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A compendium of fisheries indicators for target tuna stocks in the WCPFC Convention Area

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Contents

1 Executive Summary

The principal purpose of this paper is to provide empirical information on recent patterns in fisheries for the SC's consideration. For SC18, we present a compendium of fishery indicators for all 'key' target tuna species (skipjack, bigeye, yellowfin and South Pacific albacore tuna). In 2022, a full stock assessment was conducted for skipjack but not for South Pacific albacore, bigeye or yellowfin. Trends for South Pacific albacore tuna are also described in the regularly requested stand-alone paper: *Trends in the South Pacific albacore longline and troll fisheries* (McKechnie et al., 2022).

The indicators that are documented include: total catch by gear, nominal CPUE trends, spatial distribution of catch and associated trends, size composition of the catch and trends in average size. These include data available from the WCPFC databases as of 12 July 2022. It is difficult to confidently interpret the stock status-related implications of trends in any indicators in isolation from other data sets and a population dynamics model. Therefore, short-term stochastic projections for WCPO South Pacific albacore, bigeye and yellowfin stocks are also presented to assess potential stock status at the end of 2022 in light of recent catch and effort trends.

2 Data and Methods

To track developments in key target tuna species not formally assessed in the current year, a formal request was made to develop stock indicators (Scientific Committee's Work Programme for 2008-2010, Project 24), and these were first reported to SC4 in 2008 (Hampton and Williams, 2008). More recent versions of this now-annual SC paper have addressed the request from SC9 for descriptive text to assist in interpreting the paper contents.

Stock indicators for skipjack, bigeye, yellowfin and South Pacific albacore tuna are presented here. Skipjack had a full assessment conducted this year (Castillo-Jordan et al., 2022) and will be presented at SC18. South Pacific albacore was assessed in 2021 (Castillo-Jordan et al., 2021); bigeye and yellowfin tuna were last assessed in 2020 (Ducharme-Barth et al., 2020 and Vincent et al., 2020, respectively). Commentary provided in this paper compares the values of various indicators to previous years, in particular comparisons of 2021 values to 2020 and to the average from 2016-2020.

Short-term stochastic projections for WCPO bigeye, yellowfin and South Pacific albacore are included for further information; projections for WCPO skipjack are not provided as an assessment is being conducted in 2022 and the final model uncertainty grid has not yet been approved by SC. For bigeye and yellowfin stocks, projections were from 2018, and for South Pacific albacore from 2019, using the most recent assessments (Ducharme-Barth et al., 2020, Vincent et al., 2020, Castillo-Jordan et al., 2021). Future recruitments were modelled as deviations around the stock recruitment relationship from the period over which the stock-recruitment relationship was estimated within the assessment model. For each stock, projections were performed over the grid of assessment runs defined by SC16 (bigeye and yellowfin) and SC17 (South Pacific albacore) and results were weighted as defined by the relevant SC meeting. Stocks were projected through 2019, 2020 and 2021 as necessary using actual catch and effort levels in those years, and then through to 2023 assuming 2021 catch and effort levels remained constant. We note that the near-future stock status of most of these stocks will initially be influenced by recent recruitment levels estimated within the stock assessment model, and they by the estimated stock recruitment relationship and random recruitment deviations sampled from the historical period. Those recruitments will take several years to reach the adult biomass, dependent on the species.

Indicators are based on annual catch estimates for the WCPFC Convention Area, and aggregate catch and effort data for the gear specific analyses. In some instances, individual fleets have been used for particular indicators. Given the large number of indicators, descriptive text is tabulated below for each stock.

Please note that the figures here may include or exclude specific fleets that are included in summaries made for other purposes (e.g. CMM tables) and therefore these numbers may not be identical to those produced elsewhere. Furthermore, these numbers will change as more data become available.

3 Note on reduced observer coverage in 2020 and 2021

Observer coverage levels were greatly reduced in 2020 and 2021 due to the impacts of COVID-19. To estimate the potential errors associated with lower observer sampling rates, Peatman et al. (2022) reviewed potential impacts on purse seine species composition estimates. They determined that catch estimates of bigeye, and to a lesser extent yellowfin, were most sensitive to reduced observer coverage.

Regarding the figures presented and discussed in this paper, the indicators potentially most affected by the reduced observer coverage are the 2020/2021 values for the total purse seine catch and CPUE estimates for bigeye, yellowfin and skipjack. Size distributions of catch may also be affected by the decreased sampling of on-board catch. Longline catch and CPUE are likely less affected.

Acknowledgments

The authors would like to thank Nan Yao for a careful of the final draft of this paper.

4 References

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Skipjack tuna

Figure	Indicator	Description
Figure 1	Total catch by gear	Total catch in 2021 was 1,547,945t, a 10% decrease from 2020 and a 14% decrease from the 2016-2020 average. Purse seine catch in 2021 (1,254,022t) was a 11% decrease from 2020 and a 13% decrease from the 2016-2020 average. Pole and line catch (97,908t) was a 39% decrease from 2020 and a 37% decrease from the 2016-2020 average catch. Catch by other gears (see Williams and Ruaia (2022) for descriptions) totaled 192,182t; a 25% increase from 2020 and 5% decrease from the average catch in 2016-2020. In 2021, percentage catch by gear was: purse seine - 81%, other gear - 12%, pole-and-line - 6%, longline - <1%.
Figure 2 - top	Tropical pole and line CPUE	Pole and line CPUE for the Japanese fleet in 2021 (7t per day) increased by 21% from 2020 and increased by 12% from the 2016-2020 average. Pole and line CPUE for the Solomon Islands fleet in 2021 (2.89t per day) increased by 56% from 2020 and increased by 57% from the 2016-2020 average. The 2021 Solomon Islands fleet CPUE was the highest in nearly a decade, and close to the mean CPUE level of 3-5 mt/day between 1990 and 2014.
Figure 2 - bottom	Tropical purse seine CPUE	Free-school CPUE in 2021 (22.94t per day) decreased by 2% from 2020 and decreased by 5% from the 2016-2020 average. Log-associated CPUE in 2021 (13.62t per day) decreased by 43% from 2020 and decreased by 50% from the 2016-2020 average. Drifting FAD CPUE in 2021 (30.76t per day) decreased by 16% from 2020 and decreased by 16% from the 2016-2020 average. Anchored FAD CPUE in 2021 (14.01t per day) increased by 32% from 2020 and increased by 6% from the 2016-2020 average.
Figure 3	Maps of catch by gear	Compared to the longer time frame, the reduction in pole and line catch in recent years is notable, particularly in the equatorial zone. Two consecutive relatively strong La Niña events shifted catches in 2020 and 2021 westward from the distribution during the preceding five years; a period that saw a preponderance of El Niño conditions.
Figure 4	Purse seine effort and CPUE maps	Purse seine CPUE has generally been higher in the central and eastern regions of the tropical WCPO, with some notably high catch rates achieved at the margins of this area, particularly towards the WCPFC-CA northeast equatorial region.
Figure 5	Spatial concentration of catch	90% of the purse seine catch in 2021 was taken in 596 1^ox 1^o squares. This was a 11% decrease from 2020 and a 9% decrease from the 2016-2020 average. Over the longer term (25 years), the minimum number of 1^ox 1^o squares in which 90% of the purse seine catch has been taken has slowly, but steadily, increased from a range of 550-600 to a range of 600-650. 90% of the pole and line catch was taken in 262 1^ox 1^o degree squares. This was an 3% increase from 2020 and an 11% decrease from the 2016-2020 average. After experiencing a sharp contraction between 1980 and 2000 (from 800+ to less than 400 cells), the pole-and-line fishery has been relatively steady over the past 20 years, in terms of how many 1^ox 1^o cells (between 250 and 350) from which 90% of the catch has been taken.
Figure 6	Catch at length by gear type in both numbers and weight	In most years, the catch at length in numbers of fish is broadly bimodal. One peak comprises small fish, generally smaller than 40 cm, taken in the Indonesia/Philippines fisheries; the other peak is comprised of larger fish, generally between 45 and 70 cm, mostly caught in the purse seine fisheries. While numbers of skipjack caught is roughly equal between the two fisheries, catch by weight is dominated by the purse seine fisheries. In 2021, the purse seine weight frequency distribution was strongly concentrated between fish of lengths between 40 and 60 cm, more so than any year in the past decade. This truncated distribution may be due to COVID-related sampling reductions.

Figure	Indicator	Description
Figure 7	Mean weight by gear type	The mean weight of individual fish taken across all gears in 2021 (1.74kg) decreased by 1% from 2020 and decreased by 6% from 2016-2020 average. The mean weight of Indonesia / Philippines domestic caught fish (0.64kg) increased by 34% from 2020 and increased by 28% from the 2016-2020 average. The mean weight of pole and line caught fish (2.02kg) remained unchanged from 2020 and decreased by 5% from the average in 2016-2020. The mean weight of skipjack from FAD sets (1.96kg) increased by 6% from 2020 and decreased by 9% from the 2016-2020 average. The mean weight of skipjack from free-school (unassociated) purse seine sets (3.02kg) decreased by 18% from 2020 and decreased by 22% from the 2016-2020 average. Note that mean weight values from 2021 are likely biased due to overall low observer coverage with most observer coverage, and therefore size samples, coming from Papua New Guinea and Solomon Islands archipelagic waters and High Seas Pocket 1 catches.
NA	Stochastic stock projections	NA - as a new assessment has been undertaken in 2022, and final grid still to be selected by SC, no projection is presented for skipjack here.

South Pacific albacore tuna

Figure	Indicator	Description
Figure 8	Total catch by gear	For the southern WCPFC-CA, total albacore catch was 49,273t, a 24% decrease from 2020 and a 28% decrease from the 2016-2020 average. Longline catch in 2021 (44,698t) decreased by 25% from 2020 and decreased by 32% from the 2016-2020 average. Catch by other gear (mostly troll catch) (4,556t) decreased by 10% from 2020 and increased by 40% from the 2016-2020 average. In 2021, percentage catch by gear was: longline - 91%, other gear - 9%, pole-and-line - <1%, purse seine - <1%. Note that numbers may differ slightly to those tabulated in the South Pacific albacore trends paper (McKechnie et al., 2022).
Figure 9	Southern longline CPUE (south of 10^{o}S)	Japanese longline CPUE in 2021 (1.39 fish per 100 hooks) decreased by 8% from 2020 and increased by 15% from the 2016-2020 average. Korean longline CPUE (0.33 fish per 100 hooks) decreased by 29% from 2020 and decreased by 46% from the 2016-2020 average. Chinese longline CPUE (0.85 fish per 100 hooks) decreased by 17% from 2020 and decreased by 43% from the 2016-2020 average. Finally, Chinese Taipei longline CPUE in 2021 (1.26 fish per 100 hooks) decreased by 23% from 2020 and decreased by 30% from the 2016-2020 average. The Combined CPUE time series is a weighted average of the other time series; as there is only CPUE data for the Japanese fleet prior to 1963, the Combined CPUE trend is the same as the Japanese CPUE for those years. The 2021 Combined mean CPUE value of 3.84 fish per 100 hooks is the lowest on record.
Figure 10	Maps of catch by gear	In recent years, catches have concentrated in the 10^{o}S-20^{o}S latitudinal band. While 2021 estimates remain provisional, the spatial distribution of the longline catch is similar to the distribution of catches seen over the preceding 5-year period. The troll catch in 2020 and 2021 increased considerably from the previous few years, achieving a level last seen in the early 2000s.
Figure 11	Longline effort and CPUE maps	Over the entire time series, catch rates have been highest south of 10^{o}S, and the overall pattern is for increasing CPUE as you move from north to south. In the more recent period, catch rates have been highest in the high seas areas between 30^{o}S and 40^{o}S. CPUE in the region around southern Melanesia (Vanuatu, New Caledonia, Fiji) shows a decline over time, with 2021 values notably lower than the preceding five years.
Figure 12	Spatial concentration of catch	90% of the longline catch in 2021 was taken in 56 5^{o}x 5^o degree squares of the southern WCPO. This was a 2% increase from 2020 and a 5% increase from the 2016-2020 average. The trend over the past decade has been a steady increase in the minimum fished area to capture 90% of the catch, increasing from around 40 to around 55 5^{o}x 5^o degree squares.
Figure 13	Catch at length by gear type in both numbers and weight	The catch in numbers of fish and weight (t) shows that the largest fish are caught in the longline fisheries and the troll catch is made up of small fish, typically less than 80cm in length. There is little apparent trend in the peak of the length mode from the longline fishery. The recent (3-4 years) increase in the numbers, and total catch weight, of albacore in the 50-70cm size range over the previous three years landed by the 'Other' fishery sector, leveled off in 2021.

Figure	Indicator	Description
Figure 14	Mean weight by gear type	While the mean weight of individual fish taken across all gears is relatively stable over the long-term, 2021 (13.57kg) was a 3% increase from 2020 and a 5% decrease from the 2016-2020 average. The mean weight of longline caught fish (16.26kg) increased by 5% from 2020 and increased by 4% from the 2016-2020 average. The mean weight of fish caught in other gears (4.63kg), almost all troll, was a 5% increase from 2020 and increased by 2% from the 2016-2020 average.
Figure 15	Stochastic stock projections	Under recent fishery conditions, the South Pacific albacore stock component within the WCPFC Convention Areas is projected to decline, then recover slightly. The projections indicate that median WCPFC-CA $SB_{2023}/SB_{F=0} = 0.40$, and the corresponding risk that median $SB_{2023}/SB_{F=0} < LRP = 17\%$. Longline vulnerable biomass within the WCPFC-CA is 58% of the level seen in 2013 + 8%. MSY related metrics are developed at the South Pacific-wide scale. Median $SB_{2023}/SB_{MSY} = 1.75$. $F_{2019-2022}/F_{MSY} = 0.30$. The risk that $SB_{2023} < SB_{MSY} = 6\%$ and $F_{2019-2022} > F_{MSY} = 1\%$. Note the Limit Reference Point (LRP) is 20% $SB_{F=0}$.

