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Fisheries indicators for the southern bluefin tuna stock 2013–14

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Research by the Australian Bureau of Agricultural and Resource Economics and Sciences

August 2014

Working Paper CCSBT-ESC/1409/16 prepared for the CCSBT Extended Scientific Committee for the 19th Meeting of the Scientific Committee

1–6 September 2014, Auckland, New Zealand

Cataloguing data

Patterson, H and I Stobutzki 2014, *Fisheries indicators for the southern bluefin tuna stock 2013–14*, ABARES, Canberra, August. CC BY 3.0.

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Acknowledgements

The authors thank Patty Hobsbawn and Mark Chambers (ABARES) and Jessica Farley (CSIRO) for their assistance in preparing this report. This work was funded by the Fisheries Resources Research Fund and ABARES.

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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 2011, at the eighteenth meeting of the CCSBT, 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 CCSBT will set the TAC guided by the outcome of the MP unless the CCSBT decides otherwise based on all available information. 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 full stock assessment has not been updated. In a stock assessment year, such as 2014, the consideration of indicators can assist in interpreting the outcomes of the operating model and also include some information that is not incorporated into the model-based assessments.

The 2013–14 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 less likely to be affected by unreported catches because of the catch documentation activities that have been undertaken by CCSBT members.

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 in the Great Australian Bight exhibited increases over the past 12 months (scientific aerial survey index, surface abundance per unit effort (SAPUE) / commercial spotting index); the trolling index indicated a slight decline. Indeed, the scientific aerial survey index is the highest index obtained in the past 10 years of the survey. Indicators of age 4+ SBT exhibited mixed trends with the catch per unit effort (CPUE) from the New Zealand domestic and charter fisheries both decreasing slightly in 2013. However, the New Zealand domestic longline fishery nominal CPUE has generally exhibited a sharp increase since 2007. Similarly, the Japanese longline nominal CPUE for ages 4+ increased. The median length class of SBT on the spawning ground decreased in 2012–13 and 2013–14 compared to the previous seasons, with a large increase in small fish reported in the fishery. The mean and median age of SBT also decreased in 2012–13.

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). This has continued since the implementation of the agreed management procedure, which specifies full stock assessments every three years. Indicators are important in the intervening years to provide a broad perspective on recent changes in the status of the stock and as part of the consideration of whether there are indications of exceptional circumstances arising. In a stock assessment year, such as 2014, the consideration of indicators can assist in interpreting the outcomes of the operating model and also include some information that is not incorporated into the model-based assessments.

The suite of indicators considered includes some that reflect the status of the juvenile portion of the stock and some the spawning stock. Most of the indicators are fisheries dependent but the suite includes the few fisheries-independent indicators 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 less likely to be affected by unreported catches because of the catch documentation activities that have been undertaken. The 2013–14 update of fishery indicators for the SBT stock summarises indicators in the same groups presented in previous updates in 2007 to 2013 (Hartog et al. 2007, Hartog & Preece 2008, Phillips 2009, Patterson et al. 2010, 2011, 2012, 2013):

1) Indicators unaffected by the unreported catch:

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

2) Indicators that may be affected by the unreported catch

- Reported global catch and retrospective estimates of unreported 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 et al. (2013) with the most recent data available through the CCSBT data exchange in June 2014.

2 Indicators unaffected by unreported catch

Scientific aerial survey

The scientific aerial survey index has been updated from data provided by Australia through the CCSBT data exchange (AU_AerialSurvey_93_14).

The scientific aerial survey provides a fisheries-independent estimate of the relative abundance of aggregated 2–4 year old SBT (Eveson et al. 2014). 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 et al. 2014). In line with previous years, the index is based on the line-transect aerial survey conducted in the Great Australian Bight (GAB) between January and March (detailed in Eveson et al. 2014).

During the initial time period of the survey, 1993 to 2000, the index showed a declining trend in the relative abundance of juveniles in the GAB (Fig. 1) and the distribution of SBT sightings contracted spatially (Fig. 3 in Eveson et al. 2014). Between 2000 and 2009, the index was relatively stable and low (Fig. 1) and the spatial distribution of SBT sightings remained relatively contracted (Fig. 3 in Eveson et al. 2014). However, in 2009, there were more sightings in the eastern area of the GAB.

Between 2010 and 2014 the index has shown more variation with an increasing trend in relative abundance (Fig. 1). The spatial distribution of SBT sightings during the survey has expanded to cover a broader area of the GAB, more similar to the early survey years (Fig. 3 in Eveson et al 2014). However, in 2010–12 most of the sightings were in the eastern half of the survey area.

The index of relative juvenile abundance in 2014 (the 2013–14 fishing season) is substantially higher than the 2013 estimate (2012–13 fishing season). Indeed, the 2014 index is the highest index obtained for the scientific aerial survey over the past 10 years. The distribution of sightings of SBT included a greater proportion in the westernmost transect lines than has been seen since 2006 (Fig. 3 in Eveson et al. 2014).

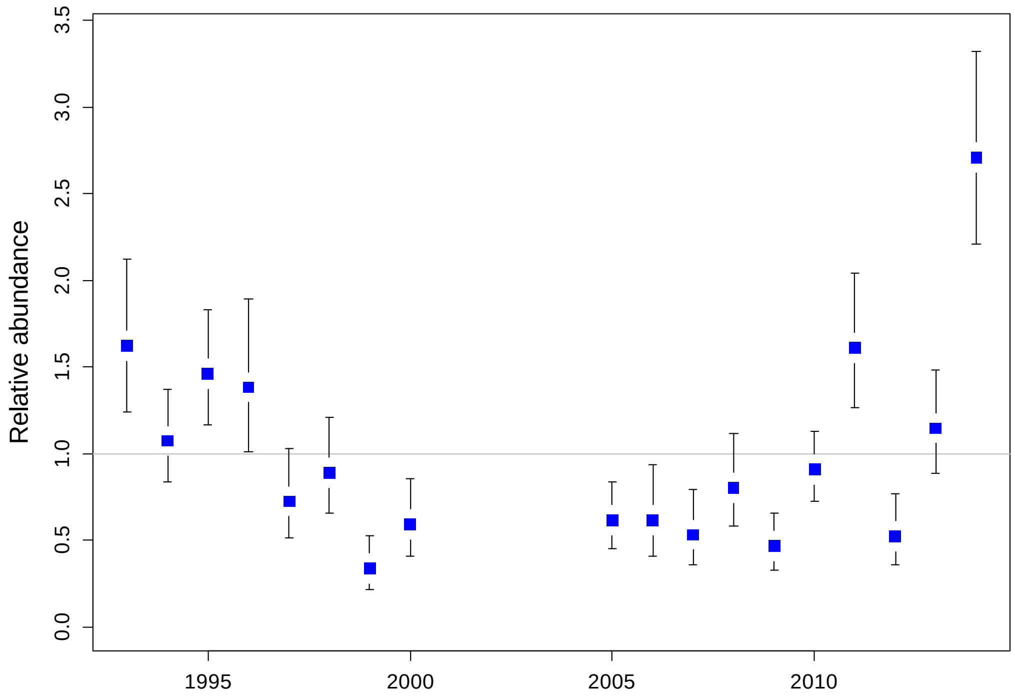

Fig. 1. Scientific aerial survey of relative abundance for juvenile SBT in the Great Australian Bight, January–March (hence the 2014 value represents the 2013–14 fishing season etc) from Eveson et al. (2014). Vertical lines are 90 per cent confidence intervals. The horizontal line represents a relative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

Surface abundance per unit effort (SAPUE) / commercial spotting index

The commercial spotting (SAPUE) index has been updated from data provided by Australia 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). 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.

Interpretation of the SAPUE index requires caution as the spatial and temporal coverage is influenced by the commercial fishing operations. Therefore, there may be substantial changes in coverage over time, lack of coverage in areas where commercial fishing is not taking place, and changes in operations over time. However, the SAPUE may provide a qualitative indicator of juvenile SBT abundance in the GAB. Farley et al. (2014a) 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 the commercial spotting flights cover a much smaller area than the scientific line transect aerial survey.

The SAPUE index shows a general increasing trend from 2003 to 2011, followed by a decline in 2012, with increases in 2013 and 2014 (Fig. 2). The 2013–14 value was substantially higher than the value in 2012–13 (Fig. 2). The general pattern shows some similarities with the scientific aerial survey index. However, since 2010 there has been a shift in the spatial distribution of commercial spotting operations, away from the original core fishing area, towards the east (see Fig. 1 Farley et al. 2014a). The percent of total search effort occurring in the previous 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. 2014a).

Note that the SAPUE is now from 2003 onwards, rather than 2002. This is due to a change in the standardisation model that includes variables that were not collected in 2002

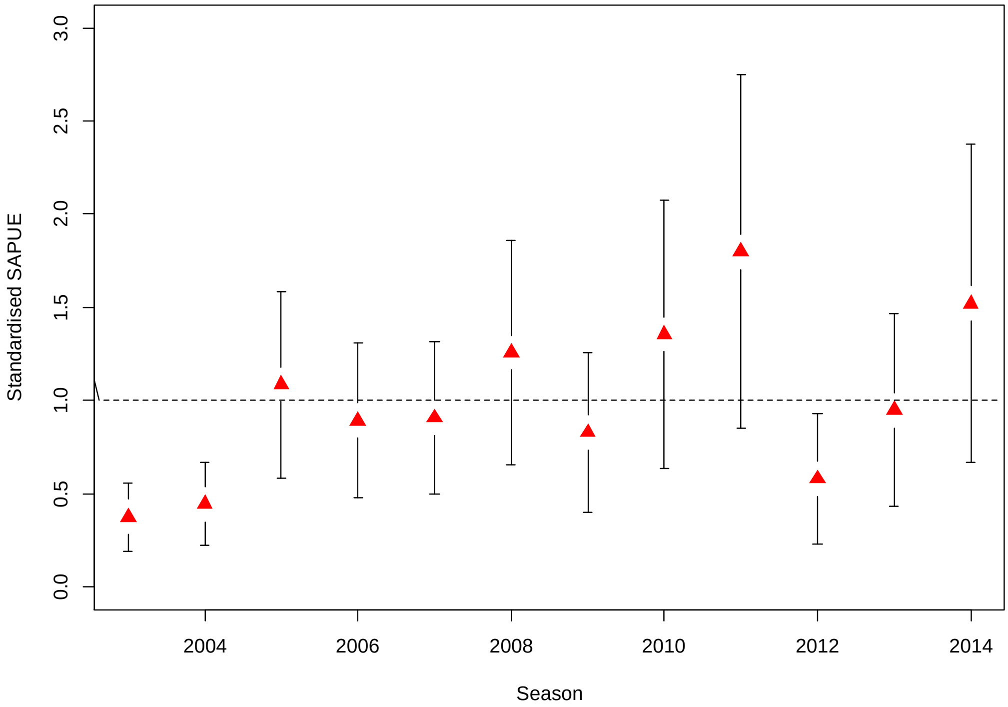

Fig. 2. The SAPUE index of relative surface abundance of juvenile SBT in the Great Australian Bight, December–March (Farley et al. 2014a). Estimates are median ± 2 standard errors. The dashed horizontal line indicates the mean. 'Season' represents the second year in a split-year fishing season, i.e.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

Trolling index

The trolling survey index has been updated from data provided by Japan through the CCSBT data exchange (JP_Trollindex2014).

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 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).

Since 2006, the piston-line trolling survey has shown substantial variation with little overall trend. The survey index increasing until 2008, declining until 2010, and then increasing in 2011 to its highest point. In 2011, the scientific aerial survey recorded the highest percentage of schools of fish estimated to be less than 8 kg on average (assumed to be 1 year olds) (Eveson et al. 2014). However the relatively high proportions of 1 year olds in the aerial surveys in adjacent years are not matched by high piston-line trolling survey.

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. The index declined slightly in 2014.

