# SCIENTIFIC COMMITTEE
# NINETEENTH REGULAR SESSION

## Koror, Palau

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**Shark research plan 2021-2025 mid-term review**

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**WCPFC-SC19-2023/EB-WP-06**

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# Executive Summary

This document represents a mid-term review of the WCPFC's third Shark Research Plan (SRP) covering the years 2021-2025. The this review will be augmented by input from an Informal Working Group (SRP-IWG) at the SC19. This document includes commentary on progress against the plan and on existing and new project proposals within the plan. New projects have emerged from stock assessment and other recommendations as well as feedback from an online Informal Working Group that reviewed an earlier draft of this review.

The following recommendations are proposed for the SC19 to consider:

1. Recommend reinstating the Informal Small Group on sharks (ISG-sharks) at SC19 for annual ongoing review and amendment of the SRP. This can replace the need for a mid-term review. When the ISG develops its terms of reference we suggest that it considers including the following:
   (a) The ISG-sharks rank the projects listed within Table 5 and Table 6 for prioritisation within the shark research plan[1].
   (b) The ISG-sharks consider streamlining the projects and merge or remove projects where necessary.
   (c) The ISG-sharks develop a schedule for and allocate a start date for the projects listed in Table 5 and Table 6.
   (d) The ISG-sharks develop terms of reference for all projects including stock assessments intended to begin in 2024.
2. Extend the current shark research plan to 2030 to encompass two assessment cycles.
3. As there are now many sharks being released and cut free, and a number of EEZs have non-retention policies for all sharks, data on sharks is becoming more uncertain rather than improving overtime. This is introducing further challenges to assessing status of key shark stocks. For less common species such as threshers (all species), whale shark and manta and mobulid rays, integrated stock assessment is unlikely to be possible. For these these stock we suggested attempting simpler fishery characterisations that may provide some indications of trends. Given the data challenges for estimation of stock status of most sharks, other methods should be explored, in particular, close-kin mark recapture (CKMR). It is recommended that the Regional Observer Program sampling protocols should include training of observers to include methods for non-lethal biological sampling and contamination free genetic sampling. Sampling of tissues should begin, under a 'shark sampling plan', to build a sample database for future studies.
4. SC19 should note Table 5 and consider any proposed changes.
5. The data gaps and proposed work identified in Table 6 and Table 7 should be considered by the ISG-sharks who should also propose timelines for the agreed work. The ISG should put forward its priority projects to the SC19 to be considered

[1]Note: projects from the SRP elevated to the SC workplan for prioritisation will get re-prioritised as per the agreed SC prioritisation process.

for funding along side other projects using the SC project scoring criteria (SC17 Summary report Table WP-01).

# 1 Introduction

The first Western and Central Pacific Fisheries Commission (WCPFC) Shark Research Plan (SRP) was developed to design, plan and co-ordinate research relevant to the management of elasmobranchs in the Western and Central Pacific Ocean (WCPO) (Clarke and Harley, 2010). At the $11^{th}$ meeting of the WCPFC Scientific Committee (SC) the SC agreed on the second phase of the SRP (Brouwer and Harley, 2015) with the third SRP (SRP3), covering 2021-2025, being agreed to in 2020 (Brouwer and Hamer, 2020). This paper outlines the progress against the SRP3.

The SRP is a living document that can change as the information needs of the WCPFC evolve. The plan is designed to be assessed annually by the SC usually through an Informal Small Group (ISG) and the following years' work is finalised by the SC. However, due to the COVID-19 pandemic disruptions the SRP work plan has not been thoroughly reviewed in recent years. It is anticipated that this document will be finalised at SC19, as will the 2024 project list. This review was developed with input from an online Informal Working Group (SRP-IWG) consisting of Commission Members, Cooperating non-Members, and participating Territories (CCMs), and WCPFC Observers as per the process that was followed during the development of the SRP3 (Table 1).

This plan falls within the umbrella of Articles 5(d) and 10.1(c) of the Convention which state that:

1. "*the members of the Commission shall... assess the impacts of fishing, other human activities and environmental factors on target stocks, non-target species, and species belonging to the same ecosystem or dependent upon or associated with the target stocks...*"; and
2. "*... the functions of the Commission shall be to adopt, where necessary, conservation and management measures (CMMs) and recommendations for non-target species and species dependent on or associated with the target stocks, with a view to maintaining or restoring populations of such species above levels at which their reproduction may become seriously threatened.*"

In response to this, focus of this plan are the WCPFC Key Sharks, but it does not preclude other elasmobranchs should the need arise for information on any other species. As with its forerunners, this plan could also support the efforts of the WCPFC's members to meet their obligations under other relevant international instruments. Importantly, the WCPFC budget may not be sufficient (nor is it expected) to complete all the recommended work for successful implementation of the plan. Member countries and other organisations are encouraged to undertake some of the work through funding external to the WCPFC.

The intent of this document is to help to co-ordinate work within the WCPO, review the work progress against the intended work in the SRP3, and provide commentary on the future work plan within the SRP3.

# 2 Key shark species designation

The process for designating key sharks within the WCPFC is described in WCPFC (2012). This document provides a framework for evaluating proposals for new key shark species by

describing the range of issues to be considered. *When key shark species are designated for data provision they are included in the Scientific Data to be Provided to the Commission. When key shark species are designated for assessment, they are included in the WCPFC's Shark Research Plan.* In this process shark species were prioritised for designation as Key Sharks, but not for research purposes. As such there is no prioritisation among species to guide research planning.

While species are not prioritised for research within the Shark Research Plan, *d*e facto prioritisation for work has occurred where initial stock assessments have been undertaken for species or stocks with the most data such as silky sharks (e.g. Rice, 2012), or research into threatened charismatic megafauna such as whale sharks (e.g. ABNJ, 2018). While research projects have been prioritised within the Scientific Committee no species prioritisation has taken place. The ISG-sharks could consider if species prioritisation for research is required or if the current data driven approach is adequate.

# 3 Methods

Data from Members, Cooperating Non-Members and Participating Territories (CCMs) of the WCPFC held by the Pacific Community (SPC) were extracted from various databases at SPC. Longline and purse seine logsheet, as well as observer data and annual catch estimates were requested, including:

- Longline
  - WCPFC public domain yearbook catch and effort data aggregated by year and flag.
  - 5x5° aggregated best estimates by day, flag, latitude and longitude, catch and effort.
  - Operational (logsheet[2]) catch and effort data from 1970-2022, by day, flag, Exclusive Economic Zone (EEZ), latitude and longitude, set type, catch and effort.
  - Observer data[2], including all set, gear, catch, fate and condition information.
- Purse-seine
  - WCPFC public domain yearbook catch and effort data aggregated by year and flag.
  - 1x1° aggregated best estimates by day, flag, latitude and longitude, set type, catch and effort.
  - Operational (logsheet[2]) catch and effort data, by day, flag, EEZ, latitude and longitude, set type, catch and effort.
  - Observer data[1] including all set, gear, catch fate and condition information.

[2]Note: Not all logsheet and observer data are available for stock assessments of elasmobranchs. As a result, the SPC could not release logsheet or observer data from some WCPFC member countries for the silky shark stock assessment and related analyses.

All data were collated and analyses were performed in R (R-Core Team, 2020). The total shark catch by flag were calculated from the unraised logsheet data. Observers are instructed to observe every hook to the extent possible, and when breaks occur these are recorded. On longline vessels, each fish is identified, measured, sexed, allocated a fate code, and condition code on capture and release (if the fish is observed being released/discarded).

Shark fate and condition information were extracted from the longline merged dataset. For each fish observed, observers record the fate of the fish and allocate the fate to one of 26 codes (Table 2). The fish condition is recorded at capture and release (if the fish is released) and allocated to one of six codes (Table 3). Fate codes were grouped into four broad groups (Escaped, Discarded, Cut free and Retained; noting that the finned state was included as retained). These data were then collated by year and vessel flag. The observers record the gear characteristics.

# 4 Review and Discussion

## 4.1 Data review

In the SPC raised dataset (L-best) no data were collected on sharks prior to 1995, small amounts of data have been collected since 2000, but this increased markedly in 2017 (Figure 1). Most of these records are reported to the generic shark code "SHK" but with some reporting to species groups such as "MAK" and "THR". Prior to 2017 about half the catch was raised as species specific codes, while since then only about 25% of the catch is species specific and around 75% is raised to the generic "SHK". This pattern with very high catch in recent years is largely driven by a single flag who has started reporting shark catch.

For the WCPFC yearbook data, in the annual catch estimates, most catch is recorded to species specific codes for all gears (Figure 2). For the observed longline catch almost all of the catch is recorded to species specific codes (Figure 3). In longline vessel logsheets, catch reporting to the species level has improved since 2010 with almost all catch being reported to the generic shark code "SHK" prior to 2010 and almost half the catch being reported to species specific codes (mostly blue sharks) since 2015 (Figure 4). For the purse seine vessels logsheet reporting improvements have also been noted since around 2005, and over the last 10 years about half the catch is reported to a species level primarily silky and oceanic whitetip sharks. Both longline and purse seine vessels catch reporting increased after 2010 (Figure 4).

Purse seine and, in particular, longline observed catch has increased sine 2010 (Figure 5). The longline observed catch is almost all recorded to a species level. Prior to 2010 few purse seine data exist and those few records were reported to generic shark codes. But since 2010, reported catch has increased and almost all of it is reported to species specific codes (Figure 5). Most of the longline observed catch was blue, thresher and mako sharks and the purse seine catch was mostly silky and whale sharks.

Retention rates of sharks in the WCPO have changed over recent years (Figure 6). While silky, oceanic whitetip and thresher sharks have been mostly released and cut free since about 2011, mako and blue sharks have largely been retained. After 2020 the retention rates drop for these species but these data are based on few records and once observer

rates normalise post COVID this analysis will need to be repeated to evaluate the reality of this trend.

Most sharks are alive and healthy at capture, but hammerhead sharks have lower capture survival rates (Figure 7). Condition on release is less well captured by observers with the condition of most fish in most years being unknown (Figure 8). In more recent years, recoding of condition at release has improved. Some species such as the rays, makos and threshers are alive and healthy at release, but about half the oceanic whitetip and probeagle sharks are dead at release.

Hook type can impact the survivability of sharks. Generally speaking, the trends in shark condition at capture by hook type show few obvious trends (Figure 9). However, some studies have shown that combinations of hook type and leader type are more important factors influencing shark survival (Afonso et al., 2012) and these trends would need to be explored in more detail. One reason for this may be that some sets have more than one hook type recorded but individual hook types are not ascribed to individual fish. Revising the observer data collection protocols would assist with this.

With most species now being released SC will need to re-consider the assessment schedule into the future as these will require considerable work on catch reconstructions to undertake the assessments. If these are not reliable then alternative approaches to monitoring population trends will need to be considered.

## 4.2 Observer data collection bias

Observer data within the WCPO can have some biases as the observer effort is not always representative of the fishing effort in space, time and by vessel flag. Observer effort in some areas such as the Hawaiian EEZ is relatively high, while in other areas such as the high seas and some parts of the tropics, observer information is deficient (Figure 10). This has also changed over time with some CCMs like Fiji and Tonga increasing their observer coverage in the more recent years (Figure 11). In addition, different observer programs may have different practices and operate in different areas (Figure 12 and Figure 13).

For sharks, generally the fate of fish differs between observer program collecting the information (Figure 14) and the vessel flag catching the fish (Figure 15). CPUE standardisations should therefore include observer program and/or vessel flag as factors within the model. Looking at silky and oceanic whitetip sharks their fates are similar (Figure 6), but this varies substantially between programs (Figure 14) and by vessel flag (Figure 15). Retention rates are high for these two species in the Chinese Taipei and Japanese observer programs and those flagged vessels. French Polynesia and New Caledonia mostly cut their silky and oceanic whitetip sharks free. Fiji and New Zealand have switched from retaining them to discarding and cutting them free.

Overall the gear that lands oceanic whitetip sharks and silky sharks are similar (Figure 16 and Figure 17). However, the gear characteristics change substantially between fleets. For example the observed hooks set varies between programs with fewer hooks set observed in the Australian, New Zealand and French Polynesian programs (Figure 18).

While the shark fate does not change much between flags and observer programs, the gear characteristic does change substantially. For example the observed hooks between floats varies between programs with fewer hooks between floats observed in the Australian,

Hawaiian and New Zealand programs (Figure 19). While the hooks between floats has changed through time for French Polynesia, decreasing in the most recent years. Similarly, for floatline length, the observer programmes from Australia, Hawaii, New Zealand and New Caledonia have shorter floatline lengths and those for Fiji and Chinese Taipei have changed through time with Fiji becoming longer and Chinese Taipei becoming shorter (Figure 17 and Figure 18). Both of these factors impact the depth of the hooks and will effect the catchability of sharks.

In this data summary we have not included analyses of detailed gear characteristics by flag, observer program and species. However, these should be included in fishery characterisations, at a species level, to evaluate the implications of different data sources and observer coverage. These analyses will provide insights into the catchability of the different species and whether observer program and vessel flag will need to be taken into account when undertaking CPUE standardisations.

## 4.3 Workplan review

The shark stock assessment plan is presented in Table 4. Overall the original assessment plan outlined in Table 9 of Brouwer and Hamer (2020) is going to schedule but there are a number of suggested changes for the upcoming assessments:

1. As agreed at SC18 the silky shark (and all future shark assessments) will be undertaken over two years to allow enough time for the data characterisation, CPUE standardisation and catch reconstruction.

2. The porbeagle shark assessment was not done or planned for in 2022 as scheduled. It is recommended that it would be more appropriate to assess this stock within the CCSBT where most of the catch occurs. WCPFC may want to support that assessment (if it occurs) through data provision.

3. The Pacific wide silky and thresher shark assessments were not approved for 2023, the ISG-shark should consider if these assessments are still required, and if "yes", when should they be conducted noting that a silky shark assessment for the WCPO region is currently underway. The previous bigeye thresher assessment (ABNJ, 2017) was inconclusive and based on non-conventional reference points (WCPFC, 2017), assessments for this species are probably going to be challenging and other methods to monitor the stock such as fishery characterisations, CPUE analysis and/or close-kin mark-recapture (CKMR) should be considered.

4. As many sharks are being released and cut free, and a number of EEZs have non-retention policies for all sharks, data on many sharks is becoming more sparse and trends are challenging to interpret. As a result for less common species such as threshers (all species), hammerheads (all species), whale sharks and manta and mobulid rays stock assessments are not recommended, but fishery characterisations should be attempted to evaluate trends in catch/populations. The feasibility of alternative approaches for estimating stock status, such as CKMR should be explored.

5. The development of the next SRP is considered here. However, as many sharks are discarded or cut-free data are becoming more sparse (not improving as expected when the first SRP was developed) and as such, data improvements and improved assessments for many species are less likely to be possible. In addition for continuity,

and provide opportunity to better explored the implications of these data challenges, it may be prudent for the plan to encompass two assessment cycles. Therefore, it is recommended to extend the current shark research plan to 2030 with annual reviews by ISG-sharks at SC meetings.