Bigeye tuna

Figure	Indicator	Description
Figure 16	Total catch by gear	Total catch in 2021 was 169,113t, a 9% increase from 2020 and a 13% increase from the 2016-2020 average. Longline catch in 2021 (49,511t) decreased by 15% from 2020 and decreased by 22% from the 2016-2020 average. Purse seine catch in 2021 (79,167t) increased by 8% from 2020 and increased by 17% from the 2016-2020 average. Pole and line catch (1,682t) decreased by 5% from 2020 and decreased by 38% from the 2016-2020 average. Catch by other gears (see Williams and Ruaia (2022) for descriptions) totaled 38,753t and was an 81% increase from 2020 and 141% increase from the 2016-2020 average. In 2021, percentage catch by gear was: purse seine - 47%, longline - 29%, other gear - 23%, pole-and-line - 1%.
Figure 17 - top	Tropical pole and line CPUE	Japanese pole and line CPUE in 2021 (0.013t per day) increased by 450% from 2020 and decreased by 10% from the 2016-2020 average.
Figure 17 - middle	Tropical purse seine CPUE	Free-school CPUE in 2021 (0.32t per day) increased by 35% from 2020 and decreased by 13% from the 2016-2020 average. Log-associated CPUE in 2021 (1.62t per day) decreased by 10% from 2020 and decreased by 21% from the 2016-2020 average. Drifting FAD CPUE in 2021 (3.68t per day) decreased by 10% from 2020 and increased by 10% from the 2016-2020 average. Anchored FAD CPUE in 2021 (0.24t per day) increased by 70% from 2020 and decreased by 25% from the 2016-2020 average.
Figure 17 - bottom	Tropical longline CPUE (20^{o}N to 10^{o}S)	Japanese longline CPUE in 2021 (0.37 fish per 100 hooks) decreased by 28% from 2020 and decreased by 16% from the 2016-2020 average. Korean longline CPUE (0.6 fish per 100 hooks) decreased by 5% from 2020 and increased by 6% from the 2016-2020 average. US (Hawaiian) longline CPUE (0.24 fish per 100 hooks) decreased by 25% from 2020 and decreased by 27% from the 2016-2020 average.
Figure 18	Maps of catch by gear	Compared to the longer time frame, a higher proportion of the catch in recent years has been taken by purse seine, and longline catches have concentrated more into the 10^{o}N-10^{o}S equatorial band.
Figure 19	Longline effort and CPUE maps	Longline CPUE in the recent period has generally been lower than that seen across the longer time frame. Higher catch rates are now generally limited to the equatorial eastern region of the WCPFC-CA.
Figure 20	Purse seine effort and CPUE maps	While areas of high bigeye catch rates have become more fragmented in recent years, higher catch rates in the tropical eastern region still extend further west in the tropical northern hemisphere (to 10^{o}N) and to the southeast of the tropical region. A couple of purse seine bigeye “hotspots” are noted for 2021, at around 155^{o}W and 180^o, along the equator.
Figure 21	Spatial concentration of catch	90% of the longline catch in 2021 was taken in 87 5^{o}x 5^o degree squares of the southern WCPO. This was a 16% decrease from 2020 and a 16% decrease from the 2016-2020 average. There has been little or no trend in longline catch concentration over the past 40 years, with around 100 cells accounting for 90% of the catch. 90% of the purse seine catch in 2021 was taken in 595 1^{o}x 1^o degree squares of the southern WCPO. This was a 7% increase from 2020 and a 3% increase from the 2016-2020 average. The spatial concentration of bigeye purse seine catch has shown little trend since leveling off at around 550 cells in the early 2000s.

Figure	Indicator	Description
Figure 22	Catch at length by gear type in both numbers and weight	The catch in numbers of fish was predominantly made up of small fish (<50cm) in the most recent years from the Indonesia/Philippines fisheries. Larger fish (>100cm), as well as the majority of the total catch, are generally caught in the longline fisheries. Intermediate sized fish (40cm-80cm) are taken in the purse seine fisheries. In 2021, the number of small bigeye caught in the Indonesia/Philippines fisheries, in the 10-30 cm range, continued a trend of increasing numbers since 2017 and now exceeds 2016 levels, noting the 2021 bigeye catch estimate for Indonesia is provisional at this stage. More bigeye <70cm were taken in FAD sets in 2021 than has been the case in the past several years. Note that this may be due to overall low observer coverage with most observer coverage, and therefore size samples, coming from Papua New Guinea and Solomon Islands archipelagic waters and High Seas Pocket 1 catches.
Figure 23	Mean weight by gear type	The mean weight of individual fish taken across all gears in 2021 (2.49kg) decreased by 18% from 2020 and decreased by 45% from the 2016-2020 average. The mean weight of longline caught fish (45.97kg) increased by 22% from 2020 and increased by 9% from the 2016-2020 average. The mean weight of Indonesia / Philippines domestic caught fish (0.8kg) increased by 44% from 2020 and increased by 6% from the 2016-2020 average. The mean weight of free-school caught purse seine fish (8.41kg) decreased by 21% from 2020 and decreased by 28% from the 2016-2020 average. The mean weight of FAD caught fish (3.96kg) decreased by 34% from 2020 and decreased by 30% from the 2016-2020 average.
Figure 24	Stochastic stock projections	Under recent fishery conditions and **long-term recruitment assumptions**, the bigeye stock is projected to increase slightly. The projections indicate that median $F_{2019-2022}/F_{MSY} = 2.08$; median $SB_{2023}/SB_{F=0} = 0.43$; median $SB_{2023}/SB_{MSY} = 2.26$. The risk that $SB_{2023}/SB_{F=0} < LRP = 1\%, SB_{2023} < SB_{MSY} = 0\%$ and $F_{2019-2022} > F_{MSY} = 67\%$. Under recent fishery conditions and **recent recruitment assumptions**, the bigeye stock is projected to increase slightly from recent assessed depletion levels. The projections indicate that median $F_{2019-2022}/F_{MSY} = 0.61$; median $SB_{2023}/SB_{F=0} = 0.46$; median $SB_{2023}/SB_{MSY} = 1.96$. The risk that $SB_{2023}/SB_{F=0} < LRP = 0\%, SB_{2023} < SB_{MSY} = 0\%$ and $F_{2019-2022} > F_{MSY} = 35\%$. Note the Limit Reference Point (LRP) is 20% $SB_{F=0}$. For both future assumptions, particularly that where long-term recruitment is assumed, **MSY values are sensitive to changes in the catch estimates of domestic fisheries in Region 7**.

Yellowfin tuna

Figure	Indicator	Description
Figure 25	Total catch by gear	Total catch in 2021 was 695,097t, a 5% decrease from 2020 and a 1% decrease from the 2016-2020 average. Purse seine catch in 2021 (405,915t) increased by 1% from 2020 and decreased by 1% from the 2016-2020 average. Longline catch in 2021 (71,847t) decreased by 4% from 2020 and decreased by 21% from the 2016-2020 average. Pole and line catch (15,392t) decreased by 50% from 2020 and decreased by 37% from the 2016-2020 average. Catch by other gear (see Williams and Ruaia (2022) for descriptions) totaled 201,943t and was a 11% decrease from 2020 and a 13% increase from the average catch in 2016-2020. This is mainly due to the large fluctuations in estimates for the other gears in Indonesia in recent years. In 2021, percentage catch by gear was: purse seine - 58%, other gear - 29%, longline - 10%, pole-and-line - 2%.
Figure 26 - top	Tropical pole and line CPUE	Japanese pole and line CPUE in 2021 (0.291t per day) increased by 474% from 2020 and increased by 482% from the 2016-2020 average. At the time of writing this report the Solomon Islands CPUE is too variable to be informative, probably due to the small size of the fishery.
Figure 26 - middle	Tropical purse seine CPUE	Free-school CPUE in 2021 (8.35t per day) was a 16% increase and increased by 7% from the 2016-2020 average. Log-associated CPUE in 2021 (7.74t per day) decreased by 11% from 2020 and decreased by 2% from the 2016-2020 average. Drifting FAD CPUE in 2021 (8.21t per day) increased by 4% from 2020 and increased by 28% from the 2016-2020 average. Anchored FAD CPUE in 2021 (10.59t per day) increased by 31% from 2020 and increased by 3% from the 2016-2020 average.
Figure 26 - bottom	Tropical longline CPUE (20^oN to 10^oS)	Japanese longline CPUE in 2021 (1.03 fish per 100 hooks) increased by 39% from 2020 and increased by 23% from the 2016-2020 average. Korean longline CPUE (0.68 fish per 100 hooks) decreased by 22% from 2020 and decreased by 1% from the 2016-2020 average.
Figure 27	Maps of catch by gear	Compared to the longer time frame, a slightly higher proportion of the catch in recent years has been taken by the purse seine fishery within the 10^oN-10^oS equatorial band, with catches higher in the mid-tropical WCPO band, mirroring skipjack. Catch in the Indonesian/Philippines region remains notably high.
Figure 28	Longline effort and CPUE maps	Longline CPUE in the recent period has generally been lower than that seen across the longer time frame. Relatively high catch rates are now found only in the tropical western region of the WCPFC-CA. Over the last five years, there was a strong contraction in the high CPUE area compared to the long-term, however a relatively high CPUE region in the region of the Kiribati Line Islands was present in 2021.
Figure 29	Purse seine effort and CPUE maps	Areas of high CPUE have fragmented over time, across the tropical WCPFC-CA, and were concentrated in the west of the tropical region in 2021, with some localised high CPUE achieved in other areas, particularly around the Marshall Islands.
Figure 30	Spatial concentration of catch	90% of the longline catch in 2021 was taken in 90 5^ox 5^o degree squares of the southern WCPO. This was a 7% decrease from 2020 and a 6% decrease from the 2016-2020 average. 90% of the purse seine catch in 2021 was taken in 474 1^ox 1^o degree squares of the southern WCPO. This was an 6% decrease from 2020 and a 8% decrease from the 2016-2020 average.

Figure	Indicator	Description
Figure 31	Catch at length by gear type in both numbers and weight	The catch in numbers of fish was predominantly made up of small fish (<50cm) from the Indonesia/Philippines fisheries. Large fish (>90cm) are mostly caught in the longline and unassociated purse seine fisheries and larger yellowfin dominate the catch by weight, in contrast to catch in number. The total number of yellowfin taken in the Indonesia/Philippines fisheries was down slightly from the high numbers seen in the 2018-2020 catches, and a sizable increase in PS-associated catch of 40-60 cm yellowfin is noted.
Figure 32	Mean weight by gear type	The mean weight of individual fish taken across all gears in 2021 (2.21kg) increased by 15% from 2020 and decreased by 13% from the 2016-2020 average. The mean weight of longline caught fish (30.5kg) increased by 28% from 2020 and increased by 5% from the 2016-2020 average. The mean weight of Indonesia / Philippines domestic caught fish (1.02kg) increased by 29% from 2020 and increased by 20% from the 2016-2020 average. The mean weight of free-school caught purse seine fish (8.66kg) decreased by 43% from 2020 and decreased by 46% from the 2016-2020 average. The mean weight of FAD caught fish (2.53kg) decreased by 33% from 2020 and decreased by 38% from the 2016-2020 average.
Figure 33	Stochastic stock projections	Under recent fishery conditions, the yellowfin stock is projected to increase increase from recent assessed depletion levels. The projections indicate that median $F_{2019-2022}/F_{MSY} = 0.36$; median $SB_{2023}/SB_{F=0} = 0.60$; median $SB_{2023}/SB_{MSY} = 2.73$. The risk that $SB_{2023}/SB_{F=0} < LRP = 0\%$, $SB_{2023} < SB_{MSY} = 0\%$ and $F_{2019-2022} > F_{MSY} = 5\%$. Note the Limit Reference Point (LRP) is 20% $SB_{F=0}$.

5 Figures

Skipjack

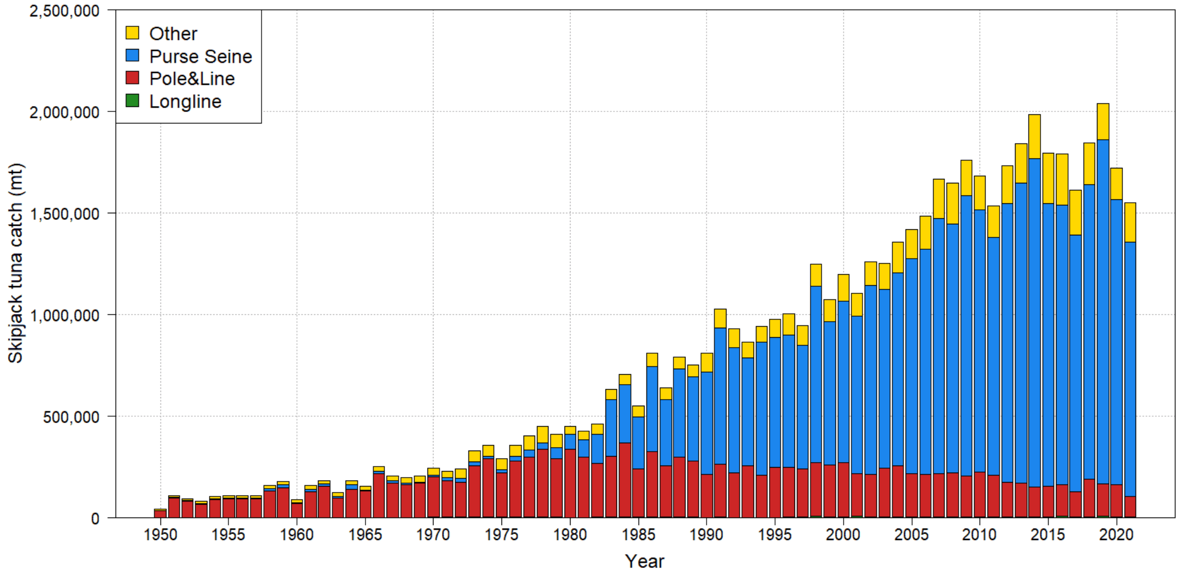


Figure 1: Skipjack tuna catch (mt) by gear type and year for the WCPFC-Convention Area.

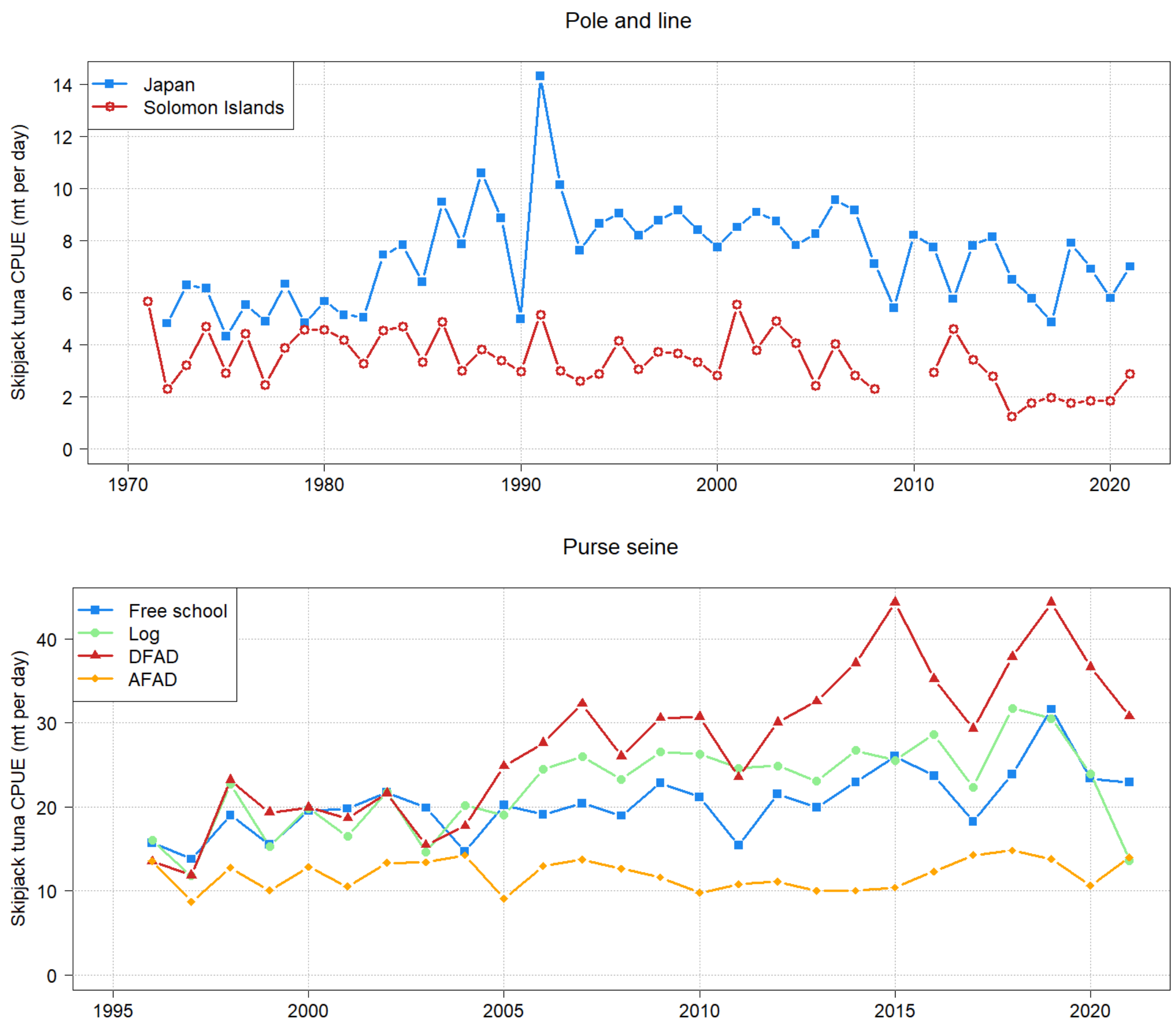


Figure 2: Skipjack tuna catch per unit effort in the tropical WCPO by year for major pole and line fishing fleets (top), and purse seine (all fleets combined) for the major set types (bottom). Note different time series lengths.

