FISHERY INDICATORS FOR THE SBT STOCK 2007/08

J Hartog
A Preece

Prepared for the CCSBT 5th Management Procedure Workshop 2-7 September and the 13th Meeting of the Extended Scientific Committee 8-12 September 2008
Rotorua, New Zealand

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Abstract

Fishery indicators have played an important role in the provision of advice to the Commission on the status of the SBT stock by the CCSBT Scientific Committee (SC) and its Trilateral predecessor extending back to at least 1988. Indicators can provide a broad perspective on recent changes in the status of the stock and allow for information that is not readily incorporated into a model-based assessment to be evaluated for consistency with respect to the results from model-based assessments. As such, fishery indicators provide an important addition and measure of robustness to the overall stock assessment process. In 2006, results from two independent reviews of data anomalies in the Japanese market and Australian Farming operations were made available. The reviews suggested that many of the indicators related to total catches, CPUE and size composition might not be reliable since the mid-1980s. We have presented the indicators in the same format as the equivalent 2007 paper, grouping the indicators by those that were considered by the SC to be unaffected and those that may be affected by the unreported catch identified in the reviews. We restrict the interpretation of indicators to the subset that are considered either unaffected, or the least likely to be affected by the uncertainties raised in the independent reviews.

Introduction

Fishery indicators have played an important role in the provision of advice to managers on the status of the SBT stock by the CCSBT Scientific Committee (SC) and its Trilateral predecessor extending back to at least 1988 (e.g. Anon 1988). Indicators have been used to provide a broad perspective on recent changes in the status of the stock, independent of more formal, analytical stock assessments. While the SBT analytical assessments attempt to integrate all available data into a single model framework, it can be difficult to evaluate the overall consistency and robustness of the results because (1) the highly aggregated nature of much of the input data ignores important trends that can be observed on fine temporal and spatial scales, and (2) model results are sensitive to the assumptions that are inevitably embedded in the model structure, related to population and fishery dynamics, and the statistical properties of observations and processes. Stock assessment models are generally poor at estimating the most recent abundance trends (particularly for the youngest ages). These estimates inherently have more uncertainty associated with them and are most reliant upon time series consistency assumptions (e.g. in stock/recruitment relationships, selectivities and catchabilities). Thus, fishery indicators provide an important additional input to the overall stock assessment and provision of management advice.

In 2006, results from two independent reviews of data anomalies in the Japanese market and Australian Farming operations were presented. The reviews were commissioned at the CCSBT 12 meeting in October 2005 to determine if unreported catches had been occurring relative to TAC, and the extent, period and source of the over-catch (Anon, 2006). The Japanese Market Review (JMR, Lou et al 2006) identified significant levels of unreported catch passing through the Japanese market. The Australian Farm Review (AFR, Fushimi et al 2006) panel could not agree, given the available data, on whether there had been an over-catch relative to the Australian TAC because of weight loss during tow and potential bias in the 40 fish sample (used to determine average weight of SBT caught). The AFR noted that there was no evidence for misreporting of numbers of SBT.

The outcomes of the two reviews introduce substantial uncertainty into the reliability of many data sources, and it follows that many of the fishery indicators that we traditionally report may not be reliable. The uncertainty about the longline CPUE-based indicators is particularly large. The patterns over time, and by area and even age, may not be reliable, but in the absence of information on where, when and by whom any unreported longline catches were taken, it is impossible to say whether, or to what extent, the indicators are affected. We have nonetheless updated these indicators with the data provided in the annual CCSBT data exchange. The age composition inferred from the Australian surface fishery data is also uncertain, however due to the apparent ability of the purse seine fleet to selectively target specific age classes this indicator was not considered to be very informative in the past.

There are some indicators which are not affected by the outcomes of the two reviews. These are: the scientific aerial survey, the commercial spotters index (SAPUE), the Japanese Acoustic index and Trolling index, the estimates of juvenile harvest rates from the recent tagging program (the analysis does not use catch or catch-derived size frequency information), NZ longline CPUE, Indonesian CPUE from the data collected by students from the Indonesian Fishery School, Indonesian spawning grounds size and age composition and total catches, NZ size composition of the catch and changes in SBT growth rates.

This paper updates the indicators from Hartog et al (2007) with the most recent data from the annual CCSBT exchange, and provides interpretation for indicators that are considered by the SC to be unaffected by the results of the Japanese market review and Australian Farm Review. This paper does not investigate or use any of the unreported catch scenarios suggested by the reviews. While we are limited by the set of indicators that are unaffected by the review results, we attempt to assess recent trends and cohort strength, to provide advice to the 2008 SC on stock status, and these are summarized qualitatively in Table 4. A more comprehensive list of indicators was discussed in Polacheck et al (2004), and the table of key results from that analysis are appended to this report.

Indicators unaffected by the unreported catch

Aerial spotting data in Great Australian Bight

Aerial Survey

Annual aerial surveys were conducted over the GAB between 1991 and 2000 based on line transect methodology using a consistent survey with broad spatial and temporal coverage (Cowling et al. 2002). The data from the surveys have been used to provide annual indices of surface density for juvenile SBT (Figure 1) and constitute a fishery-independent estimate of aggregated 2-4 year old relative abundance (Bravington 2002).

The survey was suspended in 2001 until 2005, at which time the juvenile estimate was similar to 2000. Eveson et al (2008) note that the relative abundance in the Great Australian Bight from the 2008 scientific aerial survey is higher than the 2005-2007 estimates, but also note that this estimate is not statistically significant as the 90% confidence interval on the 2008 estimate overlaps with he confidence intervals for the previous 3 years. The relative abundance in recent years is significantly below the average level in the mid 1990s.

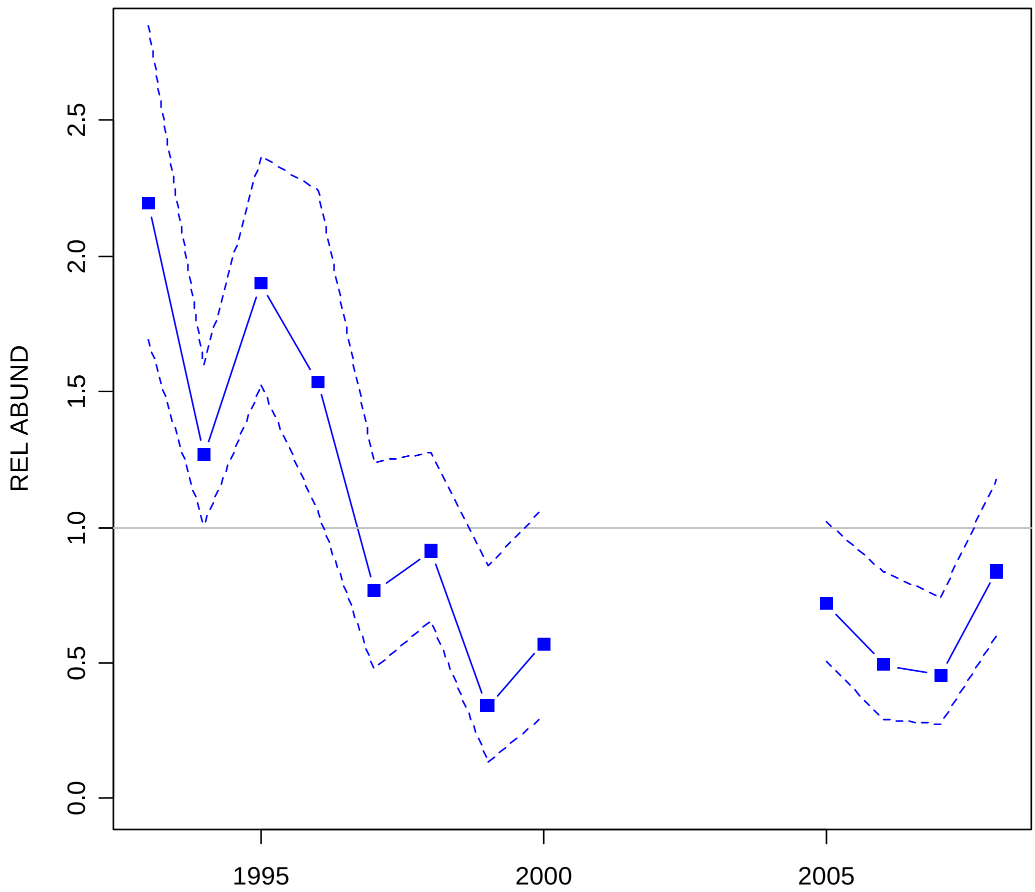

Figure 1: Time series of relative abundance estimates based on January, February and March, with 90% confidence intervals (from Eveson et al 2008).

Commercial Sightings (SAPUE Index)

Data on the sightings of SBT schools in the GAB were collected by experienced tuna spotters as part of commercial spotting operations over seven fishing seasons (2001-02 to 2007-08). The commercial spotting data were used to produce standardised fishery-dependent indices of SBT relative abundance (surface abundance per unit effort – SAPUE).

We note (primarily from Farley and Basson, 2008):

- The estimated index is lowest in 2003 and 2004. The 2008 estimate is the highest and those for 2006 and 2007 are both close to the average over the past 7 seasons (Figure 2).
- The index reflects the abundance of 2, 3 and 4 year olds combined. The two low years would therefore represent 1999-2001 year classes as 4, 3 and 2 year olds in 2003, and 2000-2002 year classes as 4, 3 and 2 year olds in 2004.
- In 2005, there also appeared to be many 1-year olds in the GAB. This was apparent through the relatively large number of below 10kg fish that were sampled for length from the farming operations. It is unclear and unknown whether the index in 2005 reflects a substantial proportion of age 1 fish or not, compared to other years, due to the selective nature of the PS fishery.

Farley and Basson (2008) again urge caution when directly comparing the last four years of the SAPUE with the four overlapping years of data in the scientific aerial survey. This is because the data are collected differently for each source and the commercial flights cover a much smaller spatial area than the line transect aerial survey. It is, however, encouraging that the overall pattern of the indices in these years is similar.

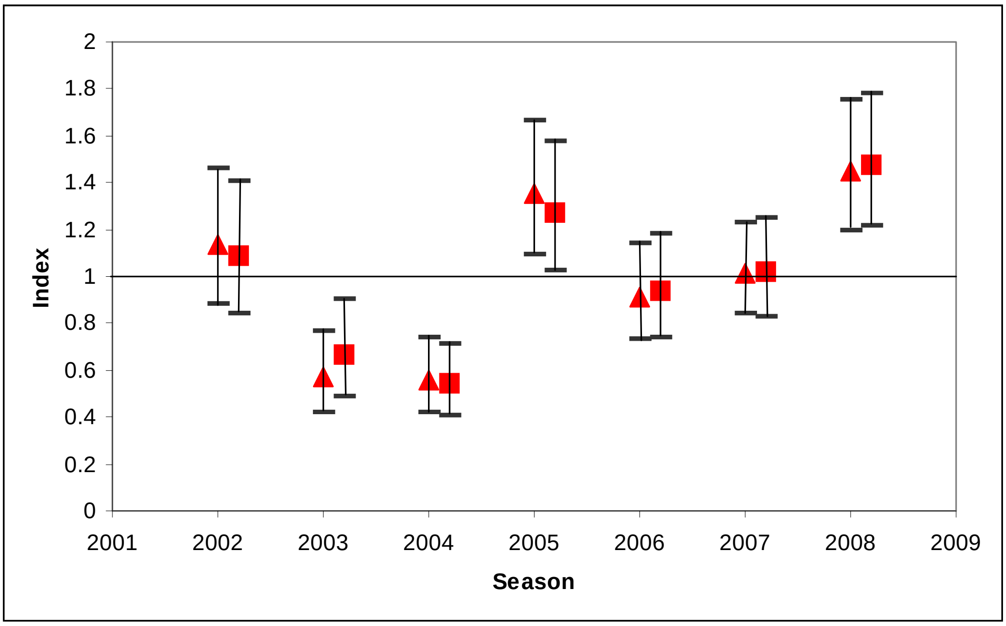

Figure 2: Estimates of standardised relative surface abundance, scaled to the mean over the period, for models with companies 1,2, 5 and 6 for (i) swell included as a covariate (triangles) and (ii) swell excluded as a covariate (squares). All months were included (December – March). The median and exp(predicted value + or – 2 standard errors) are shown. Values are scaled to the mean over the period. The horizontal line at 1 indicates the mean. 'Season' is indicated by the second year in a split year so that, e.g. 2002 implies the 2001/2002 season.

