%, 60%, and 70% for comparison of performance metrics across CMPs. Further noted was a set of MP time frames suggested by Panel 4 (short: 1-10; medium: 11-20; long: 21-30). The technical team would need to evaluate these time frames to determine whether they are appropriate tuning targets.

4.8 Discussion on MSE development next steps

4.8.1 Panel interactions including Slick tool

The MSE expert demonstrated the features of the Slick Shiny App, an interactive tool for viewing results of the North Atlantic swordfish MSE. The Group provided significant feedback on how to improve the app to best present results to Panel 4, and the MSE expert will revise Slick accordingly.

It was suggested that the MSE expert consider creating a winnowed down, executive summary-type Slick object for managers, perhaps with only one performance metric per management objective. The Group discussed whether it is appropriate for the SCRS to propose to Panel 4 specific performance metrics to prioritize, or whether all metrics should be included so Panel 4 can view which they think are most important. The concern is that showing all results could be overwhelming.

The individual Slick plots were also discussed. The Kobe Time and violin plots were thought to be most informative. The Line plots were also highlighted, and it was requested to add an option to display a projection of yield. The Group cautioned that spider plots can be misleading based on how the metrics are scaled and since they assume all metrics are equally weighted. If spider plots are shown, clear disclaimers must be included.

The Group reviewed and amended the draft Panel 4 agenda. It was noted that the summary and decision documents produced for the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE) (Anon. 2023) in March 2023 were well received. A single updated summary document will be produced for the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE) in June 2023. The Group identified the key decision points for the meeting, including operationalizing management objectives, refining key performance metrics, and determining whether to apply a minimum TAC change between management cycles (for logistical reasons to reduce management burden).

Other important decisions were discussed that can be made at a later date, including CMP culling, tolerance for asymmetrical TAC changes where larger TAC decreases are acceptable, and the CMP review period (e.g., after 3 cycles).

4.8.2 Ambassador sessions

There will be ambassador sessions before each Panel 4 meeting for the remainder of 2023. The First N-SWO MSE Ambassadors Webinar one is scheduled for 12 June 2023. There will be one session in English without interpretation and one in Spanish with Spanish-to-French interpretation. The ambassadors will present the background and structure of the MSE, as well as qualitative preliminary results. The quantitative MSE results updated for the new reference set of OMs and CMP tuning will not be available until the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE) on 30 June 2023.

4.8.3 CMP development

The Group discussed in detail the tasks that must be completed prior to upcoming meetings to stay on track to finalize the MSE by the September SCRS Plenary meeting. The MSE expert encouraged participants to contribute new CMP types for testing. The Group agreed not to update the MSE with the new length composition data because it would require a major, time-consuming model update, and it is unlikely to be influential on relative CMP performance.

To prepare for the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE), the following tasks must be completed by 16 June 2023:

1. By 29 May 2023: Condition 9 new reference OMs.
2. 29 May - 2 June 2023: Develop new CMPs, if any. Include one variant with no stability restriction.
3. 29 May – 2 June 2023: Import new OMs into MSE framework (fix the way the deviations are calculated for recent years in the combined index).
4. 29 May 2023 – 2 June 2023: Convergence test to determine appropriate number of simulations.
5. 5-9 June 2023: Tune all CMPs to the following objectives:
   - $PGK_{6\text{-}10}$=0.6
   - LRP=0.15 [Only if 0.15 LRP satisficing criteria not met based on $PGK_{6\text{-}10}$ tuning]
   - Tune at least 1 CMP (with and without 25% stability cap) to
     - $PGK_{6\text{-}10}$=0.51
     - $PGK_{6\text{-}10}$=0.7
     - LRP=0.15 [Only if 0.15 LRP satisficing criteria not met based on $PGK_{6\text{-}10}$ tuning]
     - LRP=0.1 [Only if 0.1 LRP satisficing criteria not met based on $PGK_{6\text{-}10}$ tuning]
     - LRP=0.05 [Only if 0.05 LRP satisficing criteria not met based on $PGK_{6\text{-}10}$ tuning]
6. Update the Trial Specifications Document, including description of robustness OMs (robustness OMs will not be conditioned by June 2023).
7. Update performance metrics (check yield in trade-off plot).
8. Produce figures:
   - Trade-off (PGK vs. TAC; LRP vs. TAC; include error bars)
   - Kobe time
   - Line (SSB & yield)
   - Something for stability (should be seen in the time-series plot for yield, violin plots of change in TAC)
9. Revise Slick (e.g., add yield to line plots), and create updated Slick object.
10. Delete OM diagnostic reports from old reference set.

The following additional tasks will be completed by the Second Intersessional Meeting of the North Atlantic Swordfish MSE Technical Sub-group (4-5 September 2023):

1. Respond to the input of the Second Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE).
2. Compare stock status from the OM dynamics to the SP estimates.
3. Update OM diagnostic reports for new reference set.
4. Condition robustness OMs, potentially prioritizing climate change OMs.
5. Test highest performing CMPs with a 4-year management cycle.

6. Update combined index (which uses all raw data rather than all indices) with 2021 and 2022. The Chair will obtain the raw data from CPC scientists. Adding more recent data is desirable because it will result in a shorter data lag (e.g., if 2022 data are included and the MP is implemented in 2024, that is considered a 2-year lag). These data should be provided by August 2023.

Updating individual CPC indices through 2022 will only be necessary if individual indices are used in CMPs. For updating, CPUE models will be refit with new data but using the same model. This would also require a commitment from the relevant CPC to update the index for MP application and an effort by the MSE expert to examine observation error by index. Any updated index will need to be presented to the SCRS in September 2023.

5. Closed-loop simulation study for South Atlantic swordfish

SCRS/P/2023/070 summarized a set of southern Atlantic SWO closed-loop simulations. OMs for the southern stock were parameterized by fitting open MSE's Rapid Conditioning Model to catch, indices, and length-composition data for the southern stock. For the Beverton-Holt steepness (Mace and Doonan, 1988) and von Bertalanffy growth parameters, OMs used the output from a multi-variate prior on steepness defined in Taylor *et al*., 2022a. Ten MPs were tested that included surplus production models, delay-difference, and age-structured models. To illustrate an option for MPs selection from among these MPs, the analysis used a satisficing criterion that selected MPs that avoided the 40%B_{MSY} LRP with 90% probability, where the probability of being in the green quadrant was more than 50%, and where the catch was at least 50% of the reference catch (a proxy for MSY). The presentation proposed an additional set of candidate OMs to test. These included: an axis for different prior choices, fitting steepness or just keeping multivariate prior, and the choice of steepness cluster. The presentation also emphasized the need to clarify what the overall objectives of the southern Swordfish MSE are i.e., if there is a plan to implement an MP soon or to develop simulations for southern swordfish slowly with a plan to implement an MP in the longer term.

The Group discussed the presentation. They asked how the data sources for each MP were specified in the code, noting that which indices are used in model fitting must be specified in custom MPs. It was also noted that there might be value in using the approach applied to the Southern stock for the Northern stock to determine if results were comparable in terms of MP ranking. In response, it was noted the while the architecture of the computer code that was applied to southern swordfish was identical to the North, the approach for parameterizing OMs was different. Therefore, it would be reasonable to expect some differences in the results.

The Group also discussed the scope of the southern swordfish MSE. The Group recognized the relevance of this study for the southern stock, as this type of study can help address some of the inherent uncertainties of stock assessment, particularly in evaluating the performance of model-based MPs. In this regard, the Group reviewed the need for the study's continuation and determined that the work should be continued based on the work already completed. They noted that SCRS has latitude to undertake projects that they deem important but that given the amount of work currently underway on other stocks, a more practical way to move forward would be to continue some slow development on the closed-loop simulations that might be considered for application in the future.

6. Responses to the Commission

The Group reviewed the two requests from the Commission. Both responses will be further developed once additional analysis is has been completed for the September Species Group meeting.

7. Recommendations

Recommendations without financial implications

The Group recommends that the SCRS develop a shared online ICCAT hosted ageing software. SmartDots (ICES, 2020) developed by ICES has been used for swordfish and discussed as an example for such platform. It was further noted that Canada is also developing a platform based on SmartDots. This software could be used by other ICCAT Species Groups.

Noting that there is a seasonality of the catch of undersized swordfish in the Mediterranean and that undersized swordfish are subject to large post-release mortality and that there is concern that the measure is not effective, the Group recommends exploring impacts of:

1) Removing or adjusting the minimum size limit.
2) Shifting the timing of the current temporal closure during the period of high catch of undersized fish.

Given the importance of including discards (dead and alive) in the reported catch, the Group recommends developing and adopt standard methods for raising observed discards to the total effort and that these be reported in Task 1 data. The Group recommends that fleets fishing where sampling gaps still remain collaborate with the SWOYP to provide samples that will address current uncertainties related to the assessment of the three swordfish stocks.

Given the increase in availability of the spatial data by sex, the Group recommends assessing the sensitivity of stock status to introducing the use of age-sex keys in the population model.

The Group recommends comparing the methods used to generate swordfish electronic tagging tracks.

Noting the importance of properly stored and labelled historical samples, the Group recommends that a plan for long-term archiving of biological samples be created for SWOYP.

The Group continues to note that there is a general lack of reported discard data by most CPCs, which is important to inform the stock assessment and ongoing MSE work. As such, the Group recommends national scientists to use their domestic observer programmes information to estimate dead discards and live releases. The estimates should go back in time as far as possible.
Furthermore, the Group recommends that the submission of size samples to the ICCAT Secretariat, as part of the CPCs Task 1 and 2 data submission obligations, be completed using the ST04-T2SZ statistical form. Size samples reported with the ST04-T2SZ form shall include all samples collected by the CPC from all fisheries and size samples of dead and live discards (when applicable) collected by its National Observer Programme. This recommendation does not preclude CPCs from the optional reporting of size samples collected by their National Observer Programme using the ST09-DomObPrg form.

The Group recommends that CPCs make available biological samples from their fisheries to the SCRS. The SCRS relies on biological samples (e.g., fin spines/otoliths for determining age structure; tissue for close kin and stock mixing analysis, gonads for estimating maturity and fecundity) to estimate the status of ICCAT stocks and make science and management recommendations. The Group stresses that it has been difficult obtaining these samples from CPCs and that they are vital to producing scientifically robust stock assessments. Within this sampling requirement should be an allowance for sampling by onboard observers on undersized swordfish in the Mediterranean that are dead at haulback.

Recommendations with financial implications

The Group recommends revising and updating the Longline section (chapter 3.1.2) of the ICCAT Manual, that was last updated in 2014. This concerns most of the Species' Groups in ICCAT, as multiple species are captured in the various methods under longline fisheries. The Group will prepare a budget for this work to be presented

by September 2023 to the Swordfish Species Group. If accepted, such budget could be shared by the several Species Groups of concern (€3,000).

Biology and stock structure study - Swordfish Year Program (SWOYP) (this recommendation applies to both the North and South Atlantic and Mediterranean stocks): An understanding of the species biology, including age, growth and reproductive parameters, as well as stock structure and mixing is crucial for the application of biologically realistic stock assessment models and, ultimately, for effective conservation and management. Given the current uncertainties that still exist, the Group recommends as high priority to continue biological studies on swordfish. An ICCAT project on swordfish biology, genetics and satellite tagging started in 2018 and the Group recommends that the project continues for 2024 and is provided with financial support. The Group further recommends the use of a multistock research cruise to fill spatial-temporal samples gaps that are common among ICCAT Species Groups.

