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The western and central Pacific tuna fishery: 2021 overview and status of stocks

Tuna Fisheries Assessment
Report no. 22

FAME
Fisheries, Aquaculture and Marine Ecosystems Division

The western and central Pacific tuna fishery: 2021 overview and status of stocks

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Preface

The Tuna Fisheries Assessment Report ("TFAR") provides current information on the tuna fisheries of the western and central Pacific Ocean (WCPO) and the fish stocks (mainly tuna) that are impacted by them. The information provided in this report is summary in nature, but a list of references (mostly accessible via the internet) is included for those seeking further details. This report is a smart PDF so if you click on a reference within the document it will take you to the figure/section; to return to the page you were on, press alt and the left arrow key.

This report focuses on the primary tuna stocks targeted by the main WCPO industrial fisheries – skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bigeye (*T. obesus*) and South Pacific albacore tuna (*T. alalunga*).

The report is divided into three parts: the first section provides an overview of the fishery, with emphasis on developments over the past few years; the second summarises the most recent information on the status of the stocks; and the third summarises information concerning the interaction between the tuna fisheries, other associated and dependent species and their environment. The data used in compiling the report are those which were available to the Oceanic Fisheries Programme (OFP) at the time of publication, and are subject to change as improvements continue to be made to recent and historical catch statistics from the region. The fisheries statistics presented will usually be complete through the end of the year prior to publication. However, some minor revisions to statistics may occasionally be made for recent years. The stock assessment information presented is the most recent available at the time of publication.

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Further information, including a French version of this report, is available at the OFP webpage.

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1 The western and central Pacific tuna fishery

The tuna fisheries in the western and central Pacific Ocean (WCPO), encompassed by the Western and Central Pacific Fisheries Commission Convention Area (WCPFC-CA) (Figure 1), are diverse, ranging from small-scale, artisanal operations in the coastal waters of Pacific states, to large-scale, industrial purse seine, pole-and-line and longline operations in the exclusive economic zones (EEZs) of Pacific states and in international waters (high seas). The main species targeted by these fisheries are skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and albacore tuna (*T. alalunga*).

The current fishery characterisation includes updates to historical data, which show that 2021 was the 9th highest catch year in history, and represented a decline of appproximately 2.5% from 2020. We expect revisions to the 2021 catch estimates in next year's report, as estimates in the most recent year are preliminary. The WCPFC-CA tuna catch for 2021 represented 54% of the global tuna catch (Figure 2, the provisional estimate for 2021 being 4,910,113 t, a decrease of almost 7% from the 2019 record global catch).

Annual total catch of the four main tuna species in the WCPFC-CA increased steadily during the 1980s as the purse seine fleet expanded, and remained relatively stable during most of the 1990s until a sharp increase in catch in 1998. Total tuna catch continued to increase up until 2012, primarily due to increases in purse seine catch, and has been relatively stable over the past decade (Figure 2 and Table 1), at a total catch level of 2.6 to 3.0 million metric tonnes (hereafter abbreviated as "t"). The provisional total WCPFC-CA tuna catch for 2021 was estimated at approximately 2,635,291 t – 12% less than the record high of 2,986,743 t estimated in 2019, and a decline of 2.5% from 2020. In 2021, the purse seine fishery accounted for an estimated 1,835,129 t (70% of the total catch), a drop from the record high of 2,101,405 t estimated in 2019 for this fishery. The pole-and-line fishery landed an estimated 177,611 t (7% of the catch), substantially lower than the highest value of 415,016 t recorded in 1984, a time of much greater pole-and-line fishery participation. The longline fishery in 2021 accounted for an estimated 194,799 t (7% of the catch) – also lower than the highest value (284,849 t) recorded in 2004 and the lowest since 1993. Troll gear accounted for <1% of the total catch (9,402 t), well below the highest value (25,845 t) recorded in 2000. The remaining 16% (418,350 t) was taken by a variety of artisanal gear, mostly in eastern Indonesia, the Philippines and Vietnam, which is a record catch.

Text Box 1 - Summary of 2021 WCPFC-CA tuna catch by gear

Gear	Catch (1000 t)	% of total gear catch	change from 2020	Notes
Purse seine	1835	70%	-2%	4% below 5 yr avg.
Longline	195	7%	-9%	lowest since 1993
Pole-Line	178	7%	-11%	11% below 5 yr avg.
Troll	9	<1%	-6%	15% above 5 yr avg.
Other	418	16%	5%	new record catch
Total	2635	100%	-3%	5% below 5 yr avg.

The 2021 WCPFC-CA catch of skipjack (1,625,795 t – 62% of the total catch) was 20% less than the highest value (2,037,921 t in 2019), and a decrease of 5% from 2020 (Figure 3 and Table 2). The WCPFC-CA yellowfin catch for 2021 (777,763 t – 30% of the total catch) was a record catch, exceeding the previous high in 2017 by 62,300t. The WCPFC-CA bigeye catch for 2021 (149,693 t – 6% of the total catch) was well below the highest value (195,052 t) recorded in 2004, and a 3% decrease from the 2020 catch. The WCPFC-CA albacore catch for 2021 (82,040 t – 3% of the total catch) was also well below the highest value (148,051 t) recorded in 2002, and a 13% decrease from the 2020 catch.

Total tuna catch within the WCPFC-CA was also tabulated by individual country EEZ (and on the High Seas) and by flag nation, for the period of 1990-2021 (Figure 4). In 2021, the top ten 'EEZs' (one of which is the High Seas) accounted for 94% of the total catch while the top 10 flag states accounted for 85% of the total catch. Indonesia was both the top EEZ and top flag nation in catch. Tuna catch in the High Seas totalled approximately 12% of the total, down considerably from the period 1990-2007 when High Seas catches accounted for at least 25% of the annual total WCPFC-CA tuna catch.

Within the WCPFC-CA, South Pacific and North Pacific albacore are assessed separately – SPC[1] conducts the South Pacific albacore assessment; the ISC[2] conducts the North Pacific albacore assessment, which covers the entire North Pacific, including the waters of the Inter-American Tropical Tuna Commission Convention Area (IATTC-CA). The albacore tuna catch in the WCPFC-CA north of the equator was 32,443 t in 2021, which is 21% lower than the average of the previous five years, and less than one-third the highest catch of 104,798 t, taken in 1976 (Table 9). North Pacific albacore is not discussed further in this report; details of the latest assessment can be found in ISC ALBWG (2020).

Text Box 2 - Summary of 2021 WCPFC-CA tuna catch by species

Species	Catch (1000 t)	% of total tuna catch	change from 2020	Notes
Albacore	82	3%	-13%	lowest since 2000
Bigeye	150	6%	-3%	equal to 5 yr avg.
Skipjack	1626	62%	-5%	lowest since 2017
Yellowfin	778	30%	6%	new record catch
Total	2636	100%	-3%	5% below 5 yr avg.

In 2021, for the first time, a South–Pacific wide albacore stock assessment was conducted jointly by the SPC and IATTC, utilizing data from both Convention Areas (Table 7 and Table 8). South Pacific albacore catch in the WCPFC-CA totalled 49,540 t in 2021, which is nearly 28% lower than than the average of the previous five years, and 39% lower than the highest value (80,986 t), recorded in 2010. Note that these values include catch within the overlap area with the IATTC-CA. For the Eastern Pacific Ocean (EPO), exclusive of the overlap region, South Pacific albacore catch was 22,312 t in 2021; however this total is provisional. Average catches in the EPO over the period 2017–2021 were 15,740 t.

Several indices of annual fishing effort for the major gears employed in the commercial tuna fisheries are summarised in Table 3, Figure 5 (purse seine), Figure 6 (longline) and Figure 7 (pole-and-line). For the purse seine fleet, excluding the Indonesian, Philippine and Vietnamese domestic vessels, the number of active vessels peaked in 2014 and 2015 at 313. The percentage of purse seiners flagged to, or chartered by, Pacific Island states has steadily increased from 0 as late as 1979 to a high of 56% (146 out of 262) in 2021. The increase in number of purse seine sets and purse seine fishing days has mirrored the rise in number of vessels, although the peak in both measures of fishing effort, sets and days, occured a few years earlier (2011–2013) at around 65,000 days/sets. Purse seine vessels can make more than one set per day, and a day of searching (with no sets made) is counted as a fishing day.

The 2021 purse seine skipjack catch (1,327,308 t – 82% of the total skipjack catch) was 5% lower than the 2020 catch (Table 4). The 2021 purse seine catch of yellowfin tuna (429,959 t) was a 7% increase from 2020 (Table 5). The 2021 purse seine catch of bigeye tuna (76,436 t) was a 5% increase from 2020, and represented 51% of the total 2021 bigeye catch (Table 6). It is important to note that the purse seine species composition for 2021 will be revised once all observer data for 2021 have been received and processed, and the current estimate should therefore be considered preliminary. Note, however, that due to COVID-19[3] related restrictions on observer placements, coverage levels were less than 30% of purse seine sets and bycatch estimates are expected to be correspondingly imprecise relative to previous years (Peatman and Nicol 2021). Observer coverage of the purse seine and longline fleets is further discussed in subsection 3.1 Observer coverage.

The commercial longline fleet (excluding Vietnamese and Indonesian domestic and Japanese coastal longliners) peaked in size in 1994 at a total of 5,068 vessels (Table 3 and Figure 6). The fleet has steadily declined since then, and totalled 1,543 vessels in 2021. The percentage of longliners flagged to Pacific Island countries has steadily increased from 0 in the mid-1970s to around 30% in 2012 and has fluctuated between 25% and 31% through 2021. While the number of longline vessels has declined over the history of the fishery, a more direct measure of effort – hooks fished – has shown a different trend. Total hooks

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[1] The Pacific Community, formerly Secretariat of the Pacific Community

[2] The International Scientific Committee for Tuna and Tuna-like Species in North Pacific Ocean, and the Albacore Working Group

[3] Coronaviridae Study Group of the International Committee on Taxonomy of Viruses. Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat Microbiol* **5**, 536–544 (2020). `https://doi.org/10.1038/s41564-020-0695-z`

fished in the WCPFC-CA increased from a level of 400 million in the mid 1970s to 600 million in the early 2000s to 800 million in the early 2010s. The peak year in hooks fished was 2012 at 888 million hooks; the level in 2021 was 612 million hooks, a decline of 12% from the 2020 level, and nearly 16% below the average of the previous five years.

Text Box 3 - Summary of 2021 WCPFC-CA commercial fishing effort

Gear	unit	Number	change from 2020	Notes
Purse seine	vessels	262	-4%	lowest since 2008
Purse seine	days	47,828	-4%	lowest since 2007
Purse seine	sets	51,499	-4%	lowest since 2009
Longline	vessels	1,543	-2%	lowest on record
Longline	hooks	611,700,000	-12%	lowest since 2001
Pole-and-line	vessels	92	-6%	lowest on record
Pole-and-line	days	7,641	-5%	lowest on record

The recent longline catch estimates are often uncertain and subject to revision due to delays in reporting. Nevertheless, the bigeye catch was down 13% from 2021 and was the lowest since 1983, while the yellowfin catch (74,271 t) for 2021 was a 1% decrease on the 2020 catch and was the lowest since 1999.

The pole-and-line fleet has been contracting in size continuously since 1974, when the number of vessels peaked at 798, and totalled just 92 vessels in 2021, down from 97 in 2020 (Table 3 and Figure 7). Pole-and-line effort, measured in fishing days, has shown a similar decline, from a high of 88,567 days in 1977 to 7,641 days in 2021, noting, however that 2021 numbers are subject to revision.

Skipjack accounts for the majority of the pole-and-line tuna catch (87%), with yellowfin tuna (12%) making up the bulk of the remaining catch. The Japanese distant-water and offshore fleet and the Indonesian fleet account for most of the WCPFC-CA pole-and-line catch.

The 2021 troll catch in the WCPFC-CA was 9,402 t, a decline of 6% from 2021, but 15% above the average of the previous five years. In recent years, albacore has comprised roughly half the troll catch, mainly by the New Zealand fleet (average 2,424 t catch per year) but with a small catch by the United States (average 572 t per year). Skipjack and yellowfin tuna are also taken in smaller quantities; however much of the tropical small-scale troll fisheries catch is reported under “Other gears”.

2 Status of tuna stocks

The sections below provide a summary of the recent developments in fisheries for each species, and the results from the most recent stock assessments. A summary of the important biological reference points for the four stocks is provided in Table 10. Bigeye and yellowfin tuna stocks were last assessed in 2020, the South Pacific albacore stock was assessed in 2021, and the skipjack tuna stock was assessed in 2022. Due to uncertainty in the fisheries data for the most recent year, data from the year immediately preceding the assessment year is not included in the bigeye, yellowfin and albacore assessments. Thus, the bigeye and yellowfin tuna assessments include data through 2018, while South Pacific albacore currently includes data through 2019. Skipjack, with its shorter lifespan and importance of young fish to the fishery, includes the most recent year of data (which is mostly purse seine logsheet data which is available on a more timely basis than longline data); thus the 2022 assessment included fisheries data through 2021. Information on the status of other oceanic fisheries resources (e.g. billfishes and sharks) is provided in subsection 3.4 Catch and status of billfish and sharks.

2.1 Skipjack tuna

The 2021 WCPFC-CA skipjack catch of 1,625,795 t was considerably lower than the highest value (2,037,921 t) recorded in 2019 (Table 4 and Figure 8). As in recent years, the main contributor to the overall catch of skipjack was the purse seine fishery (1,327,308 t in 2021 – 82% of total skipjack catch). The next-highest proportion of the catch was by pole-and-line gear (146,840 t – 9%). The longline fishery accounted for less than 1% of the total catch. The vast majority of skipjack are taken in equatorial areas including Indonesia and the Philippines, and most of the remainder is taken in the seasonal domestic fishery off Japan (Figure 8).

The dominant size of the WCPFC-CA skipjack catch (by weight) typically ranges from 40 cm to 60 cm, corresponding to fish that are 1 to 2+ years old (Figure 8). For pole-and-line, skipjack typically range from 40 cm to 55 cm, while in the domestic fisheries of Indonesia and the Philippines they are much smaller (20–40 cm). In general, skipjack taken in unassociated (free-swimming) schools are larger than those taken in schools associated with Fish Aggregating Devices (FADs).

Stock assessment

The most recent assessment of skipjack in the WCPO was conducted in 2022, and included data from 1972 to 2021, using the same eight region model structure developed for the 2019 assessment (Castillo Jordán et al. 2022); readers are referred to that document for more details on model configuration and settings. The 2022 assessment featured a number of new model developments, including changes to the approaches for estimating fishing mortality and effective sample sizes for size composition data, use of variable tag mixing periods, and development of new CPUE indices for the equatorial purse seine fishery. The Scientific Committee (SC) of the Western and Central Pacific Fisheries Commission (WCPFC) approved the assessment and provided equal weighting to the 18 models in the structural uncertainty grid used for management advice. The grid was comprised of three axes, one related to tag mixing, one to growth estimation and one to steepness of the stock-recruitment relationship. Median values from the 18 models for key reference points are discussed below.

While estimates of fishing mortality for skipjack have increased over time, current fishing mortality rates for skipjack tuna are estimated to be about 0.32 times the level of fishing mortality associated with maximum sustainable yield ($\mathrm{F}_{\mathrm{MSY}}$). Therefore, overfishing is not occurring (i.e. $\mathrm{F}_{recent} < \mathrm{F}_{\mathrm{MSY}}$). Median spawning biomass[4] is estimated to be at 51% of the level predicted in the absence of fishing. Recent spawning biomass levels are estimated to be well above the Limit Reference Point (LRP) of 20% of the level predicted in the absence of fishing ($\mathrm{SB}/\mathrm{SB}_{F=0} > 0.2$). Overall, the spawning biomass and recruitment have shown a recent declining trend since peaks in the late 2000s. Fishing mortality continues to increase and remains higher for adults than juveniles. Depletion ($\mathrm{SB}/\mathrm{SB}_{F=0}$) continues to trend downwards, although the trend is mostly influenced by the long-term increasing trend in the estimates of unfished spawning biomass ($\mathrm{SB}_{F=0}$) rather than the declining trend in the estimated spawning biomass (SB). The trends in spawning biomass and depletion vary among model regions, with declining trends more prevalent in the equatorial regions. In terms of stock status, the 2022 stock assessment of skipjack tuna for the WCPO, indicated that according to WCPFC reference points the stock is not overfished, nor undergoing overfishing. Under status quo fishing conditions, where catch and effort levels are maintained at the average 2018–2021 levels, the stock is projected to have zero probability of dropping below the LRP. A number of illustrative plots on exploitation history, present status and future projections are shown in Figure 9.

While the WCPFC SC at its 18th Regular Session (SC18) approved the 2022 assessment as the best available science on the stock status, they could not agree on a management advice statement to provide to the WCPFC. A summary of the key assessment outcomes is provided below.

- The median spawning biomass depletion level for the structural uncertainty grid is $\mathrm{SB}_{recent}/\mathrm{SB}_{F=0} = 0.51$ with a likely range of 0.43 to 0.64 (80th percentile). There were no individual models where $\mathrm{SB}_{recent}/\mathrm{SB}_{F=0} < 0.2$, which indicated a zero probability that recent spawning biomass is below the LRP.
- The median $\mathrm{F}_{recent}/\mathrm{F}_{\mathrm{MSY}}$ for the model grid is 0.32, with a likely range of 0.18 to 0.45 (80th percentile) and no grid models with values of $\mathrm{F}_{recent}/\mathrm{F}_{\mathrm{MSY}} > 1$. Therefore, there is zero probability that overfishing is occurring.
- The largest uncertainty in the structural uncertainty grid relates to how the tag mixing periods are assigned, followed by the choice of growth models.
- SC18 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and the level of fishing mortality is sustainable.

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[4] As key tuna stock assessments generally incorporate the pattern of fecundity at size within the calculation of adult biomass (skipjack being the exception at present), this is more accurately called “spawning potential”. However, we have used the term “spawning biomass” throughout this document, for simplicity.

- SC18 noted that the stock was assessed to be above the adopted LRP and fished at rates below F_{MSY} with 100% probability. Therefore, the skipjack stock is not overfished, nor subject to overfishing. At the same time, it was also noted that fishing mortality is continuously increasing for both adult and juvenile stages while the estimated spawning potential has shown a declining trend since the mid to late 2000s, and spawning potential depletion reached a historically low level in recent years.
- SC18 noted that levels of fishing mortality and depletion differ between regions, and that fishery impact was highest in the tropical region (Regions 5, 6, 7 and 8 in the stock assessment model), mainly due to the purse seine fisheries in the equatorial Pacific and the "other" fisheries within the Western Pacific.

A number of recommendations were provided to be considered for future assessments, and these can found in the SC18 Summary Report. Briefly, the key recommendations included; developing strategies for more timely provision of the assessment papers for review prior to SC, enhancing model diagnostics and more exploration of data conflicts, investigation/inclusion of effort creep scenarios for CPUE indices, further work on tag mixing and tag reporting rates, improvements to modelling of CPUE, and exploring evidence for the increasing recruitment over time.

2.2 Yellowfin tuna

The total WCPFC-CA yellowfin catch in 2021, of 777,763 t, was a record catch (Table 5 and Figure 10). The purse seine catch (429,959 t) increased by 7%, and the longline catch (74,271 t) was a decline of less than 1%, from 2020 levels. The remainder of the yellowfin tuna catch comes from pole-and-line and troll, and the domestic fisheries in Indonesia, Vietnam and the Philippines. The purse seine catch of yellowfin tuna is typically around four times the size of the longline catch.

As with skipjack, most of the yellowfin catch is taken in equatorial areas by large purse seine vessels, and a variety of gears in the Indonesian and Philippines fisheries. The domestic surface fisheries of the Philippines and Indonesia take large numbers of small yellowfin in the range 20–50 cm (Figure 10). In the purse seine fishery, greater numbers of smaller yellowfin are caught in log and FAD sets than in unassociated sets. A major proportion (by weight) of the purse seine catch is adult (> 100 cm) yellowfin tuna.

Stock assessment

The most recent assessment of yellowfin tuna in the WCPO was conducted in 2020 (Vincent et al. 2020) and included data from 1952 to 2018. The 2020 assessment had nine regions similar to the previous assessment but only applied the 10°N spatial structure. The 2020 assessment incorporated further developments including: index fisheries with CPUE standardised using spatiotemporal models, use of additional information on yellowfin growth from otoliths, and inclusion of new tagging data including historic data from the Japanese tagging program. The tag mixing period was also enforced as the actual days at liberty rather than as quarter of release and recapture. The analysis presented the results as a structural uncertainty grid comprised of 72 model runs that were equally weighted by SC16 when developing management advice. Across the range of model runs in the assessment, stock status was was most sensitive to the choice of growth models, with the most optimistic stock status estimates being those using a growth curve estimated externally from otolith data or applying the otolith data as conditional-age-at-length within the model. Models where growth was estimated from modal size progression in compostion data were the most pessimistic. Additional axes of uncertainty in the yellowfin grid included multiple values for steepness in the stock–recruitment relationship, a range of scalars to weight the size-frequency data, and an assumed mixing period of either 1 or 2 quarters for tagged fish.

Fishing mortality on both juvenile and adult fish has increased steadily since the early years of the fishery, although juvenile mortality shows signs of levelling off in recent years. Current fishing mortality rates for yellowfin tuna, however, are estimated to be below F_{MSY} in all models, which indicates that overfishing is not occurring. Spawning biomass showed a continuous decline from the 1950s to the 2000s, but appears to have leveled off after around 2010. Consistent with this trend in spawning biomass, absolute recruitment has been variable throughout the assessment period, but somewhat lower in the past three decades relative to the 1950s and 1960s. Recent spawning biomass levels are uniformly (all models) estimated to be above the SB_{MSY} level and the LRP of 20% of the level predicted in the absence of fishing. Under status quo fishing conditions, where effort and catch levels are maintained at the average 2016–2018 levels, the stock is projected to have zero probability of dropping below the LRP. A number of illustrative plots on exploitation history, present status and future projections are shown in Figure 11.

The conclusions of the WCPFC at its 16th Regular Session (SC16), which were presented as recommendations to the WCPFC in 2020, are outlined below.

- Based on the uncertainty grid adopted by SC16, the WCPO yellowfin tuna spawning biomass is above the biomass LRP and recent F is below F_{MSY}. The stock is not experiencing overfishing (0% probability $F_{recent} > F_{\mathrm{MSY}}$) and is not in an overfished condition (0% probability $SB_{recent}/SB_{F=0} < \mathrm{LRP}$). Additionally, stochastic projections predict there is no risk of breaching the LRP (0% probability $SB_{2048}/SB_{F=0} < 0.2$) under average 2016–2018 fishing conditions.
- Levels of fishing mortality and depletion differ between regions, and fishery impact was highest in the tropical region (Regions 3, 4, 7 and 8 in the stock assessment model), mainly due to the purse seine fisheries in the equatorial Pacific and the "other" fisheries within the western Pacific.
- WCPFC could consider reducing fishing mortality on yellowfin, from fisheries that take juveniles, with the goal to increase maximum fishery yields and reduce any further impacts on the spawning biomass for this stock in the tropical regions.
- Although the structural uncertainty grid presents a positive indication of stock status, the high level of unresolved conflict among the data inputs used in the assessment suggests additional caution may be appropriate when interpreting assessment outcomes to guide management decisions.
- SC16 recommends as a precautionary approach that the fishing mortality on yellowfin tuna stock should not be increased from the level that maintains spawning biomass at 2012–2015 levels until the WCPFC can agree on an appropriate target reference point.

2.3 Bigeye tuna

The 2021 WCPFC-CA bigeye tuna catch was 149,693 t, which was well below the highest value (195,052 t) recorded in 2004. A 3,396 t increase in purse seine catch, coupled with a 7,618 t decrease in the longline fishery, and a nearly 700 t decrease in the catch by "Other gears" (Table 6 and Figure 12) resulted in an overall 5,000 t decrease in total bigeye catch relative to 2020. Of the total bigeye catch in 2021, 34% was caught by longline, 51% by purse seine, and the remainder was distributed across troll, pole-and-line, and other gears.

The majority of the WCPFC-CA catch is taken in equatorial areas, by both purse seine and longline, but with some longline catch in sub-tropical areas (e.g. east of Japan and off the east coast of Australia) (Figure 12). In the equatorial areas, much of the longline catch is taken in the central Pacific, contiguous with the important traditional bigeye longline area in the eastern Pacific.

As with skipjack and yellowfin tuna, the domestic surface fisheries of the Philippines and Indonesia take large numbers of small bigeye in the range of 20–50 cm. In addition, large numbers of small 25–75 cm bigeye are taken by purse seine fishing on FADs (Figure 12) which, along with the fisheries of the Philippines and Indonesia, account for the bulk of the catch by number. The longline fishery, which lands bigeye mostly above 100 cm, accounts for most of the catch by weight in the WCPFC-CA. This contrasts with large yellowfin tuna, which (in addition to the longline gear) are also taken in significant amounts from unassociated schools in the purse seine fishery and in the Philippines handline fishery. Large bigeye are very rarely taken in the WCPO purse seine fishery, and only a relatively small amount is taken by the handline fishery in the Philippines. Bigeye sampled in the longline fishery are predominantly adult fish, with a mean size of approximately 130 cm with most between 80 and 160 cm.

Stock assessment

The most recent assessment of bigeye tuna in the WCPO was conducted in 2020 (Ducharme-Barth et al. 2020), and included data from 1952 to 2018. This assessment utilised only the new otolith-based growth estimates first introduced in the 2017 assessment (McKechnie et al. 2017) but also incorporated additional age-length data from otolith readings as well as length increment data from tag recaptures and implemented a Richards growth model. Additionally, only the 10°N spatial structure was considered; an "index fishery" approach using spatiotemporal modelling to standardise CPUE was implemented, and updates were incorporated for tag data models, purse seine catch estimates, size composition data, and biological parameters for the length–weight relationship and reproductive biomass. Management advice was formulated from the results of an uncertainty grid of 24 models that addressed several key model uncertainties. The most influential factor contributing to uncertainty around estimated stock status was the data weighting selected for the size–frequency data. Assessment outcomes became increasingly optimistic as greater weight was placed on the size–frequency data. Additional model uncertainties addressed in the grid included natural mortality and steepness of the stock–recruitment relationship.