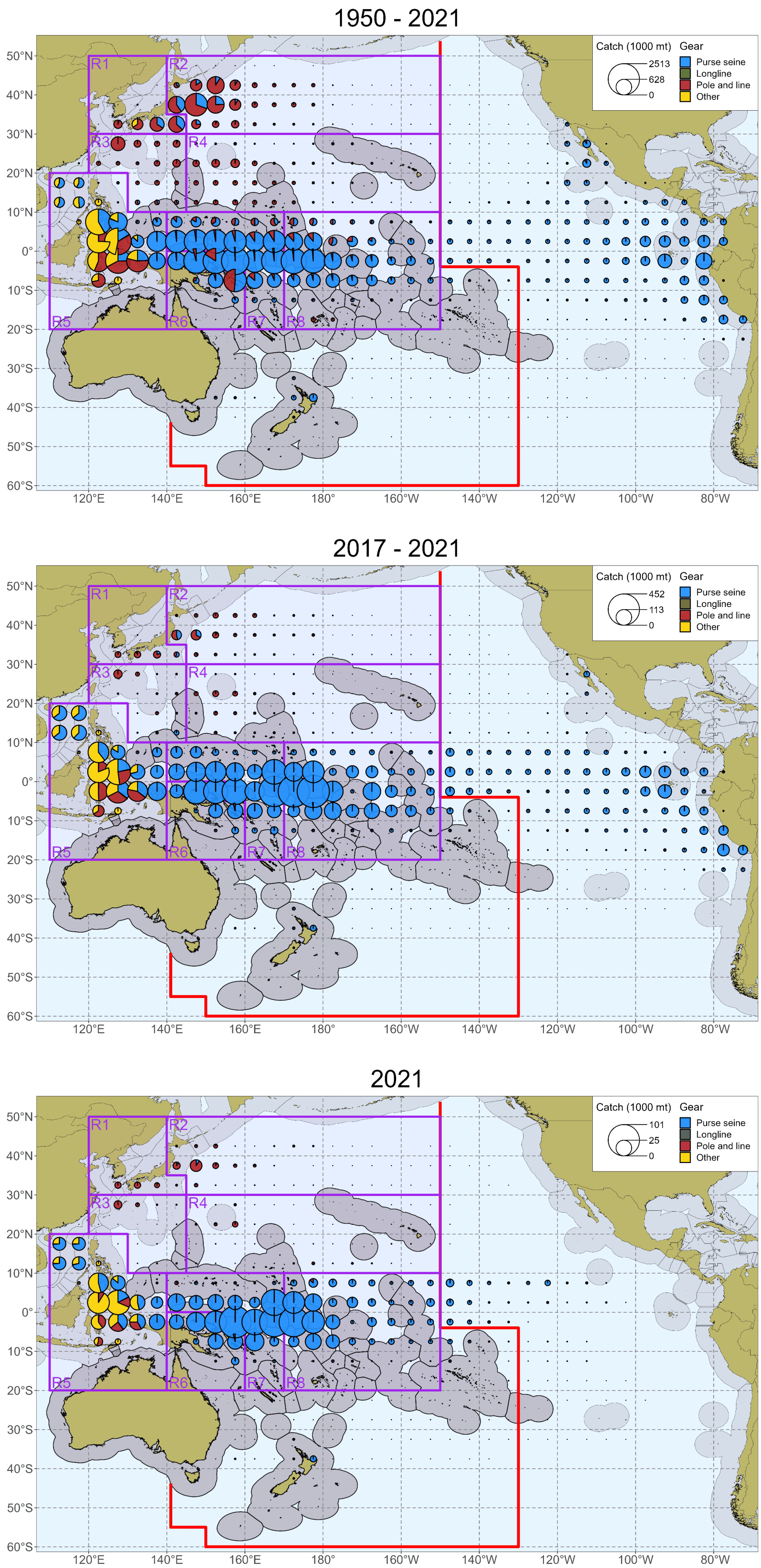


Figure 3: Skipjack tuna catch distribution by gear type and 5^{o}x 5^o region for the Pacific Ocean for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note that the scale differs between panels and the figure legends provide the catch associated with each maximum circle size. The skipjack assessment regions are outlined in purple, the WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

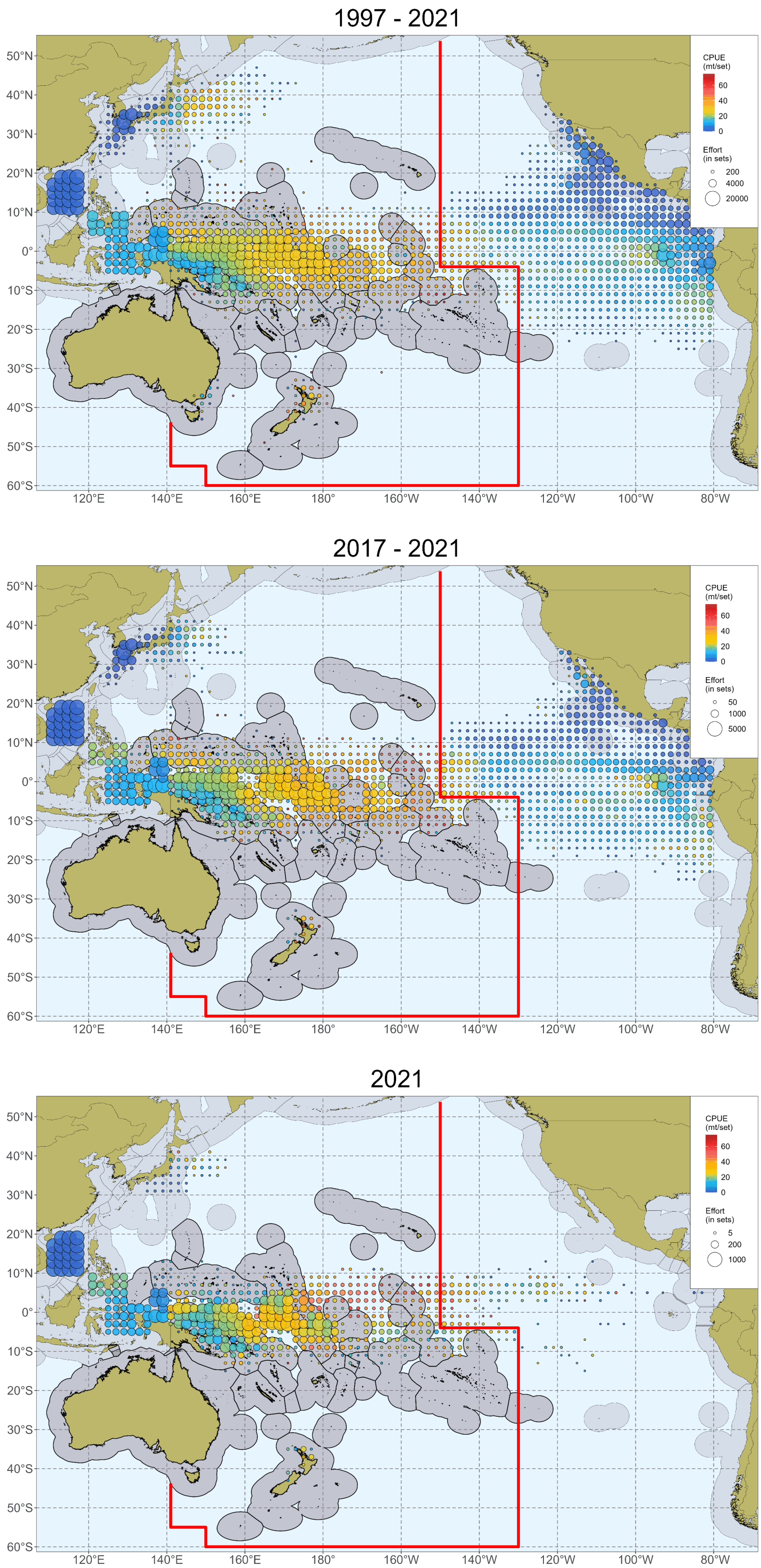


Figure 4: Distribution of 2^ox 2^o purse seine effort (represented by circle size) and skipjack tuna CPUE (represented by colour) for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in scales between plots. The WCPFC-CA is outlined in red. CPUE data for the EPO in 2021 are incomplete.

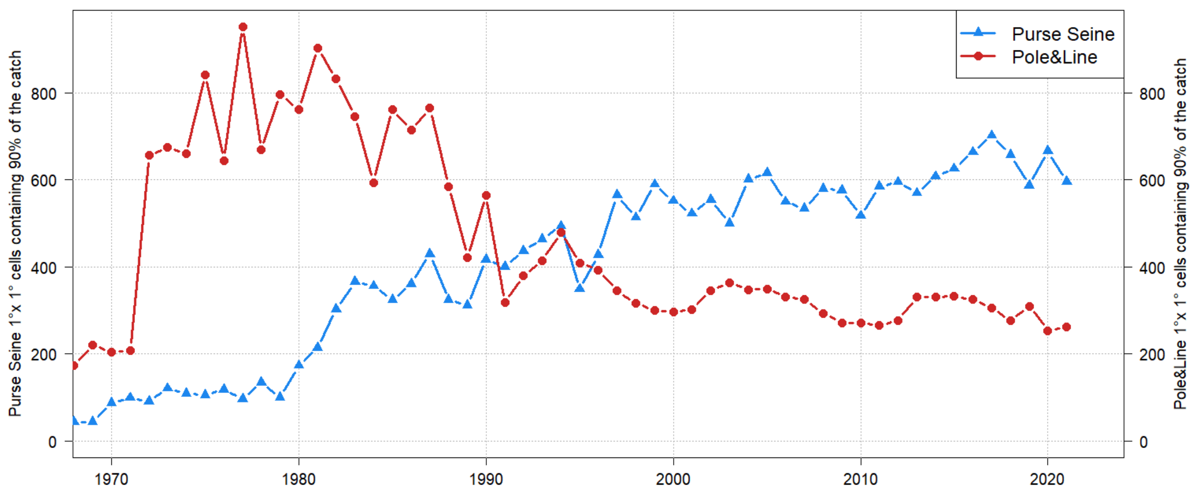


Figure 5: Spatial concentration of skipjack tuna catch for purse seine and pole and line fisheries by year for the WCPO.

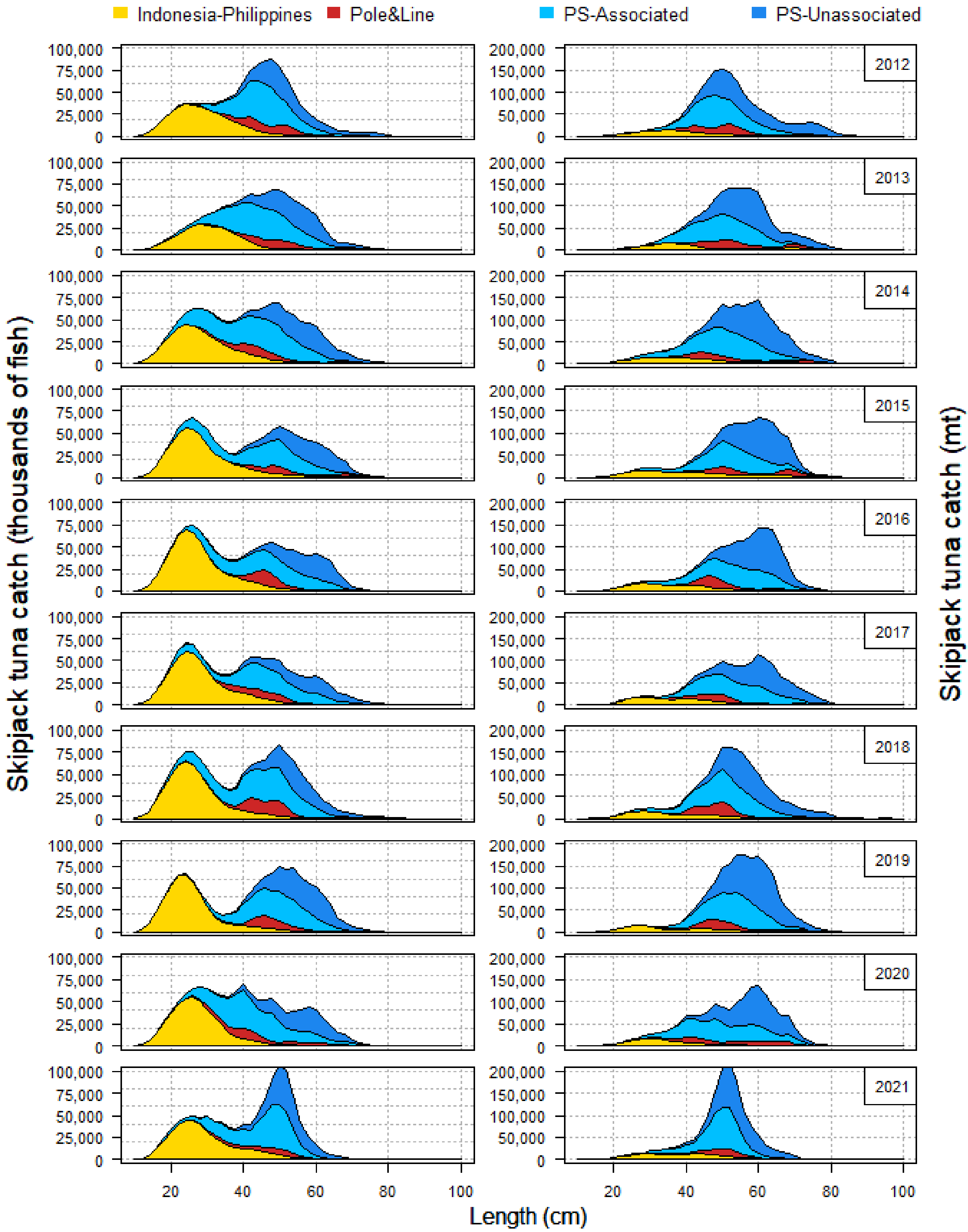


Figure 6: Catch-at-size of skipjack tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right).

