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# A compendium of fisheries indicators for tuna stocks not assessed in 2016 (bigeye and yellowfin tuna)

**WCPFC-SC12-2016/SA-WP-03**

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# Abstract

The principle purpose of this paper is to provide empirical information on recent patterns in fisheries for the SC's consideration, for principal target tuna species for which full stock assessments have not been conducted in that year. For SC12, it presents a compendium of fishery indicators for bigeye and yellowfin tuna. Trends for south Pacific albacore tuna are described in a stand-alone paper.

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 loaded into the WCPFC databases on 5 July 2016.

It is difficult to correctly interpret the stock status-related implications of trends in any indicators in isolation of other data sets and a population dynamics model. Therefore commentary provided in this paper typically relates to comparisons of the values of various indicators to previous years, in particular comparisons of 2015 values to 2014 and the average over 2010-14. In turn, short term stochastic projections for WCPO bigeye and yellowfin stocks are also presented to assess potential stock status in 2016 in light of recent catch and effort trends.


# Introduction

Following development of stock indicators for key species not formally assessed (Scientific Committee's Work Programme for 2008-2010, Project 24: Development and reporting of stock indicators for those key species not formally assessed), stock indicators were first reported at SC4 in 2008 with the paper of Hampton and Williams (2008). Indicators for all key tuna species were reported in 2012 (Harley et al., 2012) and in 2013 (Harley and Williams, 2013). The latter paper addressed the request from SC9 for descriptive text to assist in interpreting the paper contents.

Based upon the difficulty in correctly interpreting stock status-related implications from indicator trends in isolation from other data sets and a population dynamics model, in 2015 an alternative approach was taken using catch-based stochastic short term projections for the three tropical tuna stocks (Scott et al., 2015). Concern was raised by SC11 on whether those projections contained a similar quality of information as a stock assessment. The retrospective analyses for bigeye (Scott et al., 2016) have been conducted in response to these concerns.

Pending further discussion at SC12, and noting the stock assessment for WCPO skipjack tuna (WCPFC-SC12-2016/SA-WP-04) and the separate paper on south Pacific albacore trends (WCPFC-SC12-2016/SA-WP-06), the stock indicators for bigeye and yellowfin tuna have been updated and are presented here. Commentary provided in this paper provides comparisons of the values of various indicators to previous years, in particular comparisons of 2015 values to 2014 and the average over 2011-14. Short term stochastic projections similar to those of Scott et al. (2015) are also included for further information. These projected the stocks forward based upon their assessed status in 2012 from the most recent assessments (Davies et al., 2014; Harley et al., 2014) through 2013, 2014 and 2015 based upon recorded catch or effort levels by fleet, and through 2016 based upon the assumption that 2015 levels would continue. Future recruitments were modelled as deviations around the stock recruitment relationship drawn from the most recent 10 years in the assessment.

## Indicators and data sources

A range of indicators are provided in the following series of graphs and are based upon an equally wide range of data extracts. Indicators for bigeye and yellowfin are based on annual catch estimates for the 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, the descriptive text is tabulated 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. Further these numbers will change as more data become available.

| **Bigeye tuna** | | |
|---|---|---|
| **Figure** | **Indicator** | **Description** |
| Figure 3 | Total catch by gear | Total catch in 2015 (134,084t) was a 16% decrease over 2014 and a 13% decrease over 2010-14. Longline catches (63,986t) were 13% lower both than in 2014 and on 2010-14. Pole and line catches (5,667t) were a 20% increase on 2014 and an 8% increase on 2010-14. Purse seine catches (48,772t) were down 26% on 2014 and 25% down on 2010-14. Catches from other gears (15,659t) were 3% higher than in 2014 and 54% higher than the 2010-14 average. |
| Figure 4 - top | Tropical pole and line CPUE | Pole and line CPUE in 2015 (0.005t per day) was down 69% on 2014 and 68% on the 2010-14 average. |
| Figure 4 – middle | Tropical purse seine CPUE | Free-school CPUE in 2015 (0.25t per day) was 24% higher than in 2014 and 50% higher than the 2010-14 average. Log CPUE (1.81t per day) was a 15% increase on both 2014 and the 2010-14 average. Drifting FAD CPUE (1.93t per day) was a 30% decrease on 2014 and a 28% decrease on 2010-14. Anchored FAD CPUE (0.39t per day) was a 44% decrease on 2014 and a 39% reduction on 2010-14. Note that commentary on recent CPUE trends is provided in a separate section later in this report. |
| Figure 4 – bottom | Tropical longline CPUE (20°N-10°S) | Japanese longline CPUE in 2015 (0.58 fish per 100 hooks) was an 81% increase on 2014, and a 79% increase on 2010-14. Korean longline CPUE (0.63 fish per 100 hooks) was a 32% increase on 2014 and a 52% increase on 2010-14. US (Hawaiian) longline CPUE (0.51 fish per 100 hooks) was a 32% decrease on 2014, but a 7% increase on 2010-14. Note that commentary on recent CPUE trends is provided in a separate section later in this report. |
| Figure 5 | 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 10N-10S equatorial band. |
| Figure 6 | Longline effort and CPUE maps | Longline CPUE in the recent period has generally been lower than that seen across the longer timeframe. Higher catch rates are now generally limited to the equatorial eastern region of the WCPFC-CA. |
| Figure 7 | Purse seine effort and CPUE maps | While areas of high bigeye catch rates have become more fragmented, higher catch rates have been seen further west in the tropical northern hemisphere (to 10°N) and to the southeast of the tropical region in recent years. |
| Figure 8 | Concentration of catches | 90% of the longline catch in 2015 was taken in 88 5x5 degree squares. This was a 5% decrease on 2014 and a 9% decrease on 2010-14. 90% of the purse seine catch was taken in 571 1x1 degree squares; a 4% decrease on 2014 and a 2% decrease on 2010-14. |
| Figure 9 | Catch at length by gear type in both numbers and weight | - |
| Figure 10 | Mean weight by gear type | The mean weight of individual fish taken across all gears in 2015 (6.61kg) was a 10% decrease on 2014 and a 17% decrease on 2010-14. The mean weight of longline caught fish (42.29kg) was a 25% increase on 2014 but a 4% decrease on 2010-14. The mean weight of Indonesia / Philippines domestic caught fish (0.83kg) was a 29% decrease on 2014 and a 26% decrease on 2010-14. The mean weight of free-school caught fish (14.13kg) was a 26% increase on 2014 and a 19% increase on 2010-14. The mean weight of FAD caught fish (6.56kg) was a 9% increase on 2014 and a 12% increase on 2010-14. |
| Figure 11 | Stochastic stock projections | No further decline in the bigeye stock was projected under recent conditions, assuming recent estimated recruitments continue. $F_{2016}/F_{MSY}$ = 1.11; $SB_{2016}/SB_{F=0}$ = 0.17 |

