**SCIENTIFIC COMMITTEE**
**SEVENTEENTH REGULAR SESSION**

Electronic Meeting
11-19 August 2021

# An updated review of potential options for managing swordfish taken as bycatch in longline fisheries

**WCPFC-SC17-2021/MI-IP-10**

**Australia**
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Australian Government

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# Contents

# 1. Executive Summary

WCPFC16 in 2019 tasked the SC to review a suite of technical work to inform the strengthening of management arrangements for both target and bycatch fisheries for swordfish in the southern Convention area. This was in recognition that the current measure for the swordfish stock in that area (CMM 2009-03) does not contain the provisions required to ensure the stocks future sustainability. In relation to fisheries taking swordfish as bycatch, WCPFC16 requested that SC16 "*consider a review (self-funded and developed by Australia, in consultation with interested CCMs) of possible measures and options relevant to the management of swordfish taken as bycatch in longline fisheries. The review may include information from available research and literature, logbook and observer data (in appropriately aggregated forms).*"

SC16 considered a review (SC16-MI-IP-22) which identified a range of potential "bycatch fishery" management options, including a prohibition on swordfish retention; a prohibition on *live* or *undersized* swordfish retention; fleet specific bycatch limits; gear limitations, and spatial and temporal combination options of these. The paper reviewed relevant research and summarised WCPFC fishery data relating to, firstly, logbook-based species catch proportions (highlighting fleets/areas where swordfish to tuna catch ratios are higher) and secondly, observer data on the use of fishing methods known to increase swordfish catches (and fishing mortality) including light sticks, squid bait and night setting. The review spatially aggregated data to subregion, high seas and inzone fisheries, to inform spatial management options and to recognise that high seas fisheries account for the majority of bycatch of swordfish in the stock area.

This revised paper to SC17 updates the SC16 review paper, to include:

- Information on bycatch and target fleet catches by subregion and in zone / high seas—highlighting that high seas bycatch fleets and swordfish target fisheries account for the majority of swordfish catch (and fishing mortality).
- Additional catch ratio information—highlighting strata (fleets x seasons x subregions) for which swordfish may be a commercially important component of the total tuna fishery catch
- Observer data-based information on life status (at landing to the boat)—highlighting significant variation between fleets and areas in the proportion of swordfish landed alive.
- Updated data pertaining to the use of specific fishing methods (bait, lightsticks, night setting)
- Post release mortality (PRM) information from electronic tagging studies.

The Commission may need to consider including more than one option for managing swordfish bycatch (similar to CMMs for seabirds and sharks) in a revised CMM, to accommodate the specific circumstances of each fleet/fishery and to avoid or minimise impacts on tuna catches. The options that can be included might also depend on the status of the stock. Regardless, the key requirement of potential bycatch management option is that they are implementable, effective in helping achieve the objectives (stock sustainability and fishery economic viability) and enforceable. Ideally, they will complement existing measures and rely on MCS tools already in place. This review will, alongside the revised 2021 stock assessment and catch projections work scheduled for after SC17, assist WCPFC consideration of a revised future draft CMM.

Australia is seeking that SC17 provide further feedback regarding:

- the likely effectiveness of the proposed bycatch management options presented (in controlling fishing mortality), ideas for additional or amended options and additional information that would assist consideration of options.
- specific catch scenarios (if any) associated with the above bycatch management options that could be evaluated, post SC17, through projections using the revised 2021 assessment.

# 2. Background

## 2.1 Aim and scope of this paper

This paper provides an update to the paper (SC16-MI-IP-22) previously provided to SC16 in 2020. It addresses the request by WCPFC16 that SC16:

- "*consider a review (self-funded and developed by Australia, in consultation with interested CCMs) of possible measures and options relevant to the management of swordfish taken as bycatch in longline fisheries. The review may include information from available research and literature, logbook and observer data (in appropriately aggregated forms).*"

This review paper comprises 4 main parts:

- A brief background and history of progress on this issue.
- A brief summary of swordfish catch data – to help Commission members understand where, when and which fleets take the majority of swordfish in the SWPO stock area, as bycatch or targeted catch. A more detailed breakdown is provided in SC17-MI-IP-12.
- A brief overview of global fisheries for swordfish focussed on how target and bycatch management approaches for this species have been enacted in other RFMOs.
- Identification of a range of potential management options for longline fleets taking swordfish as bycatch.

This paper acts as a repository of relevant data and information relating to longline fisheries taking swordfish as bycatch and will be updated as further information is identified.

It does not attempt to provide recommendations on what bycatch management options the Commission should adopt in future. Recommendations on both swordfish bycatch and targeted catch management in a future CMM should be developed after consideration of the full suite of technical work and information papers being developed to support decision making by the Commission on this issue. They include the 2021 Stock Assessment (SC17-SA-WP-04), the range of supporting information papers (see below), including this paper, and the outcomes of catch projections to be run by the Science Service Provider following SC17.

## 2.2 The issue

Swordfish in the south-west Pacific Ocean represents a currently healthy resource (based on the 2017 assessment) that has the potential to make a valuable future contribution to some WCPFC SIDS fisheries and is already an important component of some WCPFC CCM fisheries, either as a target species, or a significant retained bycatch species.

Currently, this potential is being undermined by a measure (CMM 2009-03 - Conservation and Management for Swordfish) that lacks provisions to ensure the ongoing sustainability of the stock. Specifically, the lack of any restrictions in the area north of 20°S (particularly the high seas), allows for unrestrained increases in fishing mortality. Flag based limits for the area south of 20°S place a cap on the number of vessels targeting swordfish and on catches of swordfish (by flag). However, these limits may be too high to prevent future overfishing (when combined with unconstrained northern catches) or to prevent sub-regional localized depletions. At WCPFC15 in 2018, Australia stated its intention to seek a Commission process to revise and strengthen CMM 2009-03, and has been helping the Commission to progress this issue in the period since.

Given the significant catches taken in both target and high seas bycatch fisheries, both fishery types will need to be appropriately managed under a future revised CMM. Please note:

- *This paper* provides WCPFC members information relating to fisheries taking swordfish as **bycatch** in direct response to the request by WCPFC16 that that the SC review potential management options for longline fisheries that take swordfish as a bycatch.
- *Other papers* presented to SC17 (including the updated stock assessment SC17-SA-WP-04 as well as SC17-SA-IP-07, SC17-SA-IP-08, SC17-SA-IP-12, SC17-MI-08 and SC17-MI-IP-12) provide WCPFC members with information relevant to the consideration of future potential management conditions for swordfish targeting fisheries (and bycatch fisheries).
- *Furthermore*, the WCPFC SSP has been tasked with undertaking a suite of projections (following SC17) using the new assessment, to explore the implications of a range of future target and bycatch fishery catch levels, to inform development of a revised CMM.
- Finally, the term "bycatch fishery" is used to separate catch by fisheries not specifically targeting swordfish from those that do (target fisheries). It is recognised that for some fisheries, this bycatch is still significant and commercially important.

## 2.3 Progress towards revising CMM 2009-03

The following section provides an overview of progress to date towards the review and updating of CMM2009-03, to provide further context for the information provided in this paper.

In **2019**, Australia consulted with and sought WCPFC member's feedback and inputs on this issue at subregional meetings and at WCPFC16. In December 2019, WCPFC16 considered a discussion paper (WCPFC16-2019-DP19), including the key concerns regarding the management of this stock and the high-level principles identified by Australia for strengthening the CMM. The principles identified in the paper were for a future revised measure that would:

- apply in EEZs and high seas throughout the whole area of the stock (consistent with Article 3 and Article 5 of the WCPFC Convention).
- be reflective of our current best understanding of swordfish science and its assessed status.
- prevent further increases in fishing mortality on the stock to avoid future overfishing and an overfished stock (as per Article 5).
- accommodate subregional zone-based management approaches and limits and ensure compatible management and limits on the high seas (as per Article 8).
- recognize the sovereign rights of coastal States to explore, exploit, conserve and manage HMS within areas under their national jurisdiction (as per Article 7).
- recognize the special requirements of, and avoid transferring a disproportionate burden of conservation upon, SIDS and Participating Territories (as per Article 30).
- seek the development of a consistent set of conservation and management measures for fish stocks that occur in both the WCPFC and IATTC Convention Areas (as per Article 22).

Following discussion between WCPFC members and general agreement that the current measure requires revision and strengthening, WCPFC16:

- tasked the Scientific Committee in 2020 (SC16) to consider a review (funded/developed by Australia, in consultation with interested CCMs) of possible measures and options relevant to the management of swordfish taken as bycatch in longline fisheries.
- tasked the Scientific Committee in 2021 (SC17) to provide an evaluation of the long-term future of the southwest Pacific swordfish stock status under CMM 2009-03 based upon the latest SC-agreed stock assessment, utilising a range of future catch projections.
- requested the WCPFC Chair to write to the IATTC Chair to seek further assessment and CMM development and cooperation with the WCPFC in the management of the resource.

In **2020**, in response to the first WCPFC16 tasking (above), Australia developed a review paper for SC16 (now updated here as MI IP10, 2021) that identified a range of potential "bycatch fishery" management options for consideration to strengthen CMM 2009-03. These potential options included:

- Prohibition on swordfish retention,
- Prohibition on *live* or *undersized* swordfish retention,
- Fleet specific bycatch limits,
- Gear limitations, and
- Spatial and temporal combination options

The paper reviewed relevant research and summarised WCPFC fishery data relating to, firstly, logbook based species catch proportions (to highlight fleets and areas where swordfish catch proportions are higher relative to target tuna catches) and secondly, observer based data on the use of fishing methods known to increase swordfish catch rates (and therefore fishing mortality) including light sticks, squid bait and night setting. The review spatially aggregated data to subregion, high seas and inzone fisheries, to inform spatial management options and to recognise that high seas fisheries account for the majority of bycatch.

Feedback (and Australia's responses to that feedback) provided by WCPFC members regarding this paper is summarised in Appendix 1. In brief the feedback highlighted:

- The need to test bycatch management options (and target fishery management options) in the context of the assessment and projections work
- The need for more explicit information on the relative catches taken by fisheries targeting or taking swordfish as bycatch (now included in this paper and SC17-MI-IP12).
- The need for the future CMM to manage the impacts of swordfish targeting fisheries (not just bycatch fisheries).
- The commercial/economic importance of swordfish to some longline fisheries targeting tuna.
- Concern over whether approaches used to manage other bycatch species (e.g. sharks) can be applied to manage swordfish bycatch (See Appendix 1)
- The need to better understand post release survival in swordfish to help assess non-retention options (now included in this paper).
- Concerns that some fleets use very similar methods to target tuna as others use to target swordfish would be impacted if those methods were restricted.

In **2021** a number of additional papers have been submitted to the 17th Meeting of the scientific committee for review and to inform scientific advice to the Commission regarding the management of the swordfish stock (and target and bycatch fisheries taking swordfish). These are outlined in section 3 below.

# 3. Swordfish bycatch statistics

The following statistics and figures are largely derived from data tables contained in the SC17-MI-IP12 (SPC, 2021) paper to SC17. The four subregions referred to below are illustrated in Figure 1.

In the period since 2000, total catch of swordfish in the SWPO stock area peaked at over 9500 t in 2008 but has shown a declining trend since 2012 to under 6000 t in 2020 (Figure 2; SPC, MI-IP12). Annual catches by flag in the stock area are provided in Table 6 of SC17-MI-IP12. Only three longline fleets (Australia, New Zealand and European Union/Spain) are known to target swordfish. All other longline fleets in the stock area are believed to target tuna and take swordfish as a bycatch. About half of the total annual catch (46.2 -56.6%) is taken north of 20S and half taken south of 20S.

Throughout this period, swordfish bycatch has comprised a key component of the total catch, accounting for 37-67% of the total annual catch (Figure 2). More recently, over the past 5 years (2016-2020):

- Swordfish bycatch has accounted for 55-66% (SC17-MP-IP12; SPC, 2021) of the total annual catch.
- North of 20S, >98% of the catch is taken as bycatch, and of that 83-88% is bycatch taken on the high seas (SPC, MI-IP12).
- 39-50% of the total annual (recent) catch from the stock has been taken north of 20S as bycatch on the high seas, and the majority of that bycatch is taken in the north-eastern high seas (Figure 3).
- South of 20S, about a fifth of the total annual catch (15.9-25.5%) is taken as bycatch with the majority (75-85%) taken by target fisheries operating on the high seas and in EEZs. Within the southern area, catches in the western half are largely high seas and EEZ target fishery catch. Recent catches in the eastern half are lower and a mix of high seas target catch and inzone bycatch (Figure 3).

For bycatch fisheries, the proportion of the total catch (of all species or just “swordfish+tuna”) that comprises swordfish can vary significantly between fleets, areas and by season.