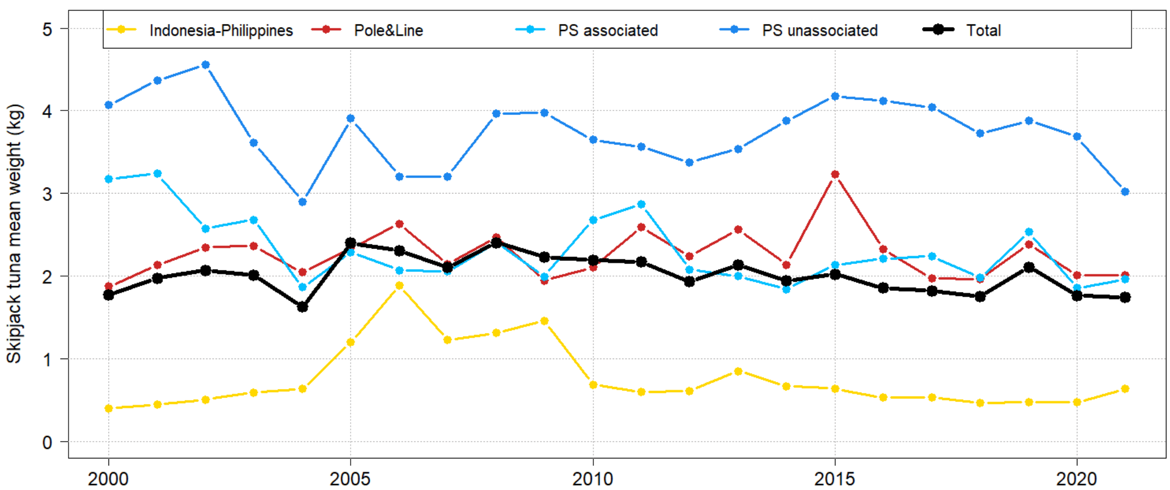


Figure 7: Mean weight of individual skipjack tuna taken by gear and year for the WCPO. The 'total' line represents the mean skipjack weight for the total catch.

South Pacific albacore

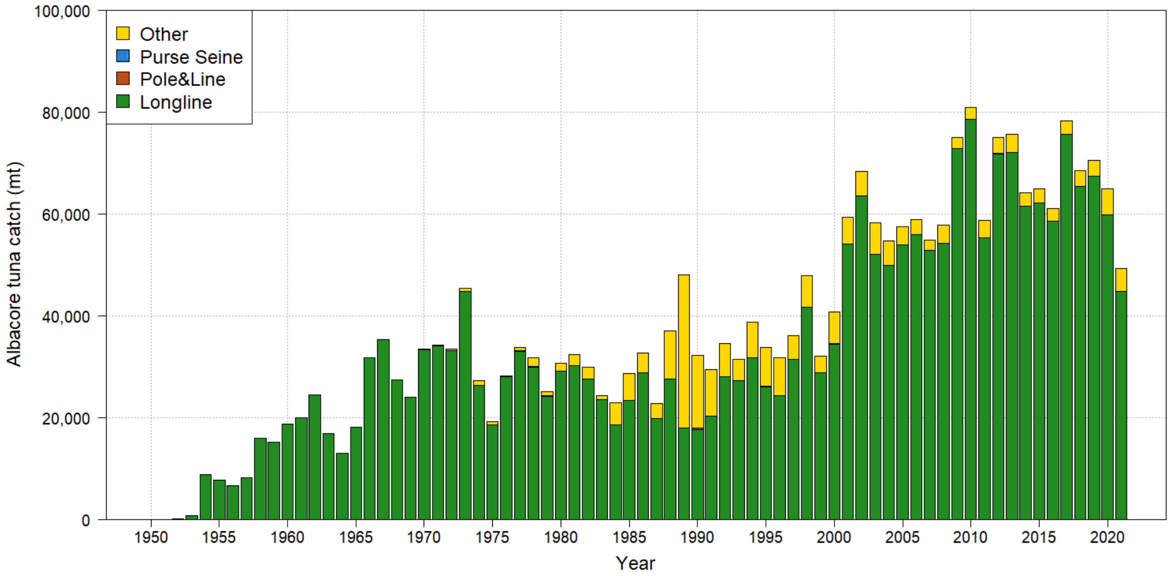


Figure 8: South Pacific albacore tuna catch (mt) by gear type and year for the WCPFC-Convention Area south of the equator. Note: 'Other' gear here is primarily troll gear, but includes driftnet catches in the 1980s and early 1990s.

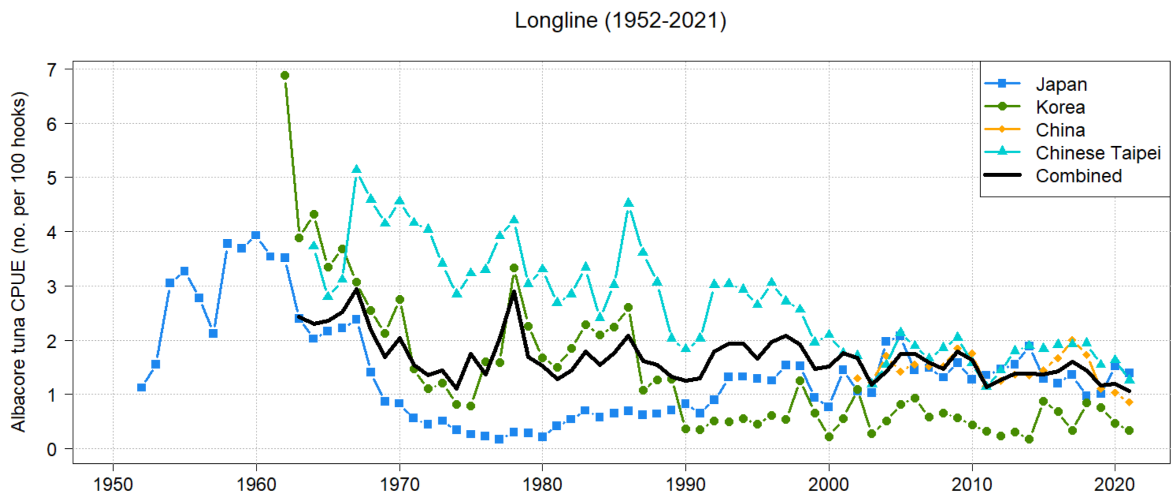


Figure 9: South Pacific albacore tuna catch per unit effort in the southern WCPFC-CA (south of 10°S) by year for major longline fleets.

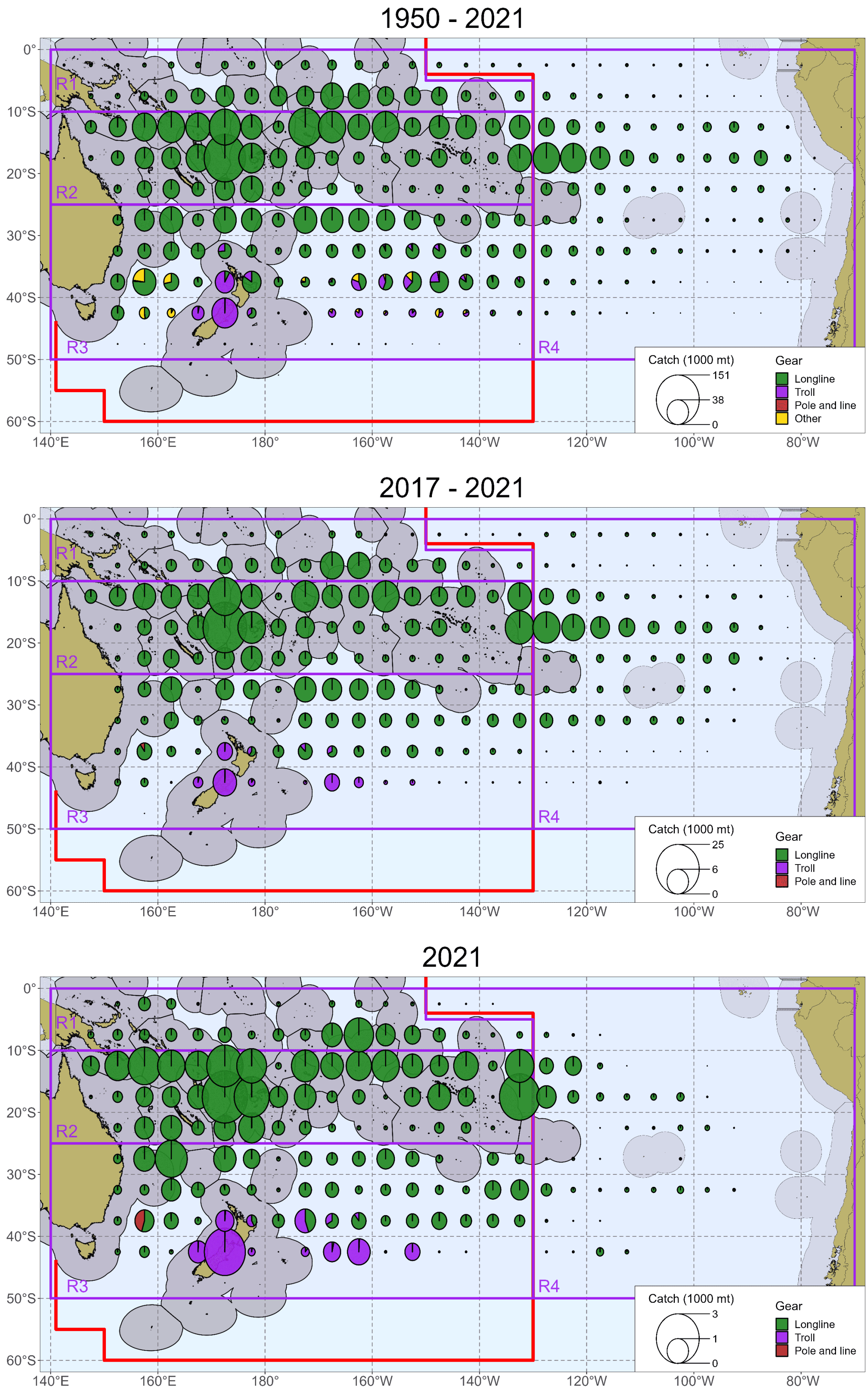


Figure 10: South Pacific albacore tuna catch distribution by gear type and 5°x 5° region for the Pacific Ocean for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note that the scale differs between panels and the figure legends provide the catch associated with each maximum circle size. The albacore assessment regions are outlined in purple, the WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

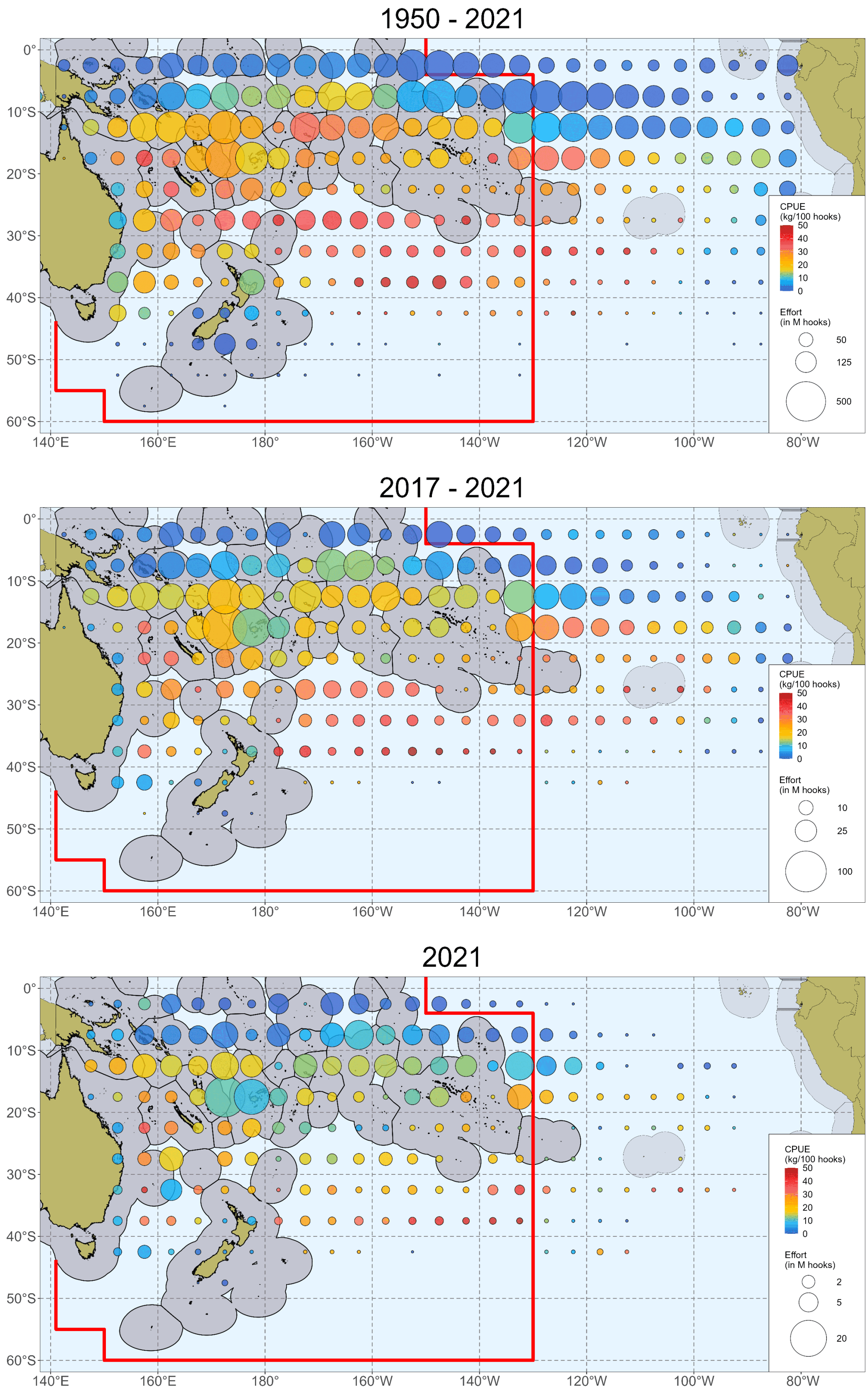


Figure 11: Distribution of 5^{o}x 5^o longline effort (represented by circle size) and South Pacific albacore tuna CPUE (represented by colour) for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in scales between plots. The WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

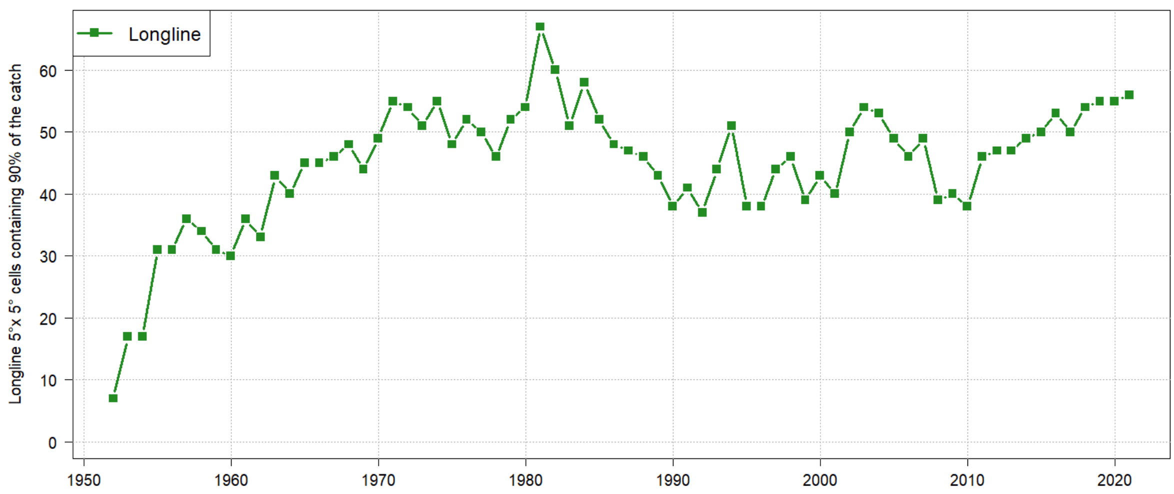


Figure 12: Spatial concentration of South Pacific albacore tuna catch for the longline fishery by year for the WCPO.

