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# Fisheries indicators for the southern bluefin tuna stock 2015–16

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# Contents

# Summary

Fishery indicators have played an important role in the provision of advice to the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) on the status of the southern bluefin tuna (SBT) stock by the CCSBT Extended Scientific Committee (ESC) and its trilateral predecessor.

In 2001, it was agreed to monitor and review fishery indicators on an annual basis and fishery indicators are included in the development of the Scientific Committee's advice on status of the stock. Fishery indicators are particularly important in years where the stock assessment has not been updated.

In 2011, the Commission agreed on the Management Procedure (MP) that would be used to guide the setting of the SBT global total allowable catch (TAC) to ensure that the SBT spawning stock biomass achieves the interim rebuilding target of 20 per cent of the original spawning stock biomass. The review of fishery indicators forms part of the MP's metarule process to determine whether exceptional circumstances exist.

The 2015–16 update of fishery indicators for the SBT stock summarises indicators in two groups: (1) indicators unaffected by the unreported catch identified by the 2006 Japanese Market Review and Australian Farm Review; and (2) indicators that may be affected by the unreported catch. Data collected in the longline fisheries after 2006 are unlikely to be affected by unreported catches because of the catch documentation activities that have been undertaken by CCSBT members, and therefore only the historical data and some standardised indicators are possibly affected.

In this paper, interpretation of indicators is limited to subset 1, and recent trends in some indices from subset 2. Two of the three indicators of juvenile (age 1–4) SBT abundance (i.e. scientific aerial survey index and the trolling index) were undertaken in 2016; the SAPUE/commercial spotting index was not updated. Both the scientific aerial survey and trolling index increased since the last update. Indicators of age 4+ SBT exhibited mixed trends with the catch per unit effort (CPUE) from both the New Zealand joint venture fishery and the New Zealand domestic longline fishery increasing in 2015. Similarly, the Japanese longline nominal CPUE for ages 4+ increased. The median length class of SBT on the spawning ground decreased in 2015–16 compared to the previous seasons, with a large increase in small (young) fish reported in the fishery. There remains a strong need to understand the location of these catches. The mean age of SBT increased very slightly in 2014–15 while the median remained the same.

# 1 Background

Fishery indicators have played an important role in the provision of advice to the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) on the status of the southern bluefin tuna (SBT) stock by the CCSBT Extended Scientific Committee (ESC). In 2001 it was agreed to monitor and review fishery indicators on an annual basis (CCSBT-SC 2001). The review of fishery indicators forms part of the management procedure's metarule process, undertaken by the ESC, to determine whether exceptional circumstances exist (Attachment 10, ESC18).

Indicators can provide a broad perspective on recent changes in the status of the SBT stock and include some information that is not otherwise incorporated into model-based assessments. In particular, some indicators reflect the status of the juvenile portion of the stock and represent the only fisheries-independent data available to the ESC.

Some fisheries-dependent indicators could have been affected by unreported catches and potential biases identified by the 2006 Japanese Market Review (Lou et al. 2006) and Australian Farm Review (Fushimi et al. 2006). Data collected in the longline fisheries after 2006 are unlikely to be affected by unreported catches because of the catch characterisation and documentation activities that have been undertaken by the CCSBT members. The 2014-15 update of fishery indicators for the SBT stock summarises indicators in the same groups presented in previous updates in 2007 to 2014 (Hartog et al. 2007, Hartog & Preece 2008, Phillips 2009, Patterson et al. 2010, 2011, 2012, 2013, Patterson & Stobutzki 2014, 2015):

**(1) Indicators unaffected by the unreported catch:**

- Aerial spotting data in the Great Australian Bight (scientific aerial survey; commercial spotting index/surface abundance per unit effort [SAPUE])
- Trolling index
- New Zealand catch per unit effort (CPUE; charter and domestic fleets)
- New Zealand longline fishery size composition (charter and domestic fleets)
- Indonesian longline fishery size/age composition.

**(2) Indicators that may be affected by the unreported catch**

- Reported global catch
- Japanese, Korean and Taiwanese CPUE
- Size/age composition in the Japanese, Korean and Taiwanese longline fisheries
- Age composition in the Australian surface fishery.

In this paper, the interpretation of indicators is restricted to the subset (1) considered to be unaffected by the unreported catch, and recent trends in some indicators from subset 2. This paper updates the information provided by Patterson & Stobutzki (2015) with the most recent data available through the CCSBT data exchange in June 2016.

# 2 Indicators unaffected by unreported catch

## Scientific aerial survey

The scientific aerial survey index was updated in 2016 through the CCSBT data exchange (Sec-AerialSurvey (1993_2016)).

A line-transect aerial survey conducted in the Great Australian Bight between January and March provides a fisheries-independent estimate of the relative abundance of aggregated 2–4 year old SBT (Eveson and Farley 2016). The survey was suspended in 2001 because of logistical problems, but re-established in 2005 after analyses demonstrated that the survey provides a suitable indicator of relative juvenile abundance (Eveson and 2016).

The historic trend in the scientific aerial survey index and the spatial distribution of sightings is discussed fully in Eveson and Farley (2016). This index of relative juvenile abundance in 2016 (the 2015–16 fishing season) was substantially higher than the 2014 estimate (2013–14 fishing season). Indeed, the 2016 index was the highest index obtained for the scientific aerial survey over the past 10 years.

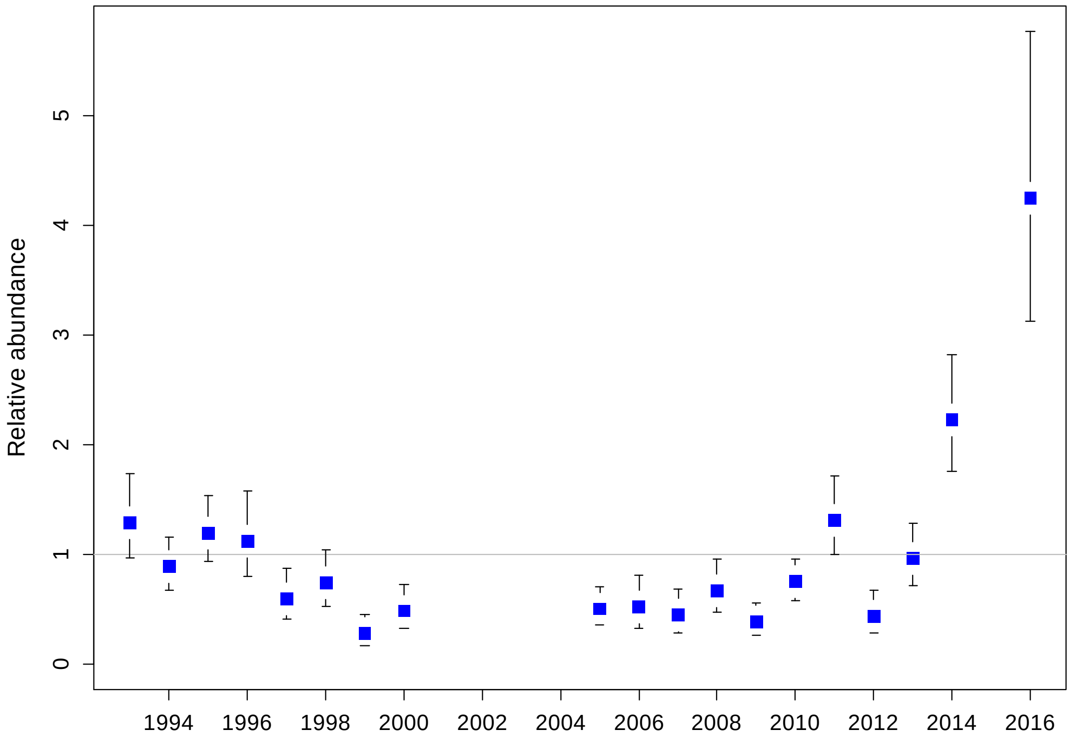


**Figure 1. Scientific aerial survey of relative abundance for juvenile SBT in the Great Australian Bight, January–March (hence the 2014 value represents the 2013–14 fishing season etc) from Eveson and Farley (2016). Vertical lines are 90 per cent confidence intervals. The horizontal line represents a relative abundance of 1.0.**

# Commercial spotting index / Surface abundance per unit effort (SAPUE)

There was no update of the commercial spotting index in 2015 or 2016, therefore there is no updated index for the 2014–15 or 2015–16 seasons. The commercial spotting (SAPUE) index was updated in 2014 from data provided by Australia in 2014 through the CCSBT data exchange (AU_CommercialSpotting_2003_14).

Data on sightings of SBT schools in the Great Australian Bight were collected by experienced tuna spotters as part of commercial spotting operations over eleven fishing seasons, 2001–02 to 2013–14. The data were used to produce standardised fishery-dependent indices of juvenile SBT relative abundance (surface abundance per unit effort; SAPUE). Unlike the statistically designed scientific aerial survey, the commercial spotting is governed by business considerations and fishing operations which may result in biases (Basson & Farley 2014).

The SAPUE index reflects the aggregated abundance of age 2–4 year old SBT. The lowest values in the series (2002–03 and 2003–04) therefore represent, as age 2–4 year olds, the low year classes observed in 1999–2001 and 2000–02 in other data sets. Farley et al. (2014) urge caution when directly comparing the SAPUE with the overlapping period of the scientific aerial survey index (2004–05 to 2013–14) as the data were collected using different methods and commercial flights cover a much smaller area than the scientific line transect aerial survey. The spatial distribution of commercial spotting operations has changed in recent years, away from the original core fishing area and the area surveyed in the scientific aerial survey. The per cent of total search effort occurring in the core area decreased from ~80-89 per cent in 2002–2008, to only 4.1 per cent in 2013 and 0.5 per cent in 2014 (see Farley et al. 2014). Note that the SAPUE is from 2003 onwards, rather than 2002, due to a change in the model that includes variables that were not collected in 2002.

Median estimates have varied over the series, however an increasing trend is discernible up to 2011 (Fig. 2). The 2013–14 value was substantially higher than the value in 2012–13 (Fig. 2).

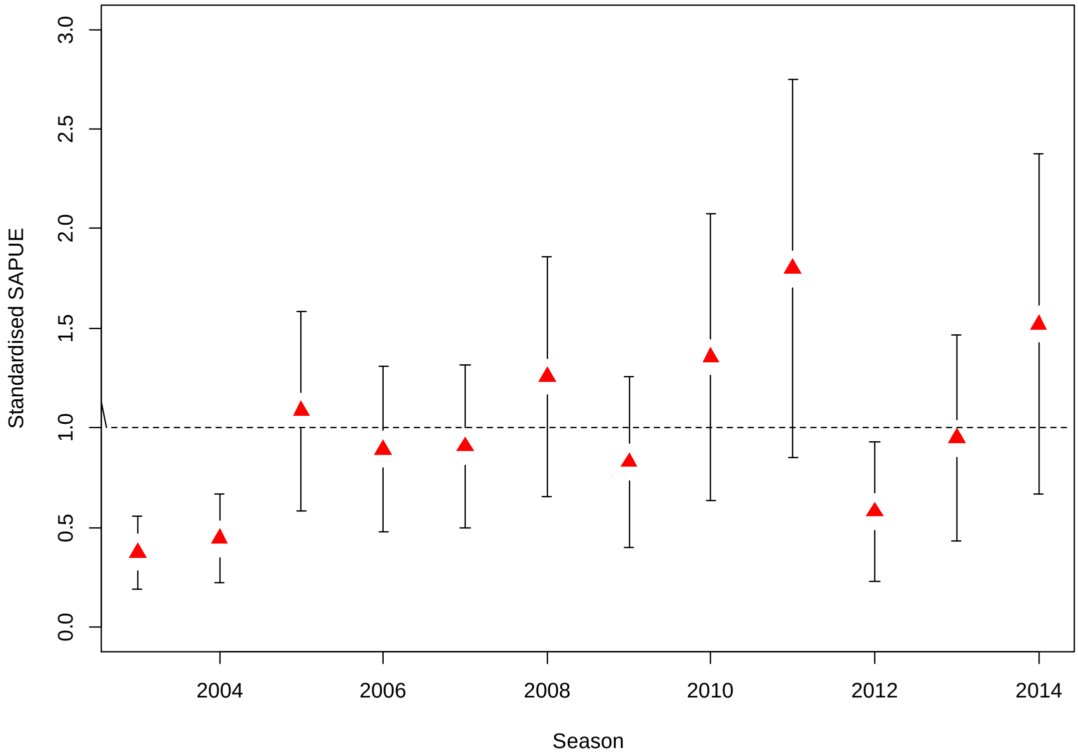


**Fig. 2. SAPUE index of relative surface abundance of juvenile SBT in the Great Australian Bight, December–March (Farley et al. 2014). Estimates are median ± 2 standard errors. The dashed horizontal line indicates the mean. 'Season' represents the second year in a split-year fishing season, i.e. 2014 is the 2013–14 fishing season.**

# Trolling index

The trolling survey index was updated in 2016 from data provided by Japan in 2016 through the CCSBT data exchange (JP_Trollindex2016). No trolling survey was conducted in 2015.

The trolling survey is conducted by the Japanese National Research Institute of Far Seas Fisheries and is designed to provide a qualitative index of relative recruitment strength of age 1 SBT off the Western Australian coast (CCSBT-ESC13 2008, para 115). The objective of the recent piston-line trolling survey has been to provide a rough recruitment index at low cost (Itoh et al. 2013). The ESC 2015 identified research needed if the index was to be considered for the MP in future (CCSBT-SC 2015). The trolling index is comprised of: (1) a piston-line trolling survey, 2006–14; (2) trolling catch data from the acoustic survey 'on' the piston line, 2005–06; and (3) trolling catch data from the acoustic survey off the piston line, 1996–2003 and 2005–06 (Itoh & Sakai 2009). Methods used to obtain comparable data from these three sources are documented by Itoh (2007) and Japan has noted that all the indices reflect the number of SBT schools per 100 km, but have not been merged or converted to be quantitatively the same (CCSBT-SC 2010, para 81).

In 2012, the index steeply declined to the lowest level recorded for the piston-line survey and well below the average median value (red line, Fig 3). However, in 2013 the index increased to just below the average median value and declined slightly in 2014. In 2016, the index was above the average median value.