- For many fisheries, and particularly WCPFC SIDS longline fisheries, the level of swordfish catch and/or proportion of swordfish in the total catch has been consistently very low across seasons and areas.
- However, for other fisheries, and particularly distant water fishing nation fleets in the north east and south-western regions (examples in Table 1 and Figure 4), swordfish bycatch (in term of catch and proportion of total catch) can be significant in certain areas and seasons and is likely to comprise a commercially important component of the total retained catch (Table 1 and Appendix 2).

Further information and data relating to fisheries catching swordfish in the SWPO can be found in the following SC17 papers:

- SC17-SA-WP-04 – Stock Assessment of South West Pacific swordfish (Ducharme-Barth et al 2021)
- SC17-SA-IP-07 - Background analyses for the 2021 stock assessment of Southwest Pacific swordfish (Ducharme-Barth et al 2021)
- SC17-SA-IP-08 - Biology, stock structure, fisheries, and status of swordfish, Xiphias gladius, in the Pacific Ocean - a review (Moore, 2021)
- SC17-SA-IP-12 - Connectivity of broadbill swordfish targeted by the Australian Eastern Tuna and Billfish Fishery with the broader Western Pacific Ocean (Evans et al, 2021)

- SC17-SA-IP-17 - Broadbill swordfish movements and transition rates across stock assessment spatial regions in the western and central Pacific (Patterson et al 2021)
- SC17-MI-IP-12 - Catch and effort data summaries to support discussions on the new swordfish CMM (SPC, 2021) – note this includes a summary of catch by flags.
- SC17-MI-IP-08 - Appropriate LRPs for Southwest Pacific Striped Marlin and Other Billfish (Project 104) (Brouwer and Hamer, 2021)

# 4. Review of global swordfish management approaches

Broadbill swordfish are a species that are targeted and/or taken as a significant bycatch in many "tuna" fisheries around the world. Management of this species has varied but it is clear that as a result of its biology and behaviour (longer lived, less productive, smaller stock sizes, and subregional fidelity and tendency to aggregate to seafloor features such as seamounts), it is a species whose stocks are typically less resilient to fishing pressure, and more susceptible to localised depletion, than many tuna species that these fisheries also target.

A number of regional swordfish fisheries around the world have gone through initial rapid expansion and then large declines, with failure in many of these being related to fleet overcapacity (Ward and Elscot, 2000 and Govender et al 2016). Currently both the Mediterranean and South Atlantic stocks are overfished. Management of some swordfish stocks is made more challenging due to a significant proportion of the swordfish being taken as an incidental catch from longline fleets targeting tuna and in some cases, blue sharks.

There are currently considered to be eight swordfish stocks globally that are managed by different Regional Fisheries Management Organisations (RFMOs), including:

- Indian Ocean Tuna Commission (IOTC) – Indian Ocean Stock
- Western and Central Pacific Fisheries Commission (WCPFC) – North Pacific and South-western Pacific stocks
- IATTC – North-eastern Pacific, South-eastern Pacific stocks
- ICCAT – Mediterranean Sea, North Atlantic, South Atlantic stocks

**Tables 2 and 3** provide a brief overview of these stocks and key management approaches taken with each. WCPFC and ICCAT have management measures that apply directly to swordfish. IATTC has no management measures that apply directly to swordfish, although management measures that apply to tuna fisheries may also benefit swordfish stocks (IATTC, 2019b). A number of countries implement additional domestic management measures for swordfish in their fisheries that are not required by RFMO CMMs or resolutions, but this review has not attempted to cover domestic fishery situations.

# 5. Swordfish bycatch management options

The following sections outline five potential options for managing the take of swordfish bycatch in longline fisheries. For each option, a range of benefits and limitations (pro's and con's) is provided.

In identifying bycatch fishery management options, Australia has also attempted to review any relevant research and sourced relevant regional longline logbook and observer data from WCPFC/SPC.

This revised paper to SC17 updates the SC16 review paper, to include:

- Information on bycatch and target fleet catches by subregion and in zone / high seas (Figures – highlighting that high seas bycatch fleets and swordfish target fisheries account for the majority of swordfish catch (and fishing mortality).

- Additional catch ratio information - highlighting strata (fleets x seasons x subregions) for which swordfish may be a commercially important component of the total tuna fishery catch
- Updated regional observer data on the use of fishing methods known to increase swordfish catch rates (and therefore fishing mortality) including light sticks (**Figure 6**) and night setting (**Figure 7**).
- Observer data-based information on life status (at landing) – highlighting significant variation between fleets and areas in the proportion of swordfish landed alive.
- Post release mortality information – based on electronic tagging studies of longline caught swordfish.

The logbook and observer data are aggregated into four spatial quadrants (**Figure 1**) covering the stock area and within each quadrant, into high seas and EEZs (combined). This approach recognises the need to present data in a way that can inform any possible spatial management options.

The data pertaining to species compositions, gears, fishing methods and life status are presented to inform Commission members consideration of different management options, but further development and analyses may be required. As a general observation, further information may be required relating to fleet specific gears and fishing methods to assist CCMs in assessing the potential implications of any of the management options presented. Review of these options against existing monitoring and compliance mechanisms will also be required.

Australia will continue to work and identify information and data relevant to strengthening these aspects of the review, including through feedback from the SC and TCC.

## 5.1 Prohibition of swordfish retention

### *Description*

Prohibiting the retention of swordfish in fisheries where they are traditionally taken as a bycatch would act to prevent targeting and maximise post release survival rates of fish taken by these fisheries. For an economically valuable bycatch species like swordfish, this type of measure would normally only be fully applied in situations of very poor stock status. Partial application, for example in association with season or trip catch limits, or in specific areas, could also be considered.

### *Examples*

- Oceanic Whitetip Shark retention ban in all RFMO's with silky, thresher and hammerhead sharks banned in some RFMO's (Tototti et al, 2015).
- Black and blue marlin retention ban in Australian Commonwealth fisheries (FMA, 1991)
- Chinook salmon part and full season bans in some gillnet fisheries in Canada (PSC, 2004).

### *Key considerations*

The effectiveness of this measure is dependent on the following factors:

- A high proportion of fish alive when hauled and high post-release survival.
- Practicality of adjusting fishing practices/gear changes to either improve the survival of the species at the point of landing or avoid capture of the prohibited species.
- Reliable and timely catch and discard monitoring and reporting

**Table 5** provides a summary of the proportion of swordfish reported as alive when hauled to the vessel (landed) based on longline observer data, from the SWPO swordfish stock area, by fleet and for the period 2015-2020. For fleets with relatively high sample sizes (>300 fish observed), the percentage alive when landed varies by fleet between 30-55%. Furthermore, within fleets, the data suggest that the proportion landed alive can vary by area (**Table 6**), possibly due to regional differences in operational (fishing method) and environmental/oceanographic conditions. However,

the data should be interpreted with caution given the typically low observer coverage rates on longline fleets, particularly on the high seas, and subsequently how representative the data are.

Published studies show considerable variation in the average life status of landed swordfish in longline fisheries. Notably:

- Campbell (2000)—32% survival at landing on Australian longliners in the Coral Sea pre-2000.
- Campbell (2000)—50% alive at landing for Japanese longliners in the Australian EEZ pre-1996. In both cases, classification of "vigorous" alive fish was much lower.
- Sharples (2000)—longline observer data for the WCPO area (across fleets) indicated 34% of swordfish were alive at landing (over half of these barely alive, injured or unknown alive).
- Coehlo and Munoz-Lechuga (2019)—14.8% alive at landing in Portuguese Atlantic Ocean longline swordfish fishery
- Huang et al (2016)—15% alive at landing in an Atlantic tuna fishery
- Kerstetter and Graves (2006)—20-25% alive at landing in Atlantic fishery.

Some of these studies have identified factors that may influence life status at landing in any given fishery. Studies have demonstrated varied results in relation to whether hook type is significantly related to at haul life status, with some (e.g. Curran et al 2011, Epperly et al 2012; Reinhardt et al, 2016) indicating circle hooks are related to higher swordfish survival at landing to the boat (relative to J hooks) however other studies did not find statistically significant differences (e.g. Huang et al 2016; Kerstetter and Graves, 2006; Pacheco et al 2011). Coehlo and Munoz-Lechuga (2019) have demonstrated the proportion of swordfish alive at haul in an Atlantic longline fishery to also be related to fish size (higher survival of larger fish) and water temperature (higher survival in colder waters). These and other factors are likely to play a role in SWPO longline fisheries and could be further examined via model-based analyses of regional observer longline data.

Some research indicates that post-release mortality (PRM) for swordfish (caught by longline and judged to be in good condition at release) is difficult to estimate precisely but relatively low. A study conducted off Australia indicated PRM of 10% (min) to 29% (max) (Evans, 2010). A similar study off New Zealand indicated PRM of 10% (min) to 41%(max) (Holdsworth et al 2010). Similar rates have been estimated from studies on longline captured swordfish in the Atlantic (e.g Abascal et al 2010 – 40%, Abascal et al 2015). However, using these studies to infer PRM for the range of fleets in the SWPO is challenging because of the potential effects of different fishing methods (e.g. gears, depths, soak times, at capture and release handling etc), different environmental conditions in different subregions, and different average physiological states of the fish (e.g. during spawning v feeding seasons) (K.Evans, CSIRO, pers comm). However, it may be possible to explore the potential usefulness of non-retention conditions, via catch projections, utilising "best" and "worst" case PRM scenarios (using these studies as a guide), and best- and worst-case life status at landing information from observers (e.g. Tables 5 and 6).

### *Recommendation*

This management option would be most suitable in fisheries where:

- Swordfish make little economic contribution to fisheries profitability or economic sustainability, or, current fishing mortality levels are unsustainable
- There is a relatively high proportion of fish alive when hauled/landed and high post-release survival, and
- Vessels have appropriate monitoring (observers or EM) to ensure accurate data is available on the quantity and life status of fish discarded under this measure.

This measure might be considered for either full or partial application, for example in specific months or areas or in response to a catch trigger being reached. However, it may be possible to explore the potential usefulness of non-retention conditions, via catch projections, utilising "minimum" and "maximum" likely PRM scenarios (using these studies as a guide), and minimum and maximum likely life status at landing information from observers.

## 5.2 No retention of live and/or undersized/immature swordfish

### *Description*

This type of measure would act to prevent the retention of **live** or **undersized (e.g. immature)** fish when hauled to the vessel, only allowing retention of dead fish or fish larger than the specified size limit. This type of measure has a reduced economic impact, allowing retention of some fish. As per Option 1, it could be applied in full or partially (under specific circumstances).

### *Examples*

- Porbeagle, shortfin mako and longfin mako sharks in Australia (Bruce et al, 2014).
- All sharks - Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) (Worm et al, 2014).
- Other RFMOs encourage the release of live sharks, especially juveniles that are caught incidentally and are not used for food and/or subsistence (CITES, 2014).
- Minimum size limits to protect juvenile swordfish have been previously applied by ICCAT (Neilson et al, 2013)

### *Key considerations*

Similar to the full retention ban option above, the effectiveness of this measure is dependent on the following factors:

- A relatively high level of on-board monitoring to ensure compliance with the measures.
- Reporting data being timely, reliable and accurate to enable analysis of interactions.
- Information on then proportion of live fish when hauled and the level of post-release survival.
- Whether vessel operators are capable of adjusting fishing practices/gear to either avoid capture of the species or improve the survival of the species at haul and after release.

This option has a key advantage over option 1 in that there is no waste of fish that are bought to the boat dead, but it does require more at-sea monitoring to be effective. If size limits were calibrated to size at maturity information they may allow more fish to grow to spawning size. However, where at haul and/or post release mortality are very high (and potentially high in small fish; see discussion under option 1), this measure would not result in any significant reduction of mortality of the prohibited species.

The use of minimum size limits in isolation has been found to be inadequate in swordfish fisheries (Ward et al. 2000). In the northern Atlantic case, the introduction of a minimum size regulation had little, if any, immediate effect on the rate of overfishing and the corresponding rate of depletion of the stock (Neilson et al, 2013). Coehlo and Munoz_Lechuga (2019) have also demonstrated that the proportion of swordfish alive at haul/landing is lower for smaller sized fish in an Atlantic longline fishery.

### *Recommendation*

This management option is more suited to fisheries that:

- Are identified as catching a high proportion of smaller or juvenile swordfish

- Do not target swordfish but wish to maintain some economic benefit from the bycatch taken,
- Have a relatively high proportion of live fish at haul and/or low post-release mortality,
- Are able to modify fishing practices with minimal economic impact to improve the condition of fish upon hauling to maximise the change of post-release survival (e.g. the use of circle hooks), and
- Have appropriate monitoring to allow assessment of compliance with the measure.

The efficacy of such a measure might potentially be tested by catch projections, noting that the stock assessment uses and provides information relating to catch at size and a maturity ogive (for example to set size limits at 50 or 100% size at maturity). This measure might be considered for either full or partial application, for example in specific months or areas or in response to a catch triggers being reached.