Tagging data and estimates of fishing mortality

Conventional tagging

Eveson and Polacheck (2008) provide an update of the analysis of the conventional tag-return data since 2007 (Polacheck and Eveson, 2007). A tag attrition model was used to estimate cohort and age-specific fishing mortality rates for different groups of tag releases conditional on estimates of natural mortality, tag shedding and reporting rates (the latter three derived from separate analyses). The estimated fishing mortality rates are independent of the catch and catch-at-age data, because the tag-attrition model does not use commercial catch as an input.

The results continue to show high estimates of fishing mortality rates at ages 3 and above in years 2004 to 2006 for fish tagged at age 2 and older, many over 0.5 (Table 1). The most recent results, i.e., the estimates for 2007, suggest a lower fishing mortality rate for age 3 fish (0.26), but a high mortality rate for age 4 fish (~2). Overall the results suggest high fishing mortality rates for fish in the GAB, but it is not clear to what extent this represents the overall juvenile population.

Table 1: Estimates of age-specific fishing mortality rates (F) for different cohorts derived from tags released in the waters around southern Australia. Results are presented separately for tags released at different ages. Lower and upper 5% refer to the lower and upper 5th percentiles from the bootstrap estimates (i.e. the 90% confidence interval). Results were derived using assumptions outlined in Table 8 of Eveson and Polacheck 2008. (F estimates > 0.4 are highlighted)

Cohort	Age at release	Number of releases	Age	Year	F	Lower 5%	Upper 5%
1999	2	750	2	2001	0.000	0.000	0.000
			3	2002	0.036	0.020	0.057
			4	2003	0.259	0.199	0.328
			5	2004	0.099	0.050	0.159
			6	2005	0.063	0.000	0.135
			7	2006	0.041	0.000	0.097
			8	2007	0.021	0.000	0.064
2000	1	1921	1	2001	0.000	0.000	0.000
			2	2002	0.006	0.001	0.010
			3	2003	0.174	0.141	0.208
			4	2004	0.072	0.047	0.101
			5	2005	0.021	0.005	0.040
			6	2006	0.012	0.000	0.036
			7	2007	0.000	0.000	0.000
2000	2	492	2	2002	0.004	0.000	0.011
			3	2003	0.272	0.207	0.348
			4	2004	0.477	0.334	0.654
			5	2005	0.453	0.227	0.826
			6	2006	0.038	0.000	0.133
			7	2007	0.175	0.000	0.582
2000	3	3276	3	2003	0.154	0.139	0.170
			4	2004	0.282	0.251	0.313
			5	2005	0.156	0.124	0.190
			6	2006	0.079	0.049	0.112

			7	2007	0.017	0.004	0.033
2001	1	2748	1	2002	0.000	0.000	0.000
			2	2003	0.008	0.004	0.012
			3	2004	0.215	0.181	0.252
			4	2005	0.057	0.036	0.078
			5	2006	0.031	0.012	0.054
			6	2007	0.015	0.004	0.033
2001	2	5869	2	2003	0.009	0.007	0.012
			3	2004	0.746	0.698	0.797
			4	2005	0.685	0.597	0.806
			5	2006	0.550	0.410	0.754
			6	2007	0.051	0.018	0.096
2001	3	1146	3	2004	0.583	0.512	0.662
			4	2005	0.789	0.632	1.009
			5	2006	1.491	0.822	3.063
			6	2007	0.591	-1.026	1.743
2002	1	3316	1	2003	0.001	0.000	0.002
			2	2004	0.023	0.016	0.030
			3	2005	0.115	0.092	0.139
			4	2006	0.075	0.050	0.103
			5	2007	0.015	0.004	0.029
2002	2	6256	2	2004	0.029	0.024	0.034
			3	2005	0.518	0.479	0.559
			4	2006	0.836	0.728	0.964
			5	2007	0.631	0.481	0.845
2002	3	720	3	2005	0.205	0.157	0.256
			4	2006	1.140	0.833	1.561
			5	2007	0.765	0.409	1.852
2003	1	2662	1	2004	0.000	0.000	0.000
			2	2005	0.044	0.031	0.057
			3	2006	0.502	0.425	0.587
			4	2007	0.363	0.281	0.467
2003	2	8692	2	2005	0.028	0.024	0.033
			3	2006	1.046	0.966	1.131
			4	2007	2.124	1.582	3.306
2003	3	3127	3	2006	0.285	0.252	0.321
			4	2007	0.491	0.433	0.557
2004	1	7084	1	2005	0.000	0.000	0.001
			2	2006	0.018	0.013	0.024
			3	2007	0.091	0.077	0.106
2004	2	7591	2	2006	0.025	0.020	0.030
			3	2007	0.262	0.242	0.282
2004	3	479	3	2007	0.168	0.123	0.224

Archival Tagging

Archival tagging commenced in 1993 and provides a potential alternative source of data from which exploitation rates can be estimated. Archival tags are highly valued by Australian fishermen and non-reporting is thought to be low within the Australian surface and longline fisheries. However, similar to conventional tags, reporting rates for archival tags in the high seas fisheries appear to be low. Table 2 summarizes the releases and return rates to date for RMP and SRP tagging combined (Bob Kennedy, pers. comm.). Overall, the majority of releases were 3 year olds, the main exception being the tagging of some smaller fish off WA in 2003 and 2004. We consider these results to be unaffected by the market review in so far as they are lower bounds to the true recovery numbers.

Table 3 summarizes the releases and return rates for SBT tagged under the global spatial dynamics project, where the age of release is primarily 3–4 year olds (Polacheck et al 2008). There has been a high rate (25%) of recapture from archival tags released as part of the global spatial dynamics project in 2004. This rate of recapture is comparable to some of the early years in the RMP archival tagging (Table 2). The 2005 and 2006 data show a rate of return of 15% and 11%, much lower than the 2004 rate of 25%, and this suggests reporting rates may have declined and may be low in some longline fisheries (see Polacheck et al 2008).

Table 2: Number of releases and recaptures of RMP and SRP archival tagged SBT.

Year	Total Releases	Total Recaptures	Same Season Recaptures	Percent Recaptured	Percent Recaptured excluding same season recaptures
1993	29	4	0	13.8%	13.8%
1994	157	22	2	14.0%	12.7%
1995	143	48	3	33.6%	31.5%
1998	112	33	9	29.5%	21.4%
1999	61	13	1	21.3%	19.7%
2000	27	9	0	33.3%	33.3%
2001	50	8	0	16.0%	16.0%
2002	64	7	0	10.9%	10.9%
2003	119	5	1	4.2%	3.4%
2004	137	26	2	19.0%	17.5%
2005	227	23	4	10.1%	8.4%
2006	189	9	2	4.8%	3.7%
2007	227	1	1	0.4%	0.0%

Table 3: Numbers of archival-tagged SBT releases in the Global Spatial Dynamics Project by area and year, together with recapture numbers, as of July 10, 2008.

Year		Indian Ocean	Western Australia	South Australia	New Zealand	Total
2004	Number released	37	22	23	6	88
	Number Recaptured	6	6	9	1	22
2005	Number released	48	15	40		103
	Number Recaptured	5	3	7		15
2006	Number released	25	39	35	30	129
	Number Recaptured	1	2	9	2	14
2007	Number released	57	50	24	19	150
	Number Recaptured			1		1
2008	Number released	19	49		20	88
	Number Recaptured					0
Total deployed		186	175	122	75	558
Total recaptured		12	11	26	3	52

Acoustic estimates of age 1 SBT off Western Australia

From 1996 through 2006, the Japanese National Research Institute for Far Seas Fisheries (NRIFSF) and collaborating agencies in Japan conducted an acoustic survey of 1 and 2 year old SBT in the Albany area off the southern coast of Western Australia. The survey employed standard line transect survey methods, and a standardized acoustic methodology. Age 1 fish were estimated to have been the dominant age class detected and a standardized index was estimated for this age class (Itoh and Nishidia 2003, Itoh 2006). Research by Hobday et al (2008) using acoustic tags on small fish to identify migration behaviours, has identified inter-annual differences in factors that impact on the calculation and interpretation of the acoustic survey data as an index of abundance. The SC (Anon, 2007) noted concerns about the representativeness of the acoustic survey.

Between 1997 and 2000, the survey index for age 1 has declined rapidly and since then remained close to zero (and in fact was zero in 2003) (Figure 3). The survey did not operate in 2004 and ceased in 2007. While substantial uncertainty exists about the adequacy of the survey to provide a quantitative direct measure of abundance, the near total absence of SBT in the survey area for 6 consecutive surveys, following 4 years of consistent detections, is of concern.

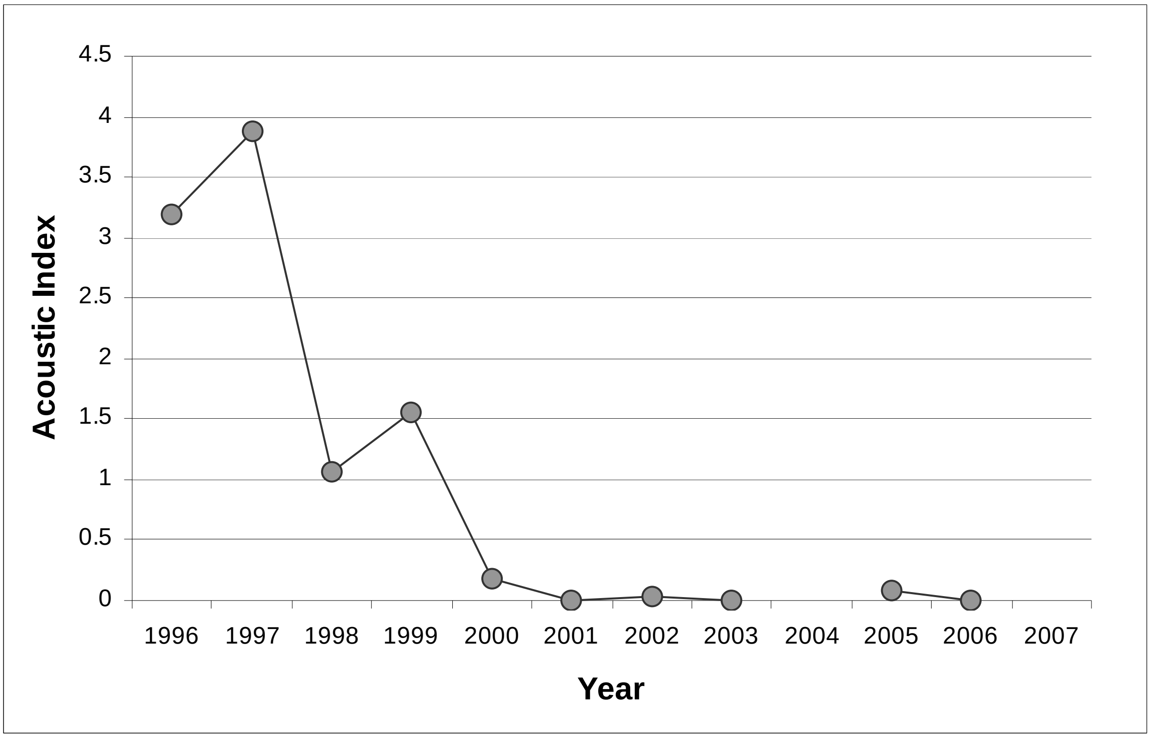

Figure 3: Relative biomass index for one year old SBT off Western Australia from acoustic surveys (Itoh and Nishidia 2003, Itoh 2006). The index has been standardized to the mean value over all years.