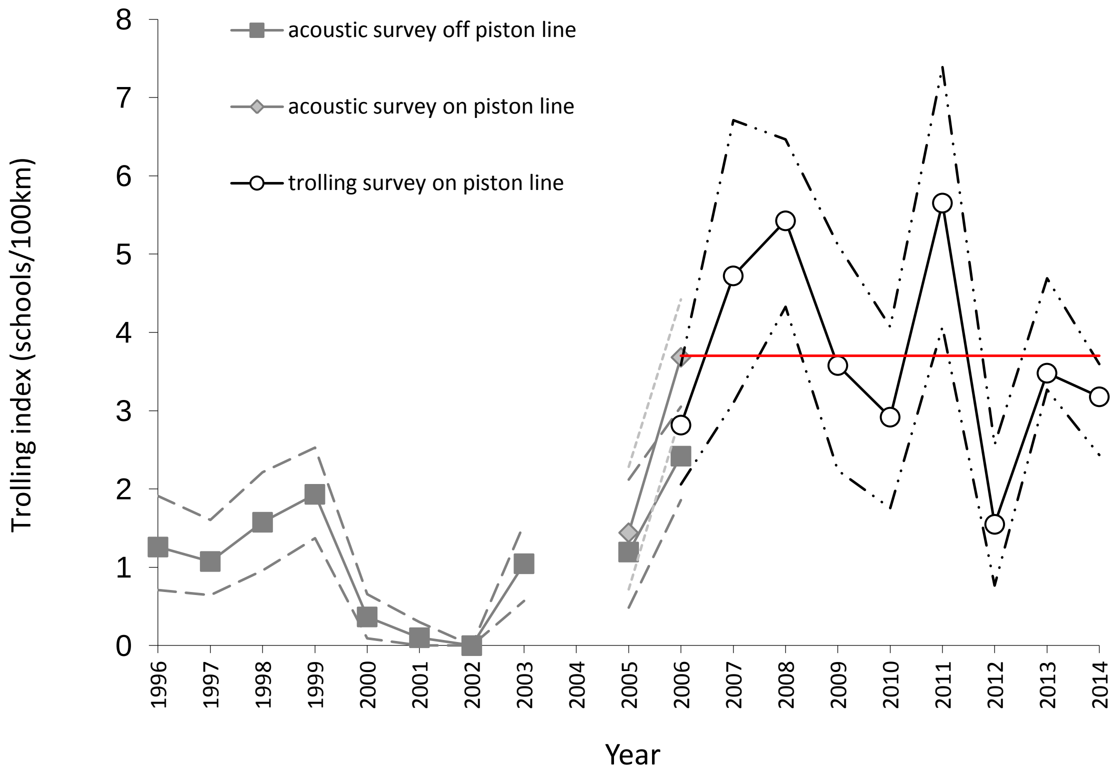

Fig. 3. Trolling index, showing number of schools per 100 km off the Western Australian coast in January. Dashed lines are 90 per cent confidence intervals. The red line shows the average median value of the piston line survey from 2006–14.

Catch per unit effort

New Zealand charter longline CPUE

New Zealand (NZ) charter (joint venture) longline CPUE for statistical areas 5 and 6 (aggregated for all age classes) was updated from CPUE input data provided in the 2014 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 stable, but with the increase in TAC since 2008–09, the domestic fishery component has now almost doubled.

The CPUE in the southern fishery (CCSBT statistical area 6) has been variable over time, but has displayed a general increase from 2005 to 2010 and fluctuating slightly since then. The CPUE declined slightly in 2013 from 2012 levels, but remains well above the ten-year mean level. There has been very little or zero effort and catch in statistical area 5 in recent years.

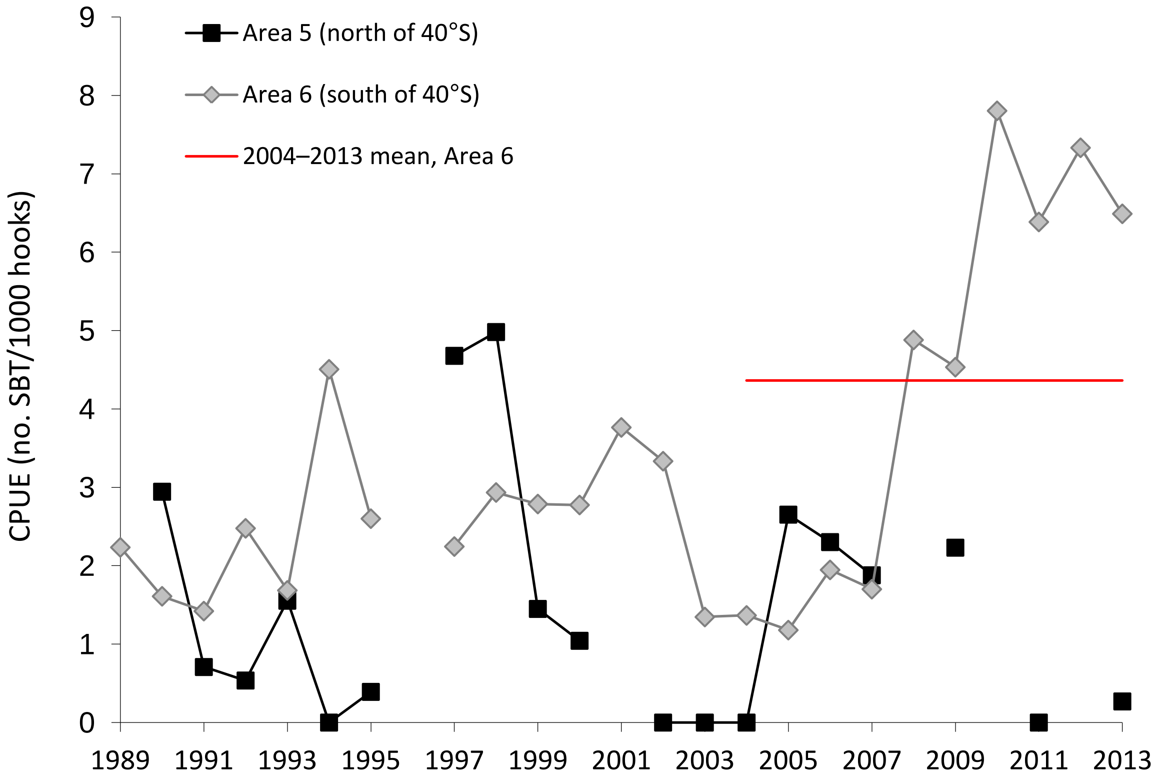

Fig. 4. Nominal CPUE (number per 1000 hooks) for the NZ charter fishery. The red horizontal line indicates the 10-year mean (2004–13) in Area 6.

New Zealand domestic longline CPUE

The nominal CPUE from the NZ domestic longline fishery was updated from aggregated catch and effort data provided in the 2014 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 fishery 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/1409/SBT Fisheries - New Zealand). As noted above, with the increase in NZ TAC since 2008–09, the domestic catches have almost doubled.

From 1990 to 2006, the series displayed a relatively stable pattern, except for a sharp peak in 1995 that declined again in 1996. Since 2006, CPUE in the NZ domestic fishery has increased steadily, with a sharp increase seen in 2012 to its highest level. There was a slight decrease in 2013; however the CPUE remains high compared with the earlier part of the series.

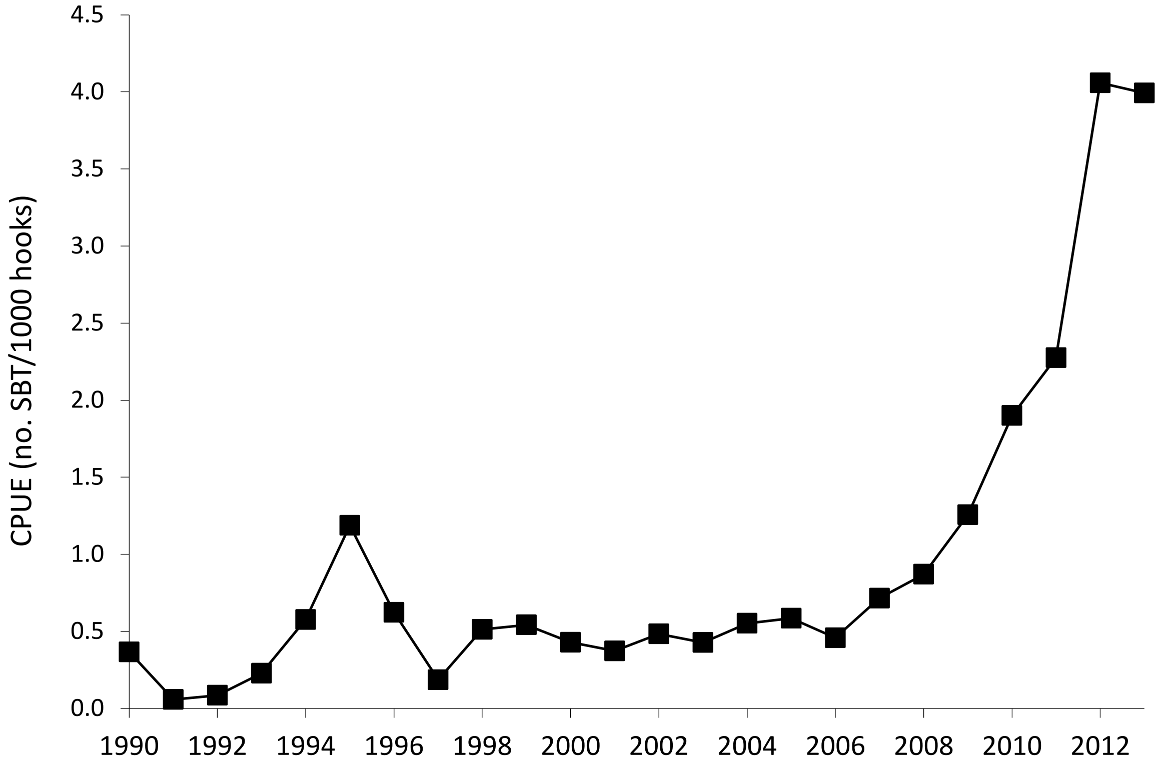

Fig. 5. Nominal CPUE (number per 1000 hooks) for the NZ domestic longline fishery.

Catch size/age composition

New Zealand longline fishery size composition

Size composition data for SBT caught by the NZ charter and domestic fisheries were extracted from the 2014 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 charter fishery 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

Since 1989, in the NZ charter fishery catch, age 4 and age 5 SBT have displayed trends of increase over several years, followed by a decrease (e.g. 1989–95, 1997–2003, 2006–11). In general, age 3 SBT have been less variable, aside from the early part of the series (1989–95). 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 2013, however, ages 3 and 4 decreased, while age 5 increased.

The NZ charter fishery catches virtually no age 0–2 SBT and so there are no clear trends in the abundance of this size/age class (Fig. 6). Given the general 100 per cent observer coverage in the NZ charter 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. No information on the size structure of discards is available (CCSBT-ESC/1409/SBT Fisheries - New Zealand).

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 abundance of age 3 SBT (2006 and 2010) (Fig. 7). The abundance of the juvenile age classes declined in 2004 (similar to the trend observed in the NZ joint venture fishery). All age classes declined in 2013 (Fig. 7). There is a lower level of observer coverage in the NZ domestic fishery, and some unreported discarding of juveniles may occur.

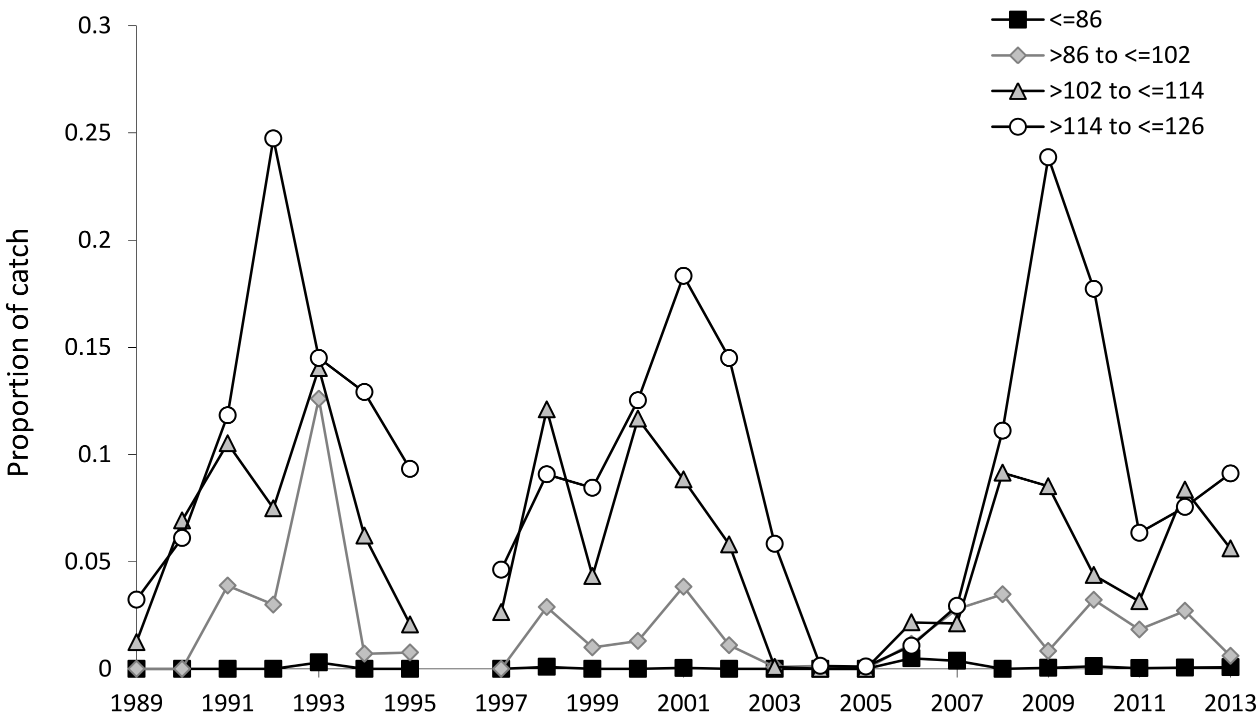

Fig. 6. Size composition for the NZ joint venture longline fishery, where age 0–2<86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.