The accepted 'best available science' stock status for WCPFC sharks is presented in Figure 20. These data show that oceanic whitetip sharks are overfished and overfishing is taking place; silky sharks are experiencing overfishing; and North Pacific mako and both North and South Pacific blue sharks are not overfished nor experiencing overfishing (Hare et al., 2021).

The overall project plan for the SRP3 was outlined in Table 7 of Brouwer and Hamer (2020). This has been updated here and comments provided in Table 5. The assessments generally, have been commented on above, but two additional projects recommended by the SC have also been completed for blue and southwest pacific shortfin mako shark and have been added to the stock assessment section of Table 5. Under section 1b of Table 5 two projects were listed and one complete. The second (catch reconstruction using fin trade data) should be re-assessed by the SC19 to consider the necessity and feasibility of this work. Typically, as part of the work leading into the current stock assessments catch reconstruction is undertaken as part of that work and fin trade data has been problematic. Estimated from fin trade data appear to be excessively large and the trends contradict those of the estimated population trends. This project was given a medium priority in SRP3 and will need to be re-considered by SC19.

Section 2 of Table 5 contains information on shark catch mitigation. Two projects are still scheduled, both will need consideration at SC19. Two projects on post-release survival were scheduled for completion in 2023. For the first project 2bi) Table 5 work has been done in the IATTC that is relevant, and SC19 should consider if this work is enough to remove this from the future work plan or amend it. The second project 2bii) on whale shark post-release survival, has so far been unsuccessful. This work is still relevant and the ISG-sharks should consider the issues with this work and if it should continue or be modified.

Section 3 of Table 5 presents the projects relevant to improving our understanding of shark biology. All of this work was due to start in 2023, however, all these projects have been delayed as COVID-19 has impacted observer deployments and training and no samples have been collected for analysis. This work should be re-scheduled once enough samples have been collected. The observer data improvement projects are presented in 4a) Table 5. All four projects are ongoing but the shark identification manual is complete (Park et al., 2019) and is currently being used as a training material and as an identification guide by observers and skippers. However, due to the COVID-19 pandemic, observer training was postponed and SPC is currently looking at getting protocols developed for shark biological sampling through a consultancy. However, ROP training in conversion factor measurement collection have recently been introduced into the observer protocols. Observer protocols should be updated to include non-lethal sampling for genetic studies including CKMR.

Lastly, Table 6 includes a list of research needs that are currently not in the SRP3. These work streams will need to be considered by SC19, prioritised and scheduled within SRP3 or future SRPs. This is divided into three sections mantas, hammerhead sharks and general research. Note that we could start collecting tissue samples as soon as possible as

these could be used to improve the temporal span of population trends should CKMR studies be undertaken and tissue samples could also be used for life-history studies such as DNA ageing and stock structure studies.

Work on manta and mobulid rays is relevant as there is some concern over the impact of catch on these species. The work required includes post release survival, fishery characterisations, biological investigations and stock structure information. Some of these projects can be linked, and these linkages are noted in Table 6.

Similar approaches are noted for hammerhead sharks, but biological investigations are not included as it is unlikely that enough samples could be obtained within the lifetime of the current SRP for viable biological studies.

General research projects are also included in Table 6 these include a review of the effectiveness of CMM2019-04-sharks (which has subsequently been replaced by CMM2022-04; developing a new SRP or extending SRP3; and CKMR scoping studies. The CMM-sharks has never had a specific review to evaluate its effectiveness and it has been in place for a number of years so a review would seem timely. However, given the reduction in observer coverage over the COVID years and a change in the CMM in 2022, the CMM-sharks review may more effective if the start date is in 2026 or 2027. The SRP roll-over is discussed above. The SPC pre-assessment workshop noted that as shark assessments are becoming increasingly difficult, and recommended that alternative approaches to assessing population size should be investigated. If this work includes CKMR, the first stage would be to undertake a scoping analysis to develop a sampling plan for effective sample collection for each species or species identified as most suitable for CKMR.

## 4.4 Reserach recommendations from recent assessments

The following research recommendations have been made in stock assessment papers which fall under the 2021-2025 Shark Research Plan (Large et al., 2022; Neubauer et al., 2021a; Neubauer et al., 2021b; Tremblay-Boyer et al., 2019).

### Southwest Pacific shortfin mako shark

- Poor representation of mature female southwest Pacific shortfin mako sharks in commercial fishing data suggests that all inferences for this important partition of the stock are derived from assumptions and estimates of biological and fisheries parameters, with no direct observations to assess the appropriateness of these assumptions/estimates. In the absence of alternative data sources on trends in this component of the stock, this issues will likely remain in future, and alternative assessment approaches should be explored.
- Relatively consistent estimates of fishing mortality and related reference points for southwest Pacific shortfin mako sharks suggest that recent declines in catch may have been sufficient to reduce fishing mortality below critical levels. However, we note that these statistics are based on a single set of assumptions, and further work will be required to test the robustness of these preliminary statistics.
- Future assessments should spend increased effort to reconstruct spatio-temporal abundance patterns for shortfin mako, and develop a better understanding of how these patterns drive regional abundance indices.

- Additional tagging should be carried out using satellite tags on southwest Pacific shortfin mako sharks in a range of locations, especially known nursery grounds off southeast Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. Such tagging may help to resolve questions about the degree of natal homing and mixing of the stock.
- Tagging of southwest Pacific shortfin mako sharks may also help to obtain better estimates of natural mortality, if carried out in sufficient numbers. This could be taken up as part of the WCPFC Shark Research Plan to assess the feasibility and scale of such an analysis.
- Additional growth studies and validation of ageing methods from a range of locations could help build a better understanding of typical growth, as well as regional growth differences. Current growth data are conflicting, despite evidence that populations at locations of current tagging studies are likely connected or represent individuals from the same population.
- Genetic/genomic studies could be undertaken to augment the tagging work to help resolve the stock/sub-stock structure patterns. To support this work, a strategic tissue sampling program for sharks is recommended with samples to be stored and curated in the Pacific Marine Specimen Bank.

### Oceanic whitetip shark

- The predictions of recent and latest stock status were highly sensitive to assumptions made about discard and post-release mortality for oceanic whitetip shark. In particular, the final status in relation to F-based reference points was more sensitive to assumptions about discard mortality than the scaling of the overall catch. It was recommended that ongoing and new studies on this topic for this species be prioritized and projections of current stock status be updated with estimates of PRM specific to oceanic whitetip shark in the WCPO.
- It was recommended that spatial trends in shark length for the longline dataset be analysed in a dedicated study in order to determine the likely cause for a north-south increase in the mean length observed, and that approaches to standardize the length dataset be investigated accordingly. This might enable the detection of a temporal signal in lengths which could inform the assessment model.
- There is a single fork length to total length conversion for the oceanic whitetip shark in the WCPO, based on a fork length measurement starting from the upper jaw (UFL). Comprehensive length-length conversions would facilitate the inclusion of data collected elsewhere in a different length format. It was recommended that additional length-length conversions be obtained, and, more specifically, a length-length conversion from total length (TL) to fork length measurements starting from the lower jaw (LFL). A TL to- LFL conversion would enable the addition of more observed lengths from SPC-held records.
- Historical catches for the target fleet were poorly estimated in the current assessment and previous iterations reconstructing catches for oceanic whitetip sharks. It is unlikely that the data present in SPC's observer records is adequate on its own to provide informative estimates. It was recommended that a direct collaboration

with countries having participated in the shark target fleet be undertaken to either produce an historical time series of targeted catch, or reliable anchor points that can be used to scale catches reconstructed from observer longline datasets.

- Growth studies in the last 20 years have highlighted considerable uncertainty in the growth and fecundity parameters for oceanic whitetip sharks. It is unclear if the variability in estimated parameters is linked to methodology, or the region or time period sampled. Traditional growth and fecundity studies usually imply destructive sampling as vertebrae and gonads are required for ageing and to assess maturity. While CMM2011- 04 allows for scientific sampling, traditional destructive sampling might not be optimal given the current state of the population. However, clasper condition can be assessed visually for males, and new non-lethal methods are being developed to assess maturity in females by assesing reproductive hormones in blood samples. It was recommended that SC investigates non-lethal approaches to collect growth and maturity samples for sharks and oceanic whitetip shark in particular. This would allow to improve knowledge about uncertain life-history parameters used to inform stock assessments even when no retention measures are in place.

### General

- It was recommended that observers record the length of the trailing branchline when individuals are cut-free, as current evidence indicates this variable might be influential in post release mortality rates.
- Increased effort should be made to re-construct catch histories for sharks (and other bycatch species) from a range of sources. In the Neubauer et al., 2021b assessment catch reconstruction models showed that model assumptions and formulation can have important implications for reconstructed catch. Additional data sources, such as logsheet reported captures from reliably reporting vessels, may be incorporated into integrated catch-reconstruction models to fill gaps in observer coverage.
- Dynamic/non-equilibrium reference points, such as $SB_{F=0}$ be investigated for shark stock status, as they may be more appropriate for fisheries with uncertain early exploitation history and strong environmental influences.
- The Tremblay-Boyer et al. (2019) assessment included the alternative reference points $F/F_{lim,AS}$ and $F/F_{crash;AS}$, which are related to $F/F_{MSY}$ and can be derived from a stock assessment or a risk assessment. They invited SC to note the alternative reference points $F/F_{lim,AS}$ and $F/F_{crash;AS}$, included in that assessment.

The following research recommendations have been made in other papers which fall under the 2021-2025 Shark Research Plan (Bigelow and Carvalho, 2021).

- Continue Project 101, with the following potential modifications to the Monte Carlo analysis:
  - Relevant members consider authorizing the release of their non-ROP longline data (facilitated through SPC) for this study, specifically to provide more complete gear configurations by flag, and allow analyses similar to Caneco et al. (2014) to estimate factors affecting shark catchability and condition on longline retrieval to be conducted using a more complete dataset.

- Conduct the Monte Carlo analyses with inputs on catchability, condition on longline retrieval and gear configurations by flag.
- Conduct projections with inputs on the impact of banning shark lines and wire leaders or both and estimates of the probability of post release mortality Hutchinson et al. (2021).

These recommendations have been compiled as a potential project list in Table 7.

# 5 Recommendations

The following recommendations are proposed for the SC19 to consider:

1. Recommend reinstating the Informal Small Group on sharks (ISG-sharks) at SC19 for annual ongoing review and amendment of the SRP. This can replace the need for a mid-term review. When the ISG develops its terms of reference we suggest that it considers including the following:
   (a) The ISG-sharks rank the projects listed within Table 5 and Table 6 for prioritisation within the shark research plan[3].
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The ISG should put forward its priority projects to the SC19 to be considered for funding along side other projects using the SC project scoring criteria (SC17 Summary report Table WP-01).

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# Tables

**Table 1: Attendance list for participants in an online Informal Working Group (SRP-IWG).**

| Name | CCM/Organisation |
|---|---|
| James Larcombe | Australia |
| Laura Tremblay-Boyer | Australia |
| Toby Patterson | Australia |
| Kath Large | Dragonfly Data Science |
| Kyuhan Kim | Dragonfly Data Science |
| Phillip Neubauer | Dragonfly Data Science |
| Adele Dutilloy | FFA |
| Yasuko Semba | Japan |
| Leyla Knittweis | New Zealand |
| Stephen Brouwer | Saggitus Limited |
| Paul Hamer | SPC |
| Keith Bigelow | USA |
| Nicholas Ducharme-Barth | USA |

**Table 2: Fate codes used by observers in the WCPFC regional observer programme. Fate codes are used to describe whether the fish was retained (RET), discarded (DIS), released, (REL), cut free (CUT).**

| Code | Fate | Generic code |
|---|---|---|
| DCF | Discarded cut free | CUT |
| DDH | Discarded de hooked | |
| DSO | Discarded struck off | |
| DDL | Discarded too difficult to land | |
| DGD | Discarded gear damage (tuna only) | DIS |
| DOR | Discarded other reason (specify) | |
| DPQ | Discarded poor quality | |
| DPA | Discarded protected species, Alive | |
| DPD | Discarded protected species, Dead | |
| DPU | Discarded protected species, Unknown | |
| DSD | Discarded shark damage | |
| DTS | Discarded too small (target species) | |
| DUS | Discarded uneconomic species | |
| DWD | Discarded whale damage | |
| ESC | Escaped | ESC |
| DFR | Discarded trunk fins retained (sharks) | RET |
| RFR | Retained both fins and trunk (sharks) | |
| RSD | Retained but shark damaged | |
| RCC | Retained for crew consumption | |
| RGG | Retained gilled and gutted (for sale) | |
| RGT | Retained gilled gutted and tailed (for sale) | |
| RGO | Retained gutted only. | |
| RHG | Retained headed and gutted (billfish) | |
| ROR | Retained other reason (specify) | |
| RPT | Retained partial (e.g. fillet, loin, trunk) | |
| RWW | Retained whole | |

**Table 3: Condition codes used by observers in the WCPFC regional observer programme. Condition codes are used to describe the animal's health status; and recorded when it is first caught and again if it is discarded/released.**

| Code | Description |
|---|---|
| A0 | Alive (not categorized) |
| A1 | Alive, healthy |
| A2 | Alive, injured, distressed |
| A3 | Alive, but dying |
| D | Dead |
| U | Condition unknown |

**Table 4: The current shark related assessment plan for the WCPFC as outlined in the 2021-2025 WCPFC Shark Research Plan Table 9 (Brouwer and Hamer, 2020). The comments are the authors perspective on the work planned.**

| Species | Stock | Last assessment | 2021 | 2022 | 2023 | 2024 | 2025 | Comments |
|---|---|---|---|---|---|---|---|---|
| Blue shark | Southwest Pacific | 2016 | X | | | | | Next assessment 2026-2027 noting SC agreement to run shark assessments over two years to allow for time to do CPUE and catch reconstructions. |
| | North Pacific | 2017 | | X | | | | Next assessment 2026-2027 noting SC agreement to run shark assessments over two years to allow for time to do CPUE and catch reconstructions. |
| Shortfin mako | Southwest Pacific | - | | X | | | | Next assessment 2027-2028 noting SC agreement to run shark assessments over two years to allow for time to do CPUE and catch reconstructions. Note that the 2022 assessment had inconclusive stock status. But giving the team more time could have resulted in more conclusive stock status. |
| | North Pacific | 2018 | | | X | | | Next assessment 2029-2030 noting SC agreement to run shark assessments over two years to allow for time to do CPUE and catch reconstructions. |
| Porbeagle | Southwest Pacific | - | | | | | | Not done or planned for in 2022, probably more appropriate to get this done in CCSBT where most of the catch occurs. WCPFC may want to support that assessment (if it occurs) through data provision. |
| | Southern Ocean | 2017 | | ? | | | | |
| Silky shark | WCPO | 2018 | | | X | | | Underway SC19 will need to consider the results tabled and consider the chance of success for the 2024 assessment. |
| | Pacific | 2018 | | | | X | | Moved to 2024 - SC19 Shark ISG consider if still needed |
| Oceanic whitetip shark | WCPO | 2019 | | | | X | | Changed to 2-year time frame |
| Pelagic thresher | WCPO | - | | | | | | None planned, data rich assessment probably not possible |
| Bigeye thresher | Pacific | 2017 | | ? | | | | Not done or planned for in 2022, SC19 Shark ISG will need to consider if still necessary. The previous assessment stock status was inconclusive and based on non-conventional reference points. |
| Common thresher | WCPO | - | | | | | | None planned, data rich assessment probably not possible |
| Greater hammerhead | WCPO | - | | | | | | Not likely to be possible consider characterisation approach none currently scheduled. |
| Smooth hammerhead | WCPO | - | | | | | | |
| Scalloped hammerhead | WCPO | | | | | | | |
| Winghead shark | WCPO | - | | | | | | |
| Whale shark | WCPO | - | | | | | | Not likely to be possible consider characterisation approach none currently scheduled. |
| | Pacific | 2018 | | | X | | | |
| Giant manta | WCPO | - | | | | | | Not likely to be possible consider characterisation approach none currently scheduled. |
| Reef manta | WCPO | - | | | | | | |
| Spinetail devil ray | WCPO | - | | | | | | |
| General | WCPO | - | | | | | | Next SRP 2026-2030 work will need to be done in 2025 |