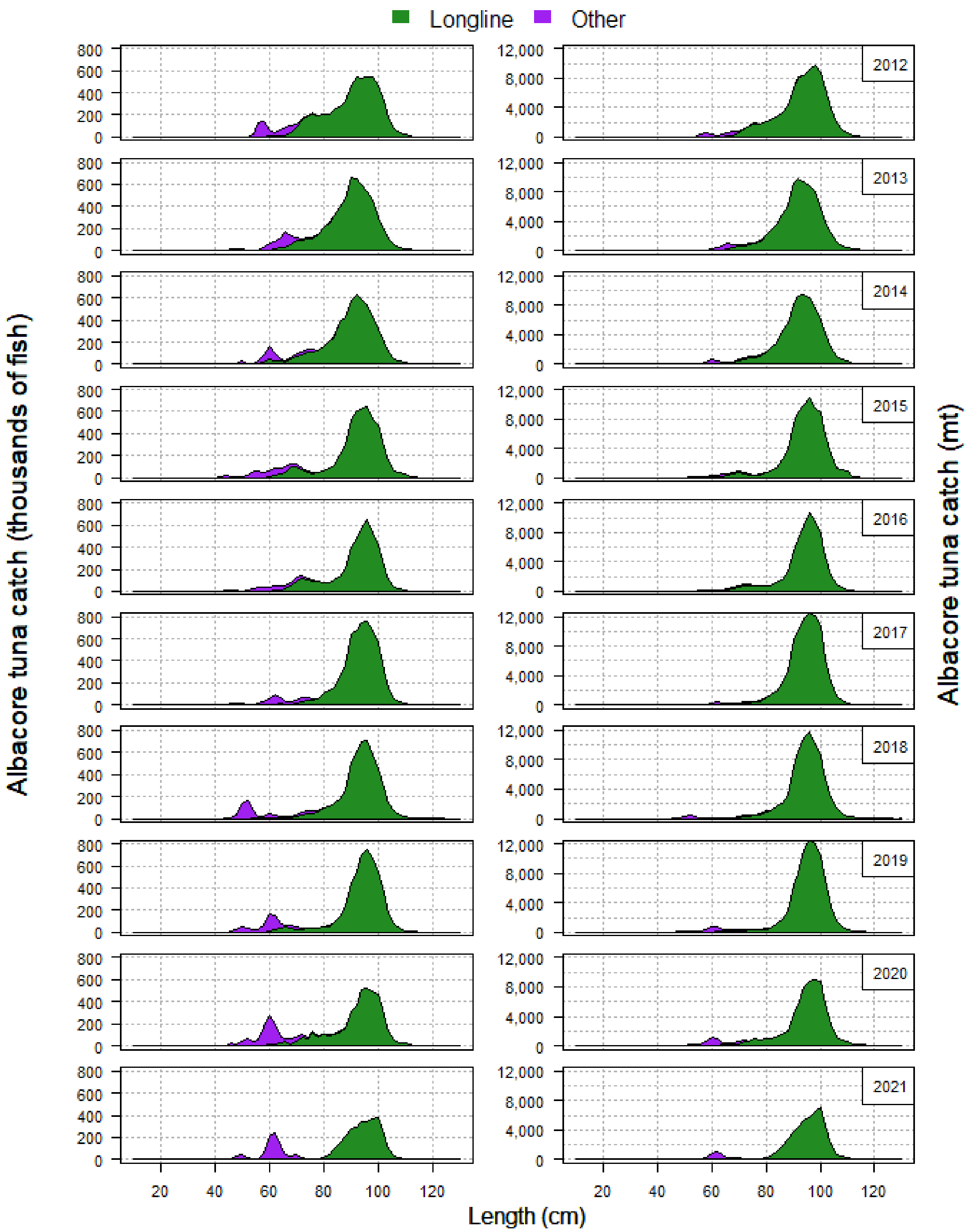


Figure 13: Catch-at-size of South Pacific albacore tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right). "Other" gear is almost entirely troll caught albacore.

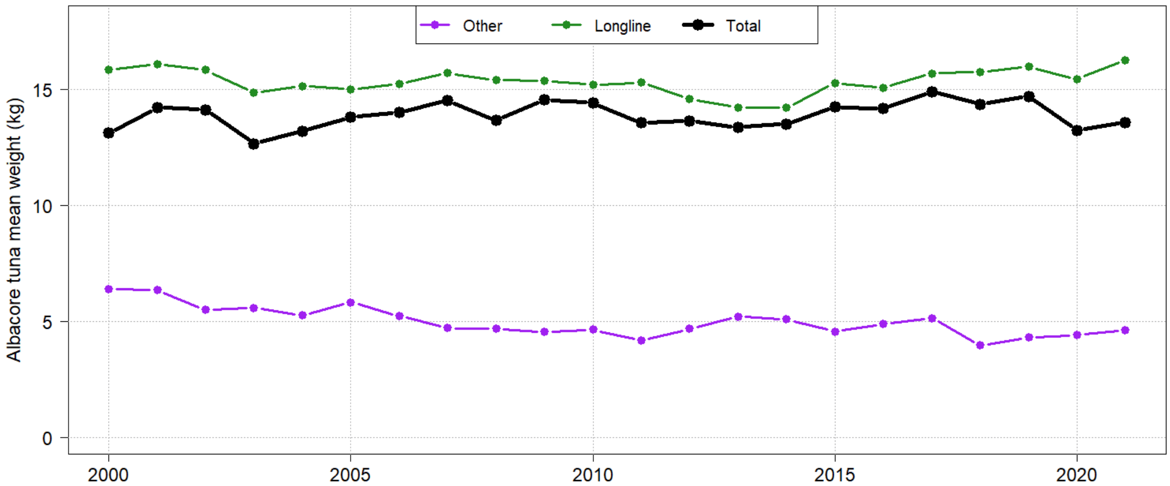


Figure 14: Mean weight of individual South Pacific albacore tuna taken by gear and year for the WCPO. The 'total' line represents the mean albacore weight for the total catch.

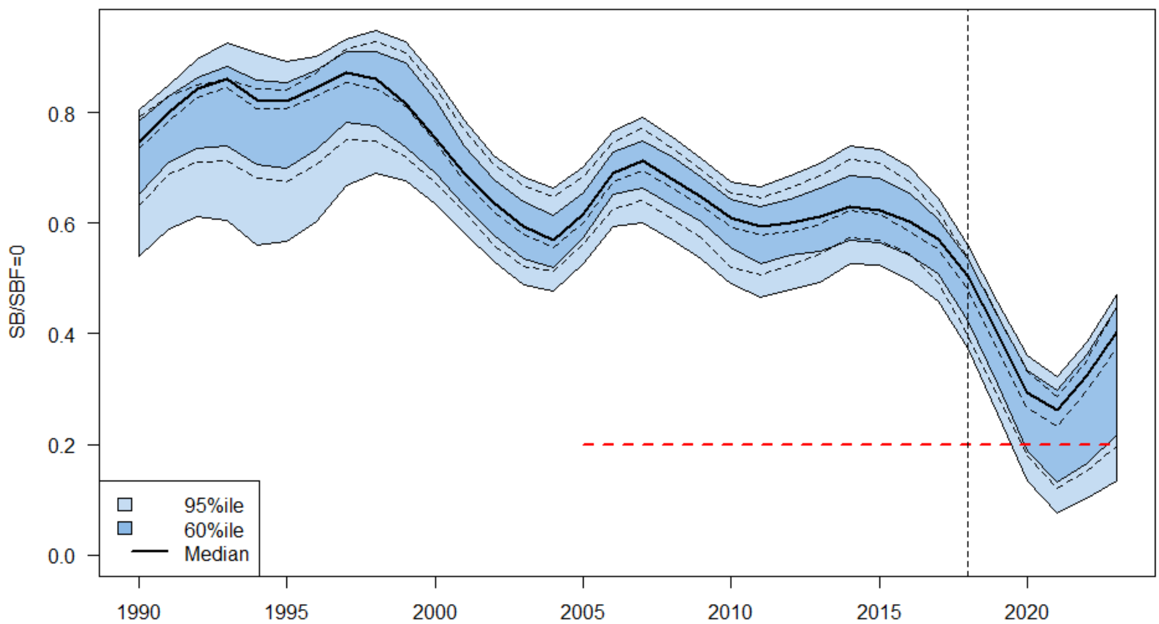


Figure 15: Stochastic projection results of albacore tuna spawning biomass ($SB/SB_{F=0}$) from 2019 using actual catch and effort levels in 2019, 2020, and 2021 and then through to 2023 assuming 2021 levels continued. Prior to 2019 the data represent the 60th and 95th percentiles of the uncertainty grid from the assessment models and the median. Levels of recruitment variability estimated for the period used to estimate the stock-recruitment relationship (1962-2016) assumed to continue in the future. Projections are from the model runs of Castillo-Jordan et al., 2021, and are projected on the basis of albacore catch. The red dashed line represents the WCPFC agreed limit reference point (0.20).

Bigeye

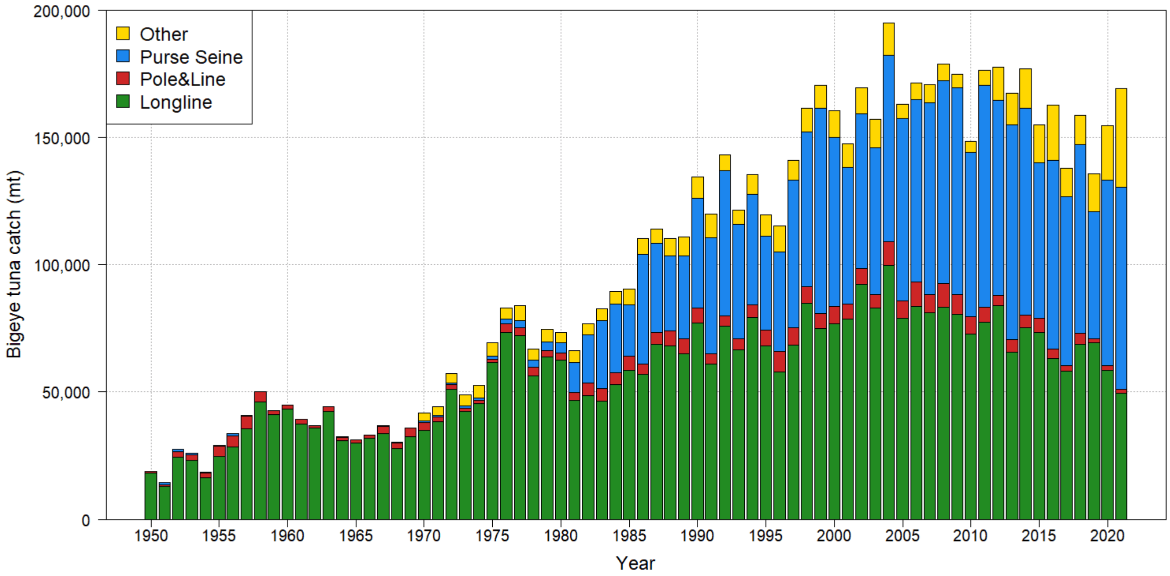


Figure 16: Bigeye tuna catch by gear type and year for the WCPFC-Convention Area.

Figure 17: Bigeye tuna catch per unit effort in the tropical WCPO by year for major pole and line fishing fleets (top), purse seine for the major set types (middle), and tropical longline for three fleets (bottom; 20^{o}N to 10^{o}S, WCP-CA). Note different time series lengths.

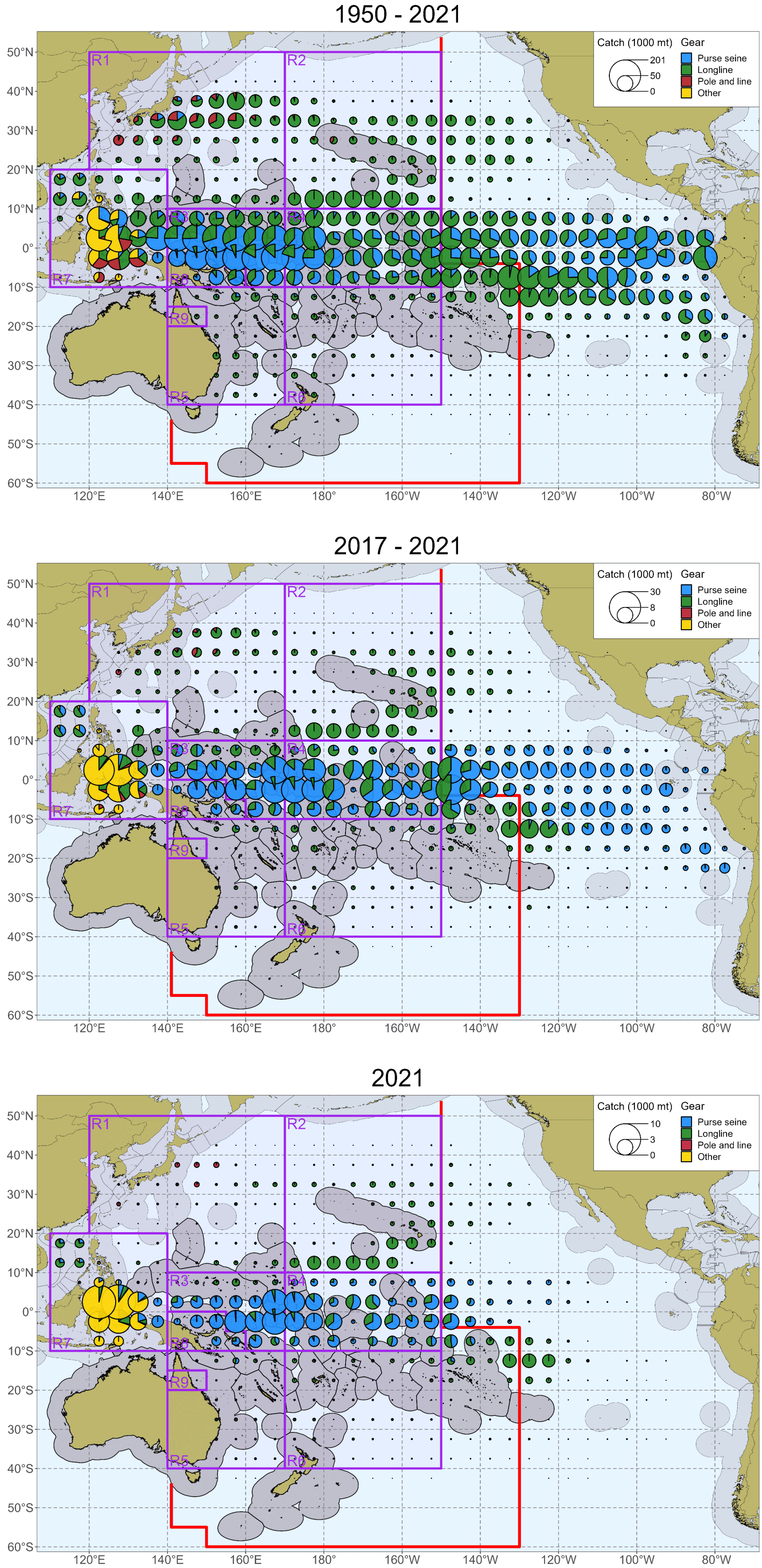


Figure 18: Bigeye tuna catch distribution by gear type and 5^{o}x 5^o region for the Pacific Ocean for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note that the scale differs between panels and the figure legends provide the catch associated with each maximum circle size. The bigeye assessment regions are outlined in purple, the WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