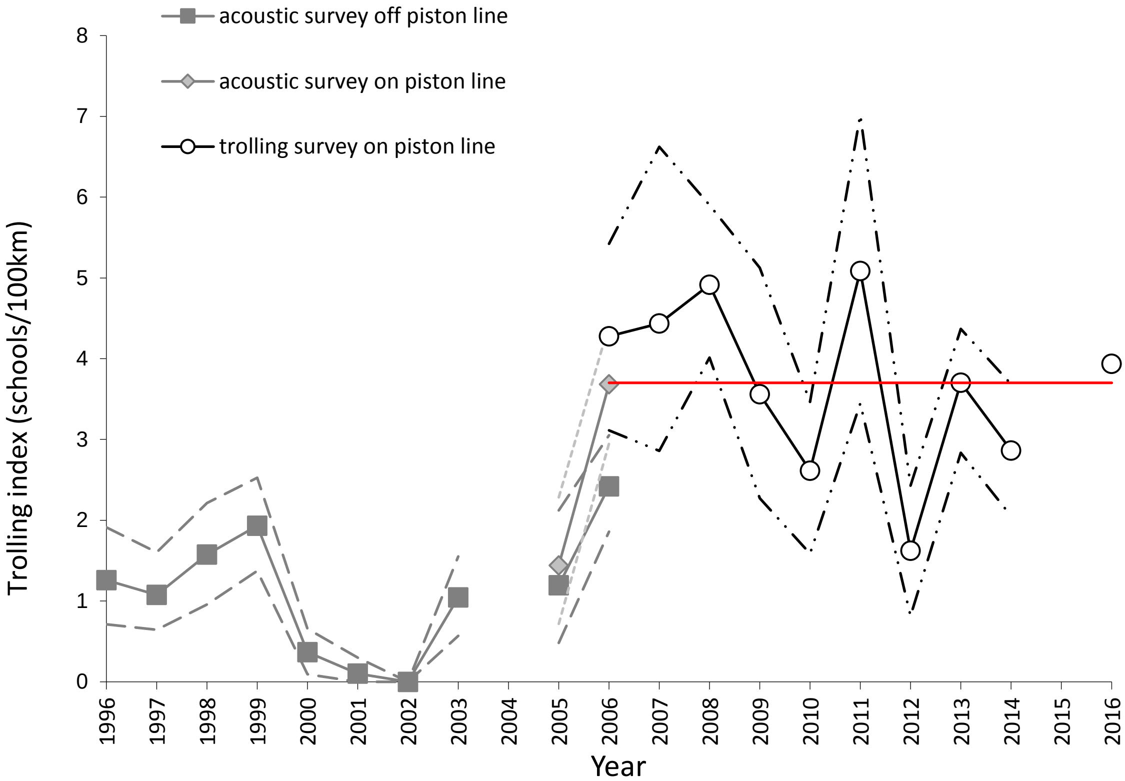


**Fig. 3. Trolling index, showing number of schools per 100 km off the Western Australian coast in January. Dashed lines are 90 per cent confidence intervals. The red line shows the average median value of the piston line survey from 2006–16.**

# Catch per unit effort

## New Zealand joint venture (charter) longline CPUE

New Zealand (NZ) joint venture (charter) longline nominal CPUE for statistical areas 5 and 6 (aggregated for all age classes) was updated from CPUE input data provided in the 2016 interim update of the CCSBT database.

The NZ charter fishery had close to 100 per cent observer coverage until 2007, and these data are assumed to be unaffected by the unreported catches identified in the Japanese Market Review (Lou et al. 2006). Observer coverage remains high (100 per cent vessels covered, >80 per cent catch observed and measured). The NZ TAC caught by the charter fishery has remained reasonably stable, but with the increase in TAC since 2009–10, the domestic component has more than doubled (CCSBT-ESC/1409/SBT Fisheries - New Zealand). The nominal CPUE in the southern fishery (CCSBT statistical area 6), where most of the catch is taken, has shown a declining trend since 2010, but 2015 was higher than the previous two years, and remains above the ten-year mean level. There has been very little or zero effort and catch in statistical area 5 in recent years; there was no effort in area 5 in 2015.

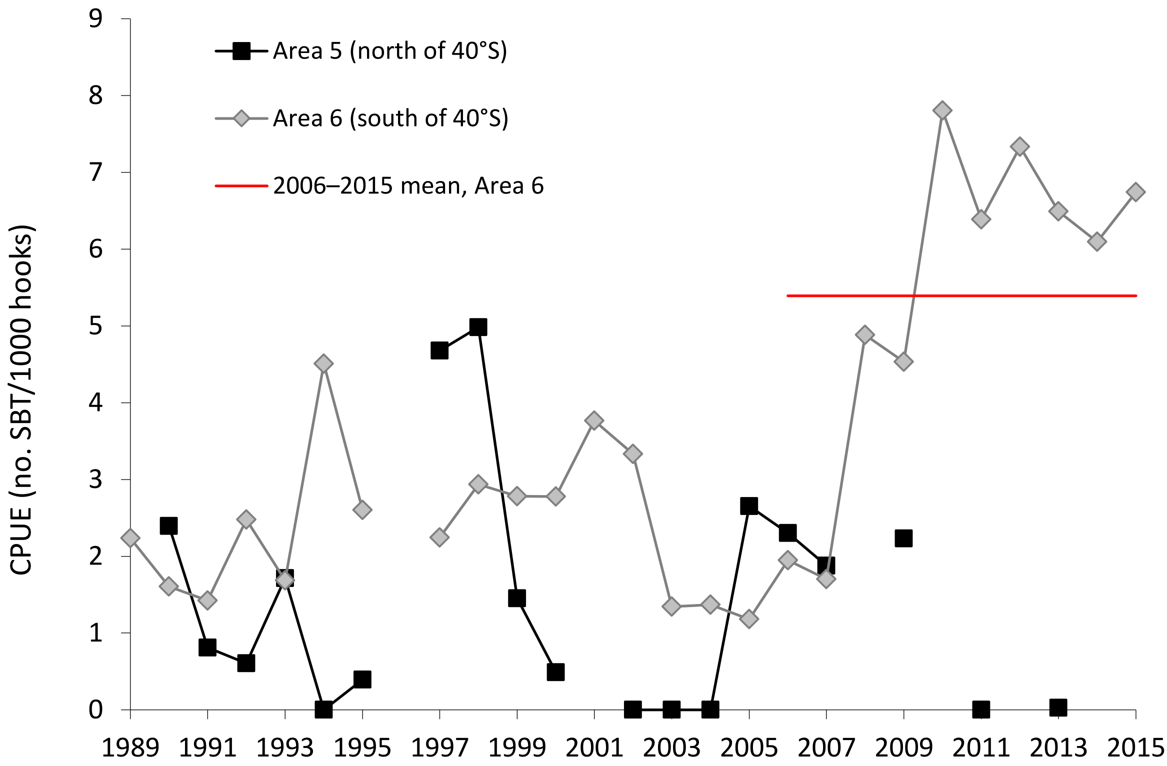


**Fig. 4. Nominal CPUE (number per 1000 hooks) for the NZ charter fishery. The red horizontal line indicates the 10-year mean (2006–15) in Area 6.**

## New Zealand domestic longline CPUE

The NZ domestic nominal CPUE was updated from aggregated catch and effort data provided in the 2015 interim update of the CCSBT database. The CPUE series has been compiled for longline vessels only; the handline/troll fishery virtually disappeared in the 1990s. The NZ domestic nominal CPUE is aggregated across all age classes and all catch, irrespective of target species.

The observer coverage in the NZ domestic fishery is lower than in the NZ joint venture fishery (CCSBT-ESC/1509/SBT Fisheries - New Zealand). With the increase in TAC to NZ in recent years, the domestic fishery catches have more than doubled since 2008–09.

Overall, catch rates in the NZ domestic fishery have increased over the last decade, with a sharp increase seen since 2007. There was a marked increase in 2014, with a smaller increase in 2015. This nominal CPUE does not take into account any fleet or operational changes. CCSBT-ESC/1409/SBT Fisheries - New Zealand notes that due to changes in the domestic fleet structure and the "Olympic system" under which the NZ fishery operated prior to 2004, trends in the domestic fishery CPUE may not provide reliable information on trends in the vulnerable biomass.

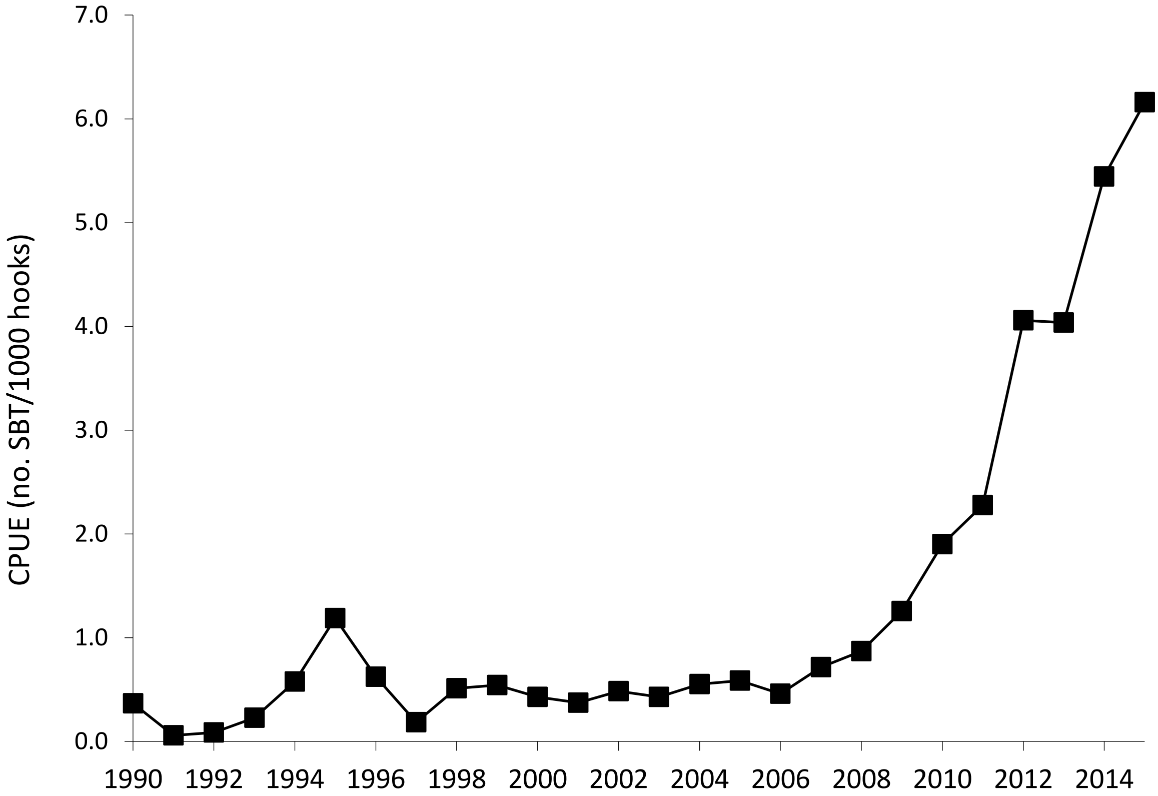


**Fig. 5. Nominal CPUE (number per 1000 hooks) for the NZ domestic longline fishery.**

# Catch size/age composition

## New Zealand longline fishery size composition (< 6 years)

Size composition data for SBT caught by the NZ joint venture and domestic fisheries were extracted from the 2016 interim update of the CCSBT database and were examined for trends in juvenile fish less than 6 years of age (Figs. 6 & 7). Fish in these size classes (i.e. <130 cm) have comprised ~19 per cent of the New Zealand joint venture catch on average since 2000.

In the NZ domestic fishery, juvenile fish aged less than 6 years have comprised on average 18 per cent of the catch, although size composition is not as well estimated for this fleet as for the charter fleet. All size composition data for the charter fishery are derived from longline vessels. The data for the early years of the domestic fishery are dominated by handline and troll caught fish and in more recent years by longline vessels. As such, caution should be used in interpreting the full time series because of this discontinuity (Hartog & Preece 2008).

It has been assumed that the following size categories represented ages 0–2, 3, 4 and 5:

≤86 cm: age 0–2

>86 to ≤102 cm: age 3

>102 to ≤114 cm: age 4

>114 to ≤126 cm: age 5

Age 4 and age 5 SBT all but disappeared from the NZ joint venture fishery in 2003 and 2004, respectively (Fig. 6). Both age classes began to show some signs of re-emergence in 2006 and this continued until 2008 and 2009 for age 4 and age 5, respectively. In 2015, ages 4 and 5 both decreased, while age 3 increased. The NZ joint venture fishery catches virtually no age 0–2 SBT, with no clear trends in the abundance of this size/age class apparent over the past decade (Fig. 6). Given the general 100 per cent observer coverage in the NZ joint venture fishery up to 2007, and continued high coverage since, it is assumed that the proportions of juveniles in the catch for these years would not be affected by unreported discarding.

In the size/age categories examined, the NZ domestic fishery has historically landed age 4 and 5 SBT, with some small, recent spikes in the landing of age 3 SBT (2006 and 2010) (Fig. 7). The abundance of the juvenile age classes declined in 2003 and 2004 (similar to the trend observed in the NZ joint venture fishery) and has been variable since that time. The two oldest age classes decreased in 2015 (Fig. 7), the age 5 class in particular. The 0–2 age class, which has been virtually zero throughout the time series, remained near zero, as did the age 3 class. There is a lower level of observer coverage in the NZ domestic fishery, and some unreported discarding of juveniles may occur.