| Yellowfin tuna | | |
|---|---|---|
| **Figure** | **Indicator** | **Description** |
| Figure 12 | Total catch by gear | Total catch in 2015 (605,963t) was a 2% increase over 2014 and a 7% increase over 2010-14. Longline catches (97,289t) were 2% lower than in 2014 but 7% higher than the 2010-14 average. Pole and line catches (36,260t) were 51% higher than in 2014 and 32% higher than 2010-14. Purse seine catches (298,847t) were 15% lower than in 2014, and 13% lower than 2010-14. Catches from other gears (173,567t) were 47% higher than 2014 and 65% higher than the 2010-14 average. |
| Figure 13 - top | Tropical pole and line CPUE | Japanese CPUE in 2015 (0.016t per day) was a 52% decrease on 2014 and 59% lower than the 2010-14 average. Data from the Solomon Islands pole and line fishery for 2015 were not available at the time of writing. |
| Figure 13 – middle | Tropical purse seine CPUE | Free-school CPUE in 2015 (4.24t per day) was a 4% decrease on 2014 and a 3% decrease on 2010-14. Log CPUE (5.88t per day) was a 6% increase on 2014 and a 15% increase on 2010-14. Drifting FAD CPUE (4.45t per day) was a 17% decrease on both 2014 and the 2010-14 average. Anchored FAD CPUE (6.54t per day) was a 4% decrease on 2014 but a 23% increase on 2010-14. |
| Figure 13 – bottom | Tropical longline CPUE (20°N to 10°S) | Japanese longline CPUE in 2015 (0.51 fish per 100 hooks) was a 243% increase on 2014 and a 197% increase on 2010-14. Korean longline CPUE (0.06 fish per 100 hooks) was a 54% decrease on 2014 and a 72% decrease on 2010-14. |
| Figure 14 | 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 slightly more into the 10N-10S equatorial band. |
| Figure 15 | Longline effort and CPUE maps | Longline CPUE in the recent period has generally been lower than that seen across the longer timeframe. Relatively high catch rates are now found in the tropical western region of the WCPFC-CA. |
| Figure 16 | Purse seine effort and CPUE maps | Purse seine CPUE in the recent period has also generally been lower than that seen across the longer timeframe. Areas of high CPUE have fragmented over time, across the tropical WCPFC-CA. |
| Figure 17 | Concentration of catches | 90% of the longline catch in 2015 was taken in 67 5x5 degree squares which was an 8% decrease on 2014 and an 18% decrease on 2010-14. 90% of the purse seine catch was taken in 539 1x1 degree squares which was 5% more than in 2014 and 13% more than the 2010-2014 average. |
| Figure 18 | Catch at length by gear type in both numbers and weight | - |
| Figure 19 | Mean weight by gear type | The mean weight of individual fish taken across all gears in 2015 (4.73kg) was a 2% increase on 2014 and a 16% increase on 2010-14. The mean weight of longline caught fish (29.83kg) was a 14% increase on 2014 but a 5% decrease on 2010-14. The mean weight of Indonesia / Philippines domestic caught fish (1.42kg) was a 10% increase on 2014 and a 39% increase on 2010-14. The mean weight of free-school caught fish (19.24kg) was a 3% decrease on both 2014 and the 2010-14 average. The mean weight of FAD caught fish (6.82kg) was a 10% increase on 2014 and a 4% decrease on 2010-14. |
| Figure 20 | Stochastic stock projections | The yellowfin stock was projected to increase under recent conditions, assuming recent estimated recruitments continue. $F_{2016}/F_{MSY} = 0.80$; $SB_{2016}/SB_{F=0} = 0.49$ |

## Comments on bigeye CPUE trends in 2014/15

The WCPO experienced a strong El-Niño event over the period 2014 – 2015. We briefly examine the catch rate information available for bigeye for those years, to identify any corresponding signals, and discuss potential causes. Note that this represents a very preliminary investigation of trends. It is anticipated that with additional data received during 2016 and further time to examine potential correlates, a more considered evaluation could be performed for SC13.

### Purse seine fishery

The purse seine fishery was centered further east in 2014/15, as anticipated due to the effects of El Niño (see Williams and Terawasi (2016) and Figure 7). Purse seine fishing in that more easterly region would be expected to result in higher catch rates of bigeye tuna within associated sets (e.g. Harley et al., 2015; Tidd et al., 2016). However Figure 4 suggests that in 2015 catch rates of bigeye tuna in drifting FAD sets fell by 28% relative to the 2010-2014 average, and that overall catches fell by 25% (Figure 3). Potential causes of these patterns may include:

- Overall reduction in purse seine effort in 2015 (Williams and Terawasi, 2016).
- Particular reductions in effort of key 'bigeye' catching fleets in 2015 compared to previous years, with around half the number of FAD sets made by those fleets, concurrent with FAD set catch rate reduction seen in Figure 4.
- changes in oceanographic conditions (see below).

As purse seine fisheries tend to catch smaller (younger) fish (Figure 10), reductions in catch rate could result from reductions in recruitment levels. However, there appears to be no clear signal of reduced numbers of smaller fish from the size distributions seen in previous years (Figure 9), noting that this is influenced by the level of fishing/sampling between years.

With regard to the oceanographic conditions, changes in the depth of the thermocline layer may influence the catchability of bigeye within purse seine fisheries. Figure 1 shows the depth of the 20°C thermocline in the tropical region during different phases of the ENSO cycle. Further east, towards the border of the WCPFC-CA with the eastern Pacific, the thermocline becomes deeper during El Niño conditions, which might actually reduce tuna catchability, counteracting the expected increase in bigeye catch rates. However, in the region 180° to 170°W, where purse seine effort was still significant in 2015 (Figure 7), the thermocline was shallower under El Niño conditions compared to La Niña conditions.

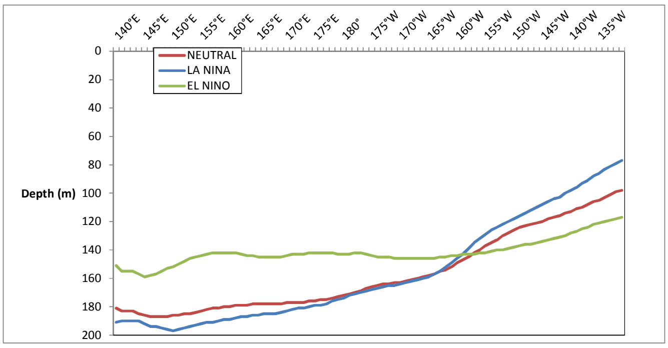


**Figure 1. Depth (m) of the 20°C thermocline across the western Pacific region between 5°N and 5°S during three example phases of the ENSO cycle (El Niño = Apr 1997-Apr 1998; La Niña = July 2010 to June 2011; Neutral = April 2012 to May 2013).**

## Longline fishery

In contrast to the reduced catch rates experienced by purse seine fleets in 2014/15, catch rates within the longline fishery generally increased over the same period. Catch rates in 2015 (in terms of the number of fish per hundred hooks) were 28-79% higher than the 2010-2014 average, dependent upon the fleet (Figure 4). Catch rates in eastern fisheries in terms of kilogrammes per hundred hooks (not shown) rather than number of fish per hundred hooks, showed further increases, implying not only were the catch numbers increasing, but also the size of fish caught was higher.

In contrast to purse seiners, higher catch rates of bigeye tuna are found slightly outside the equatorial region (Figure 6). Noting that the implications of ENSO conditions may have different influences on longline fleets in different areas, we examined the patterns in the thermocline for the latitudes between 20°N and 10°N as an example (Figure 2). In the region 170°W to 160°W, there was relatively little impact of different ENSO states on the depth of the thermocline. Further west, however, the thermocline was again shallower under El Niño conditions compared to other conditions.