Trolling index

In 2006 Japan commenced a piston-line trolling survey to provide a cost effective recruitment index of abundance of age 1 SBT (Itoh, 2007). The factors identified by Hobday et al (2008) for interpretation of an abundance index of age 1 SBT also apply to the trolling index. The trolling indices shown in Figure 5, use data from three different series. These are: 1) The piston-line trolling survey conducted in 2006 and 2007, 2) trolling catch data from the acoustic survey "on" the piston-line in 2005 and 2006, and 3) trolling catch data from the acoustic survey "off" piston line in 1996-2003 and 2005-2006. Methods used to have comparable data from these 3 sources are documented in Itoh (2007). The ability of the index to measure abundance of SBT aged 1 is still unknown (Itoh, 2007). The SC (Anon, 2007) noted that refinements to the piston line trolling survey design should address issues regarding independence of observations and the limited spatial temporal window of the current survey. The index shows an increasing trend from low levels in 2000 – 2002.

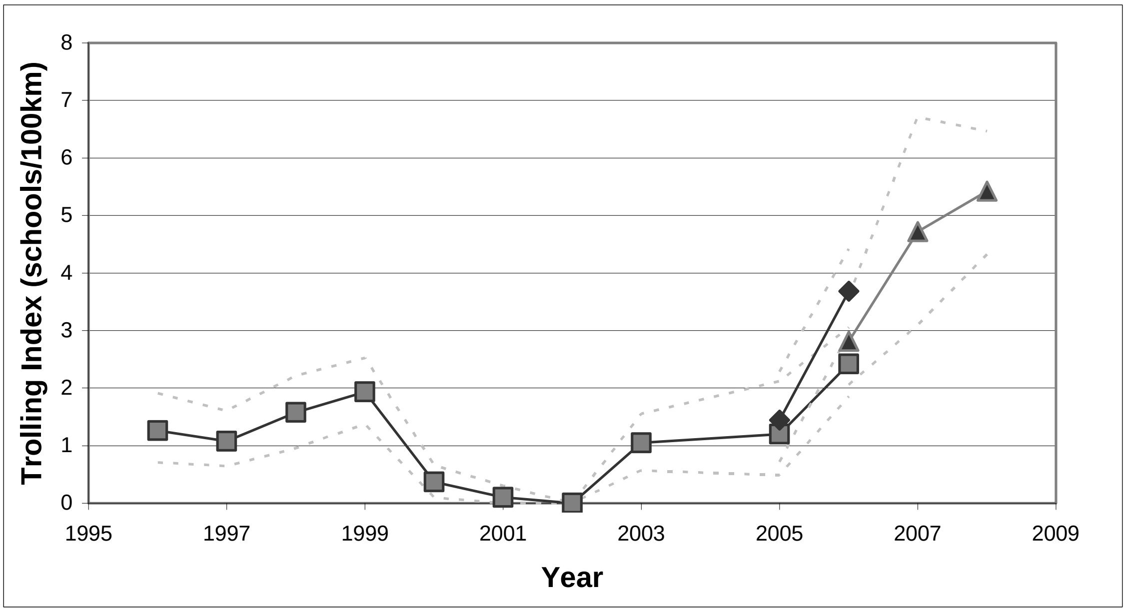

Figure 4: Trolling index showing the number of schools per 100km. The index is obtained from 3 sources. The squares represent the index obtained from the acoustic survey results that were "off the piston line". The diamonds represent the index obtained from the acoustic survey results that were "on the piston line". The triangles represent the index obtained from the trolling surveys that were "on the piston line". 90% confidence intervals are marked by the dotted lines.

CPUE

NZ JointVenture (Charter) CPUE

The NZ JV fishing operations have had 100% observer coverage and therefore should be unaffected by the unreported catches identified in the Japanese market reviews. The New Zealand fleets fish a relatively small portion of the SBT stock, such that the interpretation of catch rates might be particularly sensitive to inter-annual variability in SBT spatial distribution. The following discussion relates only to the longline fleets, as the handline/troll fishery virtually disappeared in the 1990s.

Figure 5 illustrates the catch rates for chartered Japanese longline vessels fishing in New Zealand waters from 1989 to 2007 (there was no charter fishery in 1996), partitioned into effort allocated to Statistical Areas 5 (north of 40S) and 6 (south of 40S). Catch rates in both the northern and southern fishery have both decreased in 2007. The catch rates for the southern fishery in 2006 and 2007 are an improvement over the very low catch rates between 2003 and 2005, but are still low when compared with the decade prior to this.

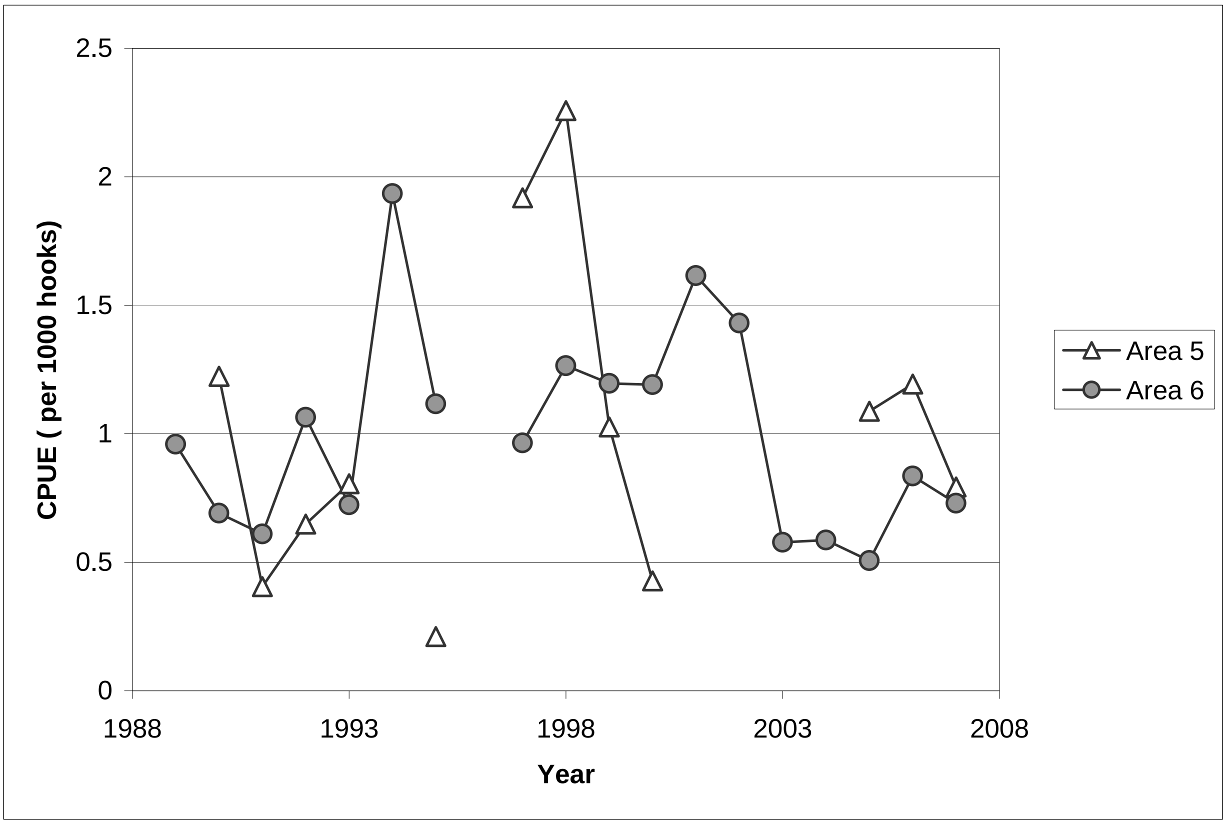

Figure 5: Nominal catch rates (numbers per 1000 hooks) for chartered Japanese longline vessels fishing in New Zealand waters (40 degrees south is the division between Area 5 and Area 6, or "South" and "North" indices). Both series have been normalized by dividing by the mean.

NZ domestic longline fishery CPUE

The New Zealand domestic catches are landed fresh, and exported as fresh fish to Japan, so we assume that these catches are unaffected by the results from the Japanese Market Review.

The New Zealand domestic longline fleet shows the 2007 catch rate has more tan doubled since 2006. There has been a general increasing trend in catch rates since 2003, which followed declining catch rates from 1999-2003. The 2006 catch rate is down on 2005, which is different from the results seen in the New Zealand charter catch rates (Figure 5), where rates improved in 2006. The 2007 catch rate is similar to the 1998-2001 catch rates, 1995 being the only rate that is higher. This also is the reverse of what is seen in the New Zealand charter catch rates (Figure 5), where rates decreased in 2007. The 2003-2006 CPUE for the domestic fleet is low relative to the 1994-2002 period (with the exception of the 1997 very low catch rate).

Figure 6: Nominal catch rates of SBT (numbers per 1000 hooks) caught by domestic New Zealand longline vessels.

Indonesian CPUE (data from Students from Indonesian Fishery School)

In 2005, data summaries and very preliminary results from investigations of the Indonesian Fishery High School (FHS) data were presented in a working paper to the CCSBT (Basson et al, 2005). These results were also reported in the Indicator papers in the previous years (Kolody et al, 2005 and Hartog et al, 2006). Further investigations of the data have raised some concerns about the quality of the data collected by the fishery high school (FHS) students, particularly with respect to some of the fishing location information and some of the species identifications. It was made very clear from the beginning that these data should be treated 'with caution' in any scientific analyses as the FHS program was not originally designed to provide robust observer data. However, we still consider a thorough analysis of the FHS data to be worthwhile as it is likely there will be some useful CPUE information that can be extracted from the dataset once the concerns about data reliability have been addressed. There is therefore no updated CPUE index for this data set this year, but we note that this work is being pursued through a PhD program, and an update on this work can be found in Sadiyah et al 2008 (CCSBT-ESC/0809/Info01).

Catch at Size/Age Composition

<u>*New Zealand Longline Fishery Catch Size Composition*</u>

The size composition of the New Zealand catch is based on the data provided to the CCSBT data exchange and shows that small fish, up to and including age 5, had almost completely disappeared from the New Zealand domestic and charter fisheries in 2004 and 2005 (Figure 7 and Figure 8), and had been in decline since 2001. The 2006 and 2007 data for the charter fishery shows a reversal of this trend (Figure 7), however the contribution of these young fish to the total catch is still very small. Given the 100% observer coverage in the charter fishery, low catches of juveniles would not seem to be attributable to discarding. The 2006 catch of small fish in the domestic fishery is high, but drops to almost zero again in 2007. Observer coverage in the domestic fishery is low.

The data for the early years of the domestic fishery is 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. However, the age 4 and 5 fish have historically made a substantial and fairly consistent contribution to the SBT catch. Figure 8 provides estimates of the proportion of the SBT catch for younger ages caught by domestic vessels from New Zealand. Note that the data for the earlier years is sparse. Nevertheless, small fish appear to have become relatively common in the catches by domestic vessels in around 1990. The proportion of small fish remained relatively constant though 2002 with perhaps some decrease. The 2006 data suggests an improvement in the availability of small fish to the New Zealand longline fleets, but overall recent years show a lack of small fish availability, with very low proportions of small fish in 2004, 2005 and 2007.