**Table 5: The current shark related stock assessment schedule planned for the WCPFC as outlined in the 2021-2025 WCPFC Shark Research Plan Table 7 (Brouwer and Hamer, 2020). The comments are the authors perspective on the work status or planned.**

| 1. Stock assessment | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| (a) Determine the stock status for WCPFC Key Sharks | | | | |
| i) Southwest Pacific blue shark assessment | High | 2020 | 2021 | Complete (SC17-SA-WP-03; SC17-SA-IP-06; SC17-SA-IP-19) - stock not overfished and overfishing not taking place |
| ii) Northwest Pacific blue shark assessment | High | 2021 | 2022 | Complete (SC18-SA-WP-06) - stock not overfished and overfishing not taking place |
| iii) North Pacific shortfin mako shark assessment | High | 2023 | 2024 | Data preparatory meeting in Novenber 2023 assessessment scheduled for presentation to SC20 |
| iv) WCPO silky shark assessment | High | 2022 | 2023 | Underway (over 2 years) 1-year delayed start new end year = 2024 (papers for SC19 XXX; YYY) |
| v) Pacific silky shark assessment | Medium | 2022 | 2023 | Not funded in for 2023 moved to 2024 - SC re-consider it's necessity |
| vi) Pacific bigeye thresher shark assessment | Medium | 2021 | 2022 | Did not happen - SC19 reconsider need |
| vii) Pacific whale shark assessment | Medium | 2022 | 2023 | Not funded in for 2023 moved to 2024 - SC re-consider it's necessity. Stock assessment probably not possible. Suggest changing to fishery characterisation for 2024 (project description at SC19), then decide what needs to happen based on the outcomes of that analysis. |
| Southwest Pacific shortfin mako shark assessment | | | | Added by SC after initial SRP - Complete (SC18-SA-WP-02; SC18-SA-IP-07; SC18-SA-IP-13) - stock status inconclusive |
| P17X5. Scientific Advice for Southwest Pacific blue shark | NA | 2021 | 2022 | Extra unscheduled work proposed by SC - Complete (SC18-SA-WP-03) |

**Table 5: Stock Assessment continued.**

| 1. Stock assessment contued | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| (b) Develop reliable catch histories for WCPFC Key Sharks as far back in time as feasible | | | | |
| i) Redefining the fleets currently assumed in the BSH NP stock assessment | Medium | 2021 | 2022 | Work completed (ISC/21/SHARKWG-2/I-01) the results indicate that no change to the fleet composition used in the assessment was required. |
| ii) The development of alternative approaches to catch reconstructions based on estimates of the global fin trade | Medium | 2024 | 2025 | On the to do list, is this still relevant given it's not widely used and there are some concerns that this overestimates catch. The development of catch histories within stock assessment may be more appropriate. |
| (c) Test and improve Medium and Data Poor assessment methods to inform management decisions | | | | |
| i) Test and improve data poor assessment methods | Medium | 2024 | 2025 | To do - still planed |
| ii) Include data poor assessment metrics as standard outputs for data rich assessments | High | Ongoing | Ongoing | Done in SP-BSH, SP-mako? SC Shark ISG may want to review these and provide a specific list for future assessments. |

**Table 5: continued: Mitigation.**

| 2. Mitigation | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| (a) Provide advice on mitigation Sharks with non-retention policies and unwanted elasmobranchs | | | | |
| i) Investigate effective mitigation for WCPFC Key Sharks | Medium | 2023 | 2025 | To do - still planed project scheduled for proposal at SC19 |
| ii) Investigate mitigation method trade-offs between mitigation methods for sharks, seabirds and sea turtles | Medium | 2023 | 2025 | To do - still planed project scheduled for proposal at SC19 |
| (b) Provide advice on safe release methods and assess release survival of WCPFC Key Sharks | | | | |
| i) Estimate silky and oceanic whitetip shark post release survival from WCPO longline fisheries | High | 2021 | 2023 | Some work undertaken in EPO (IATTC - Shaffer) preliminary results indicate a post-release mortality rate of 5.7% for silky sharks<br>Hutchinson and Bigelow - OCS (67-92% survival) FAL (100% survival) |
| ii) Estimate whale shark post release survival from WCPO purse seine fisheries | High | 2021 | 2023 | NOAA Fisheries Service, Secretariat of the Pacific Community SSP, National Fisheries Authority PNG, WCPFC Secretariat AT project TC-S and B and the ROP (2015) Project Update on Deployment Plan for Whale Shark Post-Release Mortality Tags. WCPFC, Pohnpei, Federated States of Micronesia - any results? |

**Table 5: continued: Biological data improvements.**

| 3. Biological data improvements | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| (a) Increase the understanding of important biological parameters of WCPFC Key Sharks | | | | |
| i) Silky shark and oceanic whitetip shark reproductive biology and longevity | High | 2025 | 2028 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| ii) Biology and life history of hammerhead sharks | High | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| iii) Resolving blue shark reproductive biology and reproductive schedule | Medium | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| iv) Biology of the longfin mako shark | Medium | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| v) Life history of thresher sharks | Medium | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| vi) Validated life history, biology, and stock structure of the shortfin mako in the south Pacific | Medium | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| vii) Age validation and stock structure of the silky shark and oceanic whitetip shark | Low | 2023 | 2025 | To do - still planed but probably delayed due to COVID delays for observer training in biological data collection. Schedule work once enough samples have been collected. |
| viii) Stock structure and life history of southern hemisphere porbeagle shark | Low | 2023 | 2025 | To do |

**Table 5: continued: Observer data collection.**

| 4. Observer data collection | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| (a) Improve spatio-temporal observer data for informing scientific needs | | | | |
| i) Training observers in the WCPO to be proficient in species identification | High | Ongoing | Ongoing | Material developed by SPC: Park T., Marshall L., Desurmont A., Colas B. and Smith N. 2019. Shark and ray identification manual for observers and crew of the western and central Pacific tuna fisheries. Noumea, New Caledonia: Pacific Community. 79 p.<br>Observer training ongoing |
| ii) Training observers for extraction and storage of vertebrae and shark reproductive material | High | 2021 | Ongoing | SPC currently looking at getting the protocols developed for shark biological sampling through a consultant. This should also ensure that observer training covers good sampling practices for tissue samples to reduce cross-contamination. |
| iii) Training observers for on-deck reproductive staging of elasmobranchs | High | 2021 | Ongoing | SPC currently looking at getting the protocols developed for shark biological sampling through a consultant |
| iv) Measuring elasmobranchs on purse seine and longline vessels for length-length and length-weight conversion factor development | High | Ongoing | Ongoing | ROP training conversion factor measurements have just been introduced - COVID delay. |

**Table 6: Research data gaps identified by the authors for consideration for incorperation into the WCPFC Shark Research Plan. The comments are the authors perspective on the work need.**

| Research needs | | | | |
|---|---|---|---|---|
| Title | Priority | Start year | End year | Comments |
| Mantas | | | | |
| Post-release survival | | | | Can begin anytime - no reason to delay scheduling this work if deemed a priority by the SC - needs consideration by SC19 shark ISG |
| Stock assessment | | | | Not likely to be possible consider characterisation approach |
| Fishery characterisation | | | | Could be linked to whale shark characterisation - needs consideration by SC19 shark ISG |
| General biology | | | | Schedule work once enough samples have been collected. Or undertake biological work in places where fisheries (outside on WCPFC) retain these species. |
| Movement | | | | Can be linked to post release survival work |
| Stock structure | | | | Can be linked to post release survival work, if done through movement studies. If using genetics will need an analysis to design the most appropriate sampling strategy for genetic samples. |
| Hammerhead sharks | | | | |
| Stock assessment | | | | Not likely to be possible consider characterisation approach |
| Fishery characterisation | | | | Could be linked to whale shark characterisation - needs consideration by SC19 shark ISG |
| Stock structure | | | | Probably needs genetic analysis. Post-release mortality work from purse seiners shows high degrees of mortality (75% - Eddy et al. 2016) so tagging probably not an option for that fleet. Catch rates probably too low for easy tagging from the longline fleet. If using genetics will need an analysis to design the most appropriate sampling strategy for genetic samples. Could be linked to manta work. |
| General research | | | | |
| Review on the impact of the CMMs shark and 2022-04 | | | | Suggested addition to review the shark CMMs impacts. |
| SRP 2026-2030 | | | 2025 | Next SRP 2026-2030 work will need to be done in 2025, suggest extending the current plan with a review in 2026 or 2027 |
| Genetic population estimates | | | | From PAW - Close-kin mark recapture various sharks species - would need a scoping study to analyse how where and when to collect the samples. For highly migratory species, share (import/export) of sample is necessary but it is very difficult at current regulation by CITES. This may apply to all biological sampling including close-kin for sharks, which could occur through non-lethal sampling. The SRP-IWG suggested that genetic sampling on all key sharks could start immediately and should be collected routinely by observers. these samples will be useful and temporal aspects to the genetic data are useful. The scoping study will be used to refine the sampling. This would need some discussion at the SC19 Shark ISG. |
| Review options to assess species status given the loss [degradation] of key data inputs for traditional stock and risk assessments. | | | | This work is important given the high release rates of sharks as well as the size specific retention for length measurements. These result in reduced catch information and biased length frequency samples. |

**Table 7: Potential research projects emminating from recent SC paper recommendations.**

| Project | Comments |
|---|---|
| 1) Develop alternative assessment approaches that can determine stock status in the absence of alternative data sources on trends in the adult female component of the southwest Pacific shortfin mako stock. | |
| 2) Test the robustness of these preliminary southwest Pacific shark statistics using a wider suite of assumptions. | |
| 3) Develop a better understanding of how spatio-temporal abundance patterns drive regional abundance indices for shortfin mako sharks. | |
| 4) Incorporate additional data sources, such as log-sheet reported captures from reliably reporting vessels, into integrated catch-reconstruction models to fill gaps in observer coverage to get more reliable re-construct catch histories for sharks. | Include in assessment project specifications |
| 5) To resolve questions about the degree of natal homing and mixing of the southwest Pacific shortfin mako shark stock, undertake satellite tags on in a range of locations, especially known nursery grounds off southeast Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. | |
| 6) Assess the feasibility and scale of shark tag and recapture studies to obtain better estimates of natural mortality. | |
| 7) Undertake growth studies and validation of ageing methods for short fin mako sharks from a range of locations to build a better understanding of typical growth, as well as assess regional growth differences. | Already planned? |
| 8) Develop a strategic tissue sampling program for sharks, then undertake genetic/genomic studies to augment the tagging work to help resolve the stock/sub-stock structure patterns. | Already in this plan? |
| 9) Investigate the use of dynamic/non-equilibrium reference points, such as SBF=0 as they may be more appropriate for fisheries with uncertain early exploitation history and strong environmental influences. | Used in some assessments or include in assessment project specifications |
| 10) Prioritise post-release mortality of oceanic whitetip sharks and include these in projections of current stock status. | |
| 11) Update the observer data to include recording of the length of the trailing branchline for sharks that are cut-free. | Not a research project SC decision on minimum RoP data |
| 12) Assess spatial trends in oceanic whitetip shark length from longline vessels to determine the likely cause for a north-south increase in the mean length observed, and assess approaches to standardize the length dataset. | Can be done with current data, should be scheduled before next assessment |
| 13) Develop comprehensive length-length conversions factors. | Already progressing |
| 14) For oceanic whitetip sharks produce a historical time series of targeted catch using observer data from SPC in collaboration with countries with shark target fisheries to be used as anchor points that can be used to scale catch reconstructions from observer data. | Include in assessment project specifications |
| 15) Investigates non-lethal approaches to collect growth and maturity samples for sharks, such as the use of clasper condition to visually assess male shark reproductive state, and develop non-lethal methods to assess maturity in females such as sampling reproductive hormones in blood samples. | Include in observer training |
| 16) Continue Project 101, with the following potential modifications to the Monte Carlo analysis, 1) using non-ROP longline data, specifically to provide more complete gear configurations by flag, and to estimate factors affecting shark catchability and condition on longline retrieval; 2) Conduct the Monte Carlo analyses with inputs on catchability, condition on longline retrieval and gear configurations by flag; and 3) Conduct projections with inputs on the impact of banning shark lines and wire leaders or both and estimates of the probability of post release mortality. | |