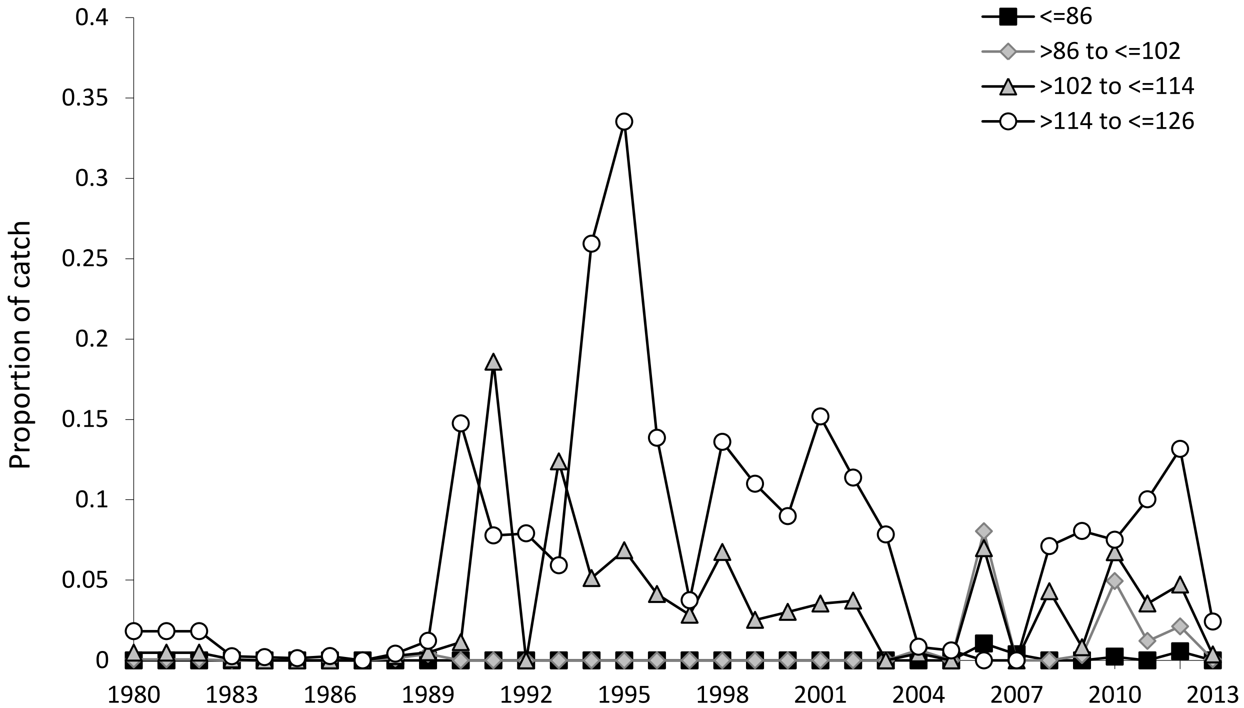

Fig. 7. Size composition for the NZ domestic longline fishery, where age 0–2<86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.

Indonesian spawning ground fishery size/age composition

The Indonesian catch data provide an important source of information about the spawning population. Interpreting the trends in the available information requires the assumption that the selectivity of this fishery has been constant over time.

The size composition data for the Indonesian fishery for the 2012–13 and 2013–14 seasons and the age composition data for 2012–13 season were provided in 2014 (Farley et al. 2014b).

From the time sampling started, 1993–94, to 2002–03 the length frequencies showed a general shift in the medium size class (2 cm size classes) from 188 cm to 168 cm (Fig. 8). Similarly, over this time period, the proportion of fish >190 cm and between 165 - 190 cm declined, while the proportion of smaller fish, <164 cm, increased (Fig. 9). The mean estimated age of all SBT caught on the spawning ground followed a similar pattern, declining from 21 years old to around 14 years old (Fig. 10). The mean estimated age of older fish (20+ years) was relatively constant over this time. The age frequency distributions show a strong shift towards the younger ages (Fig. 11)

Between 2004–05 and 2011–12 the length frequency distribution of SBT caught on the spawning ground was relatively stable, with the median size class ranging between 166–172 cm (Fig. 8). Compared with the years prior to 2004–05, there were higher proportions of smaller fish (<165 cm) in the catch and the proportions were relatively stable until 2011–12 (Fig. 9). The mean estimated age of SBT caught on the spawning ground was variable but showed some increase over this time period, estimated at 16 years in 2011–12 (Fig. 10), while the mean estimated age of older fish (20+ years) declined. The age frequency distributions show some shifting towards the older ages (Fig. 11), but the older age classes remain less frequent than in the early part of the time series.

In 2012–13 and 2013–14, the length data showed a new mode of relatively small fish in the catch, at ~145-155 cm (Fig. 8; Farley et al. 2014b). The usual mode of larger fish ~170 cm was still present. The median size class decreased from 168 cm in 2011–12 to 162 cm in 2012–13 and 2013–14 (mean size declined from 169 cm to 162 cm). In these recent years there was a much larger proportion (~30 per cent) of smaller fish (<155 cm) than has been observed previously (Fig. 9). The mean estimated age of all SBT caught reduced substantially from 16.0 years in 2011–12 to 13.2 years in 2012–13 as the proportion of SBT estimated at <10 years old in the catch increased (Fig. 10 and 11; Farley et al. 2014b). The mode of younger fish was more pronounced in the age frequency distribution in 2012–13.

The appearance of smaller fish in the catch has occurred previously. In the 2003–04 to 2006–07 spawning seasons (Fig. 8), similar modes of smaller fish appeared in the catch (Fig. 8). At the time investigation showed that at least one fishing company (Processor A) had shifted their operations to target SBT south of the spawning ground and were catching a larger proportion of smaller fish (Farley et al. 2007). While the size distribution of the recent catches shows a greater proportion of smaller fish compared to previous seasons, initial inquires indicate that the smaller fish have been reported from a larger number of vessels from different companies (OMMP5 2014). Information to determine whether these smaller fish were caught on the spawning ground and their maturity is not yet available; the OMMP5 (2014) noted that this was an important uncertainty.

There was no direct ageing of SBT caught in the Indonesian fishery in the 2011–12 season, and therefore the age-frequency for the 2011–12 season is based on the 2011–12 length frequency data and the age-length-key (ALK) from direct ageing in the previous two seasons. Direct ageing was undertaken in 2012–13.

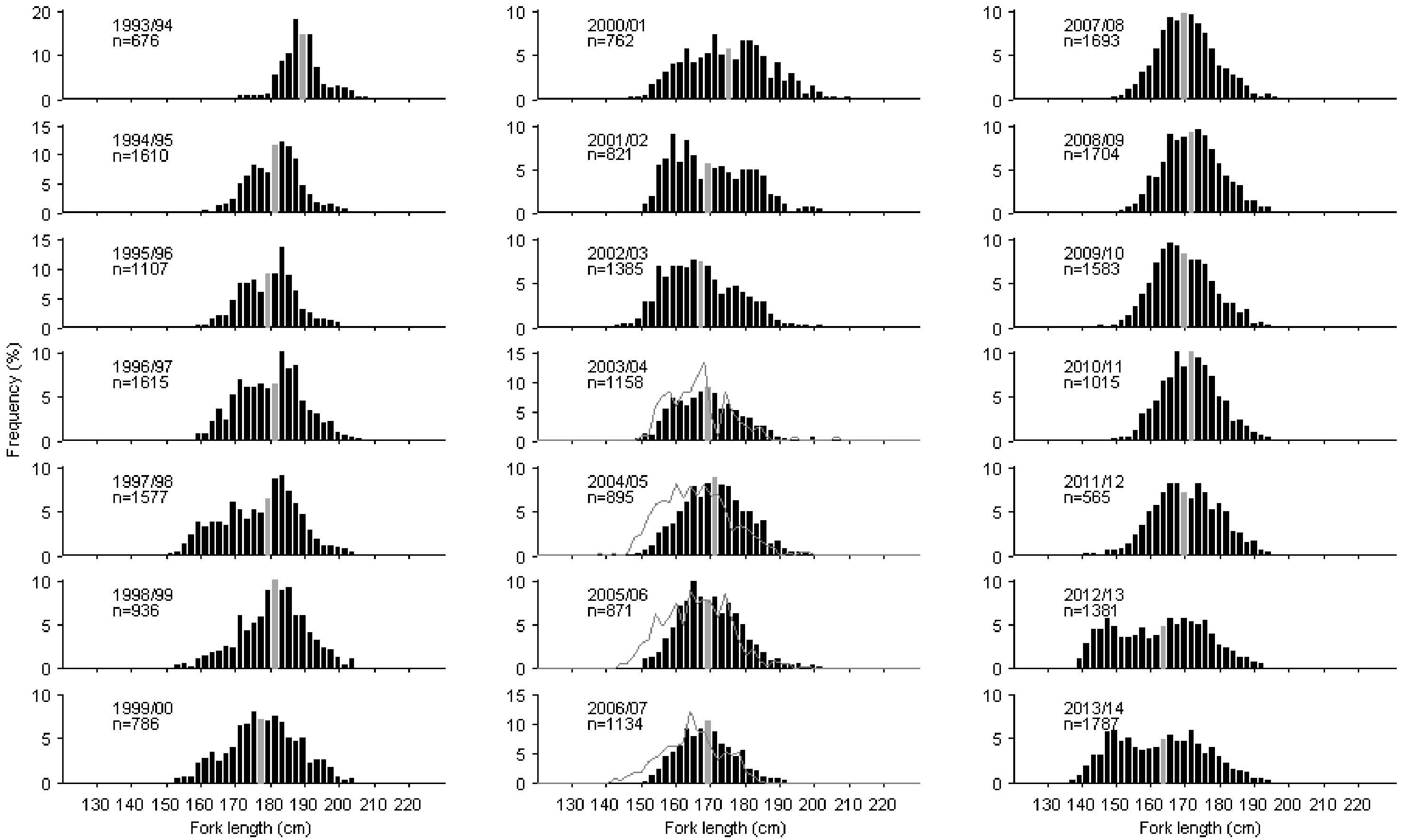

Fig. 8. Length frequency (2 cm intervals) of SBT caught on the spawning ground (bars) by spawning season (Farley et al. 2014b). The grey bar shows the median size class. For comparison, the length distribution of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2003/04 (n=121), 2004/05 (n=685), 2005/06 (n=311) and 2006/07 (n=452) seasons (grey line) (see Farley et al. 2007).

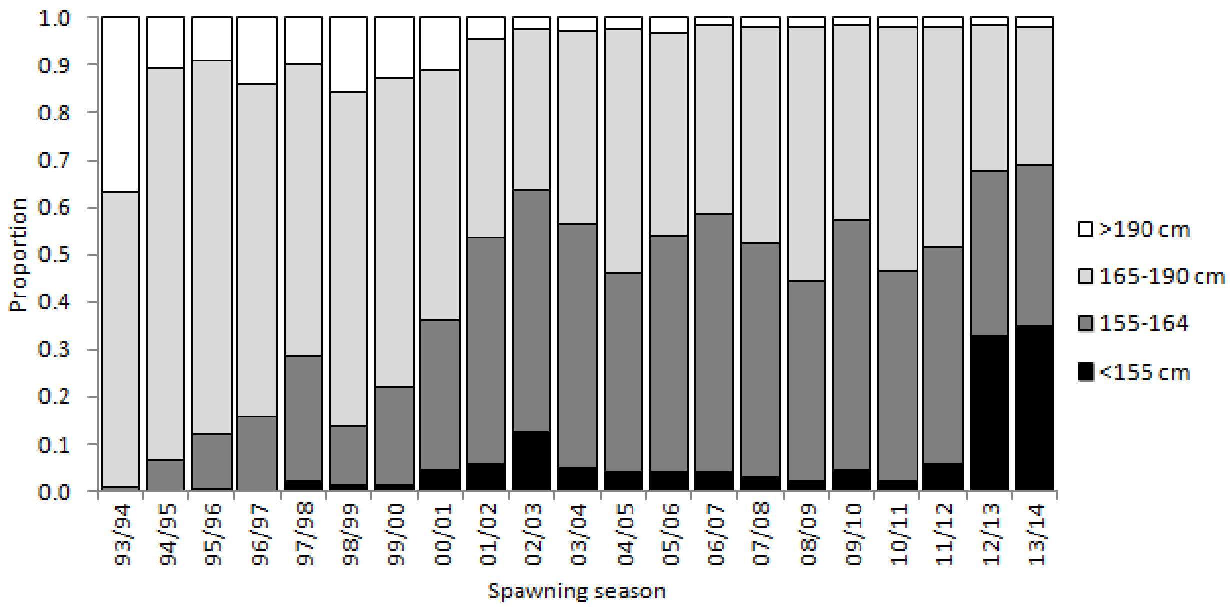

Fig. 9. Size composition of SBT caught on the spawning grounds by the Indonesian longline fishery by spawning season (from Farley et al. 2014b). Data from Processor A are excluded.