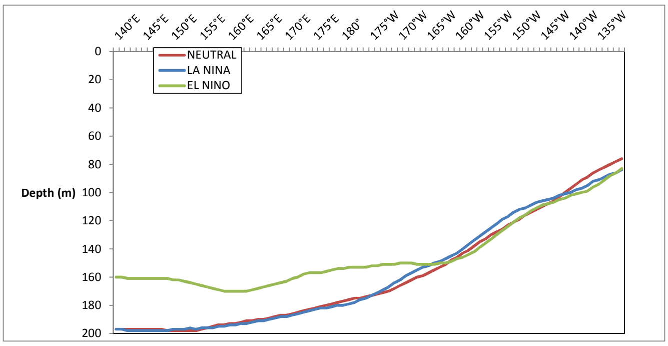


**Figure 2. Depth (m) of the 20°C thermocline across the western Pacific region between 20°N and 10°N during three example phases of the ENSO cycle (El Niño = Apr 1997-Apr 1998; La Niña = July 2010 to June 2011; Neutral = April 2012 to May 2013).**

## Potential implications of El Niño for bigeye catchability

The implications of strong El Niño conditions for bigeye catchability may vary dependent upon the strength of the event, the location being fished, and the gear being used. Differences in the temperature structure of the water column in the eastern WCPO clearly vary between ENSO events, which may affect the availability to surface gears compared to longline gears. However, this preliminary examination suggests the relationship is complex and requires further analysis.

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Williams, P. and Terawasi, P. 2016. Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions – 2015. WCPFC-SC12-2016/GN-WP-01.

## Bigeye tuna

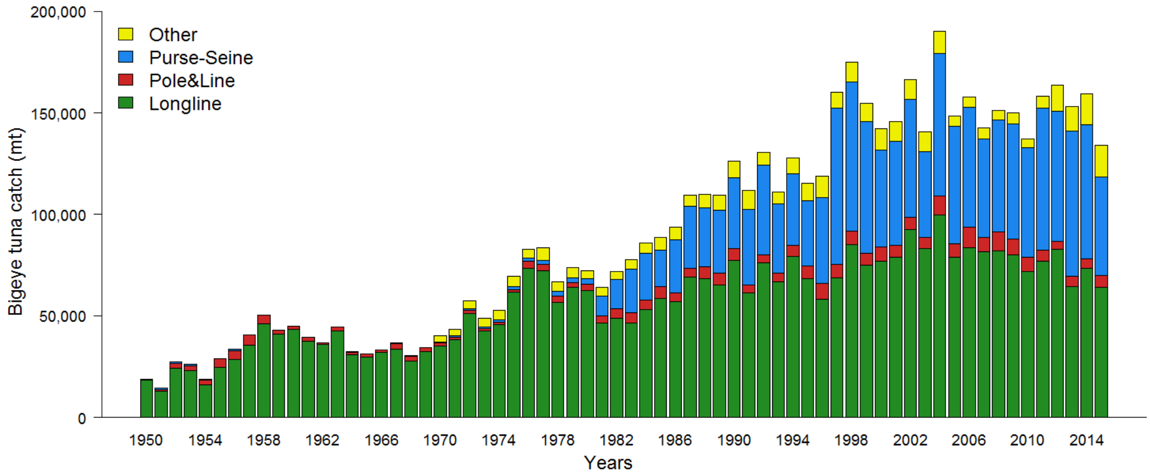


**Figure 3. Bigeye tuna catch by gear type and year for the WCPFC-Convention Area**


**Figure 4. 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; 20N to 10S, WCP-CA). Note different time series lengths.**

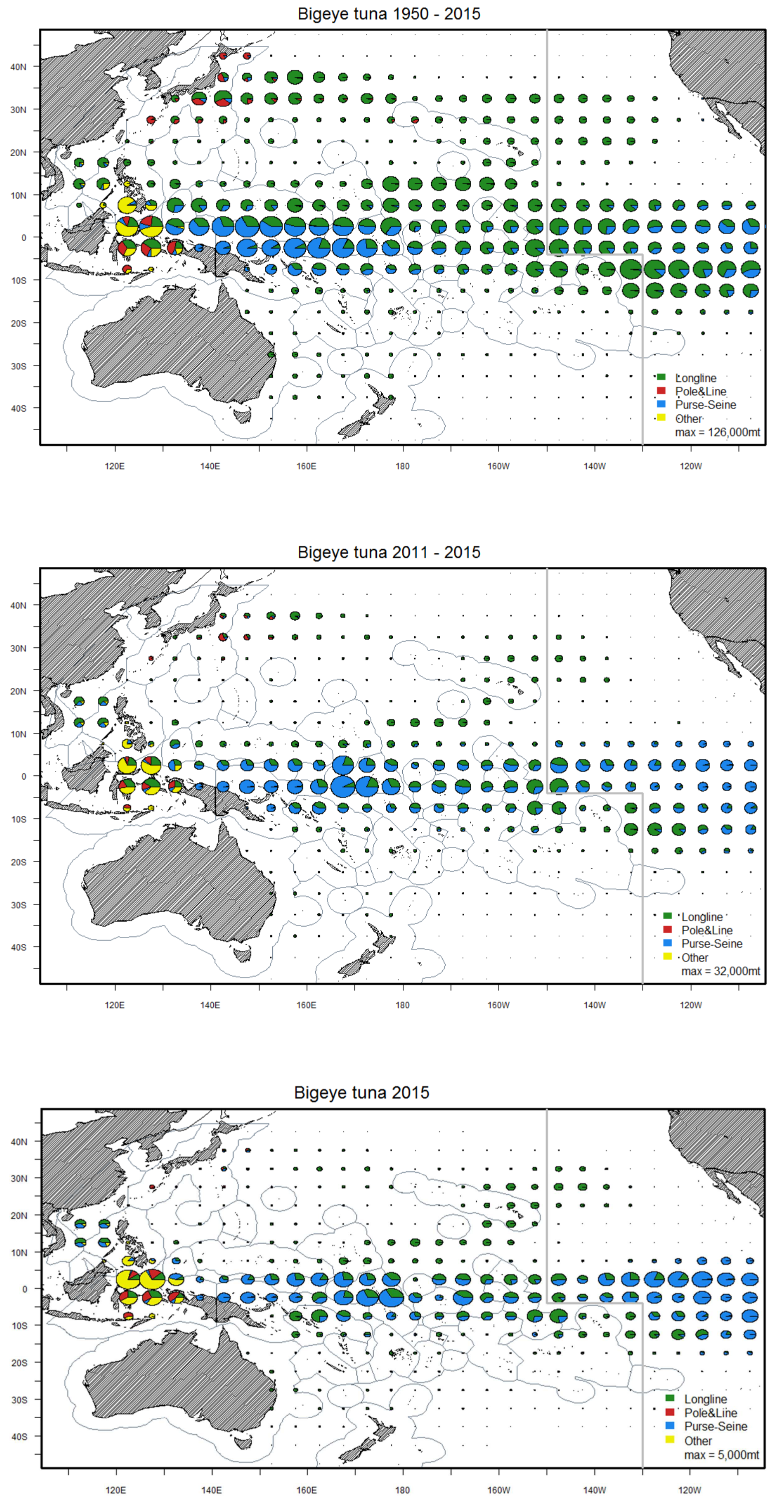


**Figure 5. Bigeye tuna catch distribution by gear type and 5x5° region for the entire Pacific Ocean for the period 1950-2015 (top), 2011-2015 (middle) and 2015 (bottom). The maximum circle size is the same for both plots, and the figure legend provides the catch associated with this maximum circle size.**