Fishing mortality is estimated to have increased over time, particularly on juveniles over the last five decades, although juvenile mortality shows signs of levelling off in recent years. Current fishing mortality rates for bigeye tuna, however, are estimated to be below F_{MSY} in 21 of the 24 models in the grid, which indicates that overfishing is likely not occurring. Spawning biomass shows a long continuous decline from the 1950s to the 2000s, but appears to have levelled off since around 2010. Absolute recruitment has been variable throughout the assessment period, with no long term trend. All models in the structural uncertainty grid estimated spawning biomass to be above both the SB_{MSY} level and the LRP of 20% of the level predicted in the absence of fishing. Under status quo fishing conditions, where effort and catch levels are maintained at the average 2016–2018 levels and the relatively positive recent (2007–2016) recruitment patterns are assumed to continue, the stock is projected to have zero probability of dropping below the LRP. A number of illustrative plots on exploitation history, present status and future projections are shown in Figure 13.

The conclusions of WCPFC SC16, which were based on placing equal weight on all 24 model runs, were presented as recommendations to the WCPFC, and are outlined below.

- The median catch in the last year of the assessment (2018) was 159,288 t which was greater than the median MSY (140,720 t).
- Based on the uncertainty grid, WCPO bigeye tuna spawning biomass is above the biomass LRP and F_{recent} is very likely below F_{MSY}.
- It was concluded that the stock is not overfished (0% probability $SB/SB_{F=0} < 0.2$) and likely not experiencing overfishing (87.5% probability $F_{recent} < F_{MSY}$).
- Levels of fishing mortality and depletion differ among regions, and the fishery impact was higher in the tropical regions (Regions 3, 4, 7 and 8 in the stock assessment model), with particularly high fishing mortality on juvenile bigeye tuna in these regions. There is also evidence that the overall stock status is buffered with biomass estimated at a more elevated level overall due to low exploitation in the temperate regions (1, 2, 6 and 9).
- Based on these results, SC16 recommended as a precautionary approach that the fishing mortality on the bigeye tuna stock should not be increased from the level that maintains spawning biomass at 2012–2015 levels until the WCPFC can agree on an appropriate target reference point.

2.4 South Pacific albacore tuna

The total WCPFC-CA South Pacific albacore catch in 2021 (49,540 t) was nearly 24% lower than the 2020 catch and was well below the historical high of 80,986 t in 2010 (Table 7 and Figure 14). Longline fishing has accounted for most of the catch of this stock (79% in the 1990s, but 95% in the most recent 10 years). The troll catch, mostly taken from November to April, has generally been in the range of 3,000–8,000 t; however it has averaged only 3,332 t over the past five years. Catches of South Pacific albacore in the eastern Pacific Ocean (EPO), i.e., in the IATTC-CA exclusive of the overlap area, are given in Table 8 and are included here because the EPO catch is included in the most recent stock assessment. Typically, the EPO catch is almost entirely taken in the longline fishery.

The longline catch is widely distributed across the South Pacific (Figure 14), with the largest catches from the western region. Much of the increase in catch in the early 2000s is attributed to that taken by vessels fishing north of latitude 20°S. The Pacific Island domestic longline fleet catch is restricted to latitudes 10°–25°S. Troll catch is distributed in New Zealand's coastal waters, mainly off the South Island, and along the sub-tropical convergence zone (STCZ). In the past, less than 20% of the overall South Pacific albacore catch was taken east of 150°W but, in the most recent five years, this has increased to over 25%.

The longline fishery takes mainly larger adult albacore, mostly in the narrow size range of 90–105 cm, and the troll fishery takes juvenile fish in the range of 45–80 cm. Juvenile albacore also occasionally appear in the longline catch in more southern latitudes.

Stock assessment

The most recent stock assessment for South Pacific albacore tuna was undertaken in 2021 (Castillo Jordán et al. 2021). Unlike the previous assessment that only considered the WCPFC-CA (Tremblay-Boyer et al. 2018), the 2021 assessment included the entire South Pacific region (south of the equator) incorporating the convention areas of both the WCPFC and the IATTC. The assessment was a collaborative effort by SPC and IATTC scientists; data covered the period 1960 to 2019.

The assessment presented the results from a structural uncertainty grid comprising 72 models. The uncertainty grid included axes for steepness of the stock–recruitment relationship (0.65, 0.80, and 0.95), recruitment distribution (estimated and SEAPODYM-derived), growth–natural mortality at age (fixed-otolith with M-at-age and length frequency with M-at-age), weighting of size composition data (10, 25 and 50) and movement (estimated and SEAPODYM-derived). The movement parameterization was the most influential in the structural uncertainty grid. The SEAPODYM biophysical model (Senina et al. 2020) movement hypothesis was down weighted by the Scientific Committee for the provision of management advice. Management advice was provided for the entire South Pacific region, and for the WCPFC and IATTC convention areas separately. We focus on the South Pacific–wide outcomes here.

South Pacific–wide, the assessment indicated the spawning biomass has continued to become more depleted across the model period (1960–2019), and more so in the most recent years. Based on the set of models in the SC17 weighted structural uncertainty grid, the South Pacific albacore stock is not considered to be overfished, and there was zero estimated risk of the stock being below the LRP of 20% $\mathrm{SB}_{F=0}$. Due to the decline in stock status estimated over the last several years, the $\mathrm{SB}_{latest}/\mathrm{SB}_{F=0}$ (year 2019; median 0.40; range 0.25–0.46) is more pessimistic than the $\mathrm{SB}_{recent}/\mathrm{SB}_{F=0}$ (years 2016–2019; median 0.52; range 0.37–0.59). Fishing mortality has generally been increasing over time, most notably for the adult component of the stock. The median F_{recent} (2015–2018 average) was estimated to be 0.24 times the fishing mortality that would support the MSY (range 0.13–0.47). Similarly, median $\mathrm{SB}_{recent}/\mathrm{SB}_{\mathrm{MSY}}$ was estimated at 3.22 (range 2.07–5.33). These estimates indicate that, according to WCPFC reference points, the stock is not overfished or currently undergoing overfishing. The addition of the IATTC region into the South Pacific albacore assessment did not notably alter the main assessment outcomes, and similar trajectories and terminal depletion levels were estimated in both the WCPFC and IATTC convention areas (Castillo Jordán et al. 2021, WCPFC Secretariat 2021).

Stock projections (Pilling and Hamer 2021), with stochastic recruitment variation and the weighted uncertainty grid, suggest that under status quo fishing conditions, where catch levels are maintained at recent 2020 levels, the stock is projected to decline further in the short-term but equilibrate over the long-term at a median depletion ($\mathrm{SB}/\mathrm{SB}_{F=0}$) of 0.47, with 19% risk of being below the LRP of 20% $\mathrm{SB}_{F=0}$ and 17% risk of F being greater than $\mathrm{F}_{\mathrm{MSY}}$ at the end of the 30-year projection period. SC17 expressed concern that the projections suggest the current catch levels will produce a notable risk of the stock breaching the LRP. Results of catch–based projections were similar for the WCPFC and IATTC convention areas. A number of illustrative plots on exploitation history, present status and future projections are shown in Figure 15.

The conclusions of the WCPFC SC at its 17th Regular Session (SC17), based on the 72 models from the weighted uncertainty grid were presented as recommendations to the WCPFC, and are outlined below.

- The median value of relative recent (2016–2019) spawning biomass depletion for South Pacific albacore ($\mathrm{SB}_{recent}/\mathrm{SB}_{F=0}$) was 0.52 with a 10th to 90th percentile interval of 0.41 to 0.57.
- There was 0% probability (0 out of 72 models) that the recent (2016–2019) spawning biomass had breached the adopted limit reference point (LRP).
- There has been a long-term increase in fishing mortality for adult South Pacific albacore, with a notable steep increase in fishing mortality since 2000.
- The median of relative recent fishing mortality for South Pacific albacore ($\mathrm{F}_{recent}/\mathrm{F}_{\mathrm{MSY}}$) was 0.24 with a 10th to 90th percentile interval of 0.15 to 0.37.
- There was 0% probability (0 out of 72 models) that the recent (2015–2018) fishing mortality was above $\mathrm{F}_{\mathrm{MSY}}$.
- The stochastic projections, based on fishing at “status quo” conditions (2017–2019 or 2020 catch or, separately, fishing effort) show a steep and rapid decline in biomass towards the LRP in the year

2021 followed by an increase in biomass thereafter. This held true for both the entire South Pacific as well as for the WCPFC-CA only.

2.5 Summary across target tuna stocks

To summarise the most recent stock assessments for the four target tuna stocks, stock status for all four species are plotted together on a single Majuro plot, along with the associated uncertainty from their respective model grids with weightings applied where required by SC (Figure 16). All four stocks are considered to be in a healthy, sustainable status as none are considered to be overfished. Yellowfin, skipjack and South Pacific albacore are estimated to have a 0% probability of currently experiencing overfishing, while bigeye is estimated to have a 12.5% probability of undergoing overfishing. To place these results in context, a summary of stock status for these same four species assessed in other ocean basins by the three other tuna Regional Fisheries Management Organizations (RFMOs) is illustrated in Figure 16. As most of the other tuna RFMOs report stock status relative to MSY-based reference points (i.e., SB/SB_{MSY} and F/F_{MSY}), we based the WCPFC status on the same criteria. The classification of stock status used in Figure 16 (bottom plot) is based upon the medians of multiple models (weighted if required by SC) for each assessment. However, the stock status estimates often carry large uncertainty, which is not evident in plots showing only medians. The pie charts in Figure 16 present a summary of the fraction of models for each assessment that esimated stock status in each of the four Kobe quadrants.

2.6 Tuna tagging

Large-scale tagging experiments are important to enhance the level of information (fishery exploitation rates and population size) that is necessary to inform stock assessments of tropical tunas in the WCPO. Tagging data have the potential to provide significant information of relevance to stock assessment, either by way of stand-alone analyses or, preferably, through their integration with other data directly in the stock assessment model. Tuna tagging has been a core activity of the Oceanic Fisheries Programme over the last 30 years, with tagging campaigns occurring in the 1970s, 1990s and, most recently, since 2006. This most recent campaign has now tagged and released 485,844 tuna in the equatorial WCPO, including over 1,800 archival tag releases, with 86,559 reported recaptures (Figure 17). A summary of tag releases and recoveries, including a breakdown by species and EEZ, is provided in Table 11.

3 Ecosystem Considerations

3.1 Observer coverage

Observer-collected data are critical to characterizing bycatch in the commercial fisheries, as well as observing and documenting operational fishing practices onboard the vessels. Placement, and protection of, observers aboard vessels has been codified in a series of WCPFC CMMs. At present, coverage of purse seine fishing activities is mandated at 100% (since 2010), while longline fishing activities are mandated at 5% (since 2012). In practice, neither of these coverage levels is being routinely met. However, coverage levels of both fleets has increased steadily since 2010 (Figure 18). Observer coverage of the purse seine fleet, measured as fishing days effectively observed onboard peaked in 2018 at just over 90%; longline coverage peaked in 2019 at just under 6%. The COVID-19 pandemic had a significant impact on observer coverage, with 2021 coverage rates declining to less than 10% and 4% for the purse seine and longline fleets, respectively. More detailed breakdowns of observer coverage by fleet and EEZ, as well as discussion on barriers to achieving to higher coverage rates, can be found in Panizza et al. (2022).

3.2 Purse seine set characterization

The two forms of purse seine fishing are characterized as fishing on Fish Aggregation Device (FADs), “Associated” or Unassociated schools (“Free school”). Catch and size composition differ between the two fishing methods and the use of FADs is regulated by several WCPFC CMMs. Between 1990 and 2009, the number of Associated and Free school sets were roughly equal with total catch slightly higher for associated sets (Figure 19). Beginning in 2010, coinciding with implementation of the PNA (Parties to the Nauru Agreement) Vessel Day Scheme, there was a sharp increase in the number of Free school sets, while the number of Associated sets has remained roughly at a constant level over the past decade.

Despite the difference in set numbers, total catch over the past decade has remained relatively equal between the two set types, indicating a much lower average catch for free school sets. However, free school purse seine fishing results in a much higher proportion of water or "skunk" sets were very low catches are made, typically due to failure of a set to effectively encircle a tuna school (Figure 19, top figure) - 42% vs less than 5% for Associated sets over the past five years.

The information concerning the non-target catch composition of the main tuna fisheries in the WCPO comes largely from the various observer programmes operating in the region. Overall, catch (in weight) from Unassociated and Free school purse seine sets are dominated by tuna species (99.7% and 97.9%, respectively), with anchored FAD sets having a slightly higher bycatch rate (96.3% tuna) than drifting FADs (Figure 20). Historically, Associated sets have accounted for the majority of bycatch of finfish and shark species, although there is some variation from year to year due to the relative proportions of Unassociated and Free school sets (Peatman et al. 2021).

3.3 Species of special interest

The tuna fisheries of the WCPO principally target four main tuna species: skipjack; yellowfin; bigeye; and albacore tuna. However, the fisheries also catch a range of other species in association with these. Some of the associated species (bycatch) are of commercial value (by-products), while many others are discarded. There are also incidents of the capture of species of ecological and/or social significance, including marine mammals, sea birds, sea turtles and some species of shark (e.g. whale sharks).

A range of conservation and management measures have been introduced by the WCPFC to reduce impacts of fisheries on species of special interest, including sea turtles, whales and seabirds (sharks are discussed in subsection 3.4 Catch and status of billfish and sharks). Spatially and temporally disaggregated summaries of observer bycatch data are publicly available[5], including observed longline and purse seine effort and interaction rates for species of special interest.

There are limited interactions between the purse seine fishery and protected species, such as whale sharks and manta rays (*Mobula birostris*). Historically, some vessels deliberately set around whale sharks associated with tuna schools, but this practice has been prohibited since 2014 in the WCPO. In a very small percentage of cases of free school sets, a whale shark is encountered; in these instances, the whale shark was apparently not seen before the set was made. Observed interaction rates between the purse seine fishery and sea turtles are low (<1 interaction per 100 sets), and interactions with seabirds are very rare.

Interactions with seabirds and marine mammals are low in all three longline fisheries (although the probability of detecting rare events with low observer coverage means that the estimates of interaction rates are uncertain). Catch of five species of marine turtles has been observed in the equatorial longline fishery, although the observed encounter rate was particularly low, and most of the turtles caught were reported to be alive at the time of release.

3.4 Catch and status of billfish and sharks

In addition to the main tuna species, annual catch estimates for the WCPFC-CA in 2021 are available for the main species of billfish (swordfish (*Xiphias gladius*) [14,258 t], blue marlin (*Makaira nigricans*) [11,263 t], striped marlin (*Kajikia audax*) [3,546 t] and black marlin (*Istiompax indica*) [3,297 t]). Note that these bycatch estimates are generally based on catch reported in logsheets and may represent an underestimate of actual bycatch.

Estimates of total billfish and shark catch, for both the purse seine (Associated and Free school sets) and the longline fisheries, based on observer data, have been produced for the period 2003-2020 (Figure 21, Peatman and Nicol 2020, 2021). These estimates show that shark and billfish catch in the longline fishery is approximately two orders of magnitude greater than in the purse seine fishery. Over the past 20 years, total annual billfish catch has remained relatively steady between 0.5 and 1.0 million indivduals in the longline fishery and generally around 5,000 individuals in the purse seine fishery, with roughly equal numbers in the Associated and Free school fisheries.

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[5] www.wcpfc.int/public-domain-bycatch

Five species of WCPFC-CA billfish have been formally assessed over the past decade: Southwest Pacific swordfish and Southwest Pacific striped marlin by SPC; North Pacific swordfish, North Pacific striped marlin and blue marlin by ISC. Stock status for these species is based on the Kobe plot, where overfished status is judged relative to spawning stock size at MSY[6]. There is considerable uncertainty in the estimates of F/F_{MSY} and SB/SB_{MSY} for all five species. Based on the assessment model grid medians, Southwest Pacific striped marlin and North Pacific striped marlin are likely in an overfished state, while overfishing is also occurring for North Pacific striped marlin.

Similar to billfish, bycatch of sharks (sharks, in this context, refers to sharks and rays) is much greater in the longline fishery (1.5-2.0 million individuals) than in the purse seine fishery (50-100 thousand individuals). Associated catch of sharks is generally higher than Free school shark catch, though in recent years the numbers have been similar. A detailed species composition of the longline shark catch, based on an analysis of observer data, was reported to SC16 (Peatman and Nicol 2020). Blue shark (*Prionace glauca*) and silky shark (*Carcharhinus falciformis*) are the most common shark species taken in the longline fisheries, with sizable numbers of shortfin mako (*Isurus oxyrinchus*), oceanic whitetip (*Carcharhinus longimanus*) and bigeye thresher (*Alopias superciliosus*) also taken (Figure 22). The decline in total longline shark catch noted earlier primaily derives from a decrease in blue shark catch from more than a million individuals in the early 2000s to around 0.7 million after 2015. Pelagic stingray is the most common (*Pteroplatytrygon violacea*) non-shark elasmobranch species taken in the longline fishery and is surpassed only by blue shark in total numbers caught.

The status of silky and oceanic whitetip sharks is of particular concern as assessments have shown that these stocks are subject to overfishing and, in the case of oceanic whitetip, is severely overfished. A WCPFC ban on the use of either shark lines or wire traces in longline sets is in place, which it is hoped will reduce the catch of silky and oceanic whitetip sharks. Over the past several years, stock assessments have also been undertaken for five WCPFC-CA shark species (Figure 23, bottom plot): South Pacific blue shark, oceanic whitetip and silky shark by SPC; North Pacific blue shark and North Pacific shortfin mako shark by ISC. Even more so than with the billfish assessments, there is considerable uncertainty in the estimates of F/F_{MSY} and SB/SB_{MSY} for all five species. Based on the assessment model grid medians, oceanic whitetip is considered to be both overfished and experiencing overfishing while overfishing is likely occurring for silky shark. Encouragingly, Southwest Pacific blue shark, assessed in 2021, has improved in status in recent years and is likely neither overfished nor experiencing overfishing.

Links to the stock assessments for the billfish and shark species listed above are given in the References section on Status of Stocks.

The SC recommendations on billfish and sharks to the WCPFC are broadly outlined below.

- Stabilise stock size or catch/ensure no increase in fishing pressure
  - Southwest Pacific swordfish
  - Pacific blue marlin
- Reduce catch and/or rebuild the stock and/or reduce effort and/or enhance data collection efforts
  - Southwest Pacific striped marlin
  - Western and central north Pacific striped marlin
  - Southwest Pacific blue shark
  - Silky shark
  - Oceanic whitetip shark

3.5 Ecosystem and climate indices

The WCPFC, primarily through the work of its SC, has been considering the application of ecosystem indicators to assist with advice generation on the impacts of fisheries targeting tuna and tuna-like species on the broader pelagic ecosystem since SC11 in 2015. At SC18, a set of candidate ecosystem and climate indicators was presented for consideration for adoption (SPC-OFP 2022a). At SC18, several recommendations concerning the reporting of Ecosystem and Bycatch issues were made. In particular,

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[6] Because the WCPFC has not agreed upon LRPs for billfish or shark, the Kobe plot, rather than the depletion-based Majuro plot, is the default.

"SC18 recommended that available information and updates on the impacts of climate change be included or combined with status of stocks reporting." Further, SC18 recommended that "Ecosystem and Bycatch Indicators" be presented annually to the SC as a standing agenda item, and the identification of their implications and subsequent triggers be developed.

Beginning in 2022, a new section has been added to the TFAR, to present a summary of a selected number of the important ecosystem and climate indicators. Note that many of the indicators in the SPC-OFP (2022a) report are already covered elsewhere in the TFAR; those included here are non-repetitive. The indicators are illustrated in Figure 24 and briefly described below; for additional detail refer to SPC-OFP (2022a).

Mean fish condition, abbreviated as K_{rel}, is a relative measure of the average "fatness" of a tuna. Values greater than 1.0 indicate fatter tuna than expected given the fish length and may be indicative of good feeding conditions.

The climate indices are defined in the figure text; only a brief description is provided here.
Sea surface temperature (SST) anomalies. Three different measures of SST anomalies are presented, generally for the tropical Pacific region.
Warm pool indices. Three different indices measuring the size, eastern extent and depth of the tropical Pacific warm pool are presented.
Climate indices. Two well known climate indices are identified as useful monitors of the large scale oceanic environment.

3.6 El Niño Southern Oscillation forecast

One of the major factors influencing the distribution of tuna species, perhaps mostly notably for skipjack, is the El Niño Southern Oscillation (ENSO, Figure 25) (Lehodey et al. 1997). The two extremes of the oscillation, El Niño and La Niña, result in very different distributions of purse seine fishing effort. At the time this report went to press, a medium-strength La Niña event was in progress and forecast to continue across the Pacific from November 2022 to March 2023. The forecast is remarkably similar to the forecast at the same time both for the last two years. Both the 2020–21 and 2021–22 La Niñas did develop into a medium size event and a "back to back to back" occurrence of La Niña events is extremely rare. Typically, La Niña events result in a pooling of warm water in the western Pacific, a relative decrease in sea surface temperature in the eastern Pacific, and a concentration of skipjack in the western Pacific, although we note that every ENSO event differs in its magnitude, range and impact. The response of the purse seine fleet to fishing conditions influenced by the ENSO cycle is illustrated for the past decade in Figure 26. In 2015, a year of a very strong El Niño event, purse seine fishing was widely distributed across the tropical Pacific, with the geographic center of fishing activity located around 170°E. In neutral, or La Niña, conditions the geographic center of fishing can be as much as much as 20° of longitude to the west, a distance of more than 2000 km.

3.7 Climate change

The Spatial Ecosystem And Population Dynamics (SEAPODYM, Lehodey et al. 2014) modelling framework was used to investigate how climate change could affect the distribution and abundance of skipjack, yellowfin, and bigeye tuna and South Pacific albacore, at the Pacific basin scale, and within the EEZs of Pacific Island countries and teritories (Senina et al. 2018). The analysis formed two parts, firstly, a model parameterisation phase over the historical period (1980–2010) using an analysis of historic ocean conditions, and then projections of an ensemble of simulations to explore key sources of uncertainty in climate models. Second, five different atmospheric forcing datasets from Earth System models projected under the ("business as usual") Intergovernmental Panel on Climate Change (IPCC) Regional Concentration Pathways 8.5 (RCP8.5) emissions scenario (Figure 27) were used to drive physical-biogeochemical models through the 21^{st} century. Additional scenarios were included to explore uncertainty associated with future primary production and dissolved oxygen concentration, as well as possible adaptation through phenotypic plasticity of these tuna species to warmer spawning grounds. The impact of ocean acidification was also included for yellowfin tuna based on results from laboratory experiments.

The historical simulations (Figure 28) reflect key features of the ecology and behaviour of the four tuna species and match the total historical catch in terms of both weight and size–frequency distributions. The projections show an eastern shift in the biomass of skipjack and yellowfin tuna over time, with a large and increasing uncertainty for the second half of the century, especially for skipjack tuna. The impact is weaker for bigeye tuna and albacore, with prediction of a wider, warmer and more favourable range of spawning habitat. For albacore, a strong sensitivity to sub-surface oxygen conditions resulted in a very wide range of projected stock sizes. Historical fishing pressure was estimated to have reduced the adult stocks of all four tuna species by 30%–55% by the end of 2010. The effects of fishing on biomass strongly outweighed the decreases attributed to climate change in the short- to medium-term. Thus, fishing pressure is expected to be the dominant driver of tuna population status until the mid-century. The projected changes in abundance and redistribution of these tuna associated with climate change could have significant implications for the economic development of Pacific Island countries and territories, and the management of tuna resources, at the basin scale. In particular, larger proportions of the catch of each species are increasingly expected to be made in international waters (Bell et al. 2021). A spatial depiction of the projected redistribtion of biomass for skipjack, yellowfin and bigeye is illustrated in Figure 29.

4 For further information[7]

4.1 Fishery

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4.2 Status of the stocks

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Castillo Jordán, C. et al. 2022. Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022 - Rev.05. WCPFC-SC18-2022/SA-WP-01.

Common Oceans (ABNJ) Tuna Project. 2018. Pacific-wide Silky Shark (*Carcharhinus Falciformis*) Stock Status Assessment. WCPFC-SC14-2018/SA-WP-08.

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ISC. 2018. Stock Assessment for Swordfish (*Xiphias gladius*) in the Western and Central North Pacific Ocean through 2016 Rev 1. SC14-SA-WP-07

ISC. 2018. Stock Assessment of Shortfin Mako Shark in the North Pacific Ocean Through 2016. SC14-SA-WP-11

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ISC ALBWG. 2020. Stock assessment of albacore tuna in the North Pacific Ocean in 2020. WCPFC-SC16-2020/SA-WP-05.

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Neubauer, P. et al. 2021. Stock assessment of southwest Pacific blue shark - Rev. 01. WCPFC-SC17-2021/SA-WP-03.

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Tremblay-Boyer, L. et al. 2018. Stock assessment of South Pacific albacore tuna. WCPFC-SC14-2018/SA-WP-05 Rev2.

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[7] All WCPFC documents can be obtained by visiting the WCPFC website (`www.wcpfc.int`); hyperlinks are provided for documents listed herein.

Tremblay-Boyer, L. et al. 2019. Stock assessment for oceanic whitetip shark in the Western and Central Pacific Ocean. WCPFC-SC15-2019/SA-WP-06.