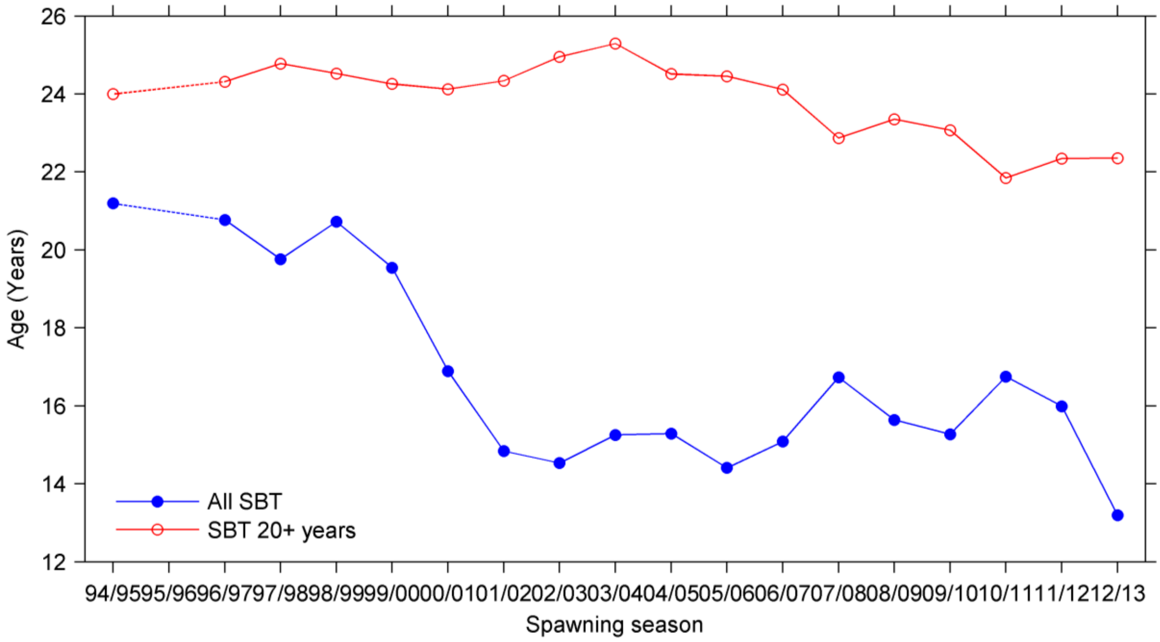

Fig. 10. Mean estimated age (years) of SBT caught on the spawning grounds by Indonesian longliners (from Farley et al. 2014b). There was no direct ageing of the 2012–13 otoliths; age frequency is based on the age-length key from the previous two seasons and 2012–13 length frequency data. Data from Processor A are excluded.

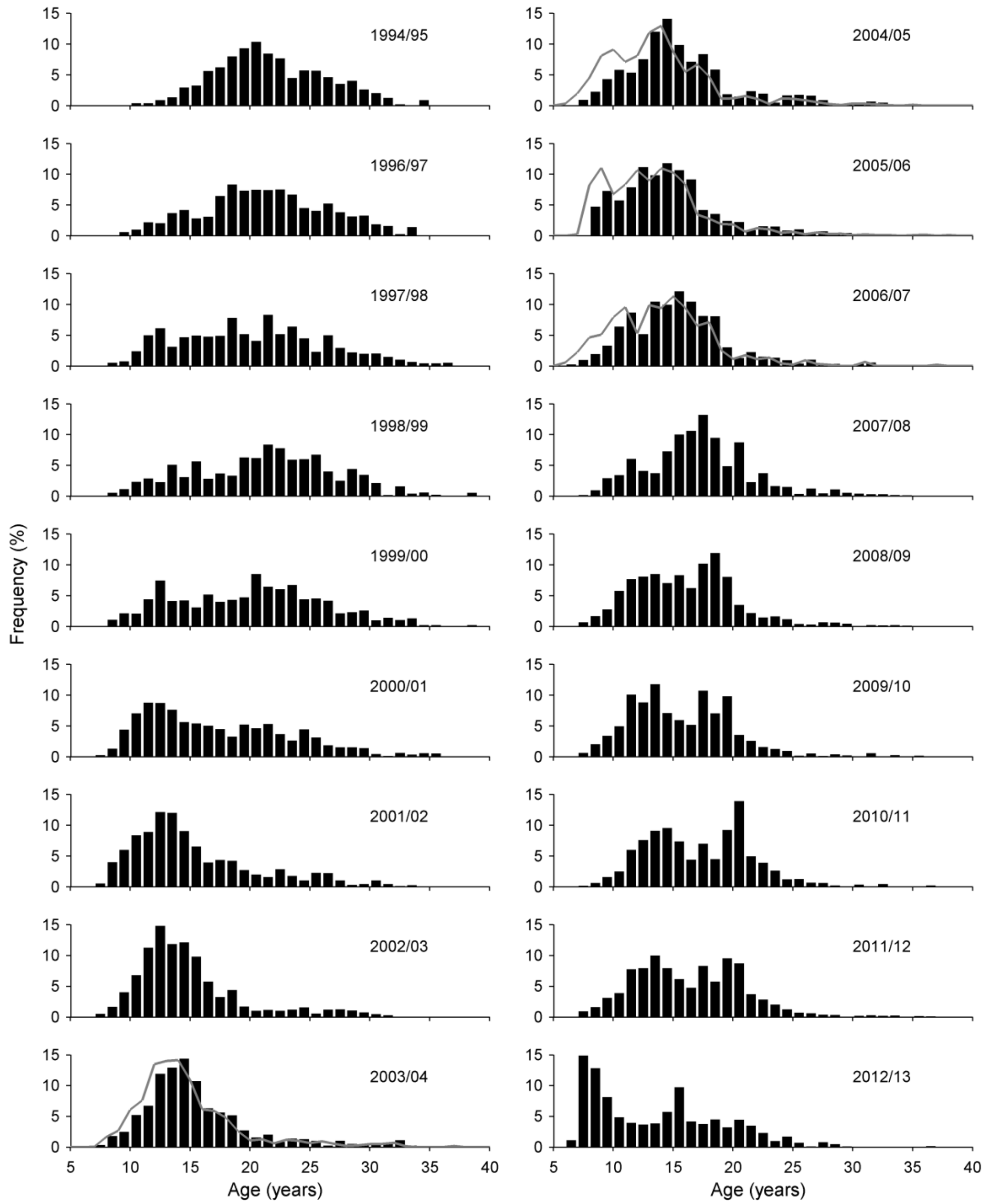

Fig. 11. Age frequency distribution of SBT in the Indonesian catch on the spawning ground by spawning season estimated using age-length keys from our sub-samples of direct aged fish and length frequency data obtained through the Indonesian monitoring program (Farley et al. 2014b). There was no direct 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 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 2014, but it is recommended that their interpretation be treated with caution. Recent trends in some of these indicators are less likely 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 June 2014 CCSBT data exchange.

Reported catches have declined since 2005 (from ~16 000 t to below 12 230 t in 2013) (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 was increased in 2012 and again in 2013.

Australia's reported catches in 2009–13 (by calendar year) were 5108 t, 4200 t, 4200 t, 4503 t and 4835 t, respectively. Japan's reported catches over the same period were 2659 t, 2223 t, 2518 t, 2528 t and 2695 t. The Taiwanese catch was 533 t and 497 t reported in 2011 and 2012, respectively, but increased to 1044 t in 2013. Korean catches have been relatively stable over the past four years with 918 t reported in 2013. The effect of retrospective unreported catches on the interpretation of other indicators in this section is unknown. Indonesian catches in 2013 were nearly twice the CCSBT allocation.

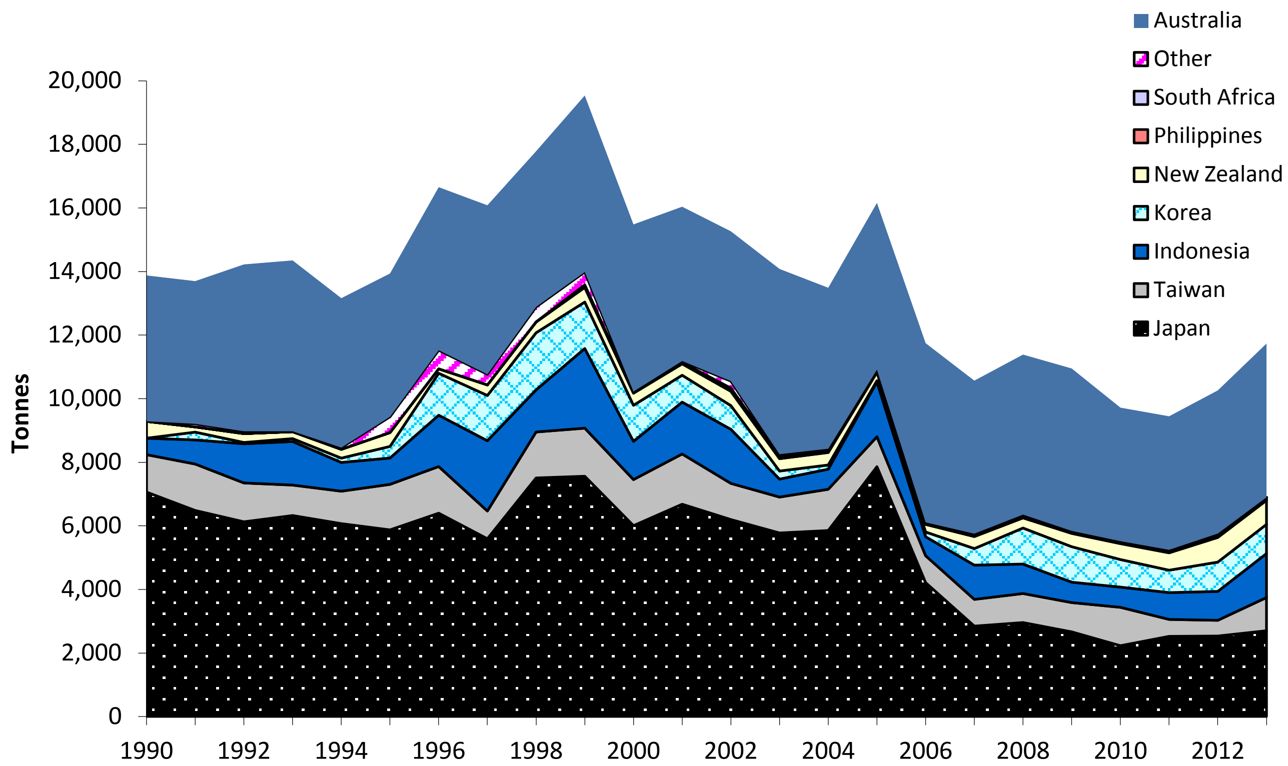

Fig. 12. Reported catches (tonnes) by country since 1990. Shaded areas are stacked so that y-axis values represent total catch reported by all Members in a calendar year.

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_13_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 and JP_CorevesselCPUE_6913) 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. 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 less 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 2013 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 2013. The series in 2013 is above the recent 10 years (2004–13) mean (Fig. 13, horizontal line).

- Nominal CPUE for age 4–7, 8–11 and 12+ SBT. The nominal CPUE series in 2013 for age 4–7 declined slightly, while an increase can be observed for age 8–11 SBT. 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. This differed from the previous years. However, the relative proportions of both age 0–2 and 3 dropped markedly in 2008 and ages 4 and 5 returned to being the dominant age classes in the juveniles. Age 4 and 5 SBT were the dominant year classes in the juveniles in 2013, with a slight increase of age 5 in 2013; all the other age classes declined in 2013 (Fig. 15). The reported discarding since 2006 (Sakai & Itoh 2013) is not incorporated in these nominal CPUE by age.

- Age-specific nominal CPUE for SBT of ages 4, 5, 6, 7, 8 and 9 in different statistical areas. The CPUE for ages 4 and 5 declined in area 9 in 2013 but increased in areas 4–7. CPUE for age 6 and 7 SBT decreased in all areas except age 7, which increased in area 9. CPUE for ages 8 and 9 increased in all areas, particularly area 9 (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 pattern in area 8 showed more stability in overall numbers of squares fished since ~1990, but with the pattern by month changing in more recent years. The number of grid squares fished in 2013 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 decreases in 2013, as did the normalised series from the core vessels (Base W0.5 and Base W0.8) (Fig. 18).