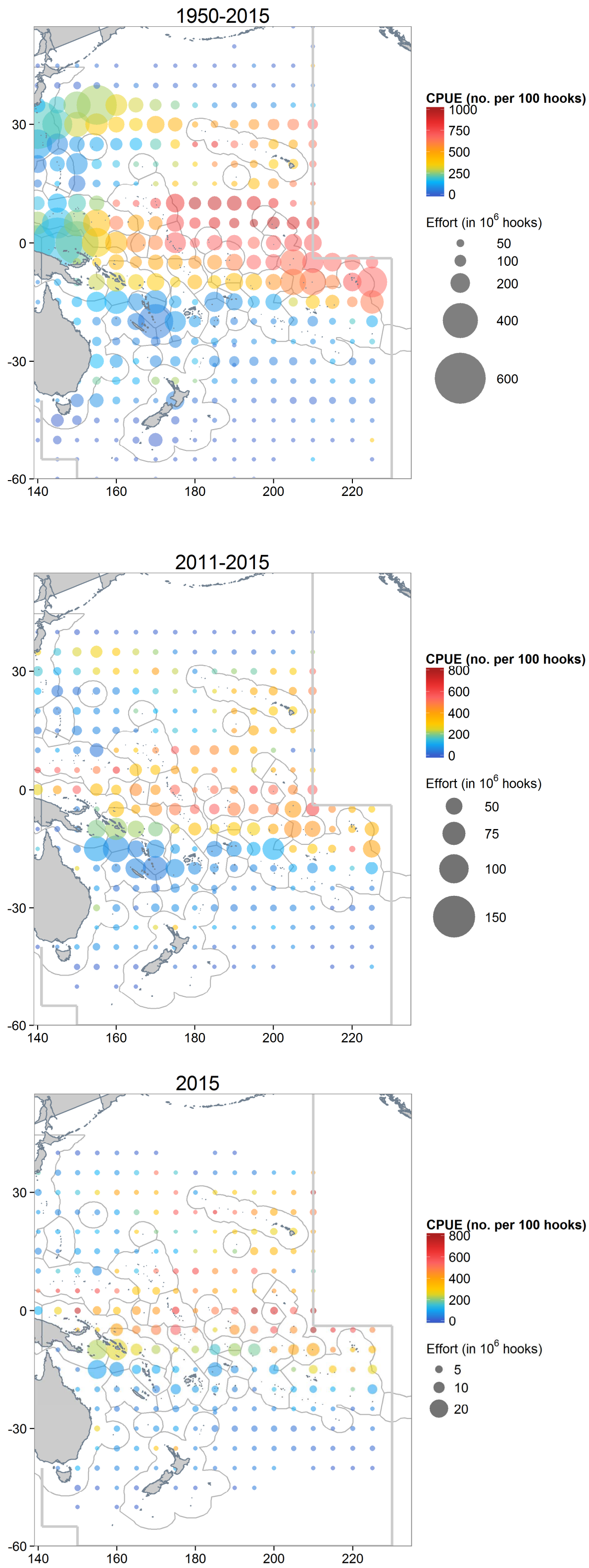


**Figure 6. Distribution of longline effort (represented by circle size) and bigeye tuna CPUE (represented by colour) for the period 1950-2015 (top), 2011-2015 (middle) and 2015 (bottom). Note the differences in scales between plots.**

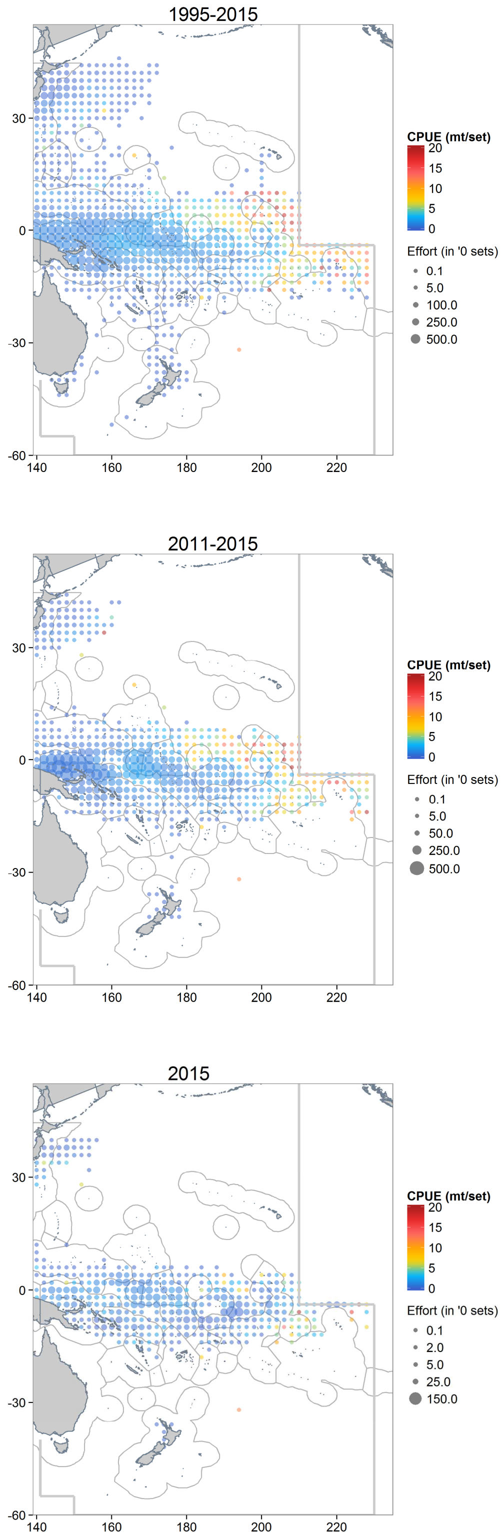


**Figure 7. Distribution of 2° by 2° purse seine effort (represented by circle size) and bigeye tuna CPUE (represented by colour) for the period 1995-2015 (top), 2011-2015 (middle) and 2015 (bottom). Note the differences in circle size scale between plots.**