## 5.3 Fleet specific bycatch limits

### *Description*

This type of measure would act to impose a limit on the total number or weight of swordfish retained by a fleet that takes swordfish as a bycatch, with the aim to manage fishing mortality of swordfish in that fleet. Currently, tuna targeting longline fleets may already be managed with catch limits on the key target species (e.g. bigeye tuna) or by effort limits (e.g. days fished). Additional swordfish bycatch limit implementation options can be considered including catch measures (number, weight of fish, percentage of catch composition), effort limits (e.g. fishing days) at a number of temporal scales (e.g. trip, season/year).

### *Examples*

Bycatch limits are one of the most commonly used tools to cap or reduce fishing mortality impacts in fisheries globally and there are many examples across fisheries and species. Examples relevant to swordfish include:

- WCPFC imposes swordfish catch limits on fleets operating south of 20°S.
- ICCAT imposes bycatch limits for Atlantic swordfish fleets via the swordfish recovery plan[1].
- IATTC impost bycatch limits on silky sharks (IATTC, 2019)

### *Key considerations*

The effectiveness of this measure is dependent on the following factors:

- Vessel operator's ability to adjust fishing practices/gear to avoid capture or improve post release survival if the limit is reached[2].
- High chance of survival for released fish to avoid unnecessary fishing mortality of discarded fish if limits are reached (Kerstetter and Graves, 2008 and Tolotti et al, 2015)[3].
- Appropriate reporting and monitoring (port and on-board) in place to ensure limits are adhered to, high-grading and discarding practices aren't occurring.

[1] Non-quoted entities were required to reduce catches by 45% of the reference year, except for entities with catches less than 100mt which couldn't increase above reference year amount (Neilson et al, 2013).

[2] A WCPFC study has also shown a reduction in swordfish bycatch after the introduction of fish only baits and circle hooks (Swimmer and Barcelo, 2018)

[3] The available studies demonstrate that the post-release survival for swordfish is relatively high in commercial fisheries, indicating that this measure could be effective. However, as discussed above these studies have not been undertaken specifically on fleets that take swordfish as bycatch which may have different post release survival due to different fishing techniques.

The adoption of catch limits for a bycatch species in fleets targeting tuna poses some challenges:

- If the limit is applied to retained catch, operators would be forced to discard fish once the limit is reached, reducing the measures effectiveness if mortality increased above agreed limits.
- If the limit was applied to total catch, it could act as a choke on catches of the target species and come at a very high economic cost.
- Limits may need to be non-transferable (within fleets) between broad subregions, to avoid the occurrence of localised depletions that would seriously impact the economic viability of targeted fleets operating in those areas and future development opportunities of WCPFC SIDS.

#### *Recommendation*

This management option would prevent shifts to targeting swordfish by current bycatch fleets in the areas where this is applied and as such is most suited for fisheries that:

- Do not target swordfish but wish to maintain economic benefit from the bycatch taken,
- Are able to modify fishing practices to firstly, actively avoid catching swordfish once limits are approached/reached, and secondly to improve the condition of fish at point of hauling to maximise the chance of post-release survival (e.g. the use of circle hooks), and
- Have appropriate monitoring to allow assessment of compliance with the measure.

Consideration can be given to the implementation of bycatch limits for bycatch fleets north of 20°S operating on the high seas (where a high proportion of total catch is taken), noting that bycatch limits were one of the measures implemented within ICCAT and contributing to the recovery of swordfish stocks in the Atlantic. At the current time, the healthy status of the stock (based on 2017 assessment) offers an opportunity to set limits that would have little if any impact on catches of the target tuna stocks for those fleets in that area but would prevent increases in swordfish catches in future to unsustainable levels[4]. If bycatch limits are approached towards the end of the season this can be managed by fishers temporarily adjusting their fishing practices or gear to stay within the limit[5].

The effectiveness of bycatch limits can be tested using catch projections, informed by information pertaining to:

- analyses of recent and potential future fleet catch levels,
- understanding of landed life status, discarding and post release mortality to determine the effect of such limits if imposed on retained catch only or if calculated to take into account likely discarding.

## 5.4 Gear limitations

#### *Description*

The banning or restriction of fishing methods and gear configuration designed specifically to target swordfish could assist in limiting potential future increases in fishing mortality on this stock by fleets that currently take swordfish as bycatch *and* do not currently use these methods to target tuna.

[4] Any development of total and fleet specific catch limits should be done in association with projections on the current stock assessment model to demonstrate that the total limits are sustainable. Where objectives for the stock extend to economic/social outcomes, such projections can help to assess the implications of catch limits for achieving those objectives also.

[5] This is common practice by fishers in the Australian fishery who each have individual allocations of target species. They adjust their fishing gear, areas and approaches depending on how close to their catch limit they are, to reduce catches of limiting species and increase catches of other species.

Under these circumstances, for such fleets, it application would not impact current tuna fishing operations, but would prevent future targeting and associated increased fishing mortality of swordfish.

In the central/southern Pacific, longliners targeting swordfish (Beverly et al, 2003; Campbell, 2003, Murray and Griggs, 2003, Nguyen and Winger, 2019; Ward and Elscot, 2000; Bigelow, 2006; NOAA, 2005; EU, 2011) will typically:

- Use lightsticks, squid bait, and afternoon/night setting,
- Set gear shallow to target the mixed layer (mainline set close to the surface with short floatlines, shorter branchlines, few branchlines between floats ~3-10)
- Target seafloor features (seamounts, canyons, ridges, rises) or strong ocean temperature fronts/convergences/eddies.
- Target the period on or close to the full moon.

### *Examples*

No examples could be found of jurisdictions that restrict fishing methods/gear use to specifically cap (and prevent targeting) or reduce fishing mortality of swordfish. Australia would welcome advice from other WCPFC members if they are aware of relevant examples. There are many examples of fishing method/gear restrictions to reduce fishing mortality of other retained bycatch/byproduct species such as for sharks (e.g. wire trace, shark line restrictions in WCPFC), turtles (e.g. circle hooks) and marlin (e.g. hook number per shot in Australian fishery in the Coral Sea area).

### *Key considerations*

#### Implementation Issues

Ideally, management measures aimed at capping or reducing catches of a bycatch species should not impact on a fleet's ability to target or catch the primary target species. While there is strong evidence that the swordfish targeting methods noted above significantly increase the catch rates of swordfish (Nguyen and Winger, 2019 and Murray and Griggs, 2003), it needs to be understood if restrictions on or the banning of any of these techniques would impact fleets targeting tuna species.

**Table 4** indicates that methods used to target swordfish are generally identifiable and distinct compared to those for targeting of yellowfin and albacore tuna (different set times, no lightsticks, different bait). However, this may not always be the case for bigeye tuna which, while often targeted in deep waters during day sets, can also be targeted in a manner similar to swordfish (i.e. shallow at night around the full moon, including using squid bait and lightsticks).

**Figure 4** indicates that in the north-east quadrant high seas area where swordfish are taken as a bycatch, swordfish bycatch levels may be somewhat higher in association with fleets that have a higher proportion of bigeye tuna in the catch. Conversely, albacore tuna fisheries or albacore/yellowfin fisheries often have very little swordfish bycatch.

Further information may be needed to assess the implications of potential restrictions on gears/methods (associated with swordfish targeting) for tuna targeting fleets, including:

- firstly, summaries of fishing gear/method (e.g. time of set, bait, light stick use etc.) and catch composition data, from observers and/or logbooks. Preliminary observer data obtained from WCPFC/SPC are provided to indicate possible fleet and area trends in light stick use (**Figure 6**) and time of day of setting (**Figure 7**). For use of squid bait, WCPFC/SPC regional observer data indicate there was only one "bycatch" fleet/CCM using squid bait. Any interpretation of longline observer data will need to take into account the coverage levels (typically very low on the high seas) and representativeness of such data.

- secondly, it may be possible to assess existing CPUE models regarding the potential effect of such restrictions on swordfish bycatch rates.

A key challenge in undertaking the above may be the availability of detailed fishing method information (OFP, 2015) for the key fleets. Depending on the outcomes of the above actions, it may be possible to consider integrating "bycatch" conditions into the CMM based on either individual gear parameters (e.g. lightsticks use) or combinations of parameters (e.g. lightsticks, squid bait and night setting). These could be further targeted to specific areas and seasons if appropriate.

#### Compliance Monitoring Issues

The inclusion of any gear or fishing method related restrictions would ideally be accompanied by appropriate monitoring mechanisms to verify compliance. MCS requirements would be dependent on what fishing techniques were prohibited and whether the presence of the gear was prohibited on vessels (Table 3). For example, if the carriage of lightsticks or squid bait was prohibited, then compliance options would include pre-trip and at-sea vessel inspections. If the use of these gear/bait were only restricted under certain circumstances (e.g. fishing at night) then a higher level of on-water monitoring would be required to ensure compliance. Other measures, e.g. restrictions on night fishing, could potentially be monitored by VMS/AIS. Analytical methods, for example comparing catch composition of vessels with and without observers (or EM), is another potential compliance monitoring tool.

#### *Recommendation*

Further information on the fishing methods and catch composition of the key swordfish bycatch fleets in the area of the SWPO stock, would assist in understanding the potential use of and implications of a gear/method-based condition in the CMM. It is unclear how representative the observer data are for various fleets (e.g. Figures 6 and 7).

The restriction or banning of the use of one or a combination of the following factors - lightsticks, squid bait and/or night setting - is an appropriate measure for swordfish bycatch fleets that do not use this combination of fishing methods to target bigeye tuna. The measure would act to limit potential future increases in fishing mortality of swordfish by these fleets, but would not necessarily reduce current fishing mortality.

For fleets that do use this combination of methods to target bigeye tuna, consideration could be given to partial limitations – e.g. day setting only, fish bait only, or no lightsticks – for example when approaching a trigger catch level of swordfish.

Compliance monitoring and verification would depend on the specific measure used (see discussion above).

## 5.5 Spatial, Temporal and Combined Management Options

#### *Description*

There are a range of combinations of the bycatch management options described above that may provide more effective and acceptable options for managing swordfish bycatch in the stock area, than a single option considered in isolation. Furthermore, the addition of specific spatial or temporal elements to those options can help to refine and focus their application. Some examples of combined management options are provided below. This list is not intended to be exhaustive.

#### *Examples*

- Non-retention or live only retention for:
    - specific times/areas or

    - when a catch trigger is reached.
- Restrictions on fishing methods for specific season/areas (e.g. spawning or aggregation areas) or when a catch trigger is reached. Similar to the FAD closure concept, this could be a prohibition in the key bycatch areas on the use of, for example, lightsticks or night setting, in a particular period of the year.
- Non-retention combined with gear limitation – for example non-retention would be more effective in combination with the use of circle hooks, which have demonstrated increased survival at haul and reduced post release mortality (Kerstetter and Graves, 2006, Carruthers et al, 2009 and Reinhardt et al, 2017).
- Effort limits with gear/bait restrictions – where fisheries are imposing effort-based limits to manage target species catches, these could be combined with gear and bait restrictions (e.g. no use of lightsticks, no night sets and/or no squid baits) to ensure that effort is not directed at swordfish.
- Spatial/Temporal closures – Large spatial temporal closures are usually only applied when stock status is poor, for example, fishery/area closures imposed on swordfish fishing by ICCAT (ICCAT, 2019) in the Mediterranean and the US in the past in the Texas/Florida/Gulf of Mexico area (Ward et al, 2000). The tendency of this species to aggregate around seamounts might suggest the potential to explore smaller exclusion areas.

The effectiveness of any combined measures in achieving the objective (of preventing future increases in swordfish fishing mortality in these fleets) would need to be examined using available research and data and possibly catch projections.

# 6. Conclusion

There is a general recognition (discussed at WCPFC16) that the current measure for the swordfish stock in the southern Convention Area (CMM 2009-03) does not contain the provisions required to ensure future sustainability. A revised stock assessment at SC17, and the catch projections work to be undertaken afterwards, will shed further light on whether recent catch levels in the fishery are sustainable. The types and level of management conditions applied to both bycatch and target fisheries for swordfish in the SWPO will be very dependent on the current and future predicted state of the stock. For example:

- Where the stock is in a healthy state that supports sustainability and fishery economic objectives, conditions included in a future measure might look to simply prevent significant increases in fishing mortality (to maintain the healthy stocks state) and as such, might have little impact on the current operations of the fisheries to which the measures apply.
- Where the stock is assessed to be subject to overfishing or overfished, then the measures applied would need to seek to reduce overall fishing mortality on the stock to remove overfishing and recover the stock.

Even if the stock is assessed to be healthy, the current CMM must be revised and strengthened to ensure the stock remains healthy into the future. There are two key elements in the current measure that require review and strengthening:

- the management of bycatch of swordfish on the high seas, which accounts for a high proportion of overall fishing mortality on the stock.
- The management of target fisheries for swordfish in the southern Convention Area, which also account for a significant proportion of the overall fishing mortality

This paper reviewed potential options for strengthening the provisions of CCM 2009-03 for managing swordfish taken as bycatch predominantly on the high seas in the stock area. The options are presented to promote discussion and may not represent the full suite of feasible and effective options.