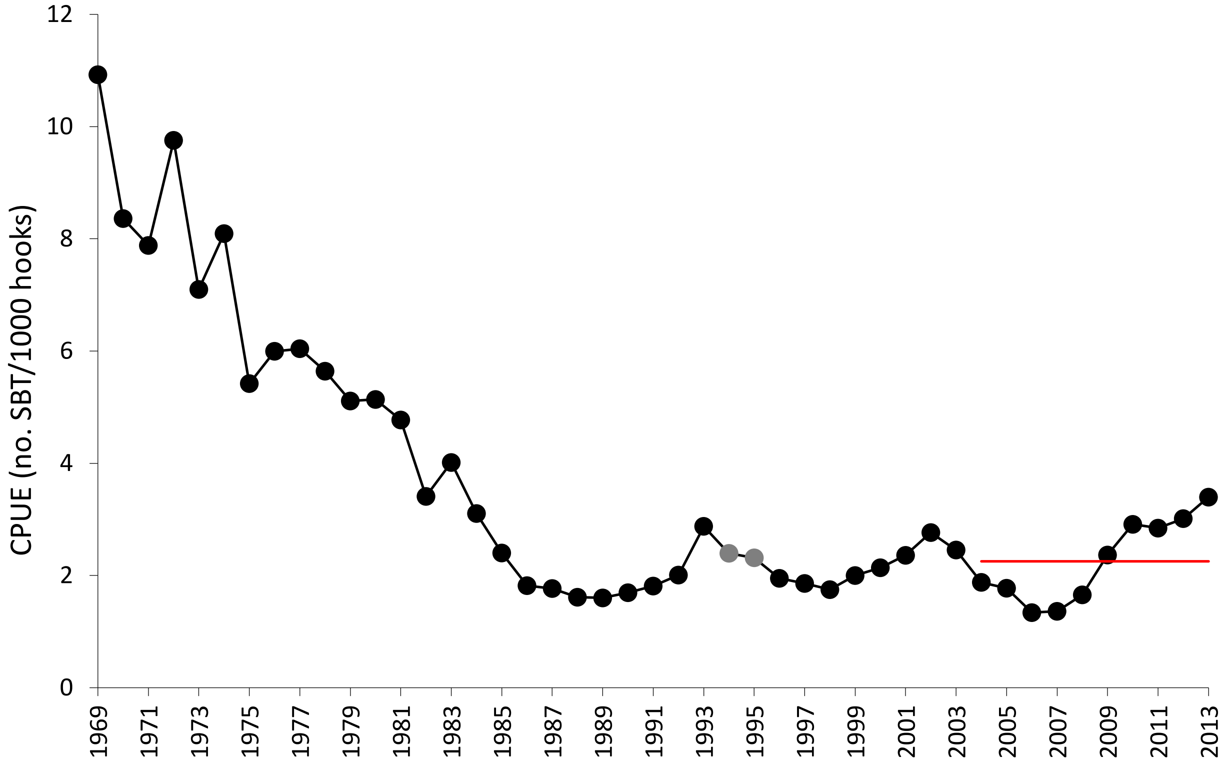

Fig. 13. Nominal CPUE of age 4+ SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9. The 1995 and 1996 values are plotted as grey circles to indicate increased uncertainty about these points due to changes in retention policies for small fish in these two years, when a policy of releasing small fish applied. The horizontal line is the 2004–13 mean.

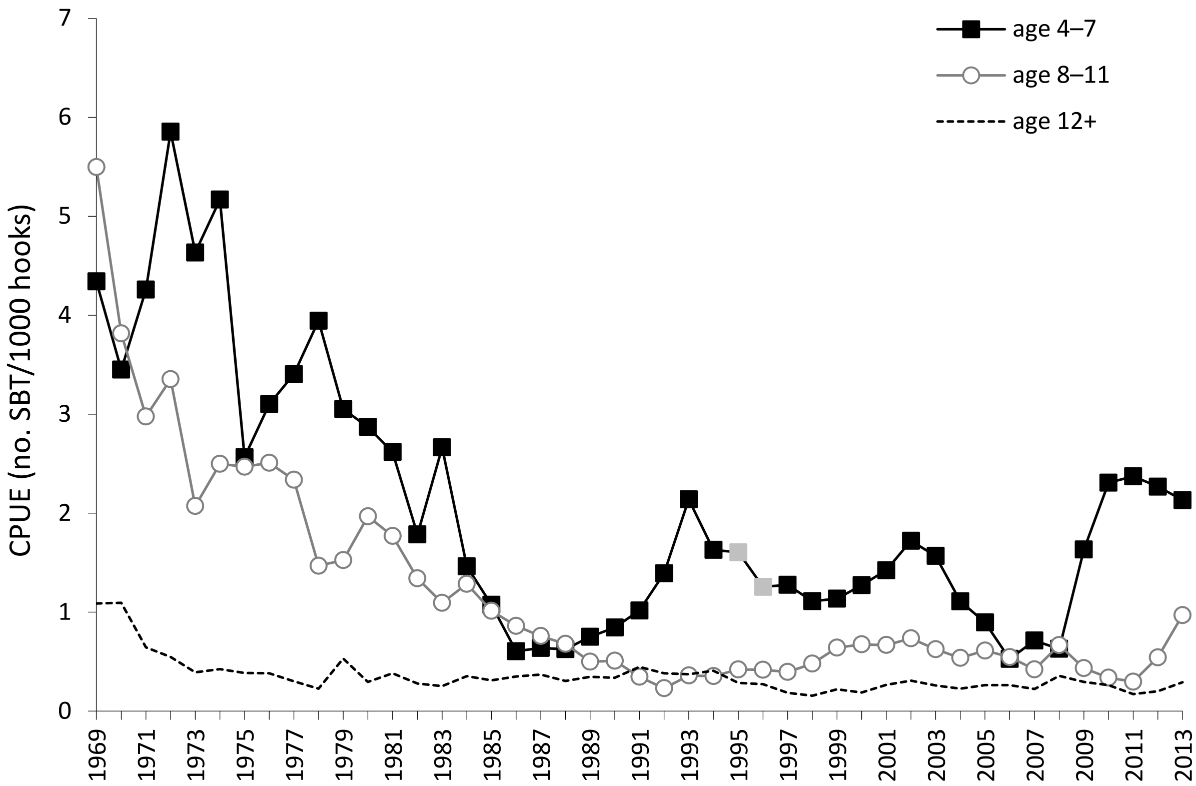

Fig. 14. Nominal CPUE of ages 4–7, 8–11 and 12+ SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9. The 1995 and 1996 values for ages 4–7 are plotted as grey squares to indicate increased uncertainty about these points due to changes in retention policies for small fish in these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

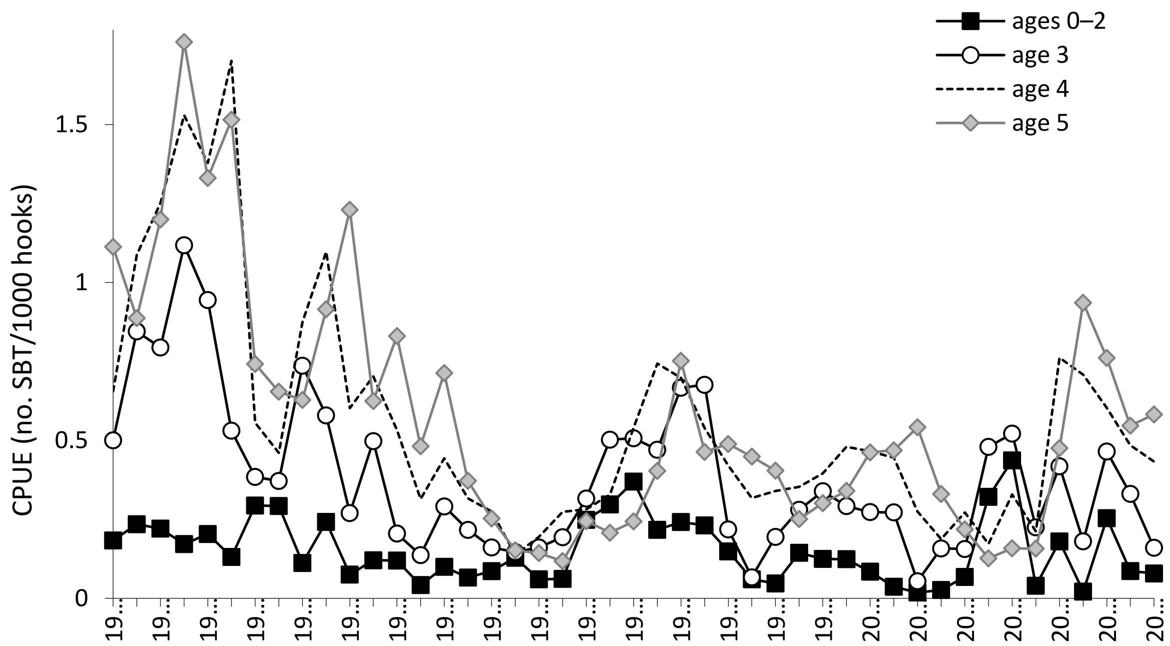

Fig. 15. Nominal CPUE of ages 0–2, 3, 4 and 5 SBT for Japanese longliners operating in statistical areas 4–9 in months 4–9.

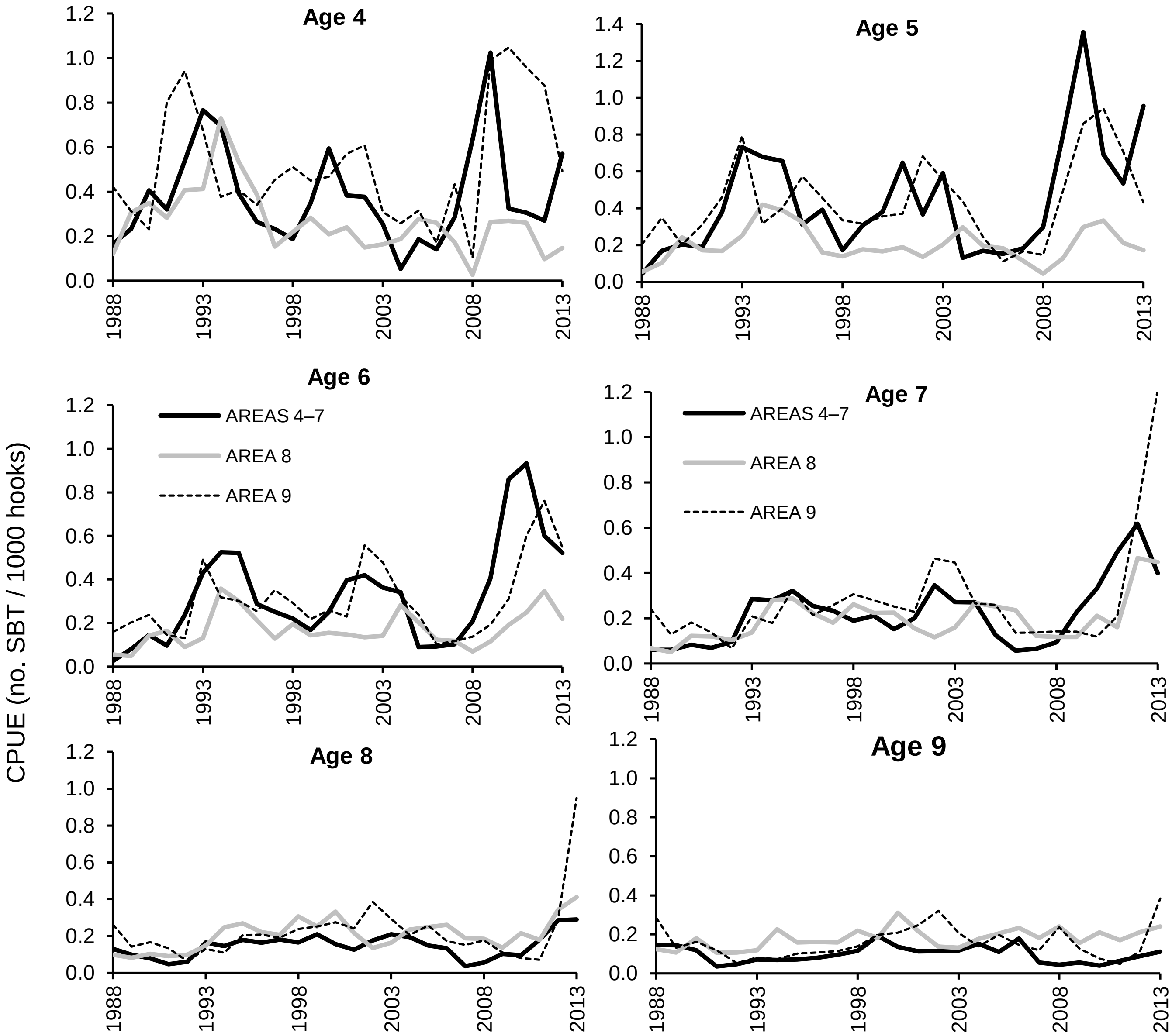

Fig. 16. Comparison of age-specific nominal CPUE for Japanese longliners in different statistical areas in months 4–9.