Several of the following activities will be funded through the 2023 ICCAT science budget, however, there are cases where additional budget will be needed, detailed below:

- Satellite tagging work: to cover expenses with deployments of previously acquired tags and some tagging equipment (tagging poles, etc.), consider the possibility of dedicated trips for tagging.
- Reproduction: ongoing work processing and analysing of gonads.
- Age and growth: finish processing spines and otoliths collected under previous phases; continuation of a bomb-radiocarbon age validation study.
- Genetics: continued population analysis of tissues samples for stock differentiation; continuation of a study on epigenetic ageing, to be completed in conjunction with the bomb radiocarbon study.
- A study on the viability study of close-kin mark recapture project to develop a fishery independent index of abundance.
- Biology technical workshop: 7-8 participants plus 2 experts (workshop should be scheduled as 5 in-person days).
- Sampling and shipping (priority on missing areas/sizes as defined in the project summary)
- MSE for N-SWO: (priority: high). The Species Group is scheduled to provide a final set of CMPs to the Commission in 2023. Additional technical work is needed in 2024 to develop an exceptional circumstances document and continue development of operating model robustness tests.

The Group recommends that further closed loop analyses be developed in 2024 for the South Atlantic stock. Thus, an expanded set of closed-loop simulations be conducted for the southern swordfish stock using OMs tailored to that stock. While the work will be predominantly done by CPC scientists and the ICCAT Secretariat, a contractor will review the simulation setup and code.

8. Review of terms of reference for research activities

No terms of reference were reviewed. Terms of Reference will be reviewed by the Species Group during the annual meeting in September 2023.

9. Other matters

No other matters were discussed.

10. Adoption of the report and closure

The report was adopted, and the meeting was closed. The Summary for the SCRS Plenary meeting will be circulated by the Chair for adoption.

References

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Table 1. Total swordfish catches (t) available in T1NC by stock, major gear group, catch type (L, DD) and year, for the period 1950 to 2021.

	SWO-N					SWO-S					SWO-M					TOTAL
	Longline		Other surf.		Total	Longline		Other surf.		Total	Longline		Other surf.		Total	
Year	L	DD	L	DD		L	DD	L	DD		L	DD	L	DD		
1950	1445		2201		3646			100		100	586				586	4332
1951	966		1615		2581			200		200	580				580	3361
1952	966		2027		2993			200		200	337				337	3530
1953	1203		2100		3303			200		200	501				501	4004
1954	305		2729		3034			100		100	452				452	3586
1955	619		2883		3502			100		100	340				340	3942
1956	374		2984		3358	1		0		1	393				393	3752
1957	1010		3568		4578	124		100		224	395		250		645	5447
1958	875		4029		4904	92		0		92	414		500		914	5910
1959	1428		4804		6232	71		100		171	401		200		601	7004
1960	1042		2786		3828	359		100		459	403		112		515	4802
1961	2060		2321		4381	816		200		1016	500		112		612	6009
1962	3202		2140		5342	769		0		769	591		112		703	6814
1963	9193		997		10190	1418		0		1418	498		224		722	12330
1964	10833		425		11258	2030		0		2030	686		112		798	14086
1965	7759		893		8652	2578		0		2578	1423		337		1760	12990
1966	8503		846		9349	1952		0		1952	1192		560		1752	13053
1967	8679		428		9107	1577		0		1577	869		448		1317	12001
1968	8985		187		9172	2348		100		2448	2570		870		3440	15060
1969	9003		200		9203	4281		200		4481	3313		410		3723	17407
1970	9484		94		9578	5426				5426	2993		348		3341	18345
1971	5243		23		5266	2164		2		2166	4496		479		4975	12407
1972	4717		49		4766	2580				2580	5399		5761		11160	18506
1973	5929		145		6074	3078				3078	4362		4373		8735	17887
1974	6267		95		6362	2753				2753	4564		5149		9713	18828
1975	8778		61		8839	3062				3062	3888		4635		8522	20423
1976	6663		33		6696	2812				2812	4318		5226		9544	19052
1977	6370		39		6409	2840		15		2855	4838		5208		10046	19310
1978	11125		702		11827	2829		17		2846	5186		6141		11327	26001
1979	11177		760		11937	3374		29		3403	5200		5455		10655	25995
1980	12831		727		13558	5287		144		5431	6230		5717		11947	30937
1981	10583		614		11197	4039		37		4076	6450		5334		11784	27056
1982	13023		192		13215	6364		83		6447	6112		4086		10198	29860
1983	14062		501		14563	5383		109		5492	6313		4383		10696	30751
1984	12664		169		12833	8986		242		9227	6709		6957		13666	35726
1985	14240		143		14383	9224		362		9586	7169		8125		15294	39263
1986	18283		203		18486	4982		912		5894	8166		8599		16765	41145
1987	20029		209		20238	5797		233		6030	8776		9544		18320	44589
1988	19126		399		19525	12602		570		13172	10250		10115		20365	53062
1989	15554		1707		17261	16573		482		17055	7875		9887		17762	52078
1990	14215		1457		15672	16705		600		17305	7346		8671		16018	48994
1991	14276	215	443		14934	13496		397		13893	7365		8381		15746	44573
1992	14356	383	655		15394	13422		391		13813	7631		7078		14709	43917
1993	15804	408	526		16738	15739		391		16130	7377		5888		13265	46133
1994	14365	708	428		15501	17839		1119		18958	8985		7097		16082	50542
1995	15864	526	715		17105	21584		347		21931	6319		6696		13015	52051
1996	13822	562	812	26	15222	17859	1	429		18289	5884		6169		12053	45564
1997	12204	439	370	12	13025	18299	21	222		18542	5389		9304		14693	46260
1998	11062	476	782	9	12329	13748	10	269		14027	6674		7695		14369	40725
1999	10717	525	376	4	11622	14823	6	672		15502	6223		7476		13699	40823
2000	9922	1137	393	1	11453	15448	1	278		15728	7129		8440		15569	42750
2001	8678	896	432	6	10011	14302	0	826	0	15128	7498		7508		15006	40145
2002	8799	607	240	8	9654	13576	0	527		14104	8042		4772		12814	36572
2003	10334	618	486	5	11444	11714	0	920		12634	10748		4945		15694	39771
2004	11410	313	341	7	12071	12558	1	523		13082	10877	9	3519		14405	39558
2005	11531	323	516	10	12380	12915		248		13163	10954	113	3555		14622	40166
2006	10896	215	409	8	11528	13984		212		14196	11323	16	3576		14915	40639
2007	11478	273	546	8	12306	15318	91	221		15629	11113	19	3094		14227	42162
2008	10394	235	465	9	11102	11980	6	384		12370	11479	1546	658		13683	37155
2009	11504	151	485	7	12146	12301		368		12668	11020	1396	819		13235	38050
2010	11077	148	441	5	11672	12087	147	361		12596	11918	1488	1347		14754	39021
2011	11796	392	511	9	12709	10854	74	277		11205	10288	1191	1162	0	12640	36555
2012	12976	391	512	10	13890	10255	140	291		10686	9131	1133	782		11046	35622
2013	11366	199	513	0	12078	8958	0	246		9204	9047	973	49		10070	31352
2014	10089	156	463	0	10708	9736	46	189		9970	9718	1168	83	0	10969	31646
2015	10194	167	391	0	10752	10047	43	254	0	10345	10675	1230	78		11983	33080
2016	9913	105	483	0	10501	10461	2	148		10611	10878	1369	53		12300	33412
2017	9462	149	684	0	10295	10281	111	145	0	10537	8345	1988	57		10390	31223
2018	8401	152	472	0	9025	10323	26	27	1	10378	6938	1682	61	0	8681	28084
2019	9340	304	600	0	10244	9975	50	57		10081	8041	89	45		8176	28501
2020	9752	113	587	0	10451	8814	57	93	0	8964	7603	0	60	0	7664	27079
2021	9130	98	517	1	9747	9350	128	33		9511	7258	188	66	0	7512	26770

Table 2. Total swordfish live releases (t) reported (classified in T1NC with the code "DL") by stock, flag CPC, major gear group, and year (1950 to 2021).

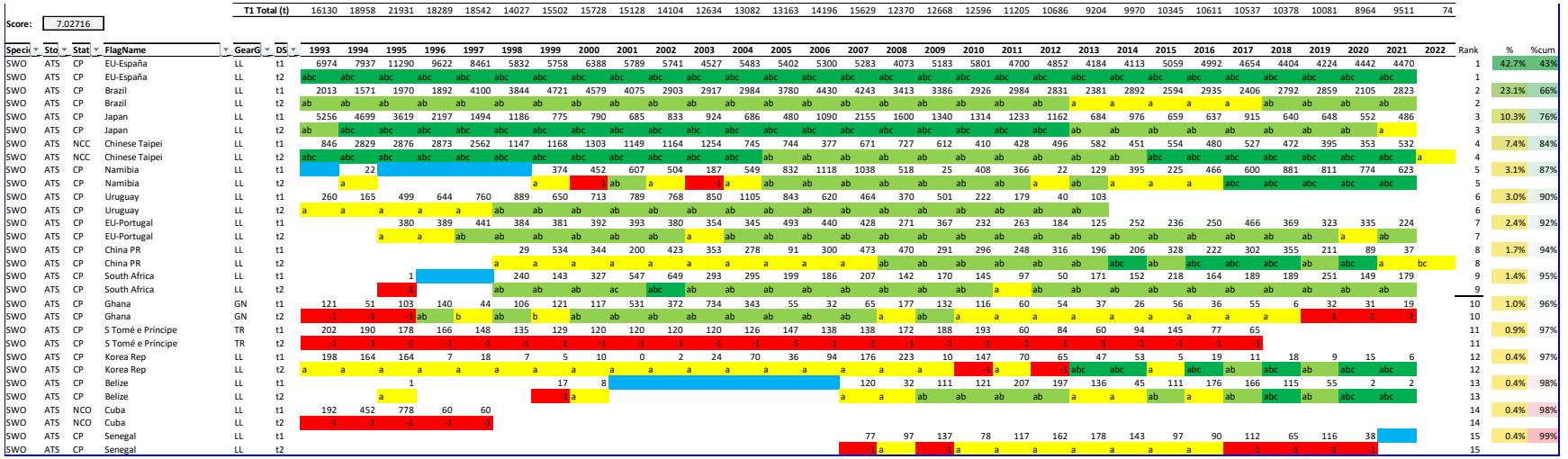
Stock	FlagName	GearGrp	2004	2006	2007	2008	2009	2000	2001	2002	2003	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SWO-N	Canada	HL																						0
		HP														0			0					
		LL														0		29	20	30	10	9	10	10
		TL																						0
		TW																0	0	0	0		0	
	Curaçao	PS																		0				
	EU-España	PS																		0				
	Korea Rep	LL																	0	0				0
	Mexico	LL		1	0	0	0						1	0	0	0	0	0	0	1	1	0	1	1
	UK-Bermuda	LL												0		0	0		0			0	0	0
	UK-British Virgin Islands	HL														0								
		HS														0								
		LL													0									
	Trinidad and Tobago	LL												0	0	0			0	0				
	Maroc	GN															0							
		HL															0		0	0				
		LL															0		0	0				0
		PS															0							
		TP															0							
	Saint Kitts and Nevis	TR																0		0				
	St Vincent and Grenadines	LL																	0					
	Japan	LL	339					331	329	224	133	123												0
	Senegal	GN															0							
	USA	LL																	27	33	73	22	35	51
	Guatemala	PS																		0				
	Guyana	LL																						0
	Total		339	1	0	0	0	331	329	224	133	123	1	0	0	0	0	29	47	64	84	31	45	63
SWO-S	Curaçao	PS																		0				
	EU-España	PS																		0				
	Korea Rep	LL											10						0	0				0
	St Vincent and Grenadines	LL																	0					
	Japan	LL																						0
	Brazil	LL			54	3																		
	South Africa	LL														0	0							
	Guatemala	PS																		0				
	Total				54	3							10			0	0		0	0				0
SWO-M	EU-España	LL																	3		15			
	Libya	LL																		0				0
	Maroc	GN															0							
		HL															0							
		LL															0			0				0
		PS															0							
		TP															0							
	Japan	LL																						0
	EU-Cyprus	LL												0		0								0
	Total													0		0	0		3	0	15			0
TOTAL			**339**	**1**	**55**	**3**	**0**	**331**	**329**	**224**	**133**	**123**	**11**	**0**	**0**	**0**	**0**	**29**	**51**	**64**	**99**	**31**	**45**	**63**