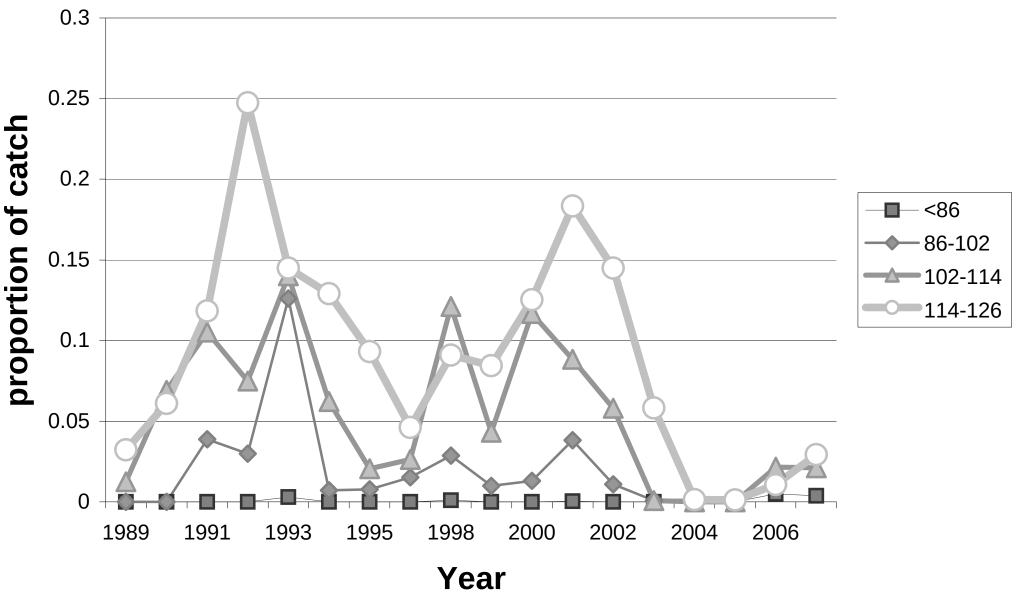

Figure 7: Estimated size composition for chartered Japanese longline vessel fishing in New Zealand waters. The estimates provide here are based on those used in the SBT stock assessment and were derived from the conversion of weight frequencies to length frequencies. For discussion, we assume that fish of size <86cm correspond to age-classes 0-2, 86-102 cm = age 3; 102-114 cm = age 4 and 114-126 cm = age 5.

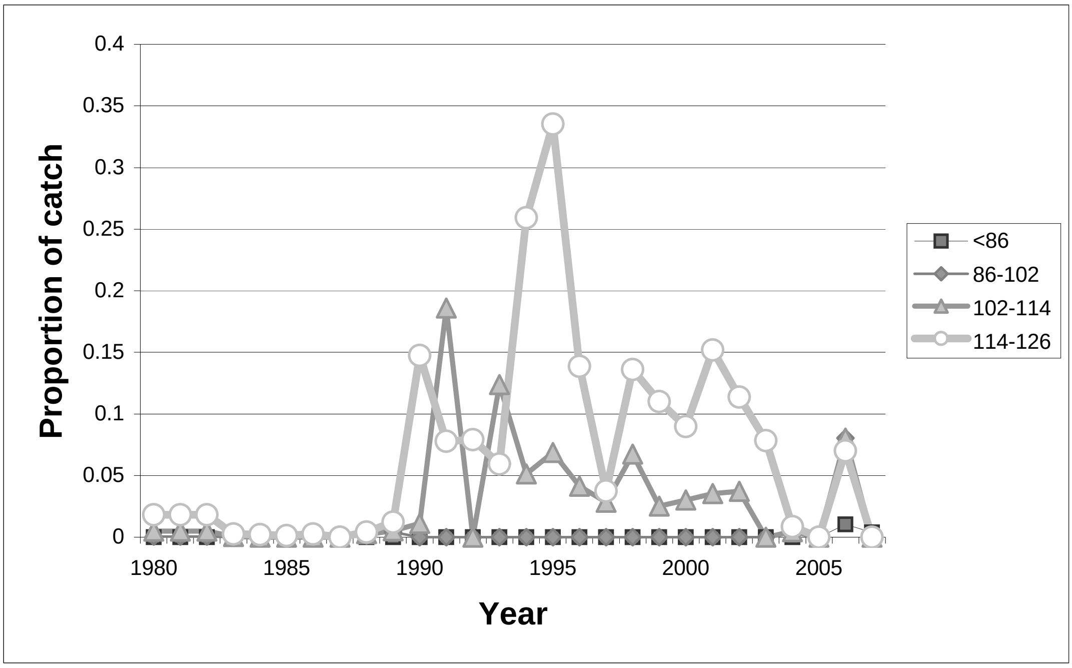

Figure 8: New Zealand domestic SBT catch estimated size/age composition. For discussion, we assume that fish of size <86cm correspond to age-classes 0-2, 86-102 cm = age 3; 102-114 cm = age 4 and 114-126 cm = age 5.

Indonesian Spawning Grounds Age/Size Composition

The SBT catch composition from the Indonesian longline fishery on the spawning ground has been estimated for a number of years now, with 15 spawning seasons of length frequency and 12 seasons of catch-at-age data. This data is considered to be an important source of information about the spawning population, predicated on the assumption that fishery selectivity is reasonably constant over time.

Data from one processing plant were from Indonesian fishing vessels believed to be fishing south of the SBT spawning ground. These data were excluded from the analysis of the length and age composition of the spawning population for the 2004/5, 2005/6, 2006/7 seasons, and are provided separately for comparison. (See Farley et al, 2008 for more detail).

We note (primarily from Farley et al, 2008):

- The mean of the size distribution declined from 188.1 to 166.8 cm between 1993/94 and 2002/03, and has remained between 168 and 170 cm for the past 5 seasons.
- In 2007/08, the relative abundance of SBT <165 cm declined slightly compared to the previous season, but has remained at between 27-34% of the catch for the past five seasons. The relative abundance of SBT >190 cm has declined since the mid-1990s, but has remained at between 1.4-3.1% of the catch for the past 5 seasons.
- Age estimates for the 2006/07 season ranged from 7 to 40 years, although an age bias plot indicates a slight upward bias in the age estimates (~1 year) by the primary otolith reader. This bias is being examined and the results presented here for the 2006/07 season should be considered preliminary.
- The median of the age distribution shifted from 19-21 years in the mid- and late-1990s down to 13-14 years in 2001/02 to 2005/06. In the 2006/07 season, the median age increased slightly to 16 years, but this may be due in part to the suspected bias in age estimates for this season.
- Similarly, the proportion of young fish (≤ 10 years) and the mean age of SBT increased in the 2006/07 season. The average age of SBT greater than 20 years has remained relatively stable over time, but has shown a slight decline over the past 3 seasons.
- The sex ratio of SBT in the Indonesian catch continues to be skewed towards females. However, this dominance of females has gradually declined over the past 8 seasons from 72% in 1999/00 to 55.6% in 2007/08.

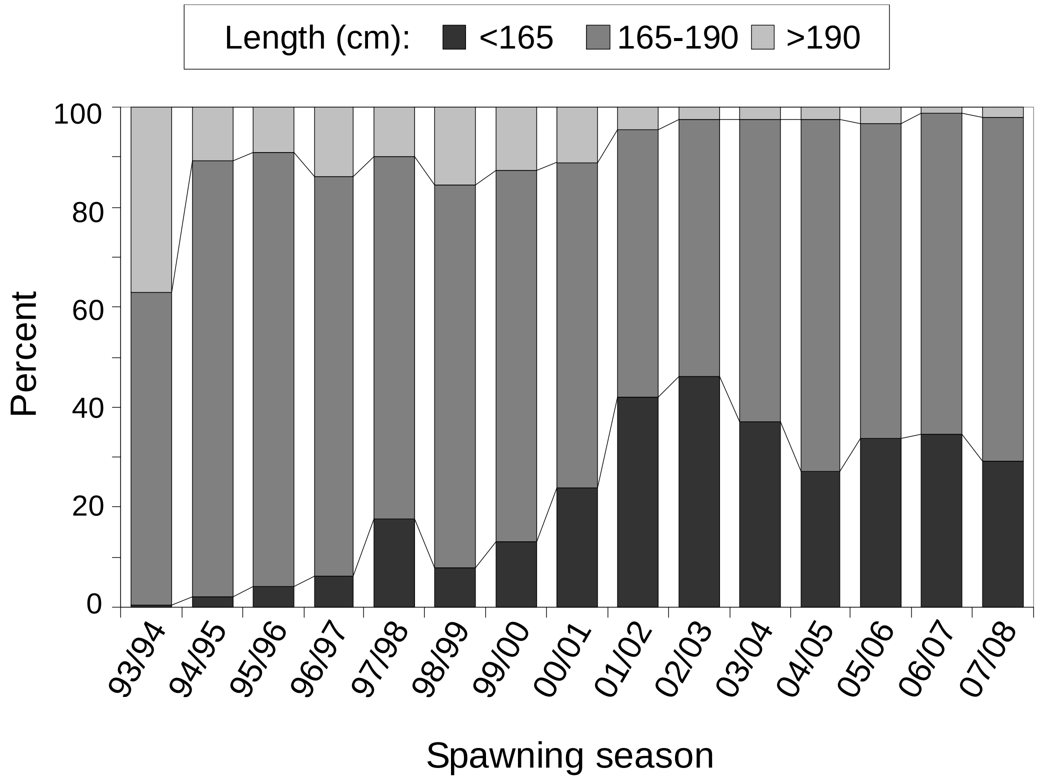

Figure 9: Proportion of SBT caught on the spawning ground by length class and season. Length data from fish caught south of the spawning grounds (Processor A) are excluded in the last 3 seasons.

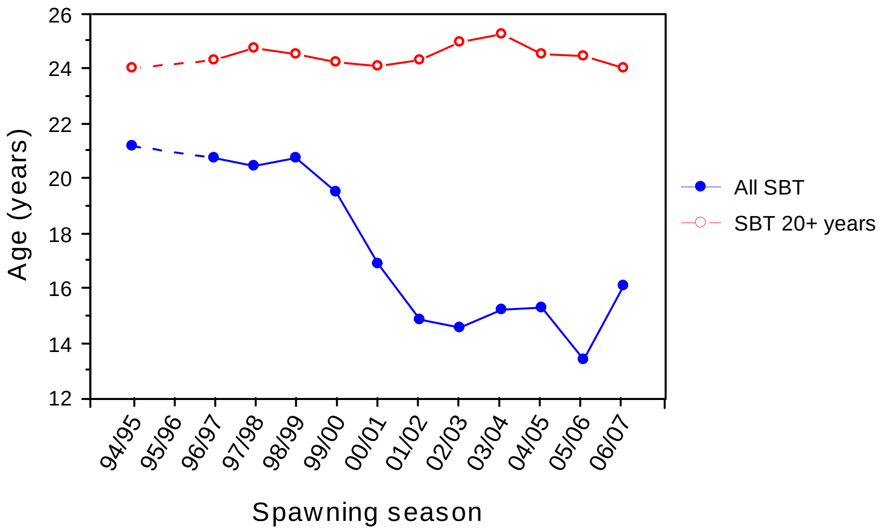

Figure 10: Estimated mean age of the catch of SBT by Indonesian longline on the spawning ground by spawning season. SBT caught south of the spawning ground are excluded.

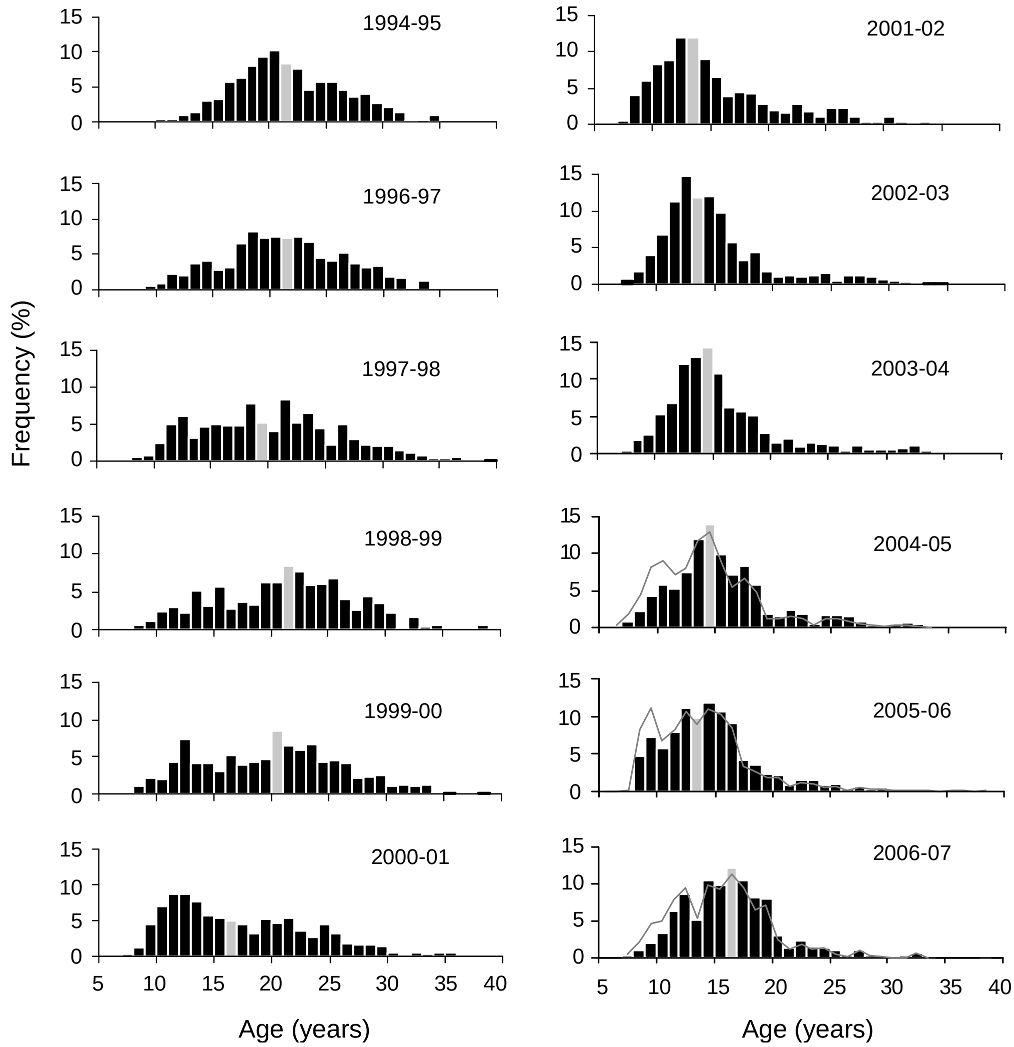

Figure 11: Age frequency distribution of SBT in the Indonesian catch on the spawning ground by spawning season. The grey bar shows the median age class. For comparison, the age distribution of SBT caught south of the spawning ground (Processor A) is shown for the latter three seasons (grey line).