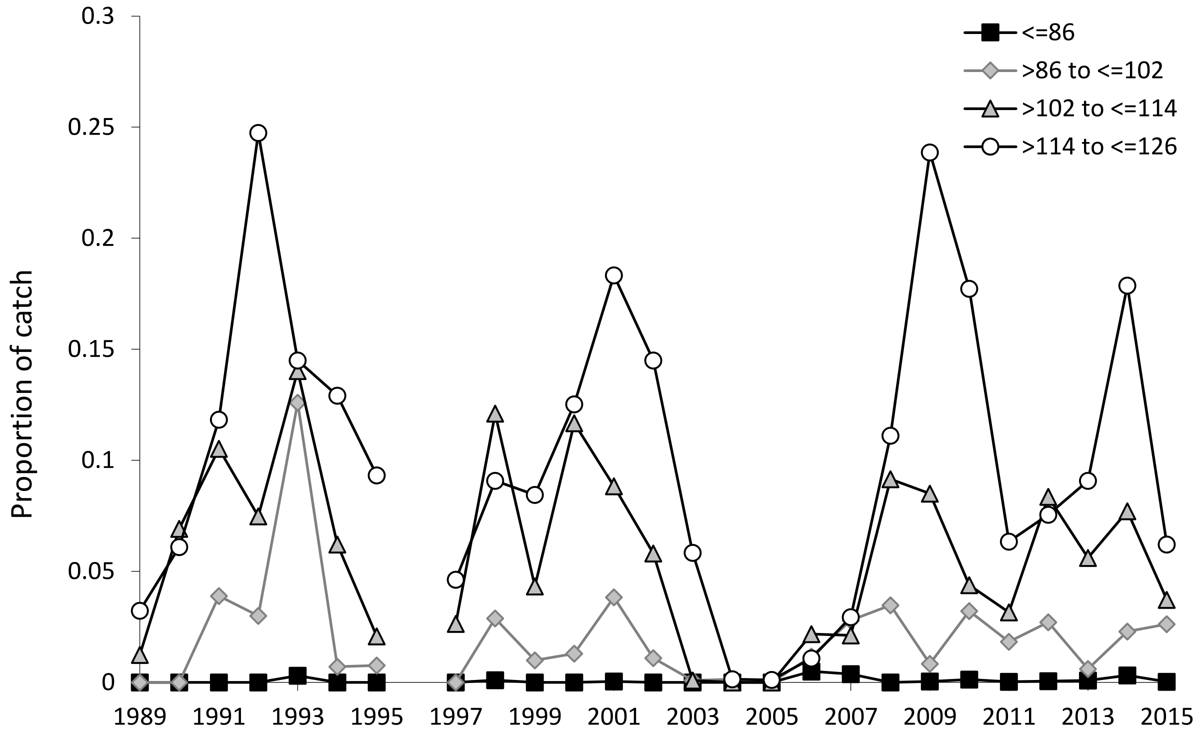


**Fig. 6. Size composition of juvenile fish (< 6 years) for the NZ joint venture longline fishery, where age 0–2<86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.**

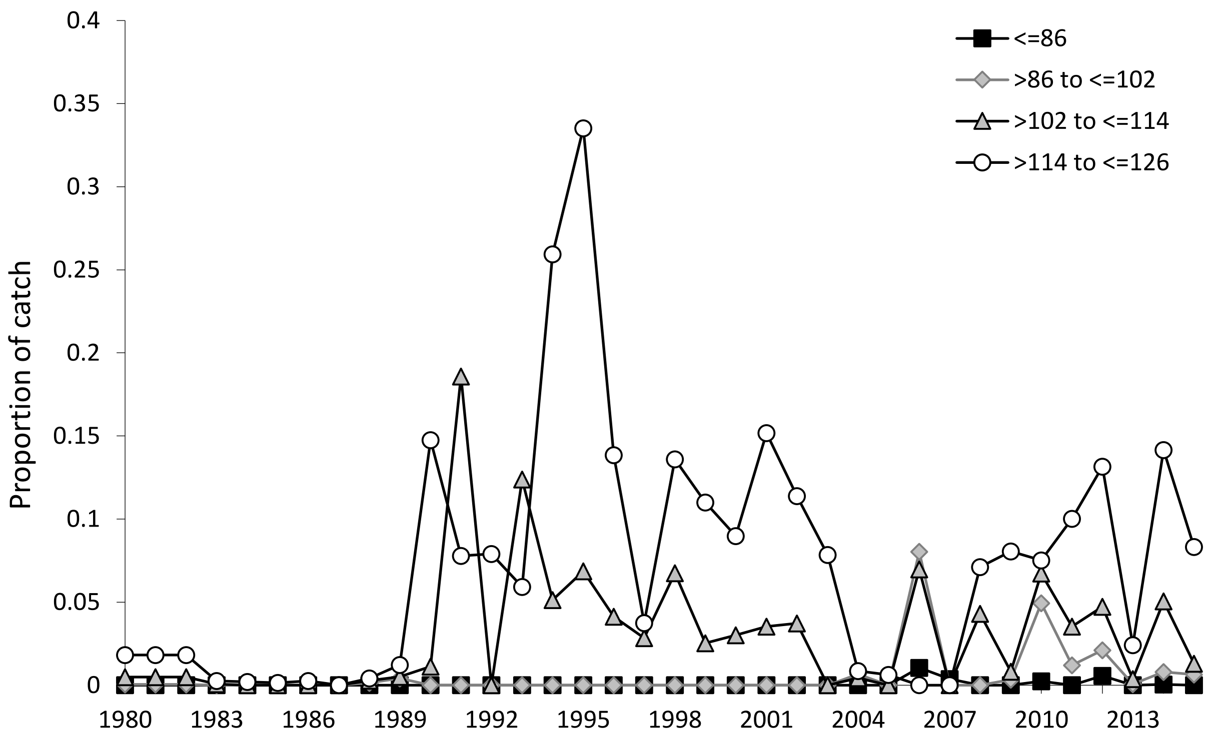


**Fig. 7. Size composition of juvenile fish (< 6 years) for the NZ domestic longline fishery, where age 0–2<86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.**

## Indonesian spawning ground size/age composition

The Indonesian catch data provide an important source of information about the spawning population if we assume that the selectivity of this fishery has been constant over time. The Indonesian size data for the 2014–15 season and the age data for 2013–14 season were provided in 2016 (Farley et al. 2016).

Since the mid- to late-1990s the size of SBT landed in this fishery has declined. In 2012–13 to 2014–15, the length data showed a new mode of relatively small fish in the catch at ~140–155 cm (Fig. 8, Fig. 9; Farley et al. 2016). The mean size class decreased from 168 cm in 2011–12 to 162 cm in 2014–15. In 2015–16, this small size class was again present and the mean size was ~160 cm.

There was also an increase in the catch of young SBT (7–10 years) in 2012–13 and 2013–14. The mean age of SBT on the spawning ground decreased substantially from 16.0 years in 2011–12 to 14.4 years in 2014–15. The mean age of fish >20 years has also decreased (Fig. 10, Fig. 11; Farley et al. 2016).

Although early investigations suggest that these small/young SBT in the Indonesian catch were taken south of the spawning ground, the catch location cannot be determined at this time (Farley et al. 2016). Resolving the location of this catch is important for interpreting the indicators, as well as the use of these data in the operating model.

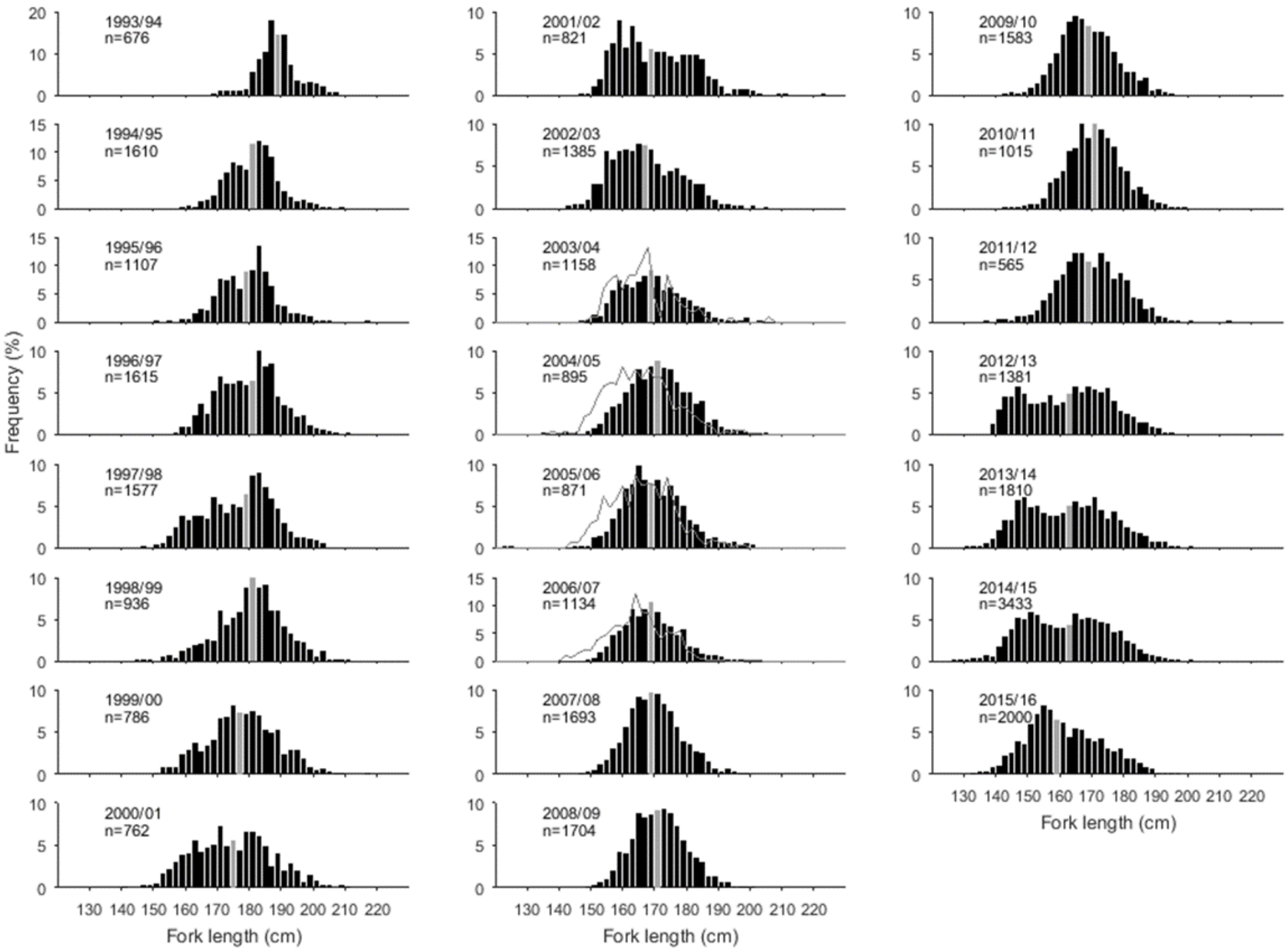


**Fig. 8. Length frequency (2 cm intervals) of SBT caught on the spawning ground (bars) by spawning season (Farley et al. 2016). The grey bar shows the median size class. For comparison, the length distribution of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2003/04 (n=121), 2004/05 (n=685), 2005/06 (n=311) and 2006/07 (n=452) seasons (grey line) (see Farley et al. 2007).**

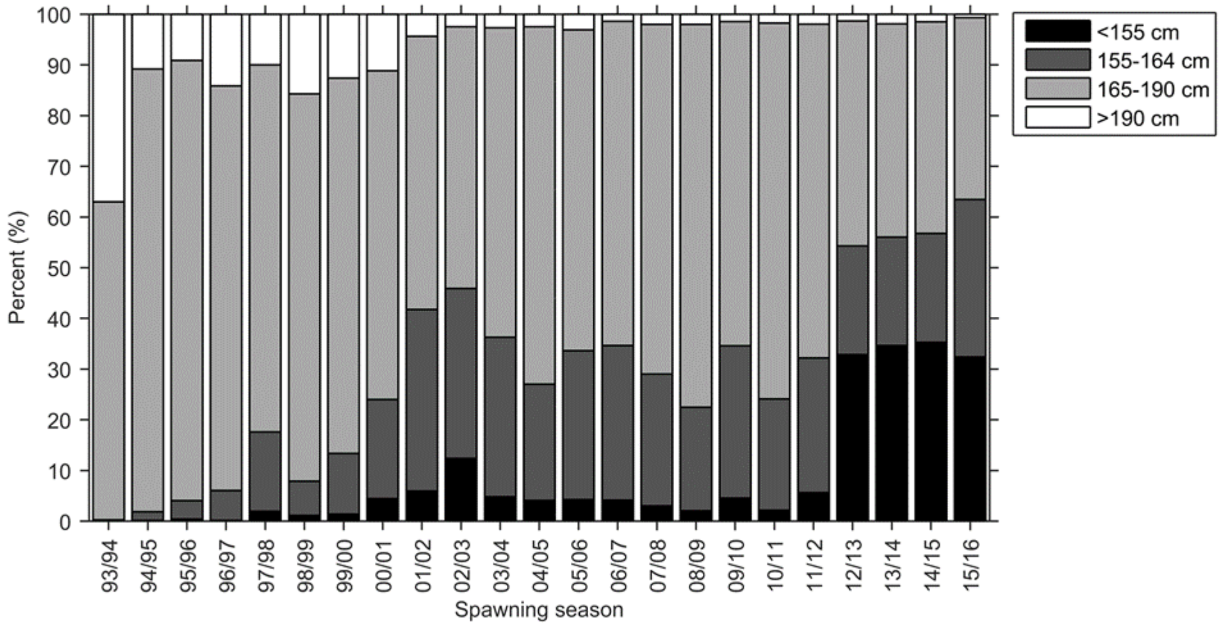


Fig. 9. Size composition of SBT caught on the spawning grounds by the Indonesian longline fishery by spawning season (from Farley et al. 2016). Data from Processor A are excluded.

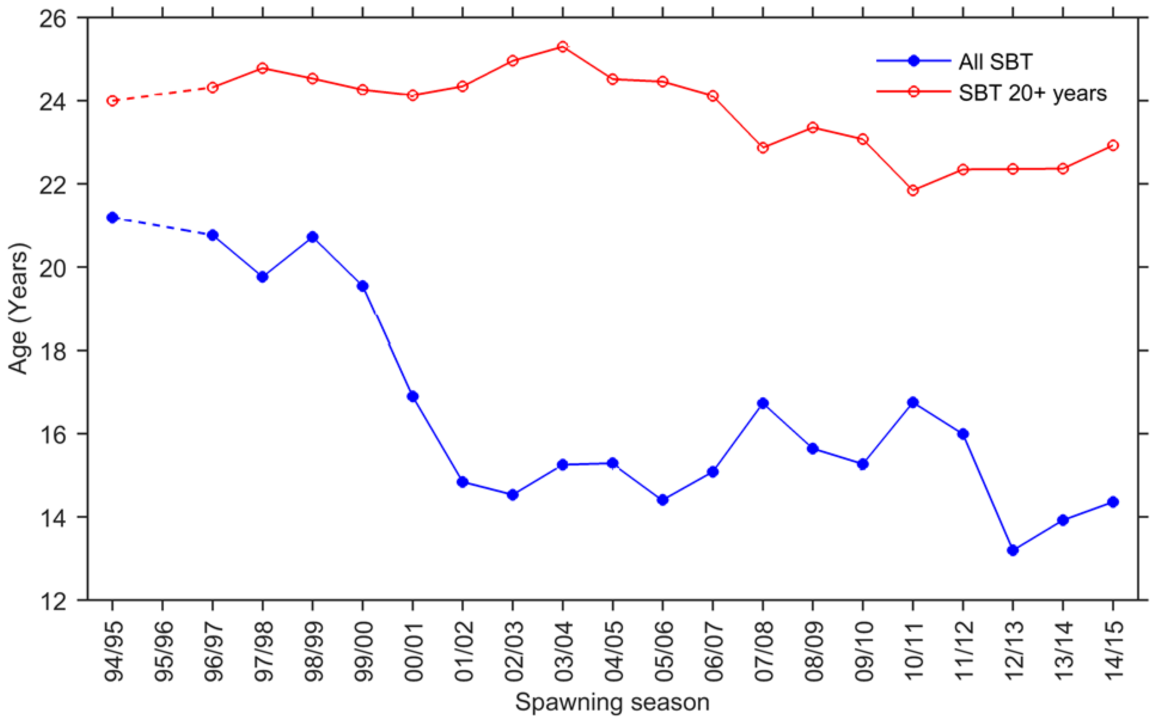


Fig. 10. Mean estimated age (years) of SBT caught on the spawning grounds by Indonesian longliners (from Farley et al. 2016). Data from Processor A are excluded. Note that there are no age data for the 1995–96 season.