Table 3. SWO-N standard SCRS catalogue on statistics (Task 1 and Task 2) for the last 30 years (1993 to 2022). Only the most important fisheries (representing ±97.5% of Task 1 total catches) are shown. For each data series, Task 1 (DSet= "t1", in t) is matched against its equivalent Task 2 dataset (DSet= "t2") availability scheme. The Task 2 scheme has a concatenation of characters ("a"= T2CE exists; "b"= T2SZ exists; "c"= T2CS exists) that represents the Task 2 joint dataset availability in a given year, flag and gear. The SWO-N overall score for the last 30 years (this catalogue) is also shown. Shaded blue cells (DSet= "t1" only) could indicate missing catches.

Score: 7.89394

Speci	Sto	Stat	FlagName	GearG	DS	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Rank	%	%cum
			T1 Total (t)			16738	15501	17105	15222	13025	12329	11622	11453	10011	9654	11444	12071	12380	11528	12306	11102	12146	11672	12709	13890	12078	10708	10752	10501	10295	9025	10244	10451	9747	0			
SWO	ATN	CP	EU-España	LL	t1	6392	6027	6948	5519	5133	4079	3993	4581	3967	3954	4585	5373	5511	5446	5564	4366	4949	4147	4885	5620	4082	3750	4013	3915	3586	3186	3112	3587	3235		1	38.4%	38%
SWO	ATN	CP	EU-España	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		1		
SWO	ATN	CP	USA	LL	t1	4044	3960	4452	4015	3399	3433	3364	3316	2498	2598	2757	2591	2273	1961	2474	2405	2691	2204	2572	3347	2812	1816	1593	1389	1301	1106	1456	1150	944		2	21.3%	60%
SWO	ATN	CP	USA	LL	t2	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		2		
SWO	ATN	CP	EU-Portugal	LL	t1	1950	1579	1593	1702	902	772	776	731	731	765	1032	1319	900	949	778	747	898	1054	1202	882	1438	1241	1420	1459	1871	1670	2346	2044	2076		3	10.6%	70%
SWO	ATN	CP	EU-Portugal	LL	t2	ab	ab	ab	ab	ab	ab	ab	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab		3		
SWO	ATN	CP	Canada	LL	t1	2206	1654	1421	646	1005	927	1136	923	984	954	1216	1161	1470	1238	1142	1115	1061	1182	1351	1502	1290	1383	1489	1473	1034	753	965	1286	1363		4	10.2%	80%
SWO	ATN	CP	Canada	LL	t2	ab	ab	ab	ab	ab	ab	abc	abc	bc	abc	abc	abc	abc	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		4		
SWO	ATN	CP	Japan	LL	t1	1126	933	1043	1494	1218	1391	1089	759	567	319	263	575	705	656	889	935	778	1062	523	639	300	545	430	379	456	325	362	417	277		5	5.9%	86%
SWO	ATN	CP	Japan	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	bc	bc	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab	ab	ab	ab	ab	ab	ab	a		5		
SWO	ATN	CP	Maroc	LL	t1	27	7	28	35	239	101	35	38	264	154	223	255	325	333	229	428	720	963	700	700	1000	1000	800	800	750	865	865	852	955		6	3.9%	90%
SWO	ATN	CP	Maroc	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	bc	abc	abc	abc	abc	abc	bc	abc	a	a	abc	bc	abc	ab	abc	abc	abc	abc	abc		6		
SWO	ATN	NCC	Chinese Taipei	LL	t1	127	507	489	521	509	286	285	347	299	310	257	30	140	172	103	82	89	88	192	193	115	85	133	152	96	169	122	158	68		7	1.8%	92%
SWO	ATN	NCC	Chinese Taipei	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	a	7		
SWO	ATN	CP	Canada	HP	t1	28	22	189	93	89	240	18	95	121	38	147	87	193	203	267	258	248	176	208	97	275	233	98	85	175	34	33	50	18		8	1.1%	93%
SWO	ATN	CP	Canada	HP	t2	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	abc		8		
SWO	ATN	CP	China PR	LL	t1	73	86	104	132	40	337	304	22	102	90	316	56	108	72	85	92	92	73	75	59	96	60	141	135	81	86	92	96	44		9	0.9%	94%
SWO	ATN	CP	China PR	LL	t2	-1	-1	-1	-1	-1	a	a	a	a	a	a	a	a	ab	a	ab	ab	ab	ab	ab	ab	a	ab	abc	abc	abc	ab	abc	abc	bc	9		
SWO	ATN	CP	USA	HL	t1	38			0	1		5	9	9	12	21	23	35	33	125	94	125	129	121	155	105	88	77	76	62	132	205	219	240		10	0.6%	95%
SWO	ATN	CP	USA	HL	t2	-1			-1	b	b	c	bc	bc	c	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc		10		
SWO	ATN	CP	EU-France	TW	t1		13	13	97	164			60		74	138	102	178	91	46	14	12	32	15	13	35	25	63	87	76	74	70	86	95		11	0.5%	95%
SWO	ATN	CP	EU-France	TW	t2		a		-1	-1	-1			-1		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ab		-1	-1	ab		-1	abc		-1	ac	11		
SWO	ATN	CP	Trinidad and Tobago	LL	t1	11	180	150	158	110	130	138	41	75	92	78	83	91	19	29	48	30	21	16	14	16	26	17	13	36	3	6	8	6		12	0.5%	96%
SWO	ATN	CP	Trinidad and Tobago	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	a	a	a	a	a	a	ab	ab	ab	a	ab	b	ab		12		
SWO	ATN	CP	Belize	LL	t1															9	1	112	106	184	141	142	76	1	3	59	145	117	111	121		13	0.4%	96%
SWO	ATN	CP	Belize	LL	t2															a	a	ab	ab	ab	ab	a	a	ab	a	ab	abc	ab	abc	abc		13		
SWO	ATN	CP	Maroc	GN	t1	2	13	32	322	13	179	60	51	243	64	98	76	9						80												14	0.4%	96%
SWO	ATN	CP	Maroc	GN	t2	-1	-1	-1	-1	-1	c	ac	ac	ac	-1	b	b	b						-1												14		
SWO	ATN	CP	Korea Rep	LL	t1	19	16	16	19	15								51	65	175	157	3		170	46	83	35	2	9	19	9	9	14	13		15	0.3%	97%
SWO	ATN	CP	Korea Rep	LL	t2	a	a	a	a	a				a				a	a	a	a	a		a	-1	abc	abc	b	abc	abc	abc	ab	abc	abc		15		
SWO	ATN	CP	USA	RR	t1				6	11	5	21	16	2	22	6	25	61	53	68	76	32	49	54	71	22	35	46	27	34	36	64	53	40		16	0.3%	97%
SWO	ATN	CP	USA	RR	t2	ab	ab	a	a	ab	ab	ab	ab	ab	ab	ab	a	a	a	a	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		16		
SWO	ATN	CP	Mexico	LL	t1	6	14	10	22	14	28	24	37	27	34	32	44	41	31	35	34	32	35	38	41	33	32	31	37	64	45	30	21	25		17	0.3%	97%
SWO	ATN	CP	Mexico	LL	t2	a	a	a	a	a	a	a	a	ac	a	a	a	a	a	a	a	a	a	a	a	a	a	a	ab	abc	abc	abc	abc	abc		17		
SWO	ATN	CP	Venezuela	LL	t1	68	60	45	74	11	7	9	30	12	25	29	46	48	15	19	5	8	16	13	18	20	18	29	53	52	31	31	14	13		18	0.2%	97%
SWO	ATN	CP	Venezuela	LL	t2	b	b	b	b	b	b	ab	ab	b	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	a	a	a	a		18		

Table 4. SWO-S standard SCRS catalogue on statistics (Task 1 and Task 2) for the last 30 years (1993 to 2022). Only the most important fisheries (representing ±97.5% of Task 1 total catches) are shown. For each data series, Task 1 (DSet= "t1", in t) is matched against its equivalent Task 2 dataset (DSet= "t2") availability scheme. The Task 2 scheme has a concatenation of characters ("a"= T2CE exists; "b"= T2SZ exists; "c"= T2CS exists) that represents the Task 2 joint dataset availability in a given year, flag and gear. The SWO-S overall score for the last 30 years (this catalogue) is also shown. Shaded blue cells (DSet= "t1" only) could indicate missing catches.