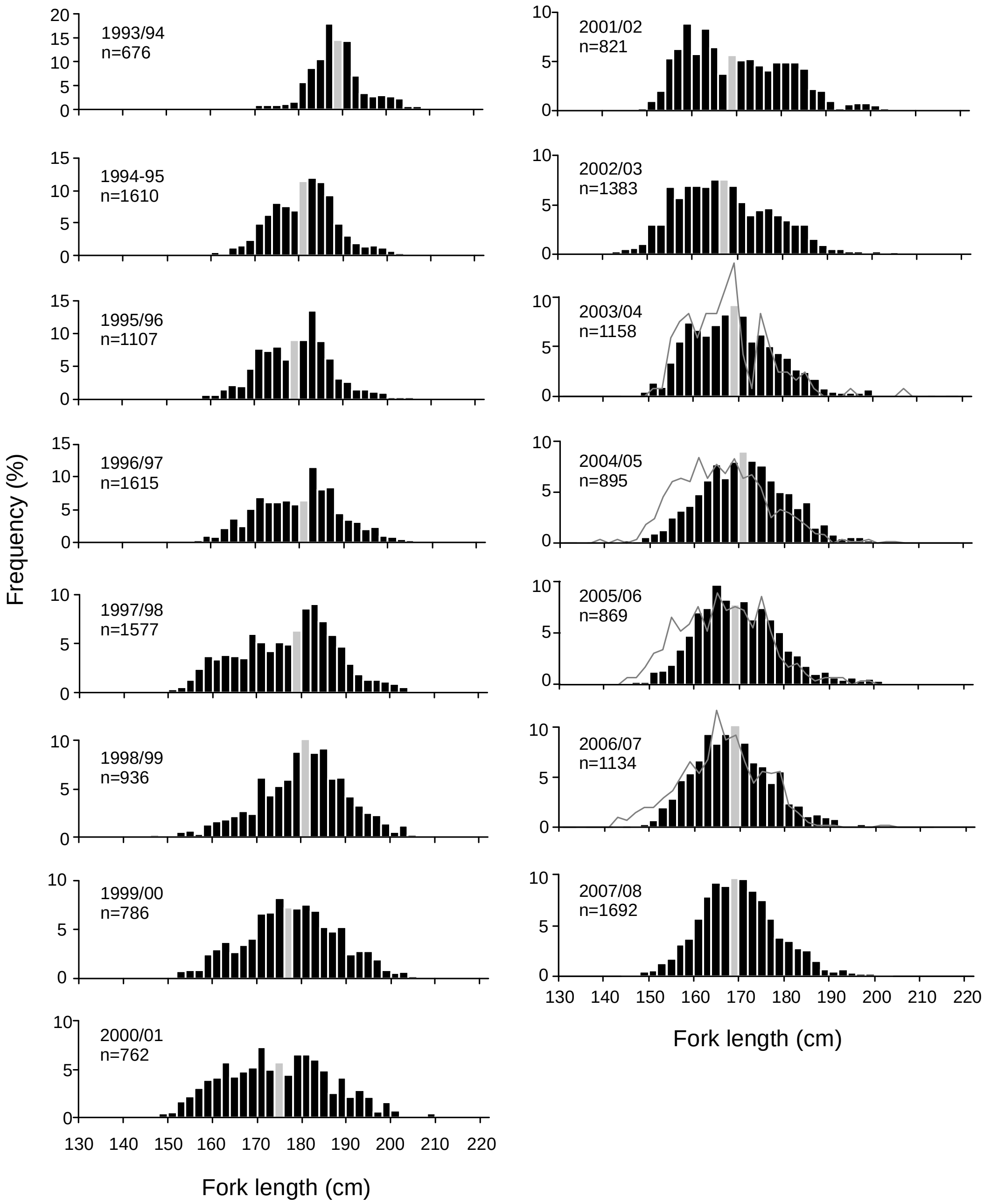

Figure 12. Length frequency (2 cm intervals) of SBT caught on the spawning ground (bars) by spawning season. The grey bar shows the median size class. For comparison, the length distribution of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2003/04 (n=121), 2004/05 (n=685), 2005/06 (n=311) and 2006/07 (n=411) seasons (grey line). Note that although some fish <130 cm have been measured in the last two seasons, they do not appear on these graphs as the numbers are too low to be visible (n=9).

Indonesian Spawning Grounds Total Catch

Total catches by year, estimated from the RIMF/CSIRO Benoa sampling programme (Iskandar Prisantoso et al, 2008) indicate that total Indonesian SBT longline catches increased from 1993-1999 and have generally declined from 1999-2007 (Figure 13). It is unclear how total catches relate to stock status given the non-target nature of the SBT fishery, the difficulty in effort standardization, and the significant changes in fleet behaviour over recent years (see Iskandar Prisantoso et al, 2008). Data from this fishery has in the past been loosely interpreted as a relative abundance index, under the assumption that effective SBT fishing effort is proportional to yellowfin tuna catch (the main target species) and the assumption that yellowfin tuna abundance has remained constant over time.

However, we note that yellowfin tuna abundance is estimated to have declined substantially in the western Pacific Ocean over the last 10 years. If this is also true for the Eastern Indian Ocean, then this pseudo-SBT-abundance index would have an optimistic bias. This is particularly evident in 2005, in which the SBT proportion is roughly double the 1994-2004 period (Figure 14). This change in proportion may be attributed in part to recent fishing activity in more southern areas, primarily by a single fishing company targeting SBT (Proctor et al, 2006).

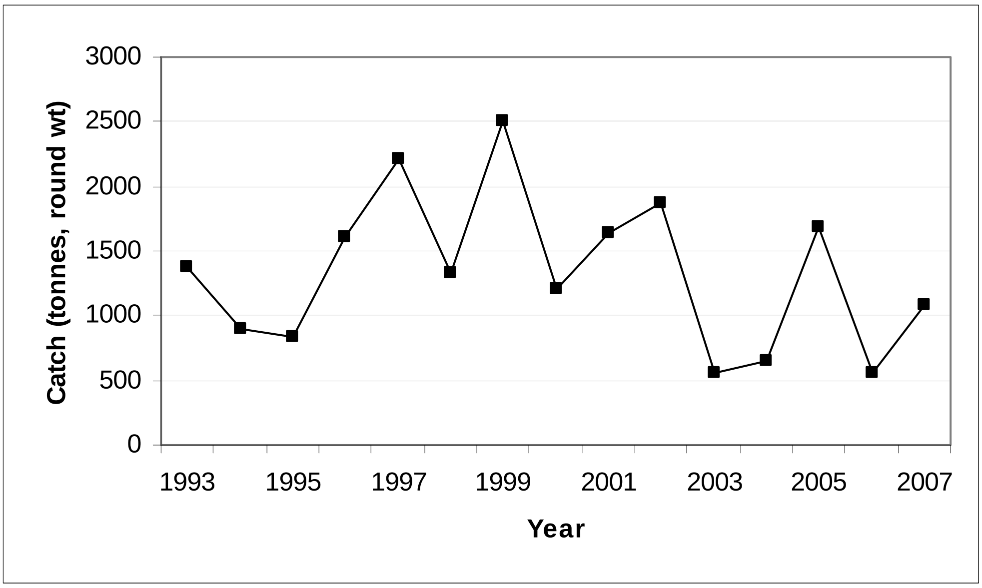

Figure 13: Estimated landings of tunas (tonnes round weight) at Benoa by year (Iskandar Prisantoso et al, 2008).

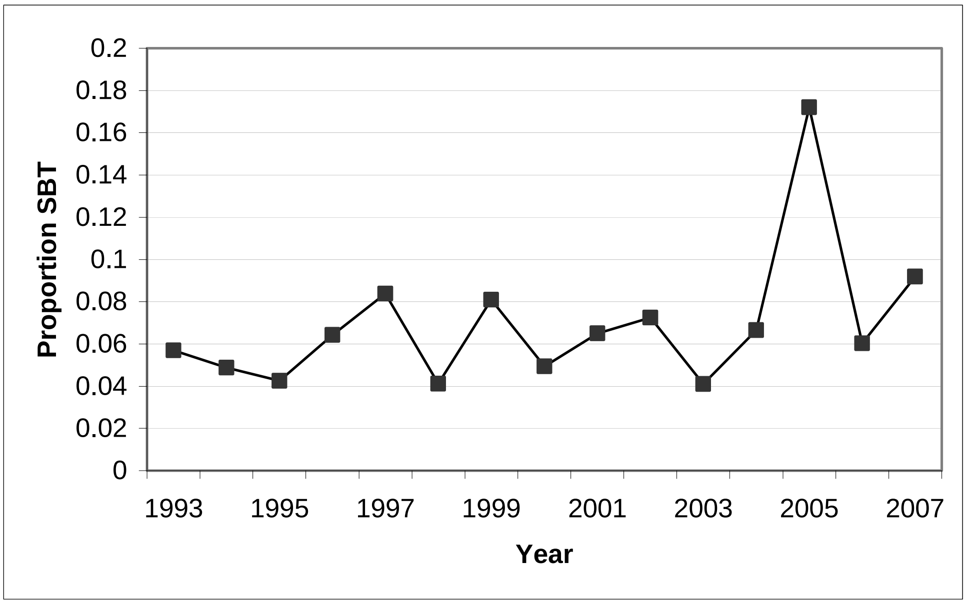

Figure 14. Estimated percent of the tuna (yellowfin, bigeye and SBT) catch that was SBT landed at Benoa by year (Iskandar Prisantoso et al, 2008).

Growth rates

The most recent comprehensive analysis of growth for southern bluefin tuna (SBT) was conducted in 2001-2002, integrating growth information from three data sources to provide comprehensive estimates of mean length-at-age (as well as variance in length-at-age) for each of the past four decades (1960s, 1970s, 1980s and 1990s) (e.g. Polacheck et al 2004).

Since then, additional data pertaining to growth of juvenile SBT during the late 1990s and early 2000s has been collected. Using direct ageing and tag-recapture data available up to the end of April 2006, Eveson et al (2006) conducted an updated analysis of juvenile growth. These results conclude that juvenile growth has not declined, and in fact appears to have increased, between the early 1990s and early 2000s. However the data available at that point were not sufficient to resolve any temporal trends within the 2000s.