It is possible that there is no single measure that suits all bycatch fleets and a more flexible approach, with a range of options to be chosen from by CCMs, for example similar to the approach already applied in WCPFC CMMs for sharks and seabirds, might be more appropriate.

The paper has presented a range of logbook and observer derived information, as well as reviewed relevant research, to assist consideration of these options going forward. These data and information have highlighted a range of considerations including:

- high seas bycatch fleets and swordfish target fisheries account for the majority of swordfish catch (and fishing mortality).
- strata (fleets x seasons x subregions) for "bycatch fleets" for which swordfish may be a commercially important component of the total tuna targeted fishery catch
- significant variation between fleets and areas in the proportion of swordfish landed alive.
- Post release mortality information – electronic tagging studies of longline caught swordfish are difficult to interpret precisely for PRM. Studies conducted in the SWPO indicate relatively moderate PRM of 10-29% (off Australia) and 10-41% (off New Zealand**), with similar findings from studies in other regions.

This paper is intended to be a central repository of scientific and technical information as well as potential management options related to bycatch fisheries in support of a future revised South-west Pacific swordfish CMM. The paper will continue to be developed as relevant data and available/historic research findings are identified and integrated, and to take into account consultations with and inputs from WCPFC members. Further analyses of fishery wide and fleet level logbook and observer data might be identified to assist proper consideration of the likely effectiveness of many of the above options.

The key requirement of any options chosen to include in a future revised CMM is that they are implementable, effective in achieving their objectives, enforceable, and wherever possible minimise impacts on target tuna species catches. Ideally these measures should be complementary with existing measures and rely on MCS tools already in place.

## 7. Request to SC17

This paper does not presume to be exhaustive in what options are available and Australia is seeking WCPFC members feedback and ideas in this regard to inform its planned work to develop a more effective swordfish CMM for adoption by the Commission in future.

Australia is seeking that SC17 provide further feedback regarding:

- the likely effectiveness of the proposed bycatch management options presented (in controlling fishing mortality), ideas for additional or amended options and additional information that would assist consideration of options.
- specific catch scenarios (if any) associated with the above bycatch management options that could be evaluated, post SC17, through projections using the revised 2021 assessment.

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# 9. Tables and Figures

**Table 1** – Examples of the "key" target and bycatch fishery strata (fleets x subregions x seasons(quarters)) where the proportion of swordfish in the total catch is > 5%. "Key fisheries" refers to those fisheries which take a substantial proportion of the overall catch from the stock at the regional level. The full set of catch proportion statistics for ***all*** fleets are provided in Appendix 2. Note that this table is derived from WCPFC public domain aggregate 5x5 by year-quarter longline data (2015-2019), which excludes cells with less than three vessels, and as such does not represent all catches in the fishery. As such, the ratios can be considered "indicative" only.

| Flag | Subregion | Quarter | Tuna (t) | Swordfish (t) | Other (t) | SWO/(SWO+TUNA) | SWO/TOTAL |
|---|---|---|---|---|---|---|---|
| AU | North-west (R1) | 1 | 198.8 | 34.3 | 38.7 | 14.7 | 12.6 |
| AU | North-west (R1) | 3 | 211.8 | 38.5 | 15.2 | 15.4 | 14.5 |
| AU | North-west (R1) | 4 | 67.0 | 19.5 | 16.2 | 22.5 | 19.0 |
| AU | South-west (R3) | 1 | 1759.8 | 769.9 | 496.4 | 30.4 | 25.4 |
| AU | South-west (R3) | 2 | 3276.6 | 777.2 | 659.7 | 19.2 | 16.5 |
| AU | South-west (R3) | 3 | 3957.5 | 1026.8 | 749.1 | 20.6 | 17.9 |
| AU | South-west (R3) | 4 | 1268.7 | 995.1 | 665.9 | 44.0 | 34.0 |
| CN | North-east (R2) | 1 | 8758.7 | 705.2 | 897.6 | 7.5 | 6.8 |
| CN | North-east (R2) | 3 | 21143.1 | 1592.9 | 1266.3 | 7.0 | 6.6 |
| CN | North-east (R2) | 4 | 13552.0 | 2049.3 | 1647.8 | 13.1 | 11.9 |
| JP | North-east (R2) | 1 | 215.8 | 27.5 | 21.9 | 11.3 | 10.4 |
| JP | North-east (R2) | 2 | 288.1 | 16.5 | 26.9 | 5.4 | 5.0 |
| JP | North-east (R2) | 3 | 173.6 | 35.7 | 6.3 | 17.1 | 16.6 |
| JP | North-east (R2) | 4 | 219.9 | 60.7 | 15.9 | 21.6 | 20.5 |
| JP | South-west (R3) | 1 | 49.2 | 7.0 | 0.3 | 12.4 | 12.4 |
| JP | South-west (R3) | 2 | 1930.2 | 524.9 | 39.5 | 21.4 | 21.0 |
| JP | South-west (R3) | 3 | 1897.2 | 109.9 | 87.4 | 5.5 | 5.2 |
| KR | North-east (R2) | 4 | 6080.3 | 353.8 | 524.6 | 5.5 | 5.1 |
| NZ | South-west (R3) | 1 | 220.1 | 376.3 | 562.3 | 63.1 | 32.5 |
| NZ | South-west (R3) | 2 | 539.7 | 440.2 | 2726.7 | 44.9 | 11.9 |
| NZ | South-west (R3) | 3 | 171.0 | 99.5 | 1460.8 | 36.8 | 5.7 |
| PT | South-west (R3) | 1 | 23.6 | 644.5 | 428.5 | 96.5 | 58.8 |
| TW | North-east (R2) | 1 | 8349.7 | 613.7 | 2035.0 | 6.8 | 5.6 |
| TW | North-east (R2) | 3 | 20283.4 | 1877.3 | 4283.8 | 8.5 | 7.1 |
| TW | North-east (R2) | 4 | 15025.8 | 2825.9 | 3434.0 | 15.8 | 13.3 |
| VU | North-east (R2) | 4 | 5279.5 | 560.8 | 909.6 | 9.6 | 8.3 |

**Table 2**: Summary of swordfish status and management in WCPFC

| | **North Pacific** (ISC Billfish Working Group, 2018) | **South Western Pacific** (Takeuchi et al, 2017) |
|---|---|---|
| **Recent Average Catches** | 10,489t (2010-2016)<br>10,068t (2016) | ~ 8,000mt |
| **Peak Historic Catch** | 22,000t (1960) and 19,000t (1993) | ~ 11,000mt |
| **Recent Depletion** | $SB_{2016}/SB_{MSY}$ = 1.87 | $SB_{recent}/SB_{MSY}$ – 1.58 (1.02 – 3.1)<br>Median $SB_{latest}/SB_{F=0}$ – 0.35 (0.27 – 0.44) |
| **Recent F** | $\mathbf{F_{2013\text{-}2015}}$ – 0.08, $\mathbf{F_{MSY}}$ – 0.17 | $\mathbf{F_{2011\text{-}2015}/F_{MSY}}$ 0.86 (0.42-1.46) |
| **Stock Status** | Not likely overfished and is not likely experiencing overfishing relative to MSY or SB20% based reference points | Not overfished and overfishing no occurring relative to MSY or 20% $SSB_{F=0}$ based reference points |
| **Management Measures** | No direct measures | Limitation of fishing capacity (vessels), maximum total catch south of 20°S (based on reference years), record of swordfish vessel numbers. |

**Table 3**: Summary of swordfish status and management in other Regional Fisheries Management Organisations

| | **ICCAT** (ICCAT, 2019a) | | | **IATTC** | | **IOTC** (IOTC, 2018, IOTC, 2019a and Williams et al, 2019) |
|---|---|---|---|---|---|---|
| | **North Atlantic** | **South Atlantic** | **Mediterranean** | **North East**[6] (Ji-Yih Yau et al, 2014) | **South East** (Hinton and Maunder, 2011 and IATTC, 2019c) | |
| **Recent Average Catches** | 11,245t*<br>2018 – 8,858t<br>*av. last 10 years, inc. discards | 10,877t*<br>2018 – 10,404t | 10,252t*<br>2018 – 7,079t | 26,007 (last 10 years, EPO, all methods)<br>2017 – 21,400 t (LL), 6,285 t (OTH), 27,688 (TOTAL) | | 27,849t (last 10 years, all methods)<br>2017 – 34,782t |
| **Peak Historic Catch** | 20,238t (1987) | 21,930t (1995) | 20,365t (1988) | 31,890t (2015) – all methods<br>25,805 (2015) – LL | | <40,000t (2004) |
| **Recent Depletion** | **$B_{2015}/B_{MSY}$ –** 1.04 (0.82 - 1.39) | **$B_{2015}/B_{MSY}$ –** 0.72 (0.53 - 1.01) | **$B_{2015}/B_{MSY}$ –** 0.12 | **EPO - $B_{2012}/B_{MSY}$** – 1.89 (1.34 – 2.44) | **$B_{RECENT}/B_{MSY}$** – 10.40 | **$SB_{2015}/SB_{MSY}$ –** 1.50 (1.05–2.45) |
| **Recent F** | **$F_{2015}/F_{MSY}$ –** 0.78 (0.62-1.01)<br>**$F_{MSY}$ –** 0.17 (0.10-0.27) | **$F_{2015}/F_{MSY}$ –** 0.98 (0.70 - 1.36)<br>**$F_{MSY}$ –** 0.28 (0.17-0.44) | **$F_{2015}/F_{MSY}$ –** 1.85<br>**$F_{MSY}$ –** 0.25 | **EPO -** N/A | $C_{RECENT}$/MSY – 0.57 | **$F_{2015}/F_{MSY}$** – 0.76 (0.41–1.04) |
| **Stock Status** | Not overfished and no overfishing occurring (2015)[7] | Overfished with no overfishing occurring (2015)[2] | Overfished and overfishing occurring (2015)[8] | Not overfished and no overfishing occurring (2014 and 2018) | Not overfished and no overfishing occurring (2011) | Not overfished and not subject to overfishing (2017) |
| **Management Measures** | **Direct**<br>TAC (2018-2021): 13,200t<br>Minimum size limit | **Direct**<br>TAC (2018-2021): 14,000t<br>Minimum size limit | **Direct**<br>3 month closure, hook and gear limits, minimum size limit, fishing capacity restrictions, TAC 10,185t (2018 with 3% annual reduction) | **Direct**<br>No measure for SEPO stock<br>**Indirect**<br>Limitation of fishing capacity, use of the Best Available Science, HCR for Tropical Tunas, Closures, FADs limitation, catch limits for Bigeye | | **Direct**<br>No direct measures (IOTC, 2012).<br>**Indirect**<br>Move towards a quota system for key species (inc. swordfish), record of swordfish vessel numbers and fishing capacity of vessels <24m and MSY-based target and limit reference points key species (IOTC, 2012). |

[6] There are two assessments undertaken that cover the North East Stock, an 2018 assessment of the WCNPO that included data across RFMOs (including IATTC) and the 2014 assessment of the EPO within the IATTC area.

[7] The current 2015 assessment indicates that the North and South Atlantic Stocks are close to $B_{MSY}$ and lower than $B_{MSY}$ respectively. However, some important uncertainties in the assessment should be noted: mortality does not account for unreported dead and live discards; quota carryovers and quota transfers across the North and South stocks are not accounted for and the total cumulative quota allocation across the North Atlantic is above the TAC if fully caught.

[8] There is uncertainty in this assessment - the level of the stock to be rebuilt is contingent on the assumption on future recruitment which is highly uncertain. Increased monitoring of landing and discards is required reduce this uncertainty and better understand the changes to discard since the establishment of minimum catching sizes.