Score:	7.02716	T1 Total (t)	16130	18958	21931	18289	18542	14027	15502	15728	15128	14104	12634	13082	13163	14196	15629	12370	12668	12596	11205	10686	9204	9970	10345	10611	10537	10378	10081	8964	9511	74			
Speci	Sto	Stat	FlagName	GearG	DS	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Rank	%	%cum
SWO	ATS	CP	EU-España	LL	t1	6974	7937	11290	9622	8461	5832	5758	6388	5789	5741	4527	5483	5402	5300	5283	4073	5183	5801	4700	4852	4184	4113	5059	4992	4654	4404	4224	4442	4470		1	42.7%	43%
SWO	ATS	CP	EU-España	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		1		
SWO	ATS	CP	Brazil	LL	t1	2013	1571	1970	1892	4100	3844	4721	4579	4075	2903	2917	2984	3780	4430	4243	3413	3386	2926	2984	2831	2381	2892	2594	2935	2406	2792	2859	2105	2823		2	23.1%	66%
SWO	ATS	CP	Brazil	LL	t2	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	a	a	a	a	ab	ab	ab	ab			2		
SWO	ATS	CP	Japan	LL	t1	5256	4699	3619	2197	1494	1186	775	790	685	833	924	686	480	1090	2155	1600	1340	1314	1233	1162	684	976	659	637	915	640	648	552	486		3	10.3%	76%
SWO	ATS	CP	Japan	LL	t2	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab	ab	ab	ab	ab	ab	ab	a		3		
SWO	ATS	NCC	Chinese Taipei	LL	t1	846	2829	2876	2873	2562	1147	1168	1303	1149	1164	1254	745	744	377	671	727	612	410	428	496	582	451	554	480	527	472	395	353	532		4	7.4%	84%
SWO	ATS	NCC	Chinese Taipei	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	a	4		
SWO	ATS	CP	Namibia	LL	t1		22					374	452	607	504	187	549	832	1118	1038	518	25	408	366	22	129	395	225	466	600	881	811	774	623		5	3.1%	87%
SWO	ATS	CP	Namibia	LL	t2		a					a	-1	ab	a	-1	a	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	a	abc	abc	abc	abc	abc		5		
SWO	ATS	CP	Uruguay	LL	t1	260	165	499	644	760	889	650	713	789	768	850	1105	843	620	464	370	501	222	179	40	103										6	3.0%	90%
SWO	ATS	CP	Uruguay	LL	t2	a	a	a	a	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab										6		
SWO	ATS	CP	EU-Portugal	LL	t1			380	389	441	384	381	392	393	380	354	345	493	440	428	271	367	232	263	184	125	252	236	250	466	369	323	335	224		7	2.4%	92%
SWO	ATS	CP	EU-Portugal	LL	t2			a	a	ab	ab	ab	ab	ab	ab	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	a	ab			7		
SWO	ATS	CP	China PR	LL	t1						29	534	344	200	423	353	278	91	300	473	470	291	296	248	316	196	206	328	222	302	355	211	89	37		8	1.7%	94%
SWO	ATS	CP	China PR	LL	t2						a	a	a	a	a	a	a	a	a	a	ab	ab	ab	ab	ab	ab	abc	ab	abc	abc	abc	ab	abc	a	bc	8		
SWO	ATS	CP	South Africa	LL	t1			1			240	143	327	547	649	293	295	199	186	207	142	170	145	97	50	171	152	218	164	189	189	251	149	179		9	1.4%	95%
SWO	ATS	CP	South Africa	LL	t2			-1			ab	ab	ab	ac	abc	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab		9		
SWO	ATS	CP	Ghana	GN	t1	121	51	103	140	44	106	121	117	531	372	734	343	55	32	65	177	132	116	60	54	37	26	56	36	55	6	32	31	19		10	1.0%	96%
SWO	ATS	CP	Ghana	GN	t2	-1	-1	-1	ab	b	ab	b	ab	ab	ab	ab	ab	ab	ab	ab	a	ab	a	a	a	a	a	a	a	a	a	-1	-1	-1		10		
SWO	ATS	CP	S Tomé e Príncipe	TR	t1	202	190	178	166	148	135	129	120	120	120	120	126	147	138	138	172	188	193	60	84	60	94	145	77	65						11	0.9%	97%
SWO	ATS	CP	S Tomé e Príncipe	TR	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1						11		
SWO	ATS	CP	Korea Rep	LL	t1	198	164	164	7	18	7	5	10	0	2	24	70	36	94	176	223	10	147	70	65	47	53	5	19	11	18	9	15	6		12	0.4%	97%
SWO	ATS	CP	Korea Rep	LL	t2	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	-1	a	-1	abc	abc	a	abc	ab	abc	ab	abc	abc		12		
SWO	ATS	CP	Belize	LL	t1			1				17	8							120	32	111	121	207	197	136	45	111	176	166	115	55	2	2		13	0.4%	98%
SWO	ATS	CP	Belize	LL	t2			a				-1	a							a	a	ab	ab	ab	ab	a	a	ab	a	ab	abc	ab	abc	abc		13		
SWO	ATS	NCO	Cuba	LL	t1	192	452	778	60	60																										14	0.4%	98%
SWO	ATS	NCO	Cuba	LL	t2	-1	-1	-1	-1	-1																										14		
SWO	ATS	CP	Senegal	LL	t1															77	97	137	78	117	162	178	143	97	90	112	65	116	38			15	0.4%	99%
SWO	ATS	CP	Senegal	LL	t2															-1	a		-1	a	a	a	a	a	a	a	-1	-1	-1	-1		15		

Table 5. SWO-M standard SCRS catalogue on statistics (Task 1 and Task 2) for the last 30 years (1993 to 2022). Only the most important fisheries (representing ±97.5% of Task 1 total catches) are shown. For each data series, Task 1 (DSet= "t1", in t) is matched against its equivalent Task 2 dataset (DSet= "t2") availability scheme. The Task 2 scheme has a concatenation of characters ("a"= T2CE exists; "b"= T2SZ exists; "c"= T2CS exists) that represents the Task 2 joint dataset availability in a given year, flag and gear. The SWO-M overall score for the last 30 years (this catalogue) is also shown. Shaded blue cells (DSet= "t1" only) could indicate missing catches.

Score:	4.71515	T1 Total (t)	13265	16082	13015	12053	14693	14369	13699	15569	15006	12814	15694	14405	14622	14915	14227	13683	13235	14754	12640	11046	10070	10969	11983	12300	10390	8681	8176	7664	7512	0			

Speci	Sto	Stat	FlagName	GearG	DS	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Rank	%	%cum
SWO	MED	CP	EU-Italy	LL	t1	3260	3844	3035	2617	2458	2458	2680	2639	2236	1841	5844	5452	5560	5253	4564	5246	5438	5919	5313	4474	3304	3921	4883	4540	3882	2289	2461	2231	1998		1	29.8%	30%
SWO	MED	CP	EU-Italy	LL	t2	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	b	ab	ab	b	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc	ac	abc	abc		1		
SWO	MED	CP	EU-Italy	GN	t1	3070	3921	4264	2657	3632	3632	3632	4863	4152	1698	2540	1483	1891	2373	1948								0								2	12.4%	42%
SWO	MED	CP	EU-Italy	GN	t2	ab	ab	b	b	b	b	b	ab	b	-1	b	b	b	b	-1								-1								2		
SWO	MED	CP	EU-España	LL	t1	1293	1402	1351	1040	1184	1409	867	1396	1402	1421	1165	930	860	1405	1648	2063	1994	1785	1730	1580	1605	2019	2289	1732	1487	1470	1548	1425	1557		3	11.7%	54%
SWO	MED	CP	EU-España	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc		3		
SWO	MED	CP	EU-Greece	LL	t1	1568	2520	974	1237	750	1650	1520	1960	1730	1680	1230	1129	1424	1374	1907	989	1132	1494	1306	877	1731	1344	761	761	392	350	745	657	686		4	9.8%	64%
SWO	MED	CP	EU-Greece	LL	t2	ab	ab	ab	-1	-1	ab	ab	ab	ab	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab	b	ab	ab	ab	ab	ab		4		
SWO	MED	CP	Maroc	GN	t1	2068	2109	1518	2461	4653	2905	2979	2503	2266	2230	1629	1299	722	603	615	587	477	410	387												5	8.8%	73%
SWO	MED	CP	Maroc	GN	t2	-1	b	-1	-1	-1	c	bc	abc	abc	b	b	b	b	b	b	abc	-1	abc	abc												5		
SWO	MED	CP	Maroc	LL	t1	517	527	169	273	245	323	259	205	754	1149	1670	1954	1801	1455	1107	1713	1388	1501	800	1003	963	968	604	1395	1350	1368	982	951	924		6	7.7%	80%
SWO	MED	CP	Maroc	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	bc	abc	abc	abc	abc	abc	abc	ab	bc	abc		6		
SWO	MED	CP	Tunisie	LL	t1	354	298	378	352	346	414	468	483	567	1138	285	791	791	949	1024	1232	1233	1238	1267	1265	1262	1302	1307	1273	1377	1338	934	918	891		7	6.9%	87%
SWO	MED	CP	Tunisie	LL	t2	-1	-1	-1	-1	-1	-1	a	a	a	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	abc	abc		7		
SWO	MED	CP	Algerie	LL	t1	173	185	247	247	247	178	126	166	439	347	238	174	93	496	492	977	570	560	234	433	467	693	705	842	755	725	517	501	446		8	3.3%	91%
SWO	MED	CP	Algerie	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	-1	-1	ab	ab	ab	ab	ab	-1	-1	-1	ab	a	ab		8		
SWO	MED	CP	EU-Malta	LL	t1	91	47	72	72	100	153	187	175	102	257	163	195	362	239	213	260	266	423	532	503	460	376	489	410	330	308	407	361	391		9	2.2%	93%
SWO	MED	CP	EU-Malta	LL	t2	-1	-1	-1	-1	-1	-1	ac	ac	ac	-1	-1	-1	abc	bc	ab	abc	ab	ab	ab	abc	ab	abc	abc	abc	abc	abc	abc	ab	abc	a	a	9		
SWO	MED	CP	Algerie	GN	t1	389	415	560	560	560	590	531	599	642	467	427	233	311	87	108																10	1.8%	94%
SWO	MED	CP	Algerie	GN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1																10		
SWO	MED	CP	Türkiye	GN	t1	292	533	306	320	350	450	230	370	360	300	274	317	341	337	352																11	1.4%	96%
SWO	MED	CP	Türkiye	GN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	ab	ab	ab	ac	c											11		
SWO	MED	CP	Türkiye	LL	t1										70	76	69	84	73	71	441	344	382	217	76	111	71	45	90	556	544	386	376	357		12	1.2%	97%
SWO	MED	CP	Türkiye	LL	t2										-1	-1	-1	-1	-1	-1	a	a	a	ab	a	ab	abc	abc	bc	ab	abc	abc	abc	abc		12		
SWO	MED	CP	EU-Italy	UN	t1																	329	921	694	718		0				0	8				13	0.7%	98%
SWO	MED	CP	EU-Italy	UN	t2														b			-1	-1	-1	-1		b				-1	-1				13		
SWO	MED	CP	EU-Cyprus	LL	t1	116	159	89	40	51	61	92	82	135	104	47	49	53	43	67	67	38	31	35	35	51	59	54	53	50	45	24	30	56		14	0.5%	98%
SWO	MED	CP	EU-Cyprus	LL	t2	a	a	a	a	a	a		-1	a	-1	a	a	a	a	ab	abc	abc	abc	abc	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc		14		
SWO	MED	CP	Libya	LL	t1							11		8	6		10	2		16								585	960	30	70	26	22	19		15	0.5%	99%
SWO	MED	CP	Libya	LL	t2						-1		a	a		-1	-1		-1									-1	-1	-1	-1	-1	-1	-1		15		
SWO	MED	CP	EU-France	LL	t1									12	27	20	19	22	20	14	14	10	73	39	10	58	119	178	172	108	83	69	104	91		16	0.3%	99%
SWO	MED	CP	EU-France	LL	t2									-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	b	-1	-1	b	-1	-1	-1	-1		16		

Table 6. Summary of SWO conventional tagging data available in ICCAT. Number of SWO releases by year and associated recoveries by year. The number of recoveries without release information (Unk) and recoveries without recovery dates (?) are also shown.