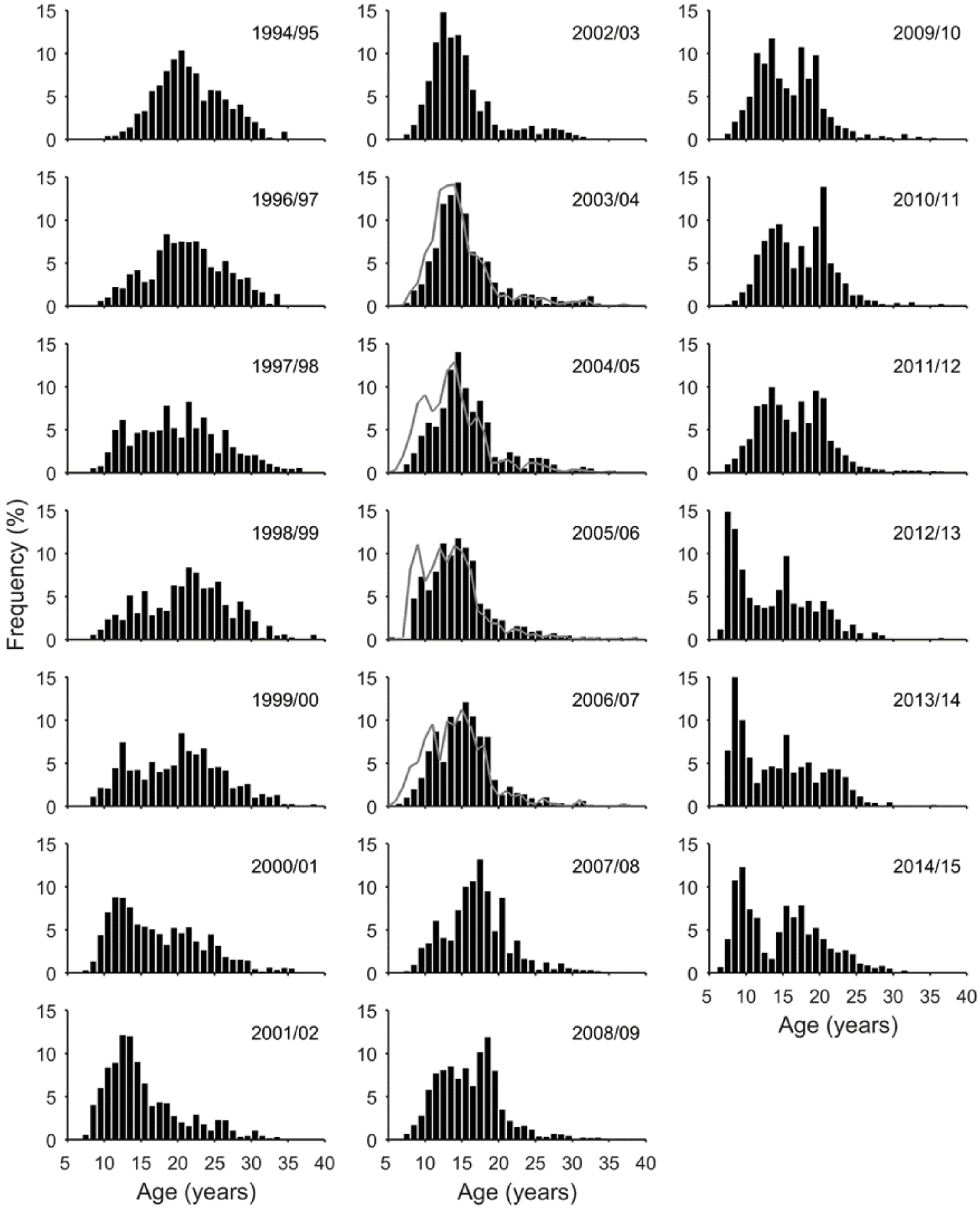


**Fig. 11. Age frequency distribution of SBT in the Indonesian catch on the spawning ground by spawning season estimated using age-length keys from our sub-samples of direct aged fish and length frequency data obtained through the Indonesian monitoring program (Farley et al. 2016). There was no direct ageing of the 2012–13 otoliths; age frequency is based on the age-length key from the previous two seasons and 2012–13 length frequency data. For comparison, the age frequency of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2004–05 to 2006–07 seasons (grey line) (see Farley et al. 2007).**

# 3 Indicators potentially affected by unreported catch

The indicators included in this section are based on fishery-dependent data and may or may not be affected by unreported catches identified in the Japanese Market Review (Lou et al. 2006) or the Australian Farm Review (Fushimi et al. 2006). These indicators have been updated with information provided through the CCSBT data exchange in 2016, but it is recommended that their interpretation be treated with caution. Recent trends in some of these indicators are unlikely to be affected by unreported catches because of the improvements in catch documentation that have been implemented since 2006.

## Global catch

Reported catch updates per country and retrospective estimates of unreported catches were obtained from official catch data provided through the 2016 CCSBT data exchange.

Reported catches have declined since 2005 (from ~16 000 t to below 12 730 t in 2015) (Fig. 12), largely due to a reduction in Japan's national allocation from 6065 t to 3000 t in 2006, the introduction of an interim catch allocation of 750 t to Indonesia's SBT fishery in 2007, and the global quota reduction in 2010. However, with the implementation of the management procedure in 2011, the global quota has increased every year since 2012.

Australia's reported catches in 2011–15 (by calendar year) were 4200 t, 4503 t and 4902 t, 4559 t and 5824 t, respectively. Japan's reported catches over the same period were 2518 t, 2528 t, 2695 t, 3371 t and 4745 t. The Taiwanese catch was 533 t and 494 t reported in 2011 and 2012, respectively, but increased to 1161 t in 2015. Korean catches have been relatively stable over the past four years with 1051 t reported in 2015. Recent Indonesian catches have exceeded their allocation at 1383 t and 1063 t in 2013 and 2014, respectively, but declined to 593 in 2015. The effect of retrospective unreported catches on the interpretation of other indicators in this section is unknown.

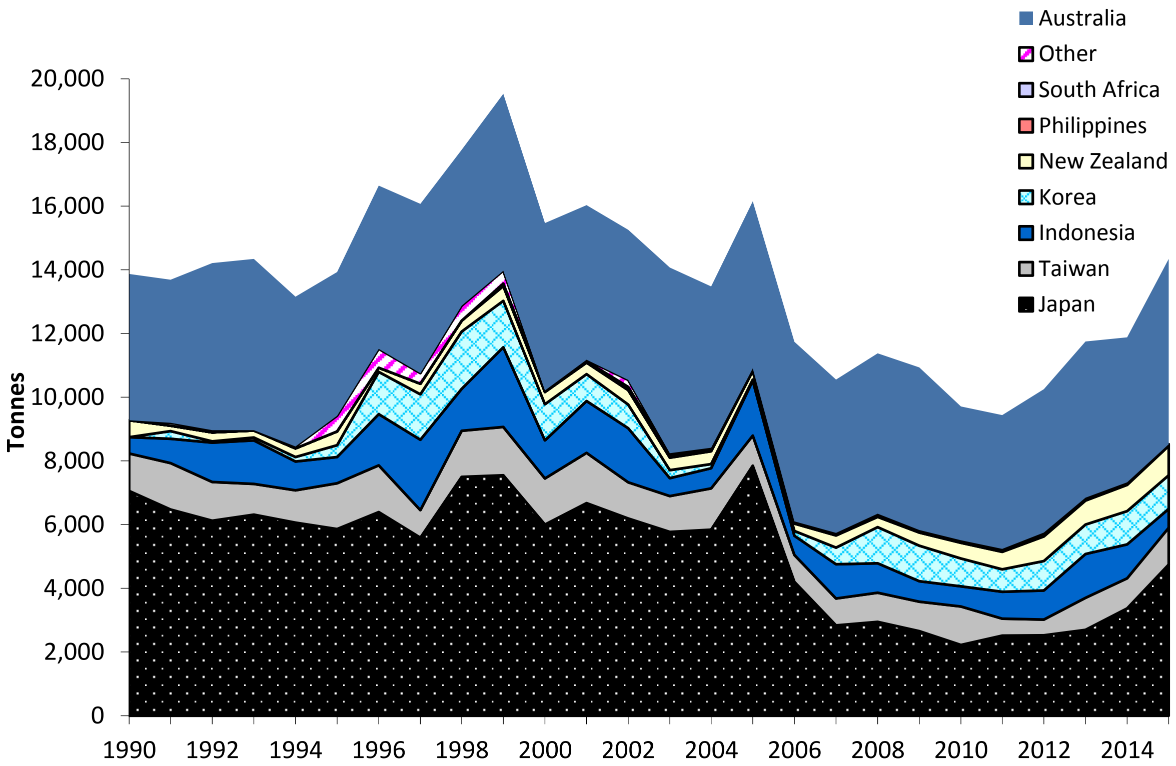


**Fig. 12. Reported catches (tonnes) by country since 1990. Shaded areas are stacked so that y-axis values represent total catch reported by all Members in a calendar year.**

# Catch per unit effort (CPUE)

## Japanese longline CPUE

Nominal CPUE series for Japanese longliners was extracted from the CPUE input data provided in the CCSBT data exchange (SEC_CPUEInputs_65_15_revised). Other effort series (e.g. number of squares fished) were derived from the same data. Standardised CPUE series were obtained from updates provided by Japan (JP_CPUE_w05_08_for_monitoring_2016SC and JP_CorevesselCPUE_6915) through the CCSBT data exchange.

There have been several perturbations significantly affecting the continuity of the Japanese longline CPUE series. Major changes were made to the management of the Japanese longline fleet in April 2006 (introduction of individual quota and removal of restrictions on fishing area and season) (Itoh 2006). In addition, reductions in the Japanese total allowable catch (TAC) have been in place since 2006 and there have been increases in reported discarding. It is not known to what extent the Japanese longline CPUE series would be affected by the unreported catches identified in 2006 (Polacheck et al. 2006). The nominal CPUE in the most recent years (since 2006) is not likely to be affected by unreported catches because of new catch documentation methods. The standardised CPUE series are still potentially affected, and should be interpreted with caution.

The following updates for 2015 have been compiled:

- Nominal aggregate CPUE for age 4+ SBT in areas 4–9 in months 4–9. The series showed an overall decline until 2006–07, followed by an increase to 2015. The data point for 2015 is above the recent 10 years (2006–15) mean (Fig. 13, horizontal line).

- Nominal CPUE for age 4–7, 8–11 and 12+ SBT. The nominal CPUE series in 2015 for ages 4–7 and 8–11 increased. The CPUE of age 12+ SBT has remained low with little variability since the early 1970s (Fig. 14).

- Nominal CPUE for age 0–2, 3, 4 and 5 SBT. In 2006 and 2007, the age composition of juvenile SBT became dominated by age 3 SBT, with an increase of a similar scale apparent in age 0–2. However, relative proportions of both age 0–2 and 3 dropped markedly in 2008. Age 4 and 5 SBT are the dominant year classes in the juveniles in 2015, with an increase in both in 2015; all the other age classes declined in 2015 (Fig. 15).

- Age-specific nominal CPUE for SBT of ages 4, 5, 6, 7, 8 and 9 in different statistical areas. CPUE for all areas increased for ages 5–9 in 2015. CPUE for age 4 fish was more variable, declining in areas 4–7(Fig. 16).

- Total number of 5×5° grid squares with Japanese longline fishing effort in months 4–9 for statistical areas 4–9, 4–7, 8 and 9. The number of grid squares fished per month has shown a strong downward trend over time in all statistical areas considered, potentially leading to over-optimism in the aggregate catch rates through a spatial hyperstability effect on the relationship between abundance and CPUE (Hartog & Preece 2008). The number of grid squares fished in 2015 was mixed in all areas, with both increases and decreases depending on the month (Fig. 17).

- Standardised CPUE. The standardised and normalised monitoring CPUE series from all vessels (W0.5, W0.8) exhibited increases in 2015, as did the normalised series from the core vessels (Base W0.5 and Base W0.8) (Fig. 18).

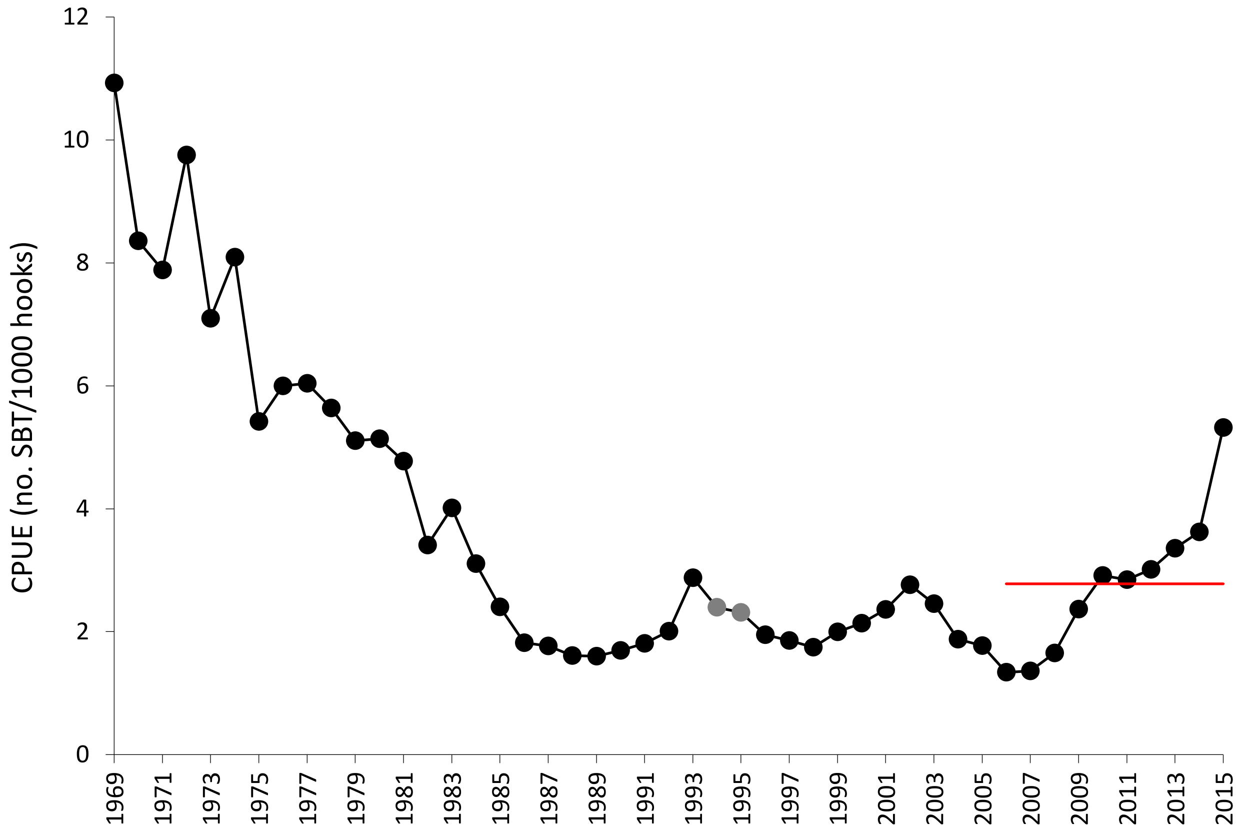


**Fig. 13. Nominal CPUE of age 4+ SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9. The 1995 and 1996 values are plotted as grey circles to indicate increased uncertainty about these points due to changes in retention policies for small fish in these two years, when a policy of releasing small fish applied. The horizontal line is the 2006–15 mean.**