# Figures

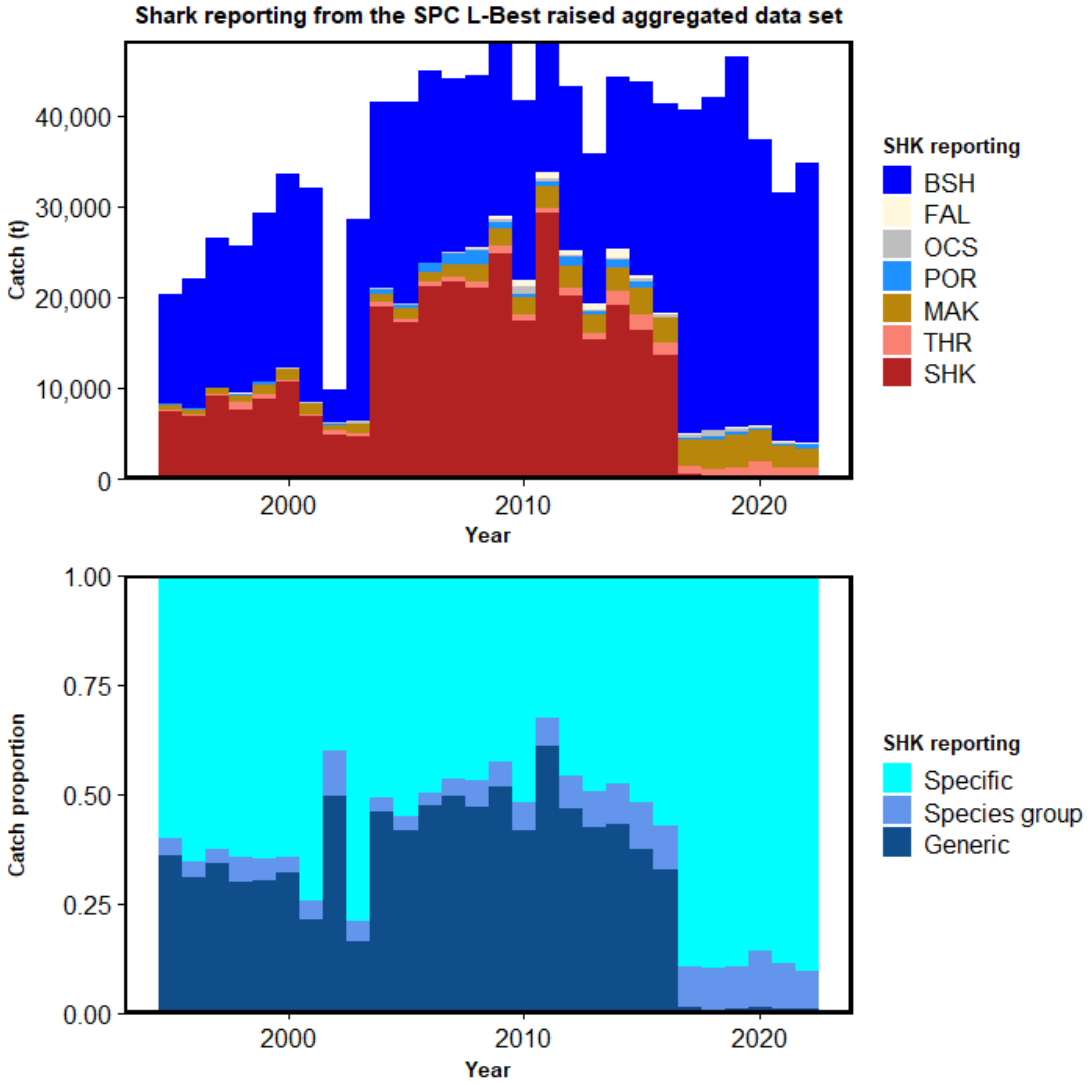


**Figure 1: Shark reporting data from the SPC L-Best dataset showing the reporting by species code (top) and as a proportion of the catch as species specific reporting, as a species group or a non-specific generic shark reporting.**

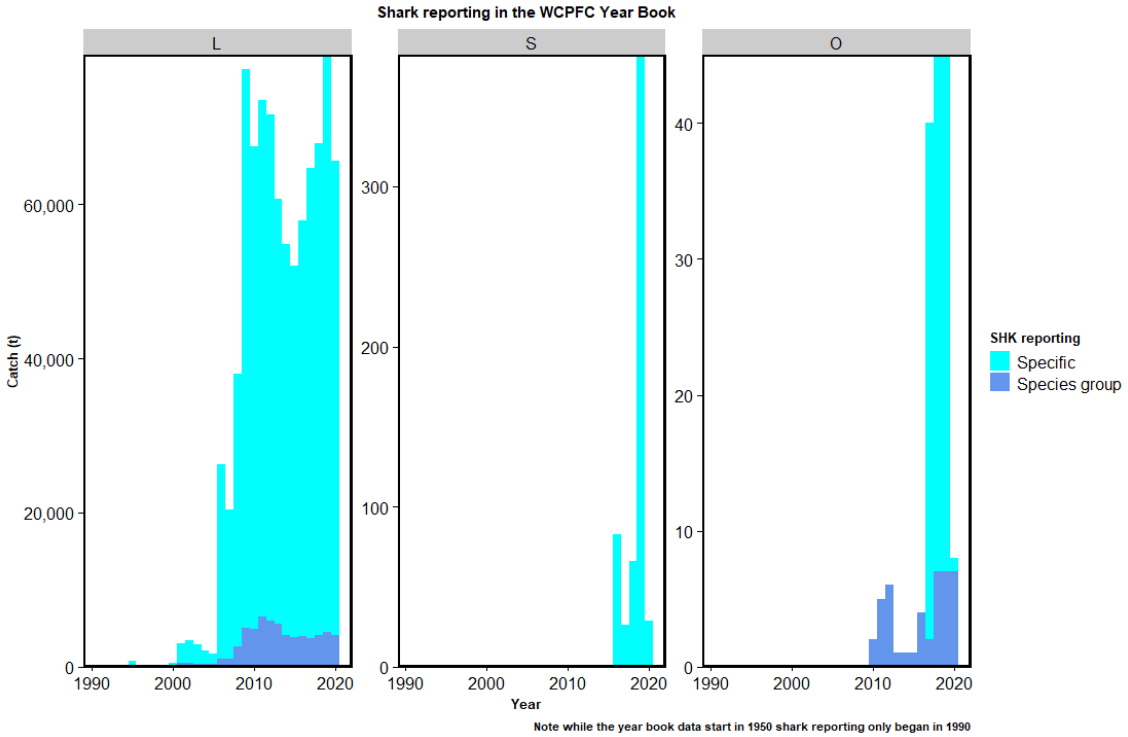


**Figure 2: Shark reporting data from the WCPFC Year Book (SPC-OFP, 2022) dataset showing the reporting as species specific reporting or species group reporting and by gear. L = Longline, S = Purse seine, O = Other.**

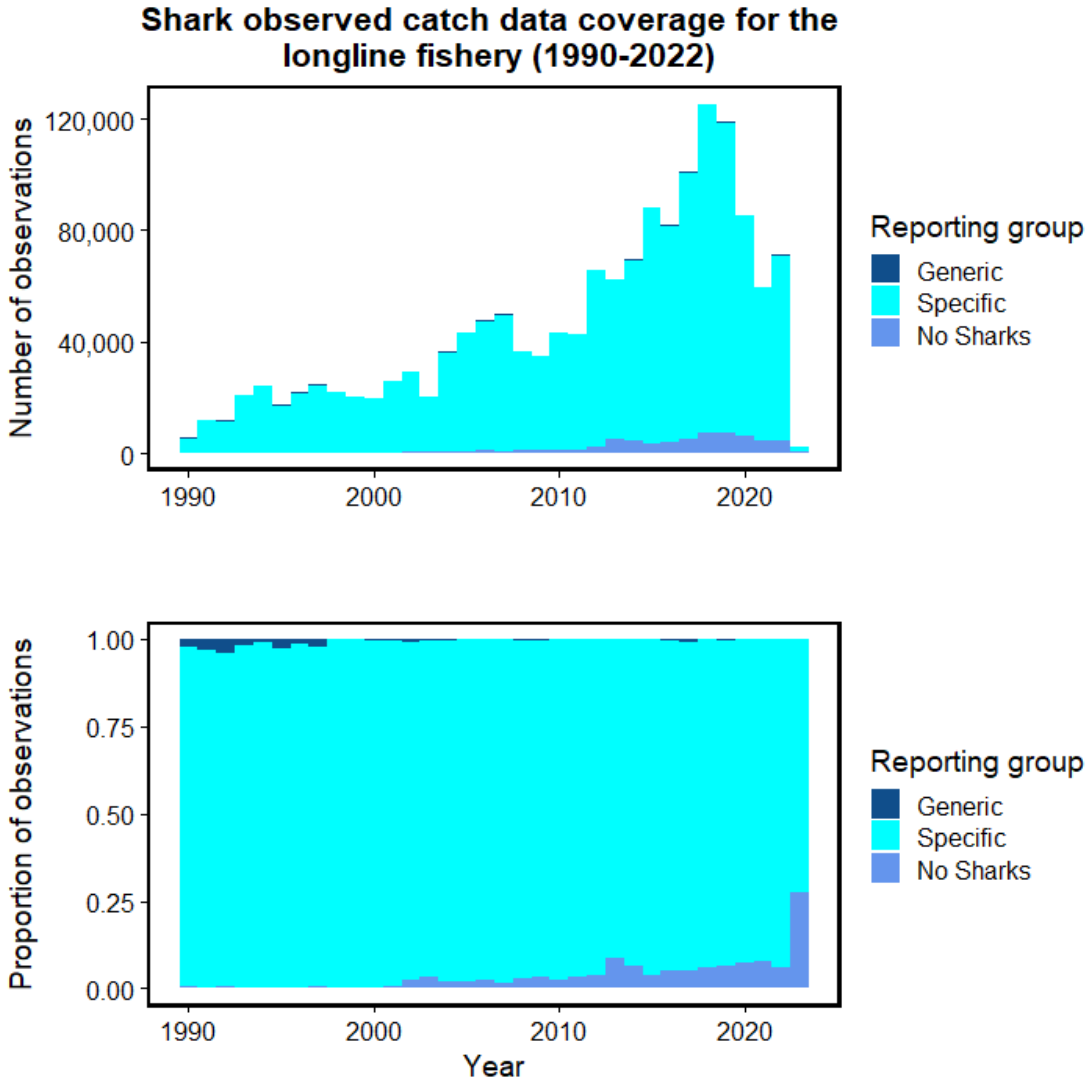


**Figure 3: Shark reporting data from the WCPFC observer programs.**

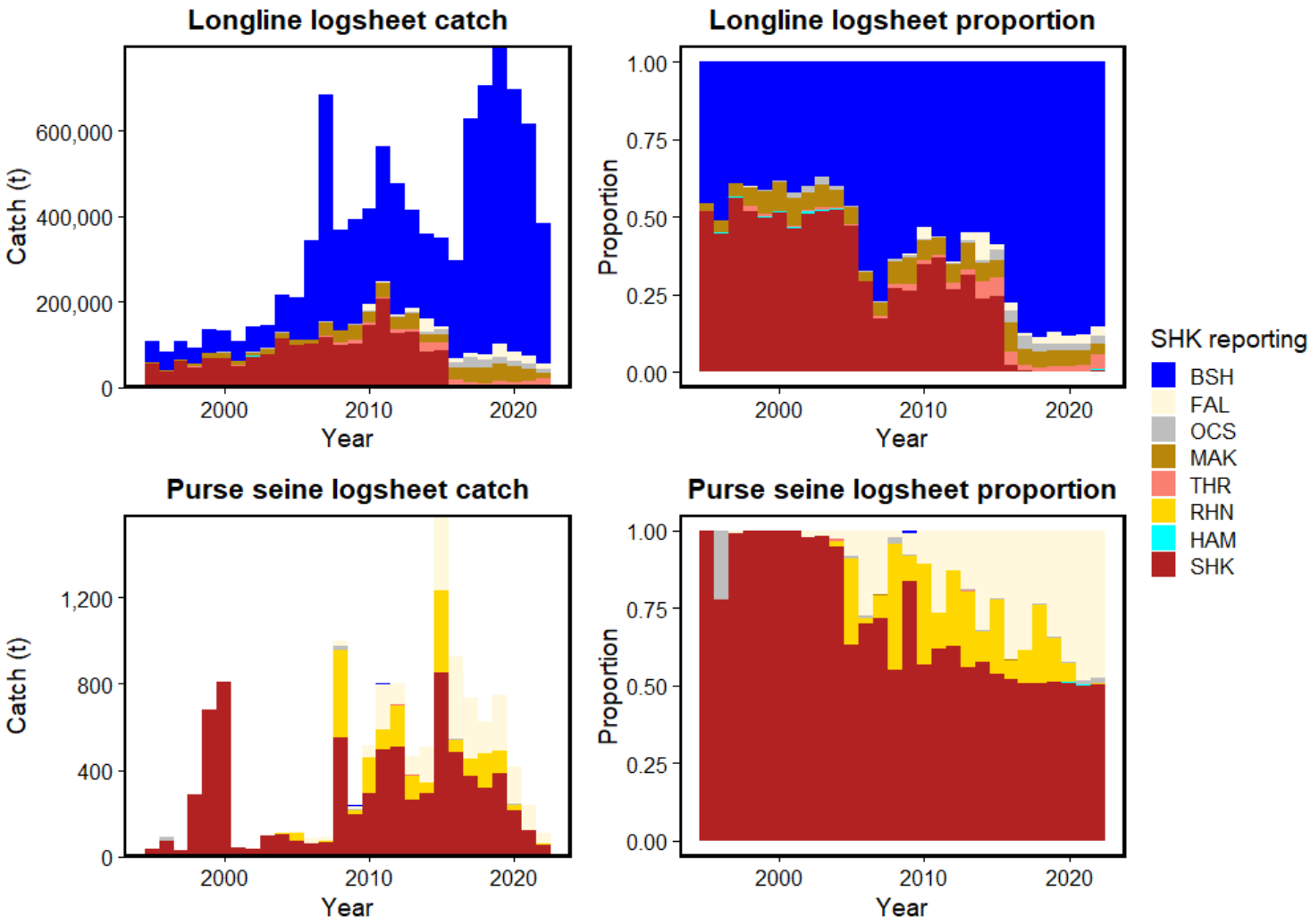


**Figure 4: Logsheet catch report on longline and purse seine vessels by year for all flags combined from 2000-2022, note the 2022 data are not complete.**

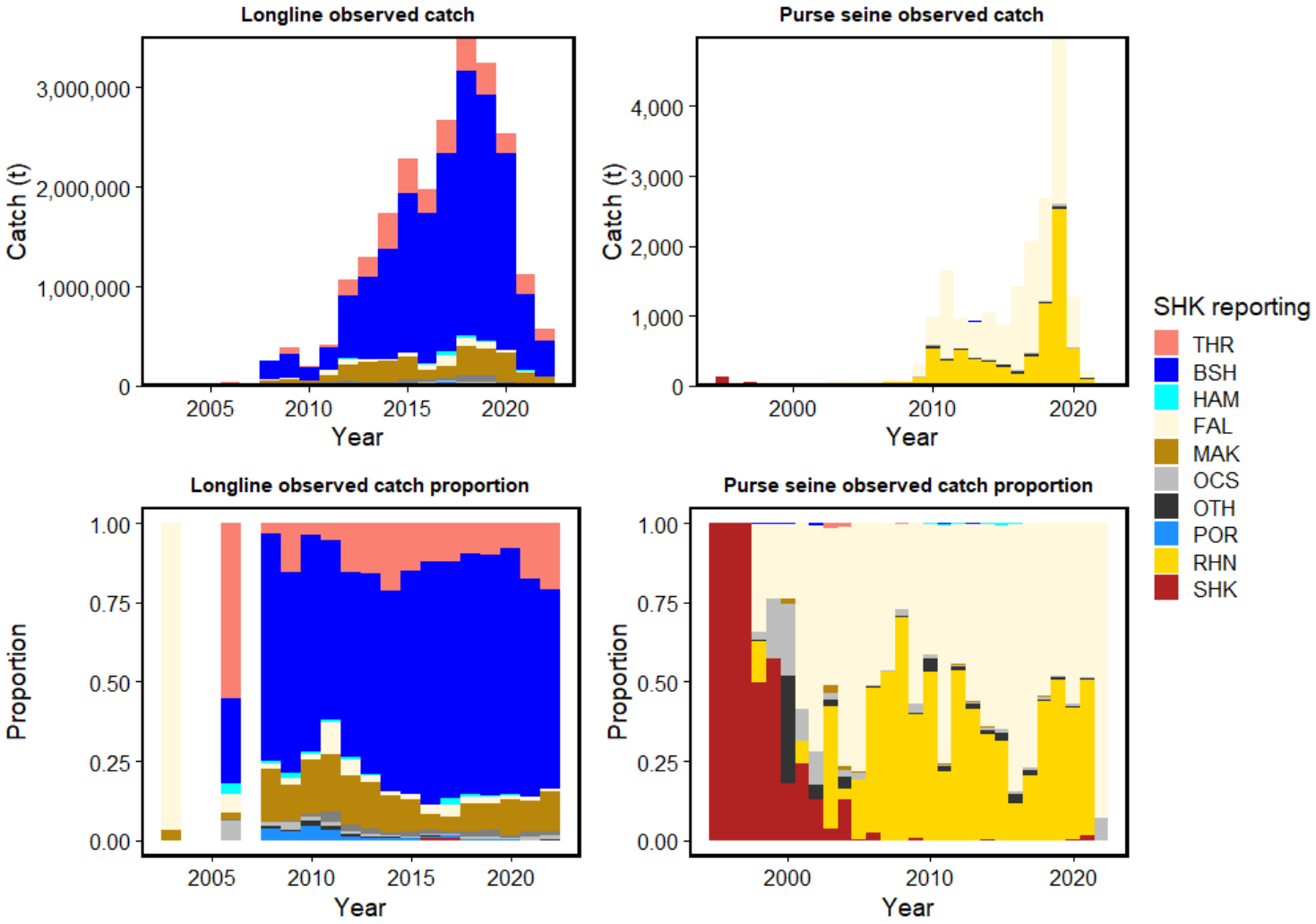


**Figure 5: Observed longline and purse seine shark catch by year for all flags combined from 2000-2022, note the 2022 data are not complete.**