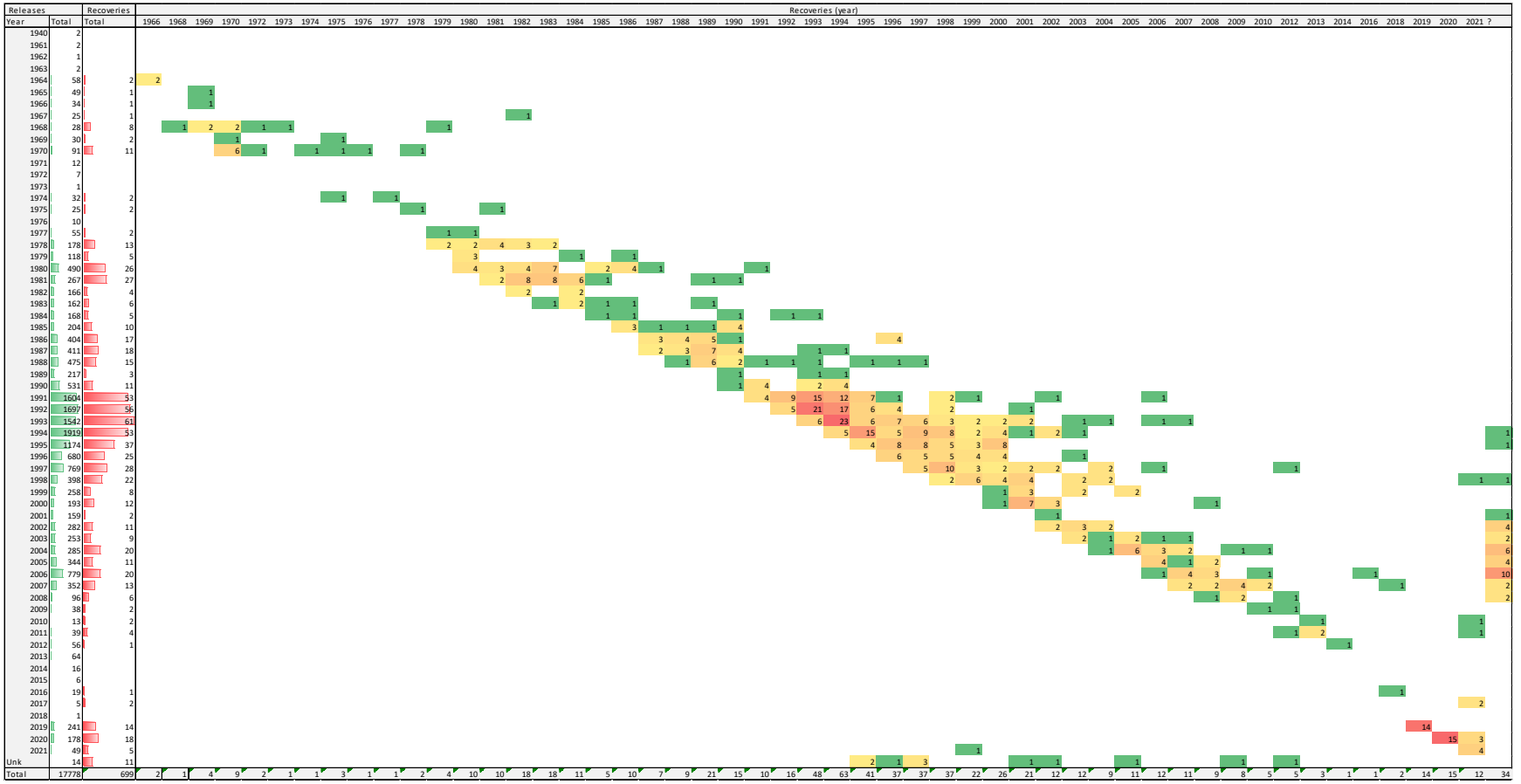


Table 7. Summary of swordfish (*Xiphias gladius*) conventional tagging data: number of recoveries grouped by number of years at liberty in each release year. The last column shows the recovery rate (%) in each release year.

Number of tag Swordfish (*Xiphias gladius*)													
			Years at liberty										
Year	Releases	Recaptures	< 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10+	15+	Unk	Error	% recapt*
1940	2	0											
1961	2	0											
1962	1	0											
1963	2	0											
1964	58	2		2									3%
1965	49	1				1							2%
1966	34	1				1							3%
1967	25	1								1			4%
1968	28	8	1	2	2	1		1	1				29%
1969	30	2		1				1					7%
1970	91	11	6		1		1	3					12%
1971	12	0											
1972	7	0											
1973	1	0											
1974	32	2		1		1							6%
1975	25	2			1			1					8%
1976	10	0											
1977	55	2		1	1								4%
1978	178	13	1	3	3	2	4						7%
1979	118	5	2	1			1	1					4%
1980	490	26	4	6	7	1		7	1				5%
1981	267	27	8	10	5	2		2					10%
1982	166	4	2	2									2%
1983	162	6	2	2	1			1					4%
1984	168	5		2				3					3%
1985	204	10	2	2	1	1	3	1					5%
1986	404	17	3	3	5	2		4					4%
1987	411	18	5	6	4	1		2					4%
1988	475	15	5	4	1		2	3					3%
1989	217	3		1			1	1					1%
1990	531	11	3	2	2	4							2%
1991	1604	53	12	8	14	12	2	3	2				3%
1992	1697	56	12	24	11	3	3	3					3%
1993	1542	61	21	11	7	7	4	8	3				4%
1994	1919	53	15	7	10	5	6	9			1		3%
1995	1174	37	9	5	9	3	8	2			1		3%
1996	680	25	10	3	7	2	2	1					4%
1997	769	28	11	6	1	3	3	3	1				4%
1998	398	22	6	4	5	1	2	2			1	1	6%
1999	258	8	1	2	1	1	1	2					3%
2000	193	12	5	5	1			1					6%
2001	159	2		1							1		1%
2002	282	11	4	3							4		4%
2003	253	9	3	1	2		1				2		4%
2004	285	20	5	2	3	1		2			6	1	7%
2005	344	11	2	3	1	1					4		3%
2006	779	20	4	3	1	1		1			10		3%
2007	352	13	4	2	4				1		2		4%
2008	96	6	2	1		1					2		6%
2009	38	2		1	1								5%
2010	13	2			1				1				15%
2011	39	4	1	2					1				10%
2012	56	1			1								2%
2013	64	0											
2014	16	0											
2015	6	0											
2016	19	1			1								5%
2017	5	2					2						40%
2018	1	0											
2019	241	14	14										6%
2020	178	18	17	1									10%
2021	60	5	3									2	8%
?	14	11									11		79%
Grand Total	17789	699	205	146	115	58	46	68	11	1	45	4	3.9%

Table 8. Reference OM configurations.

Variable	**OM grid levels (up to May 2023)**	**Revised levels (May 2023 onward)**
Natural mortality	0.1, 0.2, 0.3	No change
Steepness	0.6, 0.75, 0.9	0.69, 0.8, 0.88

Table 9. MSE status metrics, probability of being in green zone (SB>SB_{MSY} & F<F_{MSY}) of Kobe plot (PGK) for different simulation periods.

Family	Name	Description	Minimum Acceptable Values
Status	PGK_short**	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in years 1-10 (2024-2033)	51, 60, 70
	PGK_med*	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in years 11-20 (2034-2043)	51, 60, 70
	PGK_long*	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in years 21-30 (2044-2053)	51, 60, 70
	PGK	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) over all years (2024-2053)	51, 60, 70
	PGK_30	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in year 30 (2053)	51, 60, 70
	POF	Probability of Overfishing (F>FMSY) over all years (2024-2053)	
	PNOF	Probability of Not Overfishing (F<FMSY) over all years (2024-2053)	
Safety	LRP_short*	Probability of breaching the limit reference point (SB<0.4SBMSY) in any of the first 10 years (2024-2033)	5, 10, 15
	LRP_med*	Probability of breaching the limit reference point (SB<0.4SBMSY) in any of years 11-20 (2034-2043)	5, 10, 15
	LRP_long*	Probability of breaching the limit reference point (SB<0.4SBMSY) in any of years 21-30 (2044-2053)	5, 10, 15
	LRP	Probability of breaching the limit reference point (SB<0.4SBMSY) in any year (2024-2053)	5, 10, 15
Yield	TAC1	TAC (t) in the first implementation year (2024)	
	AvTAC_short*	Median TAC (t) over years 1-10 (2024-2033)	
	AvTAC_med*	Median TAC (t) over years 11-20 (2034-2043)	
	AvTAC_long*	Median TAC (t) over years 21-30 (2044-2053)	
Stability	VarC	Median variation in TAC (%) between management cycles over all years	
	MaxVarC	Maximum variation in TAC (%) between management cycles over all years	No minimum value and 25

* Note: alternative time spans are also being considered for these performance metrics: short (1-6), medium (6-10), long (11-30).

Table 10. Currently developed CMPs described in SCRS/P/2023/066.

Code	Name	Class	Description	Tuned
SP1	Surplus Production 1	Model Based	Schaefer surplus production model, with a HCR that linearly reduces F when estimated B/B_{MSY} is $<0.8B_{MSY}$	a, b, c
SP2	Surplus Production 1	Model Based	Same as SP1, but uses a Fox production model	a, b, c
IR1	Index Ratio 1	Model Free	Adjusts the TAC based on the mean Combined Index over the last 3 years to the mean index over the previous 3 years before that	a, b, c
IR2	Index Ratio 2	Model Free	Same as IR1, but mean index values are calculated as over the 2 most recent years and the 2 years before that	a, b, c
CE	Constant Exploitation Rate	Model Free	Aims to keep the exploitation rate constant at the recent historical level	a, b, c

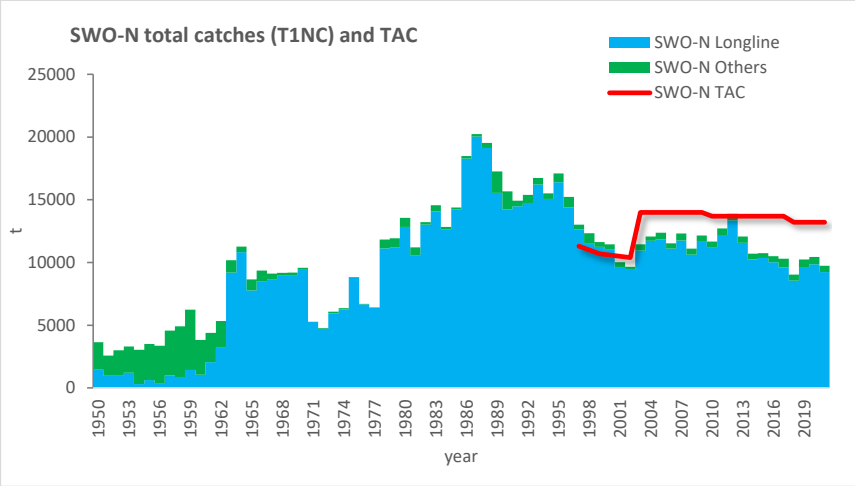


Figure 1. SWO-N total cumulative catches (landings and dead discards, t) by major gear and year, available in T1NC for the period 1950-2021. The corresponding respective TAC is also shown.

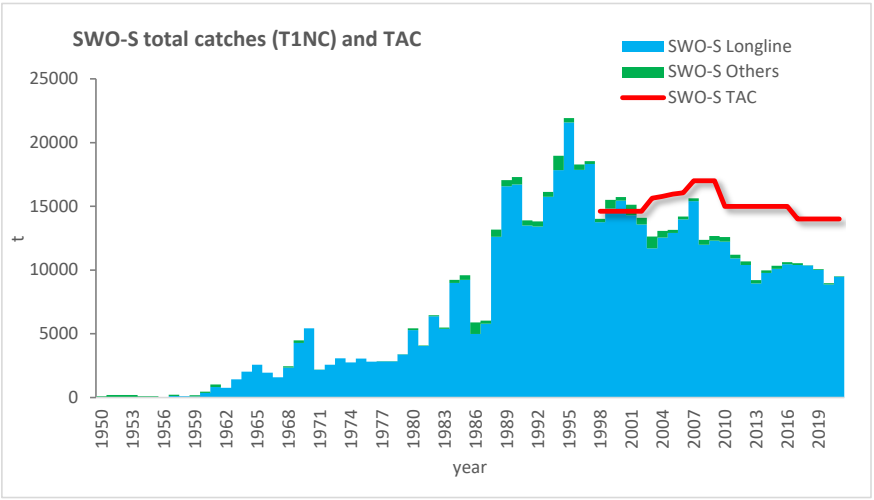


Figure 2. SWO-S total cumulative catches (landings and dead discards, t) by major gear and year, available in T1NC for the period 1950-2021. The corresponding respective TAC is also shown.