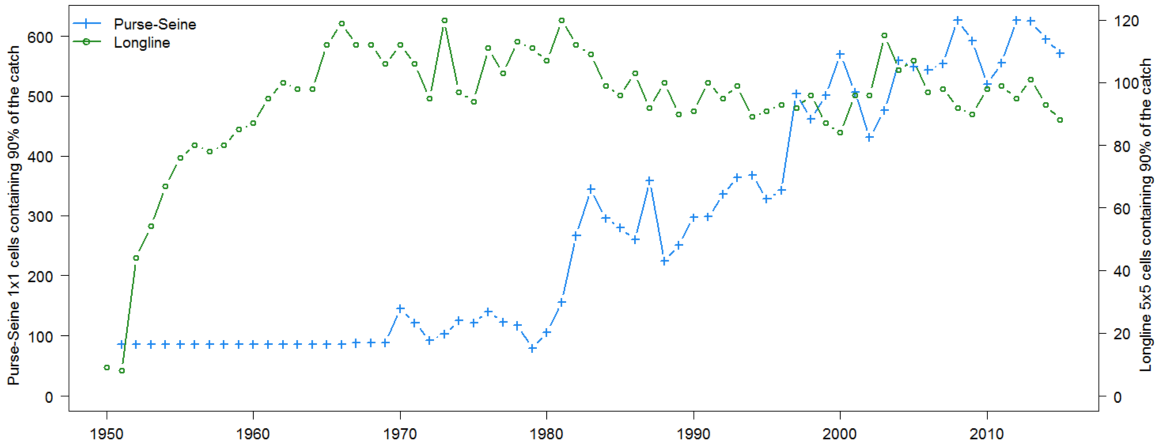


**Figure 8. Concentration of bigeye tuna catches for purse seine and longline by year for the WCPO.**

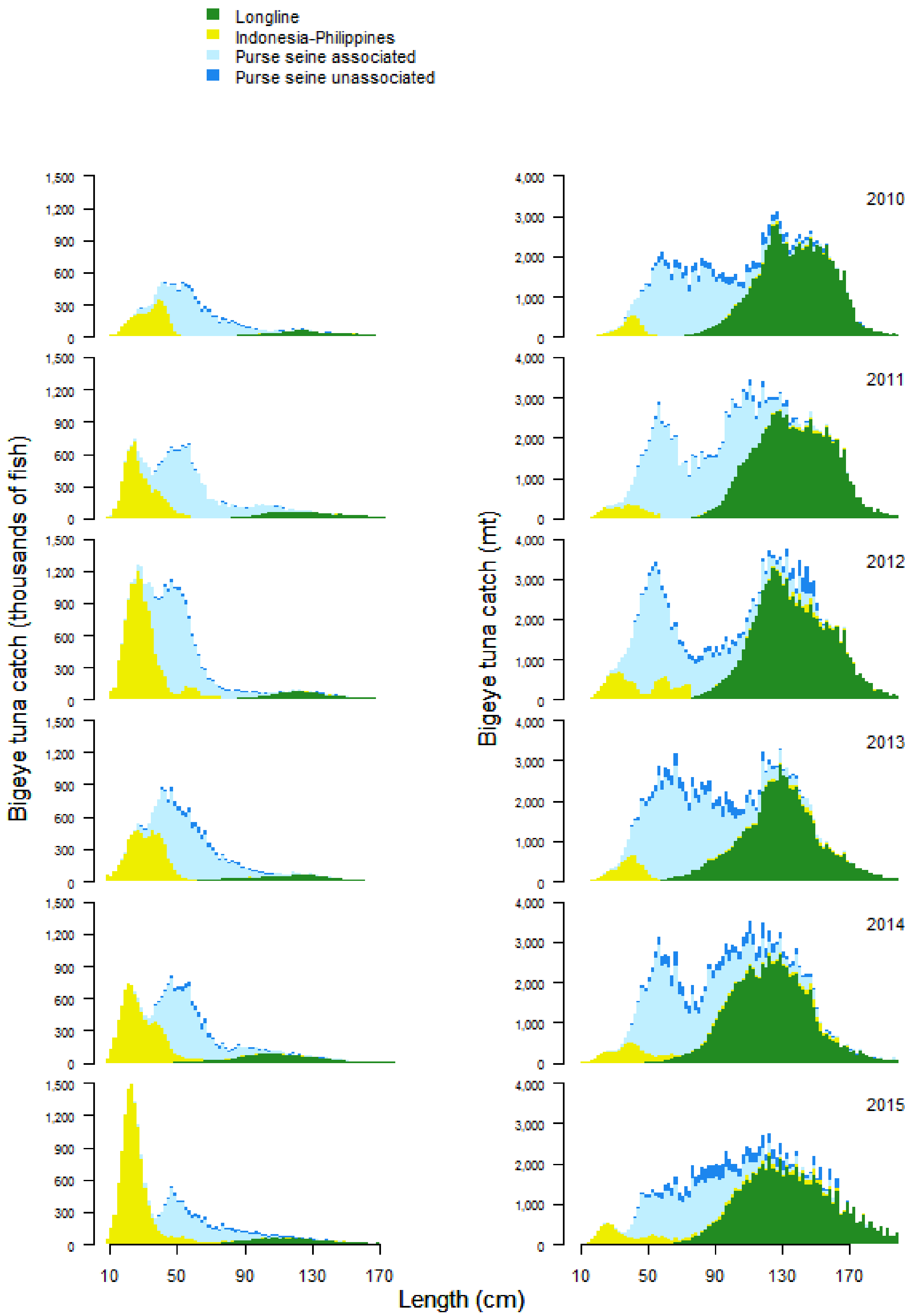


**Figure 9. Catch at size of bigeye tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right).**

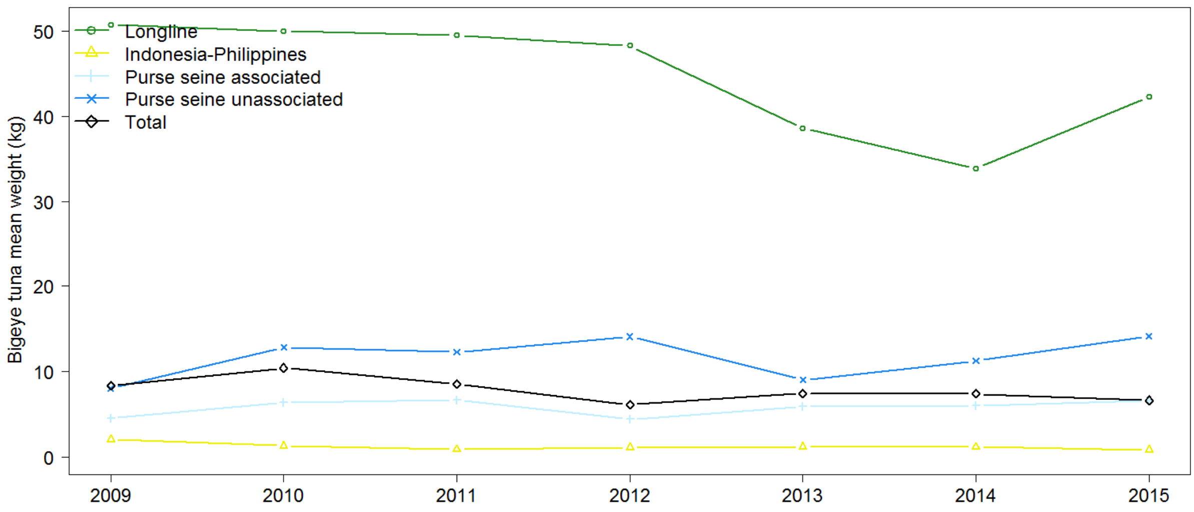


**Figure 10. Mean weight of individual bigeye tuna taken by gear and year for the WCPO. The 'total' line represents the overall catch at size.**

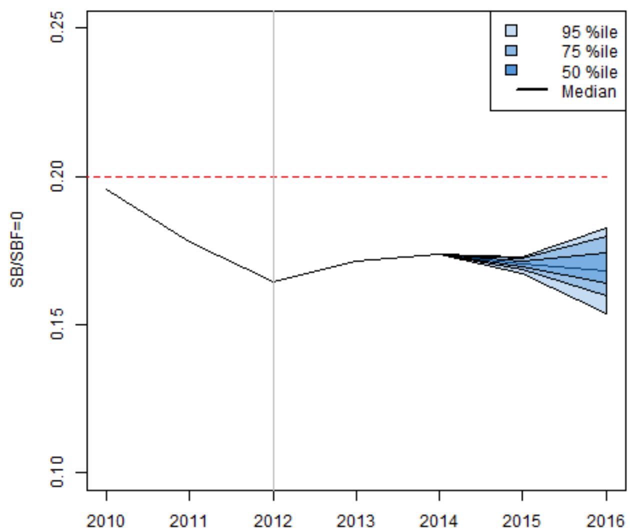


**Figure 11. Stochastic projection results of bigeye spawning biomass ($SB/SB_{F=0}$) from 2012 using actual catch and effort levels in 2013 and 2014, through 2015. Levels of variability in recruitment estimated for the the previous 10 years assumed to continue in the future**