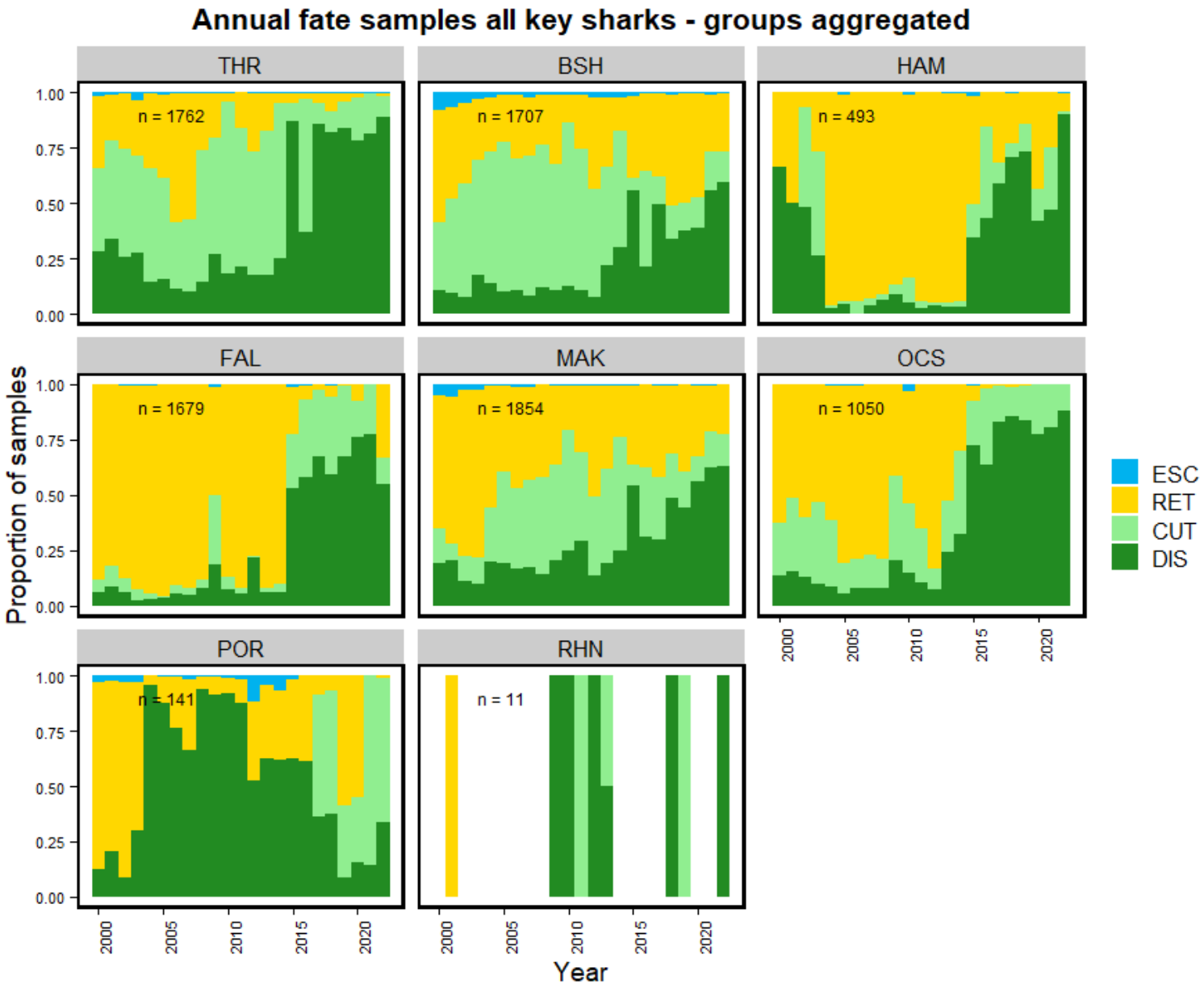


**Figure 6: The fate of sharks caught in longline sets within the WCPO. All thresher, hammerhead, mako and rays have been grouped into their respective species groups and are not shown as individual species.**

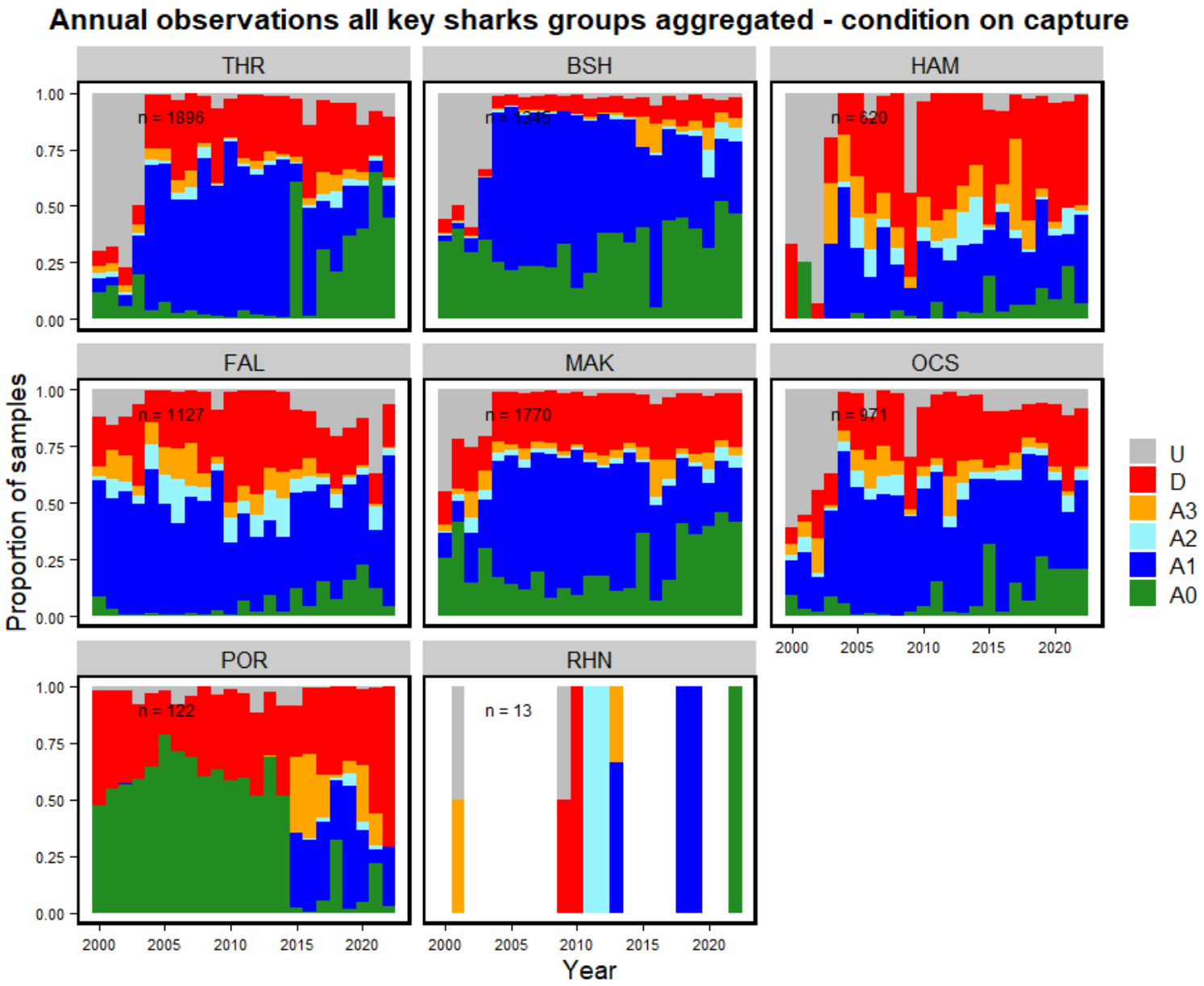


**Figure 7: The condition on capture of sharks caught in longline sets within the WCPO. All thresher, hammerhead, mako and rays have been grouped into their respective species groups and are not shown as individual species.**

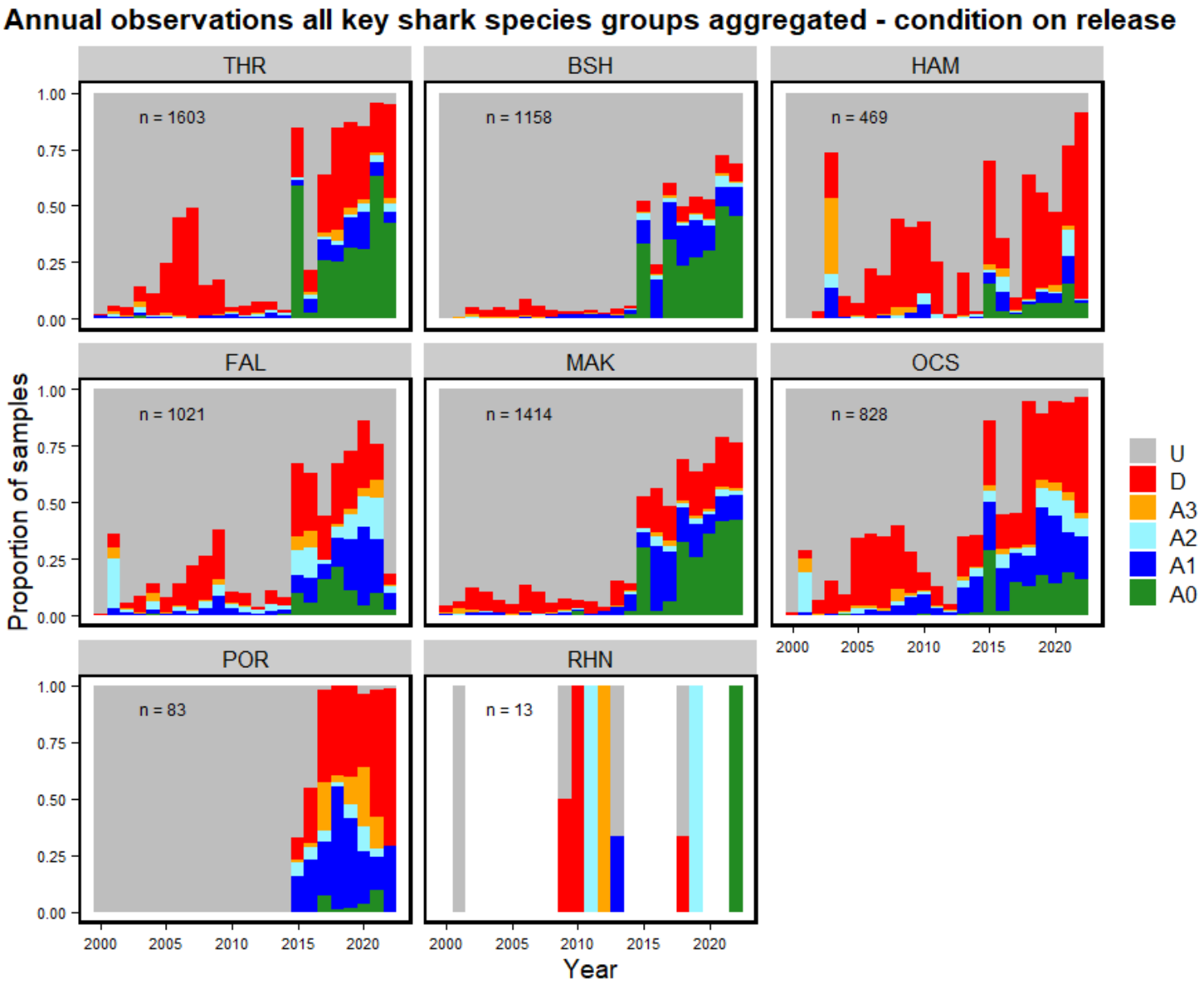


**Figure 8: The condition on release of sharks caught in longline sets within the WCPO. All thresher, hammerhead, mako and rays have been grouped into their respective species groups and are not shown as individual species.**