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5 Tables

Table 1: Catch (metric tonnes) of the four tropical target tuna species by gear for the WCPFC-CA, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	Longline	Pole-and-line	Purse seine	Troll	Other	Total
1960	129,874	98,956	5,224	0	31,195	265,249
1961	123,330	150,709	14,540	0	34,536	323,115
1962	128,804	166,141	18,875	0	34,947	348,767
1963	122,703	125,048	11,934	0	36,795	296,480
1964	102,481	167,181	29,012	0	41,334	340,008
1965	103,955	176,112	8,621	0	41,727	330,415
1966	145,278	241,730	16,913	0	46,993	450,914
1967	128,047	205,255	14,508	5	52,006	399,821
1968	120,136	183,954	15,143	14	52,327	371,574
1969	122,806	208,748	9,482	0	57,703	398,739
1970	141,360	230,142	16,222	50	69,633	457,407
1971	143,625	241,506	24,511	0	68,925	478,567
1972	161,533	242,745	29,030	268	87,209	520,785
1973	166,399	330,841	36,269	484	103,281	637,274
1974	145,192	370,499	29,547	898	109,578	655,714
1975	164,049	279,663	27,685	646	111,669	583,712
1976	198,013	382,627	40,770	25	104,582	726,017
1977	218,413	345,257	53,492	621	136,322	754,105
1978	212,059	407,482	52,041	1,686	131,084	804,352
1979	211,221	344,799	90,103	814	124,684	771,621
1980	230,625	398,498	116,755	1,489	89,969	837,336
1981	191,732	348,917	158,559	2,118	107,884	809,210
1982	179,575	316,457	255,491	2,552	107,990	862,065
1983	175,498	342,287	442,152	949	109,378	1,070,264
1984	162,111	415,016	462,277	3,124	118,478	1,161,006
1985	177,722	287,892	409,536	3,468	136,812	1,015,430
1986	169,129	360,864	660,297	2,284	146,873	1,339,447
1987	179,966	294,879	543,980	2,350	131,849	1,153,024
1988	200,774	327,997	608,996	4,671	151,193	1,293,631
1989	170,876	311,981	664,660	8,687	165,164	1,321,368
1990	188,842	247,104	795,530	7,219	203,508	1,442,203
1991	160,889	290,006	1,006,764	8,004	203,129	1,668,792
1992	199,688	259,762	975,738	6,844	163,536	1,605,568
1993	195,377	293,014	846,114	4,612	145,262	1,484,379
1994	221,367	262,721	971,563	7,493	162,850	1,625,994
1995	217,417	298,301	927,491	23,585	168,062	1,634,856
1996	215,466	301,279	896,443	17,807	208,032	1,639,027
1997	226,375	298,666	959,218	18,732	178,199	1,681,190
1998	251,197	323,645	1,257,392	19,099	213,779	2,065,112
1999	219,024	338,480	1,068,956	13,476	211,900	1,851,836
2000	248,474	319,854	1,143,294	25,845	235,670	1,973,137
2001	264,340	272,483	1,118,917	17,329	211,934	1,885,003
2002	281,627	286,202	1,265,452	16,129	222,513	2,071,923
2003	261,636	303,905	1,265,758	19,875	250,944	2,102,118
2004	284,849	322,179	1,354,239	23,445	290,666	2,275,378
2005	250,698	266,735	1,484,881	13,293	228,562	2,244,169
2006	255,653	257,594	1,525,500	10,098	255,646	2,304,491
2007	245,130	284,661	1,691,791	9,249	304,526	2,535,357
2008	247,755	269,551	1,738,057	11,740	312,905	2,580,008
2009	280,374	264,350	1,801,653	9,898	277,286	2,633,561
2010	278,578	270,123	1,708,272	11,320	260,010	2,528,303

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Table 1: *(continued)*

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
2011	261,756	275,070	1,576,066	11,973	239,331	2,364,196
2012	275,053	242,960	1,851,983	14,018	298,991	2,683,005
2013	242,834	229,560	1,934,752	9,484	313,059	2,729,689
2014	264,683	206,939	2,079,879	6,677	347,784	2,905,962
2015	271,113	214,041	1,772,737	7,564	396,680	2,662,135
2016	240,729	198,398	1,862,822	7,207	411,392	2,720,548
2017	246,325	171,570	1,833,284	7,974	331,785	2,590,938
2018	257,247	232,255	1,908,954	7,464	412,709	2,818,629
2019	270,768	195,402	2,101,405	8,060	411,108	2,986,743
2020	213,460	200,395	1,880,330	10,000	399,042	2,703,227
2021	194,799	177,611	1,835,129	9,402	418,350	2,635,291

Table 2: Catch (metric tonnes) by species for the four main tuna species taken in the WCPFC-CA, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	Albacore	Bigeye	Skipjack	Yellowfin	Total
1960	56,619	45,025	89,938	73,667	265,249
1961	51,561	39,380	156,736	75,438	323,115
1962	46,331	36,868	181,624	83,944	348,767
1963	53,675	44,346	122,703	75,756	296,480
1964	50,545	32,391	182,918	74,154	340,008
1965	70,226	31,333	155,221	73,635	330,415
1966	75,114	33,187	249,514	93,099	450,914
1967	89,303	36,750	204,829	68,939	399,821
1968	64,213	30,427	194,990	81,944	371,574
1969	72,106	36,032	203,329	87,272	398,739
1970	74,350	41,702	242,366	98,989	457,407
1971	100,737	44,142	228,722	104,966	478,567
1972	109,655	57,163	238,082	115,885	520,785
1973	131,149	48,889	329,050	128,186	637,274
1974	115,162	52,758	356,557	131,237	655,714
1975	84,651	69,314	288,468	141,279	583,712
1976	132,947	83,110	356,862	153,098	726,017
1977	83,171	84,055	401,708	185,171	754,105
1978	111,161	66,964	448,039	178,188	804,352
1979	86,007	74,557	408,847	202,210	771,621
1980	95,156	73,355	448,633	220,192	837,336
1981	88,095	66,352	426,215	228,548	809,210
1982	89,496	76,730	459,614	236,225	862,065
1983	65,988	82,856	629,453	291,967	1,070,264
1984	74,540	89,648	703,988	292,830	1,161,006
1985	77,060	90,508	547,717	300,145	1,015,430
1986	71,757	110,363	809,112	348,215	1,339,447
1987	63,645	113,979	638,743	336,657	1,153,024
1988	67,948	110,236	789,843	325,604	1,293,631
1989	73,533	110,967	749,978	386,890	1,321,368
1990	63,872	134,376	809,942	434,013	1,442,203
1991	58,322	119,886	1,025,148	465,436	1,668,792
1992	74,452	143,145	928,151	459,820	1,605,568
1993	77,496	121,643	864,459	420,781	1,484,379
1994	96,461	135,473	939,534	454,526	1,625,994
1995	91,750	119,681	977,514	445,911	1,634,856
1996	91,140	115,273	1,003,276	429,338	1,639,027
1997	112,900	141,099	943,070	484,121	1,681,190
1998	112,465	161,641	1,248,763	542,243	2,065,112
1999	131,066	170,450	1,072,197	478,123	1,851,836
2000	101,672	160,442	1,197,535	513,488	1,973,137
2001	121,561	147,535	1,104,396	511,511	1,885,003
2002	148,051	169,452	1,257,444	496,976	2,071,923
2003	123,239	157,258	1,250,353	571,268	2,102,118
2004	122,399	195,052	1,357,372	600,555	2,275,378
2005	105,371	163,189	1,418,111	557,498	2,244,169
2006	105,257	171,437	1,481,979	545,818	2,304,491
2007	126,857	170,753	1,666,126	571,621	2,535,357
2008	105,109	178,927	1,648,181	647,791	2,580,008
2009	135,622	174,965	1,760,616	562,358	2,633,561
2010	129,224	148,566	1,680,246	570,267	2,528,303
2011	115,766	176,375	1,534,896	537,159	2,364,196
2012	143,792	177,631	1,733,705	627,877	2,683,005
2013	138,397	167,323	1,840,855	583,114	2,729,689

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Table 2: *(continued)*

Year	**Albacore**	**Bigeye**	**Skipjack**	**Yellowfin**	**Total**
2014	121,720	176,901	1,985,679	621,662	2,905,962
2015	117,482	155,008	1,792,612	597,033	2,662,135
2016	101,245	162,635	1,790,256	666,412	2,720,548
2017	126,547	138,473	1,610,457	715,461	2,590,938
2018	110,949	158,717	1,843,760	705,203	2,818,629
2019	115,653	135,428	2,037,921	697,741	2,986,743
2020	94,064	154,454	1,719,697	735,012	2,703,227
2021	82,040	149,693	1,625,795	777,763	2,635,291

Table 3: Several indices of fishing effort for the three main gears used in commercial fishing of tuna in the western and central Pacific region, from 1960–2020. For vessels, the abbreviations are: DPI – domestic (Pacific Island); DNPI – domestic (non-Pacific Island), DWFN – distant water fishing nation. Longline effort (Mhks) is millions of hooks. Effort totals exclude the following: Japan coastal, Indonesia, Philippine and Vietnam domestic purse seine vessels; Vietnam and Indonesia domestic longline vessels; Japanese coastal and Indonesian domestic vessels for pole-and-line.

	Purse seine				Longline				Pole-and-line			
	Vessels		Effort		Vessels			Effort	Vessels			Effort
Year	DPI	DWFN	Days	Sets	DPI	DNPI	DWFN	Mhks	Japan	DPI	DNPI	Days
1960	0	0	0	0	0	881	1,845	254.4	0	0	0	0
1961	0	0	0	0	0	730	1,937	281.3	0	0	0	0
1962	0	0	0	0	0	695	1,848	259.1	0	0	0	0
1963	0	0	0	0	0	806	1,911	316.4	0	0	0	0
1964	0	0	0	0	0	641	1,821	221.6	0	0	0	0
1965	0	0	0	0	0	726	1,752	294.2	0	0	0	0
1966	0	0	0	0	0	175	1,861	307.3	0	0	0	0
1967	0	0	8	13	0	173	1,831	342.7	0	0	0	0
1968	0	0	51	77	0	253	1,845	359.3	0	0	0	0
1969	0	4	17	22	0	918	1,739	307.7	0	0	0	0
1970	0	6	99	120	0	1743	1,658	342.1	0	0	0	0
1971	0	6	1,939	2,654	0	1,794	1,684	378.9	0	0	0	0
1972	0	7	2,465	3,433	0	1,862	1,609	342.2	554	56	0	54,754
1973	0	6	2,657	3,591	2	2,232	1,650	364.8	650	66	0	65,381
1974	0	10	1,942	2,337	0	1,986	1,786	407.4	716	82	0	66,810
1975	0	12	2,197	2,629	0	2,147	1,763	354.2	696	81	0	66,314
1976	0	18	2,534	3,159	2	2,174	1,847	367.9	653	89	9	74,787
1977	0	15	2,253	2,721	2	2,125	1,821	363.7	662	100	20	88,567
1978	0	19	2,491	2,994	2	2,358	1,871	360.5	645	100	14	83,754
1979	0	27	3,639	4,463	2	2,505	1,868	471.0	625	98	10	79,590
1980	1	33	3,798	4,961	2	2,743	1,913	498.1	572	160	9	79,191
1981	1	42	7,763	8,114	2	2,645	1,871	461.8	548	168	18	80,060
1982	1	73	11,770	11,560	3	2,641	1,592	409.1	475	108	23	68,126
1983	8	118	18,993	16,062	4	2,527	1,437	351.3	434	91	16	58,692
1984	6	120	25,083	21,471	5	2,563	1,445	376.4	396	98	8	59,279
1985	6	110	20,819	18,418	6	2,872	1,437	386.8	356	98	0	53,866
1986	5	113	20,805	18,160	3	2,795	1,445	332.0	330	97	5	51,413
1987	5	116	24,329	19,823	4	3,179	1,415	363.7	314	112	5	48,305
1988	8	132	24,261	19,441	5	2,844	1,393	441.7	277	102	18	42,862
1989	5	152	27,110	22,115	9	2,695	1,405	401.0	269	105	15	43,480
1990	13	176	30,060	23,081	16	2,283	1,410	391.9	255	166	20	42,075
1991	15	184	37,153	31,093	27	1,965	1,455	384.6	242	154	19	32,256
1992	17	193	40,825	30,618	59	3,173	1,396	506.2	216	163	13	32,447
1993	15	183	42,751	31,219	113	3,241	1,570	393.9	203	138	19	32,113
1994	22	176	38,091	29,254	158	3,223	1,687	444.9	185	137	23	31,233
1995	21	163	37,015	28,526	217	2,984	1,624	461.8	174	145	33	31,229
1996	20	158	37,758	29,971	259	2,599	1,428	385.8	165	139	33	29,449
1997	31	158	39,328	30,681	349	3,194	1,231	377.6	163	108	26	33,060
1998	32	164	36,532	31,750	415	3,089	1,223	453.2	163	102	16	33,995
1999	40	164	38,521	27,260	405	3,075	1,151	513.9	163	103	16	33,600
2000	52	174	37,790	30,754	422	1,426	1,089	515.6	160	83	15	28,622
2001	46	161	37,977	30,398	490	2,312	1,118	592.1	155	75	11	25,809
2002	55	158	41,777	33,415	463	2,245	1,149	675.2	151	70	11	27,327
2003	59	152	44,031	33,646	482	1,622	1,139	718.9	144	69	9	22,759
2004	78	147	47,264	35,340	476	1,515	910	712.2	127	67	9	22,122
2005	86	142	49,123	40,486	475	1,473	763	650.0	128	60	11	22,122
2006	76	148	45,095	36,280	433	1,313	639	640.6	113	65	6	18,424
2007	83	162	48,256	39,430	458	1,163	518	716.0	106	58	5	18,413

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Table 3: *(continued)*

	Purse seine				Longline				Pole-and-line			
	Vessels		Effort		Vessels			Effort	Vessels			Effort
Year	DPI	DWFN	Days	Sets	DPI	DNPI	DWFN	Mhks	Japan	DPI	DNPI	Days
2008	80	175	52,363	44,849	432	1,147	604	733.8	98	50	3	16,887
2009	80	187	52,946	47,191	401	1,148	589	764.6	96	48	6	16,001
2010	87	196	55,155	54,425	509	1,165	632	774.8	95	50	2	16,153
2011	94	191	65,971	60,828	608	1,131	660	819.9	91	56	2	14,833
2012	100	191	61,690	64,903	540	630	645	887.6	87	54	1	15,241
2013	104	199	62,552	64,918	380	738	744	725.1	80	49	2	13,786
2014	109	204	60,427	65,073	540	724	656	738.0	80	47	0	11,348
2015	118	195	49,462	55,592	538	820	705	767.6	76	47	0	12,817
2016	138	160	50,352	53,542	373	783	701	691.8	76	45	0	14,464
2017	136	152	53,623	57,348	547	709	633	718.1	80	46	0	13,307
2018	132	145	50,505	57,390	609	709	631	730.1	70	40	0	13,980
2019	138	148	48,016	58,854	454	601	626	790.0	67	37	0	13,177
2020	141	130	49,579	53,497	414	562	604	695.1	59	37	1	11,811
2021	146	116	47,828	51,499	387	564	592	611.7	57	34	1	7,641

Table 4: Skipjack tuna catch (metric tonnes) by gear type for the WCPFC-CA, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	Longline	Pole-and-line	Purse seine	Troll	Other	Total
1960	0	70,428	3,728	0	15,782	89,938
1961	0	127,011	11,693	0	18,032	156,736
1962	4	152,387	11,674	0	17,559	181,624
1963	0	94,757	9,592	0	18,354	122,703
1964	5	137,106	25,006	0	20,801	182,918
1965	11	129,933	4,657	0	20,620	155,221
1966	52	215,600	10,949	0	22,913	249,514
1967	124	168,846	10,929	0	24,930	204,829
1968	83	162,379	7,599	0	24,929	194,990
1969	130	168,084	5,045	0	30,070	203,329
1970	1,608	197,873	7,670	0	35,215	242,366
1971	1,475	180,945	13,873	0	32,429	228,722
1972	1,544	172,827	18,343	0	45,368	238,082
1973	1,861	253,217	19,537	0	54,435	329,050
1974	2,124	289,202	11,209	0	54,022	356,557
1975	1,919	218,271	13,259	0	55,019	288,468
1976	2,096	276,582	22,077	0	56,107	356,862
1977	3,127	294,641	32,700	0	71,240	401,708
1978	3,233	331,401	32,176	0	81,229	448,039
1979	2,179	285,859	54,667	0	66,142	408,847
1980	632	333,597	76,108	12	38,284	448,633
1981	756	296,065	85,153	17	44,224	426,215
1982	972	264,726	145,814	64	48,038	459,614
1983	2,144	298,928	278,721	154	49,506	629,453
1984	870	366,811	287,899	284	48,124	703,988
1985	1,108	238,932	253,771	146	53,760	547,717
1986	1,439	322,665	420,043	219	64,746	809,112
1987	2,329	252,142	325,570	168	58,534	638,743
1988	1,937	295,325	434,004	299	58,278	789,843
1989	2,507	275,088	413,702	244	58,437	749,978
1990	363	211,573	503,247	176	94,583	809,942
1991	885	259,778	672,760	148	91,577	1,025,148
1992	432	218,765	617,897	168	90,889	928,151
1993	573	255,152	530,677	175	77,882	864,459
1994	379	209,636	652,327	228	76,964	939,534
1995	598	247,744	638,531	12,298	78,343	977,514
1996	3,935	242,486	651,106	6,514	99,235	1,003,276
1997	4,070	236,999	606,523	9,218	86,260	943,070
1998	5,030	266,772	866,959	8,316	101,686	1,248,763
1999	4,208	255,330	706,421	5,660	100,578	1,072,197
2000	4,559	264,407	797,991	15,005	115,573	1,197,535
2001	5,059	212,668	774,718	7,536	104,415	1,104,396
2002	3,450	207,488	932,334	6,796	107,376	1,257,444
2003	3,824	238,179	882,074	9,721	116,555	1,250,353
2004	4,051	249,936	950,066	15,118	138,201	1,357,372
2005	1,084	216,715	1,054,924	6,302	139,086	1,418,111
2006	1,528	208,731	1,110,083	3,987	157,650	1,481,979
2007	1,175	213,010	1,257,726	3,598	190,617	1,666,126
2008	803	218,570	1,226,046	4,572	198,190	1,648,181
2009	1,220	201,323	1,383,759	4,252	170,062	1,760,616
2010	1,192	223,409	1,292,137	4,705	158,803	1,680,246
2011	1,124	206,843	1,173,072	4,214	149,643	1,534,896
2012	2,004	170,538	1,372,974	6,235	181,954	1,733,705
2013	1,254	169,025	1,475,711	3,223	191,642	1,840,855

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Table 4: *(continued)*

Year	Longline	Pole-and-line	Purse seine	Troll	Other	Total
2014	1,879	148,684	1,616,536	1,567	217,013	1,985,679
2015	1,879	151,317	1,393,137	1,776	244,503	1,792,612
2016	5,642	156,603	1,376,372	1,919	249,720	1,790,256
2017	2,571	123,466	1,263,312	2,251	218,857	1,610,457
2018	4,162	183,935	1,449,431	1,947	204,285	1,843,760
2019	5,594	158,225	1,696,173	2,148	175,781	2,037,921
2020	2,313	159,440	1,404,236	2,041	151,667	1,719,697
2021	2,853	146,840	1,327,308	2,185	146,609	1,625,795

Table 5: Yellowfin tuna catch (metric tonnes) by gear type for the WCPFC-CA, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
1960	55,020	1,872	1,438	0	15,337	73,667
1961	53,166	3,259	2,777	0	16,236	75,438
1962	55,547	4,225	6,975	0	17,197	83,944
1963	53,185	2,071	2,277	0	18,223	75,756
1964	45,247	5,074	3,647	0	20,186	74,154
1965	45,493	3,434	3,752	0	20,956	73,635
1966	61,654	2,192	5,844	0	23,409	93,099
1967	36,083	3,125	3,428	0	26,303	68,939
1968	46,070	2,706	7,083	0	26,085	81,944
1969	51,627	5,166	3,867	0	26,612	87,272
1970	55,806	4,606	7,644	0	30,933	98,989
1971	57,766	5,248	9,058	0	32,894	104,966
1972	61,175	7,465	9,739	0	37,506	115,885
1973	62,291	7,458	14,609	0	43,828	128,186
1974	58,116	6,582	17,098	0	49,441	131,237
1975	69,462	7,801	12,987	0	51,029	141,279
1976	77,570	17,186	15,576	0	42,766	153,098
1977	94,414	15,257	17,430	0	58,070	185,171
1978	110,202	12,767	15,818	0	39,401	178,188
1979	108,910	11,638	32,097	0	49,565	202,210
1980	125,113	15,142	36,502	9	43,426	220,192
1981	97,114	22,044	61,398	16	47,976	228,548
1982	86,149	17,123	90,099	54	42,800	236,225
1983	90,259	17,184	136,317	51	48,156	291,967
1984	76,988	17,633	143,930	67	54,212	292,830
1985	79,973	22,717	134,057	69	63,329	300,145
1986	68,999	17,970	195,817	62	65,367	348,215
1987	75,407	19,044	182,212	48	59,946	336,657
1988	88,855	20,566	144,529	76	71,578	325,604
1989	73,306	22,133	215,964	73	75,414	386,890
1990	79,300	20,769	247,028	68	86,848	434,013
1991	63,512	19,182	285,775	51	96,916	465,436
1992	77,739	23,043	296,814	98	62,126	459,820
1993	72,055	20,486	267,646	141	60,453	420,781
1994	82,184	21,378	273,986	101	76,877	454,526
1995	88,306	23,209	250,865	2,570	80,961	445,911
1996	91,887	30,551	205,833	2,636	98,431	429,338
1997	81,065	22,845	293,618	2,838	83,755	484,121
1998	81,077	27,506	328,241	2,806	102,613	542,243
1999	71,023	26,787	275,091	3,162	102,060	478,123
2000	96,908	26,957	276,615	3,343	109,665	513,488
2001	95,569	24,443	289,725	3,716	98,058	511,511
2002	95,644	24,133	268,839	3,172	105,188	496,976
2003	95,712	24,304	325,493	3,101	122,658	571,268
2004	104,066	30,640	323,660	2,706	139,483	600,555
2005	87,417	27,007	357,404	2,508	83,162	557,498
2006	85,016	23,653	343,410	2,607	91,132	545,818
2007	82,516	26,570	353,141	2,854	106,540	571,621
2008	84,200	22,705	431,317	2,903	106,666	647,791
2009	99,373	23,918	334,666	3,027	101,374	562,358
2010	98,523	20,112	351,311	3,611	96,710	570,267
2011	97,778	36,838	315,212	3,802	83,529	537,159
2012	87,666	34,705	398,182	3,935	103,389	627,877
2013	77,346	21,924	372,649	2,460	108,735	583,114

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Table 5: *(continued)*

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
2014	100,375	24,082	379,904	2,195	115,106	621,662
2015	104,375	35,719	317,558	2,729	136,652	597,033
2016	91,870	23,387	408,705	2,803	139,647	666,412
2017	86,227	24,935	500,506	2,618	101,175	715,461
2018	97,727	26,225	382,205	2,590	196,456	705,203
2019	105,404	17,706	352,172	2,879	219,580	697,741
2020	74,624	30,622	401,628	2,927	225,211	735,012
2021	74,271	20,266	429,959	2,914	250,353	777,763

Table 6: Bigeye tuna catch (metric tonnes) by gear type for the WCPFC-CA, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
1960	43,467	1,500	58	0	0	45,025
1961	37,517	1,800	63	0	0	39,380
1962	35,895	800	173	0	0	36,868
1963	42,540	1,800	6	0	0	44,346
1964	30,989	1,143	231	0	28	32,391
1965	29,848	1,254	201	0	30	31,333
1966	31,984	1,108	9	0	86	33,187
1967	33,632	2,803	62	0	253	36,750
1968	27,757	2,272	194	0	204	30,427
1969	32,571	3,350	49	0	62	36,032
1970	34,965	3,178	591	0	2,968	41,702
1971	38,359	1,862	678	0	3,243	44,142
1972	51,040	1,762	671	0	3,690	57,163
1973	42,412	1,258	770	0	4,449	48,889
1974	45,653	1,039	1,079	0	4,987	52,758
1975	61,488	1,334	1,280	0	5,212	69,314
1976	73,325	3,423	2,008	0	4,354	83,110
1977	72,083	3,325	2,693	0	5,954	84,055
1978	56,364	3,337	2,932	0	4,331	66,964
1979	63,837	2,540	3,214	0	4,966	74,557
1980	62,537	2,916	3,816	0	4,086	73,355
1981	46,590	3,382	11,756	0	4,624	66,352
1982	48,578	4,993	19,017	0	4,142	76,730
1983	46,311	5,077	26,764	0	4,704	82,856
1984	52,976	4,557	27,068	0	5,047	89,648
1985	58,629	5,529	20,175	0	6,175	90,508
1986	56,989	4,133	42,895	0	6,346	110,363
1987	68,832	4,602	34,993	0	5,552	113,979
1988	68,288	5,890	29,255	0	6,803	110,236
1989	64,916	6,131	32,473	0	7,447	110,967
1990	77,009	5,985	43,260	0	8,122	134,376
1991	61,033	3,929	45,577	0	9,347	119,886
1992	75,966	4,055	56,923	0	6,201	143,145
1993	66,566	4,505	44,902	0	5,670	121,643
1994	79,175	5,251	43,224	0	7,823	135,473
1995	68,125	6,228	36,918	145	8,265	119,681
1996	58,054	7,940	38,923	432	9,924	115,273
1997	68,597	6,563	58,009	412	7,518	141,099
1998	85,048	6,405	60,638	507	9,043	161,641
1999	74,959	5,856	80,572	316	8,747	170,450
2000	76,924	6,838	66,280	397	10,003	160,442
2001	78,690	5,905	53,500	408	9,032	147,535
2002	92,381	6,109	60,976	713	9,273	169,452
2003	83,016	5,296	57,564	142	11,240	157,258
2004	99,709	9,238	73,313	232	12,560	195,052
2005	78,892	6,851	71,703	220	5,523	163,189
2006	83,592	9,781	71,643	157	6,264	171,437
2007	81,113	7,296	75,242	187	6,915	170,753
2008	83,428	9,204	79,869	212	6,214	178,927
2009	80,507	7,916	81,151	175	5,216	174,965
2010	72,721	7,027	64,494	275	4,049	148,566
2011	77,567	5,655	87,302	251	5,600	176,375
2012	83,971	3,934	76,634	273	12,819	177,631
2013	65,637	5,009	84,404	271	12,002	167,323