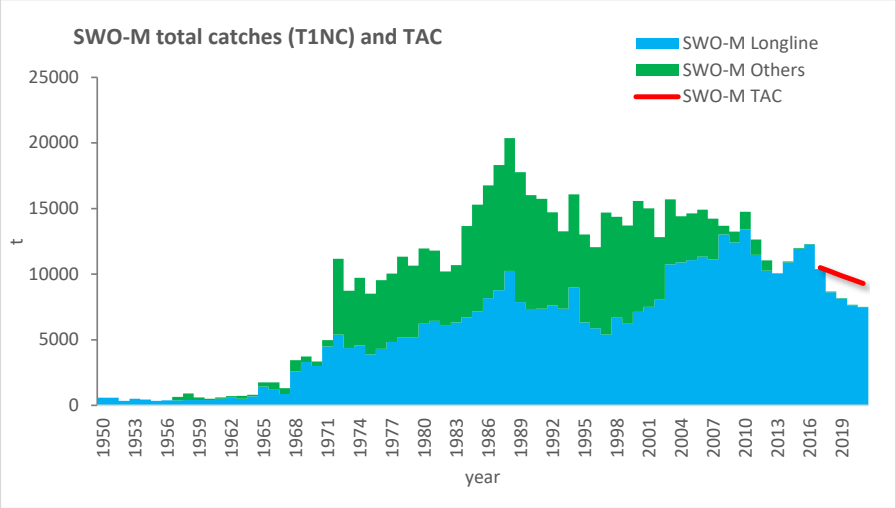


Figure 3. SWO-M total cumulative catches (landings and dead discards, t) by major gear and year, available in T1NC for the period 1950-2021. The corresponding respective TAC is also shown.

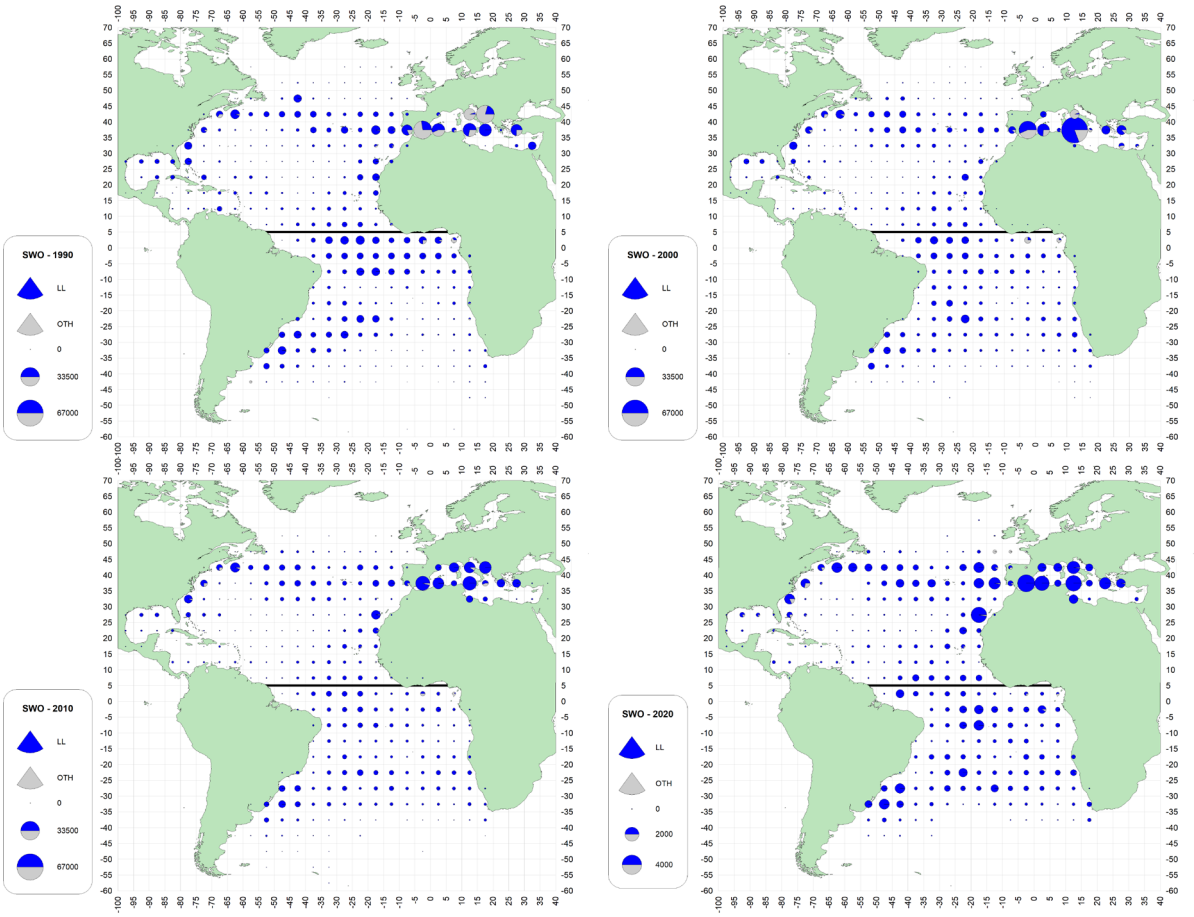


Figure 4. Swordfish maps of catch (t) distribution by major gear and decade (1990s to 2020s). The last decade only covers the cumulative catches of 2020 and 2021 (source: CATDIS).

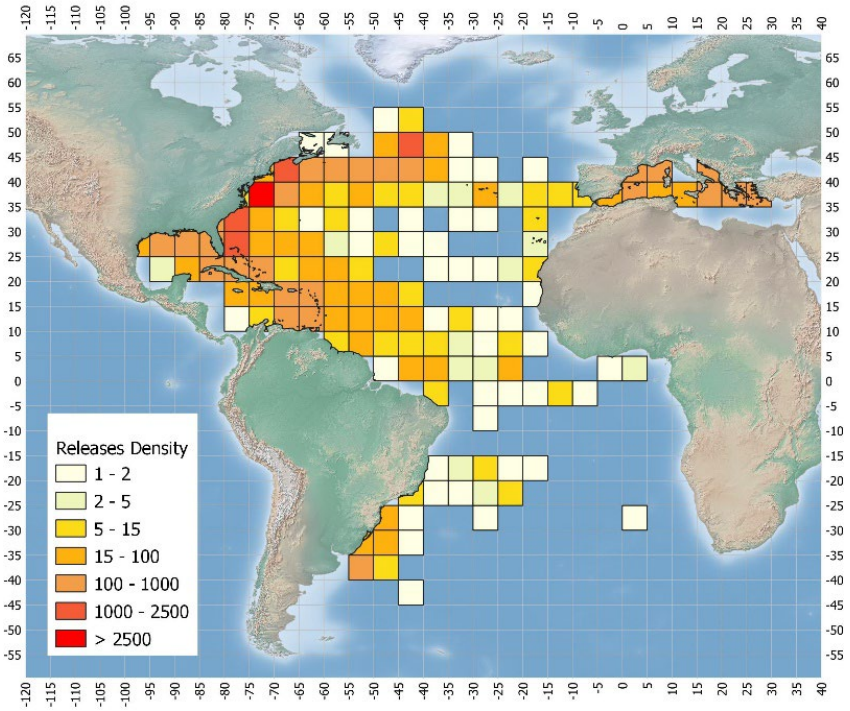


Figure 5. Density of SWO conventional tags released in a 5x5 square grid, in the ICCAT area.

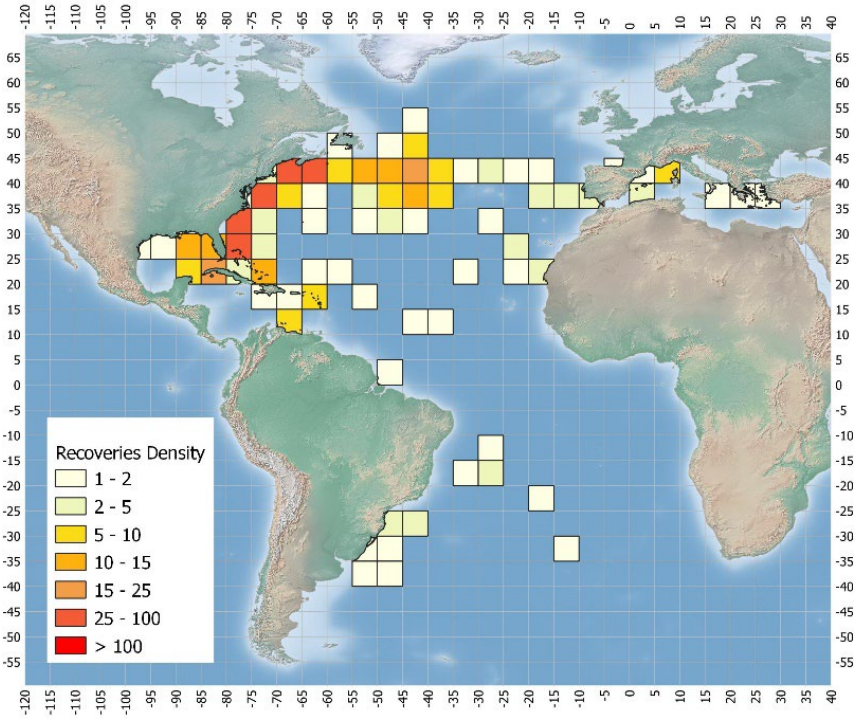


Figure 6. Density of SWO conventional tags recovered in a 5x5 square grid, in the ICCAT area.

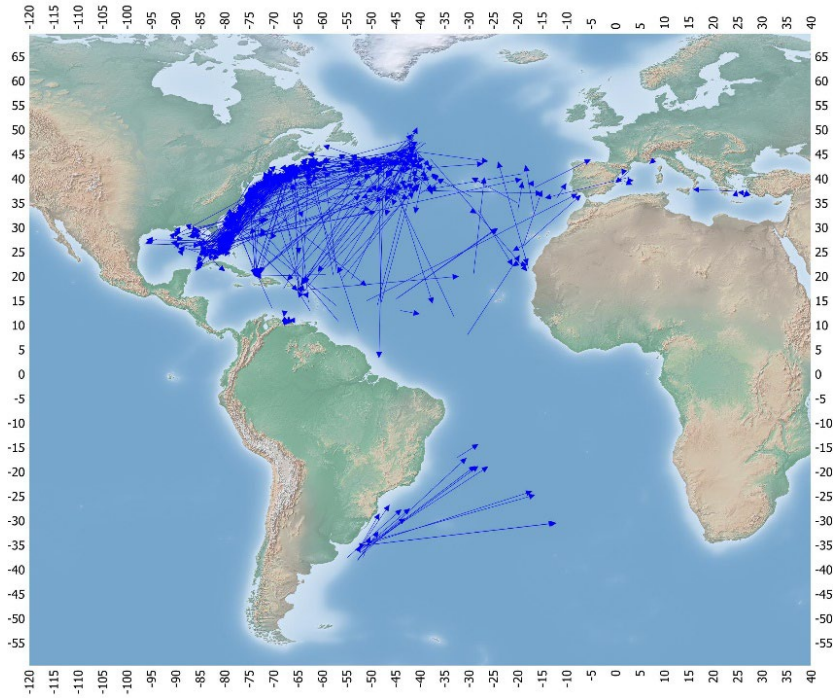


Figure 7. Apparent movement (arrows: release to recovery location) of the SWO conventional tagging.