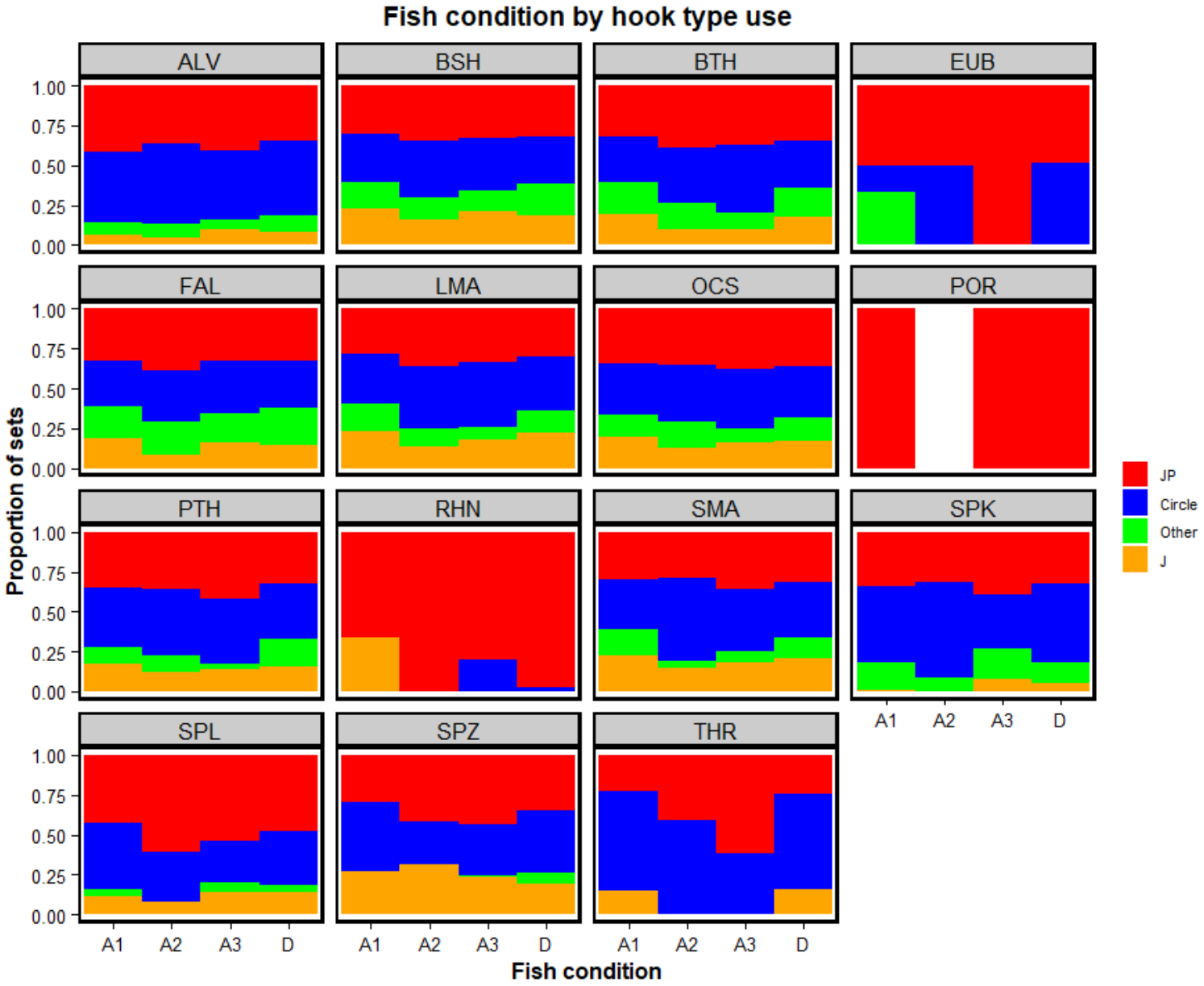


**Figure 9: The condition on capture by hook type of sharks caught in longline sets within the WCPO.**

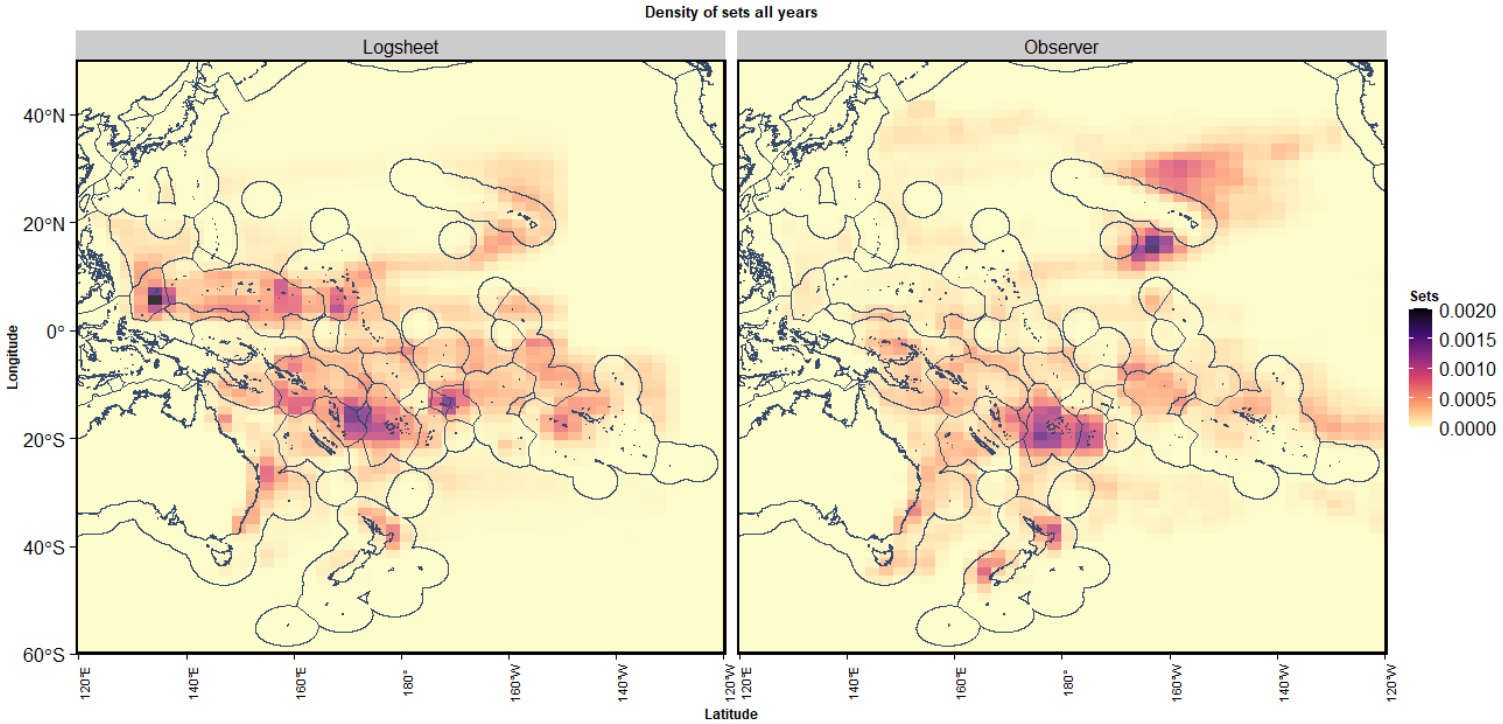


**Figure 10: WCPFC percentage of logsheet sets and observed sets per 5x5 cell from 2002-2022.**

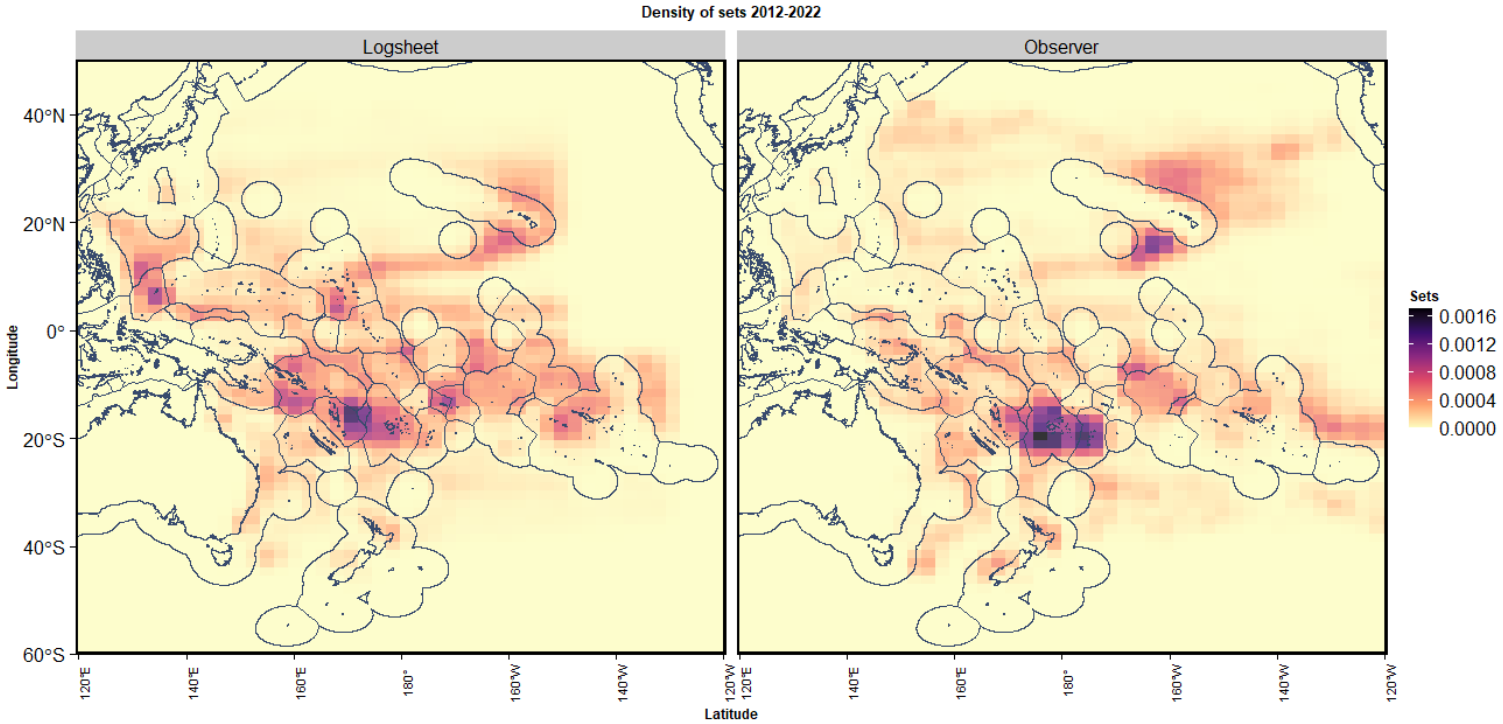


**Figure 11: WCPFC percentage of logsheet sets and observed sets per 5x5 cell from 20012-2022.**

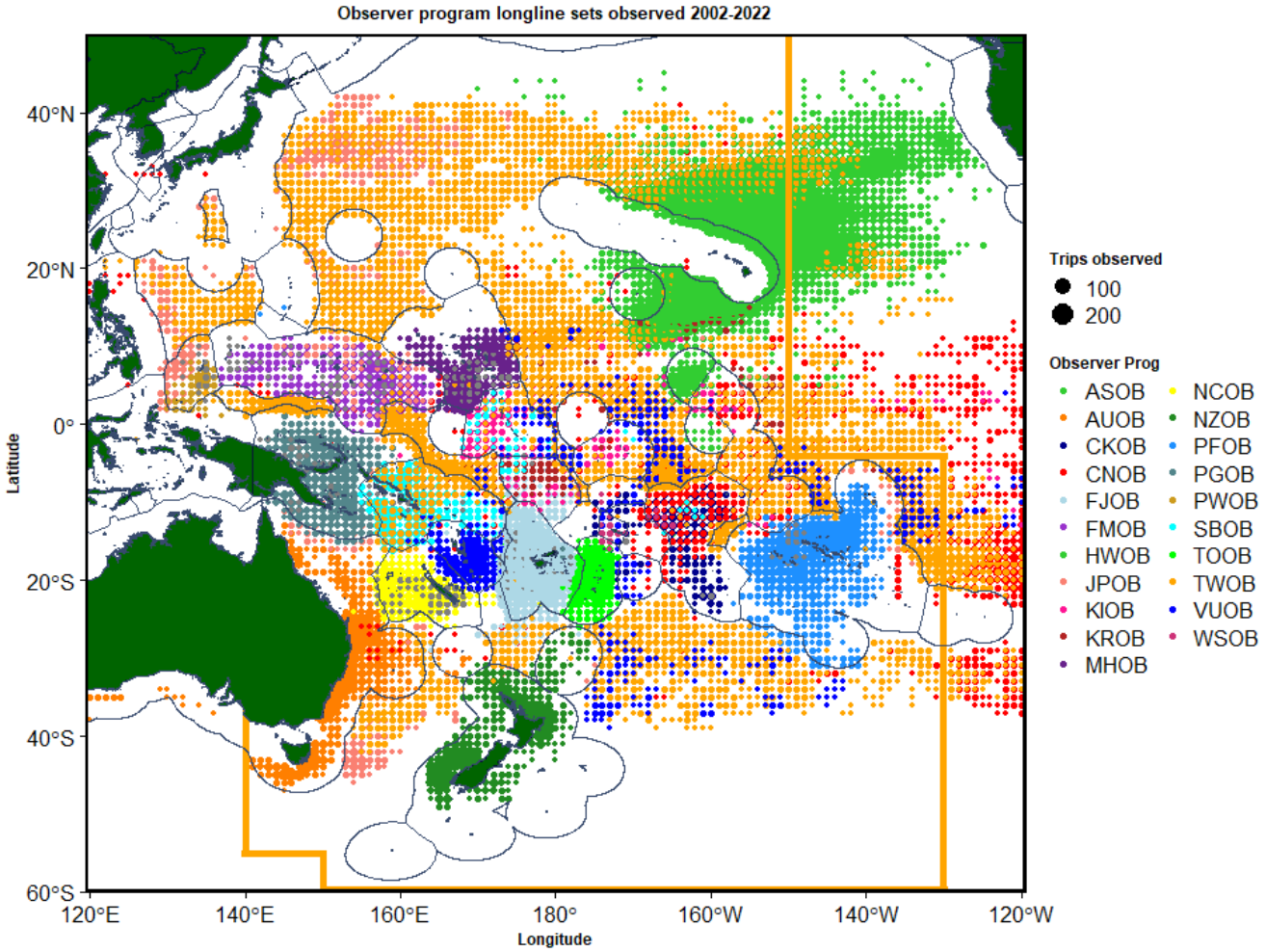


**Figure 12: WCPFC observed longline effort distribution by observer program, showing the number of observed trips per 1x1 cell all data from 2002-2022 pooled. Note these data represent observed trips per cell, if a trip crosses into an adjasent cell it will appear in both cells.**