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Table 6: *(continued)*

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
2014	75,434	4,714	81,430	312	15,011	176,901
2015	73,397	5,687	60,970	204	14,750	155,008
2016	63,077	3,933	74,056	201	21,368	162,635
2017	58,126	2,264	66,810	184	11,089	138,473
2018	68,911	4,165	74,294	135	11,212	158,717
2019	69,112	1,514	49,958	173	14,671	135,428
2020	58,212	1,773	73,040	203	21,226	154,454
2021	50,594	1,959	76,436	156	20,548	149,693

Table 7: Albacore tuna catch (metric tonnes) by gear type for the WCPFC-CA (including the overlap region with the IATTC), south of the equator, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
1960	18,750	0	0	0	0	18,750
1961	19,979	0	0	0	0	19,979
1962	24,492	0	0	0	0	24,492
1963	16,827	0	0	0	0	16,827
1964	13,058	0	0	0	0	13,058
1965	18,057	0	0	0	0	18,057
1966	31,786	0	0	0	0	31,786
1967	35,292	0	0	5	0	35,297
1968	27,332	0	0	14	0	27,346
1969	24,024	0	0	0	0	24,024
1970	33,285	100	0	50	0	33,435
1971	34,116	100	0	0	0	34,216
1972	33,079	100	0	268	0	33,447
1973	44,734	100	0	484	0	45,318
1974	26,279	100	0	898	0	27,277
1975	18,498	100	0	646	0	19,244
1976	28,024	100	0	25	0	28,149
1977	32,979	100	0	621	0	33,700
1978	29,944	100	0	1,686	0	31,730
1979	24,180	100	0	814	0	25,094
1980	29,072	100	0	1,468	0	30,640
1981	30,265	0	0	2,085	5	32,355
1982	27,499	0	0	2,434	6	29,939
1983	23,559	0	0	744	39	24,342
1984	18,541	0	0	2,773	1,589	22,903
1985	23,413	0	0	3,253	1,937	28,603
1986	28,765	0	0	2,003	1,946	32,714
1987	19,750	0	0	2,134	930	22,814
1988	27,617	0	0	4,061	5,283	36,961
1989	17,887	0	0	8,135	21,968	47,990
1990	17,671	245	0	6,740	7,538	32,194
1991	20,303	14	0	7,570	1,489	29,376
1992	28,069	11	0	6,343	65	34,488
1993	27,229	62	0	4,061	70	31,422
1994	31,673	65	0	6,929	89	38,756
1995	26,036	139	0	7,481	104	33,760
1996	24,301	30	0	7,274	156	31,761
1997	31,449	9	0	4,530	133	36,121
1998	41,732	9	0	6,113	85	47,939
1999	28,788	38	0	3,194	74	32,094
2000	34,440	80	0	6,104	139	40,763
2001	54,018	19	0	5,047	199	59,283
2002	63,598	7	0	4,517	150	68,272
2003	52,098	5	0	5,984	130	58,217
2004	49,960	6	0	4,551	123	54,640
2005	53,917	12	0	3,431	137	57,497
2006	55,923	23	0	2,749	188	58,883
2007	52,847	17	0	1,987	60	54,911
2008	54,200	12	0	3,502	160	57,874
2009	72,813	21	0	2,031	211	75,076
2010	78,643	14	0	2,139	190	80,986
2011	55,275	21	0	3,189	233	58,718
2012	71,814	26	0	2,962	248	75,050
2013	72,091	26	0	3,226	248	75,591

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Table 7: *(continued)*

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
2014	61,494	26	0	2,403	248	64,171
2015	62,089	24	0	2,602	263	64,978
2016	58,510	33	10	2,158	333	61,044
2017	75,671	12	10	2,424	199	78,316
2018	65,388	16	17	2,702	380	68,503
2019	67,428	43	2	2,779	263	70,515
2020	59,781	27	4	4,719	331	64,862
2021	45,233	13	7	4,037	250	49,540

Table 8: Albacore tuna catch (metric tonnes) by gear type for the eastern Pacific region (excluding the overlap region with the IATTC), south of the equator, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
1960	3,498	45	0	0	0	3,543
1961	3,763	0	0	0	0	3,763
1962	10,727	0	0	0	0	10,727
1963	14,268	16	0	0	0	14,284
1964	9,766	0	0	0	0	9,766
1965	7,398	0	0	0	0	7,398
1966	6,875	0	0	0	0	6,875
1967	8,660	0	0	0	0	8,660
1968	5,036	0	0	0	0	5,036
1969	781	0	0	0	0	781
1970	1,490	0	0	0	0	1,490
1971	4,414	0	0	0	0	4,414
1972	6,052	22	0	0	0	6,074
1973	1,971	41	0	0	0	2,012
1974	6,760	12	0	0	0	6,772
1975	4,351	5	0	0	0	4,356
1976	933	0	0	0	0	933
1977	5,040	0	0	0	0	5,040
1978	2,946	0	0	0	0	2,946
1979	1,982	0	0	0	0	1,982
1980	1,900	1	0	0	0	1,901
1981	2,429	0	0	0	0	2,429
1982	848	1	0	0	0	849
1983	750	0	0	0	0	750
1984	1,799	2	0	0	0	1,801
1985	3,725	0	0	0	0	3,725
1986	3,876	0	0	0	0	3,876
1987	2,229	9	0	0	0	2,238
1988	671	0	0	235	0	906
1989	851	0	0	235	0	1,086
1990	3,633	0	0	235	0	3,868
1991	5,989	0	0	235	0	6,224
1992	3,945	0	0	235	0	4,180
1993	3,769	12	0	235	0	4,016
1994	3,325	2	0	235	0	3,562
1995	4,472	0	0	243	0	4,715
1996	2,462	0	0	179	0	2,641
1997	3,208	12	0	149	0	3,369
1998	2,420	27	0	189	0	2,636
1999	7,171	100	0	309	0	7,580
2000	6,990	22	0	686	0	7,698
2001	3,981	18	0	408	0	4,407
2002	6,681	11	0	310	0	7,002
2003	5,225	7	0	688	0	5,920
2004	8,331	104	0	439	0	8,874
2005	7,079	17	0	161	0	7,257
2006	6,294	6	0	256	0	6,556
2007	4,379	0	0	80	0	4,459
2008	5,629	0	0	0	0	5,629
2009	9,338	0	0	0	0	9,338
2010	9,863	0	0	0	0	9,863
2011	7,738	9	0	0	0	7,747
2012	14,819	15	0	0	0	14,834
2013	12,391	0	0	0	0	12,391

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Table 8: *(continued)*

Year	**Longline**	**Pole-and-line**	**Purse seine**	**Troll**	**Other**	**Total**
2014	18,650	0	0	21	0	18,671
2015	18,631	0	0	0	0	18,631
2016	11,471	7	0	0	0	11,468
2017	16,196	2	0	0	0	16,188
2018	14,873	0	0	0	0	14,856
2019	15,570	0	0	0	0	15,568
2020	9,538	227	0	14	0	9,775
2021	22,092	227	0	0	0	22,312

Table 9: Albacore tuna catch (metric tonnes) by gear type for the WCPFC-CA, north of the equator, from 1960 to 2021. Note: Data for 2021 are preliminary.

Year	Longline	Pole-and-line	Purse seine	Troll	Other	Total
1960	12,637	25,156	0	0	76	37,869
1961	12,668	18,639	7	0	268	31,582
1962	12,866	8,729	53	0	191	21,839
1963	10,151	26,420	59	0	218	36,848
1964	13,182	23,858	128	0	319	37,487
1965	10,546	41,491	11	0	121	52,169
1966	19,802	22,830	111	0	585	43,328
1967	22,916	30,481	89	0	520	54,006
1968	18,895	16,597	267	0	1,109	36,868
1969	14,454	32,148	521	0	959	48,082
1970	15,696	24,385	317	0	517	40,915
1971	11,909	53,351	902	0	359	66,521
1972	14,695	60,591	277	0	645	76,208
1973	15,101	68,808	1,353	0	569	85,831
1974	13,020	73,576	161	0	1,128	87,885
1975	12,682	52,157	159	0	409	65,407
1976	16,998	85,336	1,109	0	1,355	104,798
1977	15,810	31,934	669	0	1,058	49,471
1978	12,316	59,877	1,115	0	6,123	79,431
1979	12,115	44,662	125	0	4,011	60,913
1980	13,271	46,743	329	0	4,179	64,522
1981	17,007	27,426	252	0	11,071	55,756
1982	16,377	29,615	561	0	13,117	59,670
1983	13,225	21,098	350	0	7,206	41,879
1984	12,737	26,015	3,380	0	10,022	52,154
1985	14,599	20,714	1,533	0	12,187	49,033
1986	12,937	16,096	1,542	0	9,194	39,769
1987	13,649	19,091	1,205	0	10,218	44,163
1988	14,077	6,216	1,208	235	17,656	39,392
1989	12,260	8,629	2,521	235	17,276	40,921
1990	14,499	8,532	1,995	235	24,034	49,295
1991	15,156	7,103	2,652	235	8,050	33,196
1992	17,482	13,888	4,104	235	12,392	48,101
1993	28,954	12,809	2,889	235	1,187	46,074
1994	27,956	26,391	2,026	235	1,097	57,705
1995	34,352	20,981	1,177	1,091	389	57,990
1996	37,289	20,272	581	951	286	59,379
1997	41,194	32,250	1,068	1,734	534	76,780
1998	38,310	22,953	1,554	1,357	352	64,526
1999	40,046	50,469	6,872	1,144	441	98,972
2000	35,643	21,572	2,408	996	289	60,908
2001	31,004	29,448	974	622	230	62,278
2002	26,556	48,465	3,303	931	526	79,781
2003	26,986	36,121	627	927	360	65,021
2004	27,063	32,359	7,200	838	299	67,759
2005	29,388	16,150	850	743	654	47,785
2006	29,596	15,406	364	596	412	46,374
2007	27,480	37,768	5,682	549	394	71,873
2008	25,124	19,060	825	550	1,675	47,234
2009	26,462	31,172	2,076	413	423	60,546
2010	27,499	19,561	330	590	258	48,238
2011	30,013	25,713	480	449	326	56,981
2012	29,598	33,757	4,193	613	581	68,742
2013	27,215	33,576	1,988	304	432	63,515

Continued on next page

Table 9: *(continued)*

Year	Longline	Pole-and-line	Purse seine	Troll	Other	Total
2014	26,114	29,433	2,009	200	406	58,162
2015	29,849	21,294	1,072	241	512	52,968
2016	21,627	14,442	3,679	149	324	40,221
2017	23,730	20,893	2,646	497	465	48,231
2018	21,062	17,914	3,001	90	341	42,408
2019	23,313	17,914	3,098	80	813	45,218
2020	18,721	8,533	1,419	97	607	29,377
2021	21,817	8,533	1,419	110	564	32,443

Table 10: Biological Reference Points (BRPs) and stock status from the latest stock assessments (assessment year shown in parentheses) for South Pacific albacore, bigeye, skipjack, and yellowfin tunas. All biomasses are in metric tonnes. SB_{recent} is the average spawning biomass over the last 4 years of the assessment; $SB_{F=0}$ is the average spawning biomass (over the recent 10-year period) predicted to occur in the absence of fishing; MSY is the maximum sustainable yield based on recent patterns of fishing; F_{recent}/F_{MSY} is the ratio of recent (using a window one year earlier than for SB) fishing mortality to that which will support the MSY; No. of models in the grid indicates the number of models that were included in the assessment uncertainty grid that was approved by the Scientific Committee. Values represent the medians, or weighted medians where relevant, across the model grids.

BRP	**Albacore (2021)**	**Bigeye (2020)**	**Skipjack (2022)**	**Yellowfin (2020)**
SB_{recent}	352,739	590,311	3,978,300	1,994,655
$SB_{F=0}$	678,345	1,353,367	7,616,930	3,603,980
MSY	120,020	140,720	2,648,400	1,091,200
F_{recent}/F_{MSY}	0.24	0.72	0.32	0.36
$SB_{recent}/SB_{F=0}$	0.52	0.41	0.51	0.58
No. models in grid	72	24	18	72

Table 11: Total numbers of albacore, bigeye, skipjack, and yellowfin tuna tagged during the three major tropical tuna tagging projects in the western and central Pacific region. Note: Separate EEZ results are provided for any region with more than 10,000 releases in any single programme; SSAP = Skipjack Survey and Assessment Programme (1977-1981); RTTP = Regional Tuna Tagging Programme (1989-1992); PTTP = Pacific Tuna Tagging Programme (2006-2021).

	PTTP		**RTTP**		**SSAP**	
EEZ	**Releases**	**Recoveries**	**Releases**	**Recoveries**	**Releases**	**Recoveries**
FJ	0	6	5,197	528	28,980	2,659
FM	33,833	3,211	11,711	1,779	8,791	330
ID	40,418	4,961	13,740	2,653		37
IW	29,596	2,931				
KI	45,744	4,920	14,754	851	5,212	449
NZ	2,863	8		2	15,020	1,000
PF	0	1		1	29,693	128
PG	218,466	28,743	44,502	3,677	9,079	1,077
PW	14,369	214	7,495	142	8,663	114
SB	95,212	13,408	15,226	2,372	7,870	597
Other	5,343	28,156	39,042	6,925	48,976	1,077
TOTAL	485,844	86,559	151,667	18,930	162,284	7,468

Table 12: PTTP tagging totals for the four target tuna species.

	Releases				**Recoveries**			
EEZ	**Albacore**	**Bigeye**	**Skipjack**	**Yellowfin**	**Albacore**	**Bigeye**	**Skipjack**	**Yellowfin**
FJ					3		1	2
FM		1,552	25,367	6,905		247	2,489	473
ID		506	31,548	8,364	3	59	4,218	681
IW		23,995	1,811	3,761	3	1,125	1,447	352
KI		28,265	12,447	5,027		2,480	1,749	676
NZ	2,863				6		2	
PF					1			
PG		4,488	151,629	62,349	3	742	19,844	8,045
PW		45	11,509	2,815		1	185	28
SB		581	69,942	24,687	2	93	9,646	3,599
Other	14	1,062	3,281	932	29	9,333	13,908	4,727
TOTAL	2,877	60,494	307,534	114,840	50	14,080	53,489	18,583

EEZ abbreviations: FJ = Fiji, FM = Federated States of Micronesia, ID = Indonesia, IW = International Waters (High Seas), KI = Kiribati, NZ = New Zealand, PF = French Polynesia, PG = Papua New Guinea, PW = Palau, SB = Solomon Islands, Other = Pacific Island countries and territories with low numbers of releases and/or recoveries.

6 Figures

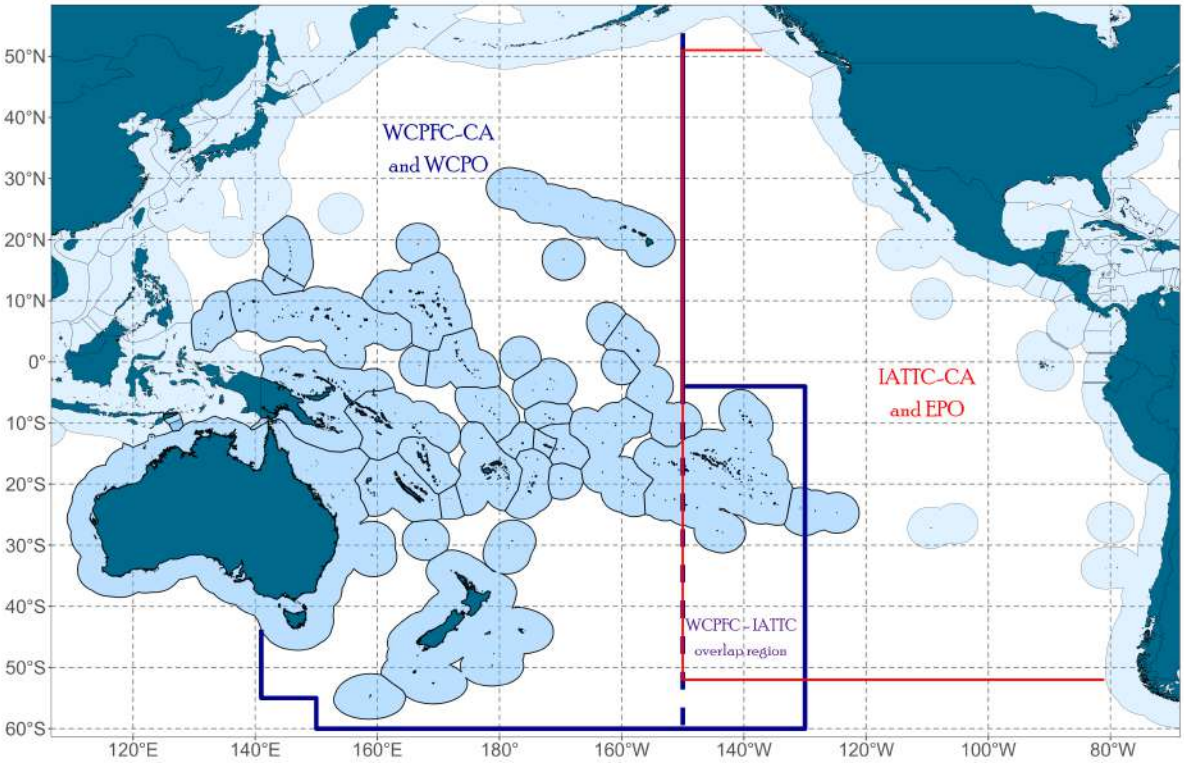


Figure 1: Important national and regional management zones in the Pacific. The WCPFC Convention Area (WCPFC-CA) is outlined in dark blue, the IATTC Convention Area (IATTC-CA) area is outlined in red. The western and central Pacific Ocean (WCPO) includes all of the WCPFC-CA, minus the overlap with the IATTC-CA; the eastern Pacific Ocean (EPO) is coincident with the IATTC-CA. The EEZs of Pacific island countries and territories are shaded light blue and high seas areas are white.

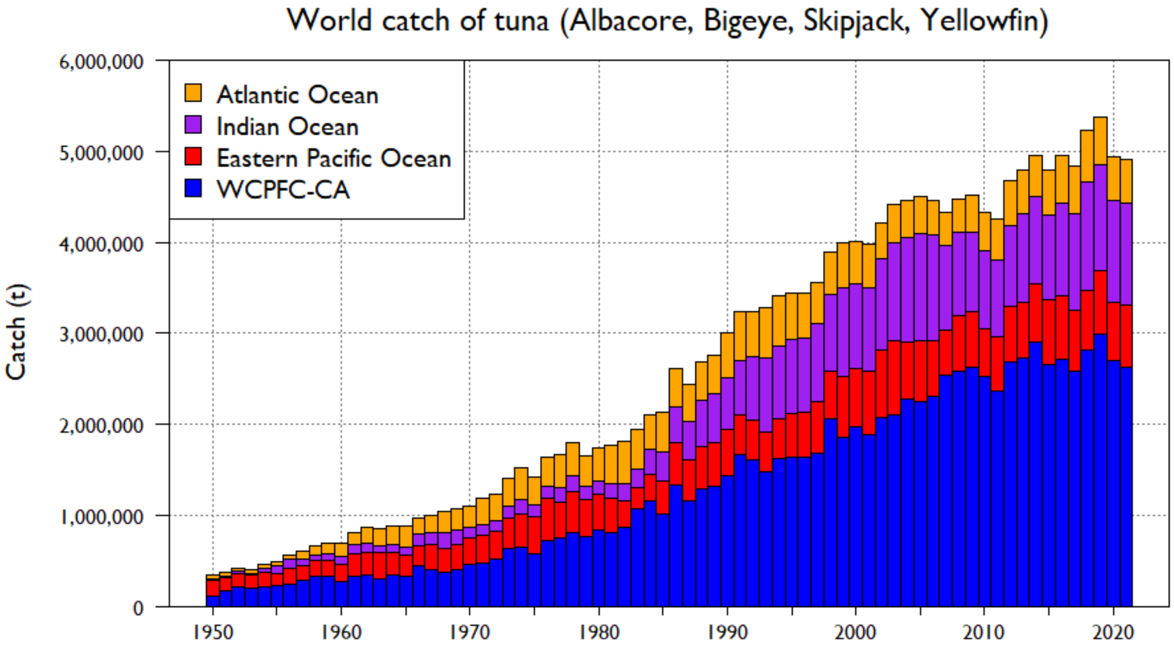
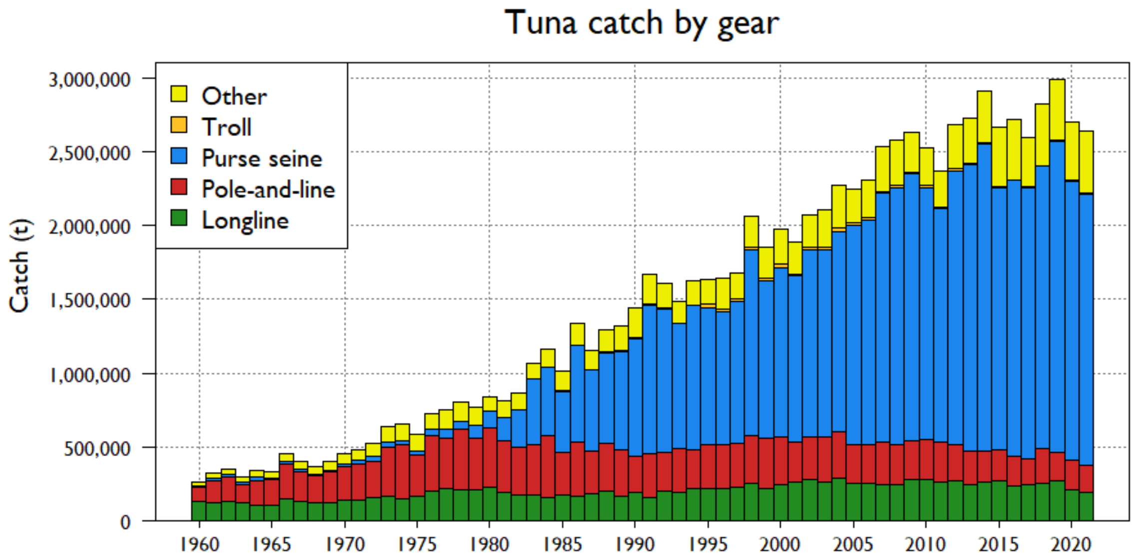


Figure 2: World catch of target tuna (albacore, bigeye, skipjack, yellowfin) 1950-2021. The WCPFC-CA total includes catch in the overlap region with the IATTAC; therefore the Eastern Pacific Ocean total does not include that catch. Data for 2021 is provisional for all areas.

Total WCPFC-CA target tuna catch plots



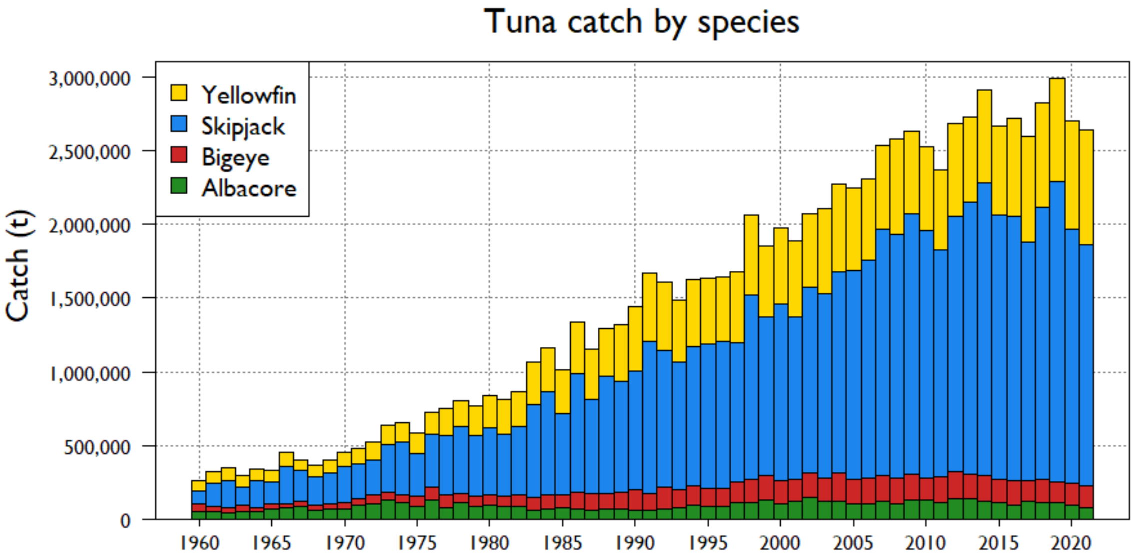
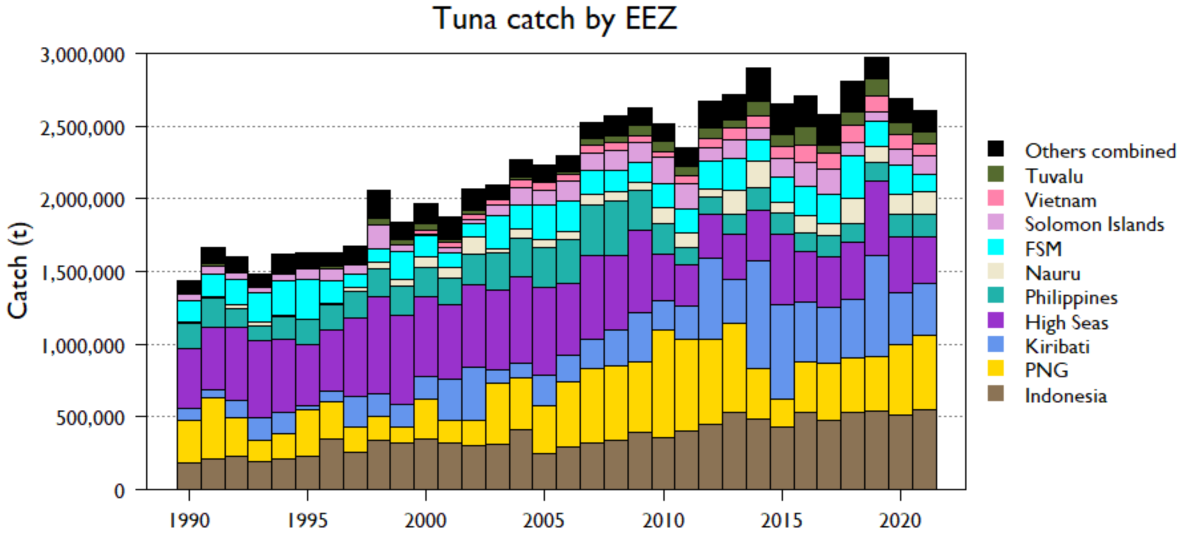


Figure 3: Catch (metric tonnes) by gear (top) and species (bottom) for the western and central Pacific region, 1960–2021. Note: data for 2021 are preliminary.