There are alternative ecological mechanisms that could explain the increasing growth rates. One pessimistic interpretation would be the decreased intra-specific competition for resources (food) because of a decrease in the size of the population. In SBT we have seen increasing growth rates during the historical period when total biomass is known to have decreased markedly. The continued increase in growth rates could indicate a further decline in the (relevant portion of the) population over the last decade. Alternatively, increased growth rates could relate to increased productivity or a decrease in inter-specific competition. We have no additional data with which to further evaluate these hypotheses.

Indicators that may be affected by the unreported catch

The Japanese Market Review provides information on estimated sizes of unreported catch over time, and possible sources of the unreported catch. However at this stage, there is no information on when, where or by whom the unreported catch was taken. The Australian Farm Review was unable to assess whether or not there was a bias in the 40 fish sample, and therefore age/size composition and total catch in weight. The following indicators may or may not have been affected by the unreported catch in the JMR or potential biases in the 40 fish sample described in the AFR. Until further information becomes available, we have decided to update these indicators with the data exchanged this year as part of the usual CCSBT data exchange, but do not suggest they are given the same weight as the previous indicator set when used to assess the status of the SBT stock.

Total Catch

Reported global catch of SBT

Figure 15 provides the estimates of total catch (in recent years) by country as reported in their official statistics provided to the CCSBT as part of the usual data exchange. In the last two years, there has been a large decrease in the overall catch, mostly attributed to the large reduction in the Japanese catch as a result of the1748 tonne reported over quota catch by Japan in the 2005 quota year, which reduced quota in 2006, and the quota reduction for 2007. Australian catch has declined slightly in 2007. There was a large decrease in the Indonesian catch in 2006, with a small increase in 2007, continuing the recent pattern of large inter-annual variation in yearly catches from the spawning ground fishery. Taiwanese catch in 2007 was much the same as it was in 2005, but we note that the total catch is around 60% of the average catch between 1995-2001. The Korean catch has increased substantially after four years of low catches, but the total catch is still a fraction of what it was in the late 1990s.

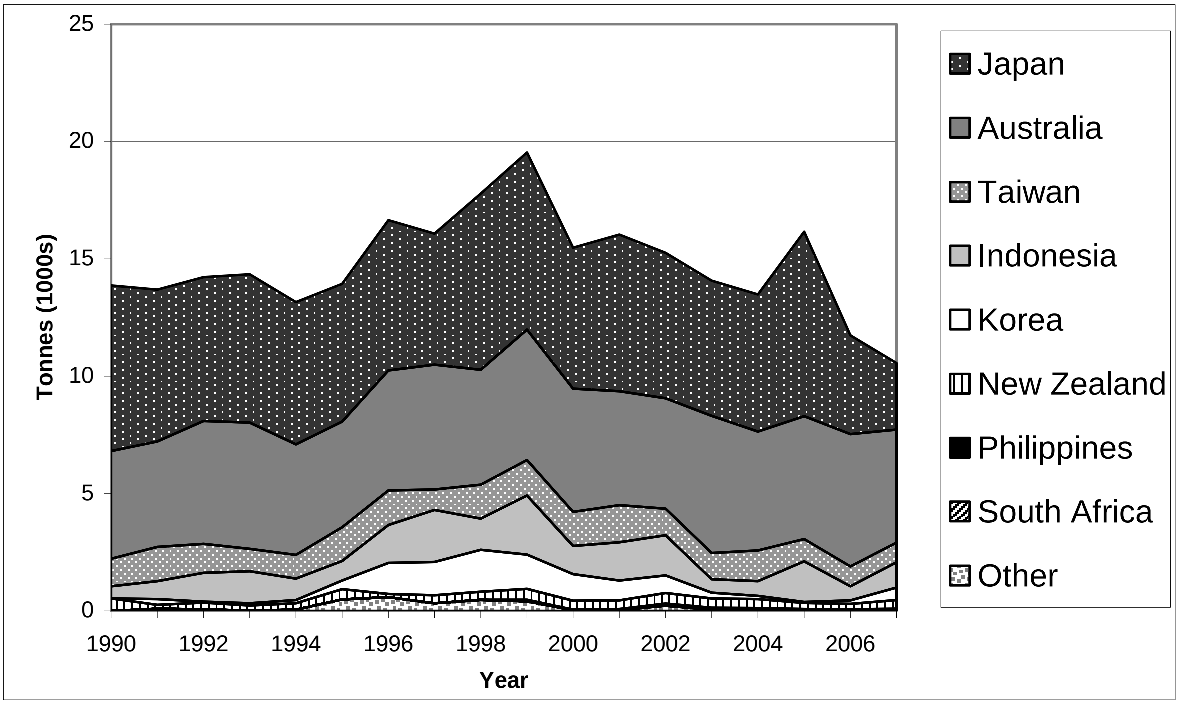

Figure 15: Estimated total catch of SBT by country since 1990.

Possible other scenarios for total global catch from the Reviews

Figure 16 shows the official reported catches of SBT for the full history of SBT catches. The IUU catch scenario used here is the same as that presented by the Chair of the Scientific Committee to CCSBT13, which was Longline Case L4 and Surface 20% (Anon, 2006). This is only one of a range of over catch scenarios that were considered at SAG7 (2006). These figures are provided not as indicators of stock status but as context for the potential problems these unreported catches may pose for the interpretation of the following indicators.

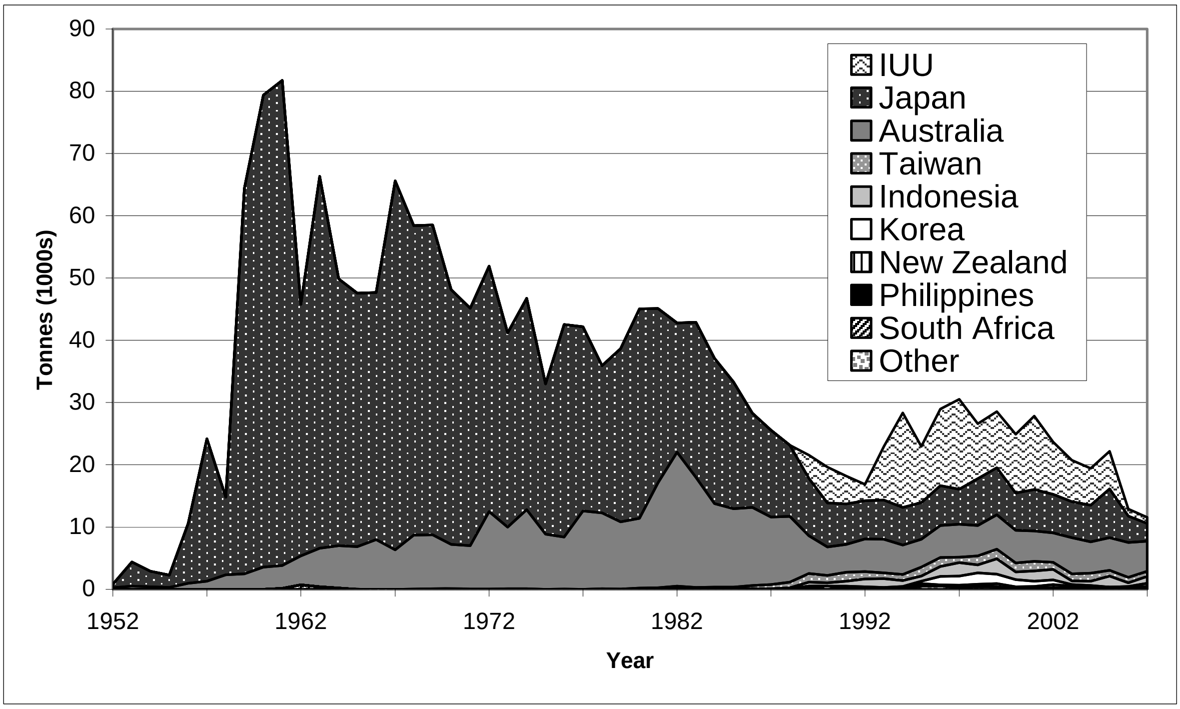

Figure 16: Official reported estimated catch of SBT for the full history of SBT catches by country. The IUU catch scenario used here is the same as that presented by the Chair of the Scientific Committee to CCSBT13, which was Longline Case L4 and Surface 20% from the Report of the Seventh Meeting of the Stock Assessment Group (SAG7, 2006). This is only one of a range of over catch scenarios that were considered at SAG7.

CPUE Indices

The CPUE indicators which are usually an important part of the Indicators assessment are provided here using the "official" reported data provided as part of the usual CCSBT data exchange.

Two of the possible sources for the unreported catch in the JMR is non-Japanese catch entering the market as Japanese domestic catches or as other tuna species. The CPUE from other countries may or may not have been affected by the unreported catches if this is the case. The other 2 sources identified in the JMR are Japanese catch that are underreported and/or Japanese catch unloaded as other tunas. The Japanese longline CPUE may or may not have been affected if either of these cases is true. The plausibility of alternative unreported catch mechanisms and therefore CPUE scenarios has been explored in SAG 2006 and working papers to that meeting (e.g. Polacheck et al (2006)).

Japanese CPUE

The Japanese official data includes 1748t of reported catch which was over quota in 2005, and a subsequent drop in catch in 2006. There was a spike in reported catches, some with very high CPUE, in December 2005 after the announcement of the market reviews (October) and advice (in late November) to the fishing vessels of the end of season (Lou et al 2006). This should not affect the data from months 4-9 that appear in these figures below up to 2005. There was a change in management of Japanese quota in 2006, and a significant quota reduction in 2007, which may result in modified fleet behaviour, and in turn affect Japanese longline CPUE (Itoh 2006, CCSBT-ESC/0609/44).

We note the following points in relation to recent Japanese CPUE from the exchanged data:

- In 2007, the nominal (aggregate age 4+) CPUE was the second lowest level observed, the lowest level being the 2006 rate (Figure 17). The CPUE series shows an overall decline since 2002.

- The overall declining CPUE trend in recent years is not an obvious result of major shifts in selectivity within the SBT age structure, as the nominal age-disaggregated indices (4-7, 8-11 and 12+) all show declining trends over the last 5 years similar to the age-aggregated series, but are evident most strongly in the 4-7 age group (Figure 18). The slight improvement in catch rates for 2007 (Figure 17) does, however, appear to be driven by the improvement of the 4-7 index (Figure 18). The catch rates for the 12+ group have remained steady in recent years (Figure 18), but they have fluctuated around this low level since the late 1990s, and are still below the catch rates seen in the late 1980s and early 1990s.

- In recent years, catch rates of ages 0-2 and 3 year old fish in the Japanese longline fishery were near or below the lowest levels observed (Figure 19), but in the last two years have increased to similar levels to those observed in the early 1990s. The catch rates of 4 and 5 year olds have increased in 2007, but are still at or around the low levels of the late 1980s. These young fish are only just vulnerable to the longline fisheries, and variation in their catch rates are generally assumed to be most affected by temporal changes in selectivity.

- Age 5 catch rates have declined consistently since 2003 (Figure 19) to a similar level to those observed in the early-1990s. This low catch rate for 5 year olds is evident in all statistical areas (Figure 20).

- The number of fished space/time cells has a strong downward trend over time (Figure 21), potentially leading to over-optimism in the aggregate catch rates through a spatial hyper-stability effect on the relationship between abundance and CPUE. In 2007, the number of cells fished has declined. This is most likely due to behavioural changes in the fleet due to the new quota levels and/or the method of allocation.

- All standardized catch rate time series suggest that CPUE has decreased from 2005 to 2006, with this trend continuing in 2007 (Figure 22). The exception to this trend is the ST window and Laslett Core Area series which show an increase in 2007.

- Nominal CPUE by cohort (Figure 23) suggests that the 2000-2002 cohorts are smaller than 1998-1999 cohorts, and that the 2003 and 2004 cohort appears to be quite strong. This interpretation is particularly sensitive to the assumption that selectivity and discarding has remained constant over this period because these young fish are only weakly recruited at this time.