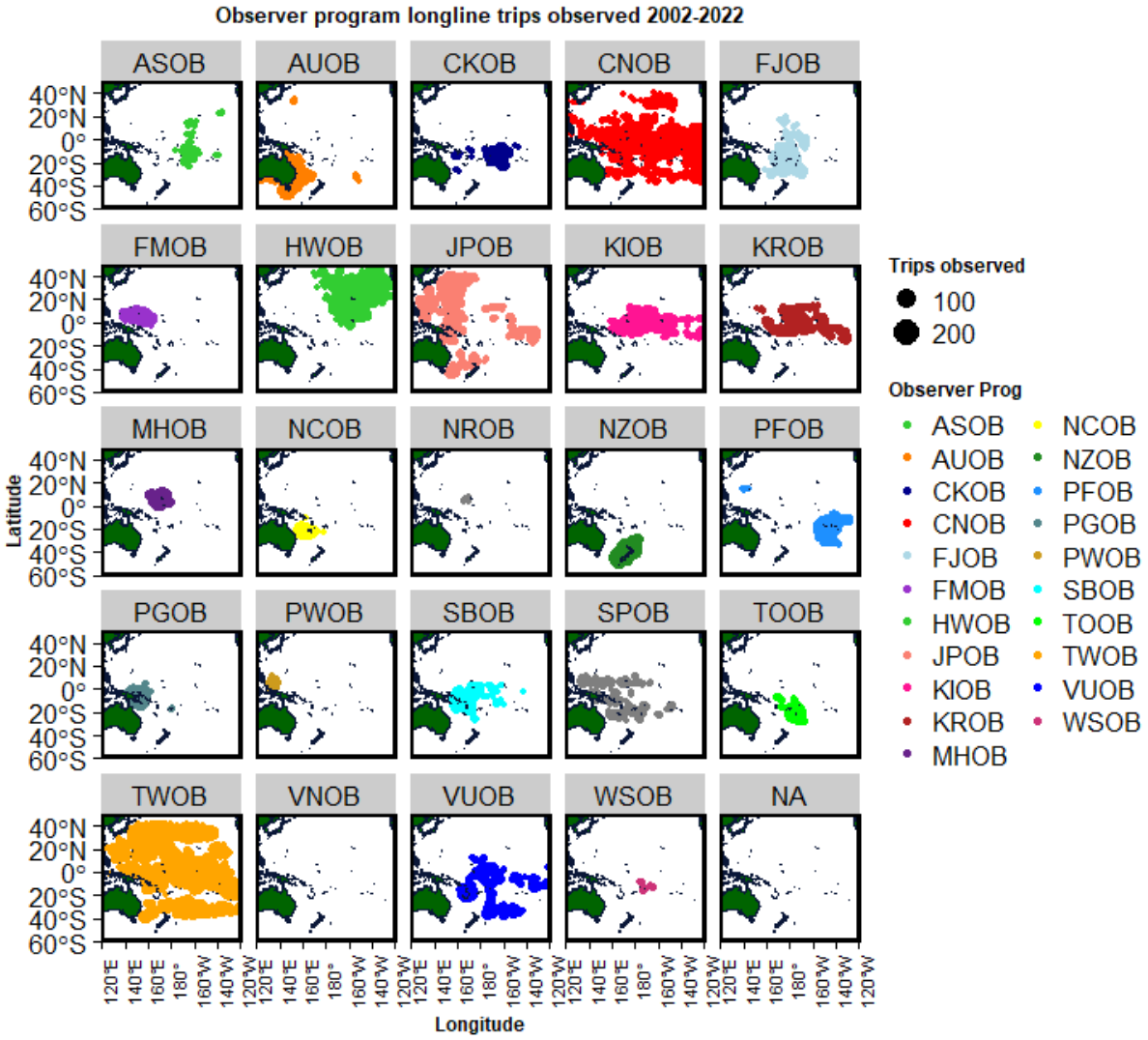


**Figure 13: WCPFC observed longline effort distribution by observer program, showing the number of observed trips per 1x1 cell all data from 2002-2022 pooled. Note these data represent observed trips per cell, if a trip crosses into an adjasent cell it will appear in both cells.**