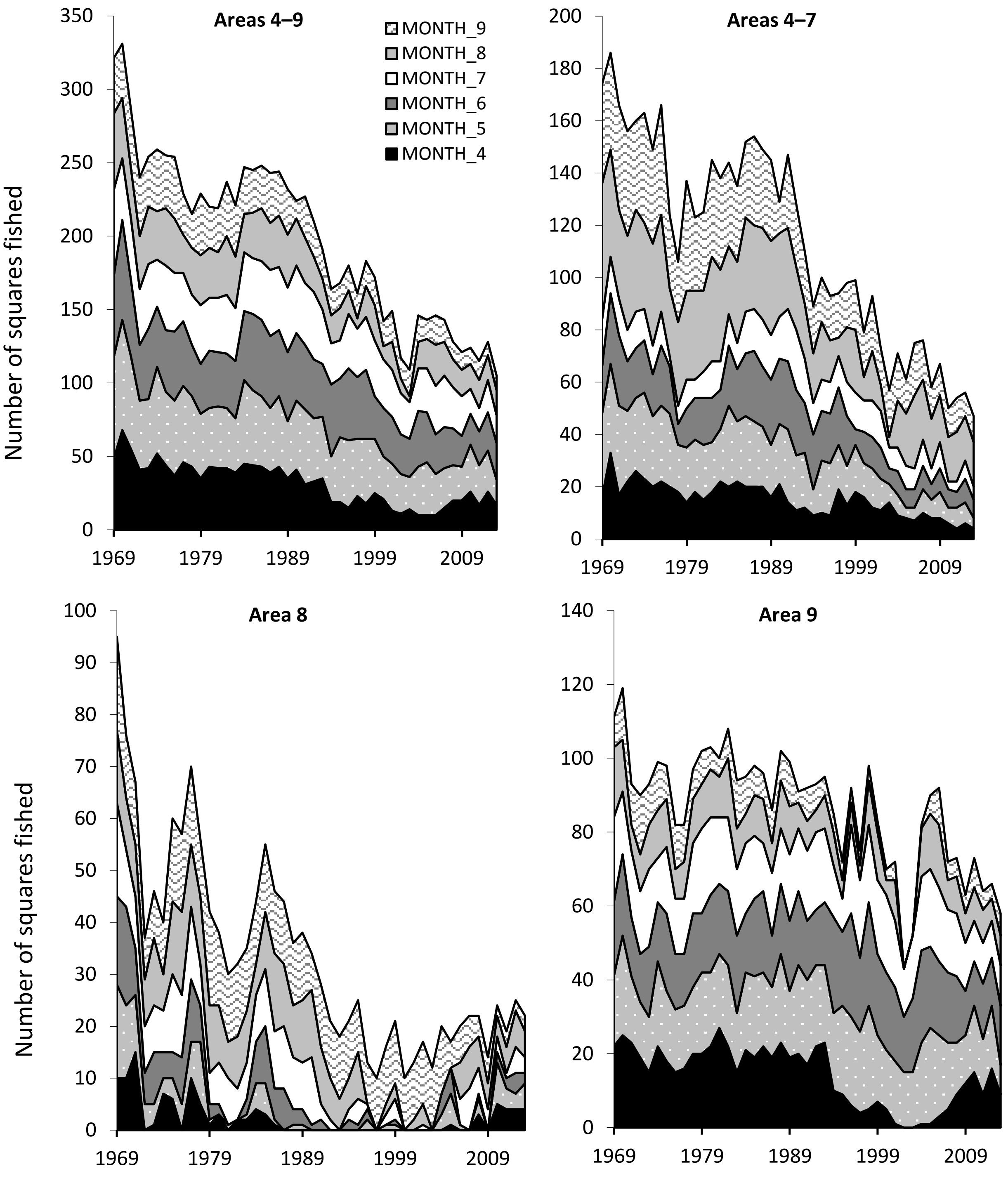

Fig. 17. Total number of 5×5° grid squares with Japanese longline fishing effort in months 4–9 for different statistical areas. Shaded series in each plot are stacked (i.e. y-axis values are cumulative), with the legend and shaded series being stacked in the same order.

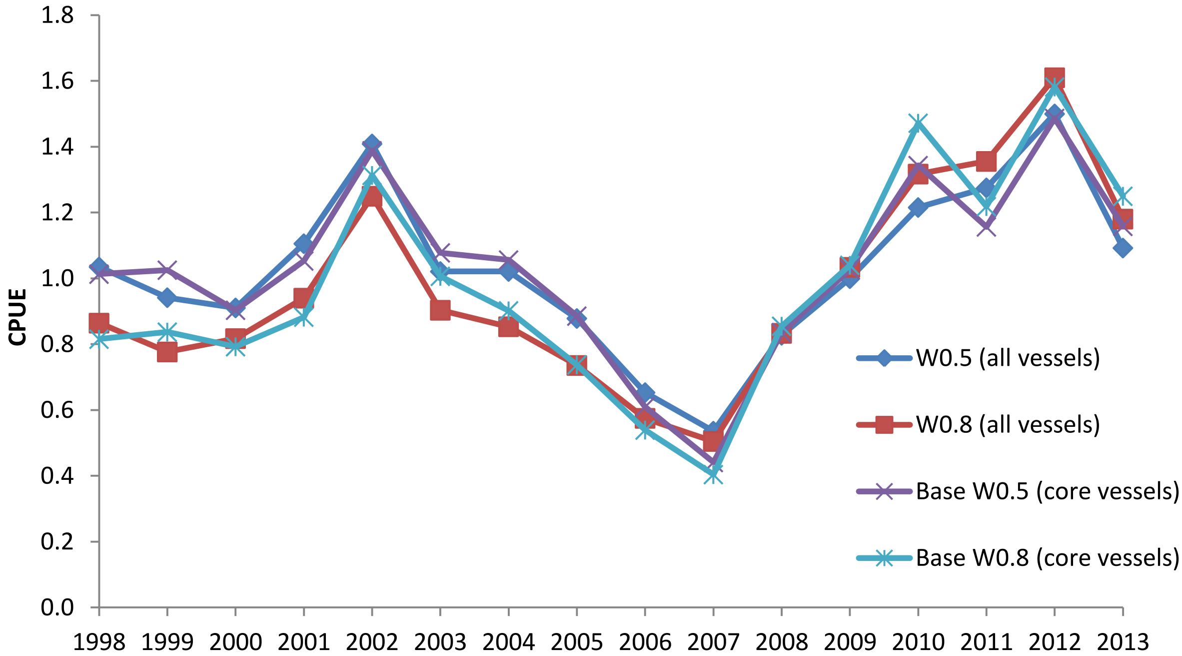

Fig. 18. Comparison of subsets of the standardised CPUE series. Each subset has been normalised by dividing by the mean.

Korean longline CPUE

The nominal CPUE series for Korean longliners were obtained from aggregated catch and effort data provided in the 2014 interim update of the CCSBT database.

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 2013 (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).

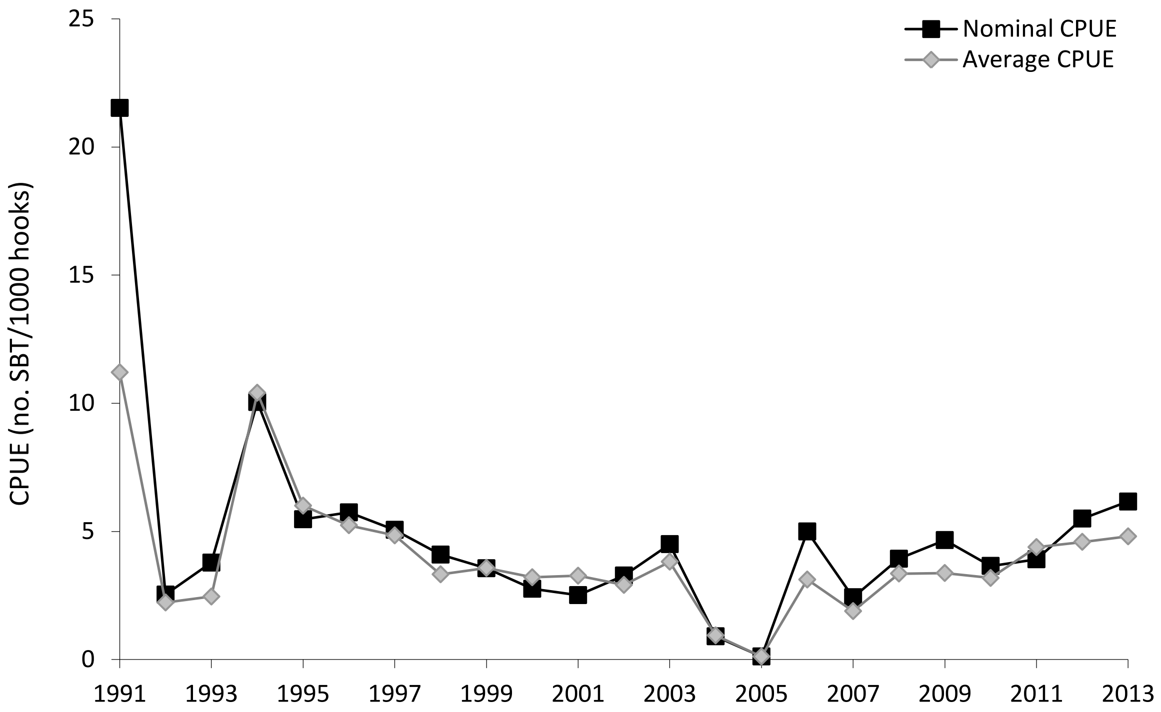

Fig. 19. Nominal and average CPUE of total SBT for Korean longliners operating in statistical areas 4–9 in months 4–9. Nominal CPUE is the total number of SBT over total effort (1000 hooks), while average CPUE is the mean of the nominal rate in each 5×5° grid square per month.

Taiwanese longline CPUE

Nominal CPUE series of Taiwanese longliners were obtained from aggregated catch and effort data provided in the 2014 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 slight increase in areas 2, 14 and 15 in 2013 and no real change in areas 8 and 9 (Fig. 20). Catch rates in 2013 were highest in the southern 10 degrees of areas 2, 14 and 15 (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 area 2, 14 and 15 since 2000 (Fig. 20, 21) (Anon 2009). Effort in areas 8 and 9 increased slightly in 2013 (Fig 22).

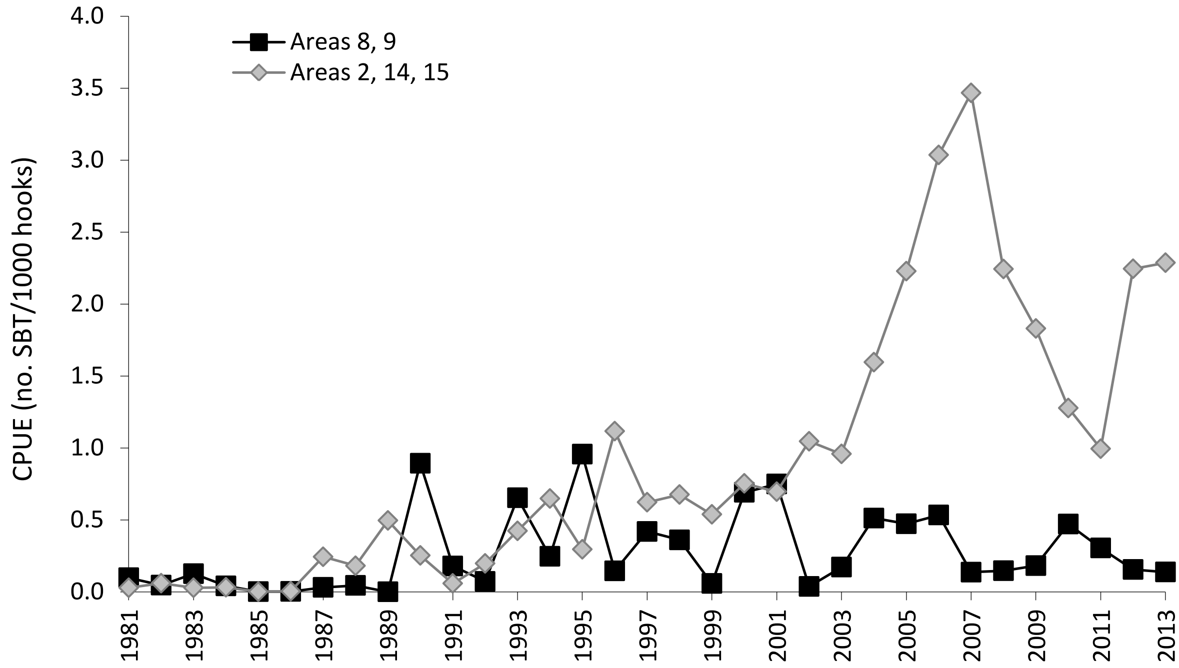

Fig. 20. Nominal CPUE of SBT for Taiwanese longliners operating in statistical areas 8 and 9 (pooled) and 2, 14 and 15 (pooled) in months 4–9.

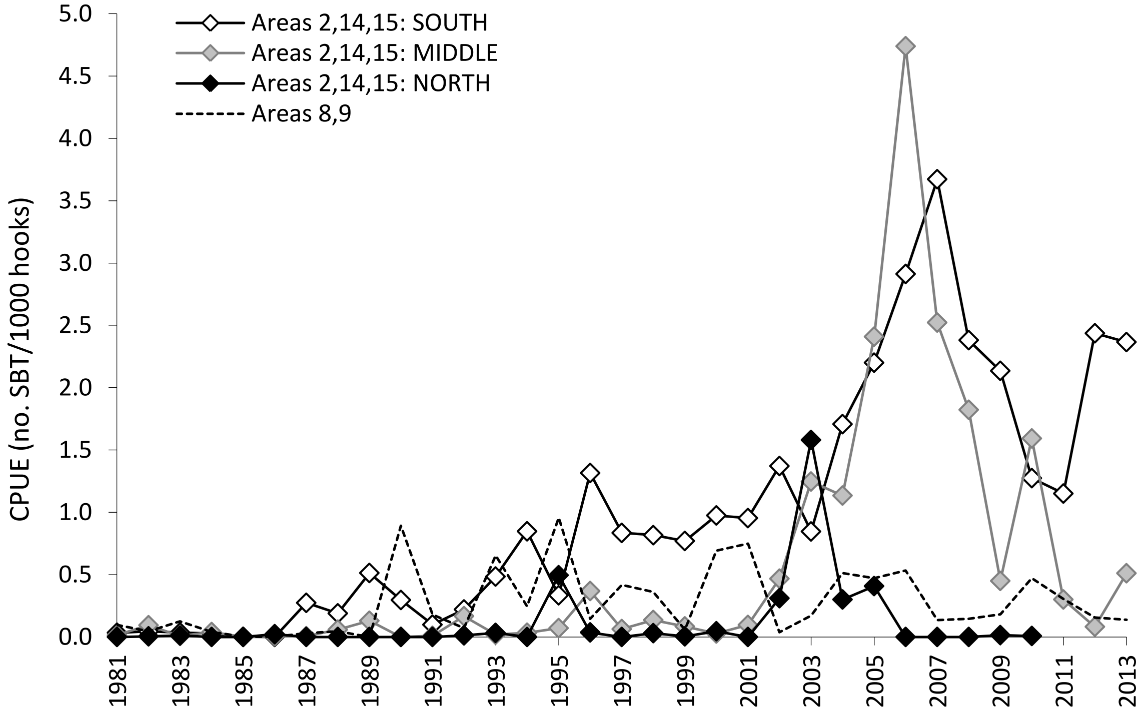

Fig. 21. Nominal CPUE of SBT for Taiwanese longliners operating in statistical areas 2, 14 and 15 (pooled) by 5° latitudinal strips: South = 30–35°S; Middle = 25–30°S; North = 20–25°S. Nominal CPUE in areas 8 and 9 (pooled) shown for comparison. Data are from months 4–9 only.