**Table 4** – Preliminary draft of characteristics of pelagic longline sets and possible monitoring tools in the tropical and southern Pacific targeting swordfish and different species of tuna (Sources: Beverly et al, 2003). *To be developed further – Australia is seeking information from WCPFC CCMs on the use of different fishing approaches (listed below) in targeting tuna and swordfish. Some information is available via submitted observer and logbook data but coverage and representativeness of that data is uncertain.*

| Method | Method Category | Swordfish | Bigeye tuna | Yellowfin Tuna | Albacore Tuna | Possible compliance tools |
|---|---|---|---|---|---|---|
| **Bait** | Squid | Yes | Yes | | | Port & at sea inspection, Observers, EM |
| | Fish | | | Yes | Yes | |
| **Light sticks** | | Yes | Sometimes | | | Port & at sea inspection, Observers, EM |
| **Hooks per float** | 3 to ~10 | Yes | At Night | Yes | | Observers, EM |
| | >10 | | During Day | | Yes | |
| **Floatline and branchline lengths** | Shorter | Yes | At Night | Yes | | Observers, EM |
| | Longer | | During Day | | Yes | |
| **Time of setting (and soaking)** | Afternoon/Evening (night) | Yes | Yes | | | VMS, AIS, Observers, EM |
| | Morning (Day) | | Yes | Yes | Yes | |
| **Moonphase importance** | | High | Moderate | ?? | Low? | |

**Table 5** – Proportion of swordfish reported by observers as "alive" in the observed catch by flag, for longline observer data from the SWPO swordfish stock area, aggregated by flag, for the period 2015-2020 (Source, SPC 2021).

| Flag | Alive | Dead | Total landed | %Alive |
|---|---|---|---|---|
| TW | 1523 | 3134 | 4657 | 32.7 |
| NZ | 934 | 2246 | 3180 | 29.4 |
| JP | 987 | 1435 | 2422 | 40.8 |
| FJ | 840 | 1039 | 1879 | 44.7 |
| CN | 560 | 1162 | 1722 | 32.5 |
| VU | 527 | 999 | 1526 | 34.5 |
| KR | 612 | 740 | 1352 | 45.3 |
| PF | 411 | 338 | 749 | 54.9 |
| KI | 139 | 206 | 345 | 40.3 |
| SB | 81 | 184 | 265 | 30.6 |
| CK | 97 | 113 | 210 | 46.2 |
| AU | 35 | 135 | 170 | 20.6 |
| ID | 44 | 111 | 155 | 28.4 |
| TO | 66 | 73 | 139 | 47.5 |
| FM | 53 | 68 | 121 | 43.8 |
| NC | 26 | 39 | 65 | 40.0 |
| TV | 11 | 42 | 53 | 20.8 |
| WS | 16 | 15 | 31 | 51.6 |
| PG | 11 | 14 | 25 | 44.0 |
| AS | 1 | 10 | 11 | 9.1 |
| US | 0 | 2 | 2 | 0.0 |
| **Total** | **6974** | **12105** | **19079** | **36.6** |

**Table 6** – Percentage of swordfish reported by observers as "alive" when hauled to the vessel for key swordfish bycatch fleets and by subregion (see map Figure 1) in the SWPO stock area, for fleet-subregion strata in which at least 300 fish were observed caught in the period 2015-2020 (Source – SPC 2021).

| Flag | North-west | North-east | South-west |
|---|---|---|---|
| CN | 41.6 | 26.8 | |
| FJ | 41.7 | | 53.4 |
| JP | | 22.7 | 57.8 |
| KI | | 36.6 | |
| KR | 42.4 | 46.7 | |
| NZ | | | 29.4 |
| PF | | 54.1 | |
| TW | 35.4 | 28.3 | 59.9 |
| VU | | 33.3 | |

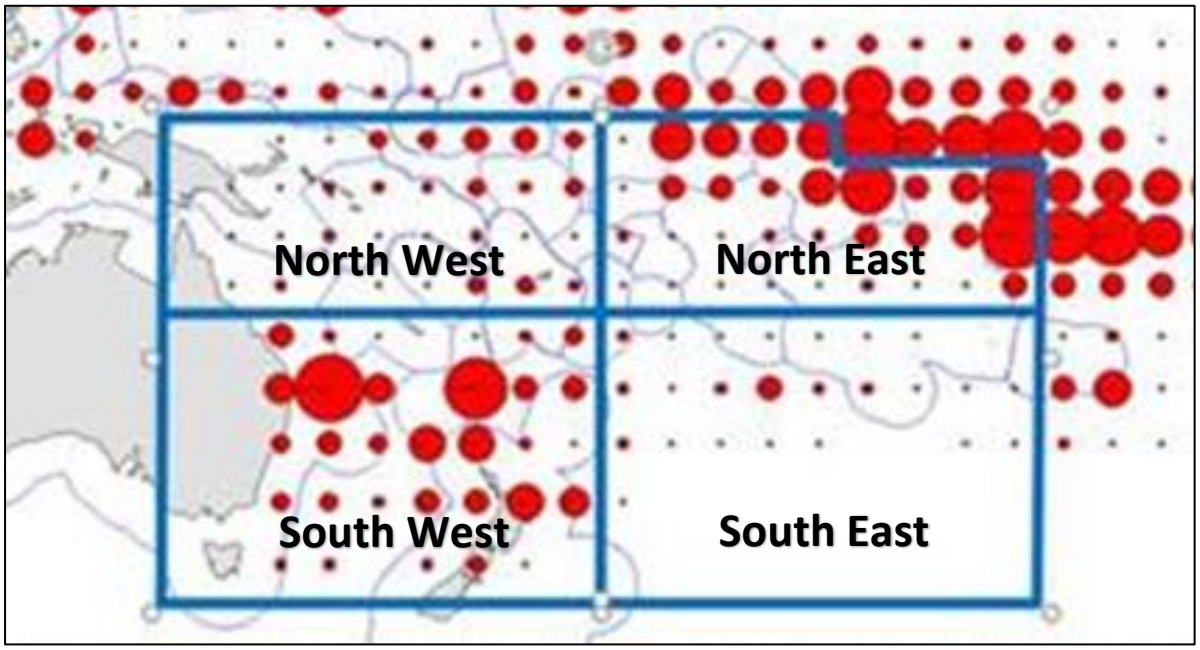


**Figure 1** - Swordfish catches (red circles, scaled to level of catch) by 5 degrees in the Pacific Ocean for the period 2015 – 2018. The blue box defines the four sub-regions into which the following data summaries for this paper are divided. For each subregion (North West, North East, South West, South East) the data summaries in this paper aggregate the data into two additional areas being EEZs and High Seas – and then within each by flag. (Source: SPC, 2019)

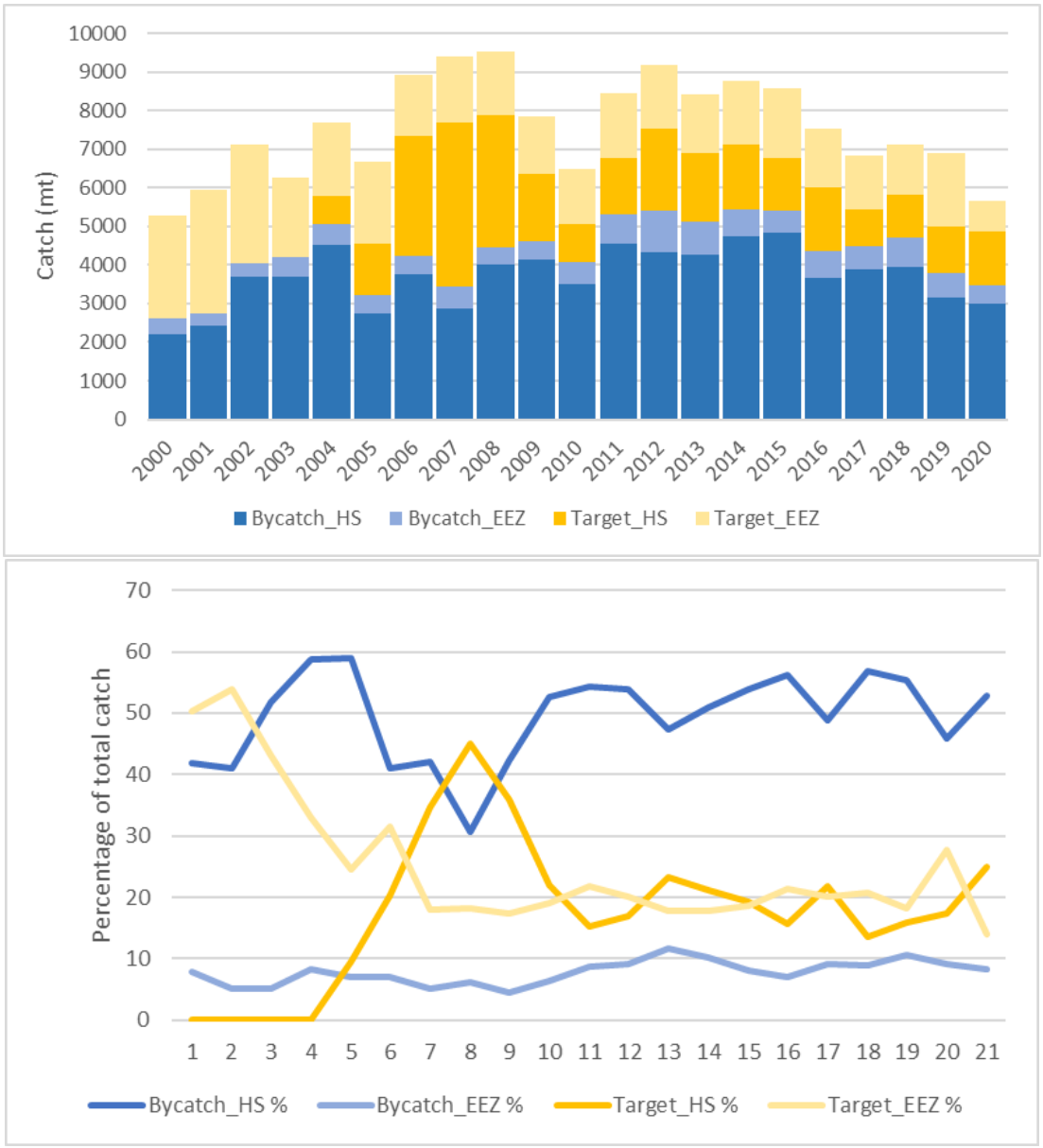


**Figure 2** – Longline catch (mt) (top panel) and percentage of catch (bottom panel) of South West Pacific swordfish by year and fishery type (target or bycatch) and zone type (high seas or EEZ) for the period 2000-2020, as reported in SC17 paper MI-IP12 (SPC, 2021).

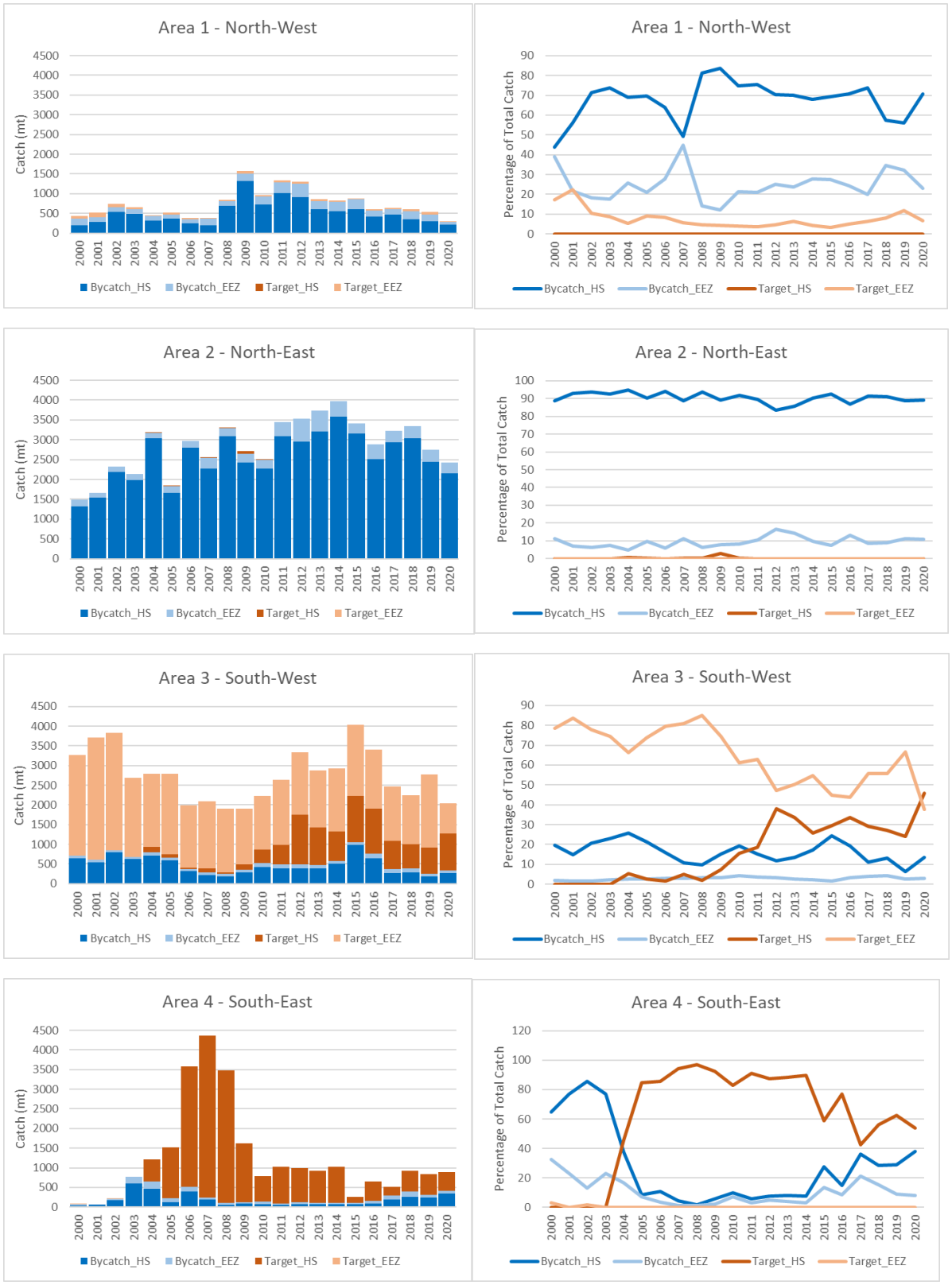


**Figure 3** – Longline catch (mt) (left side panels) and percentage of catch (right side panels) of South West Pacific swordfish in four subregions (see Fig 1 map) and by year, fishery type (target or bycatch) and zone type (high seas or EEZ) for the period 2000-2020, as reported in SC17 paper SC17-MI-IP12 (SPC, 2021).