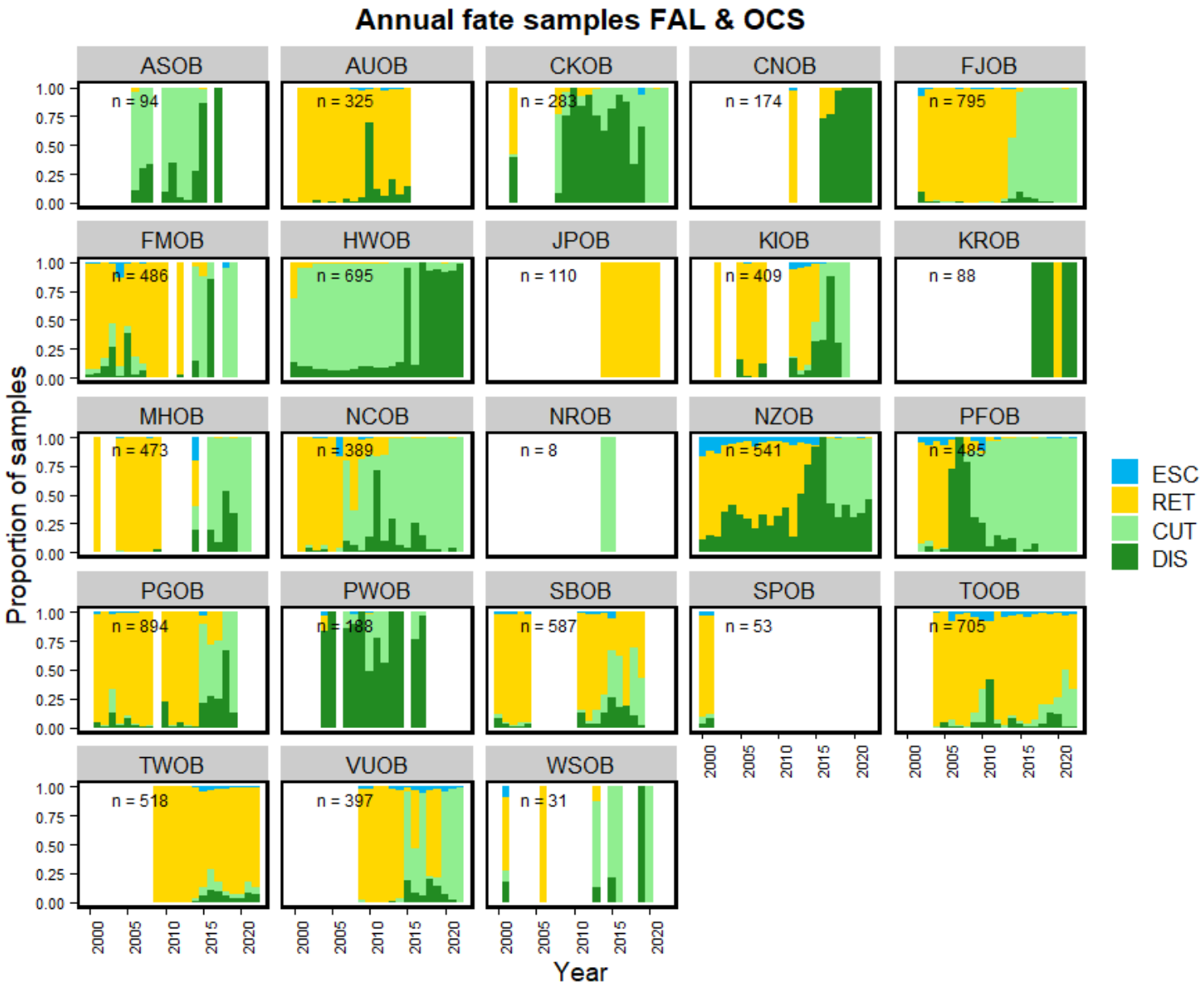


**Figure 14: WCPFC observed fate (all shark species combined) recorded by observer program.**

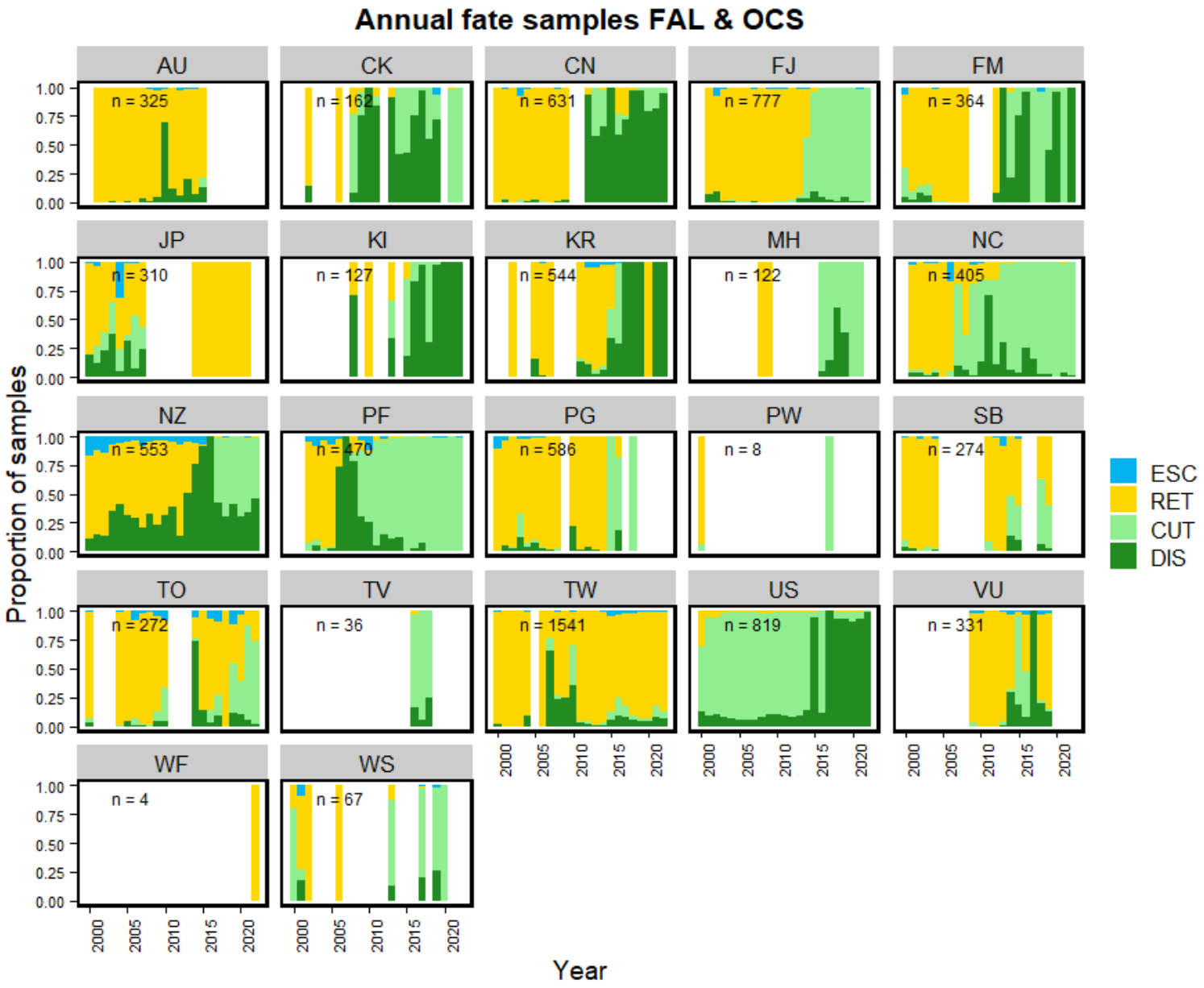


**Figure 15: WCPFC observed fate (all shark species combined) recorded by fishing vesel flag.**

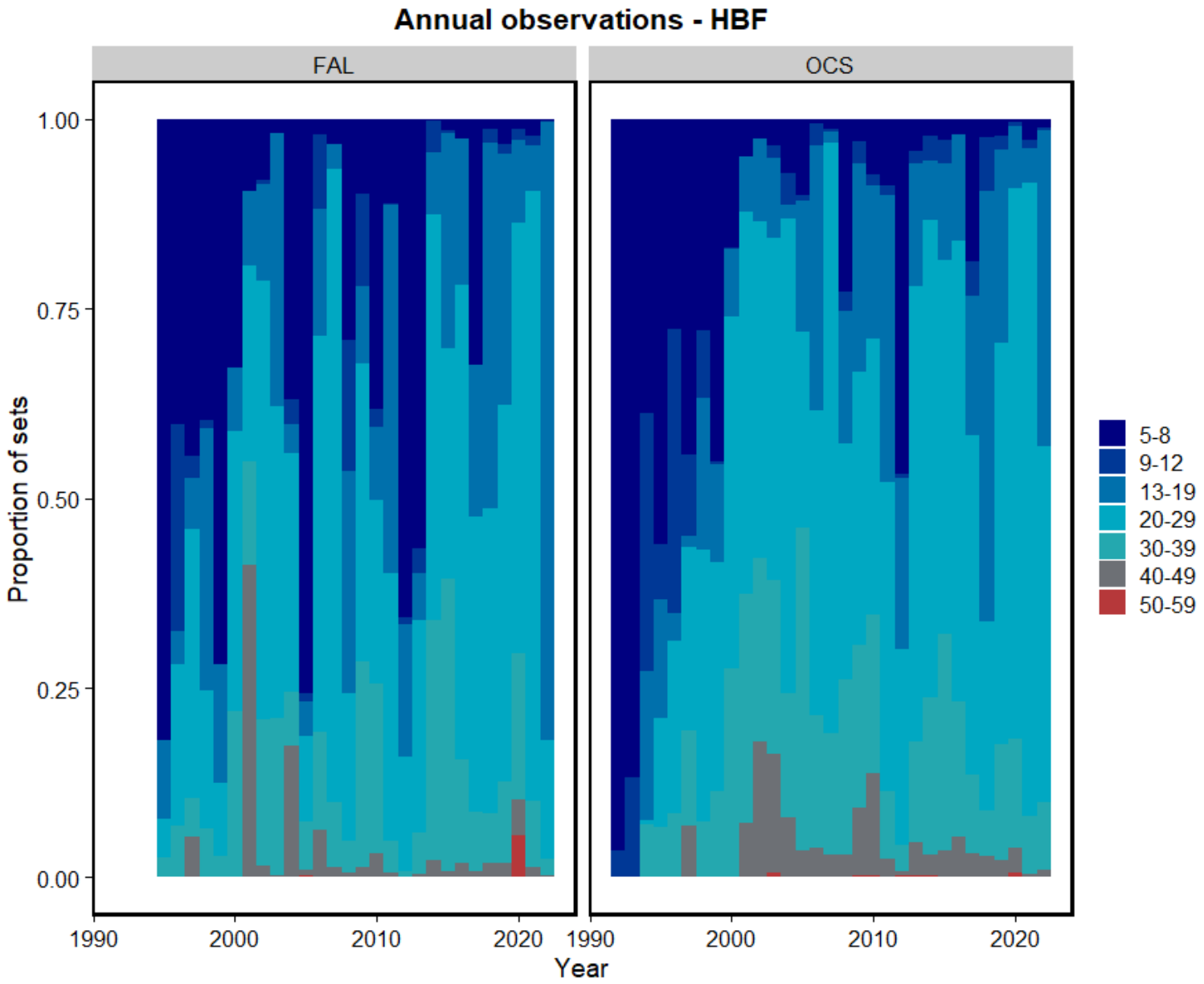


**Figure 16: WCPFC observed hook between floats for sets that caught silky and oceanic whitetip sharks.**

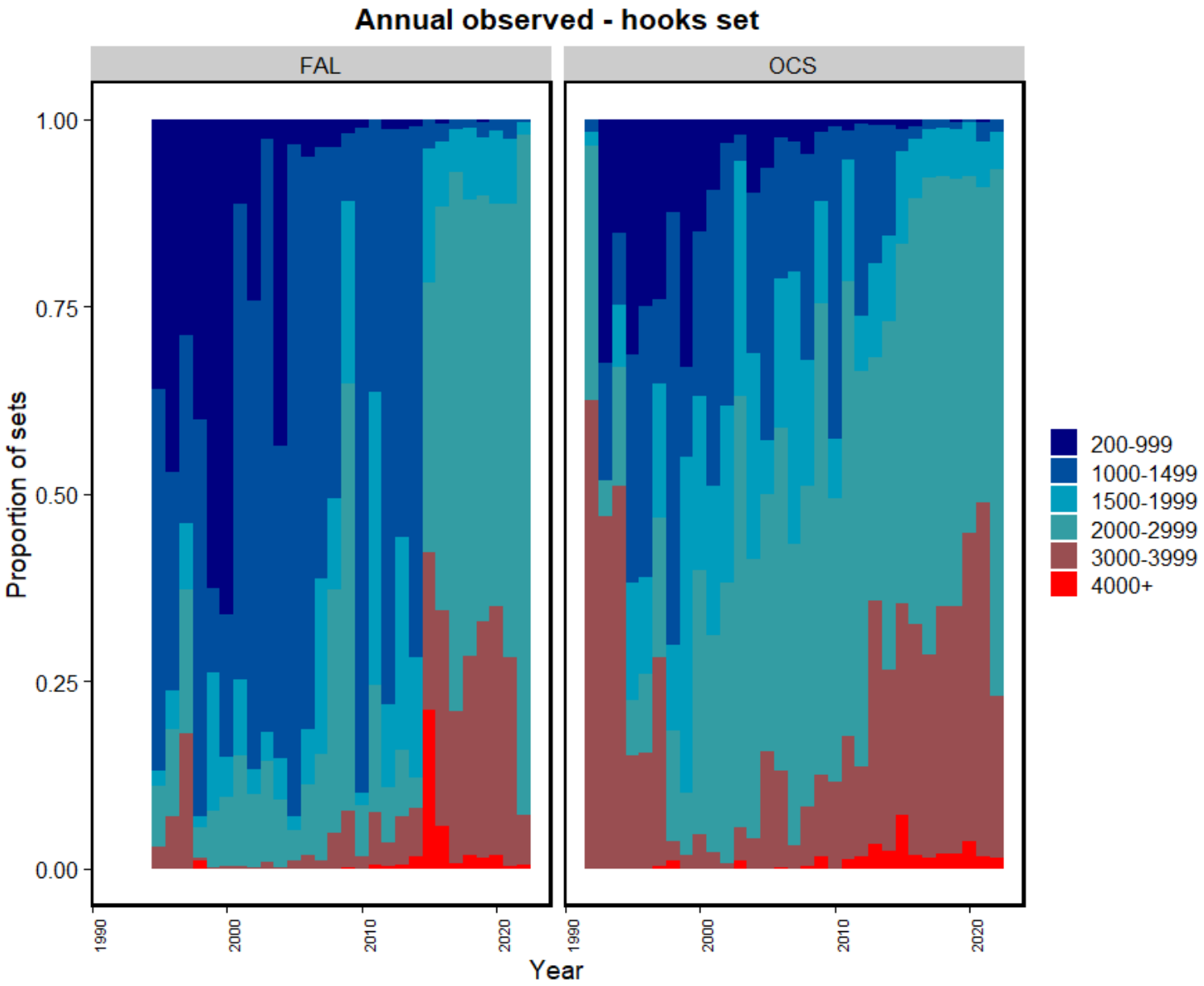


**Figure 17: WCPFC observed floatline length for sets that caught silky and oceanic whitetip sharks.**

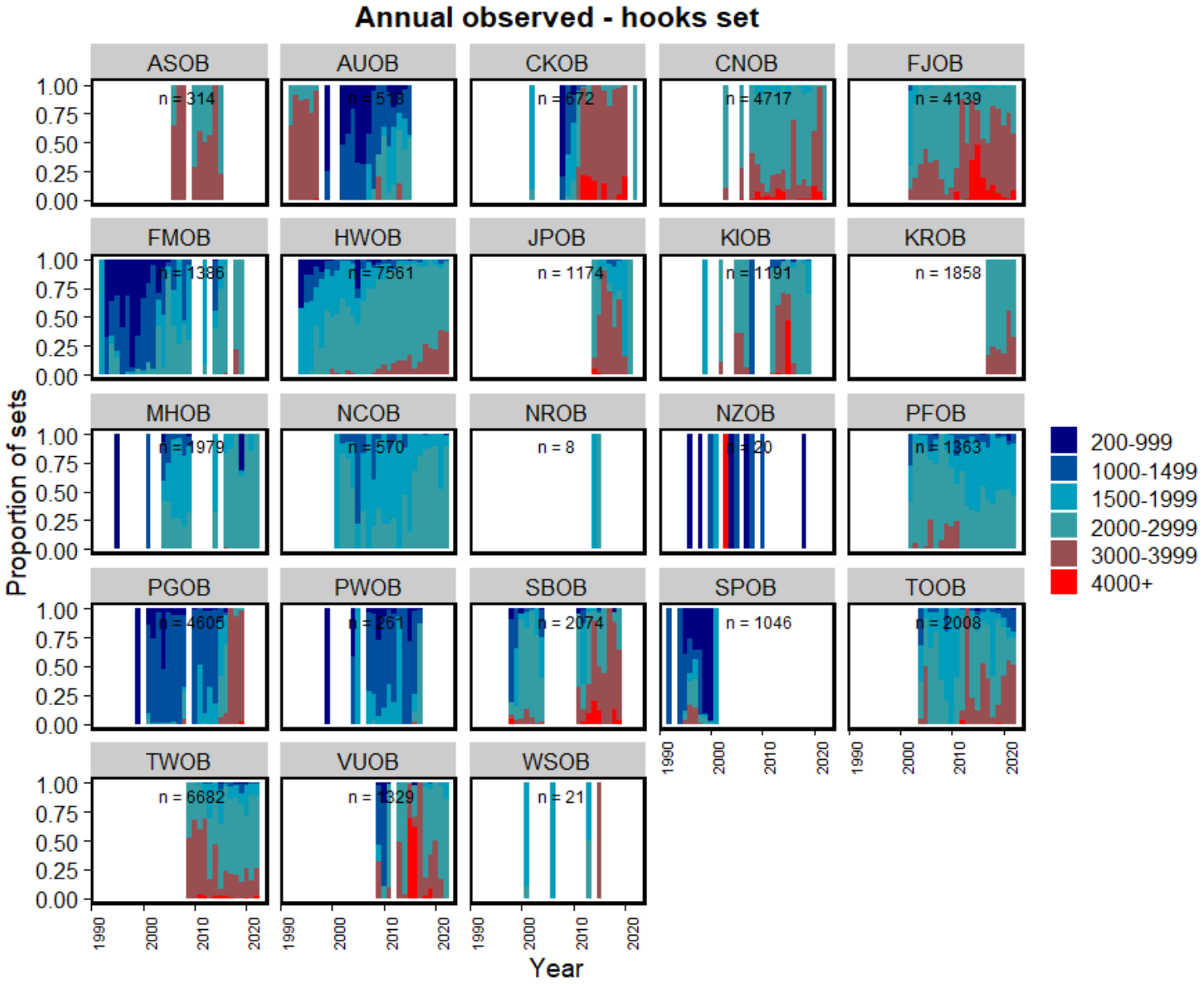


**Figure 18: WCPFC observed floatline length by WCPFC observer program.**

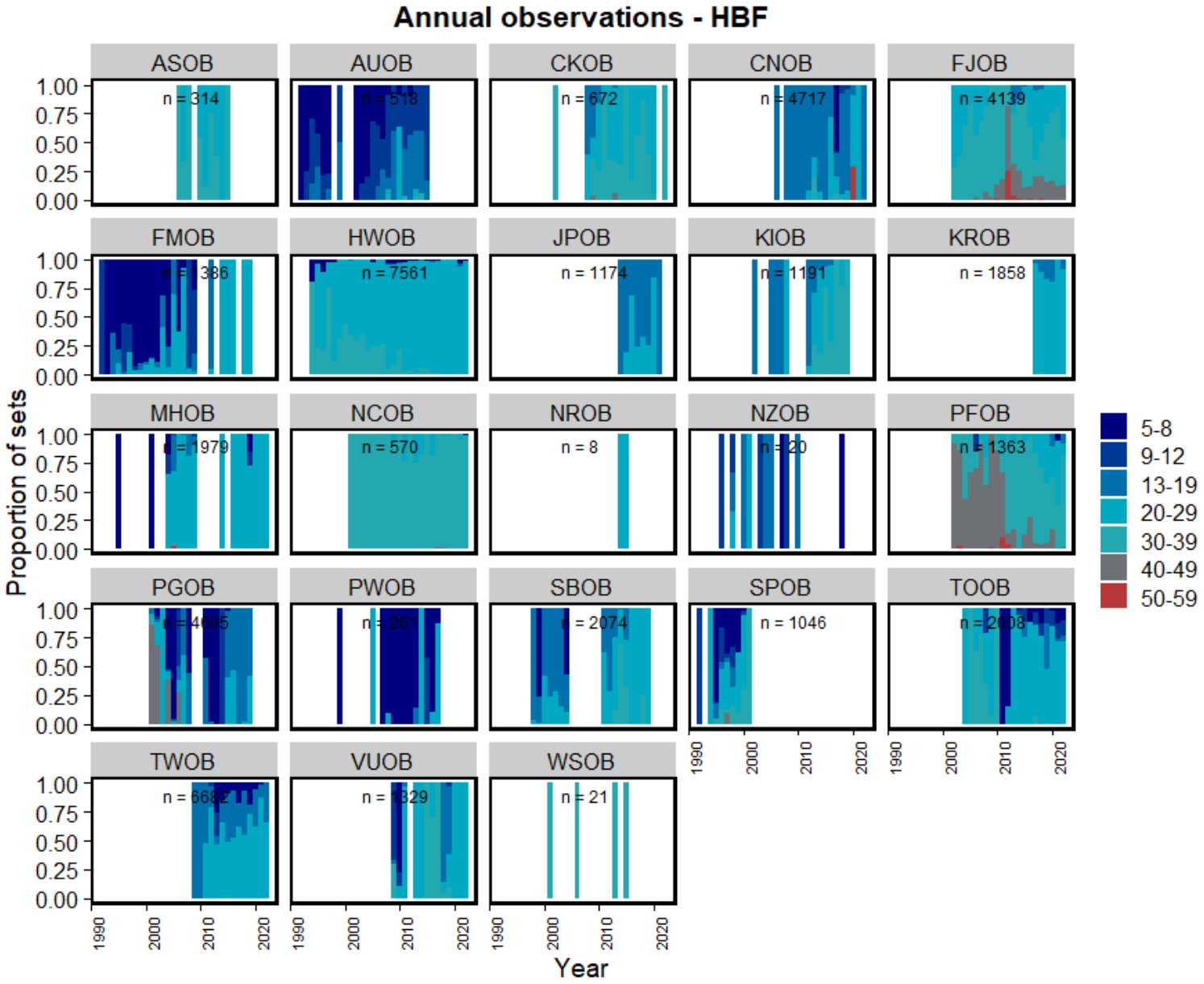


**Figure 19: WCPFC observed hook between floats by WCPFC observer program.**

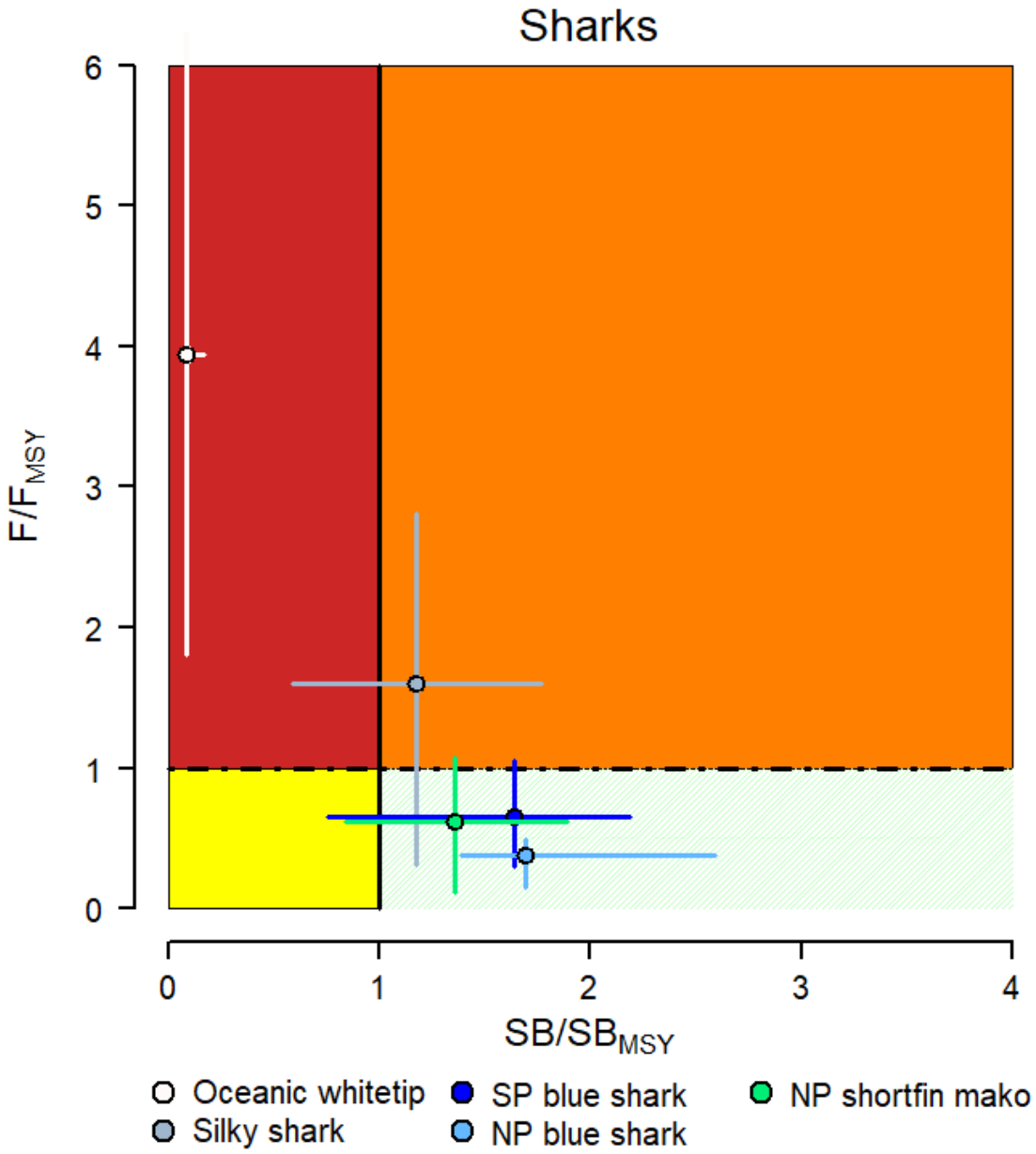


**Figure 20: Kobe plot stock status summary for WCPO sharks assessed for which stock status has been determined. The WCPFC has not yet adopted LRPs for elasmobranchs and therefore MSY-based reference points are used as a default by the WCPFC. This figure has been produced by the SPC (Hare et al., 2021).**