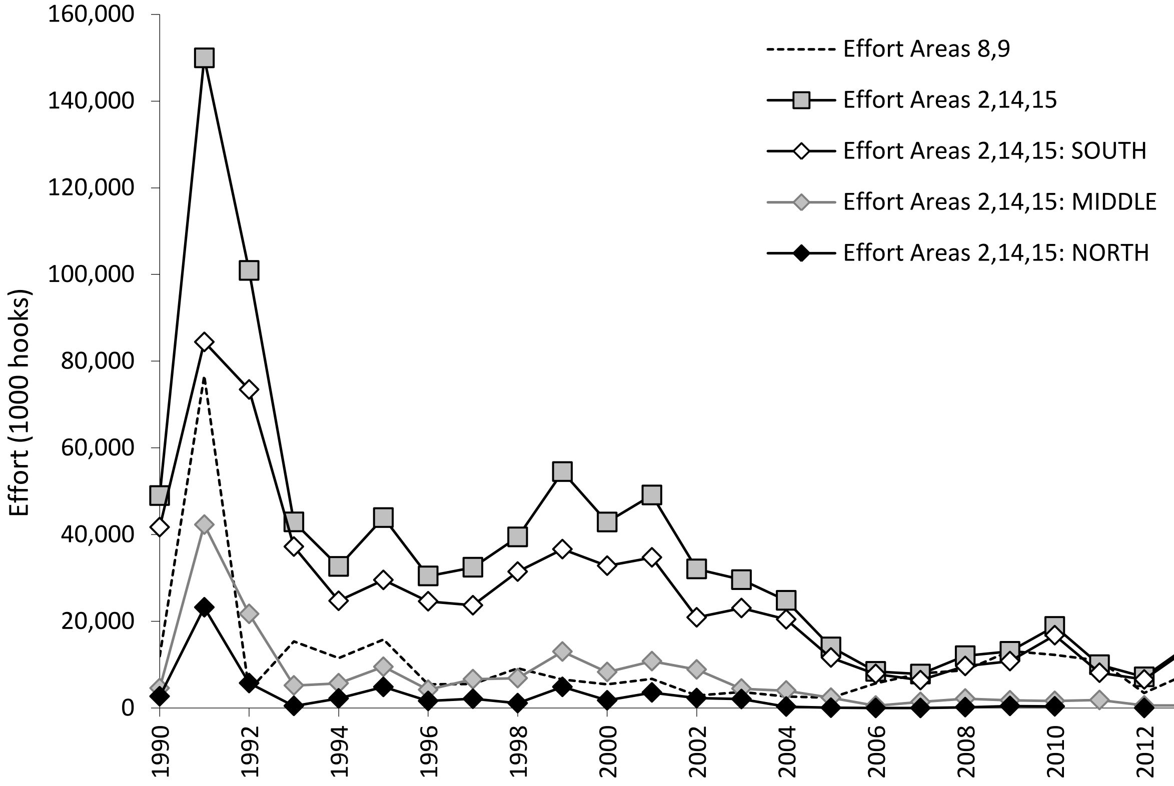

Fig. 22. Effort (1000 hooks) from Taiwanese longliners in statistical areas 8 & 9 (pooled) and 2, 14 and 15 (pooled). Areas 2, 14 and 15 are also separated into 5° latitudinal strips: South = 30–35°S; Middle = 25–30°S; North = 20–25°S. Data are from months 4–9 only.

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 2014 CCSBT data exchange (revised interim data report, June 2014). 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 all age classes examined here declined in 2013, except for age 5 which remained stable (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 commenced earlier (Sakai & Itoh 2013).

For comparison with size/age composition in the NZ, Korean and Taiwanese longline fisheries, Japanese length data have also been compiled 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 indicate a decrease in the proportion of all the size classes in 2013, except the largest size class which increased slightly (Fig. 24). The smallest size class has been relatively stable at very low levels since 2008 (Fig. 24).

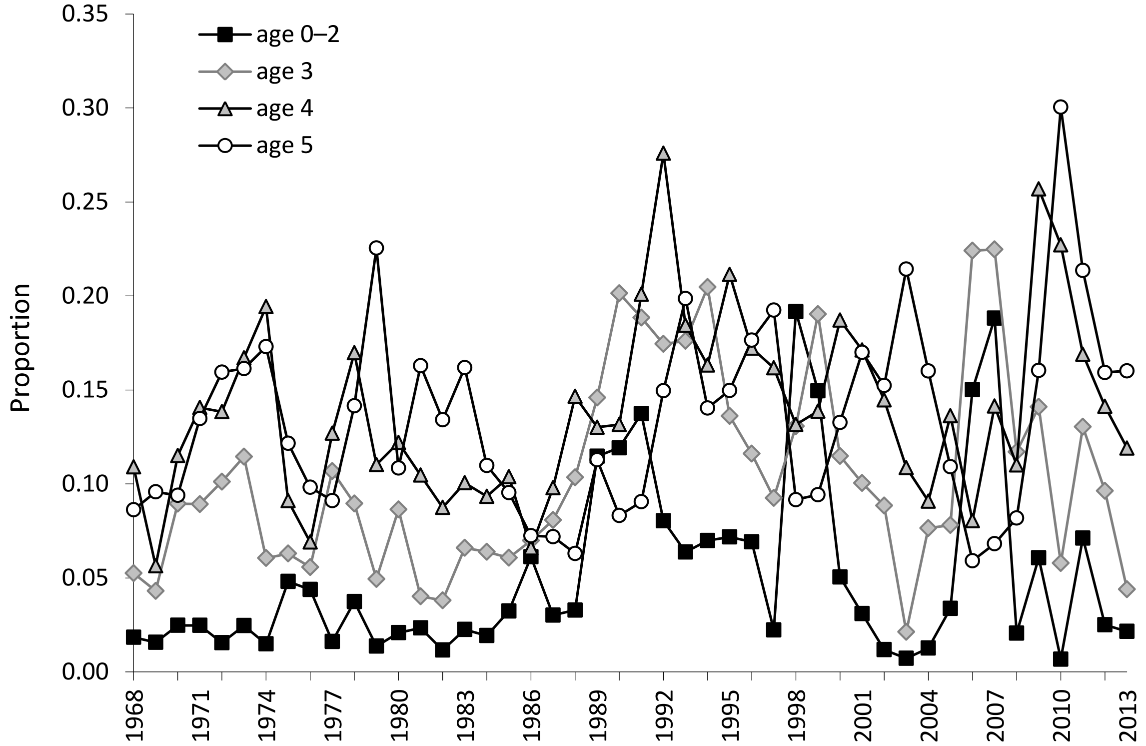

Fig. 23. Age composition (proportion of total catch) of ages 0–2, 3, 4 and 5 in the Japanese longline fishery in statistical areas 4–9, months 4–9.

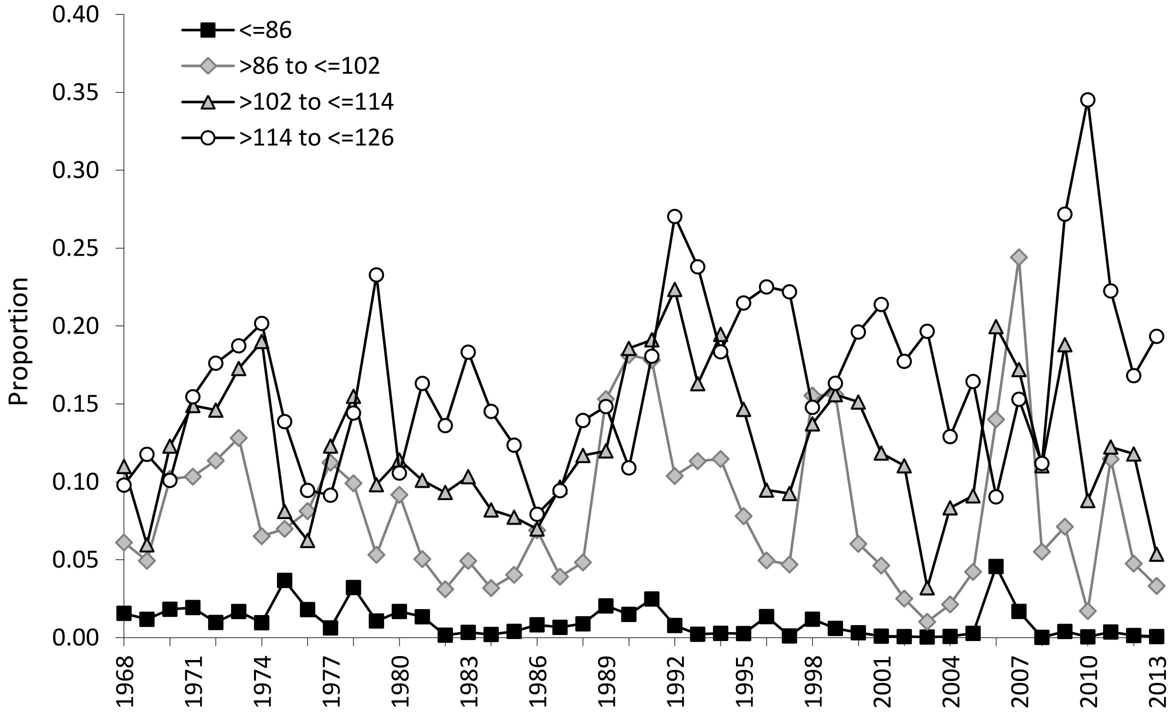

Fig. 24. Size composition (proportion of total catch) of juvenile SBT caught by Japanese longliners in statistical areas 4–9, months 4–9, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.

Korean longline fishery size/age composition

Size composition data from logbooks for SBT caught by Korean longliners were obtained from the 2014 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 CDS catch tagging information rather than logbooks. While data were provided for 2012, they were limited and no data have been provided for 2013 (Fig. 25). Coverage on vessels has been less than 10 per cent in some past years, and discarding of juveniles cannot be discounted.

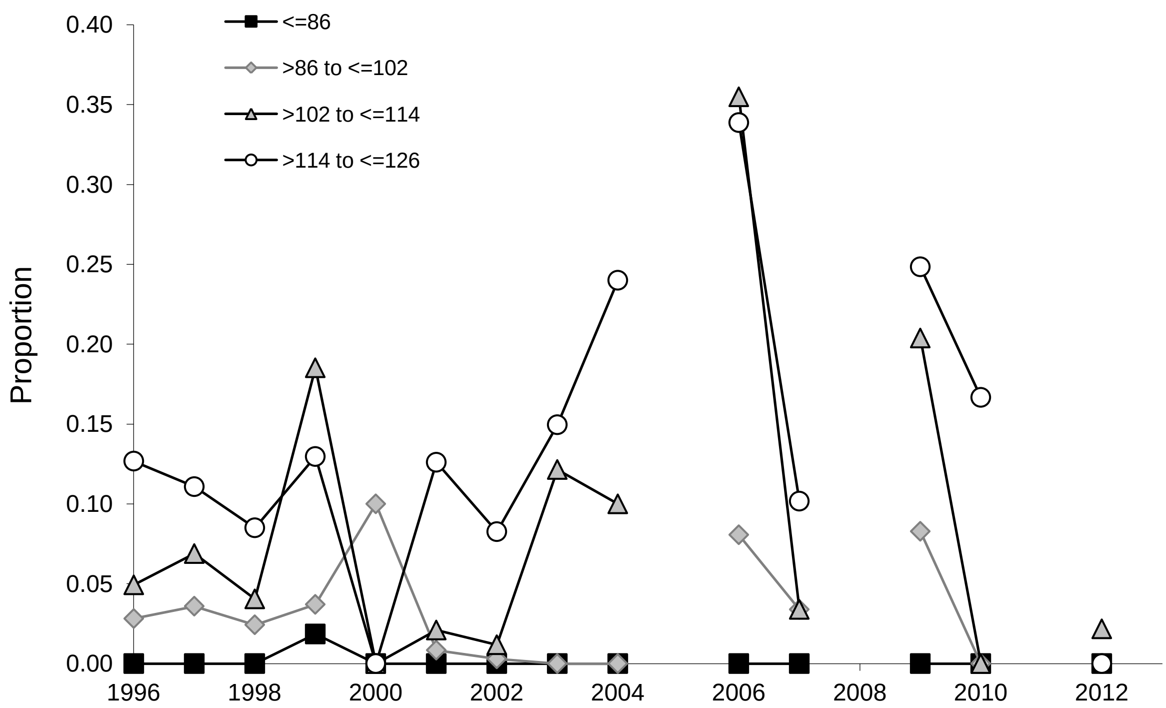

Fig. 25. Size composition (proportion of total catch) of juvenile SBT caught by Korean longliners in statistical areas 4–9, months 4–9, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.