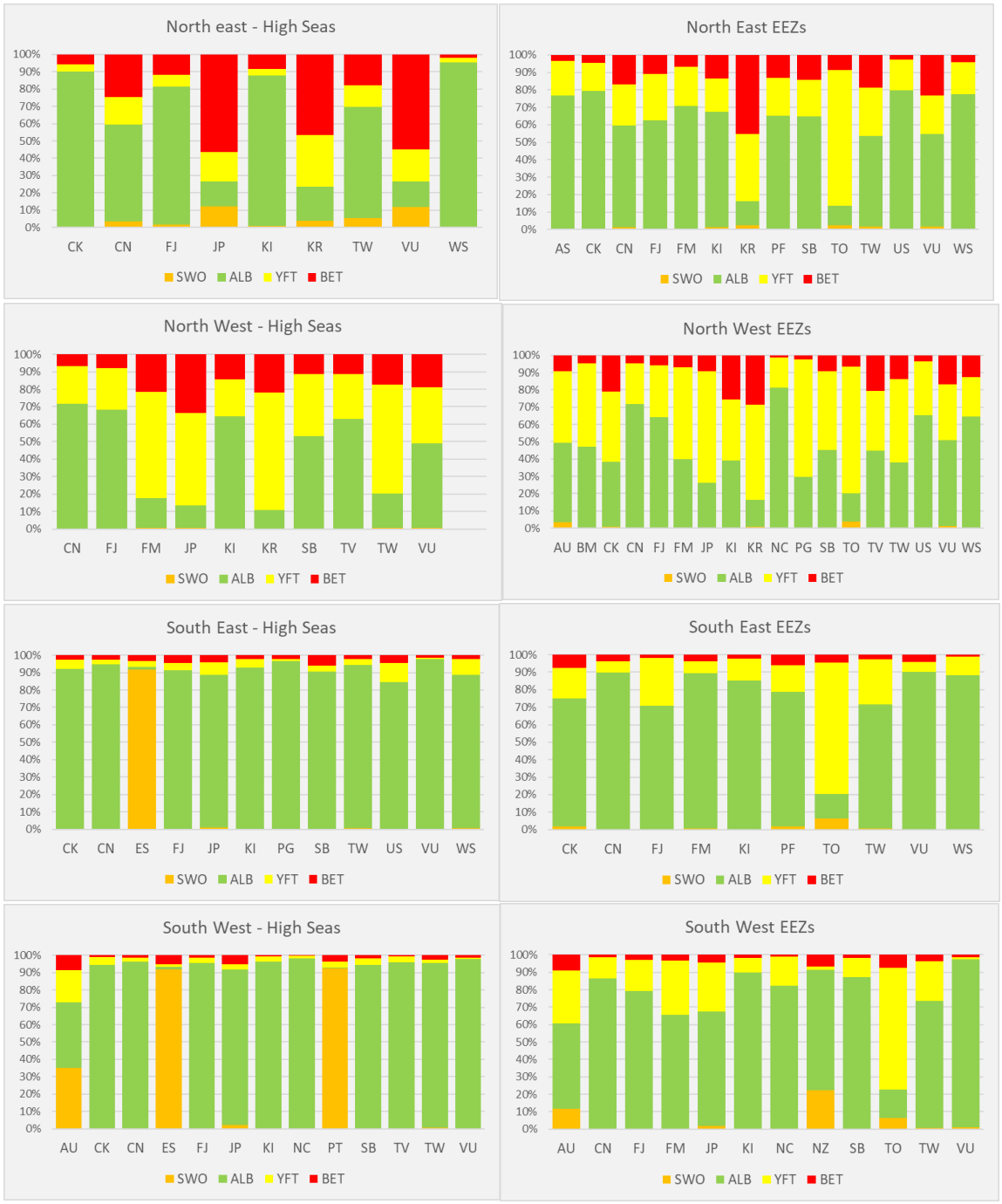


**Figure 4** – Species catch proportions (based on number caught) as recorded in logbooks for the period 2015-2020 – for data aggregated by quadrant (north east, north west, south east, south west) and within quadrant, high seas or inzone, and by flag. Note that only flag-area strata with >1000 fish (total, all species combined) were included and the number of sets reported on logbooks is highly variable across quadrants and flags (Source – SPC 2021).

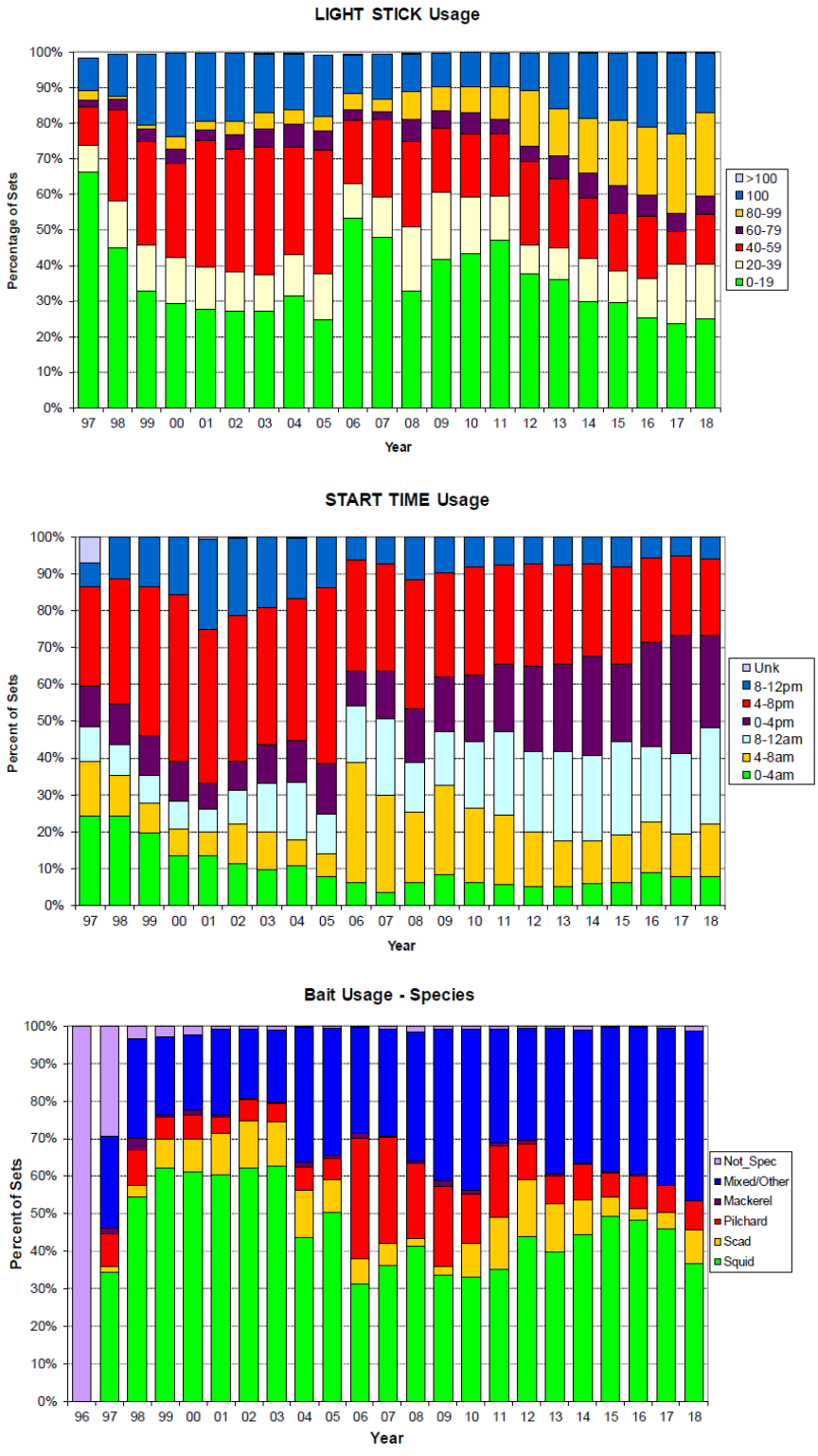


**Figure 5** – An example (using the Australian longline fleet logbook data) of the type of information that can assist in helping to understand the potential use of different bycatch management options. Shown above are the proportion of total sets fished that (top) use different amounts of lighsticks, or (middle) are set at different times of day or night, or (bottom) use different bait type. Note that lightsticks, afternoon/night setting and squid bait – are fishing methods likely to increase swordfish catch rates (they are used by swordfish targeting fleets).


**Figure 6** – The percentage of ***observed*** longline sets using light sticks – for observer data aggregated by quadrant (north east, north west, south east, south west) and within quadrant, high seas or inzone, and by flag, based on observer data for the period 2015-2021 (Source SPC, 2021). This information is presented as a preliminary example of the type of information that may assist WCPFC members to assess the implications of different bycatch management options for their fishery/fleets. Note that only data pertaining to area-flag strata comprising more than 3 vessels are represented, and the number of sets observed and the coverage (and representativeness of those sets of the broader flag/fleets) varies significantly between flag-area strata.

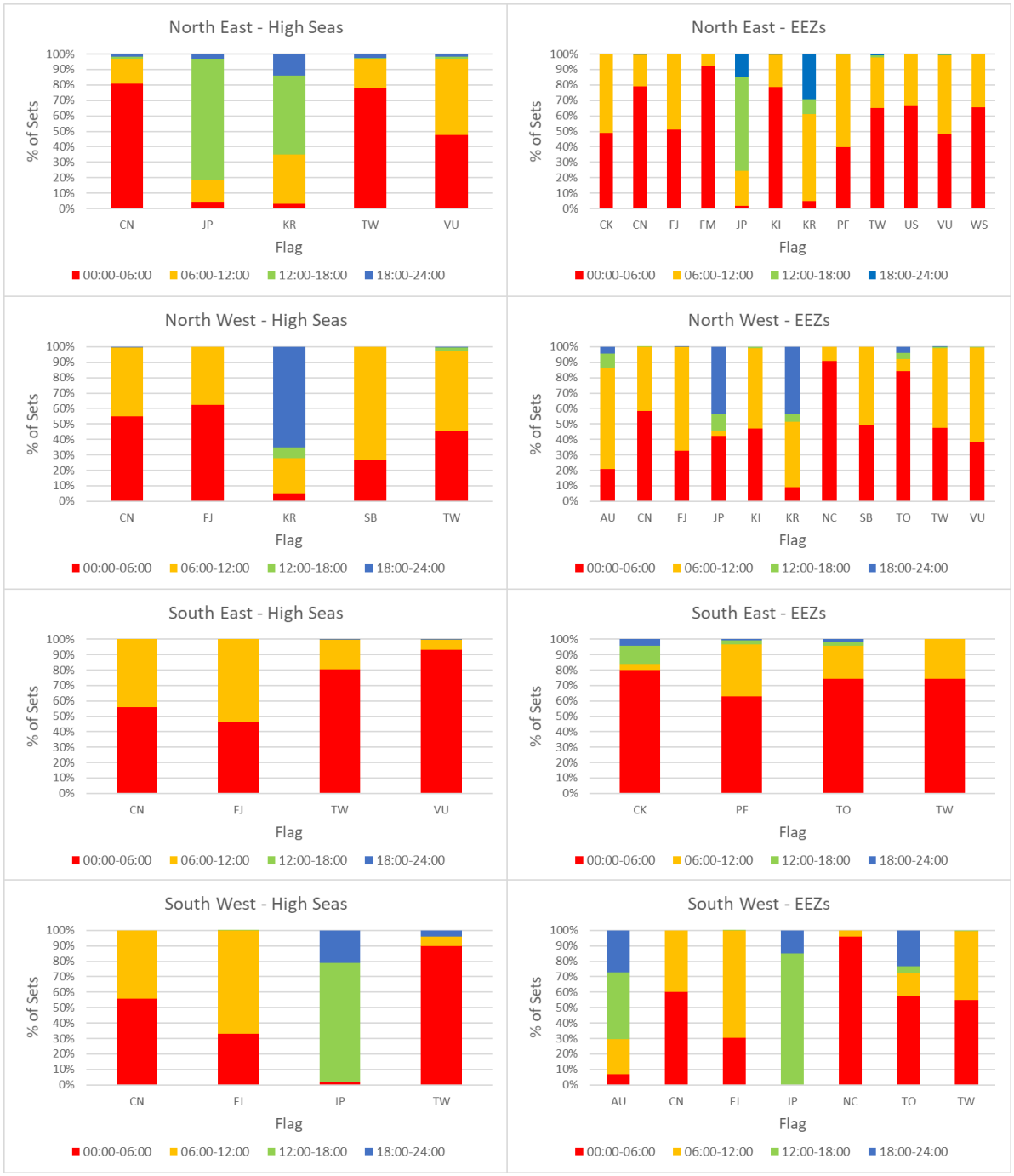


**Figure 7** – The percentage of ***observed*** longline sets by time of day of setting, aggregated by area and flag, based on observer data for the period 2015-2020 (Source SPC, 2021). This information is presented as a preliminary example of the type of information that may assist WCPFC members to assess the implications of different bycatch management options for their fishery/fleets. Note that only data pertaining to area-flag strata comprising more than 3 vessels are represented, and the number of sets observed and the coverage (and representativeness of those sets of the broader flag fleets) varies significantly.