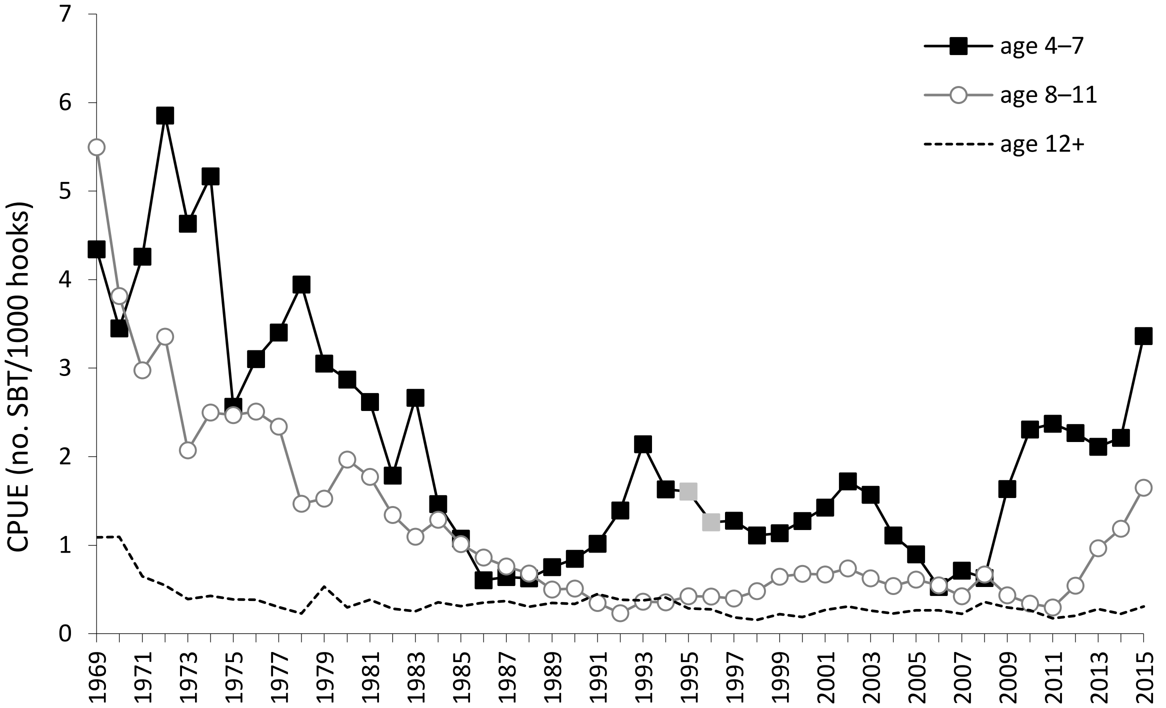


**Fig. 14. Nominal CPUE of ages 4–7, 8–11 and 12+ SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9. The 1995 and 1996 values for ages 4–7 are plotted as grey squares to indicate increased uncertainty about these points due to changes in retention policies for small fish in these two years.**

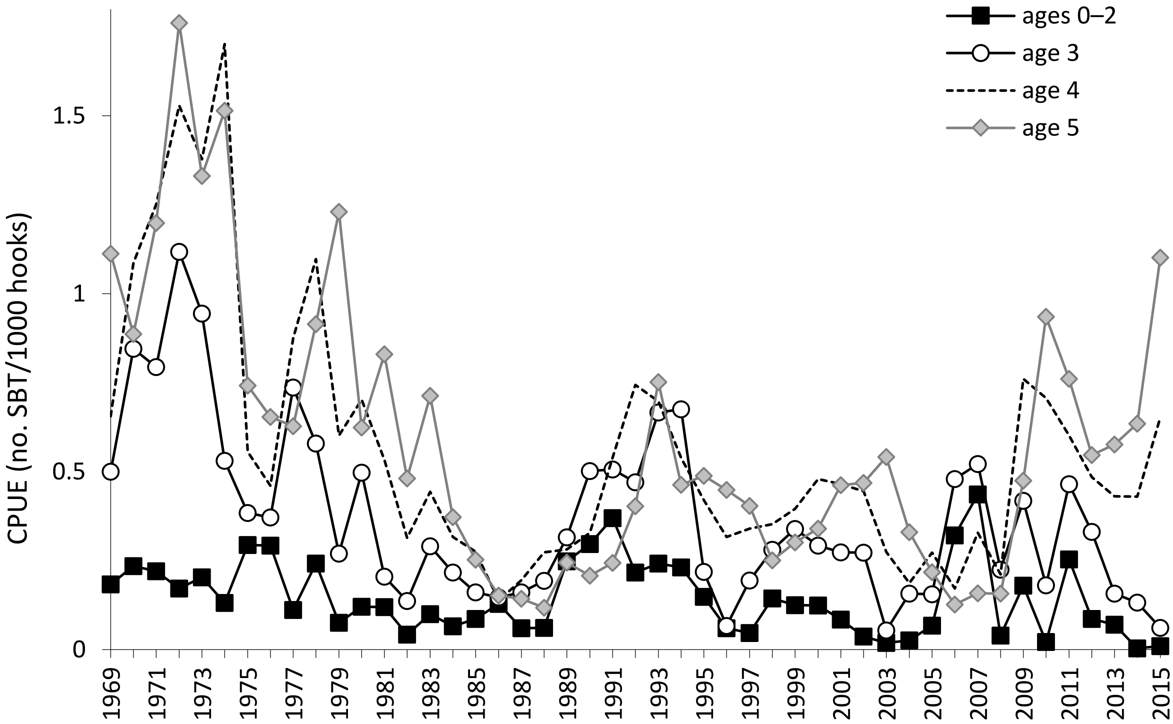


**Fig. 15. Nominal CPUE of ages 0–2, 3, 4 and 5 SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9.**

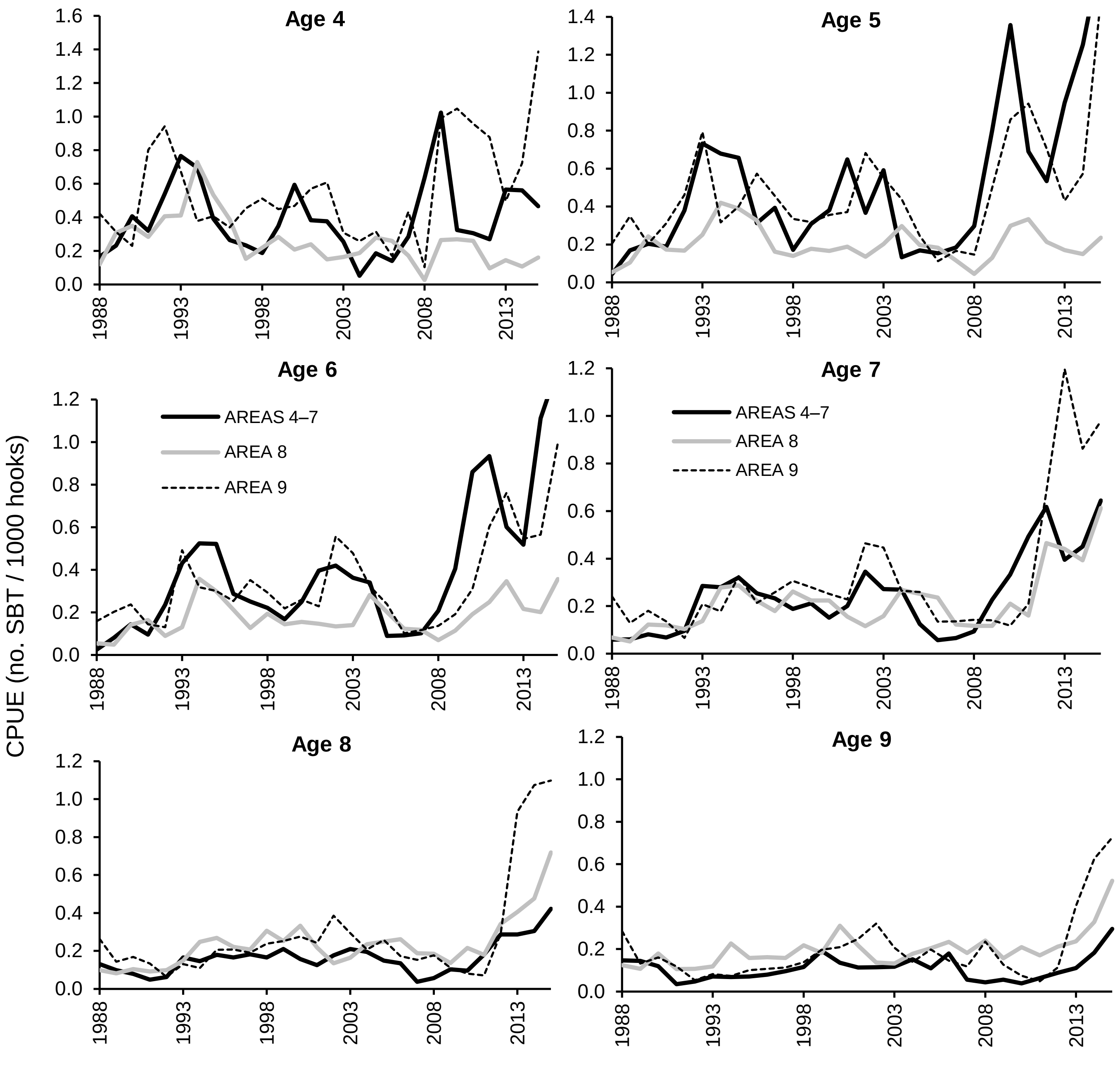


**Fig. 16. Comparison of age-specific nominal CPUE for Japanese longliners in different statistical areas in months 4–9.**

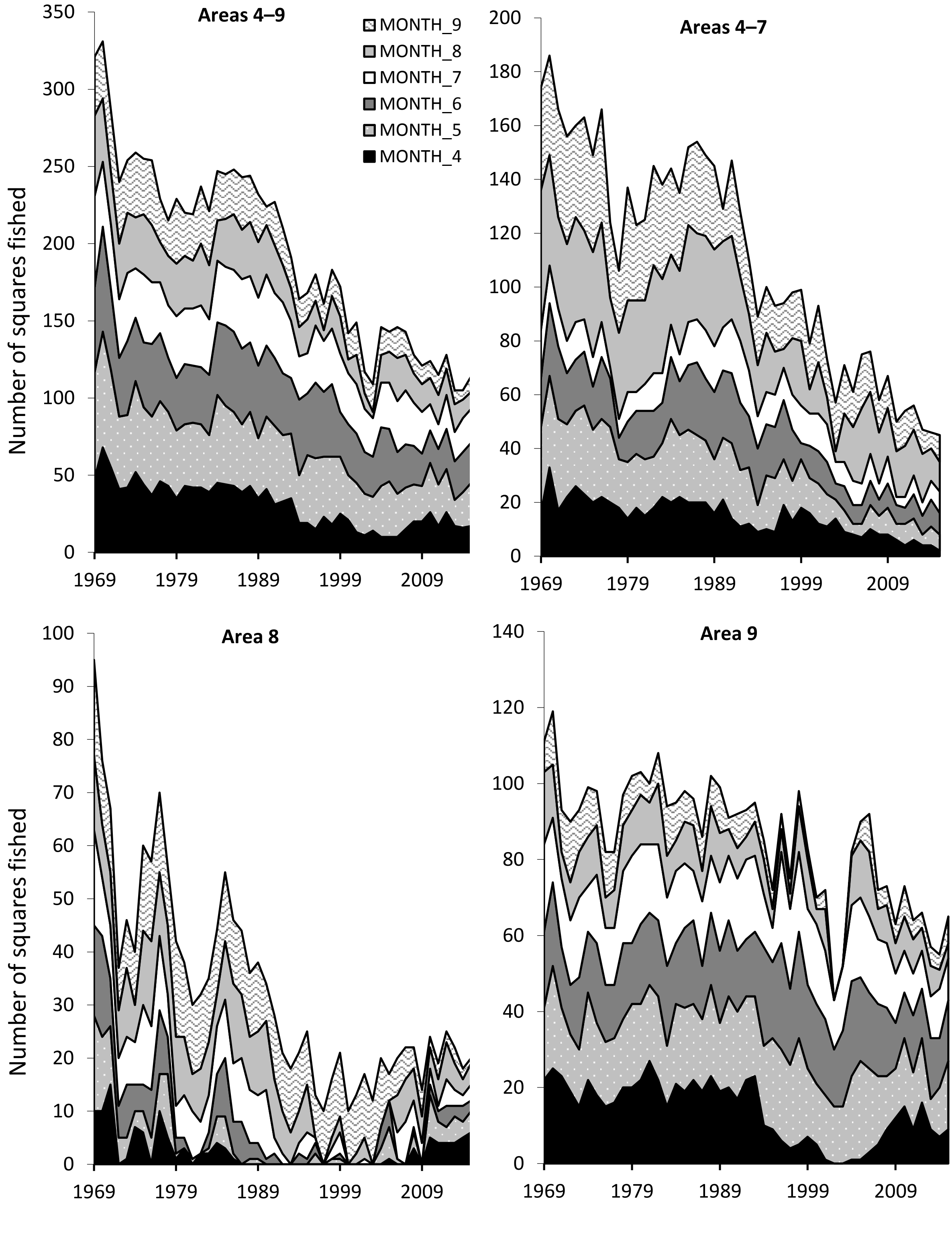


**Fig. 17. Total number of 5×5° grid squares with Japanese longline fishing effort in months 4–9 for different statistical areas. Shaded series in each plot are stacked (i.e. y-axis values are cumulative), with the legend and shaded series being stacked in the same order.**