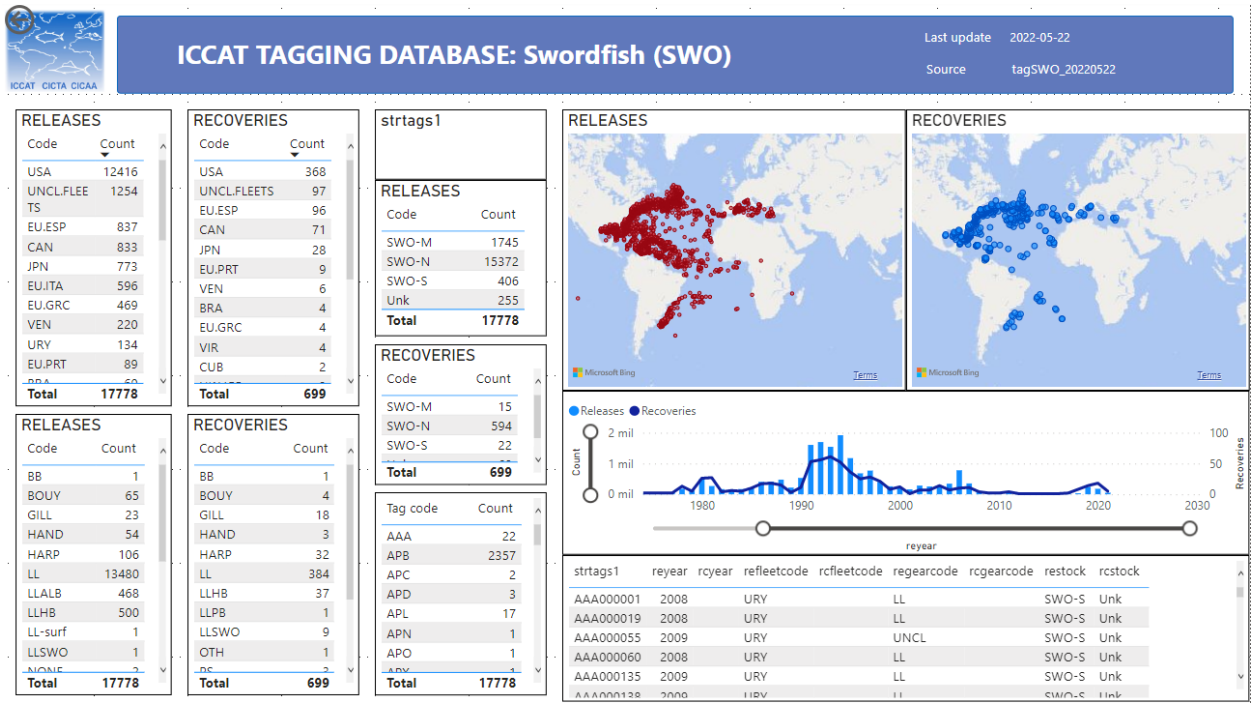


Figure 8. Snapshot of the conventional tagging dashboard (SWO).

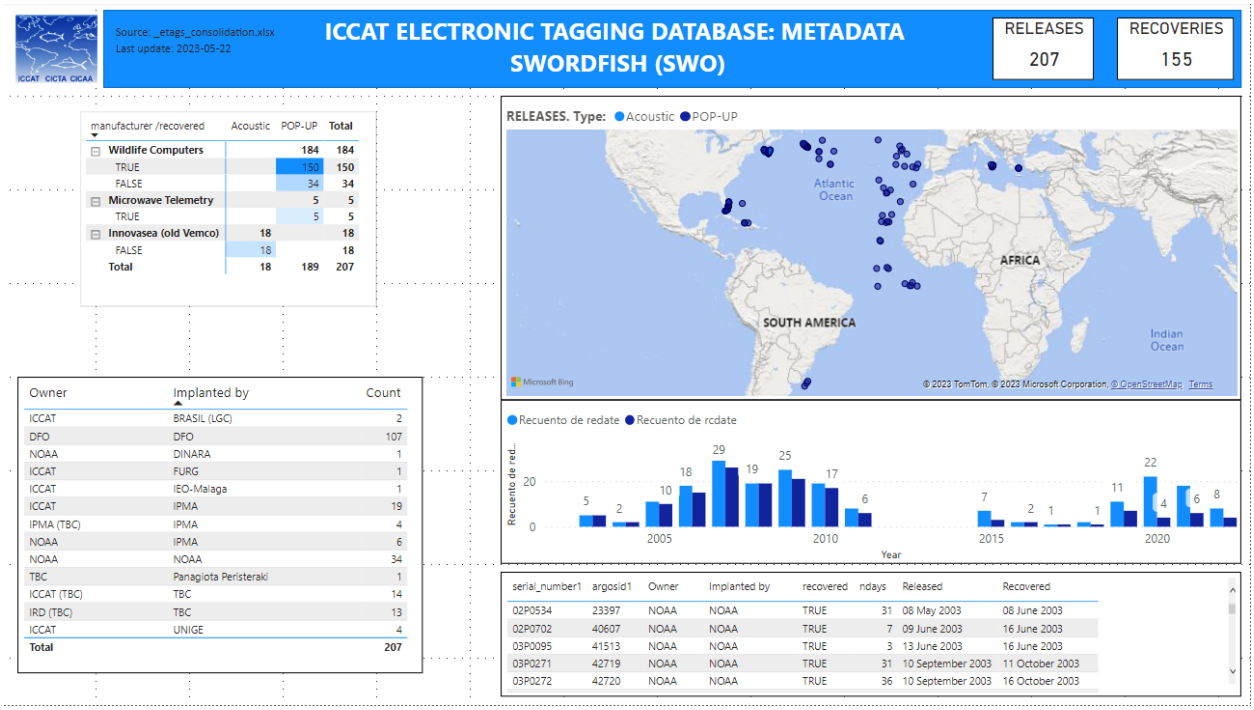


Figure 9. Snapshot of the electronic tagging dashboard (SWO).

Appendix 1

Agenda

1. Opening, adoption of the agenda and meeting arrangements

2. Review of fishery statistics

    2.1 Task 1 (catches) data
    2.2 Task 2 (catch-effort and size samples) data
    2.3 Catch-at-size, Catch-at-age, Weight at Age
    2.4 Tagging data

3. Plans for review of indices of abundance

    3.1 Best practices and catch per unit effort (CPUE) diagnostics
    3.2 Incorporation of spatial and environmental effects

4. Swordfish Year Program (SWOYP)

    4.1 Life history project
        4.1.1 Ageing and growth
        4.1.2 Reproduction and maturity
        4.1.3 Genetics and stock boundaries
        4.1.4 Sampling activities
        4.1.5 Project Phase 6 planning
    4.2 Size/sex distribution study
    4.3 Sex specific curved/straight length conversion development for the Mediterranean
    4.4 Pop-up satellite archival tag project

5. N-SWO MSE

    5.1 Review of current development state of the North Atlantic Swordfish MSE
    5.2 Review of recent Panel 4 interactions
    5.3 Presentation of candidate management procedures (CMPs) in development
    5.4 Discussion on MSE development next steps
        5.4.1 Panel interactions
        5.4.2 Ambassador sessions
        5.4.3 CMP development

6. Closed-loop simulation study for South Atlantic Swordfish

7. Responses to the Commission

8. Recommendations and workplan

9. Review of terms of reference for research activities

10. Other matters

11. Adoption of the report and closure

Appendix 2

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Appendix 3

List of papers and presentations

DocRef	*Title*	*Authors*
SCRS/2023/016	Final report for Phase 4 of the ICCAT short-term contract: swordfish biological samples collection for growth, reproduction and genetics studies	Gillespie K., Hanke A., Coelho R., Rosa D., Carnevali O., Gioacchini G. and Macías D.
SCRS/2023/062	Report of the workshop on swordfish, billfishes and small tuna age reading	Anon.
SCRS/2023/095	Development state of the North Atlantic Swordfish MSE process in May 2023	Gillespie K., Hordyk A., Schirripa M., Coelho R., Duprey N., Hanke A., Miller S., Rosa D. and Rueda L.
SCRS/2023/097	Ageing and growth workshop report	Rosa D.
SCRS/2023/102	ICCAT Rec [16-05] on discards of Swordfish in the Mediterranean: contributions for more efficient management of the fishery	Garcia–Barcelona S., Ortiz de Urbina J.M., Francisco Moreno de la Rosa J., RiojaP. and Macías D.
SCRS/2023/104	A Hierarchical Cluster Analysis of South Atlantic Swordfish CPUE Series	Taylor N.G.
SCRS/P/2023/060	Update on the age and growth component of the Swordfish Year Program	Rosa D., Busawon D., Quelle P., Krusic-Golub K.H., Andrews A., Garibaldi F., Mariani A., DiNatale A., Schirripa M., Alves Bezerra N., Su N., Gustavo Cardoso L., Arocha F., Lombardo S., Campello T., Santos M., Travassos P., Brown C., Hanke A., Gillespie K. and Coelho R.
SCRS/P/2023/061	Swordfish size and sex-ratios distribution in the Atlantic	Rosa D., Schirripa M., Gillespie K., Macias D., Forselledo R., Mourato B., Mikihiko K., Arocha F., Su N., Kerwath S., Bahou L., Pappalardo L., Diaz G., Lino P., Salmeron F., Ortiz de Urbina J., Cardoso L., Sant'Ana R., Travassos P., Santos M., Domingo A., Báez J., Hanke A., Brown C. and Coelho R.
SCRS/P/2023/062	Update on the satellite tagging of swordfish under the Swordfish Year Program	Rosa D., Gillespie K., Garibaldi F., Orbesen E., Gustavo Cardoso L., Snodgrass D., Santos C., Macias D., Ortiz de Urbina J., Forselledo R., Miller P., Domingo A., Santos M., Brown C. and Coelho R.
SCRS/P/2023/063	Key Decision Points for Developing Operating Models for North Atlantic Swordfish MSE	Hordyk A., Schirripa M., Gillespie K.
SCRS/P/2023/064	Index Diagnostic Reports for North Atlantic Swordfish MSE	Hordyk A.
SCRS/P/2023/065	Overview of Performance Metrics Developed for North Atlantic Swordfish MSE	Hordyk A.
SCRS/P/2023/066	Development and Tuning of Candidate Management Procedures for North Atlantic Swordfish MSE	Hordyk A.
SCRS/P/2023/067	Review of Preliminary Results of Candidate Management Procedures for North Atlantic Swordfish MSE	Hordyk A.
SCRS/P/2023/068	Updates and plans for future analysis on swordfish reproduction under the Short Term contract for ICCAT swordfish growth, reproduction and Genetics studies.	Macias D.