# Appendix 1

**Table A1** – Responses to comments, questions and requests received by WCPFC CCMs regarding the WCPFC SC16 (August 2020) paper on management options for fisheries taking swordfish as bycatch.

| CCM Comments, Questions, Requests | Australia Response |
|---|---|
| **Model based testing**<br><br>Bycatch management options (relating to lightsticks, bait, retention, size limits, and live release) should be tested within the context of the fishery characterisation and assessment in 2021, and data summaries provided by the SSP to quantify the scale of bycatch from non-swordfish target fisheries. | The SSP has provided summary data to quantify both bycatch and target fishery catches in SC17-MI-IP12, and those data are further summarised in Figs 2 and 3 here. The suite of catch projections requested by WCPFC16 in December 2019 was designed to account for both bycatch and target fisheries impacts and additional scenarios could be considered by the SC that test the likely impact of some of the bycatch management options. The SSP suggested any modelling along these lines wait until the SC has discussed the latest stock assessment scheduled for 2021. The SC should consider if additional projections scenarios can be specified and requested of the SSP. |
| **Target fisheries management**<br><br>Both swordfish target and bycatch fisheries need to be considered together and managed together under a revised CMM (i.e. the focus should not be on bycatch fisheries alone). Similar approaches (to those being considered for bycatch) to target fisheries might be required to ensure effective management. | The Commission will need to consider measures for both target and bycatch fisheries in developing a revised CMM. This paper responds to a specific request by WCPFC16 to provide information on potential swordfish bycatch options. Other technical work, including the fishery data summary paper (SC17-MP-IP12), updated stock assessment (SC17-SA-WP-04) and projections requested by WCPFC16, will provide important information to inform future CMM conditions for swordfish targeting fisheries (as well as bycatch fisheries). |
| **Economic value of swordfish**<br><br>a) Swordfish is not a low value fish and is an important commercial species for some longline fishers that target tunas. Thus, it is not able to be unambiguously defined as a bycatch species.<br>b) It would be beneficial to consider the economic implications of the various bycatch management options. | a) Swordfish is a commercially valuable species and normally retained for sale, regardless of whether it is targeted or taken incidentally while targeting tuna. It has been described as bycatch to emphasise it is not targeted in some fleets, not to infer that it is not commercially valuable. We have amended the document to reflect this. We would like to hear from CCMs regarding the economic importance of this species in bycatch fisheries.<br>b) While it is not feasible to develop a single overarching analysis of economic implications (as each CCMs fisheries have unique operational and economic circumstances), individual CCMs can use the information from the fishery characterisation (SC17-MI IP12), this paper (SC17-MI IP10), the assessment (SC17-SA-04) and future catch projections and associated work, alongside their own information about how their fisheries operate, |

| | |
|---|---|
| | to determine which options might be more or less acceptable to their fishery from an economic impacts perspective. |
| **Bycatch management options**<br>The paper should not refer to management options examples derived from other species, for example sharks. | The paper references management approaches adopted for other bycatch species simply to expand the options for consideration. The SC can determine where options might be less appropriate due to specific biology or fishery characteristics of swordfish |
| **Stock assessment & projections**<br>It is very important that WCPFC consider the results of the stock assessment, and detailed projections (or MSE) as the basis for CMMs of south Pacific SWO. | The bycatch options paper is only one source of information intended to inform development of a future measure. The revised stock assessment and projections as well as fishery statistics summaries (SC17-MP-IP12) and other papers presented to SC17 will also provide critical inputs to inform a future CMM. |
| **Post release survival**<br>Further research on post release survival of swordfish may be needed, including region specific (e.g. N20S high seas) as survival can vary by oceanography and gear configuration. Prohibition of retention of bycatch species should be considered as a last resort especially for species whose stock status is not overfished and not overfishing. | Research on post release mortality has been summarised and now included in this paper (Section 5.3). |
| **Fishing method overlaps**<br>At least two fleets vessels targeting tuna use methods very similar to those used for targeting swordfish (night setting and/or light sticks and/or squid bait) - so measures that restrict the use of these would have a very large impact on these tuna fisheries. Understanding the methods used by each fleet needs further investigation to inform options in the CMM. | Data sourced from the SSP pertaining to the use of night setting and light sticks has been summarised by fleet and area in Figs 6 and 7. However, the data is derived from observers, with low coverage rates, and may vary in how representative it is of each fleet. Australia will consult with CCMs individually post SC to better understand methods used by each fleet. |
| **Seabirds CMM concern**<br>Any measure requiring vessels to move away from night setting might be inconsistent with the seabirds CMM (that advocates night setting as a mitigation) | This paper is not advocating any one measure being applied and indeed, the Commission might wish to consider a future CMM that might have a table of "options" for swordfish bycatch fleets, similar to the approach taken for seabirds and sharks. This would provide flexibility for CCMs to choose an option that minimises impacts on their specific tuna operations. The Commission may also wish to consider area specific options - for example - night setting requirements do not apply north of 20S where swordfish bycatch on the high seas is highest. |

# Appendix 2

**Table A2 –** percentage of either "swordfish + tuna" catch and Total Catch that comprises swordfish, across SWPO fishery strata (fleets x subregions x seasons(quarters)) for key fisheries. "Key" fisheries mean those accounting for a significant proportion of the overall catch from the stock. Note that the data are derived from WCPFC public domain aggregate 5x5 by year-quarter longline data (2015-2019), which excludes cells with less than three vessels, and as such does not represent all catches in the fishery. As such, the ratios can be considered "indicative" but not fully representative.

| Flag | Subregion | Quarter | Tuna (t) | Swordfish (t) | Other (t) | SWO/(SWO+TUNA) | SWO/TOTAL |
|---|---|---|---|---|---|---|---|
| AU | North-west (R1) | 1 | 198.8 | 34.3 | 38.7 | 14.7 | 12.6 |
| AU | North-west (R1) | 3 | 211.8 | 38.5 | 15.2 | 15.4 | 14.5 |
| AU | North-west (R1) | 4 | 67.0 | 19.5 | 16.2 | 22.5 | 19.0 |
| AU | South-west (R3) | 1 | 1759.8 | 769.9 | 496.4 | 30.4 | 25.4 |
| AU | South-west (R3) | 2 | 3276.6 | 777.2 | 659.7 | 19.2 | 16.5 |
| AU | South-west (R3) | 3 | 3957.5 | 1026.8 | 749.1 | 20.6 | 17.9 |
| AU | South-west (R3) | 4 | 1268.7 | 995.1 | 665.9 | 44.0 | 34.0 |
| CN | North-west (R1) | 1 | 13847.0 | 172.5 | 694.9 | 1.2 | 1.2 |
| CN | North-west (R1) | 2 | 16646.7 | 131.9 | 598.0 | 0.8 | 0.8 |
| CN | North-west (R1) | 3 | 17453.5 | 141.4 | 503.1 | 0.8 | 0.8 |
| CN | North-west (R1) | 4 | 15019.2 | 161.6 | 640.9 | 1.1 | 1.0 |
| CN | North-east (R2) | 1 | 8758.7 | 705.2 | 897.6 | 7.5 | 6.8 |
| CN | North-east (R2) | 2 | 15766.9 | 574.3 | 791.4 | 3.5 | 3.4 |
| CN | North-east (R2) | 3 | 21143.1 | 1592.9 | 1266.3 | 7.0 | 6.6 |
| CN | North-east (R2) | 4 | 13552.0 | 2049.3 | 1647.8 | 13.1 | 11.9 |
| CN | South-west (R3) | 1 | 806.0 | 4.3 | 21.6 | 0.5 | 0.5 |
| CN | South-west (R3) | 2 | 2723.9 | 18.3 | 73.6 | 0.7 | 0.6 |
| CN | South-west (R3) | 3 | 3424.8 | 57.2 | 99.2 | 1.6 | 1.6 |
| CN | South-west (R3) | 4 | 937.2 | 9.1 | 63.1 | 1.0 | 0.9 |
| CN | South-east (R4) | 2 | 5393.2 | 28.3 | 140.5 | 0.5 | 0.5 |
| CN | South-east (R4) | 3 | 9164.5 | 74.2 | 241.4 | 0.8 | 0.8 |
| CN | South-east (R4) | 4 | 326.8 | 2.3 | 15.7 | 0.7 | 0.7 |
| JP | North-west (R1) | 1 | 4257.0 | 40.1 | 376.7 | 0.9 | 0.9 |
| JP | North-west (R1) | 2 | 5233.9 | 27.3 | 178.3 | 0.5 | 0.5 |
| JP | North-west (R1) | 3 | 7110.6 | 71.4 | 482.3 | 1.0 | 0.9 |
| JP | North-west (R1) | 4 | 4055.3 | 44.5 | 344.0 | 1.1 | 1.0 |
| JP | North-east (R2) | 1 | 215.8 | 27.5 | 21.9 | 11.3 | 10.4 |
| JP | North-east (R2) | 2 | 288.1 | 16.5 | 26.9 | 5.4 | 5.0 |
| JP | North-east (R2) | 3 | 173.6 | 35.7 | 6.3 | 17.1 | 16.6 |
| JP | North-east (R2) | 4 | 219.9 | 60.7 | 15.9 | 21.6 | 20.5 |
| JP | South-west (R3) | 1 | 49.2 | 7.0 | 0.3 | 12.4 | 12.4 |
| JP | South-west (R3) | 2 | 1930.2 | 524.9 | 39.5 | 21.4 | 21.0 |
| JP | South-west (R3) | 3 | 1897.2 | 109.9 | 87.4 | 5.5 | 5.2 |
| KR | North-west (R1) | 1 | 3501.9 | 79.2 | 676.4 | 2.2 | 1.9 |
| KR | North-west (R1) | 2 | 13377.6 | 156.1 | 1557.7 | 1.2 | 1.0 |
| KR | North-west (R1) | 3 | 19511.3 | 290.5 | 2101.9 | 1.5 | 1.3 |
| KR | North-west (R1) | 4 | 8559.7 | 209.5 | 1182.2 | 2.4 | 2.1 |
| KR | North-east (R2) | 1 | 4081.6 | 189.9 | 510.9 | 4.4 | 4.0 |
| KR | North-east (R2) | 2 | 2022.9 | 68.5 | 181.8 | 3.3 | 3.0 |
| KR | North-east (R2) | 3 | 7248.2 | 280.5 | 721.0 | 3.7 | 3.4 |
| KR | North-east (R2) | 4 | 6080.3 | 353.8 | 524.6 | 5.5 | 5.1 |

**Table A2 -** Percentage of either "swordfish + tuna" catch and Total Catch that comprises swordfish, across SWPO fishery strata (fleets x subregions x seasons(quarters)) for key fisheries. "Key" fisheries mean those accounting for a significant proportion of the overall catch from the stock. Note that the data are derived from WCPFC public domain aggregate 5x5 by year-quarter longline data (2015-2019), which excludes cells with less than three vessels, and as such does not represent all catches in the fishery. As such, the ratios can be considered "indicative" but not fully representative.