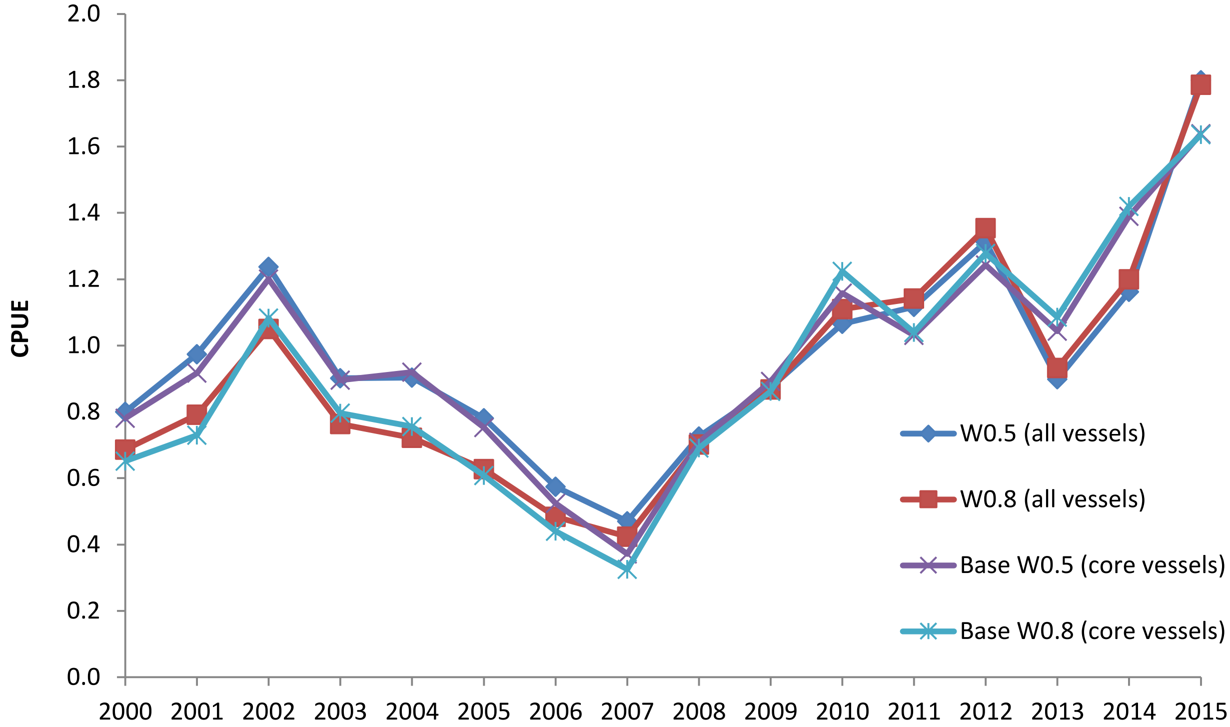


**Fig. 18. Comparison of subsets of the standardised CPUE series. Each subset has been normalised by dividing by the mean.**

## Korean longline CPUE

Nominal CPUE series for Korean longliners were obtained from aggregated catch and effort data provided in the 2015 interim update of the CCSBT database.

The Korean nominal CPUE has been reasonably stable since 1995, apart from very low catch rates in 2004 and 2005. Both nominal and average CPUE increased slightly in 2015 (Fig. 19). In 2007 and 2008, the spatial distribution of the fleet shifted from its normal pattern to take catches from western and central fishing grounds in the Indian Ocean (An et al. 2008).

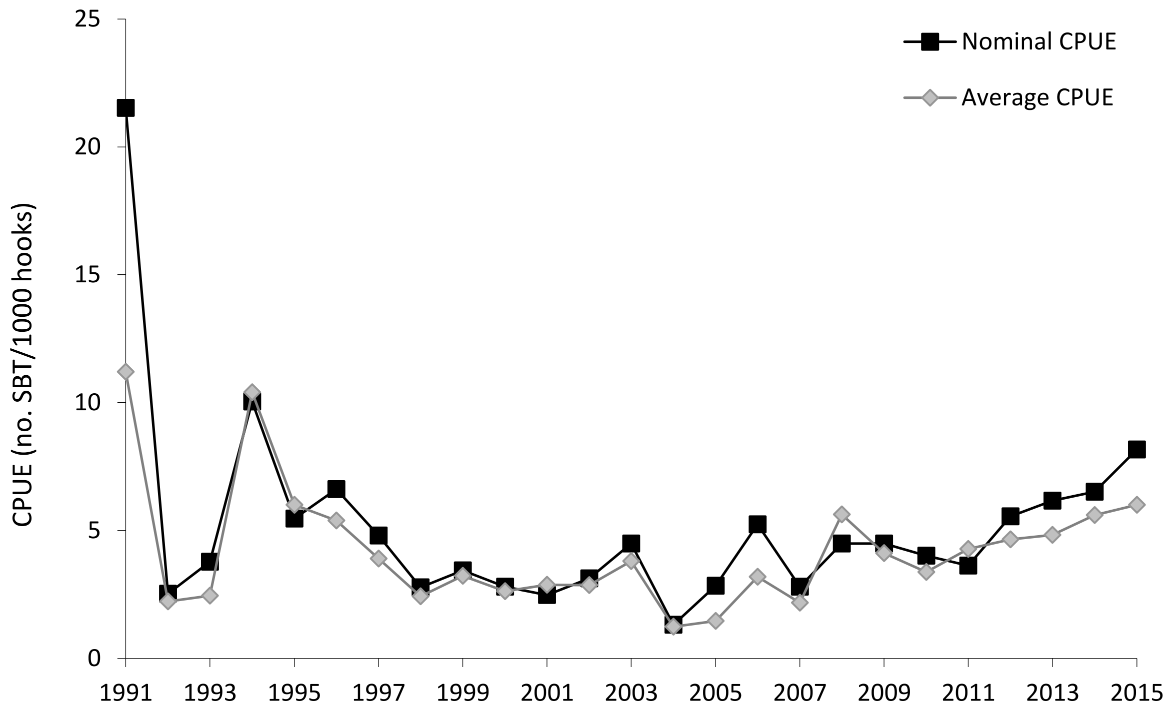


**Fig. 19. Nominal and average CPUE of total SBT for Korean longliners operating in statistical areas 4–9 in months 4–9. Nominal CPUE is the total number of SBT over total effort (1000 hooks), while average CPUE is the mean of the nominal rate in each 5×5° grid square per month.**

## Taiwanese longline CPUE

Nominal CPUE series of Taiwanese longliners were obtained from aggregated catch and effort data provided in the 2015 interim update of the CCSBT database.

The number of vessels in the Taiwanese fishery targeting SBT and catching SBT as bycatch has fluctuated since 2002 when records became more accurate (CCSBT-ESC/1309/SBT Fisheries-Taiwan). Catches began to increase in the 1980s, then stabilised from the late 1980s, but have reduced in recent years. The Taiwanese fishery operates in both the northern fishery (areas 2, 14, 15), and the southern fishery (areas 8, 9) (Fig. 20, 21). The main area of effort is the southern 5 degrees of latitude in statistical areas 2, 14 and 15, where vessels have historically targeted albacore (Fig. 22).

Catch rates have fluctuated over time, with a substantial decrease in areas 2, 14 and 15 in 2015, to the lowest level since 1992 (Fig. 20). In contrast there has been a substantial increase in the nominal catch rate in areas 8 and 9 to the highest recorded (Fig. 20). Catch rates in 2015 were highest in areas 8 and 9, with the catch rates in 2, 14 and 15 north, middle and south very similar (Fig. 21). Taiwan informed the 2009 ESC that changes in collection of fishery statistics was largely responsible for the increase seen in nominal catch rates in areas 2, 14 and 15 since 2000 (Fig. 20, 21; Anon 2009). Effort in areas 2, 14 and 15 declined in 2015, while effort in areas 8 and 9 increased (Fig 22).

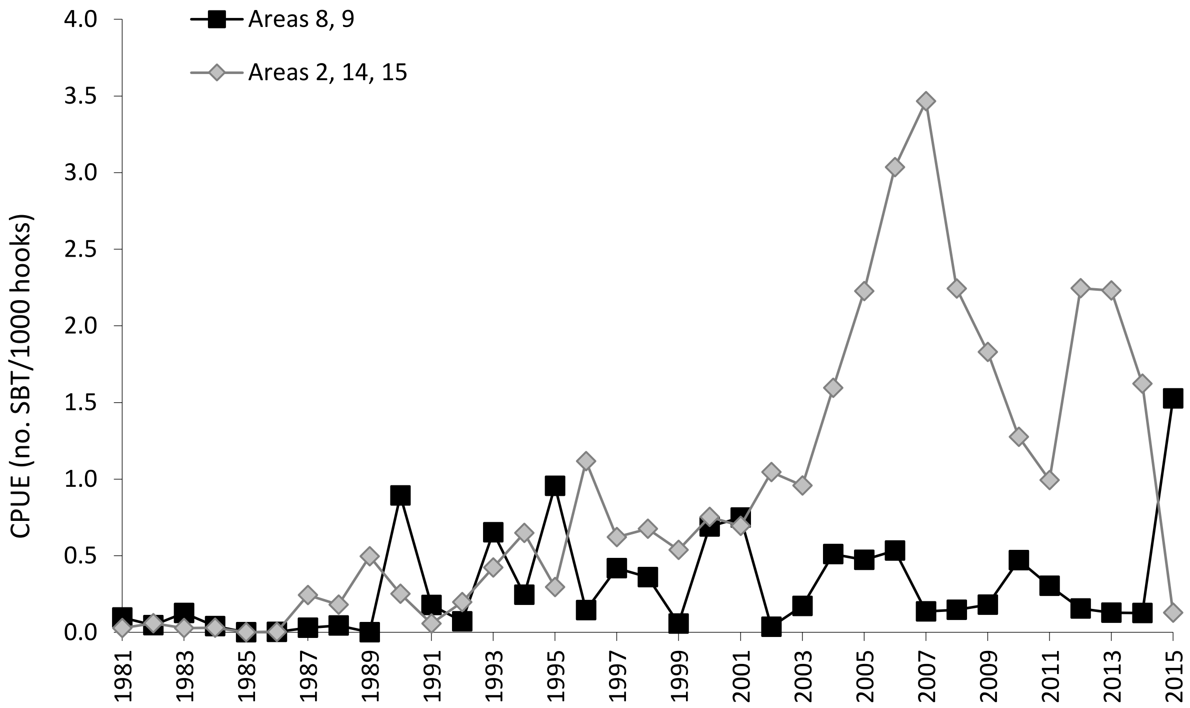


**Fig. 20. Nominal CPUE of SBT for Taiwanese longliners operating in statistical areas 8 and 9 (pooled) and 2, 14 and 15 (pooled) in months 4–9.**

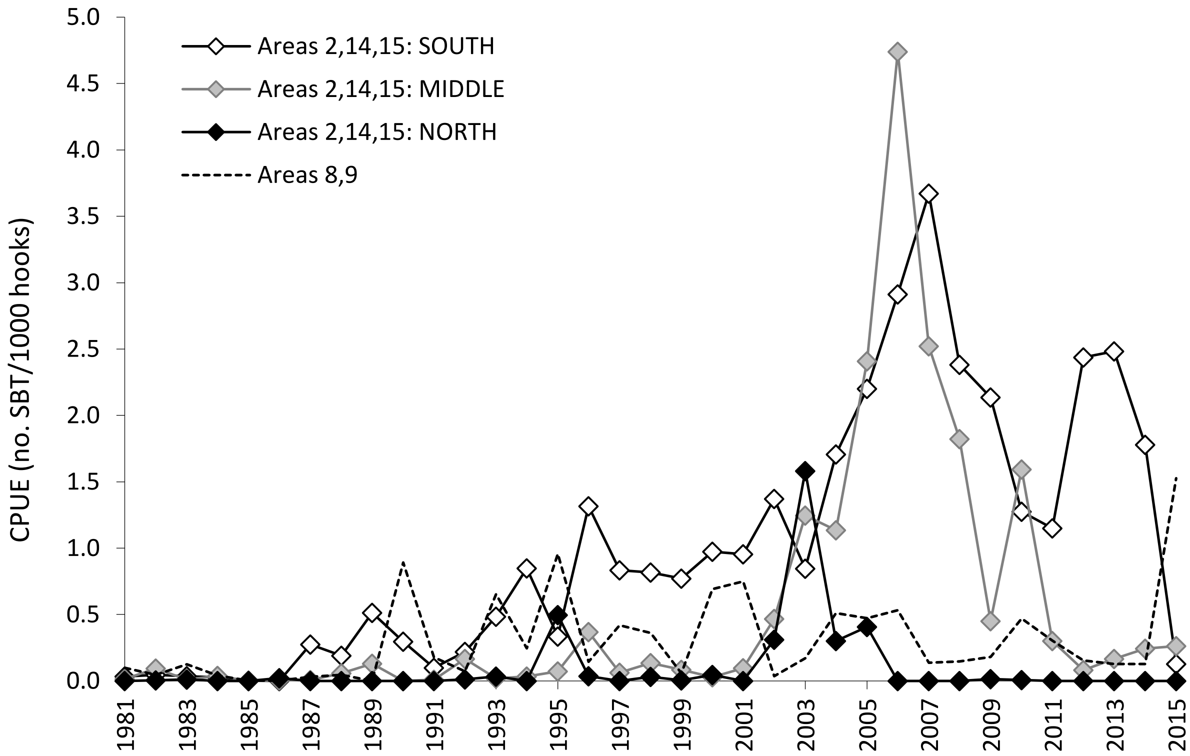

Fig. 21. Nominal CPUE of SBT for Taiwanese longliners operating in statistical areas 2, 14 and 15 (pooled) by 5° latitudinal strips: South = 30–35°S; Middle = 25–30°S; North = 20–25°S. Nominal CPUE in areas 8 and 9 (pooled) shown for comparison. Data are from months 4–9 only.