# Yellowfin

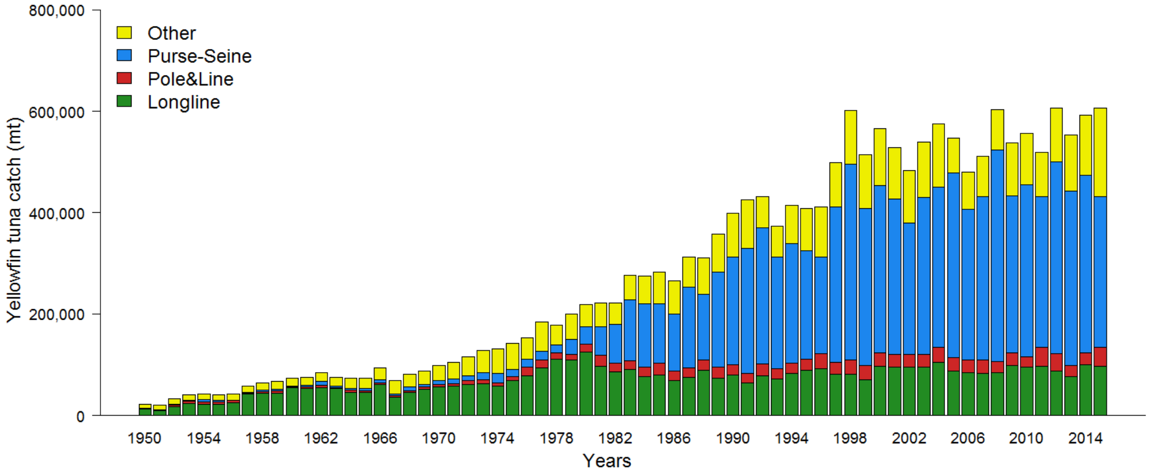


**Figure 12. Yellowfin tuna catch by gear type and year for the WCPFC-Convention Area.**


**Figure 13. Yellowfin tuna catch per unit effort by year in the tropical WCPO, for pole and line for two fleets (top), purse seine for the major set types (middle) and longline for two fleets (bottom; 20N to 10S, WCP-CA).**

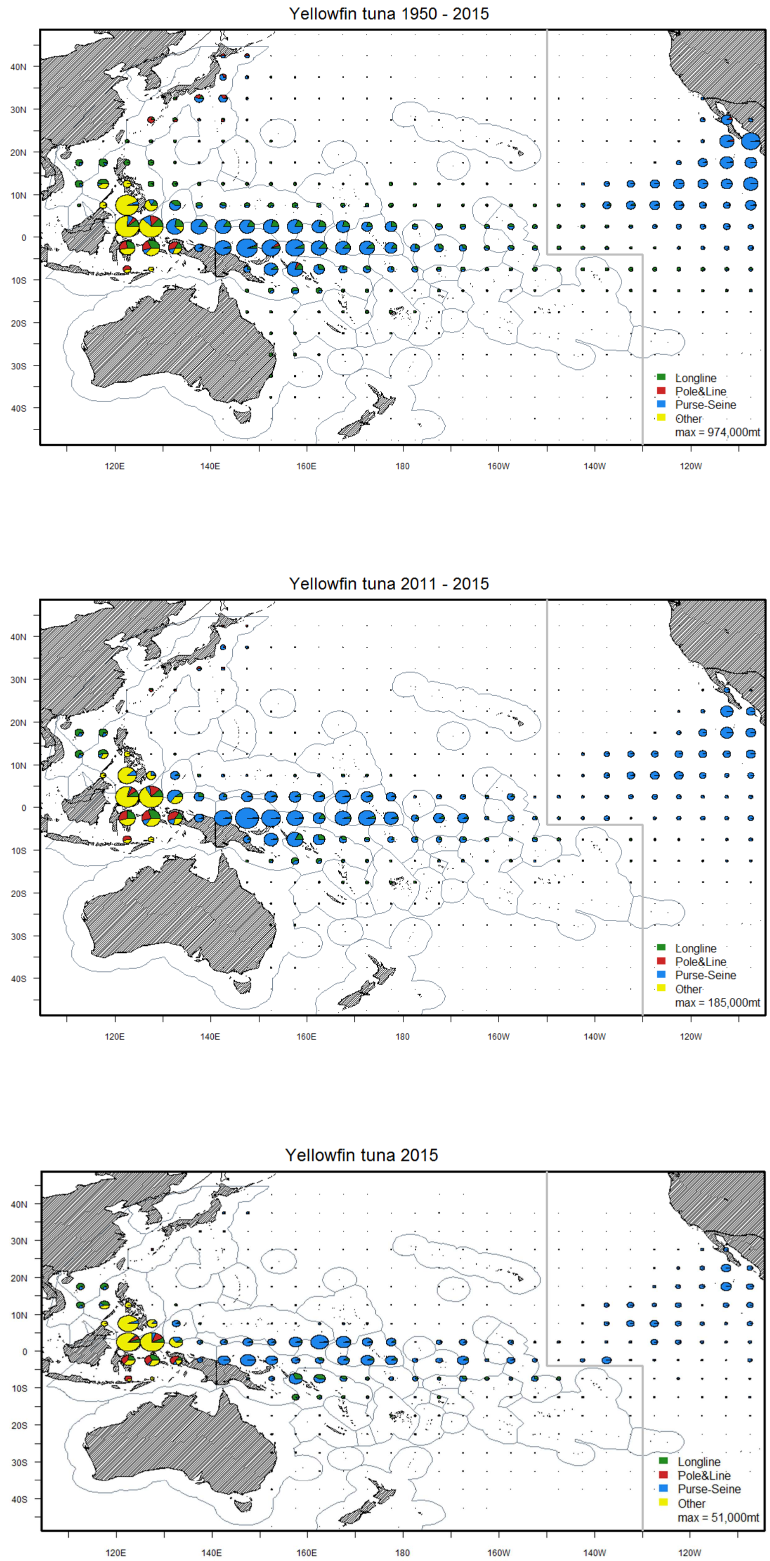


**Figure 14. Yellowfin tuna catch distribution by gear type and 5x5° region for the entire Pacific Ocean for the period 1950-2015 (top), 2011-2015 (middle) and 2015 (bottom).**