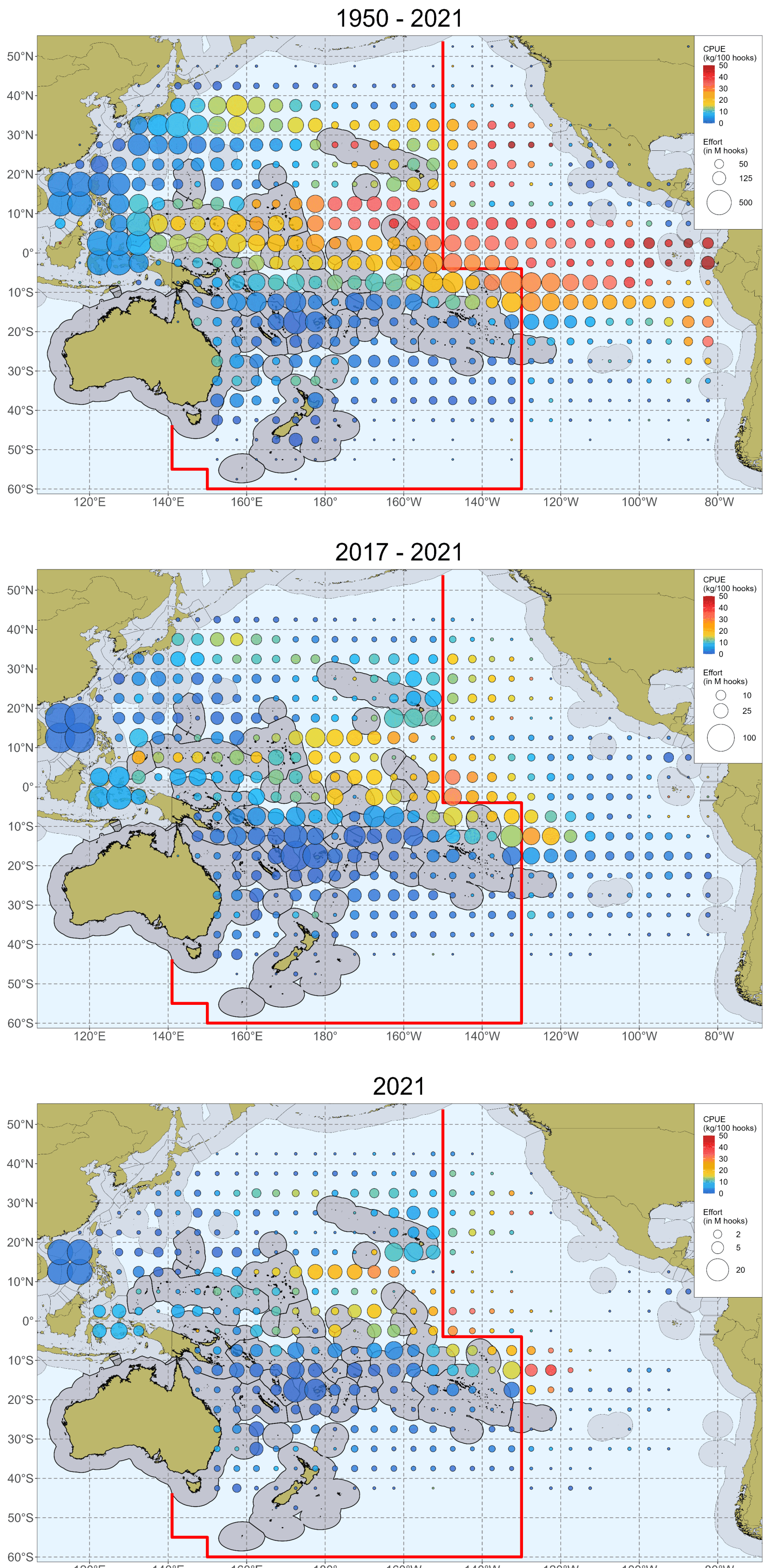


Figure 19: Distribution of 5^ox 5^o longline effort (represented by circle size) and bigeye tuna CPUE (represented by colour) for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in scales between plots. The WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

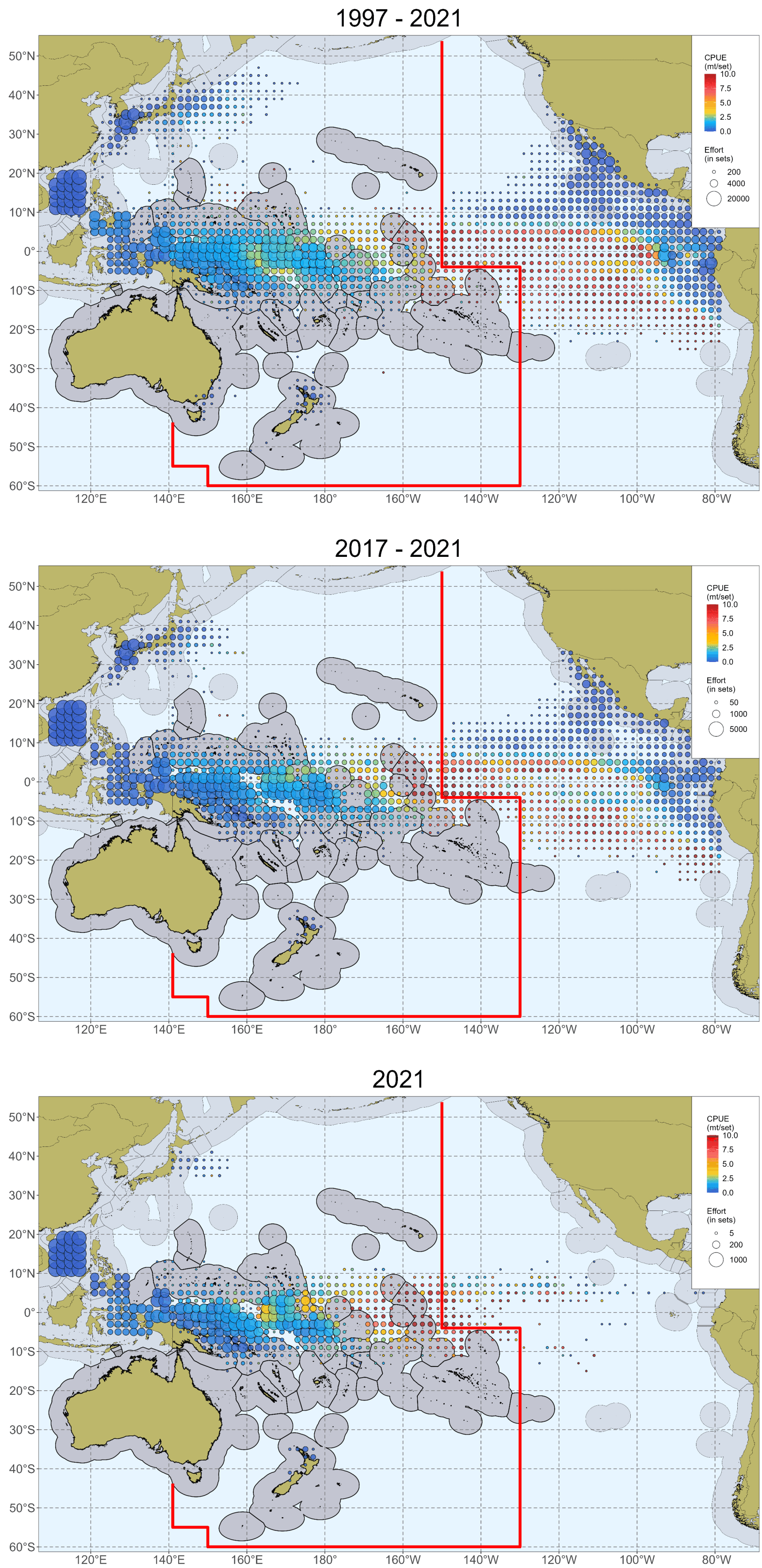


Figure 20: Distribution of 2^{o}x 2^o purse seine effort (represented by circle size) and bigeye tuna CPUE (represented by colour) for the period 1997-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in circle size scale between plots. The WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

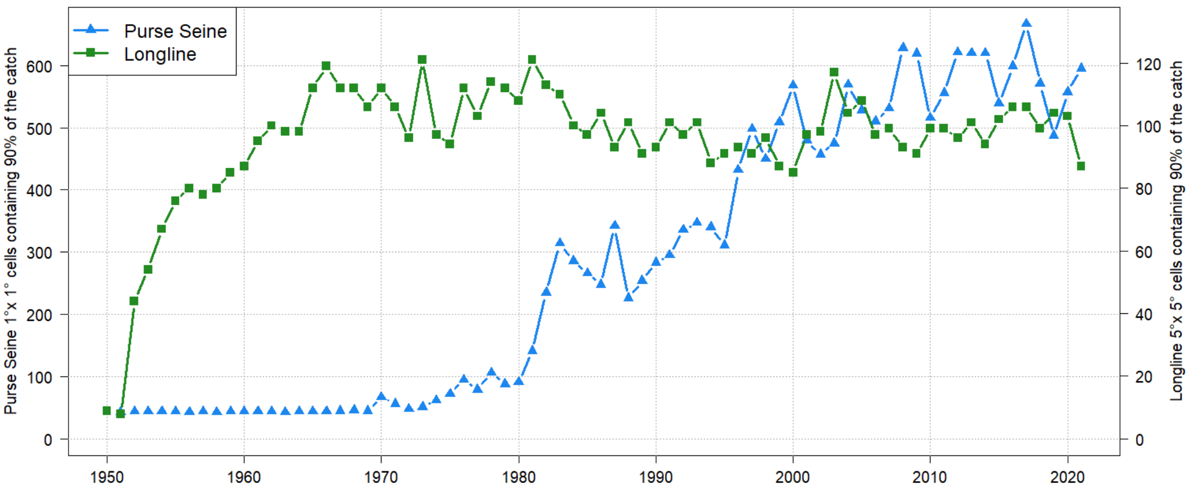


Figure 21: Spatial concentration of bigeye tuna catch for purse seine and longline by year for the WCPO.

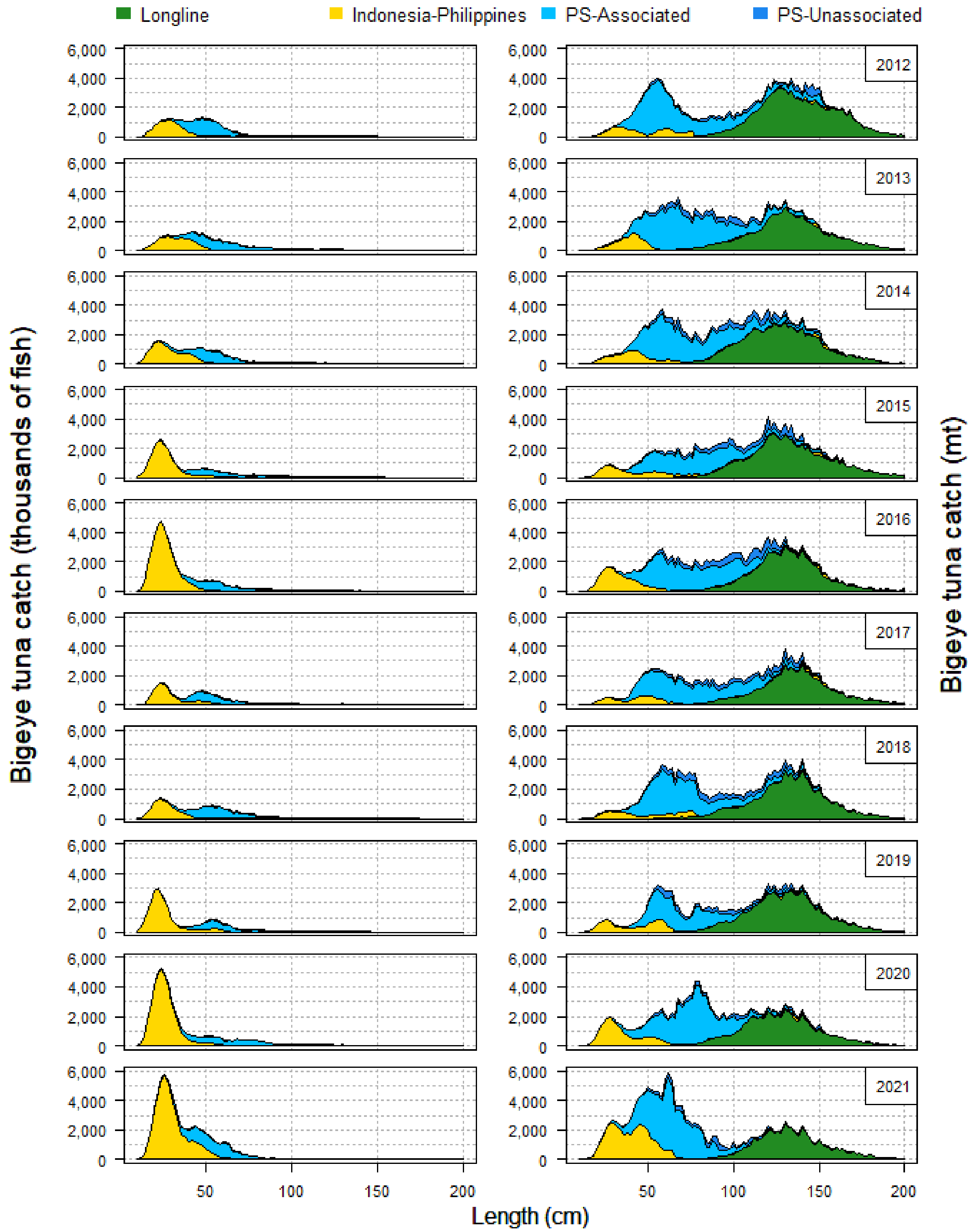


Figure 22: Catch-at-size of bigeye tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right).

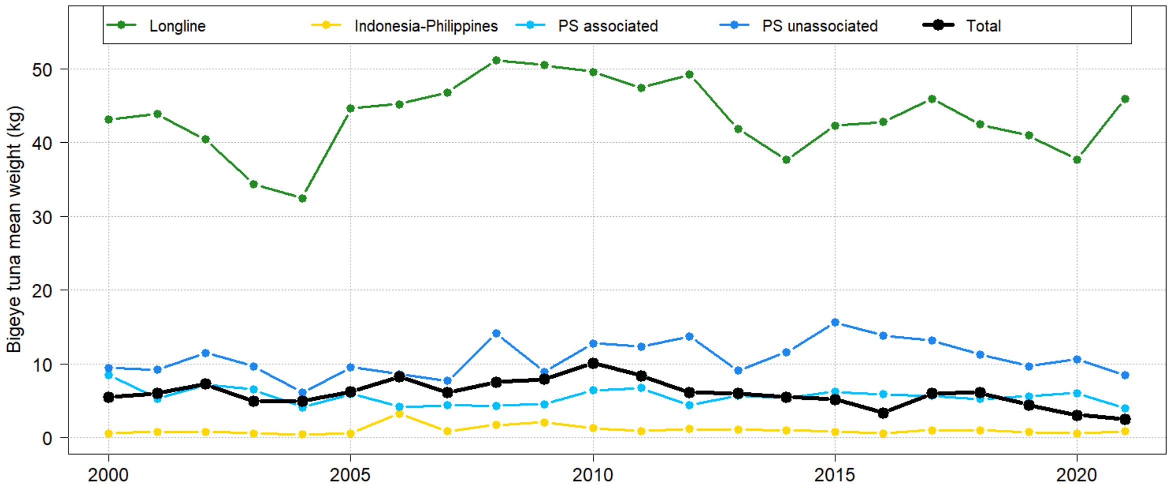
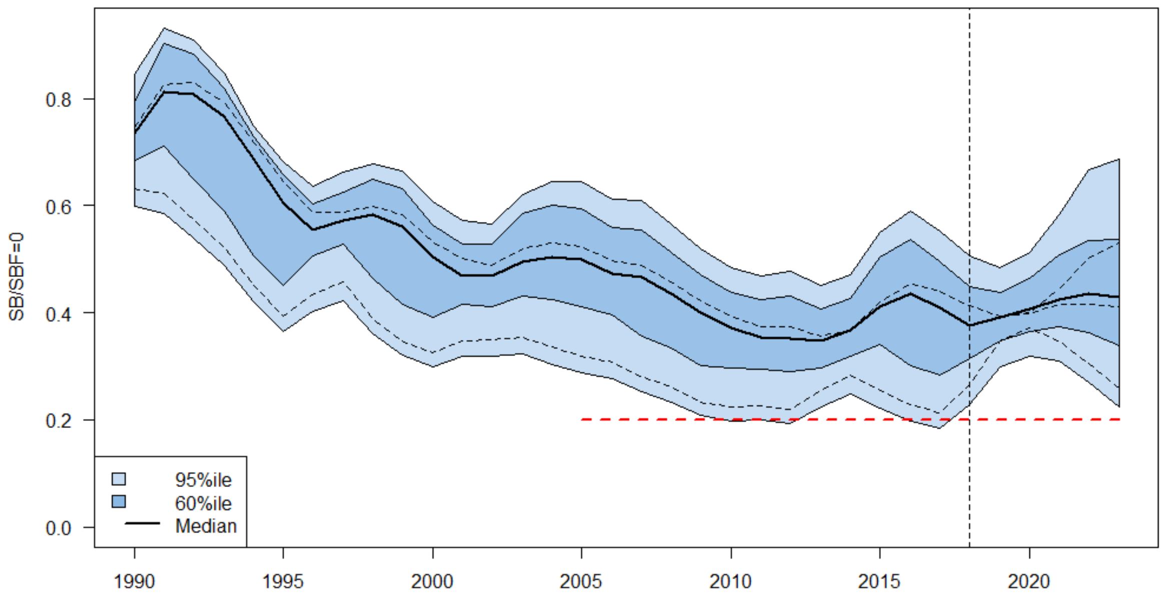


Figure 23: Mean weight of individual bigeye tuna taken by gear and year for the WCPO. The 'total' line represents the mean bigeye weight for the total catch.