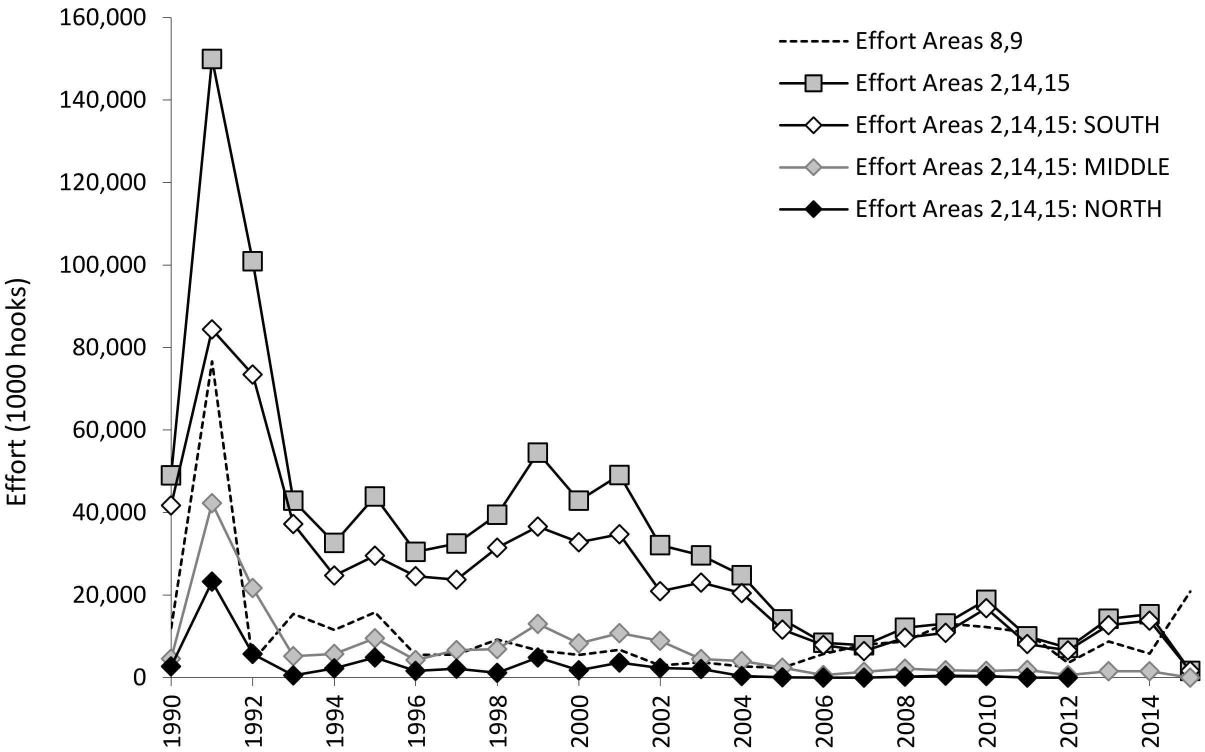


Fig. 22. Effort (1000 hooks) from Taiwanese longliners in statistical areas 8 & 9 (pooled) and 2, 14 and 15 (pooled). Areas 2, 14 and 15 are also separated into 5° latitudinal strips: South = 30–35°S; Middle = 25–30°S; North = 20–25°S. Data are from months 4–9 only.

# Catch size/age composition

Size and age composition of the unreported catch identified by the 2006 Japanese Market Review is unknown and the effect on age/size data from the bias identified in the Australian Farm Review has not been resolved. Therefore, the long-term trends in these data should be interpreted with caution. Data collected since 2006 for the longline fisheries are unlikely to be affected by unreported catches.

## Japanese longline fishery size/age composition

Size composition data for SBT caught by Japanese longliners were obtained from the CCSBT data exchange in June 2015. These data are examined in detail below for trends for juvenile fish aged less than 6 years.

The age composition of SBT caught by the Japanese longline fishery has been highly variable over time. The relative proportion of the two older age classes examined here increased in 2015, while the two younger age classes declined, or in the case of the youngest age class remained near zero (Fig. 23). Observer coverage on vessels has been less than or around 10 per cent since 2003. Discarding of juveniles has been reported since 2009 but may have commenced earlier and would impact the size/age composition (Sakai & Itoh 2013).

For comparison with size/age composition in the NZ, Korean and Taiwanese longline fisheries, Japanese length data have also been compiled for < 6 year olds, assuming that the following size categories represented ages 0–2, 3, 4 and 5:

≤86 cm: age 0–2

>86 to ≤102 cm: age 3

>102 to ≤114 cm: age 4

>114 to ≤126 cm: age 5

The age calculations take into account the time through the year at which the fish was caught, and adjusts the upper and lower cut-points to account for growth through the year, whereas the size data are simply aggregated for the entire year.

Trends in size composition of < 126 cm indicate an increase in the proportion of the largest size class in 2015, with the second largest size class (>102 to ≤114 cm) declining (Fig. 24). The smallest size class has been relatively stable at very low levels since 2008 (Fig. 24).

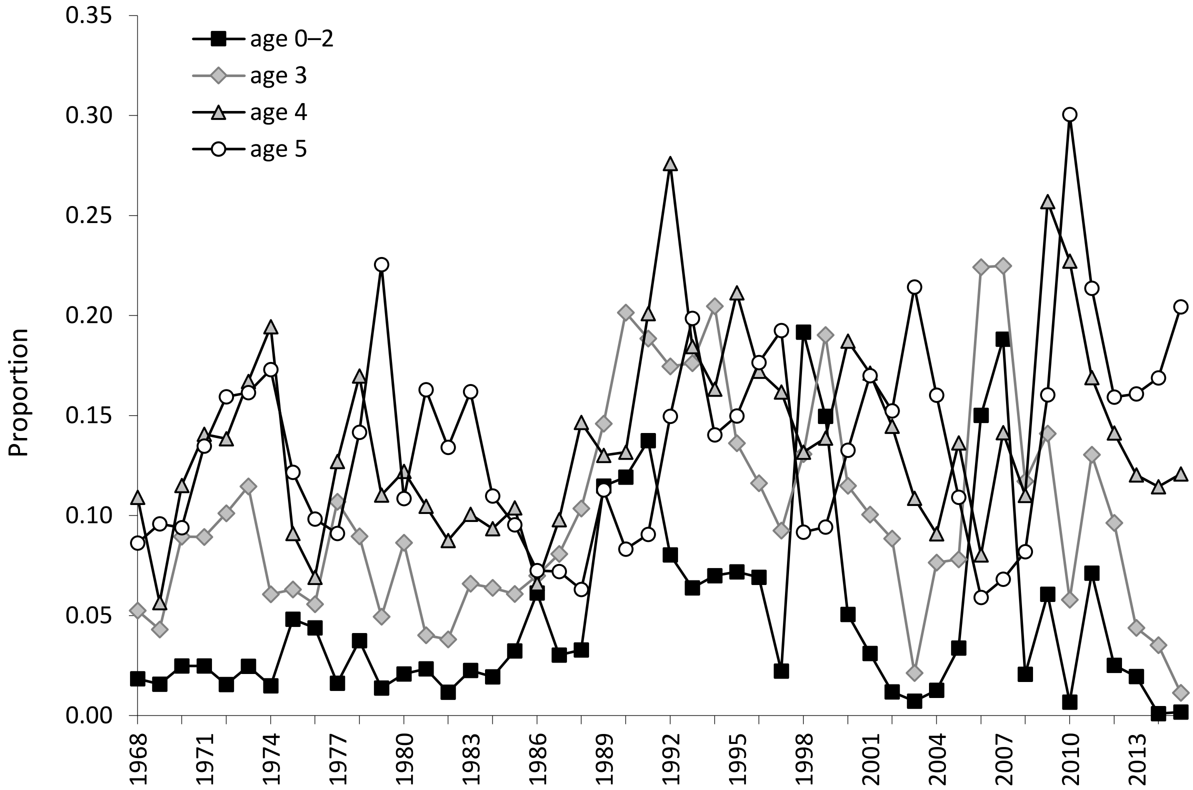


**Fig. 23. Age composition (proportion of total catch) of ages 0–2, 3, 4 and 5 in the Japanese longline fishery in statistical areas 4–9, months 4–9.**

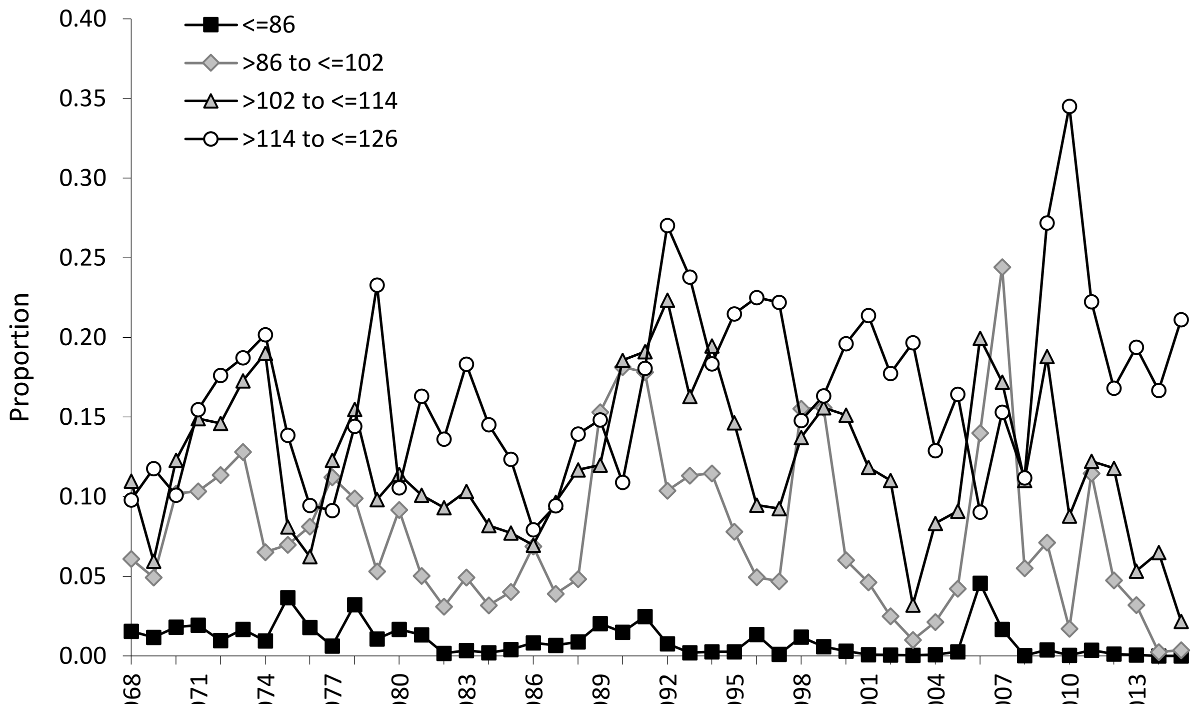


**Fig. 24. Size composition (proportion of total catch) of juvenile SBT caught by Japanese longliners in statistical areas 4–9, months 4–9, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.**

## Korean longline fishery size/age composition

Size composition data from logbooks for SBT caught by Korean longliners were obtained from the 2016 interim update of the CCSBT database. Due to the small sample sizes in some years, only raw frequencies were available and a final index for inclusion in the summary of indicators (Table 1) was therefore not calculated. This indicator should therefore be interpreted with caution.

It has been assumed that the following size categories represented ages 0–2, 3, 4 and 5:

≤86 cm: age 0–2

>86 to ≤102 cm: age 3

>102 to ≤114 cm: age 4

>114 to ≤126 cm: age 5

No data were available for the Korean size classes in 2005 and 2008. Data from 2011 were also excluded as they were taken from the catch documentation scheme catch tagging information rather than logbooks. While data were provided for 2012, they were limited and no data were provided for 2013 (Fig. 25). Data for 2015 indicate an increase from 2014 in the largest size class and a decrease in the second largest size class. The two smallest remain at or near zero. Coverage on vessels has been less than 10 per cent in some past years, and discarding of juveniles cannot be discounted.

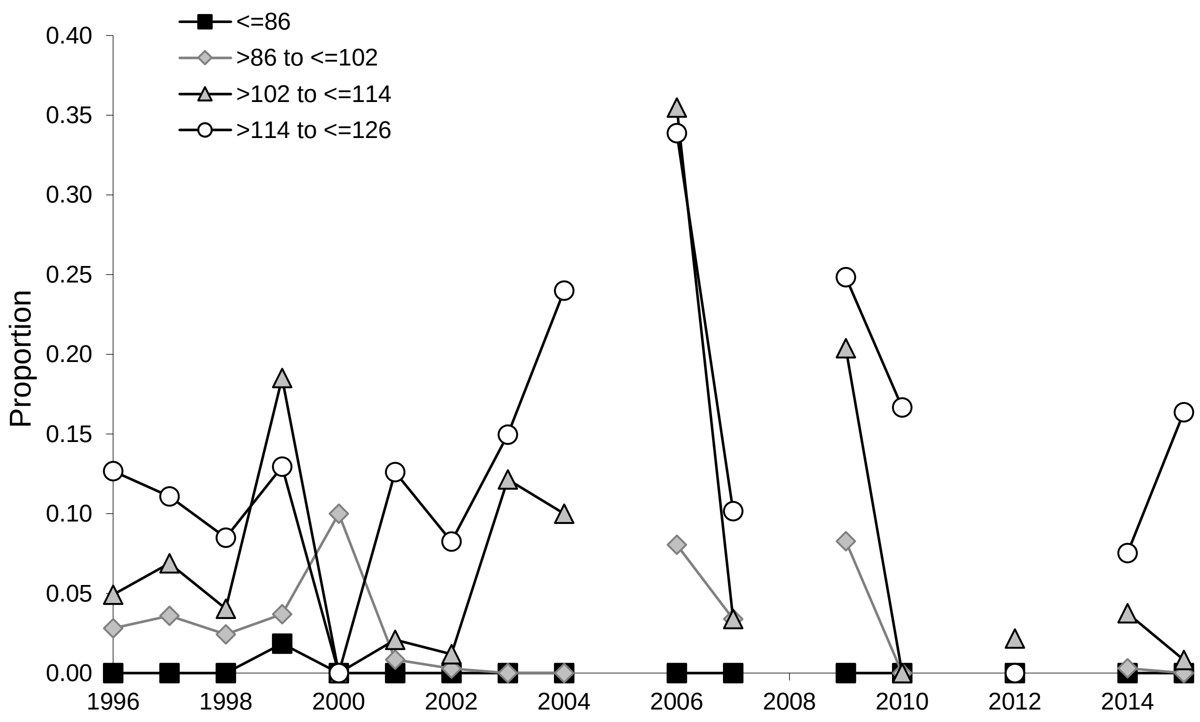


**Fig. 25. Size composition (proportion of total catch) of juvenile SBT caught by Korean longliners in statistical areas 4–9, months 4–9, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.**

## Taiwanese longline fishery size/age composition

Size composition data for SBT caught by Taiwanese longliners were obtained from the 2014 interim update of the CCSBT database (table MP_OM_CALCULATED_CATCH_AT_LENGTH). Data in this table are not linked to statistical area or month of capture. Therefore, all available size data in this table have been aggregated.

It has been assumed that the following size categories represented ages 0–2, 3, 4 and 5:

≤86 cm: age 0–2

>86 to ≤102 cm: age 3

>102 to ≤114 cm: age 4

>114 to ≤126 cm: age 5

Taiwanese longliners have historically targeted albacore in the southern sections of statistical areas 2, 14 and 15 (i.e. between 25–35°S, see 'Taiwanese longline CPUE'), and generally catch higher proportions of juvenile SBT (Hartog & Preece 2008). In 2015, proportions of the two largest size classes increased slightly, while the two smallest remained stable (Fig. 26). Observer coverage on vessels has been less than 10 per cent in some past years, and discarding of juveniles cannot be discounted.