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 2013, proportions of all age classes decreased, except for the age 5 size class, which increased substantially (Fig. 26). Observer coverage on vessels has been less than 10 per cent in some past years, and discarding of juveniles cannot be discounted.

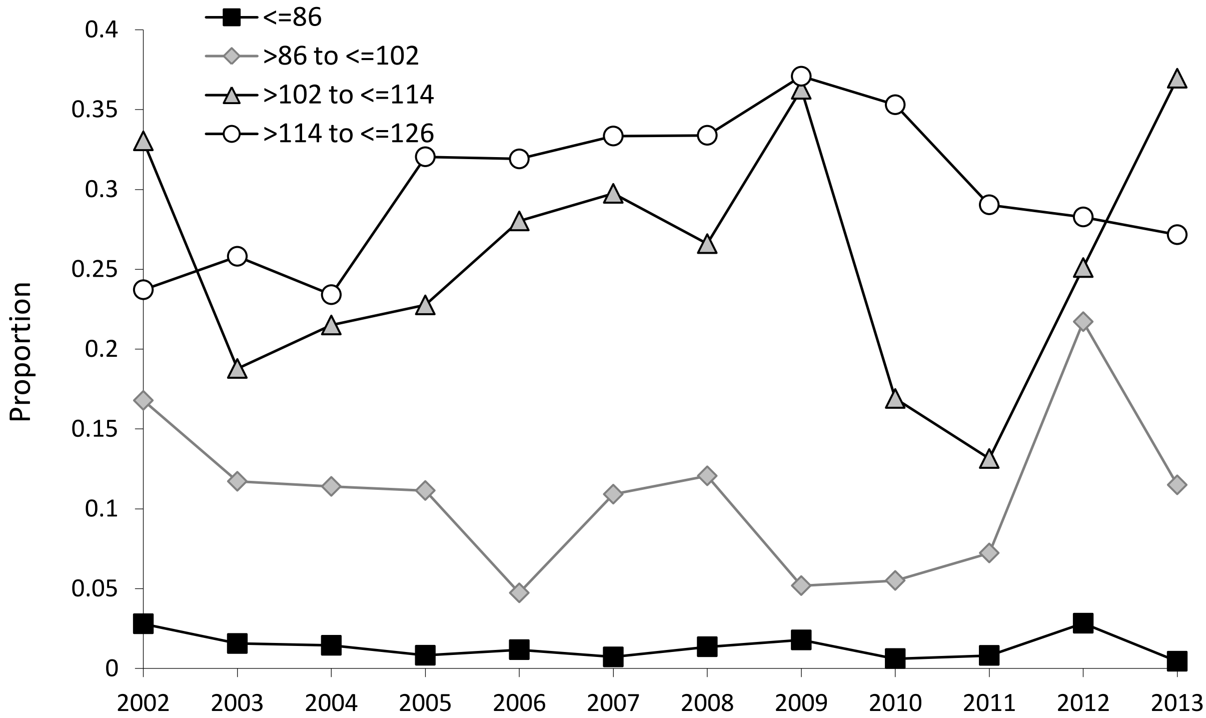

Fig. 26. Size composition (proportion of total catch) of juvenile SBT caught by Taiwanese longliners, where age 0–2≤86 cm, 86<age 3≤102 cm, 102<age 4≤114 cm, 114<age 5≤126 cm.

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_13). 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 2013, the age 2 and 3 age classes accounted for 97 per cent of the catch.

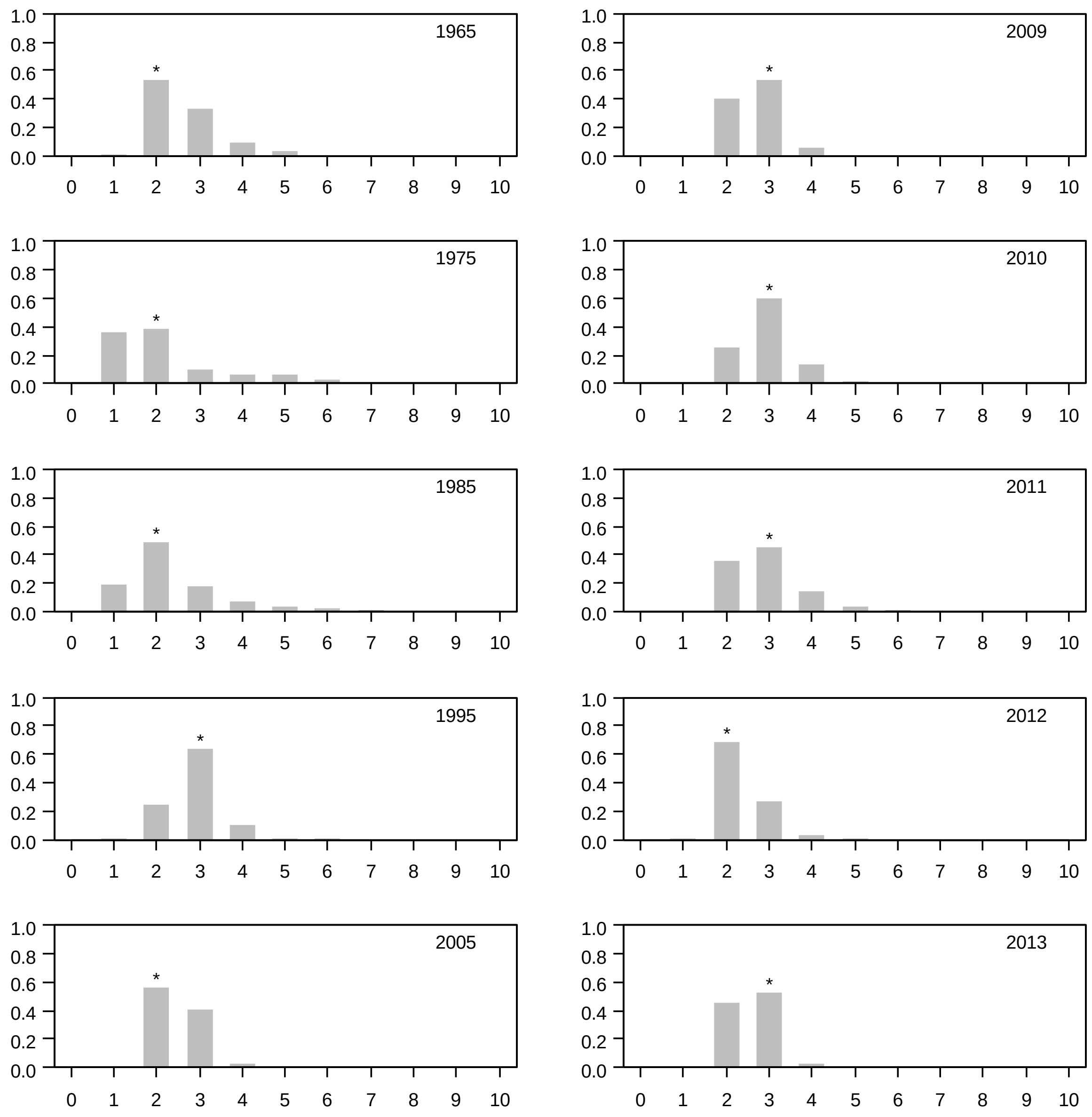

Fig. 27. Age composition in the Australian surface fishery. Median age classes are indicated with asterisks.

4 Summary

Recent trends in all indicators are summarised in Appendix 1 (with the exception of the Korean size composition which had small sample sizes in some years). Overall, there were mixed results in the indicators, with some increasing while others declined.

Potential causes for these declines 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 in 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

Two of the three indices of juvenile (age 1 to 4) abundance—the scientific aerial survey index and SAPUE index —exhibited increases over the past 12 months from values observed in the 2012–13 fishing season (austral summer). However, the trolling index declined. 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 the overall trends observed in age 1–4 SBT, indicators of age 4+ SBT were mixed. The CPUE in both the NZ domestic and charter fisheries decreased slightly in 2013, but remain relatively high. The catch rate in the NZ charter fishery for statistical area 6 decreased slightly in 2013, but remains well above the 10 year mean. There was little fishing in area 5 in 2013. Age 5 fish comprised a slightly larger portion of the NZ charter catch in 2013. There was a large increase in the proportion of small fish in the Indonesian fishery in 2012–13 and 2013–14 and median length class decreased for these 2 seasons relative to previous years. The mean age of SBT on the spawning ground decreased substantially from 16.0 years in 2011–12 to 13.2 years in 2012–13 as the proportion of SBT <10 years in the catch increased (2013–14 otoliths have not yet been aged). In addition, although potentially affected by the overcatch, the nominal CPUE for the Japanese longline fishery for 4+ SBT increased in 2013 and remains above the 10 year mean, but standardised series decreased.

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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.	2010	2011	2012	2013	2014	12 month trend
Scientific aerial survey	1993–2000 2005–14	0.34 (1999)	2.71 (2014)	0.91	1.61	0.52	1.15	2.71	↑
SAPUE index	2003–14	0.38 (2003)	1.80 (2011)	1.36	1.80	0.58	0.95	1.52	↑
Trolling index	1996–2003 2005–06 2006–14	2.82 (2006)	5.65 (2011)	2.92	5.65	1.55	3.48	3.18	↓
NZ charter nominal CPUE (Areas 5+6)	1989–2013	1.339 (1991)	7.83 (2010)	7.81	6.30	7.33	6.02		↓
NZ domestic nominal CPUE	1989–2013	0.000 (1989)	4.06 (2012)	1.90	2.28	4.06	3.99		↓
NZ charter age/size composition (proportion age 0–5 SBT)*	1989–2013	0.001 (2005)	0.414 (1993)	0.25	0.11	0.19	0.15		↓
NZ domestic age/size composition (proportion age 0–5 SBT)*	1980–2013	0.001 (1985)	0.404 (1995)	0.19	0.15	0.21	0.03		↓
Indonesian median size class	1993–94 to 2013–14	162 (2012–13; 2013–14)	188 (1993–94)	168	170	168	162	162	-
Indonesian age composition: mean age on spawning ground, all SBT	1994–95 to 2012–13	13.24 (2012–13)	21.2 (1994–95)	15.3	16.8	16.0	13.2		↓
Indonesian age composition: mean age on spawning ground 20+	1994–95 to 2012–13	21.8 (2010–11)	25.3 (2003–04)	23.1	21.8	22.4	22.4		-
Indonesian age composition: median age on spawning ground	1994–95 to 2012–13	13 (2001–03; 2012–13)	21 (1994–95; 1996–97; 1998–99)	15	17	16	13		↓

*derived from size data

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.	2010	2011	2012	2013	12 month trend
Reported global catch	1952–2013	829 t (1952)	81 750 t (1961)	9723 t	9444 t	10 258 t	11 331	↑
Japanese nominal CPUE, age 4+	1969–2013	1.390 (2006)	22.143 (1965)	2.911	2.844	3.014	3.396	↑
Japanese standardised CPUE (W0.5, W0.8, Base w0.5, Base w0.8)	1969–2013	2007 (0.235–0.361)	1969 (2.284– 2.621)	0.697–1.007	0.617–0.969	0.792–1.151	0.618–0.855	↓
Korean nominal CPUE	1991–2013	0.118 (2005)	21.523 (1991)	3.651	3.909	5.499	6.163	↑
Taiwanese nominal CPUE, Areas 8+9	1981–2013	<0.001 (1985)	0.956 (1995)	0.471	0.305	0.155	0.138	↓
Taiwanese nominal CPUE, Areas 2+14+15	1981–2013	<0.001 (1985)	3.466 (2007)	1.277	0.994	2.244	2.286	↑
Japanese age comp, age 0–2*	1969–2013	0.004 (1966)	0.191 (1998)	0.007	0.071	0.025	0.022	↓
Japanese age comp, age 3*	1969–2013	0.015 (2003)	0.284 (2007)	0.058	0.130	0.096	0.044	↓
Japanese age comp, age 4*	1969–2013	0.052 (1969)	0.286 (1992)	0.227	0.169	0.141	0.119	↓
Japanese age comp, age 5*	1969–2013	0.079 (1986)	0.300 (2010)	0.300	0.214	0.159	0.160	↑
Taiwanese age/size comp, age 0–2*	1981–2013	<0.001 (1982)	0.251 (2001)	0.006	0.008	0.028	0.005	↓
Taiwanese age/size comp, age 3*	1981–2013	0.024 (1996)	0.349 (2001)	0.055	0.072	0.217	0.115	↓
Taiwanese age/size comp, age 4*	1981–2013	0.027 (1996)	0.502 (1999)	0.169	0.131	0.251	0.370	↑
Taiwanese age/size comp, age 5*	1981–2013	0.075 (1997)	0.371 (2009)	0.353	0.290	0.283	0.272	↓
Australia surface fishery median age composition	1964–2013	age 1 (1979–80)	age 3 (multiple years)	age 3	age 3	age 2	age 3	↑

*derived from size data