SCRS/P/2023/070	Update on Southern Swordfish Closed loop simulation	Taylor N.G.
SCRS/P/2023/071	Genetic structure and diversity, fitness, evolutionary potential and distribution of Atlantic and Mediterranean swordfish stocks: new insight from ddRAD and WGS analyses	Gioacchini G., Gillespie K., Rosa D., Busawon D., Bezerra, Natália A., Travassos P., Hilário T.C., Hazin F.H.V. (in memoriam), Macías D., Galluci A.M., Poisson F., Garibaldi F., Cardoso Gustavo L., Pappalardo L., Su N., Parker, D., Tserpes G., Arocha F., Shikongo T., Di Natale A., Addis P., Mariani A., Santos M.N., Coelho R., Hanke A. and Carnevali O.
SCRS/P/2023/072	Planning for Phase 6 of the ICCAT swordfish biology program	Gillespie K., Hanke A., Coelho R., Rosa D., Carnevali O., Gioacchini G. and Macías D.
SCRS/P/2023/073	Research plans for phase five of the ICCAT short-term contract: swordfish biological samples collection for growth, reproduction and genetics studies	Gillespie K., Hanke A., Coelho R., Rosa D., Carnevali O., Gioacchini G. and Macías D.
SCRS/P/2023/074	Summary of Panel 4 NSWO MSE interactions in 2023	Gillespie K.
SCRS/P/2023/094	ICCAT Rec [16-05] on discards of Swordfish in the Mediterranean: contributions for a more efficient management of the fishery	García–Barcelona S., Rueda L., Ortiz de Urbina J.M., Moreno de la Rosa J.F., Rioja P. and Macías D.

Appendix 4

SCRS Documents and Presentation Abstracts as provided by the authors

SCRS/2023/016 – This paper summarizes work completed in phase 4 of the ICCAT swordfish biology program (SWOYP). The goal of the program is to resolve key uncertainties important to the assessment: stock boundaries and mixing; growth and ageing; and reproduction and maturity. In this phase of the program, an additional 498 swordfish were sampled for tissues, spines and otoliths, gonads, and other characteristics. Progress was made on identifying genetic markers important for stock identification; development of ageing protocols and reference sets; and developing maturity ogives. The paper identifies spatial-temporal gaps which still require sample collection to support this work.

SCRS/2023/062 – This report describes the Workshop on swordfish, billfishes and small tuna age reading that took place in IPMA-Olhão, Portugal in February 2023. The three species groups have ongoing biology programs for the improvement of the biological knowledge of the various species, specifically, the small tuna year program (SMTYP) for small tunas (focused on *Euthynnus alletteratus*, *Sarda sarda* and *Acanthocybium solandri*), the swordfish year program (SWOYP) for swordfish (*Xiphias gladius*), and the Enhanced Programme for Billfish Research (EPBR) dedicated to billfishes (focused on *Tetrapturus albidus*, *Makaira nigricans* and *Istiophorus albicans*). The three programs include age and growth studies, with collection of both spines and otoliths for the scope species, therefore the major objectives of the workshop were to enhance expertise among ICCAT scientists for these species by sharing knowledge between experts, standardize methodologies, review work already completed and progress plans for next steps in these research programs.

SCRS/2023/095 – This paper provides an update on the development of the North Atlantic Swordfish management strategy evaluation (MSE) since the last meeting of the SWO species group in September 2022. The SCRS is scheduled to provides a set of CMPs to the Commission in 2023 and important steps are required in 2023. This paper reviewed assumptions in the operating models with regard to the stock biology and fleet behaviour. Recent updates include modifications to the steepness axis to values, introducing values that the group deemed to be more plausible. This paper also outlined the SWO MSE technical team's suggestions on appropriate performance metrics and processes for developing and selecting CMPs. Lastly, the paper described next steps for engagement with ICCAT's Panel 4.

SCRS/2023/104 – This paper presents a method for clustering CPUE series with similar trends and applying it for Southern CPUE series. The method consists of visual examination of the series with Lowess fitting, residual plots, cross-correlation analysis, and hierarchical cluster analysis. The hierarchical cluster analysis uses complete linkage clustering. This computes all pairwise dissimilarities between the correlation coefficients in cluster 1 and the elements in cluster 2. It then considers the largest value of these dissimilarities as the distance between two clusters. I focused on defining two clusters. The analysis shows a highly correlated group of indices (the Uruguayan Longline, the Uruguayan historical longline, the South African Longline, the late Japanese Longline, the western Spanish Longline, the Chinese Taipei Longline, and the northern Spanish longline), and a second group that have different trajectories (the early Japanese Longline, the Brazilian Longline, and the late Chinese Taipei Longline series). Each cluster can define scenarios or Operating Models in stock assessment or Management Strategy Evaluation, respectively.

SCRS/P/2023/060 – Not provided by the authors.

SCRS/P/2023/061 – Not provided by the authors.

SCRS/P/2023/062 – Not provided by the authors.

SCRS/P/2023/063 – This presentation provided an overview of the key decision points for the operating models for the North Atlantic swordfish MSE. The presentation described the current Reference and Robustness operating models (OMs). Summaries of meta-analyses of the steepness parameter (h) of the Beverton-Holt stock-recruitment relationship were shown. A method was presented to use the Goodyear compensation ratio to determine h values to use in the Reference OMs and Robustness OMs.

SCRS/P/2023/064 - This presentation demonstrated how the indices are generated in the projections of the North Atlantic swordfish MSE. For each OM and each index, the statistical properties of the deviations

between the observed index and the predicted biomass (or numbers) associated with that index are calculated. Summary statistics of standard deviation and auto-correlation factor of the residuals in log-space are calculated, and then these statistics used to generate auto-correlated residuals for the projection period. This process was demonstrated for the Combined Index across the Reference OMs. The same process for the fleet-specific indices was demonstrated for a few select indices and OMs

SCRS/P/2023/065 - This presentation summarized the performance metrics that have been developed for the North Atlantic swordfish MSE. The performance metrics are grouped into four categories: Status, Safety, Yield, and Stability. The presentation included figures that show how the performance metrics from each category are calculated.

SCRS/P/2023/066 - This presentation provides an update on the maturity data collected and analysed by the SWOYP and the next steps for improving spatial and temporal coverage of sampling for reproductive analysis. Data analysed to date show a series of spatial/temporal gaps that need improvement to better estimate reproductive parameters as L50 and spawning periods. Sampling conducted under phases 3 and 4 of the program improved sampling coverage. The following steps in the reproduction chapter will be: to analyse the samples collected in these phases for maturity and gonad staging and obtain an improved estimate of the L50 and estimate spawning seasons and areas by stock. Some gaps remain in the temporal and spatial coverage that has to be addressed to obtain accurate estimates of reproductive parameters.

SCRS/P/2023/067 - This presentation summarized the performance of a set of preliminary candidate management procedures for the North Atlantic swordfish MSE. The results demonstrated the trade-offs between different management outcomes, and described a process for identifying the CMPs that had the highest performance. The presentation discussed the implications of different tuning targets and guided the Group in a discussion regarding the best way to present the results of the MSE to a broad audience.

SCRS/P/2023/068 - This presentation provides an update on the maturity data collected and analysed by the SWOYP and the next steps for improving spatial and temporal coverage of sampling for reproductive analysis. Data analyzed to date shows a series of spatial/temporal gaps that need improvement to better estimate reproductive parameters as L50 and spawning periods. Sampling conducted under phases 3 and 4 of the program improved sampling coverage. The following steps in the reproduction chapter will be: to analyse the samples collected in these phases for maturity and gonad staging and obtain an improved estimate of the L50 and estimate spawning seasons and areas by stock. Some gaps remain in the temporal and spatial coverage that has to be addressed to obtain accurate estimates of reproductive parameters.

SCRS/P/2023/070 - This presentation summarized a set of southern Atlantic SWO closed-loop simulations. OMs for the southern stock were parameterized by fitting openMSE's Rapid Conditioning Model to catch, indices, and length-composition data for the southern stock. For the Beverton-Holt steepness and von Bertalanffy growth parameters, OMs used the output from a multi-variate prior on steepness. Ten MPs were tested that included surplus production models, delay-difference, and age-structured models. To illustrate an option for MPs selection from among these MPs, the analysis used a satisficing criterion that selected MPs that avoided the 40%BMSY limit reference point with 90% probability, where the probability of being in the green quadrant was more than 50%, and where the catch was at least 50% of the reference catch (a proxy for MSY). The presentation proposed an additional set of candidate OMs to test. These included: an axis for different prior choices, fitting steepness or just keeping multivariate prior, and the choice of the CPUE cluster. The presentation emphasized the need to clarify the overall objectives of the southern Swordfish MSE.

SCRS/P/2023/071 – Not provided by the authors.

SCRS/P/2023/072 – The presentation outlined priorities for work in phase 6 of the swordfish biology program (SWOYP), in particular the spatial-temporal sampling gaps that still need to be addressed. This plan includes a proposal for sample collection in hypothesized spawning areas in the Sargasso Sea and the Gulf of Guinea. Additional work is needed to improve growth models and maturity ogives.

SCRS/P/2023/073 – This presentation outlines research plans for phase 5 of the swordfish biology program (SWOYP). This phase will focus on age validation studies using bomb radiocarbon and epigenetic ageing; filling gaps in maturity ogive data; and better defining stock boundaries and mixing.

SCRS/P/2023/074 – This presentation provided a summary of the SCRS's interactions with PA4 in early 2023 and described key decisions and interactions that are needed with the Panel later in 2023 in preparation for the Commission's selection of a CMP, scheduled for later 2023.

SCRS/P/2023/094 – Not provided by the authors.

SCRS/P/2023/076 – This presentation explored the consequences of the 10 cm increase of the Minimum Landing Size (MLS) following ICCAT Recommendation 16-05. It uses data from Observers (2017-2021) and Total Reported Landings to estimate the number of kilos discarded by the surface longline fleet targeting swordfish in the Spanish Mediterranean for each month the fleet is active (April to December) for the fraction of fish ranging from 90 to 100 cm straight lower jaw fork length (LJFL). This estimation on the monthly amount of discarded fish is added to the total amount of reported landings for each month of the year (from 2017 to 2021) to explore in which month of the year the TAC is reached when this fraction of fish is included in the total catches. In addition, a preliminary analysis on the carbon footprint of the fleet is conducted. Results show that reducing the MLS at 90 cm would consume the TAC earlier in the year, which would reduce the duration of the fishing season and consequently the carbon footprint of the fleet.

Appendix 5

Current management objectives and corresponding performance metrics based on input received at the March 2023 Panel 4 meeting.

Management Objectives (Res. 19-14)	*Proposed Corresponding Performance Metrics*
Status The stock should have a [51, 60, 70]% or greater probability of occurring in the green quadrant of the Kobe matrix.	*PGK_{short}:* Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in years 1-10 *PGK_{6-10}*: Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in years 6-10 *PGK_{med}:* Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in years 11-20 *PGK_{long}:* Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in years 21-30 *PGK:* Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) over years 1-30 *PGK_{30}:* Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in year 30 *POF* – Probability of overfishing (F>F_{MSY}) over years 1-30. *PNOF* – Probability of not overfishing (F<F_{MSY}) over years 1-30.
Safety There should be a [5, 10, 15]% or less probability of the stock falling below B_{LIM} (0.4*B_{MSY}) at any point during the 30-year evaluation period.	*LRP_{short}*: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) in any of years 1-10 *LRP_{med}*: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) in any of years 11-20 *LRP_{long}:* Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) in any of years 21-30 *LRP*: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) in any of years 1-30
Yield Maximize overall catch levels.	*C1* – TAC in the first management cycle (years 1-3) *$AvTAC_{short}$* – Median TAC (t) over years 1-10 *$AvTAC_{med}$* – Median TAC (t) over years 11-20 *$AvTAC_{long}$* – Median TAC (t) over years 21-30
Stability Any increase or decrease in TAC between management periods should be less than [25]%. [also test no stability limitation]	*VarC* – Median variation in TAC (%) between management cycles over years 1-30 *MaxVarC* – Maximum variation in TAC (%) between management cycles over years 1-30