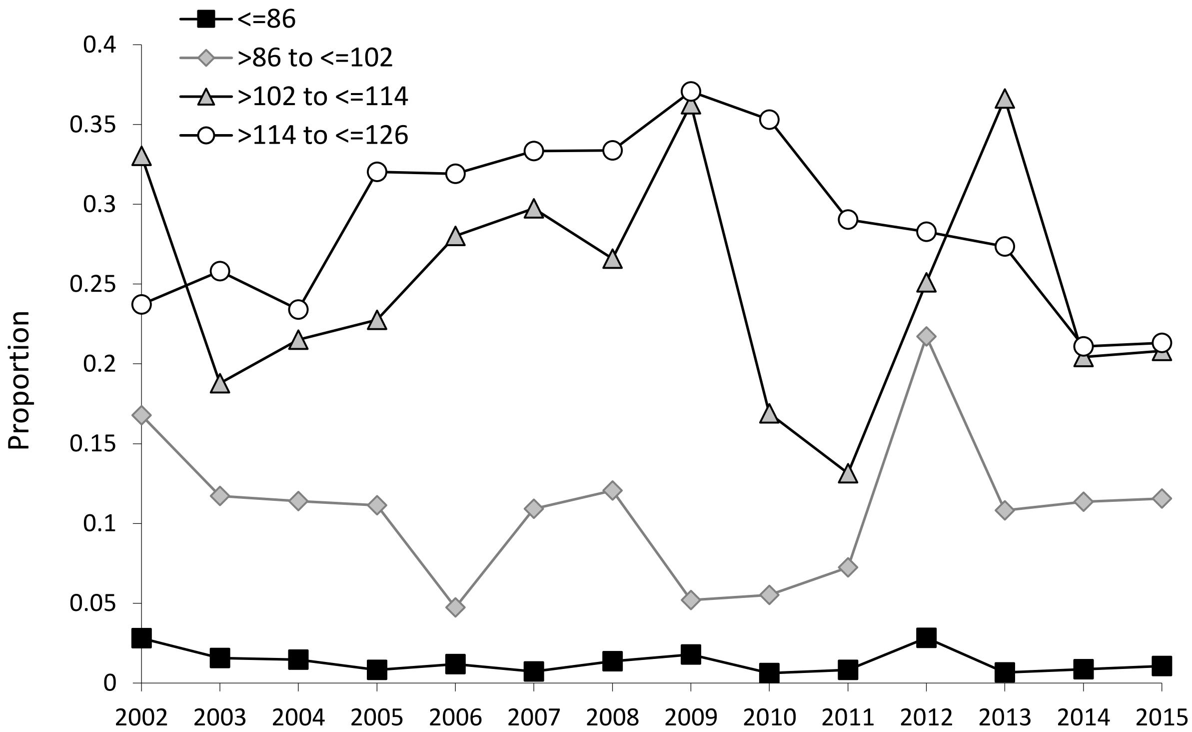


**Fig. 26. Size composition (proportion of total catch) of juvenile SBT caught by Taiwanese longliners, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.**

## Australian surface fishery age composition

The age composition of SBT caught by the Australian surface fishery was updated directly from the proportional catch-at-age data prepared by the Secretariat and provided through the CCSBT data exchange (SEC_ManagementProcedureData_52_15). The catch at age is calculated from length frequency data (Preece et al. 2004).

The 2006 Australian Farm Review was unable to resolve whether there were biases in the 40-fish sampling program that would affect the size/age composition of the reported catch (Fushimi et al. 2006). Age composition in the Australian surface fishery has not changed markedly and continues to be dominated by age 2 and age 3 SBT (Fig. 27). These two age classes have historically comprised around 90 per cent of the catch. In 2015, the age 2 and 3 age classes accounted for 92 per cent of the catch.

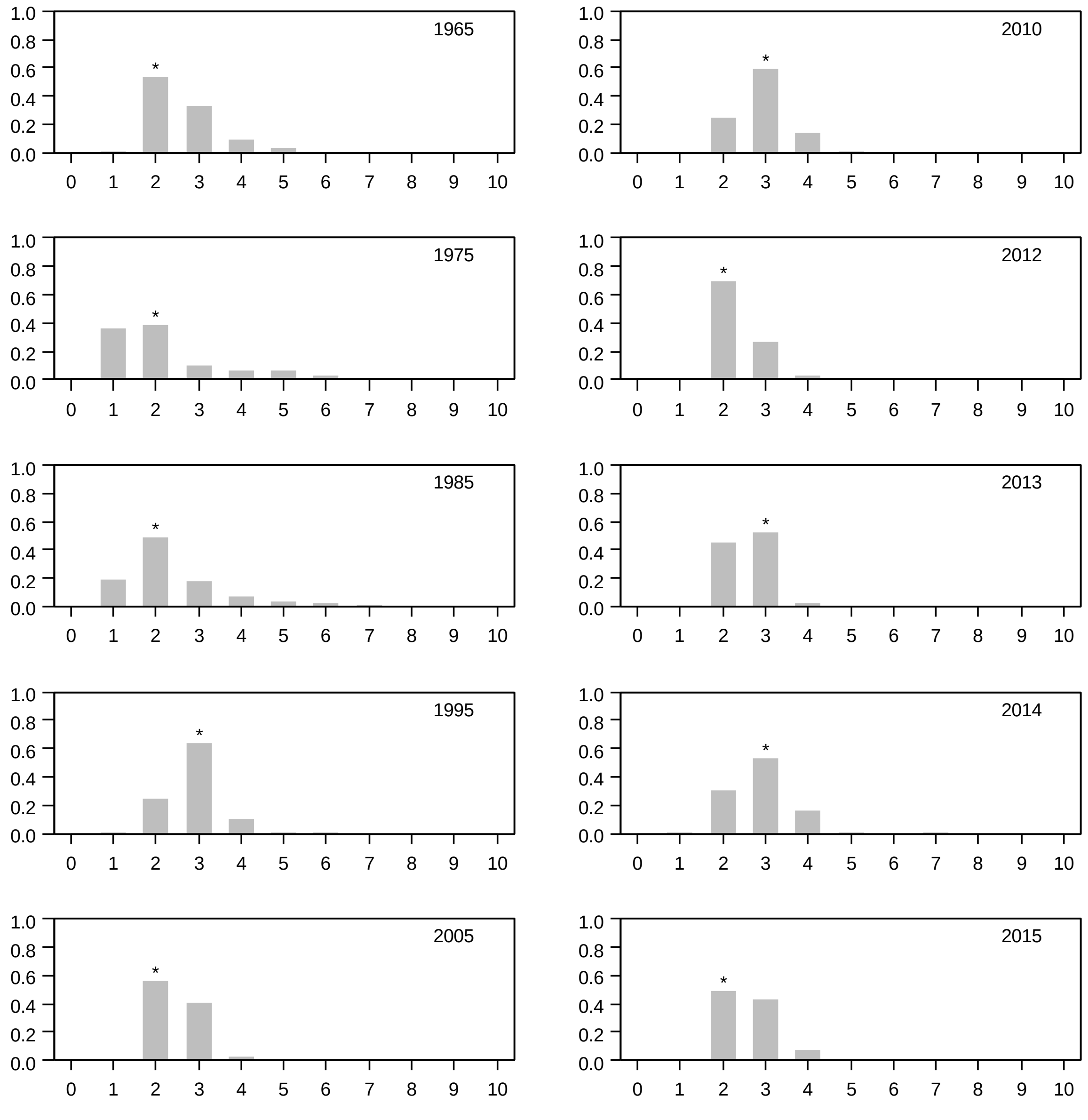


**Fig. 27. Age composition in the Australian surface fishery. Median age classes are indicated with asterisks.**

# 4 Summary

Recent trends in all indicators are summarised in Appendix 1 (with the exception of the Korean size composition due to small sample sizes in some years). Overall, there were mixed results in the indicators.

Potential causes for the changes are discussed elsewhere, and therefore the indicators presented here should be interpreted with caution. In addition, some of the indicators may have been affected in the past by unreported catch, and historical trends must continue to be interpreted with caution. The recent trends for some of these indicators are unlikely to be affected by unreported catches. In this paper, interpretation of indicators is restricted to the subset considered to be unaffected by the unreported catch.

## Trends in juvenile abundance

The two indices of juvenile (age 1 to 4) abundance that were updated in 2015–16—the scientific aerial survey index and trolling index —exhibited increases from values observed in the 2013–14 fishing season (they were not updated for the 2014–15 fishing season). The SAPUE index was not updated. The scientific aerial survey in particular exhibited a substantial increase and is at its highest level since the survey resumed in 2005.

## Trends in age 4+ SBT

Similar to previous years, the 2015 indicators of age 4+ SBT were mixed. The CPUE in both the NZ domestic fishery and the NZ charter fishery for statistical area 6 increased in 2015. There was little fishing in area 5 in 2015. However, age 5 fish comprised a smaller portion of both the NZ charter and domestic fisheries catches in 2015. There was a large increase in the proportion of small fish in the Indonesian fishery in 2013–14 to 2015–16 and median length class decreased again in 2015–16. The mean age of SBT on the spawning ground decreased substantially from 16.0 years in 2011–12 to 14.4 years in 2014–15 (2015–16 otoliths have not yet been aged). However, as discussed previously, determining the location where the smaller/younger fish have been caught is a priority for understanding these changes. In addition, although potentially affected by the overcatch, the nominal CPUE for the Japanese longline fishery for 4+ SBT increased in 2015 and remains above the 10 year mean. The standardised Japanese CPUE series also all increased.

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# Appendix 1. Recent trends in all indicators of the SBT stock

**Table 1. Recent trends in all indicators of the SBT stock. Minimum and maximum values in the time series are also shown.**

| Indicator | Period | Min. | Max. | 2012 | 2013 | 2014 | 2015 | 2016 | 12 month trend |
|---|---|---|---|---|---|---|---|---|---|
| Scientific aerial survey | 1993–2000<br>2005–15 | 0.34 (1999) | 4.25 (2016) | 0.44 | 0.96 | 2.23 | na | 4.25 | ↑** |
| SAPUE index | 2003–14 | 0.38 (2003) | 1.80 (2011) | 0.58 | 0.95 | 1.52 | na | na | - |
| Trolling index | 1996–2003<br>2005–06<br>2006–15 | 2.82 (2006) | 5.65 (2011) | 1.62 | 3.70 | 2.86 | na | 3.94 | ↑** |
| NZ charter nominal CPUE (Areas 5+6) | 1989–2015 | 1.339 (1991) | 7.83 (2010) | 7.33 | 6.49 | 6.10 | 6.74 | | ↑ |
| NZ domestic nominal CPUE | 1989–2015 | 0.000 (1989) | 6.16 (2015) | 4.06 | 4.04 | 5.44 | 6.16 | | ↑ |
| NZ charter age/size composition (proportion age 0–5 SBT)* | 1989–2015 | 0.001 (2005) | 0.414 (1993) | 0.19 | 0.15 | 0.28 | 0.13 | | ↓ |
| NZ domestic age/size composition (proportion age 0–5 SBT)* | 1980–2015 | 0.001 (1985) | 0.404 (1995) | 0.21 | 0.03 | 0.20 | 0.10 | | ↓ |
| Indonesian median size class | 1993–94 to 2014–15 | 162 (2012–13; 2013–14) | 188 (1993–94) | 168 | 162 | 162 | 162 | 158 | ↓ |
| Indonesian age composition: mean age on spawning ground, all SBT | 1994–95 to 2013–14 | 13.24 (2012–13) | 21.2 (1994–95) | 16.0 | 13.2 | 13.9 | 14.4 | | ↑ |
| Indonesian age composition: mean age on spawning ground 20+ | 1994–95 to 2013–14 | 21.8 (2010–11) | 25.3 (2003–04) | 22.4 | 22.4 | 22.4 | 22.9 | | ↑ |
| Indonesian age composition: median age on spawning ground | 1994–95 to 2013–14 | 13 (2001–03; 2012–13) | 21 (1994–95; 1996–97; 1998–99) | 16 | 13 | 13 | 13 | | - |

**Table 1. (cont'd). Recent trends in all indicators of the SBT stock. Minimum and maximum values in the time series are also shown. Japanese age composition refers to ages in statistical areas 4–9 for months 4–9 only.**

| Indicator | Period | Min. | Max. | 2012 | 2013 | 2014 | 2015 | 12 month trend |
|---|---|---|---|---|---|---|---|---|
| Reported global catch | 1952–2015 | 829 t (1952) | 81 750 t (1961) | 10 258 | 11 768 | 11 903 | 14 352 | ↑ |
| Japanese nominal CPUE, age 4+ | 1969–2015 | 1.390 (2006) | 22.143 (1965) | 3.014 | 3.355 | 3.624 | 5.319 | ↑ |
| Japanese standardised CPUE (W0.5, W0.8, Base w0.5, Base w0.8) | 1969–2015 | 2007 (0.230–0.360) | 1969 (2.284– 2.644) | 0.767–1.134 | 0.583–0.901 | 0.754–1.179 | 1.011–1.495 | ↑ |
| Korean nominal CPUE | 1991–2015 | 0.118 (2005) | 21.523 (1991) | 5.553 | 6.163 | 6.511 | 8.169 | ↑ |
| Taiwanese nominal CPUE, Areas 8+9 | 1981–2015 | <0.001 (1985) | 0.956 (1995) | 0.155 | 0.128 | 0.127 | 1.526 | ↑ |
| Taiwanese nominal CPUE, Areas 2+14+15 | 1981–2015 | <0.001 (1985) | 3.672 (2007) | 2.437 | 2.483 | 1.779 | 0.127 | ↓ |
| Japanese age comp, age 0–2* | 1969–2015 | 0.004 (1966) | 0.191 (1998) | 0.025 | 0.020 | 0.001 | 0.002 | ↑ |
| Japanese age comp, age 3* | 1969–2015 | 0.015 (2003) | 0.284 (2007) | 0.096 | 0.039 | 0.035 | 0.011 | ↓ |
| Japanese age comp, age 4* | 1969–2015 | 0.052 (1969) | 0.286 (1992) | 0.141 | 0.120 | 0.114 | 0.121 | ↑ |
| Japanese age comp, age 5* | 1969–2015 | 0.079 (1986) | 0.300 (2010) | 0.159 | 0.161 | 0.169 | 0.204 | ↑ |
| Taiwanese age/size comp, age 0–2* | 1981–2015 | <0.001 (1982) | 0.251 (2001) | 0.028 | 0.007 | 0.009 | 0.011 | ↑ |
| Taiwanese age/size comp, age 3* | 1981–2015 | 0.024 (1996) | 0.349 (2001) | 0.217 | 0.108 | 0.114 | 0.116 | ↑ |
| Taiwanese age/size comp, age 4* | 1981–2015 | 0.027 (1996) | 0.502 (1999) | 0.251 | 0.366 | 0.204 | 0.208 | ↑ |
| Taiwanese age/size comp, age 5* | 1981–2015 | 0.075 (1997) | 0.371 (2009) | 0.283 | 0.274 | 0.211 | 0.213 | ↑ |
| Australia surface fishery median age composition | 1964–2015 | age 1 (1979–80) | age 3 (multiple years) | age 2 | age 3 | age 3 | age 2 | - |

*derived from size data; ** change over 24 month period as survey not conducted in 2015; na = not available