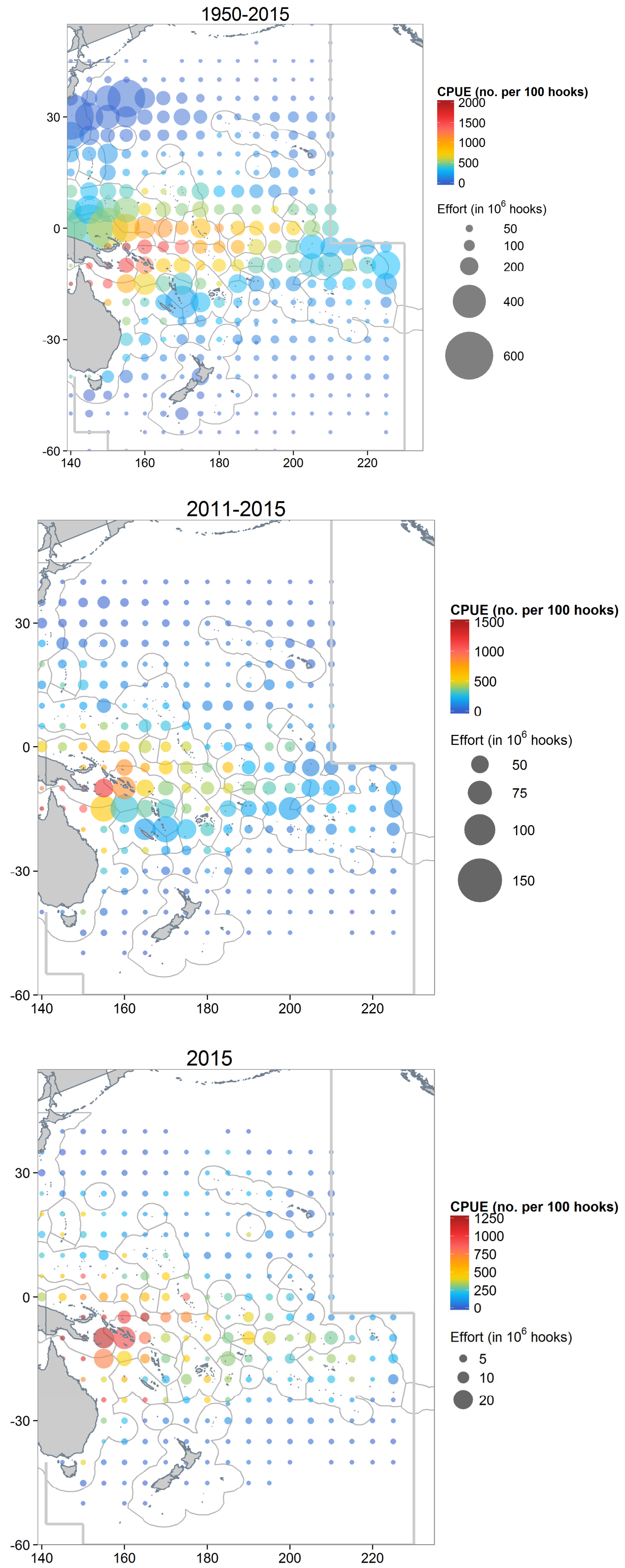


**Figure 15. Distribution of longline effort (represented by circle size) and yellowfin tuna CPUE (represented by colour) for the period 1950-2015 (top), 2011-2015 (middle) and 2015 (bottom). Note the differences in scales between plots.**

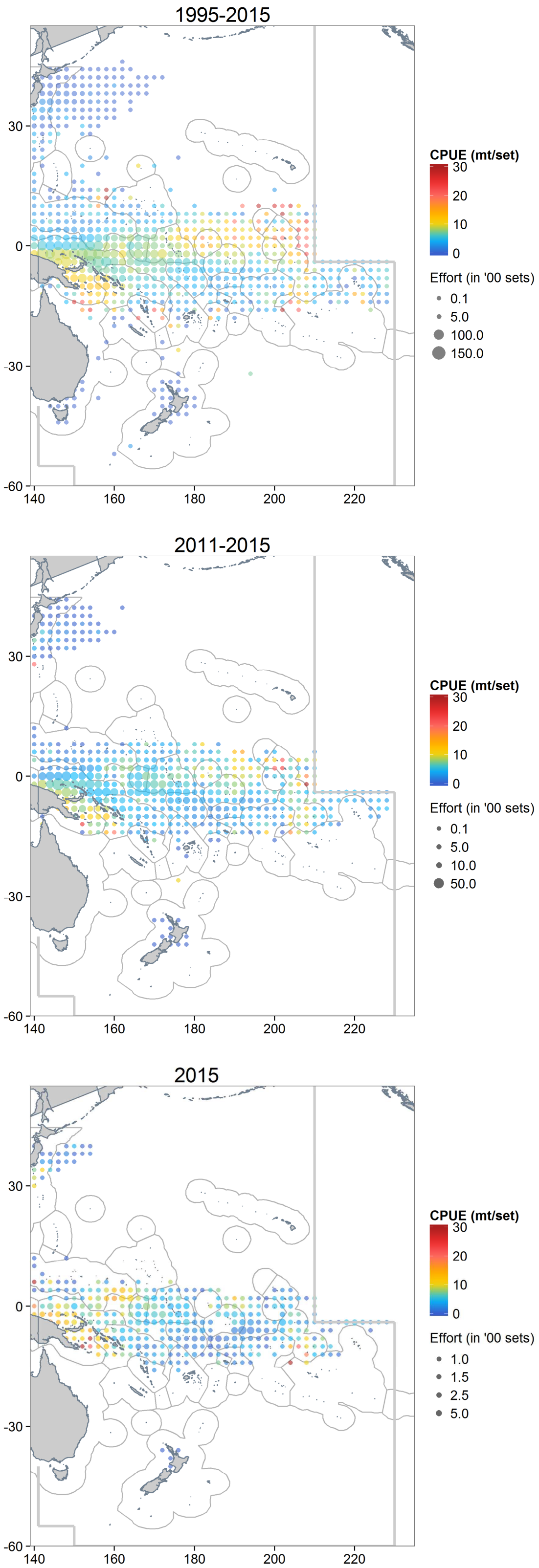


**Figure 16. Distribution of 2° by 2° purse seine effort (represented by circle size) and yellowfin tuna CPUE (represented by colour) for the period 1995-2015 (top), 2011-2015 (middle) and 2015 (bottom). Note the differences in circle size scale between plots.**