| Flag | Subregion | Quarter | Tuna (t) | Swordfish (t) | Other (t) | SWO/(SWO+TUNA) | SWO/TOTAL |
|---|---|---|---|---|---|---|---|
| NZ | South-west (R3) | 1 | 220.1 | 376.3 | 562.3 | 63.1 | 32.5 |
| NZ | South-west (R3) | 2 | 539.7 | 440.2 | 2726.7 | 44.9 | 11.9 |
| NZ | South-west (R3) | 3 | 171.0 | 99.5 | 1460.8 | 36.8 | 5.7 |
| PT | South-west (R3) | 1 | 23.6 | 644.5 | 428.5 | 96.5 | 58.8 |
| TW | North-west (R1) | 1 | 5060.4 | 98.0 | 1849.6 | 1.9 | 1.4 |
| TW | North-west (R1) | 2 | 9354.6 | 81.9 | 1879.6 | 0.9 | 0.7 |
| TW | North-west (R1) | 3 | 10353.6 | 147.3 | 1754.2 | 1.4 | 1.2 |
| TW | North-west (R1) | 4 | 5003.2 | 77.9 | 2357.3 | 1.5 | 1.0 |
| TW | North-east (R2) | 1 | 8349.7 | 613.7 | 2035.0 | 6.8 | 5.6 |
| TW | North-east (R2) | 2 | 13889.5 | 264.2 | 1929.8 | 1.9 | 1.6 |
| TW | North-east (R2) | 3 | 20283.4 | 1877.3 | 4283.8 | 8.5 | 7.1 |
| TW | North-east (R2) | 4 | 15025.8 | 2825.9 | 3434.0 | 15.8 | 13.3 |
| TW | South-west (R3) | 1 | 192.7 | 3.1 | 26.8 | 1.6 | 1.4 |
| TW | South-west (R3) | 2 | 3593.4 | 174.2 | 13371.1 | 4.6 | 1.0 |
| TW | South-west (R3) | 3 | 5127.9 | 151.7 | 1635.6 | 2.9 | 2.2 |
| TW | South-west (R3) | 4 | 210.5 | 9.7 | 82.4 | 4.4 | 3.2 |
| TW | South-east (R4) | 1 | 146.2 | 1.3 | 13.7 | 0.9 | 0.8 |
| TW | South-east (R4) | 2 | 7525.0 | 168.0 | 962.1 | 2.2 | 1.9 |
| TW | South-east (R4) | 3 | 12585.8 | 304.3 | 1834.4 | 2.4 | 2.1 |
| TW | South-east (R4) | 4 | 433.3 | 12.5 | 217.8 | 2.8 | 1.9 |
| VU | North-west (R1) | 1 | 633.1 | 8.2 | 90.5 | 1.3 | 1.1 |
| VU | North-west (R1) | 2 | 783.9 | 34.9 | 157.9 | 4.3 | 3.6 |
| VU | North-west (R1) | 3 | 125.1 | 0.5 | 10.8 | 0.4 | 0.3 |
| VU | North-west (R1) | 4 | 264.5 | 2.4 | 28.4 | 0.9 | 0.8 |
| VU | North-east (R2) | 1 | 1438.4 | 65.7 | 233.7 | 4.4 | 3.8 |
| VU | North-east (R2) | 2 | 2857.9 | 58.0 | 307.7 | 2.0 | 1.8 |
| VU | North-east (R2) | 3 | 7723.1 | 363.7 | 1078.7 | 4.5 | 4.0 |
| VU | North-east (R2) | 4 | 5279.5 | 560.8 | 909.6 | 9.6 | 8.3 |
| VU | South-west (R3) | 2 | 1011.8 | 9.1 | 228.8 | 0.9 | 0.7 |
| VU | South-west (R3) | 3 | 503.2 | 6.4 | 158.2 | 1.2 | 1.0 |
| VU | South-east (R4) | 1 | 26.9 | 0.4 | 3.9 | 1.3 | 1.1 |
| VU | South-east (R4) | 2 | 4061.2 | 42.0 | 768.2 | 1.0 | 0.9 |
| VU | South-east (R4) | 3 | 7792.9 | 61.0 | 1288.1 | 0.8 | 0.7 |

**Table A2 -** percentage of either "swordfish + tuna" catch and Total Catch that comprises swordfish, across SWPO fishery strata (fleets x subregions x seasons(quarters)) for minor bycatch fisheries (fisheries that account for only a very minor proportion of total catch from the stock). Note that the data are derived from WCPFC public domain aggregate 5x5 by year-quarter longline data (2015-2019), which excludes cells with less than three vessels, and as such does not represent all catches in the fishery. As such, the ratios can be considered "indicative" but not fully representative.

| Flag | Subregion | Quarter | Tuna (t) | Swordfish (t) | Other (t) | SWO/(SWO+TUNA) | SWO/TOTAL |
|---|---|---|---|---|---|---|---|
| CK | North-east | 1 | 485.2 | 3.7 | 103.3 | 0.8 | 0.6 |
| CK | North-east | 2 | 2977.1 | 10.6 | 277.6 | 0.4 | 0.3 |
| CK | North-east | 3 | 4757.9 | 42.5 | 615.0 | 0.9 | 0.8 |
| CK | North-east | 4 | 2278.8 | 23.3 | 341.3 | 1.0 | 0.9 |
| CK | South-east | 1 | 30.4 | 1.0 | 33.2 | 3.3 | 1.6 |
| CK | South-east | 2 | 219.2 | 5.2 | 87.4 | 2.3 | 1.7 |
| CK | South-east | 3 | 360.7 | 10.0 | 91.1 | 2.7 | 2.2 |
| CK | South-east | 4 | 77.4 | 10.7 | 55.6 | 12.2 | 7.5 |
| FJ | North-west | 1 | 9509.5 | 71.5 | 2121.7 | 0.7 | 0.6 |
| FJ | North-west | 2 | 14280.8 | 49.4 | 2151.3 | 0.3 | 0.3 |
| FJ | North-west | 3 | 12167.6 | 85.7 | 2730.9 | 0.7 | 0.6 |
| FJ | North-west | 4 | 11353.4 | 134.7 | 2913.8 | 1.2 | 0.9 |
| FJ | North-east | 1 | 134.4 | 1.8 | 15.2 | 1.3 | 1.2 |
| FJ | North-east | 2 | 149.4 | 0.3 | 8.9 | 0.2 | 0.2 |
| FJ | North-east | 4 | 130.0 | 2.1 | 13.5 | 1.6 | 1.4 |
| FJ | South-west | 1 | 1725.4 | 19.0 | 422.6 | 1.1 | 0.9 |
| FJ | South-west | 2 | 2653.8 | 14.5 | 656.7 | 0.5 | 0.4 |
| FJ | South-west | 3 | 5964.7 | 43.3 | 1528.8 | 0.7 | 0.6 |
| FJ | South-west | 4 | 3411.3 | 94.0 | 889.2 | 2.7 | 2.1 |
| FJ | South-east | 1 | 148.5 | 0.2 | 6.7 | 0.2 | 0.2 |
| FJ | South-east | 2 | 206.9 | 2.3 | 16.3 | 1.1 | 1.0 |
| FJ | South-east | 3 | 754.1 | 9.1 | 105.1 | 1.2 | 1.0 |
| FJ | South-east | 4 | 84.3 | 1.5 | 8.6 | 1.7 | 1.6 |
| FM | North-west | 2 | 389.5 | 0.6 | 29.0 | 0.2 | 0.2 |
| FM | North-east | 1 | 114.2 | 1.6 | 34.1 | 1.3 | 1.0 |
| FM | North-east | 2 | 3391.8 | 19.4 | 381.6 | 0.6 | 0.5 |
| FM | North-east | 3 | 6295.0 | 64.6 | 961.2 | 1.0 | 0.9 |
| FM | North-east | 4 | 1477.4 | 32.7 | 288.2 | 2.2 | 1.8 |
| FM | South-east | 3 | 86.0 | 1.4 | 12.9 | 1.7 | 1.4 |
| KI | North-west | 3 | 213.5 | 1.8 | 22.9 | 0.8 | 0.8 |
| KI | North-west | 4 | 387.9 | 1.7 | 25.5 | 0.4 | 0.4 |
| KI | North-east | 1 | 276.2 | 1.2 | 35.3 | 0.4 | 0.4 |
| KI | North-east | 2 | 754.2 | 0.9 | 62.6 | 0.1 | 0.1 |
| KI | North-east | 3 | 1562.2 | 11.7 | 216.4 | 0.7 | 0.7 |
| KI | North-east | 4 | 708.6 | 35.3 | 78.6 | 4.7 | 4.3 |
| KI | South-east | 2 | 62.1 | 0.2 | 4.0 | 0.3 | 0.3 |
| NC | North-west | 1 | 358.9 | 1.5 | 70.9 | 0.4 | 0.3 |
| NC | North-west | 3 | 801.9 | 1.6 | 108.8 | 0.2 | 0.2 |
| NC | North-west | 4 | 585.9 | 1.2 | 111.3 | 0.2 | 0.2 |
| NC | South-west | 1 | 1594.7 | 6.4 | 418.8 | 0.4 | 0.3 |
| NC | South-west | 2 | 2115.8 | 6.5 | 414.3 | 0.3 | 0.3 |
| NC | South-west | 3 | 1785.9 | 4.3 | 238.8 | 0.2 | 0.2 |
| NC | South-west | 4 | 1471.2 | 11.5 | 442.2 | 0.8 | 0.6 |

**Table A2 -** percentage of either "swordfish + tuna" catch and Total Catch that comprises swordfish, across SWPO fishery strata (fleets x subregions x seasons(quarters)) for minor bycatch fisheries (fisheries that account for only a very minor proportion of total catch from the stock). Note that the data are derived from WCPFC public domain aggregate 5x5 by year-quarter longline data (2015-2019), which excludes cells with less than three vessels, and as such does not represent all catches in the fishery. As such, the ratios can be considered "indicative" but not fully representative.

| Flag | Subregion | Quarter | Tuna (t) | Swordfish (t) | Other (t) | SWO/(SWO+TUNA) | SWO/TOTAL |
|---|---|---|---|---|---|---|---|
| PF | North-east | 1 | 4319.9 | 71.0 | 1629.3 | 1.6 | 1.2 |
| PF | North-east | 2 | 6425.7 | 95.1 | 1854.3 | 1.5 | 1.1 |
| PF | North-east | 3 | 5436.8 | 149.1 | 1517.9 | 2.7 | 2.1 |
| PF | North-east | 4 | 4561.0 | 159.0 | 1372.6 | 3.4 | 2.6 |
| PF | South-east | 1 | 325.5 | 6.7 | 316.7 | 2.0 | 1.0 |
| PF | South-east | 3 | 520.2 | 24.7 | 158.5 | 4.5 | 3.5 |
| PF | South-east | 4 | 1108.9 | 63.9 | 419.7 | 5.4 | 4.0 |
| PG | North-west | 1 | 746.9 | 6.3 | 117.2 | 0.8 | 0.7 |
| PG | North-west | 2 | 2103.9 | 15.9 | 131.4 | 0.7 | 0.7 |
| PG | North-west | 3 | 1698.5 | 12.5 | 123.3 | 0.7 | 0.7 |
| PG | North-west | 4 | 968.4 | 9.2 | 163.4 | 0.9 | 0.8 |
| SB | North-west | 1 | 10515.4 | 54.7 | 1057.1 | 0.5 | 0.5 |
| SB | North-west | 2 | 14299.9 | 49.0 | 1093.2 | 0.3 | 0.3 |
| SB | North-west | 3 | 13143.7 | 67.7 | 1215.7 | 0.5 | 0.5 |
| SB | North-west | 4 | 11750.1 | 89.3 | 1154.7 | 0.8 | 0.7 |
| SB | North-east | 1 | 181.3 | 1.8 | 25.0 | 1.0 | 0.8 |
| SB | North-east | 4 | 486.0 | 9.3 | 69.7 | 1.9 | 1.6 |
| SB | South-west | 4 | 291.8 | 2.1 | 27.7 | 0.7 | 0.6 |
| TO | South-west | 2 | 135.0 | 6.5 | 70.2 | 4.6 | 3.0 |
| TO | South-west | 3 | 161.2 | 16.3 | 156.2 | 9.2 | 4.9 |
| TO | South-west | 4 | 36.1 | 9.9 | 47.5 | 21.5 | 10.6 |
| TO | South-east | 1 | 171.9 | 5.6 | 35.3 | 3.2 | 2.6 |
| TO | South-east | 4 | 62.3 | 11.9 | 65.6 | 16.0 | 8.5 |
| TV | North-west | 1 | 117.9 | 1.7 | 10.1 | 1.4 | 1.3 |
| TV | North-west | 2 | 257.9 | 2.0 | 16.1 | 0.8 | 0.7 |
| TV | North-west | 3 | 98.4 | 1.4 | 7.6 | 1.4 | 1.3 |
| TV | North-west | 4 | 54.7 | 1.5 | 4.1 | 2.6 | 2.4 |
| US | North-east | 1 | 1124.1 | 2.2 | 146.7 | 0.2 | 0.2 |
| US | North-east | 2 | 3297.0 | 2.1 | 243.3 | 0.1 | 0.1 |
| US | North-east | 3 | 2720.0 | 6.9 | 321.0 | 0.3 | 0.2 |
| US | North-east | 4 | 1940.5 | 4.5 | 261.3 | 0.2 | 0.2 |
| WS | North-west | 1 | 31.1 | 0.6 | 8.3 | 1.9 | 1.5 |
| WS | North-east | 1 | 1420.3 | 9.5 | 181.3 | 0.7 | 0.6 |
| WS | North-east | 2 | 3285.6 | 7.4 | 248.1 | 0.2 | 0.2 |
| WS | North-east | 3 | 3508.4 | 13.8 | 375.4 | 0.4 | 0.4 |
| WS | North-east | 4 | 2188.3 | 22.2 | 293.9 | 1.0 | 0.9 |