Total WCPFC-CA target tuna catch plots, cont.



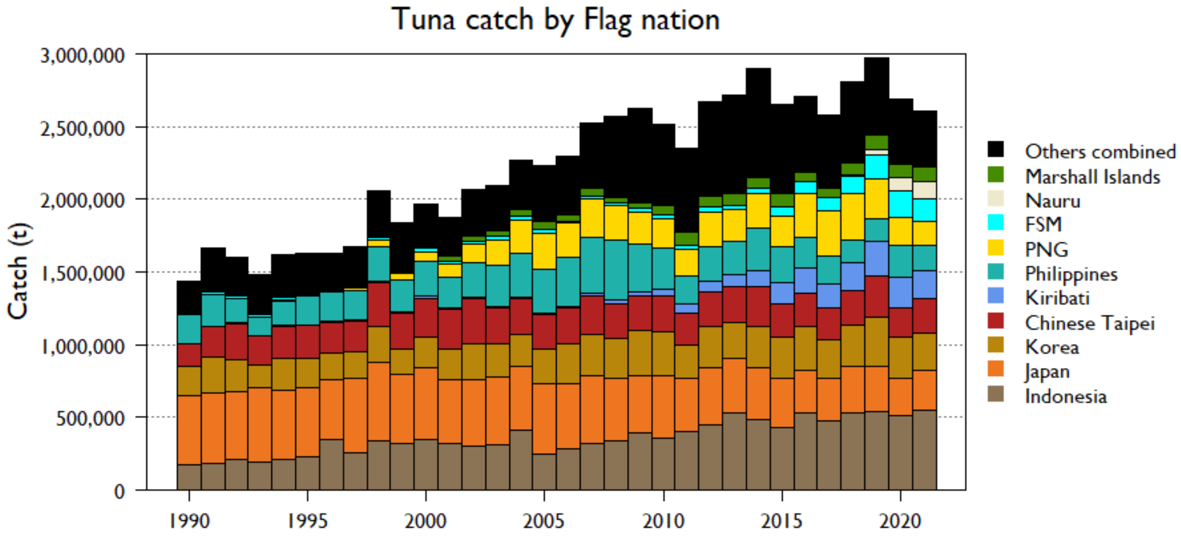


Figure 4: Catch (metric tonnes) by EEZ (top) and flag (bottom) for the western and central Pacific region, 1990–2021. The top 10 individual EEZs or flags are shown, as determined by total target tuna catch in 2021.

Purse seine catch and effort plots

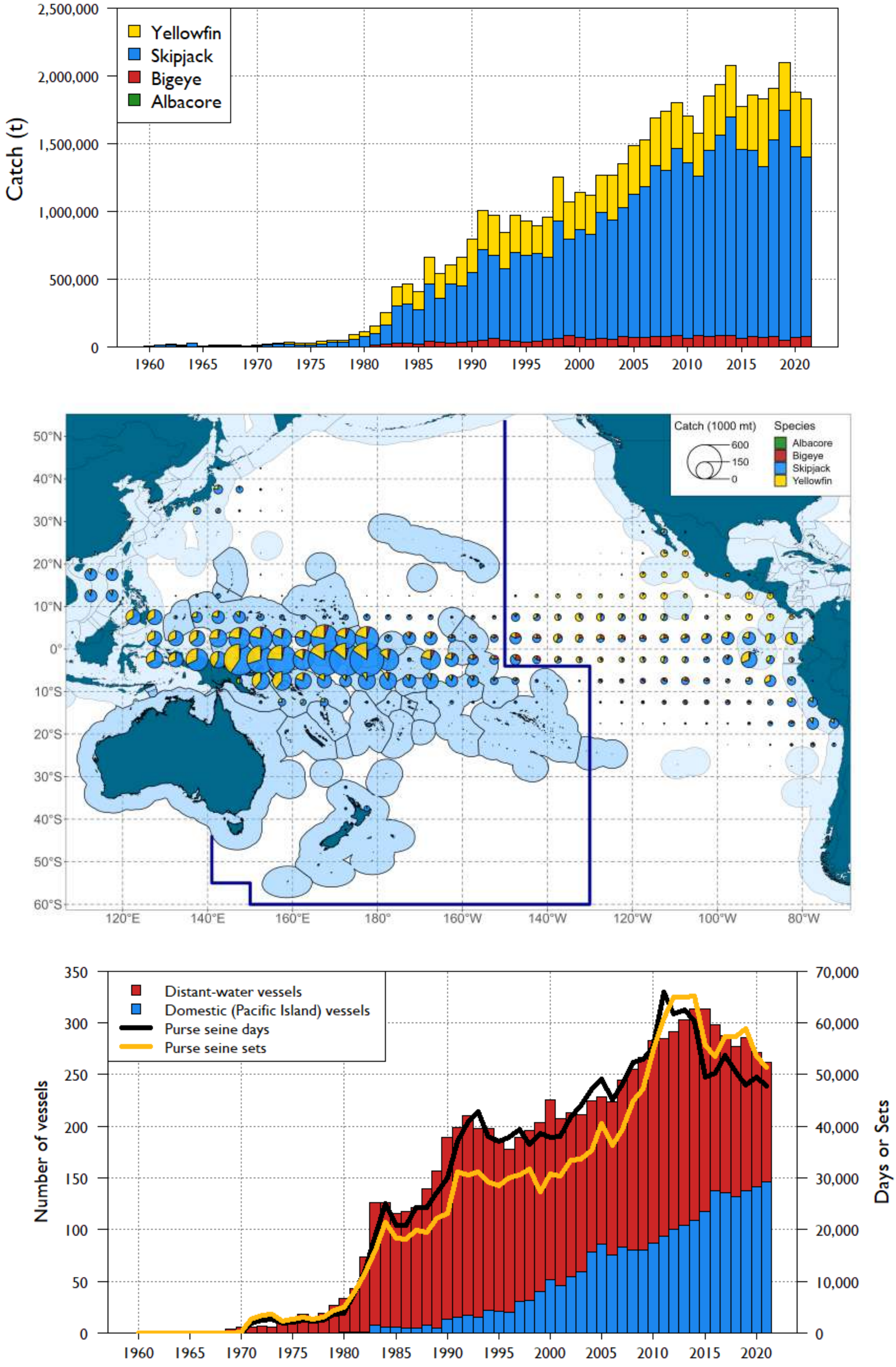


Figure 5: Time series of catch (top), recent (2017–2021) spatial distribution of catch (middle), and indices of fishing effort, in fleet sizes and number of sets and days (bottom), for the purse seine fishery in the WCPO. Effort totals exclude Japan coastal, Indonesia, Philippine and Vietnam domestic purse seine vessels.

Longline catch and effort plots

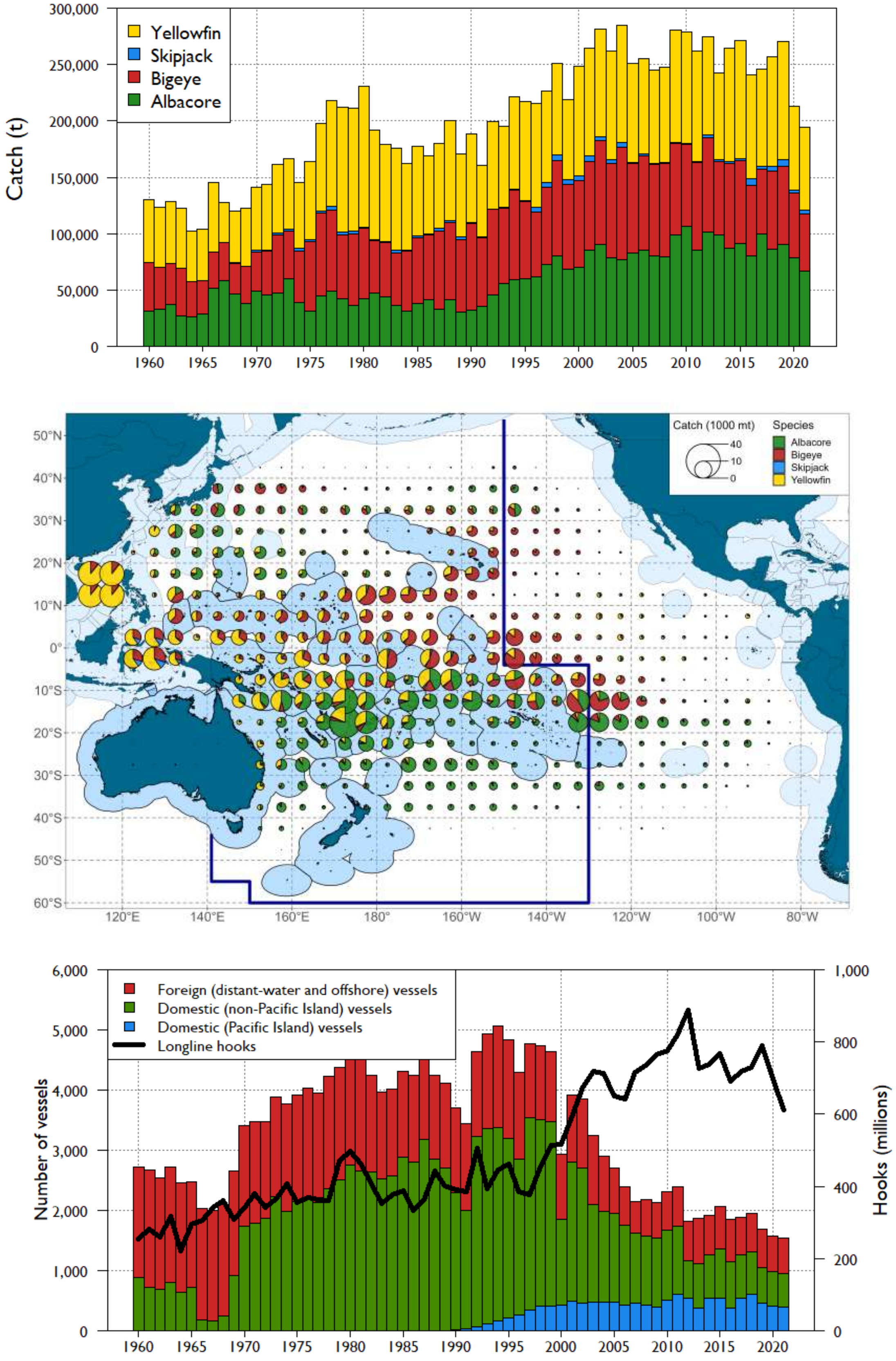


Figure 6: Time series of catch (top), recent (2017–2021) spatial distribution of catch (middle), and indices of fishing effort, in fleet sizes and number of hooks fished (bottom), for the longline fishery in the WCPFC-CA.

Pole-and-line catch and effort plots

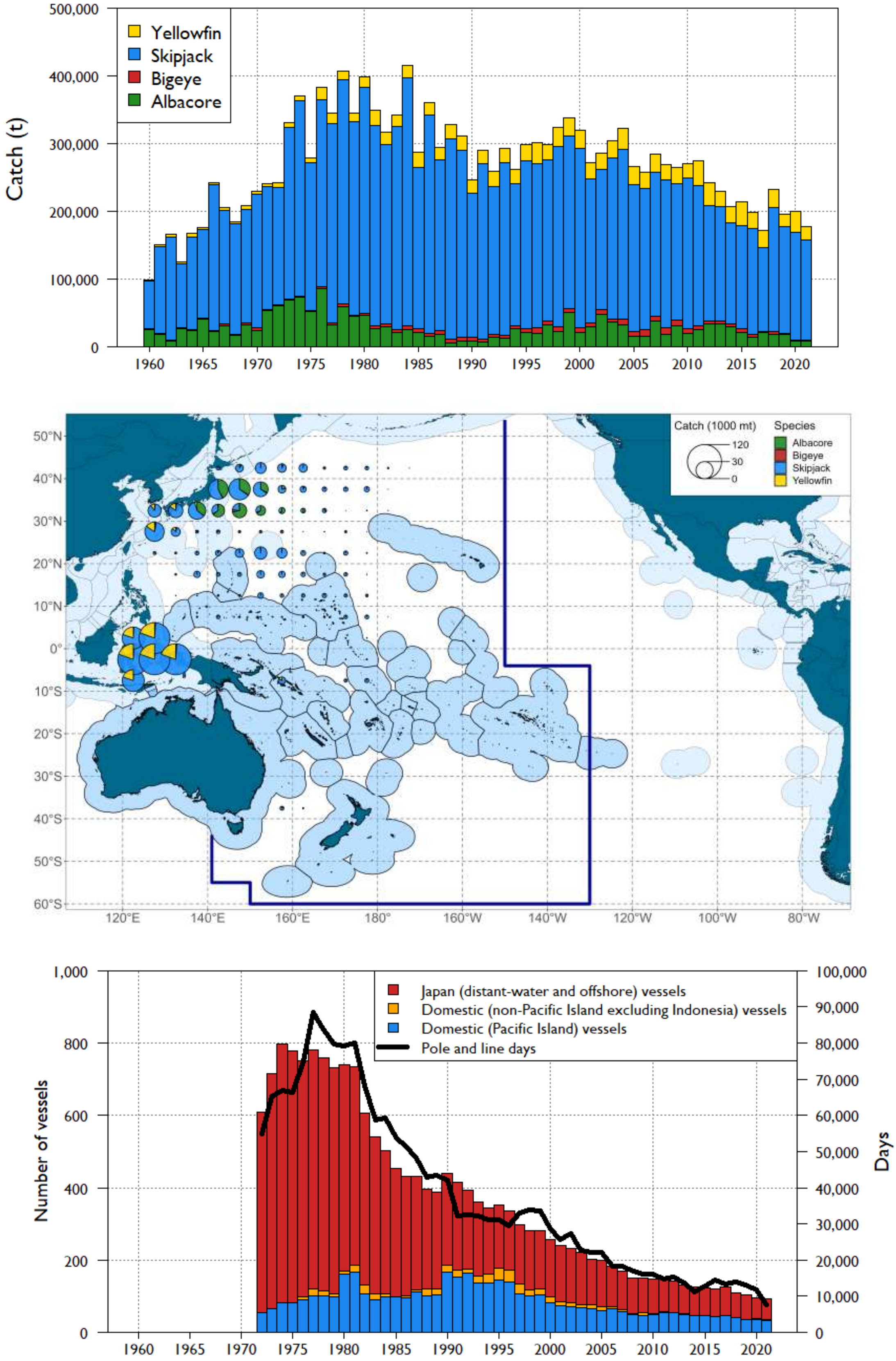


Figure 7: Time series of catch (top), recent (2017–2021) spatial distribution of catch (middle), and indices of fishing effort in fleet sizes and number of days (bottom), for the pole-and-line fishery in the WCPFC-CA. Note that vessel numbers and fishing days are not available prior to 1972.

Skipjack catch data

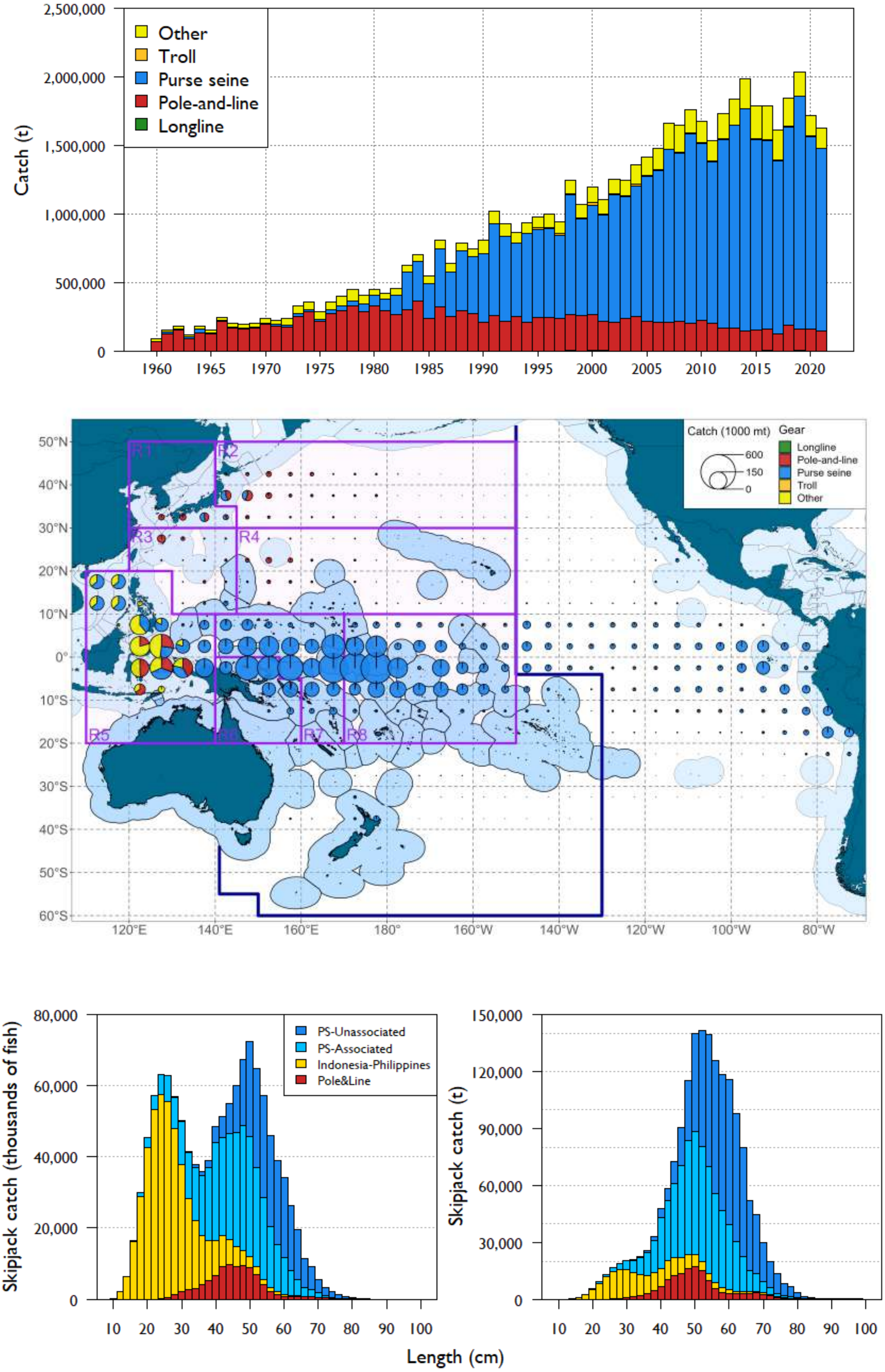


Figure 8: Time series (top), recent (2017–2021) spatial distribution and assessment regions (middle), and size composition (average for last five years, bottom) of skipjack tuna catch by gear for the WCPFC-CA.

Skipjack stock status plots

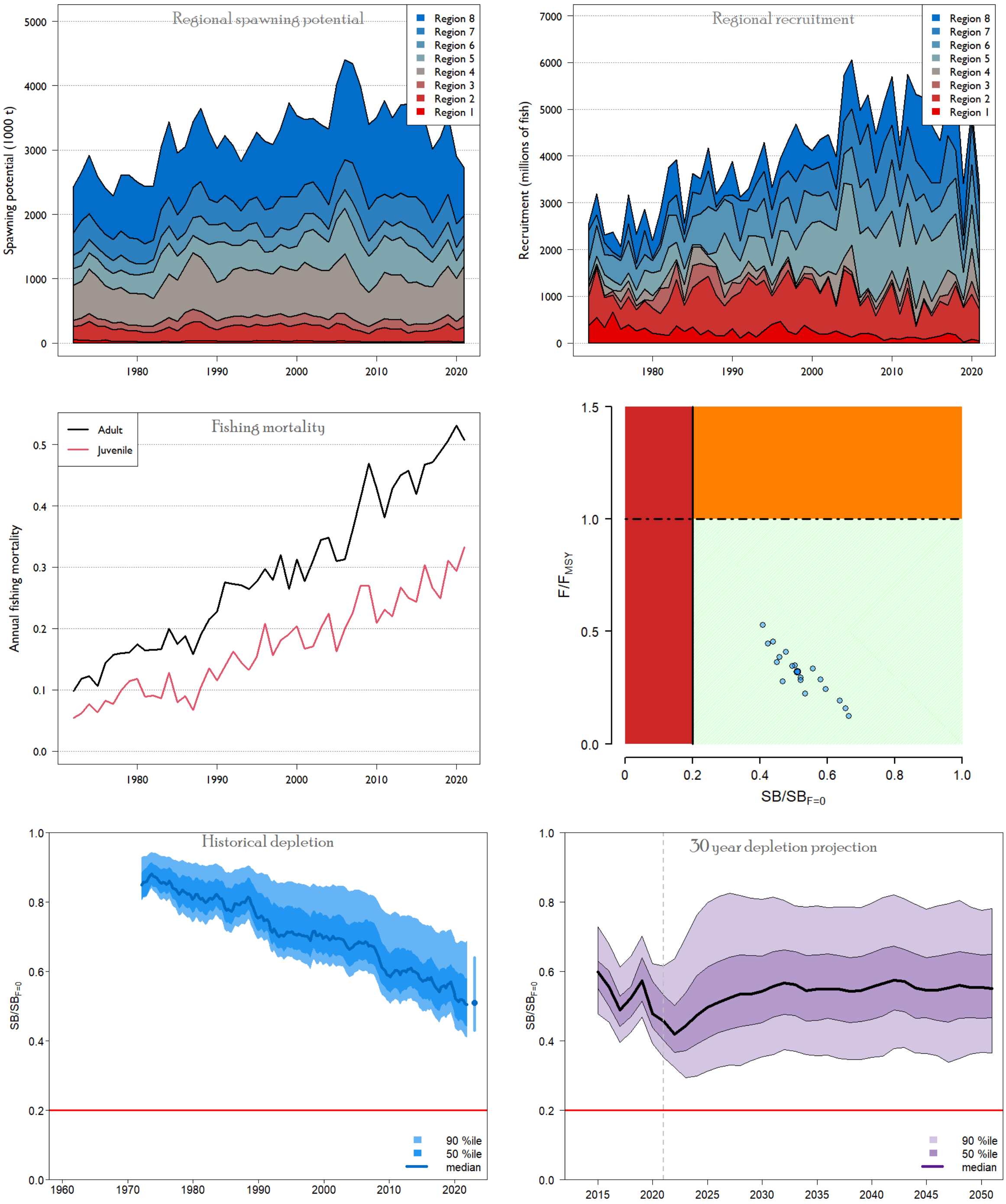


Figure 9: Estimated spawning biomass (SB) time series by model region (top left), recruitment by model region (top right), and fishing mortality for adults and juveniles (middle left) from the skipjack diagnostic case model; stock status displayed on a Majuro plot as the end points ('recent values') from the uncertainty grid of 18 models (middle right) with the weighted median value illustrated by the large blue point; the estimated level of depletion across the grid (bottom left), and 30-year projected depletion based on actual fishing levels through 2021, and assuming 2021 fishing levels afterwards (bottom right). Note that depletion is represented differently between the historical and projection plots. Historical depletion is computed instantaneously, i.e. annual spawning biomass divided by annual estimate of spawning biomass in the absence of fishing. Vertical bar shows median depletion ($SB_{recent}/SB_{F=0}$) with 80th percentile estimates. For the projections, the spawning biomass in the absence of fishing is computed as a 10 year average lagged by one year relative to the year of the SB calculation.

Yellowfin catch data

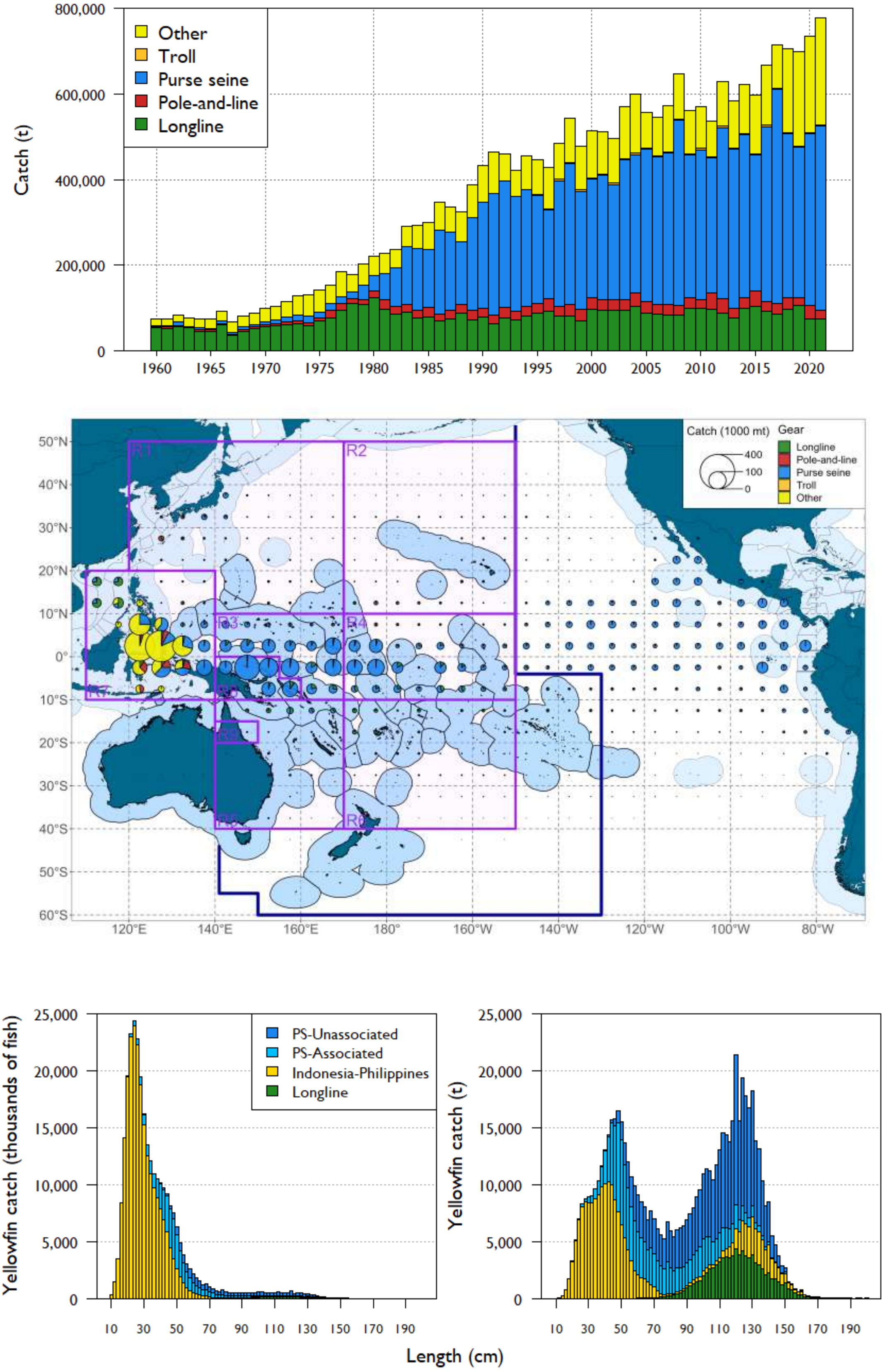


Figure 10: Time series (top), recent (2017–2021) spatial distribution and assessment regions (middle), and size composition (average for last five years, bottom) of yellowfin tuna catch by gear for the WCPFC-CA.