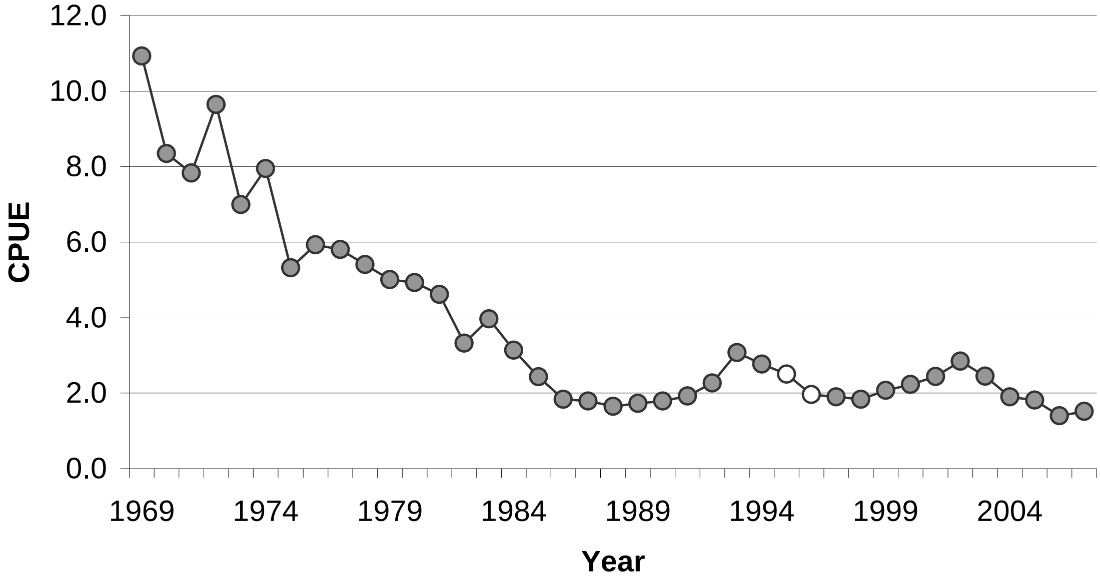

Figure 17: Trends in nominal SBT catch rates (numbers per 1000 hooks) for Japanese longliners operating in statistical areas 4-9 in months 4-9, including ages 4+ only. The 1995 and 1996 values have been plotted as open circles to indicate increased uncertainty about these points due to changes in retention policies for small fish in these two years.

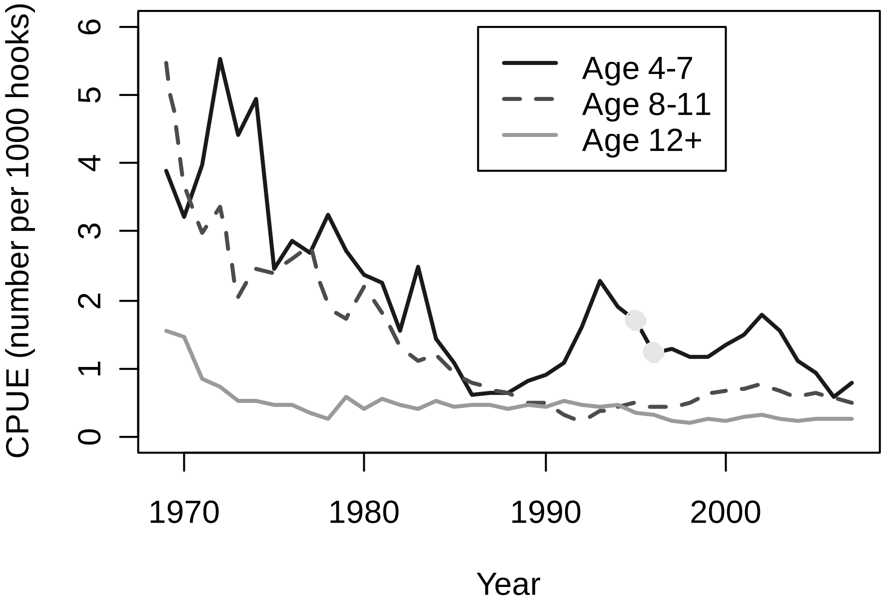

Figure 18: Trends in nominal SBT catch rates for ages 4-7, 8-11 and 12+ (numbers per 1000 hooks) for Japanese longliners operating in statistical areas 4-9 in months 4-9. The 1995 and 1996 values for the age 4-7 trend have been plotted as grey circles to indicate increased uncertainty about these points due to changes in retention policies for small fish in these two years.

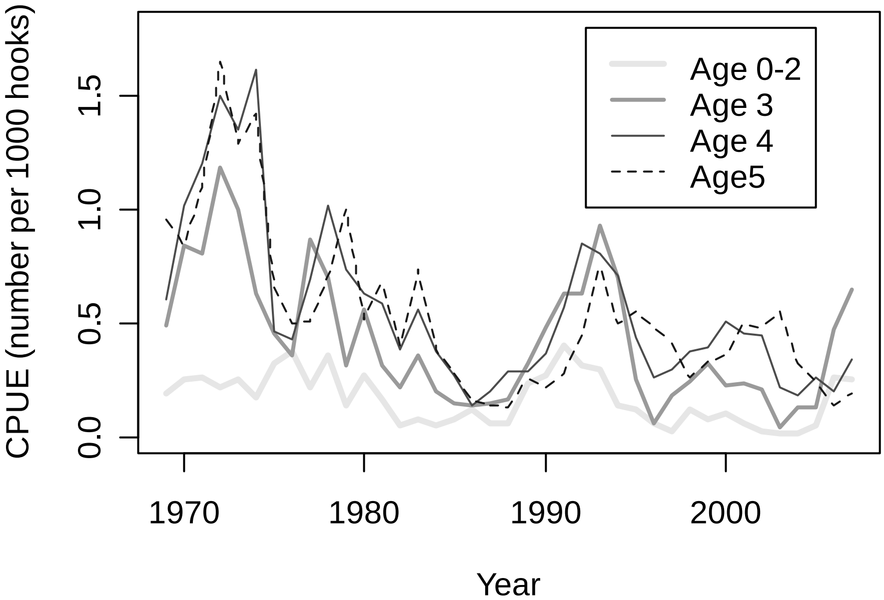

Figure 19: Nominal catch rates (number per 1000 hooks) of very young (ages 0-2 pooled, and 3, 4 and 5 individually) SBT by Japanese longliners in areas 4-9 and in months 4-9.

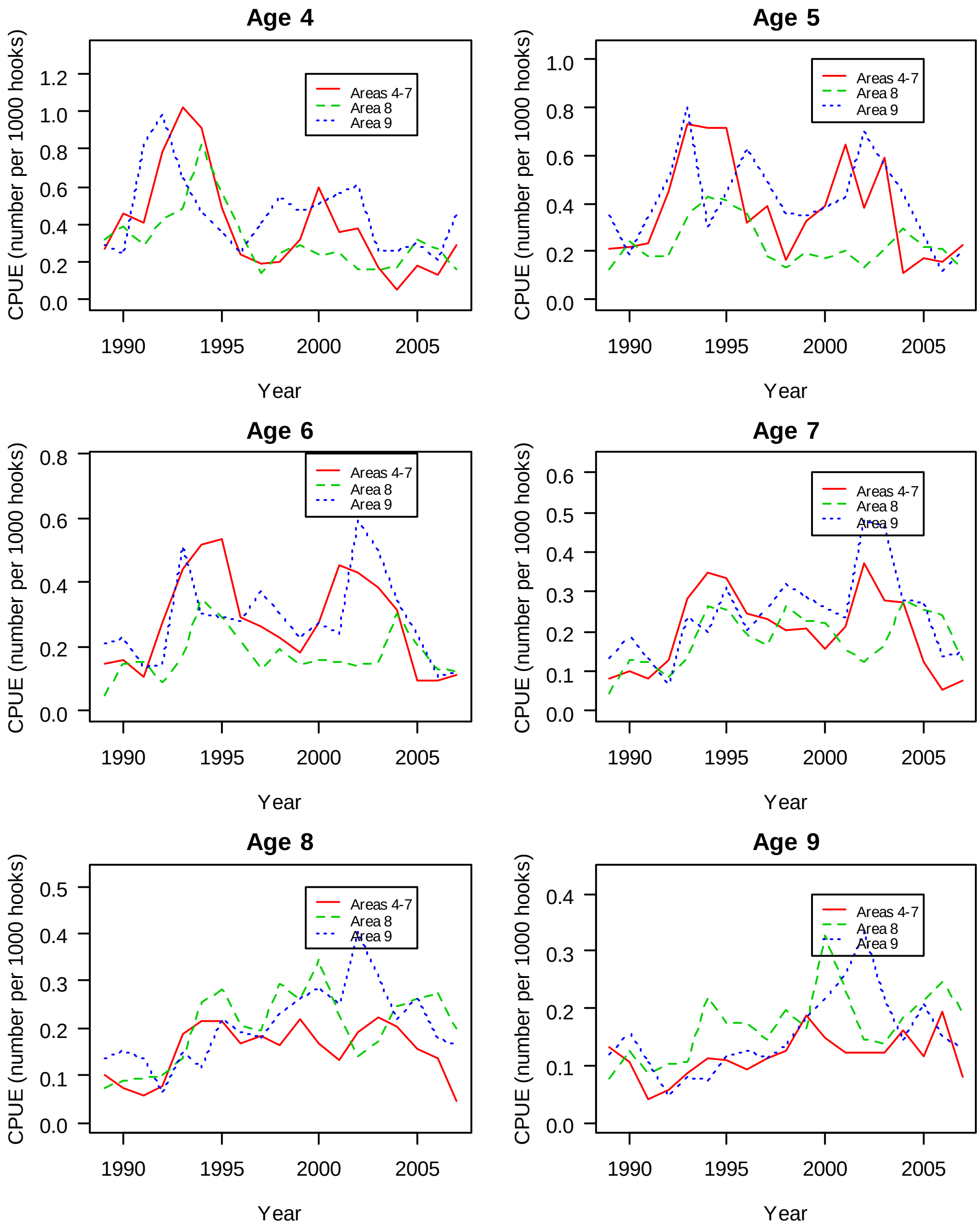

Figure 20. Comparison of age-specific nominal catch rates (number per 1000 hooks) in recent years for different fishing regions. Data is from Japanese longliners operating in months 4-9.