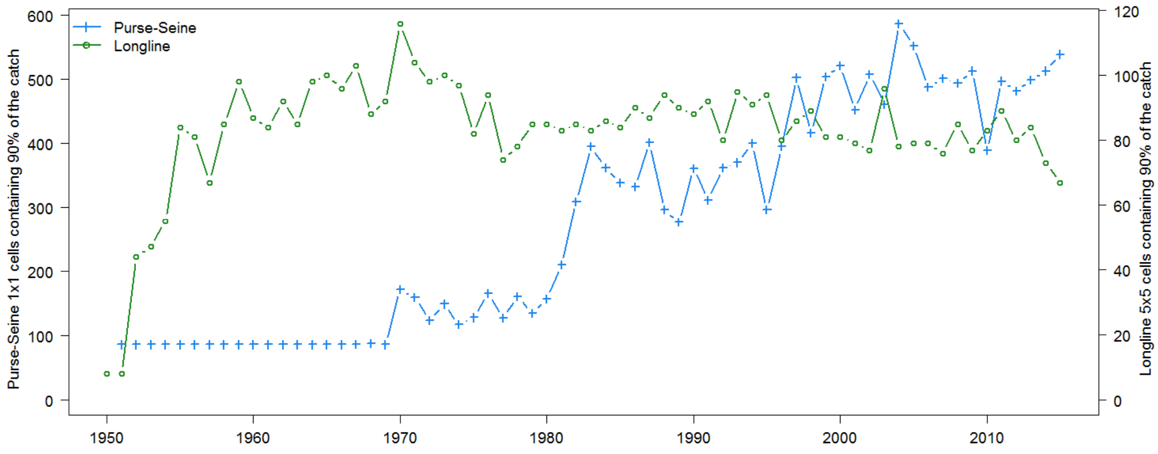


**Figure 17. Concentration of yellowfin tuna catches for purse seine and longline by year for the WCPO.**

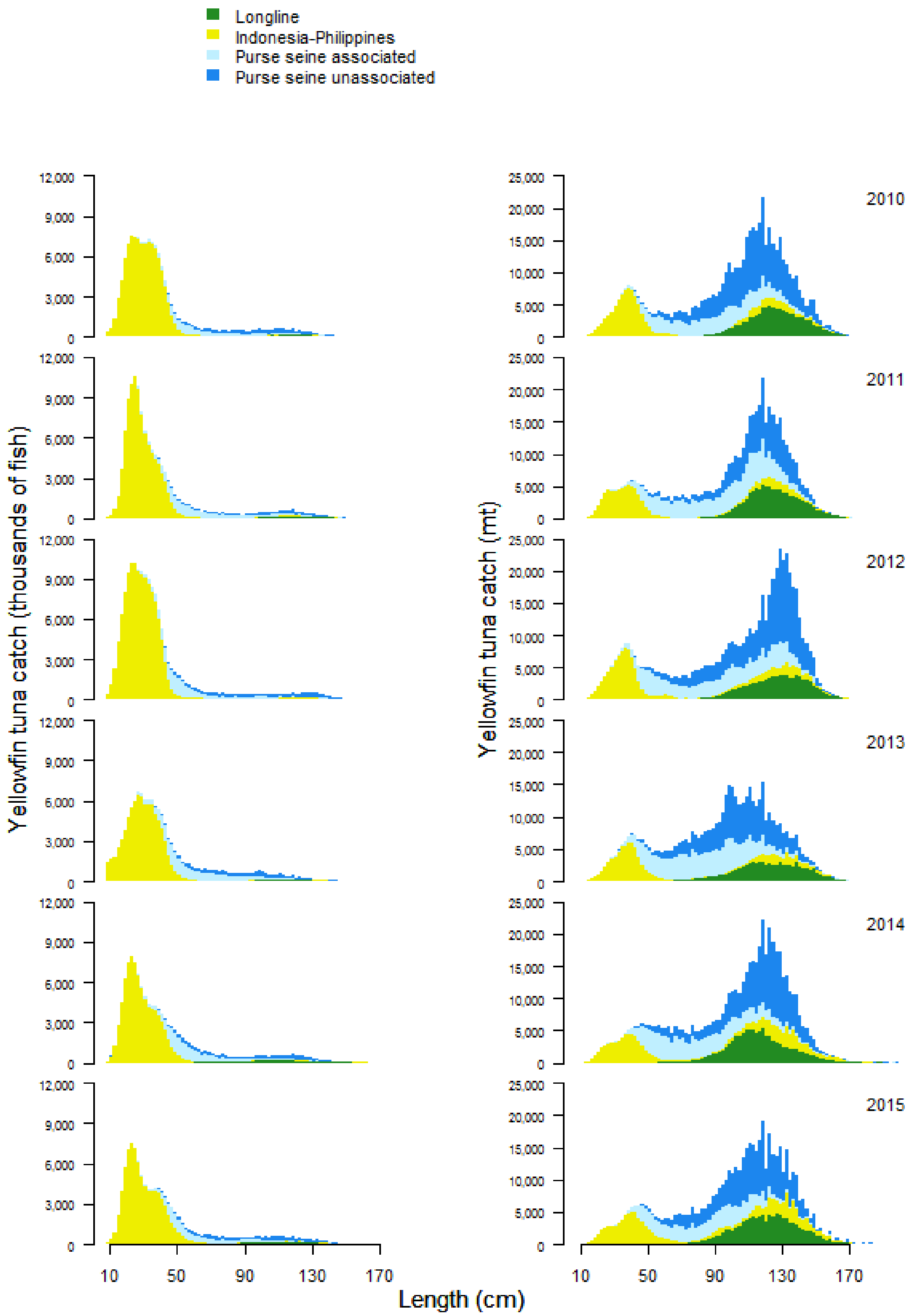


**Figure 18. Catch at size of yellowfin tuna by gear type and year for the WCPO. Catch is provided in thousands of fish (left) and metric tonnes (right).**

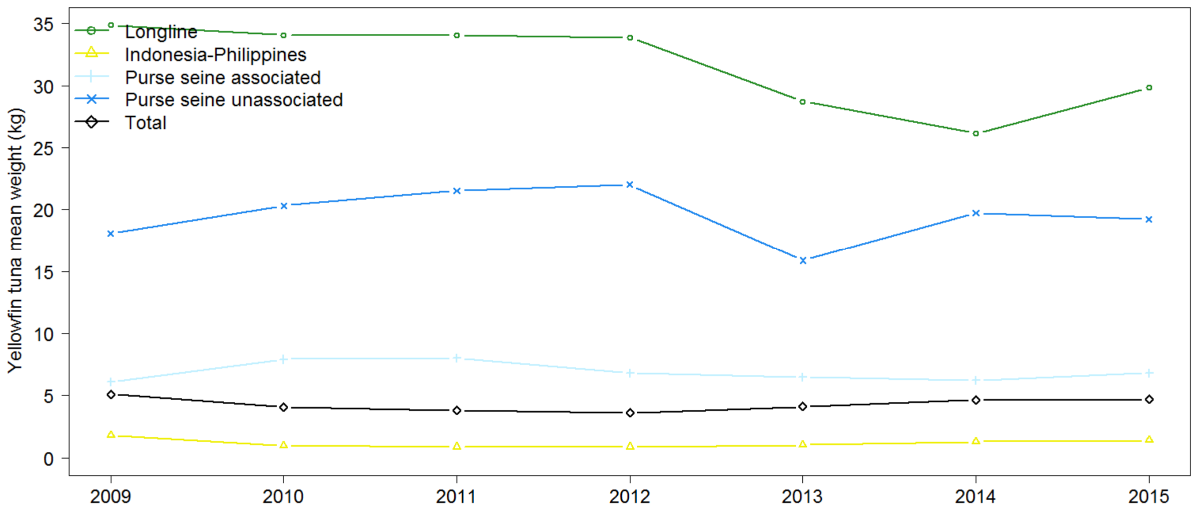


**Figure 19. Mean weight of individual yellowfin tuna taken by gear and year for the WCPO. The 'total' line represents the overall catch-at-size.**

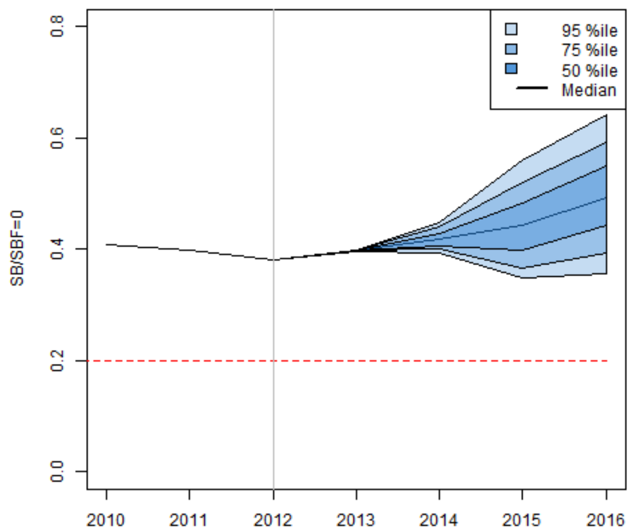


**Figure 20. Stochastic projection results of yellowfin spawning biomass ($SB/SB_{F=0}$) from 2012 using actual catch and effort levels in 2013 and 2014, through 2015. Levels of variability in recruitment estimated for the the previous 10 years assumed to continue in the future.**