Yellowfin stock status plots

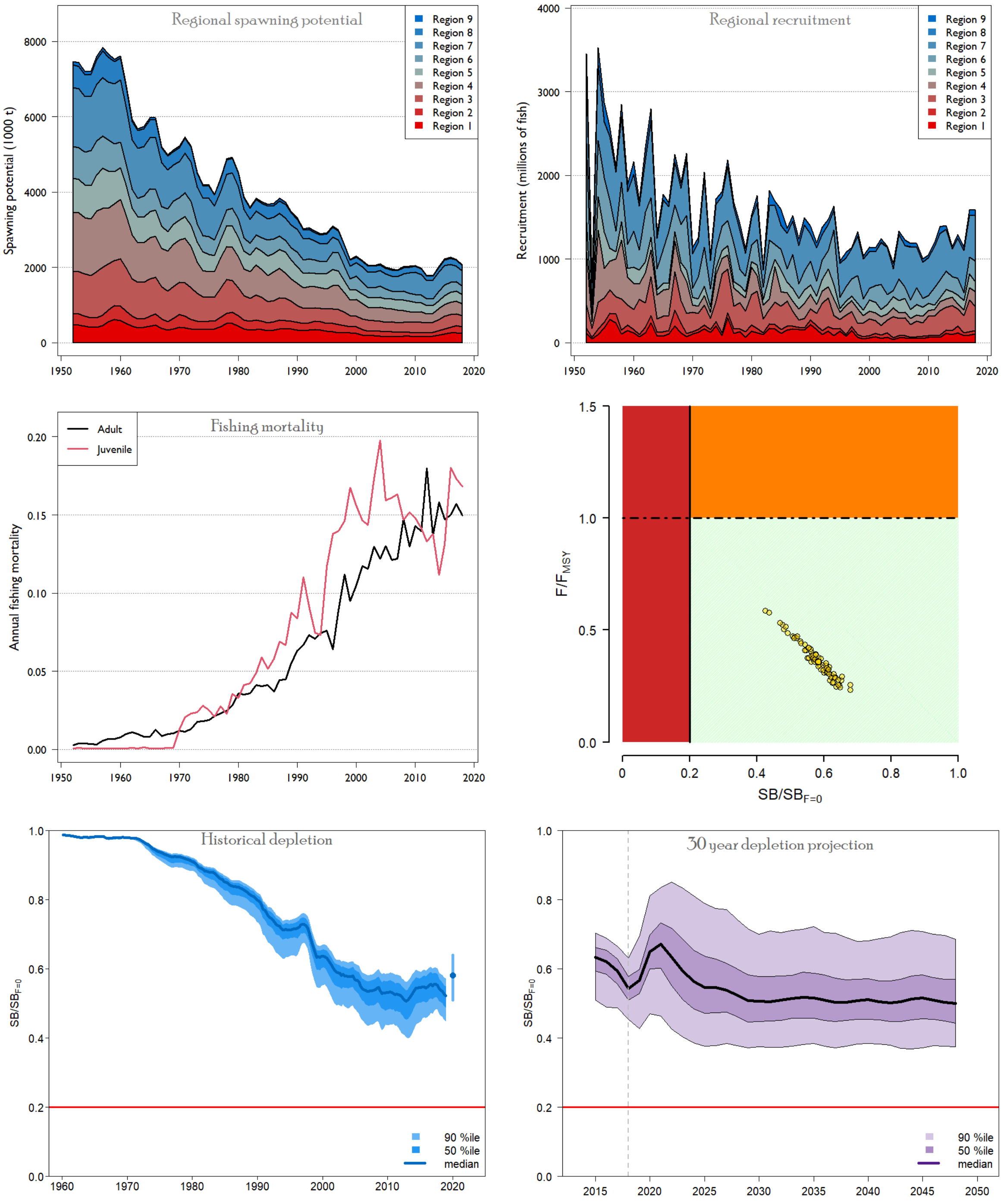


Figure 11: Estimated spawning biomass (SB) time series by model region (top left), recruitment by model region (top right), and fishing mortality for adults and juveniles (middle left) from the yellowfin diagnostic case model; stock status displayed on a Majuro Plot as the end points ('recent values') from the uncertainty grid of 72 models (middle right) with the weighted median value illustrated by the large yellow point; the estimated level of depletion across the grid (bottom left), and 30-year projected depletion based on actual catch/effort levels through 2021, and assuming 2021 fishing catch/effort levels afterwards (bottom right). Note that depletion is represented differently between the historical and projection plots. Historical depletion is computed instantaneously, i.e. annual spawning biomass divided by annual estimate of spawning biomass in the absence of fishing. Vertical bar shows median depletion ($\mathrm{SB}_{recent}/\mathrm{SB}_{F=0}$) with 80th percentile estimates. For the projections, the spawning biomass in the absence of fishing is computed as a 10 year average lagged by one year relative to the year of the SB calculation.

Bigeye catch data

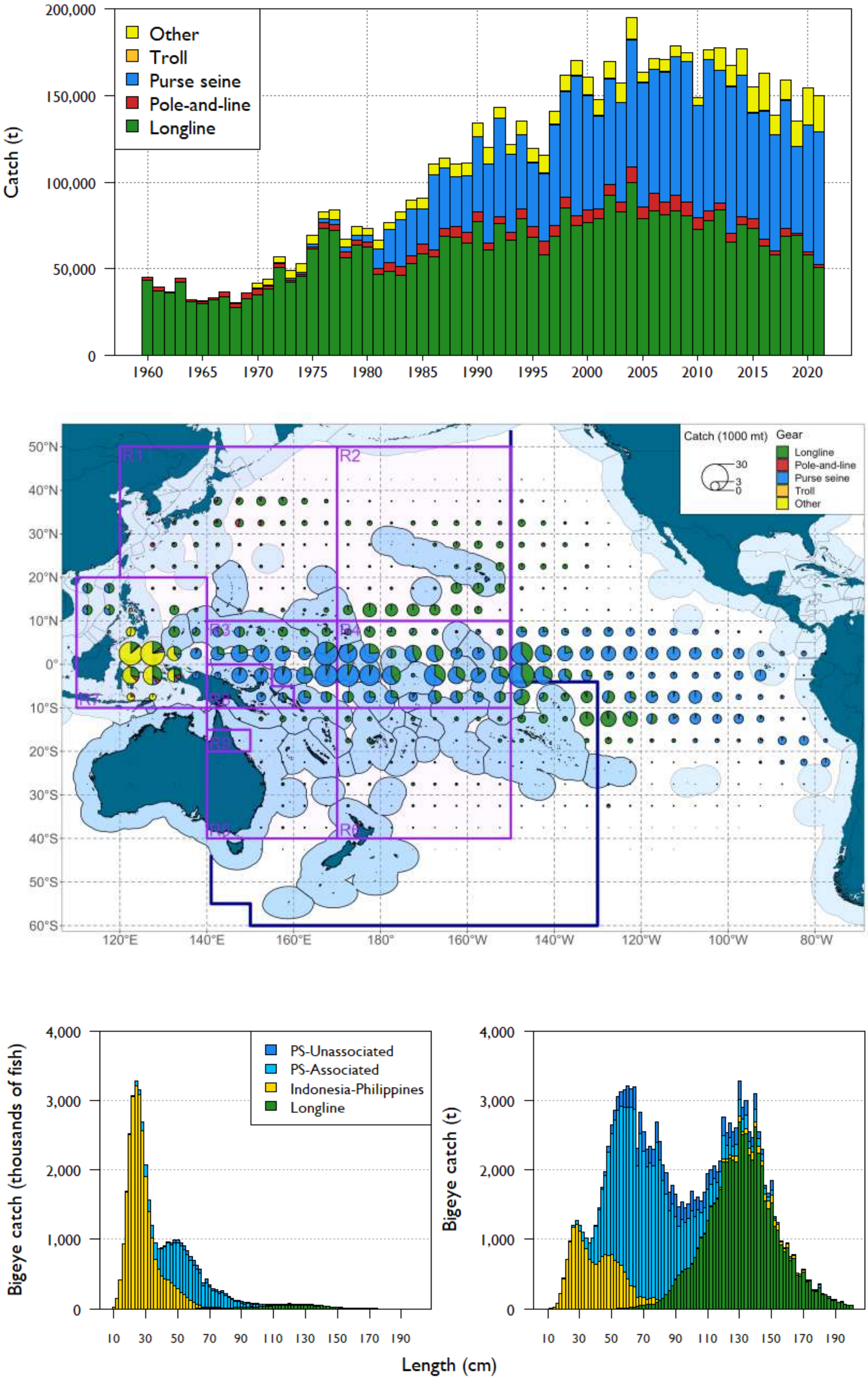


Figure 12: Time series (top), recent (2017–2021) spatial distribution and assessment regions (middle), and size composition (average for last five years, bottom) of bigeye tuna catch by gear for the WCPFC-CA.

Bigeye stock status plots

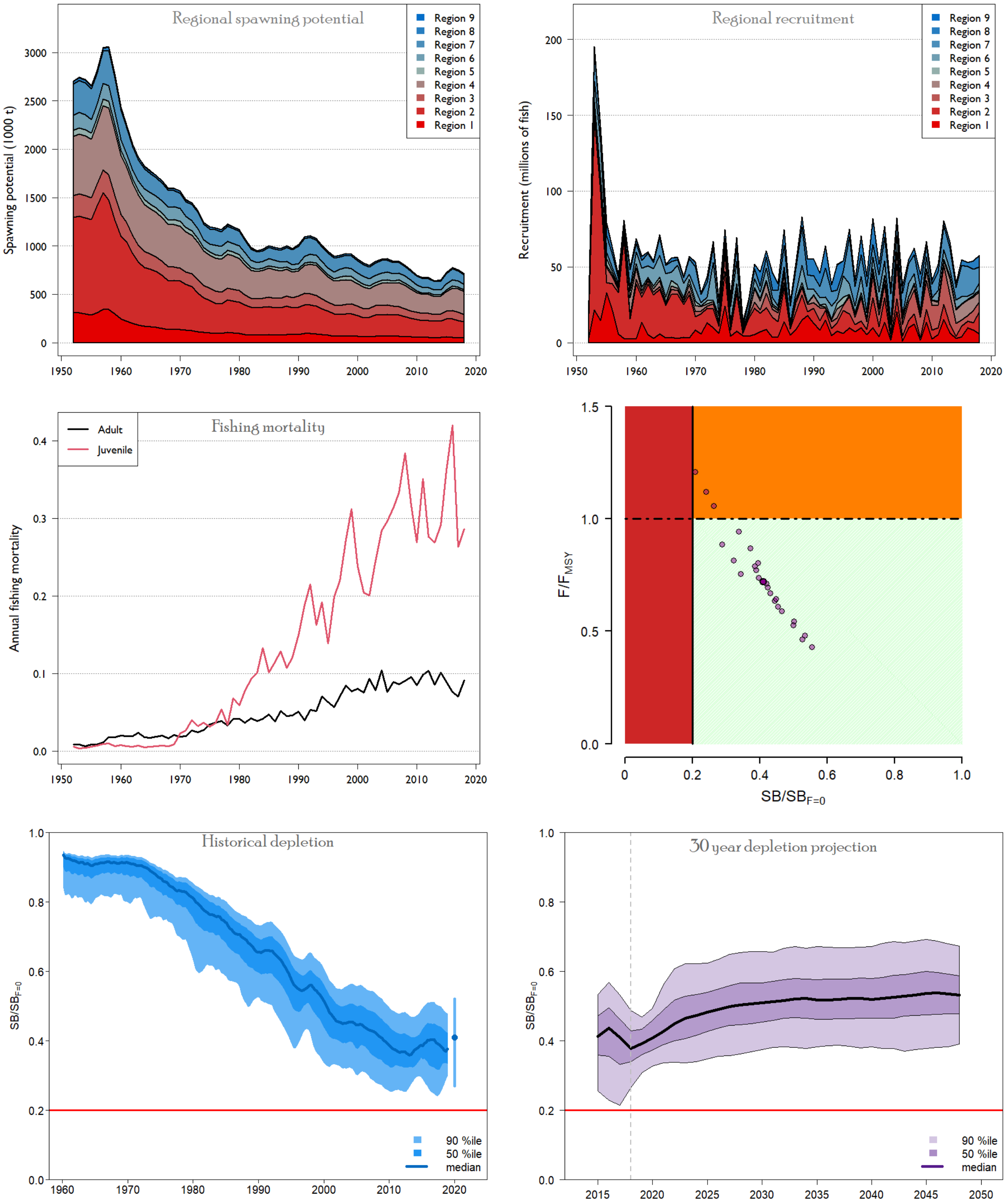


Figure 13: Estimated spawning biomass (SB) time series by model region (top left), recruitment by model region (top right), and fishing mortality for adults and juveniles (middle left) from the bigeye diagnostic case model; stock status displayed on a Majuro plot as the end points (‘recent values’) from the uncertainty grid of 24 models (middle right) with the weighted median value illustrated by the large purple point; the estimated level of depletion across the grid (bottom left), and 30-year projected depletion, under the “recent recruitment” (2007–2016) assumption, based on actual catch/effort levels through 2021, and assuming 2021 fishing catch/effort levels afterwards (bottom right). Note that depletion is represented differently between the historical and projection plots. Historical depletion is computed instantaneously, i.e. annual spawning biomass divided by annual estimate of spawning biomass in the absence of fishing. Vertical bar shows median depletion ($\mathrm{SB}_{recent}/\mathrm{SB}_{F=0}$) with 80th percentile estimates. For the projections, the spawning biomass in the absence of fishing is computed as a 10 year average lagged by one year relative to the year of the SB calculation.

South Pacific albacore catch data

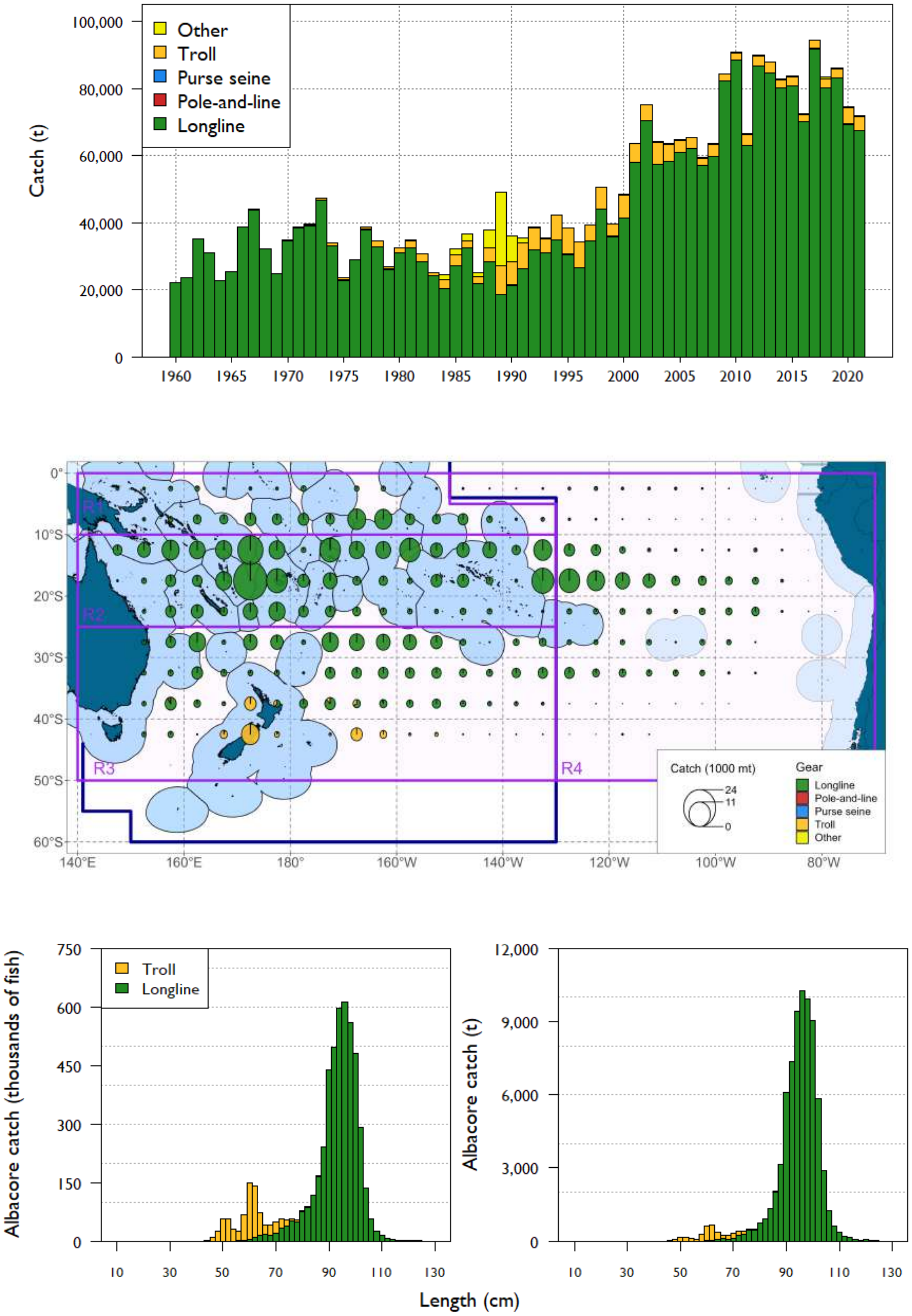


Figure 14: Time series (top), recent (2017–2021) spatial distribution and assessment regions (middle), and size composition (average for last five years, bottom) of South Pacific albacore tuna catch by gear, Pacific-wide, south of the equator. Size data represent only WCPFC-CA-caught albacore.

South Pacific albacore stock status plots

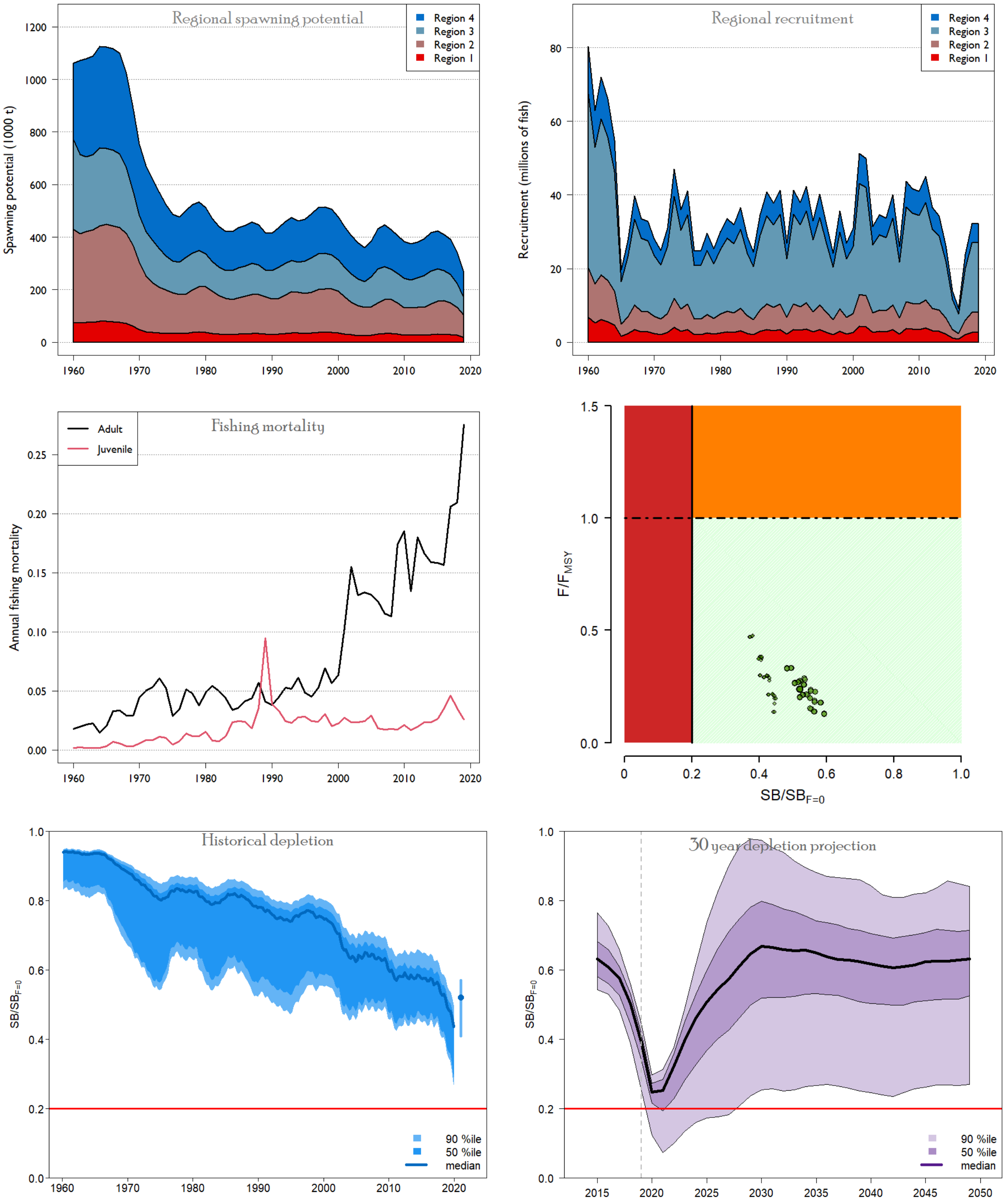


Figure 15: Estimated spawning biomass (SB) time series by model region (top left), recruitment by model region (top right), and fishing mortality for adults and juveniles (middle left) from the albacore diagnostic case model; stock status displayed on a Majuro plot as the end points ('recent values') from the uncertainty grid of 72 models (middle right) with the smallest dots indicating the down weighted SEAPODYM movement hypothesis and the single large green point is the weighted median value; the estimated level of depletion across the grid (bottom left), and 30-year projected depletion based on actual fishing levels through 2021, and assuming 2021 fishing levels afterwards (bottom right). Note that depletion is represented differently between the historical and projection plots. Historical depletion is computed instantaneously, i.e. annual spawning biomass divided by annual estimate of spawning biomass in the absence of fishing. Vertical bar shows median depletion ($SB_{recent}/SB_{F=0}$) with 80th percentile estimates. For the projections, the spawning biomass in the absence of fishing is computed as a 10 year average lagged by one year relative to the year of the SB calculation.