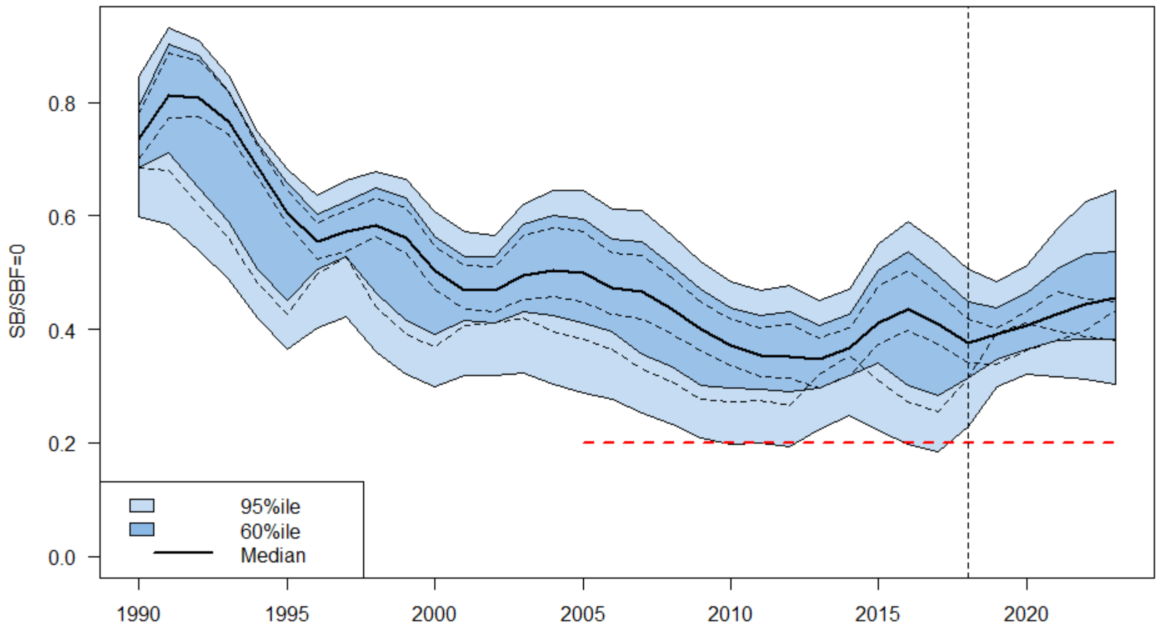


Figure 24: Bigeye spawning biomass depletion ($SB/SB_{F=0}$) from the uncertainty grid of assessment model runs for the period 1990 to 2018 (the vertical line at 2018 represents the last year of the assessment), and stochastic projection results for the period 2019 to 2023 assuming actual catch and effort levels in 2019, 2020 and 2021, and that 2021 fishing levels continued until 2023. During the projection period (2019-2023) levels of recruitment variability are assumed to match those over the time period used to estimate the "long-term" stock-recruitment relationship (1962-2016, top panel) and "recent" stock recruitment relationship (2007-2016, bottom panel). The solid black line shows the median annual depletion values (for grid model estimates prior to 2019 and for grid model projections for 2019-2023). The dashed lines indicate three example trajectories (chosen randomly out of 2400) from the model grid; the dark and light blue areas contain 60 and 95%, respectively, of depletion estimates for each year. The red dashed line represents the agreed limit reference point of $20\%SB_{F=0}$.

Yellowfin

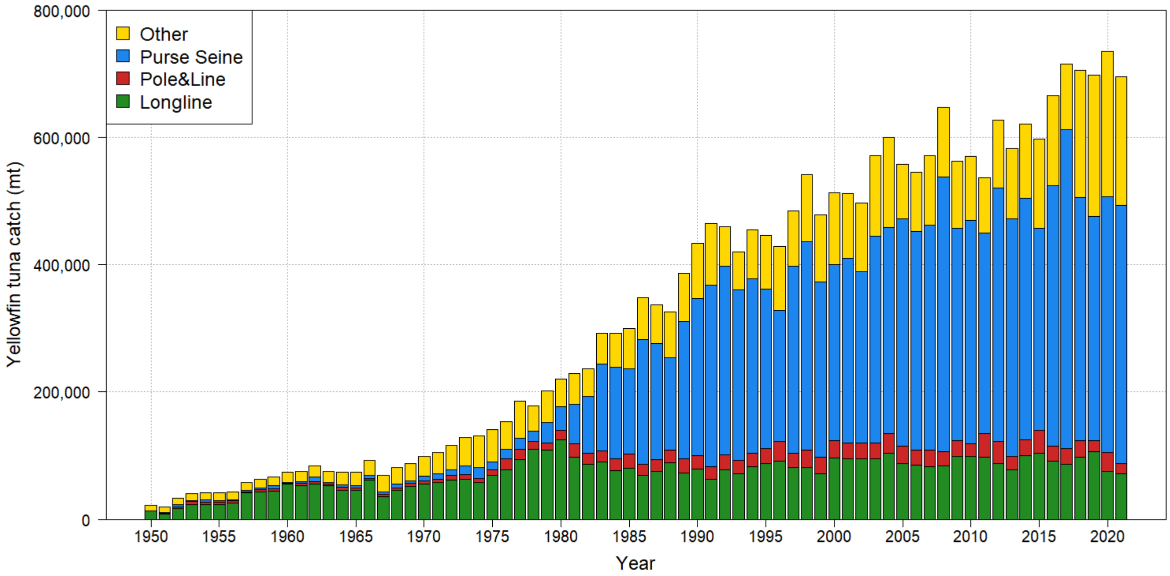


Figure 25: Yellowfin tuna catch (mt) by gear type and year for the WCPFC-Convention Area.

Figure 26: Yellowfin tuna catch per unit effort in the tropical WCPO by year for major pole and line fishing fleets (top), purse seine for the major set types (middle), and tropical longline for three fleets (bottom; 20°N to 10°S, WCP-CA). Note different time series lengths.

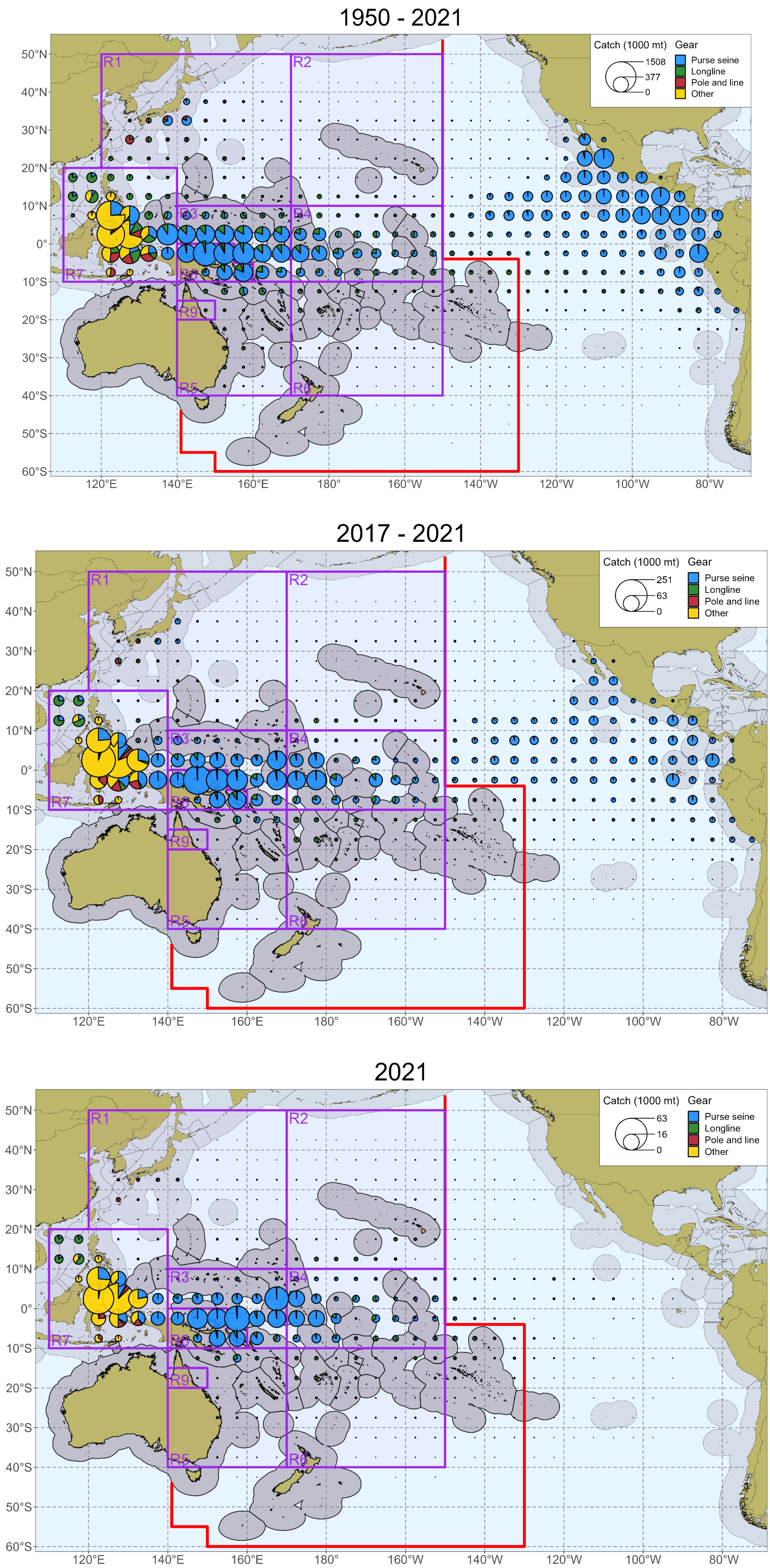


Figure 27: Yellowfin tuna catch distribution by gear type and 5^{o}x 5^o region for the Pacific Ocean for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note that the scale differs between panels and the figure legends provide the catch associated with each maximum circle size. The yellowfin assessment regions are outlined in purple, the WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

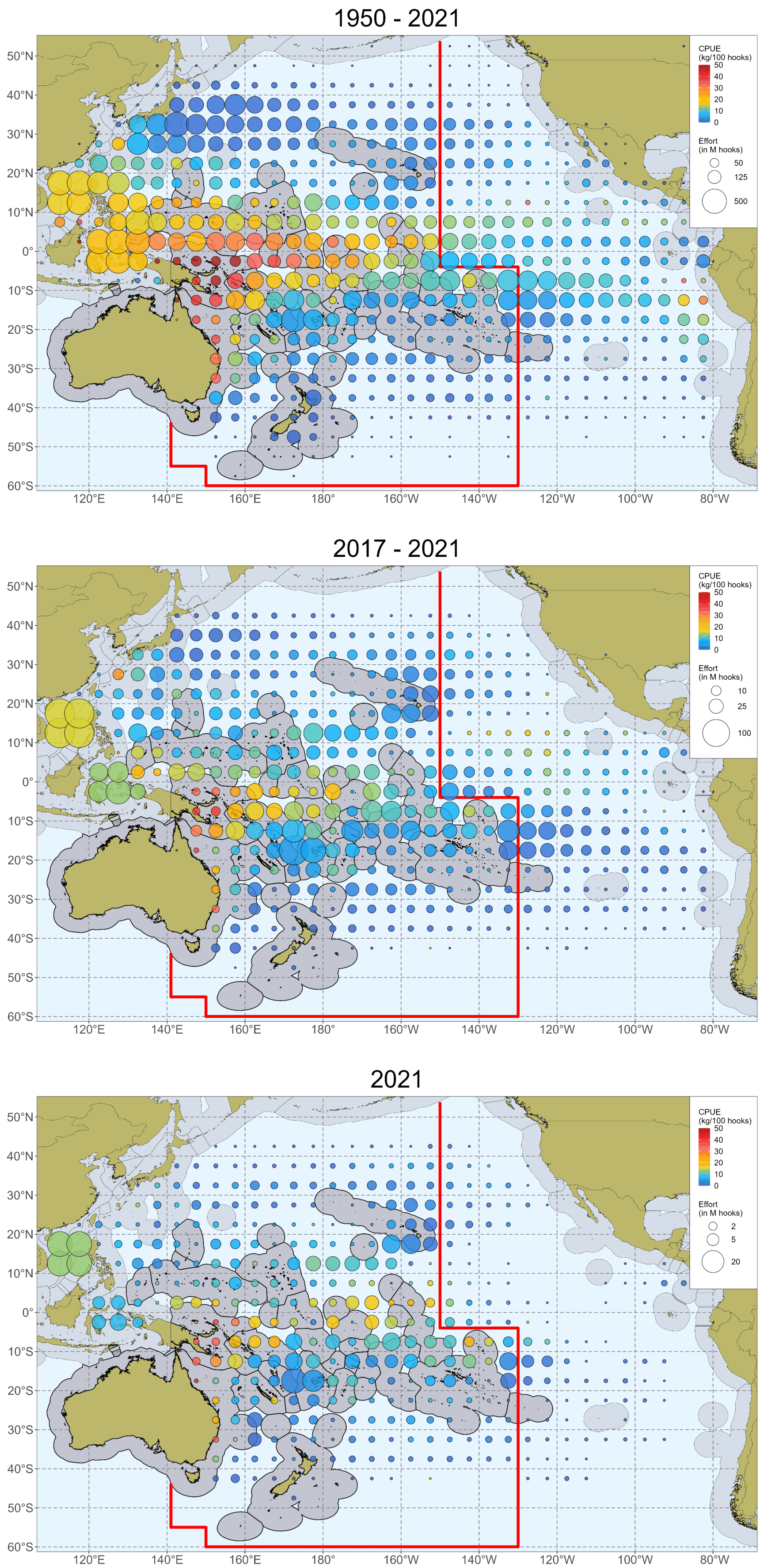


Figure 28: Distribution of 5^{o}x5^o longline effort (represented by circle size) and yellowfin tuna CPUE (represented by colour) for the period 1950-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in scales between plots. The WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