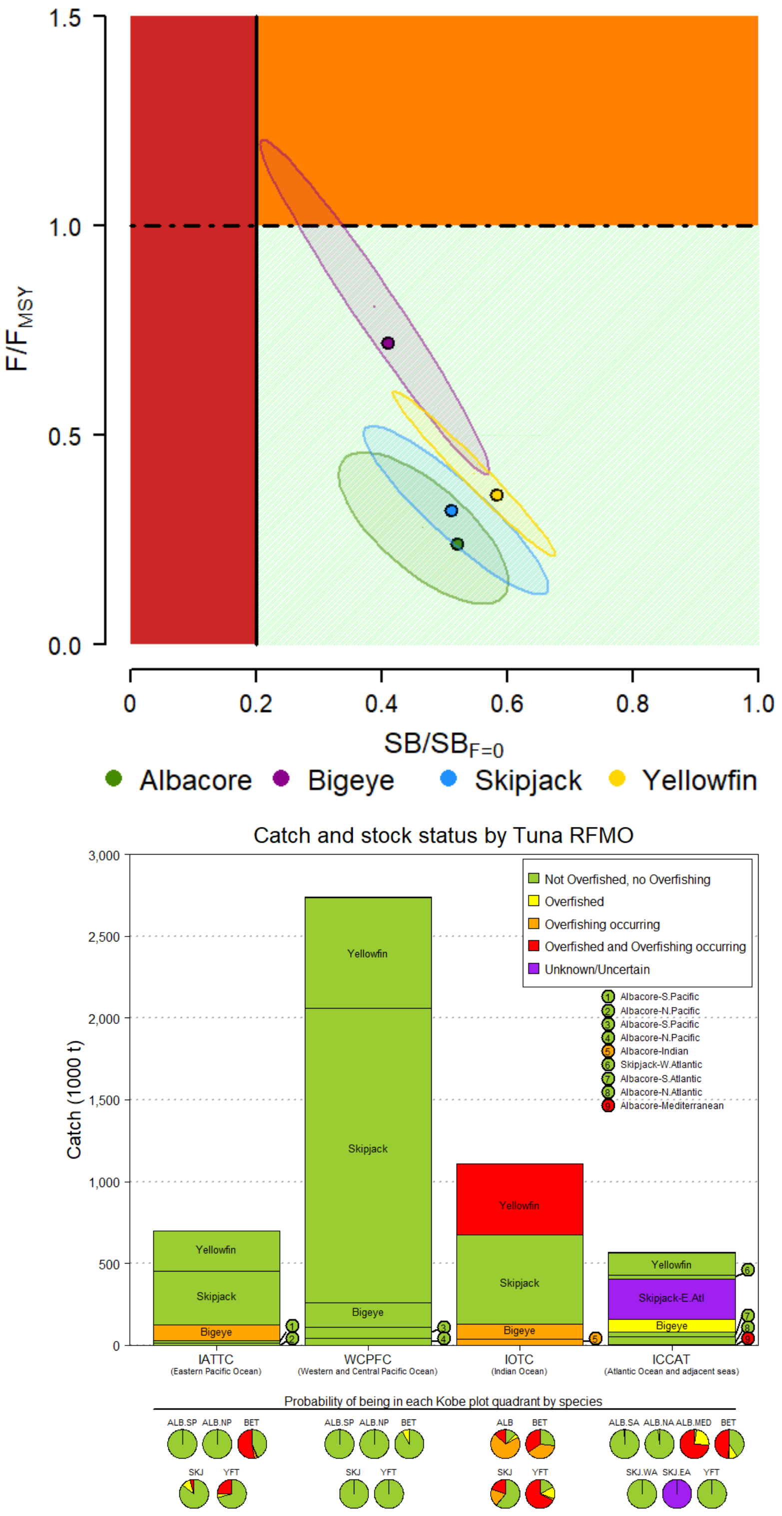


Figure 16: Majuro plot stock status summary for the four WCPO target tuna stocks (top) and a comparison of stock status for the same four tuna species in the other major ocean basins (bottom). In the Majuro plot, the grid median value is shown as a large dot, the ellipses closely approximate the distribution of values from grid models. Readers are referred to the individual species plots in earlier sections for more precise information on stock status from individual models in the uncertainty grid. The stock status comparison across ocean basins is based on spawning biomass and fishing mortality relative to their MSY values. Data are current as of October 2022 and stock status assessments were obtained directly from documents produced by the responsible tuna RFMO. See text for explanation of Kobe quadrant pie charts. Catch is average catch over the five most recent years available. The “Unknown/Uncertain” classification was used when the reliability of the reference points was stated to be uncertain or unreliable. Note that South and North Pacific albacore span both the WCPFC and the IATTC convention areas and are, therefore, included for both organisations, with the catch levels reflecting the split between the two convention areas.

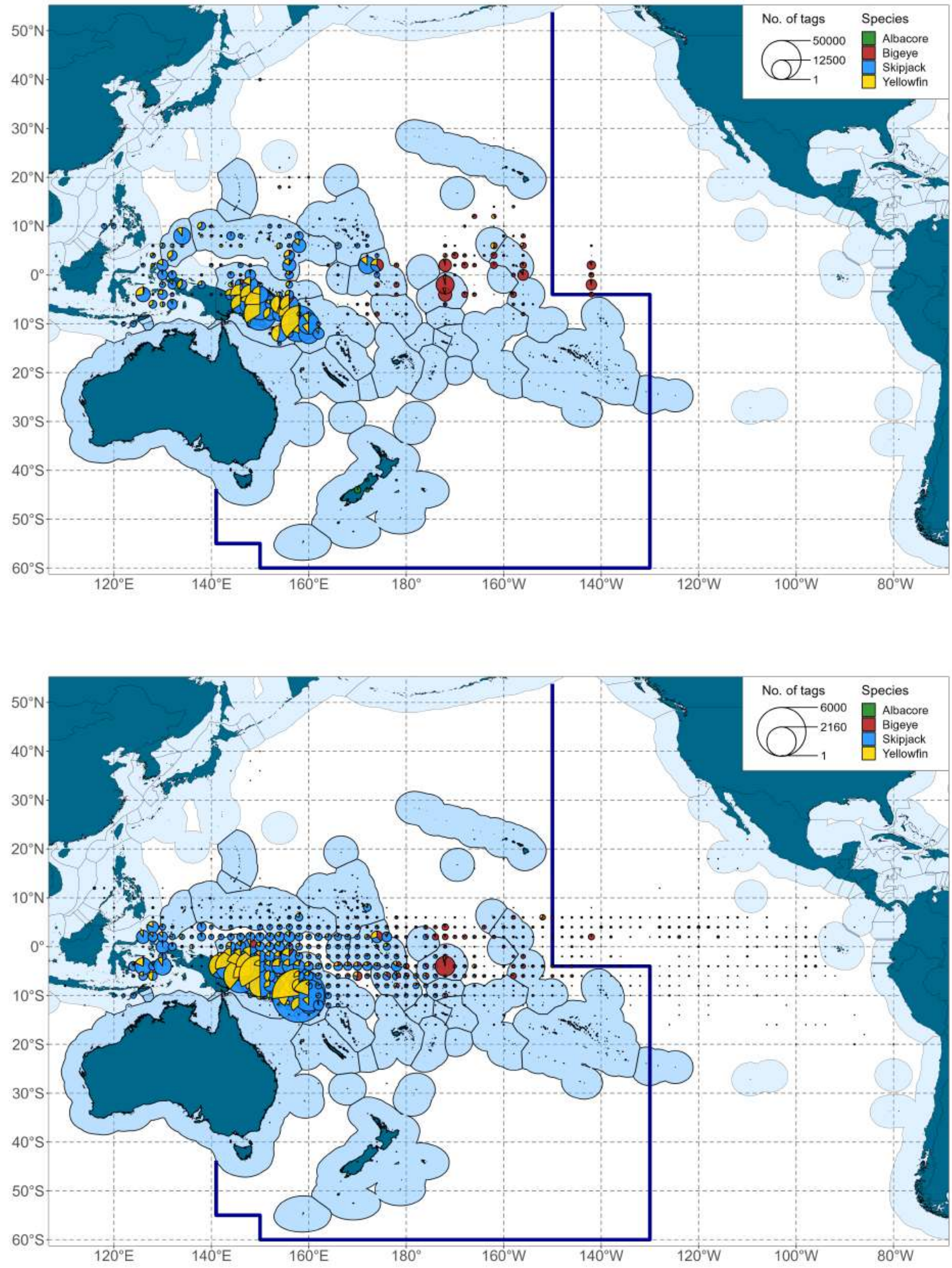


Figure 17: Tag releases (top) and recaptures (bottom) by species from the recent Pacific Tuna Tagging Programme (PTTP). Release and recovery locations have been aggregated to a 2° x 2° grid resolution for visual clarity.

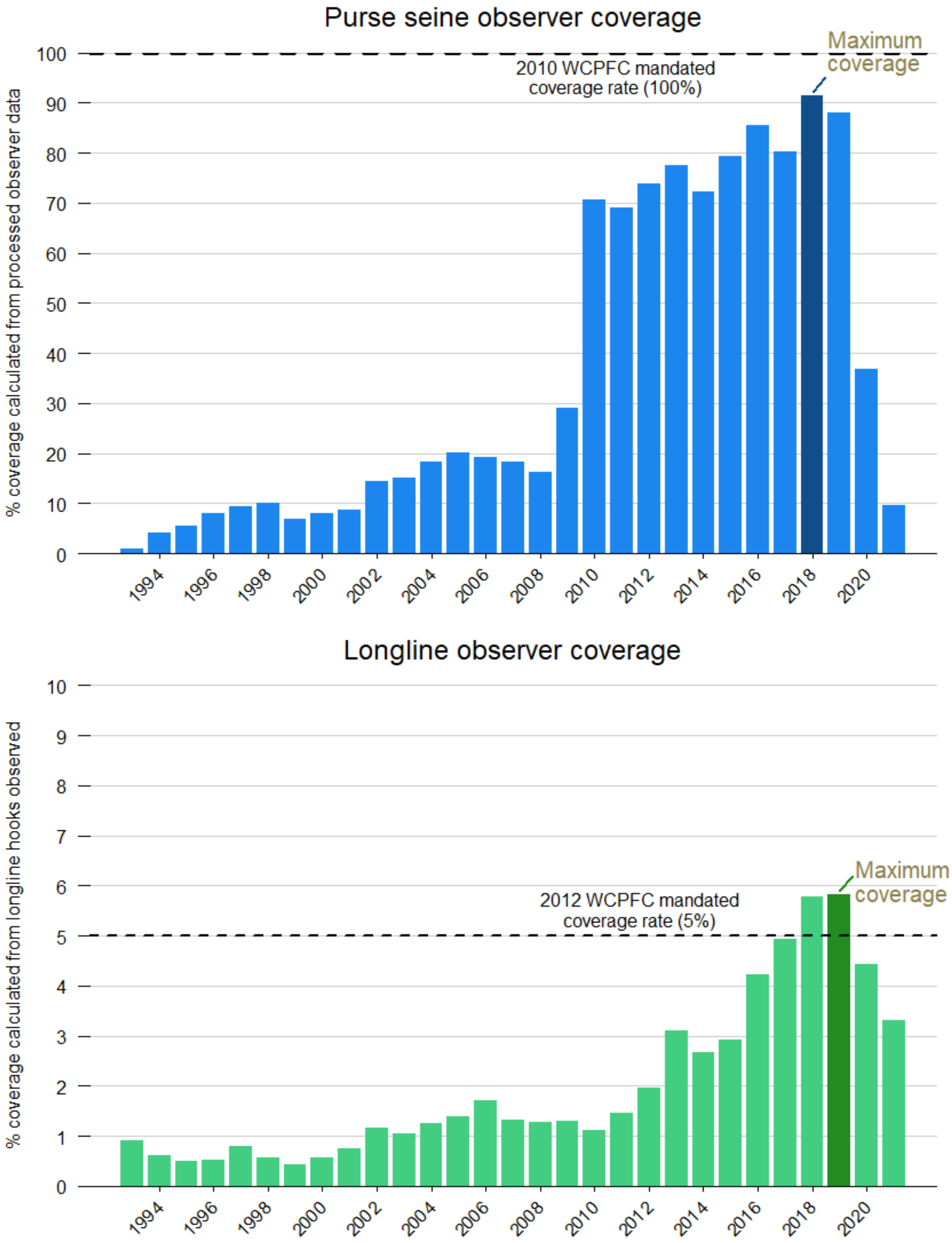


Figure 18: Observer coverage of the purse seine (top) and longline fleets (bottom) operating within the EEZs of the WCPFC-CA, over the period 1993-2021. Longline coverage is computed on the basis of hooks fished and includes fishing effort and observer coverage in both EEZs and the high seas. The Japan coastal longline fleet as well as the domestic longline fleets of Indonesia and Vietnam are excluded from effort summaries. Purse seine coverage is based on processed observer data records and represents fishing days at sea. Purse seine fishing days are computed from logsheets prior to 2010 and on VMS data for 2010-2021. Purse seine data are between 10°N and 10°S, and exclude the domestic purse seine fleets of Indonesia, Philippines and Vietnam.

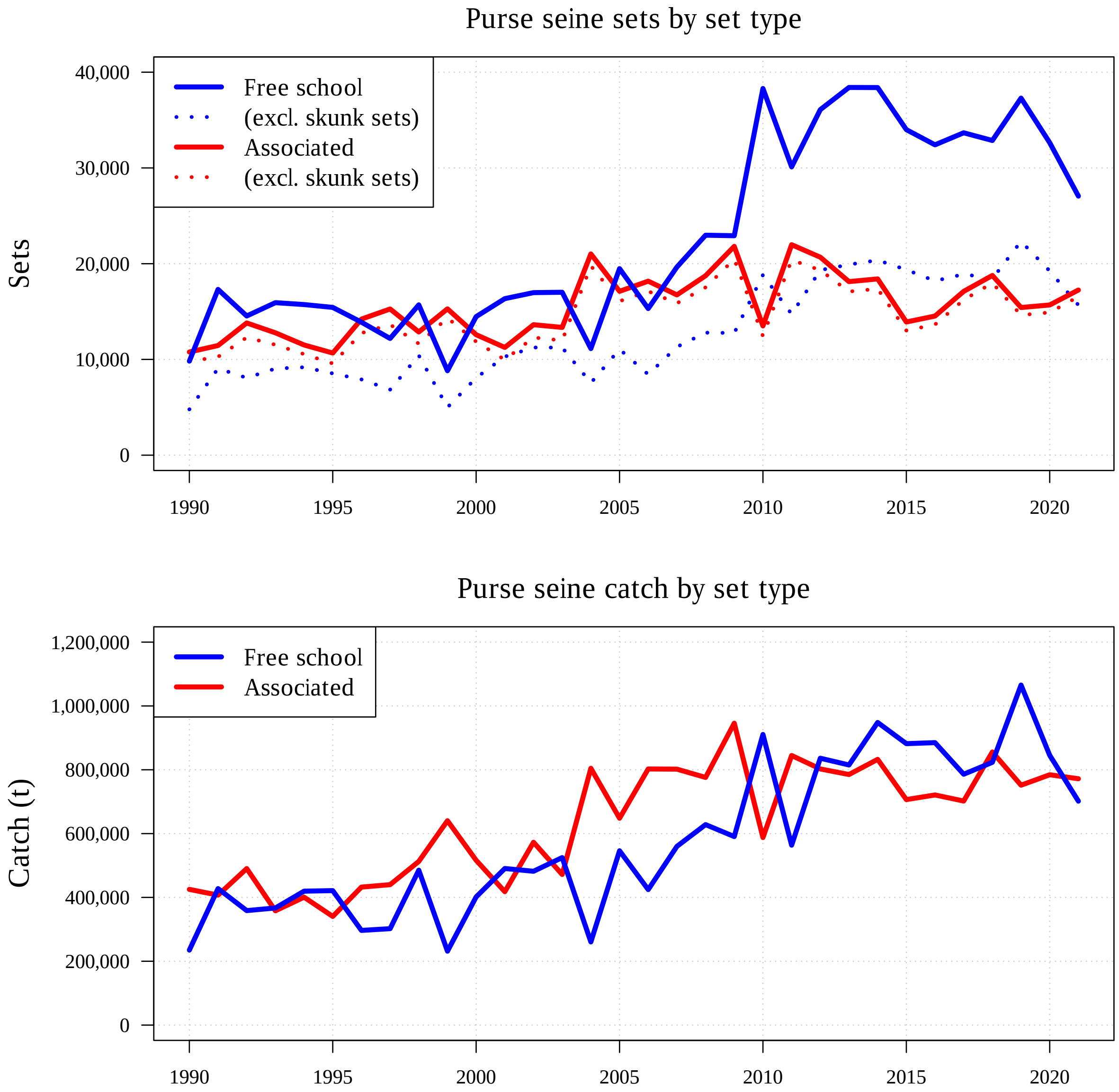


Figure 19: Illustration of the relative annual number of sets (top) and catch tonnage (bottom) by set association type (Free school vs. Associated) over the period 1990-2021. The associated sets includes all set association types, including FADs, logs, etc. Illustrated data are from raised logsheet data for the WCPFC tropical purse seine fishery excluding the domestic fleets of Indonesia, Philippines and Vietnam.

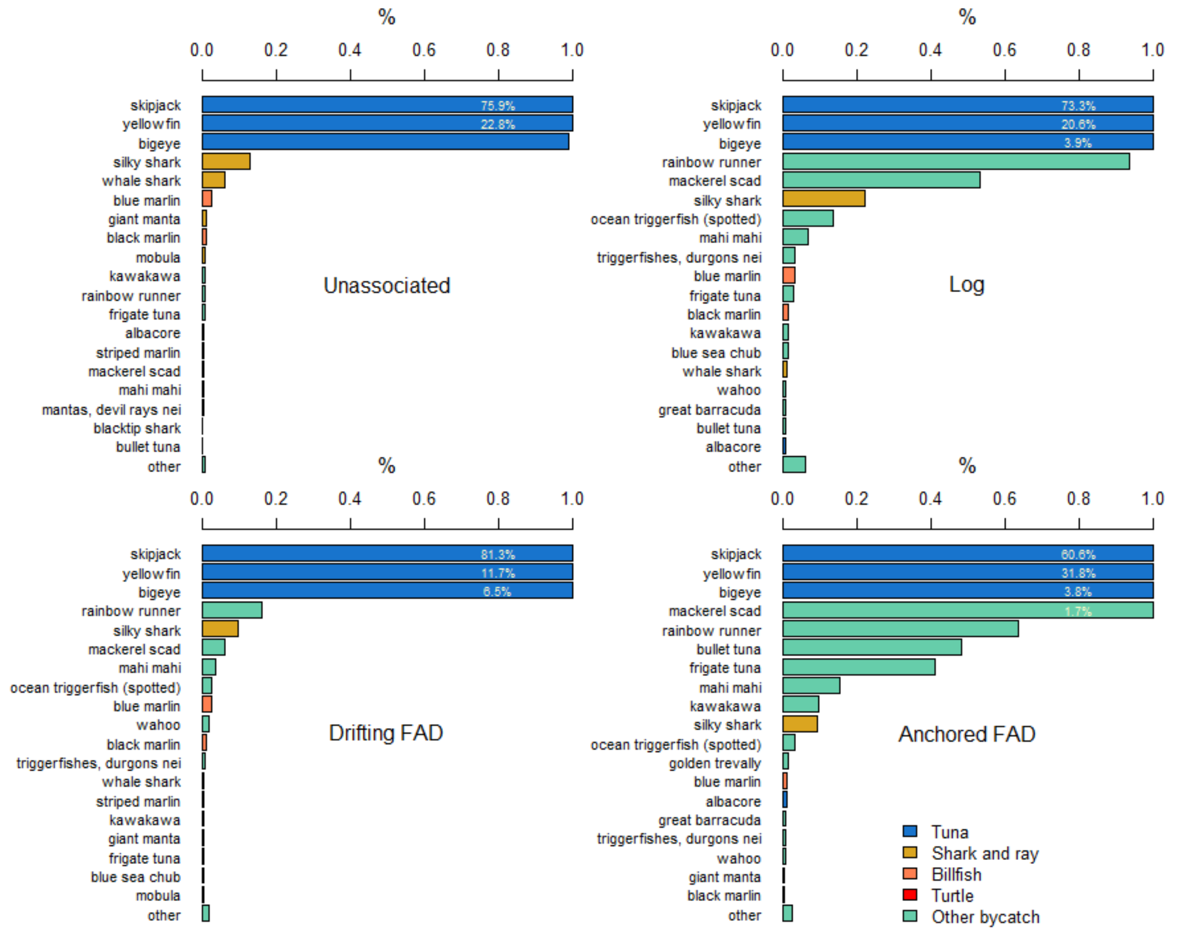


Figure 20: Catch composition of the various categories of purse seine fisheries operating in the WCPFC-CA based on observer data from the last five years' data.

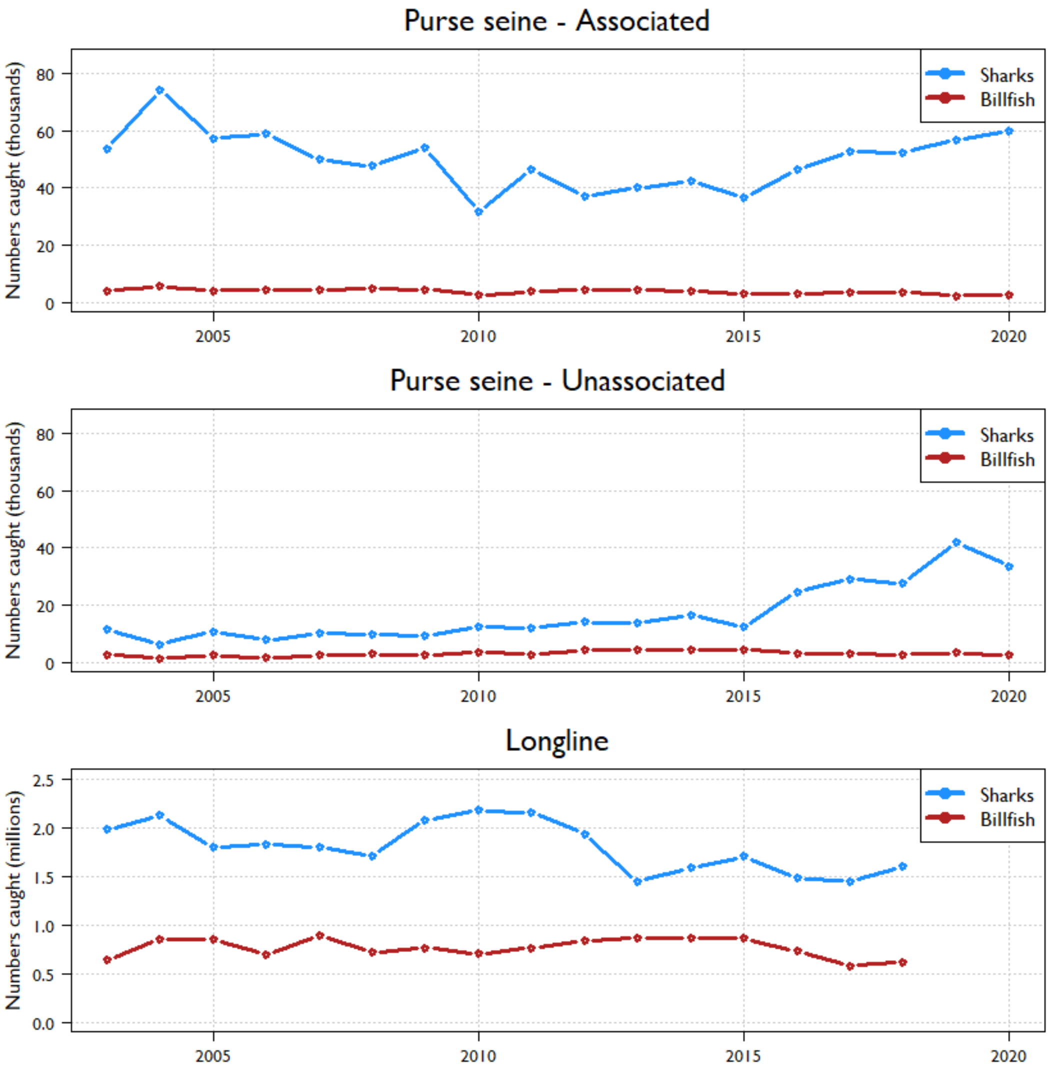


Figure 21: Estimated total catch (in numbers) of shark and billfish in the purse seine and longline fisheries operating in the WCPFC-CA. Purse seine estimates, for the period 2003-2020, are shown separately for associated sets (top figure) and unassociated sets (middle figure). Longline estimates cover the period 2003-2018 and are illustrated in the bottom figure. Note that the y-axis differs for the two gear types; numbers caught are in thousands for purse seine gear and millions for longline gear.

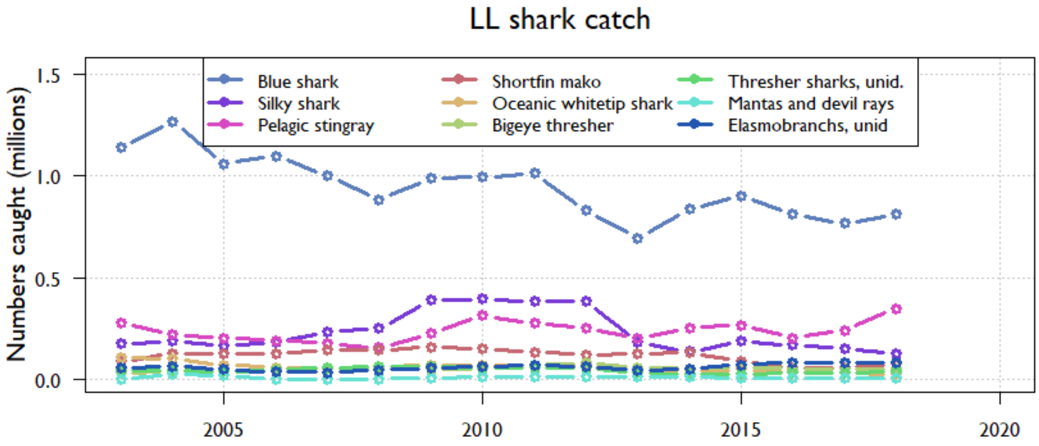


Figure 22: Estimated species composition of the longline shark catch in the WCPFC-CA, 2003-2018.

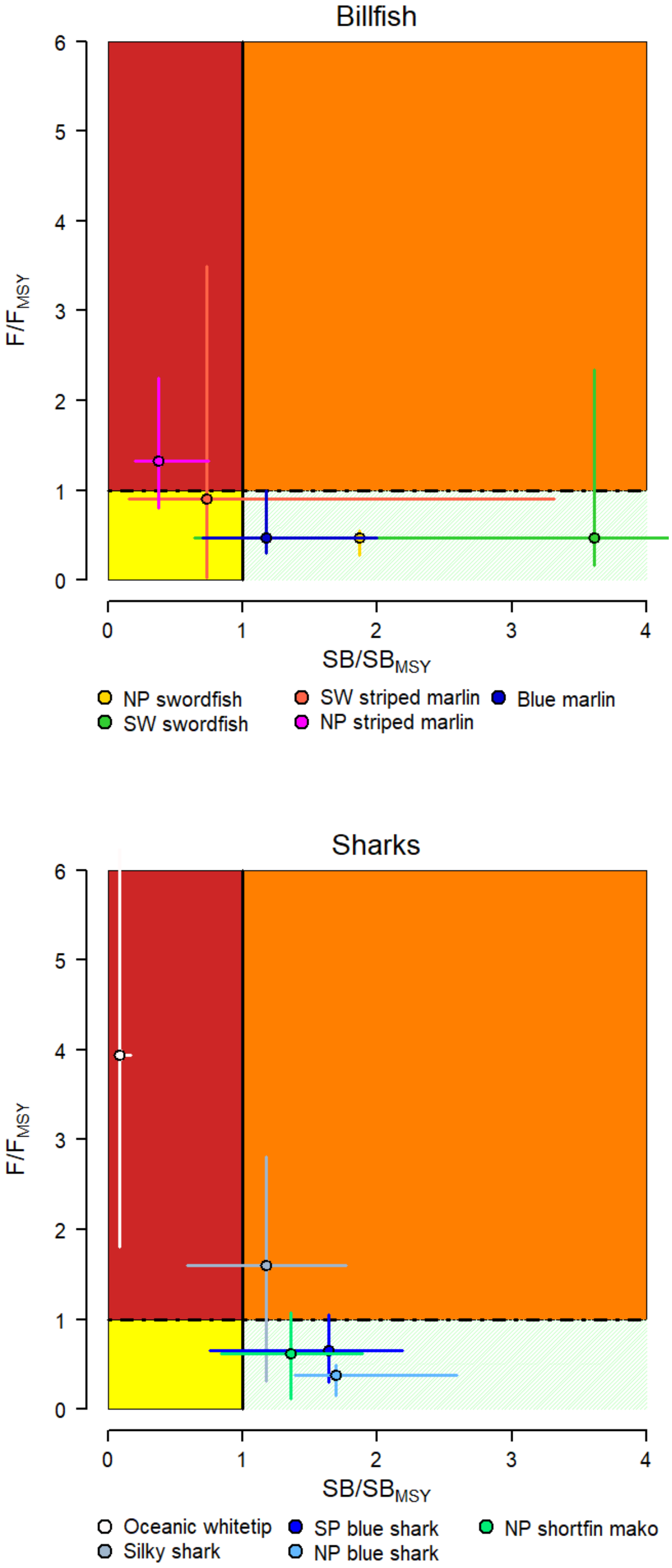
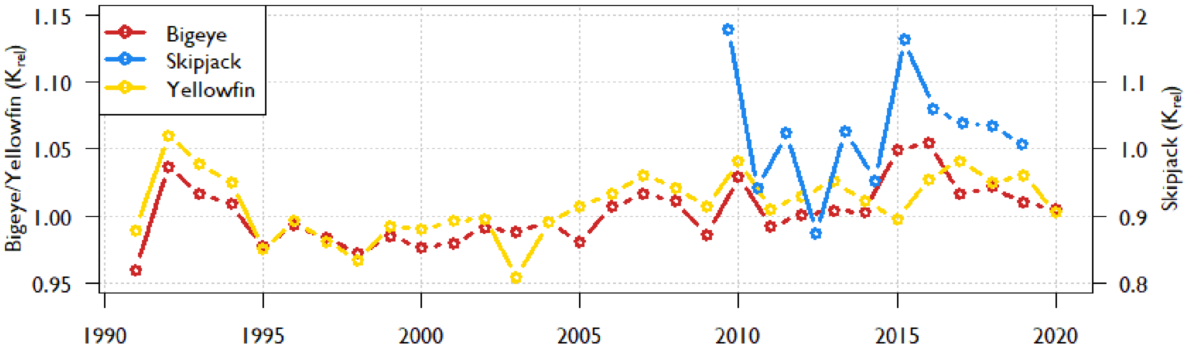


Figure 23: Kobe plot stock status summary for five species of WCPFC-CA billfishes (top) and sharks (bottom) assessed over the past decade and for which stock status has been determined. Note that this plot differs from that presented for the target tuna (the "Majuro" plot), because the WCPFC has not yet decided on LRPs for these species and therefore MSY-based reference points are used as a default.

Ecosystem and climate indices

Mean fish condition



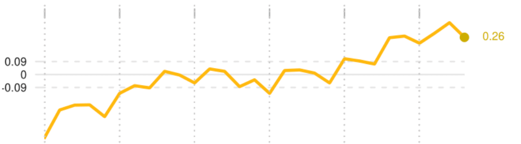
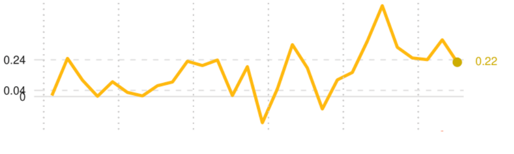
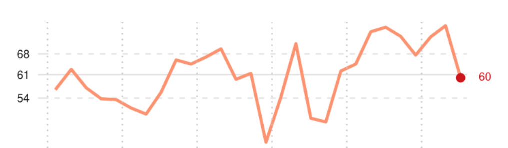
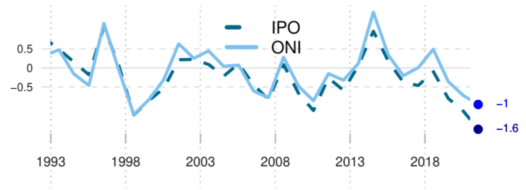
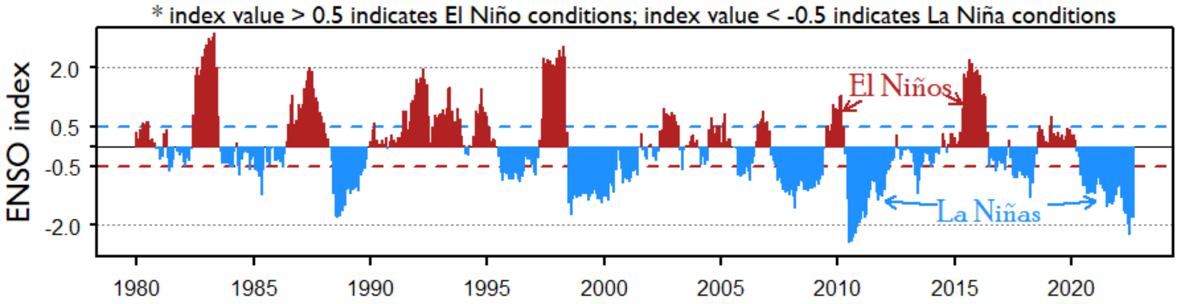
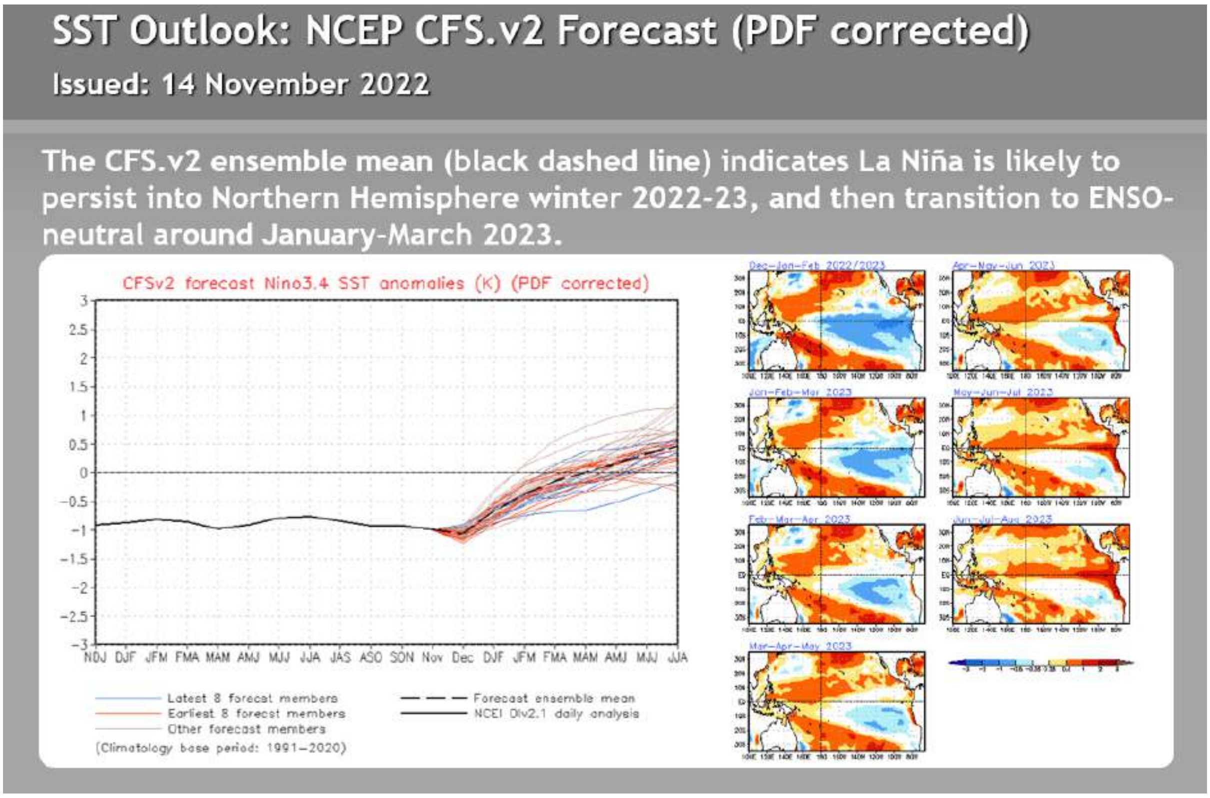
Indicator	Description	Notes	Time-series
Sea Surface Temperature Anomalies			Mean/Reference Value — — Central 50% of data range
Annual SST Anomaly	Mean annual SST anomaly (°C) across **WCPO area**	- Derived from ocean models - WCPO area western limit of 130°E - Anomaly from mean temperature 1993-2021	
	Mean annual SST anomaly (°C) across **WCPO equatorial zone**	- Derived from ocean models - Equatorial zone 5°S-5°N - Anomaly from mean temperature 1993-2021	
Nov-Apr Warm-pool SST Anomaly	Mean annual SST anomaly (°C) within warm-pool extent	- Derived from ocean models - Warm-pool defined by mean Nov-Apr temperature > 29°C	
Warm-pool Indices			
Mean Size of Warm-pool	Approximate size of warm-pool in millions of km²	- Derived from ocean models - Warm-pool defined by mean Nov-Apr temperature > 29°C	
Eastern Limit of Warm-pool Boundary	Longitude of strongest sea surface salinity boundary	- Derived from ocean models - Boundary defined as largest change over 10° distance	
Mean Warm-pool Mixed Layer Depth	Mean depth (m) of the mixed layer within warm-pool	- Derived from ocean models - Layer over which water temperature is homogenous	
Climate Indices			
Oceanic Niño (ONI) and Interdecadal Pacific Oscillation (IPO) Index	ONI indicates SST anomalies in the Niño 3.4 region during Nov-Jan each year IPO represents long-term oscillation between ENSO phases	- ONI values > 0.5 indicative of El Niño events, values < -0.5 indicative of La Niña - IPO values > 0 indicative of more El Niño events, < 0 indicative of more La Niña events	

Figure 24: Ecosystem and climate indicators developed to monitor the oceanic environment of the WCPFC-CA. Top: Mean fish condition of longline caught tuna. Bottom: WCPO Climate indices. See text for details.

El Niño Southern Oscillation figures





SST Outlook: NCEP CFS.v2 Forecast (PDF corrected)

Issued: 14 November 2022

The CFS.v2 ensemble mean (black dashed line) indicates La Niña is likely to persist into Northern Hemisphere winter 2022-23, and then transition to ENSO-neutral around January-March 2023.

Figure 25: Top figure: The "Multivariate Enso Index' (MEI)', over the period 1980-2022 (source: https://www.psl.noaa.gov/enso/mei. The MEI provides a long term perspective on the strength and duration of ENSO events; the ENSO gauges in Figure 26 were derived from this index. Bottom figure: The most recent ENSO forecast at the time this TFAR went to press. A third consecutive La Niña event (overall negative sea surface temperature anomaly and westward extension of the "cold tongue" into the western Pacific) is currently underway and is forecasted to continue until March 2023 (source: https://www.cpc.ncep.noaa.gov, forecast date: 14 November 2022).

El Niño Southern Oscillation figures, cont.

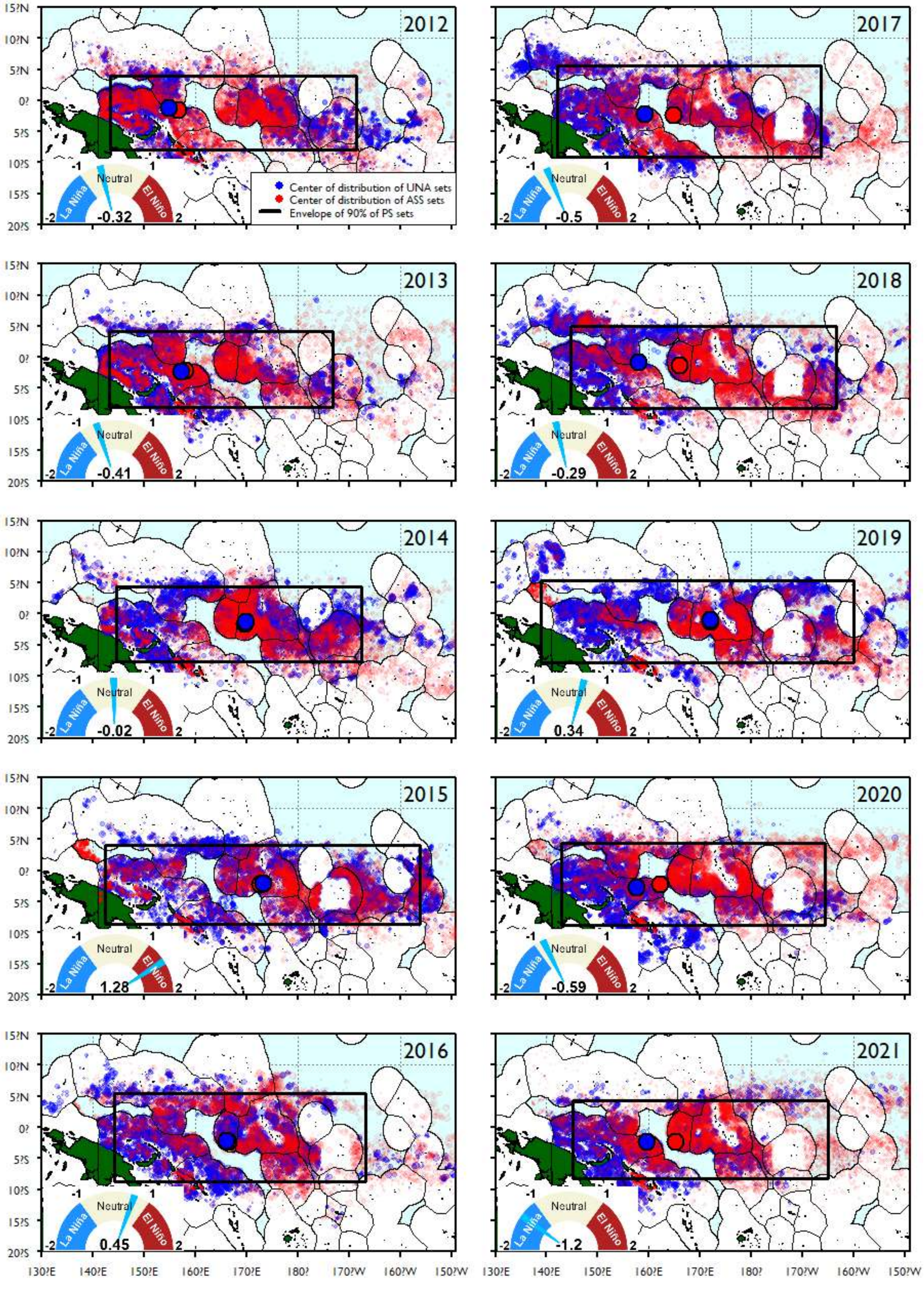


Figure 26: Illustration of the annual distribution of WCPO free school and associated sets over the period 2012-2021. Each point is scaled relative to catch size and FAD-Associated ('ASS') and Free school ('UNA') sets are coloured differently. The large coloured dots show the center of distribution for the two set types. The black box bounds 90% of all sets both north-south and east-west. The ENSO gauge in the lower left corner of each figure is the annual average of the Multivariate Enso Index (MEI), which is further described and illustrated in Figure 25. Illustrated data are from raised logsheet data for the WCPFC tropical purse seine fishery excluding the domestic fleets of Indonesia, Philippines and Vietnam.

Climate change projections

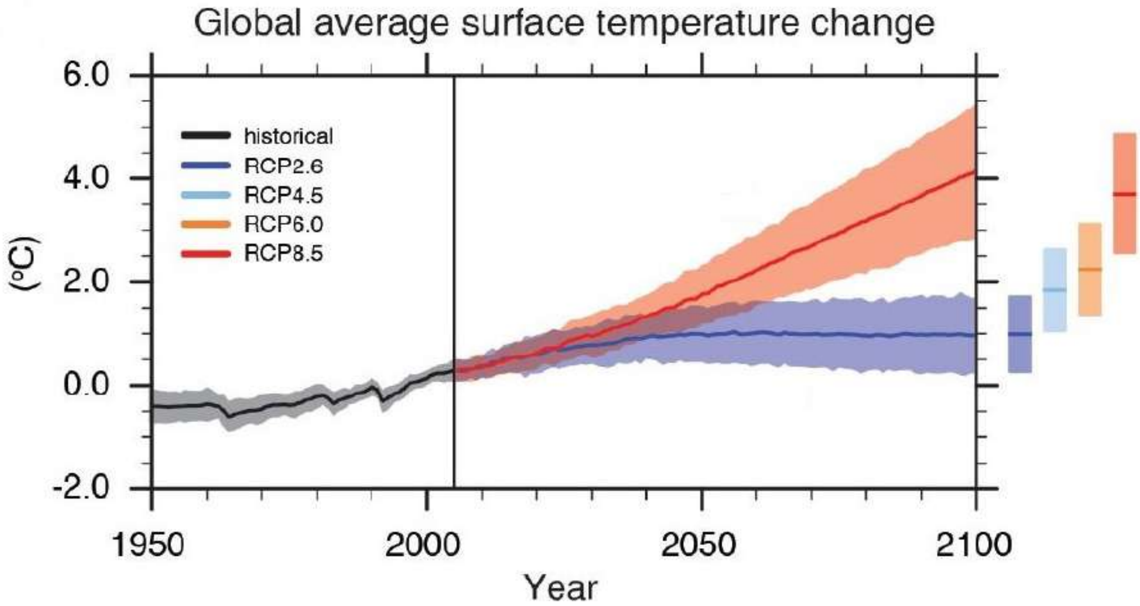


Figure 27: Two global temperature change projections developed for the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5). The illustrated trajectories represent two scenarios, termed "Representative Carbon Pathways" (RCP), reflecting different assumptions about human reponse to future greenhouse gas emissions. RCP 2.6 and RCP8.5 reflect extremes between a strong coordinated effort to reduce emissions by 30% from baseline conditions by 2100 (RCP2.6) and a "no climate policy" response wherein emissions continue to increase at current levels (RCP8.5). The bars on the right show projected temperature increases in the year 2100, and include the two other scenarios (RCP4.5 and RCP6.0) listed in the legend, for which the full time series are not displayed. Source: IPCC 2014

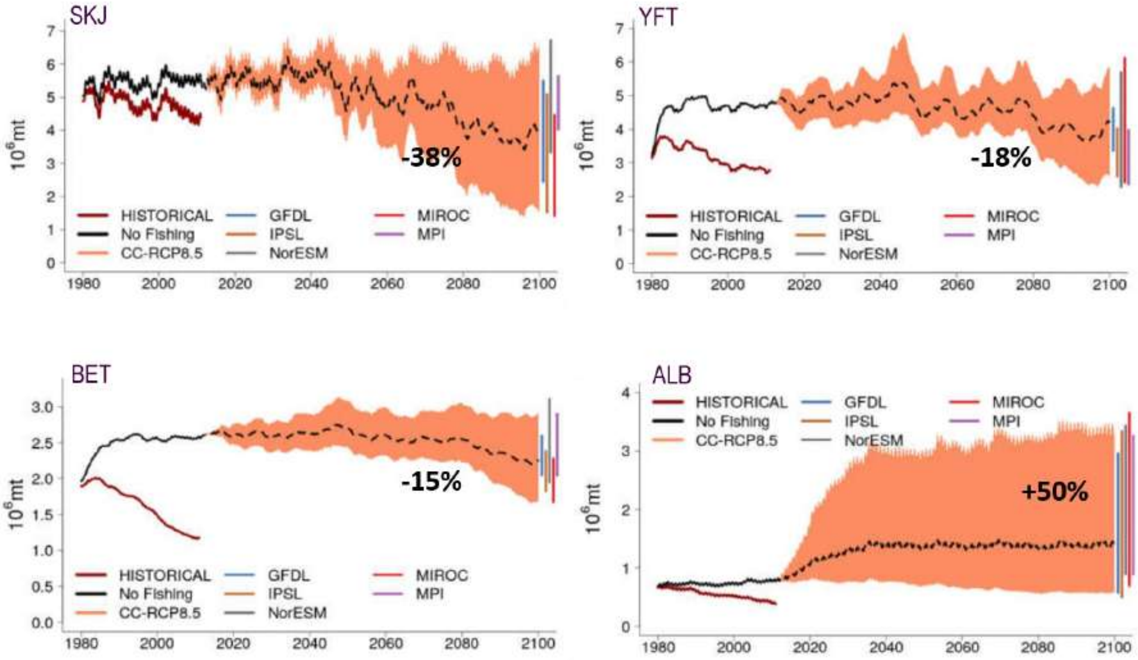


Figure 28: Envelope of predictions computed from simulation ensembles under IPCC RCP8.5 scenario for the WCPO for skipjack (SKJ), yellowfin (YFT), bigeye (BET) and albacore (ALB) tuna. The change in total biomass is presented with the average (dotted line) and its envelope bounded by the 5% and 95% quantile values of the simulation ensembles. The percentage values represent the change in the mean biomass across runs in the 1990–2010 time window compared with 2090–2100. The bars on the right hand are projected 2100 values corresponding to the four RCP scenarios defined in Figure 27. Modified from Senina et al. (2018).

Climate change projections, cont.

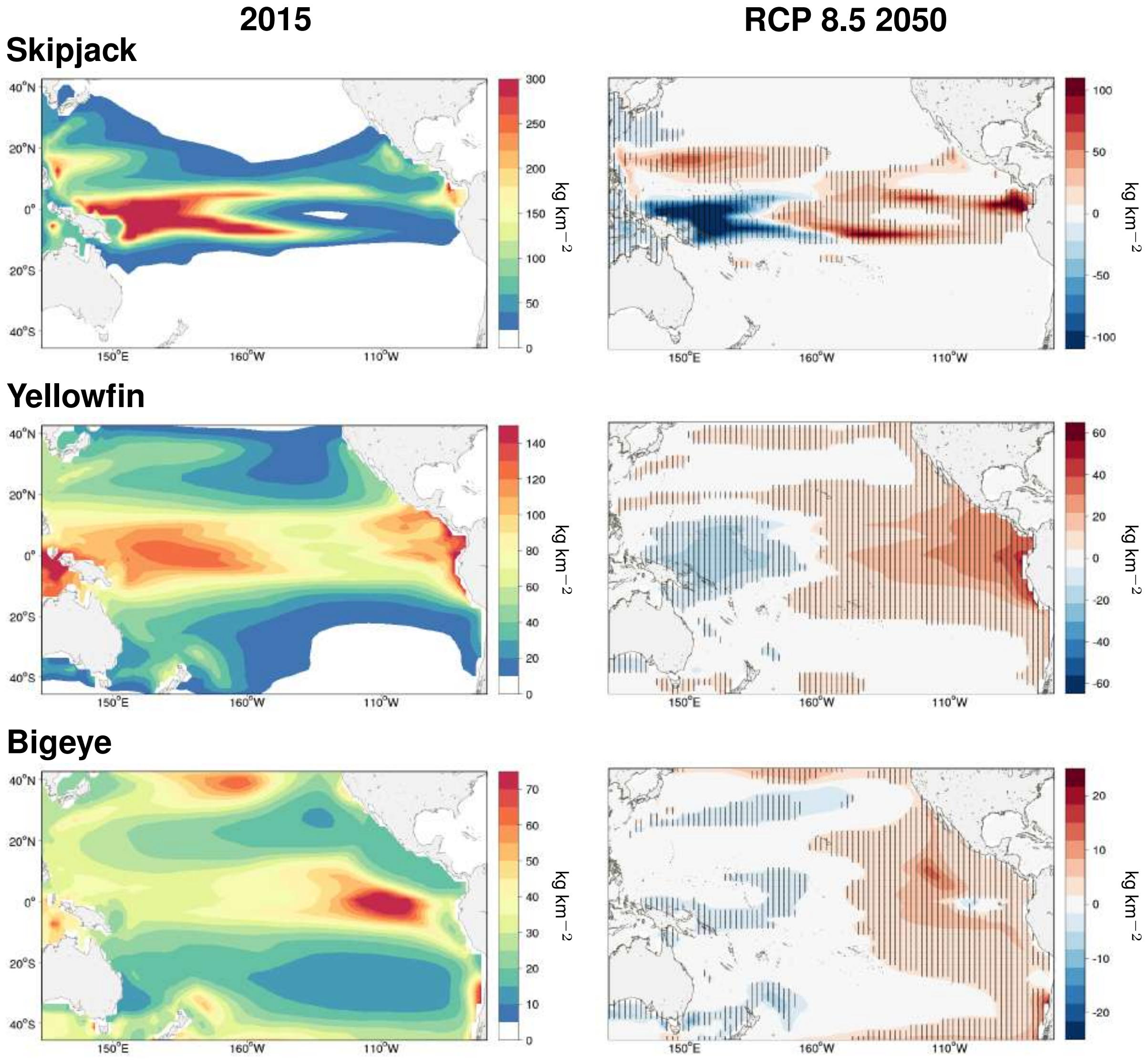


Figure 29: Average biomass distributions (kg-km^2) of skipjack, yellowfin and bigeye tuna in the Pacific Ocean basin for 2015 (averaged over 2011-2020) (left), and mean anomalies (kg-km^2) from the average 2015 biomass distribution of each tuna species projected to occur by 2050 (averaged over 2044-2053) under the RCP 8.5 greenhouse gas emissions scenario (right). Shading indicates areas where projections from four Earth System Models agree in the sign of change. Source: Bell et al. (2021).

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