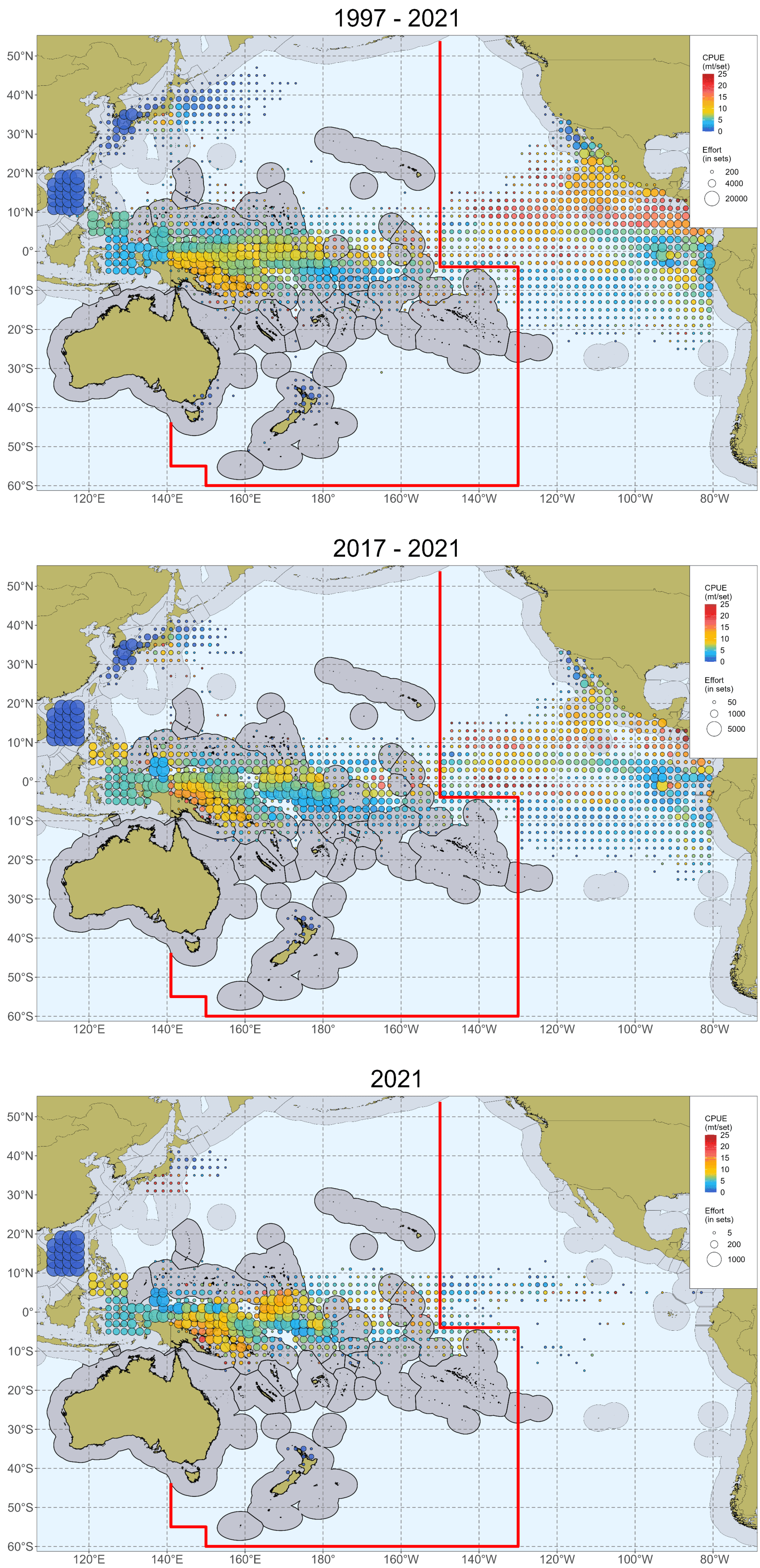


Figure 29: Distribution of 2°x 2° purse seine effort (represented by circle size) and yellowfin tuna CPUE (represented by colour) for the period 1997-2021 (top), 2017-2021 (middle) and 2021 (bottom). Note the differences in circle size scale between plots. The WCPFC-CA is outlined in red. Catch data for the EPO in 2021 are incomplete.

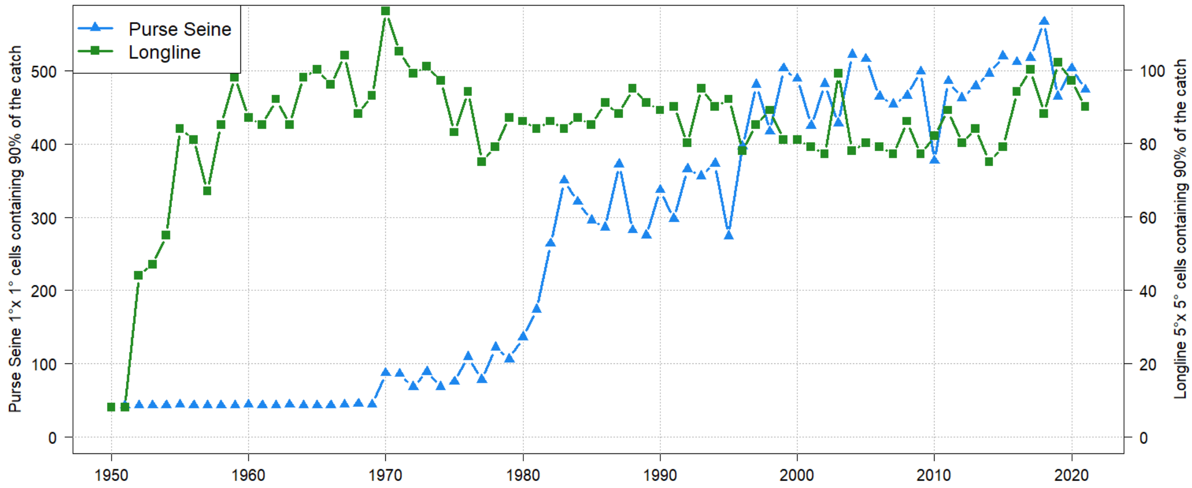


Figure 30: Spatial concentration of yellowfin tuna catch for purse seine and longline by year for the WCPO.

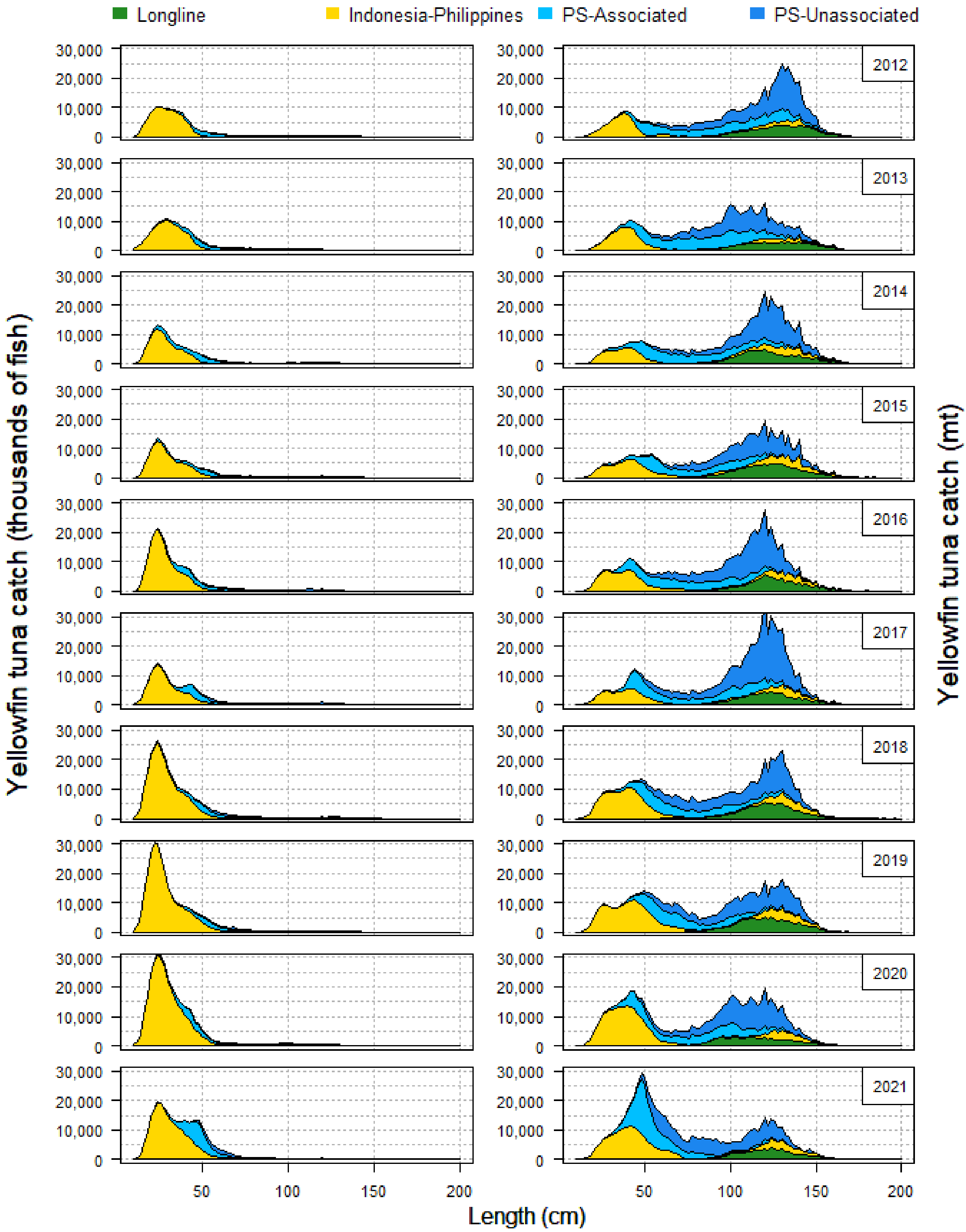


Figure 31: Catch-at-size of yellowfin tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right).

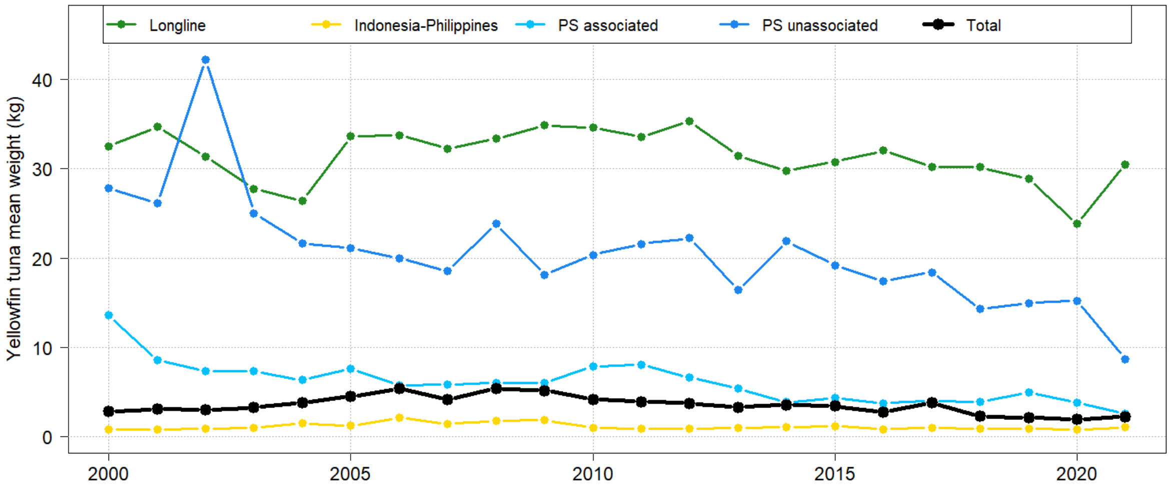


Figure 32: Mean weight of individual yellowfin tuna taken by gear and year for the WCPO. The 'total' line represents the mean yellowfin weight for the total catch.

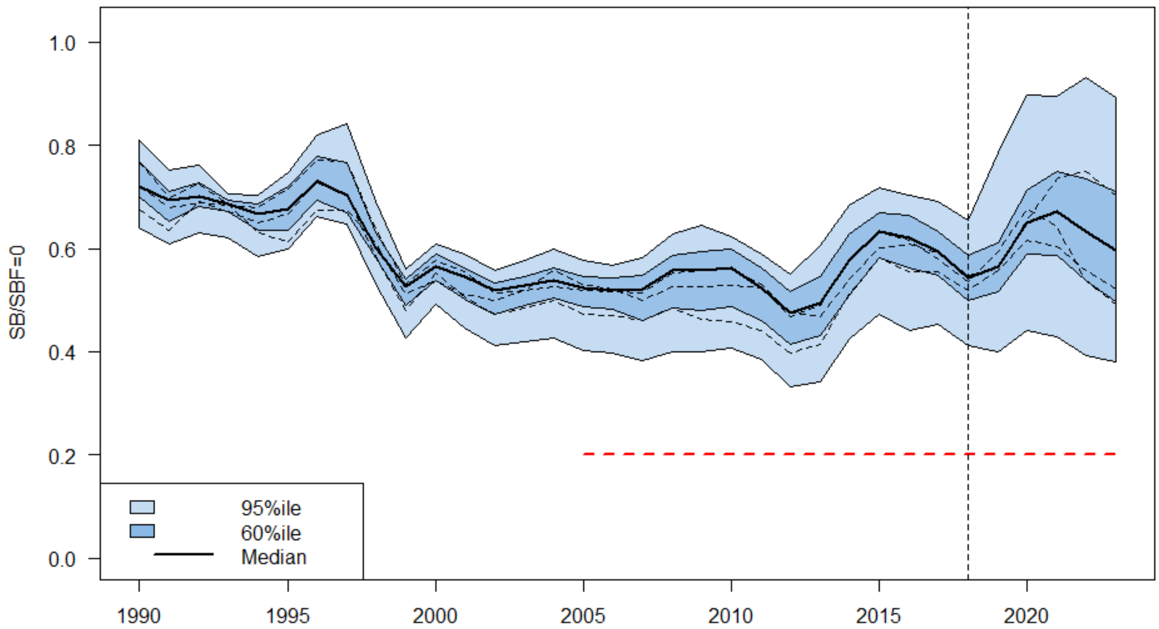


Figure 33: Yellowfin spawning biomass depletion (SB/SB$_{F=0}$) from the uncertainty grid of assessment model runs for the period 1990 to 2018 (the vertical line at 2018 represents the last year of the assessment), and stochastic projection results for the period 2019 to 2023 assuming actual catch and effort levels in 2019, 2020 and 2021, and that 2021 fishing levels continued until 2023. During the projection period (2019-2023) levels of recruitment variability are assumed to match those over the time period used to estimate the stock-recruitment relationship (1962-2017). The solid black line shows the median annual depletion values (for grid model estimates prior to 2019 and for grid model projections for 2019-2023). The dashed lines indicate three example trajectories (chosen randomly out of 5400) from the model grid; the dark and light blue areas contain 60 and 95%, respectively, of depletion estimates for each year. The red dashed line represents the agreed limit reference point of 20%SB$_{F=0}$.