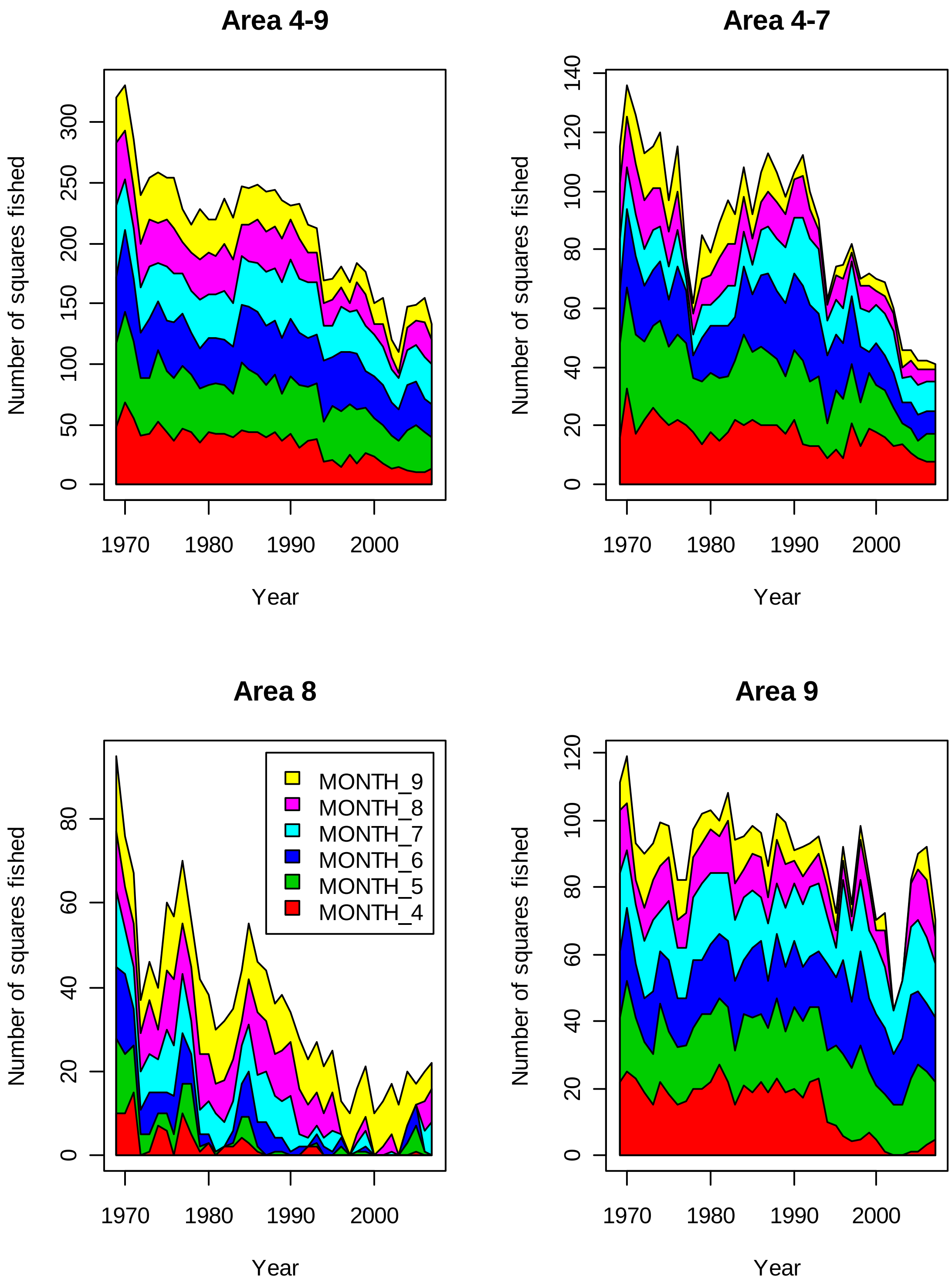

Figure 21: The total number of five-degree/month strata with fishing effort by Japanese longline vessels in months 4-9 for statistical areas 4-9, 4-7, 8 and 9. NOTE: The legend key and the shaded areas in each plot are stacked in the same order.

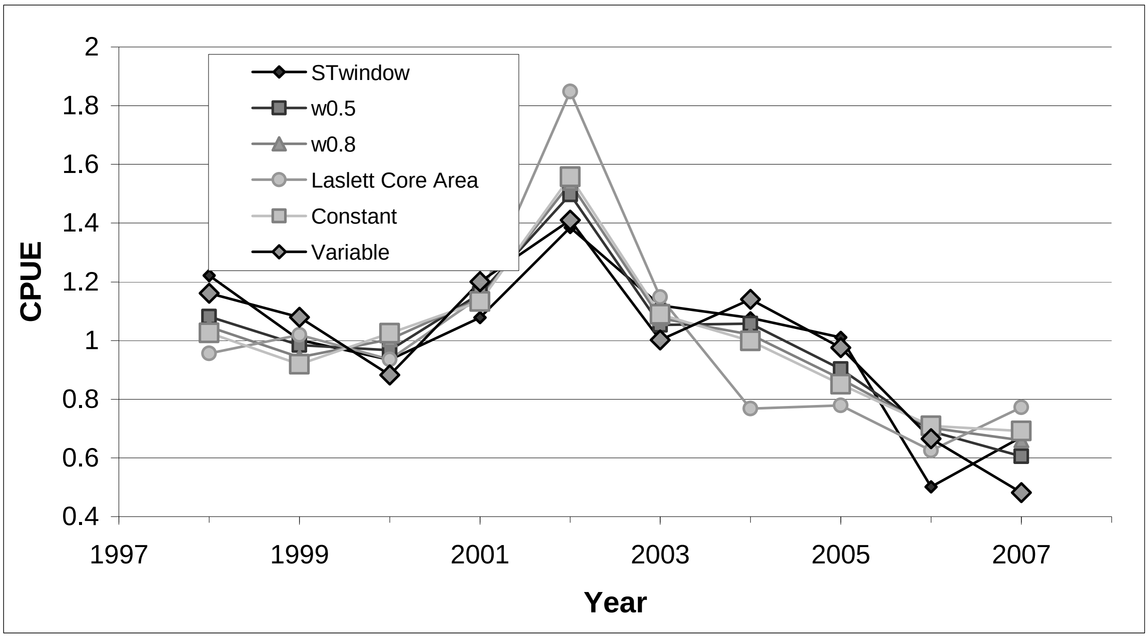

Figure 22: Comparison of the various standardized CPUE series for the last ten years. All series have been normalized by dividing by the mean for the last 10 years.

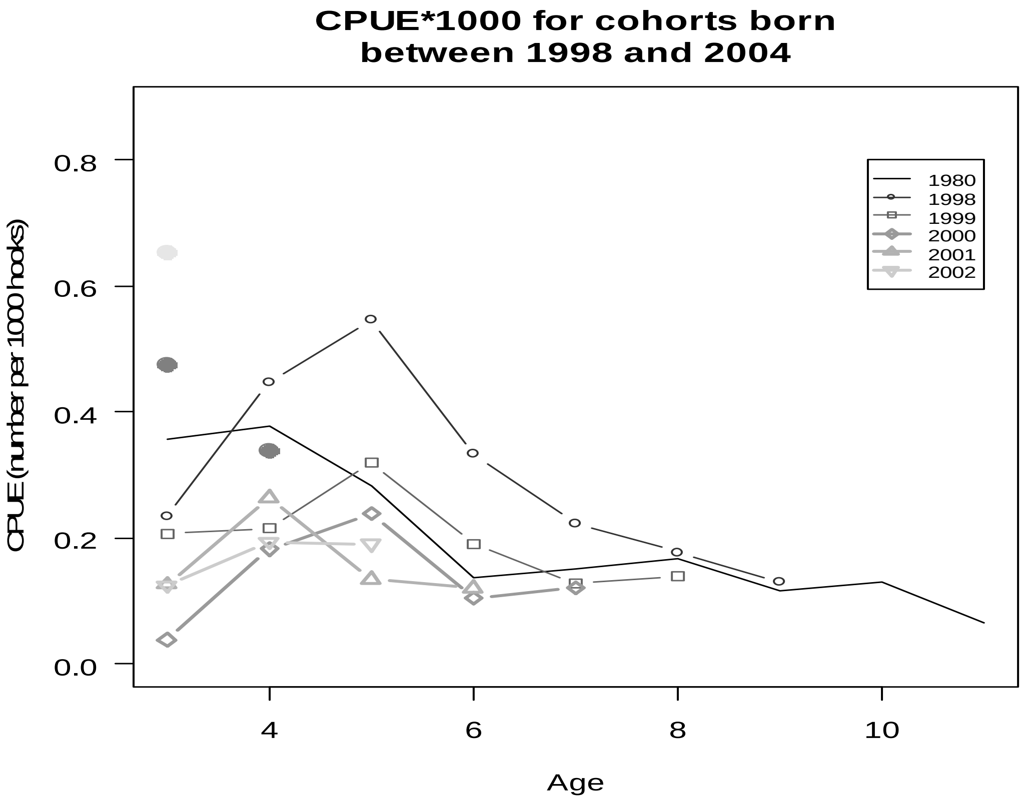

Figure 23: Nominal CPUE in Statistical Areas 4-9, months 4-9 for cohorts born between 1998 and 2004. The cohort born in 1980 is also shown for reference. The cohorts born in 2003 (solid dark grey circle) and 2004 (solid light grey circle) are not connected by lines.

Korean CPUE

The catch rates shown here (Figure 24) are from the Korean data provided to the CCSBT as part of the usual data exchange. Korean catch rates have generally declined since 1994 (Figure 24), but there has been improvement the last two years compared to 2004 and 2005. Effort has dropped substantially in the last five years (Figure 25), there being very little effort in 2005.

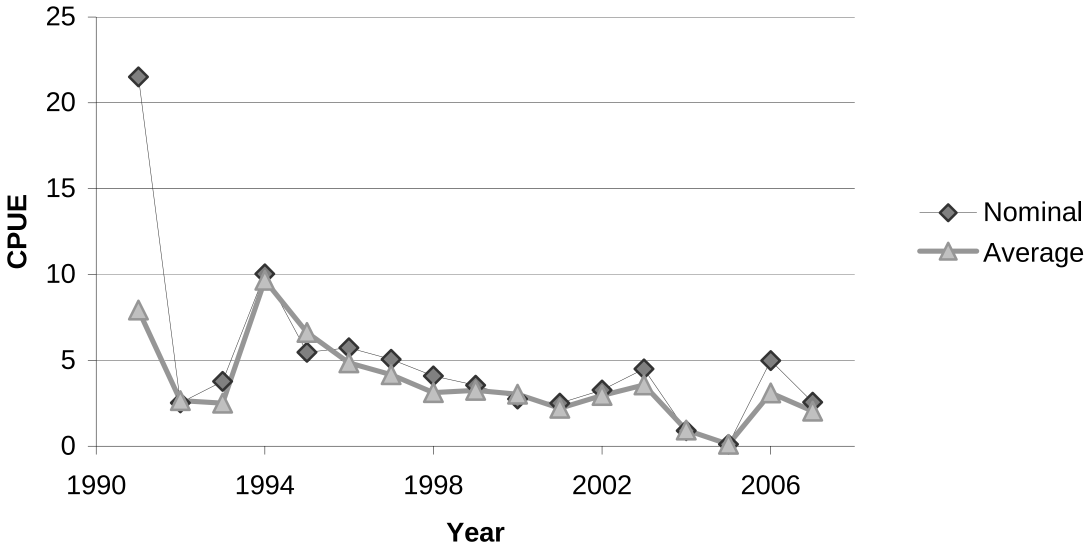

Figure 24: Trends in Korean longline catch rates (number per 1000 hooks) within statistical areas 4-9 during months 4-9. "Nominal" is the total hooks over total effort and "average" is the mean of the nominal rate in each 5x5 square/month strata.

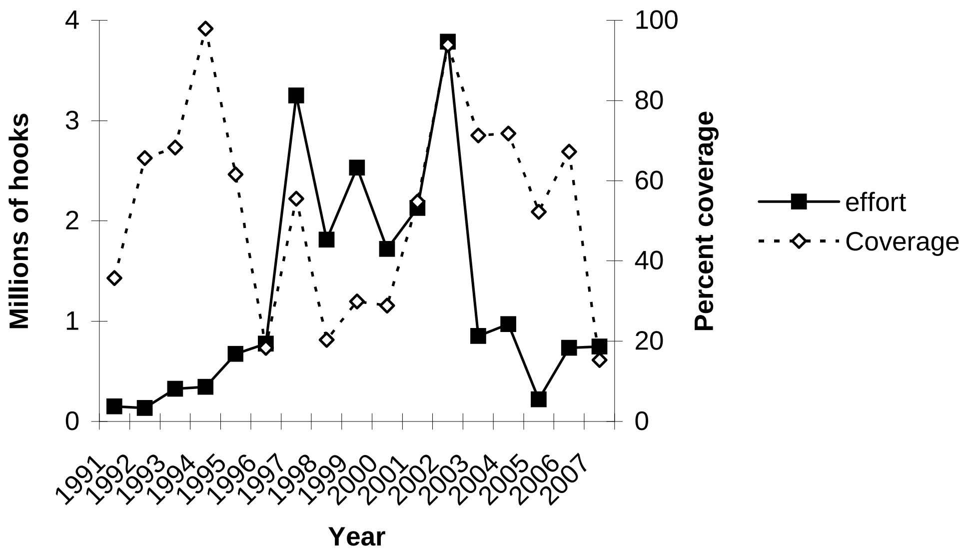

Figure 25: Total effort (millions of hooks) for which catch and effort data are available for Korean longline fishing in areas 4-9 and months 4-9. Coverage is the percent of the total reported catch by Korea for which catch and effort data were provided in all areas and regions.

Taiwanese CPUE

These figures have been updated with the most recent data provided to the CCSBT as part of the 2007 data exchange. Two new statistical areas have been defined for the Taiwanese Fishery operating north of the areas 8 and 9 (primarily targeting albacore). The boundaries of these 2 areas are: Statistical Area 14: 20 - 40S, 20-80E; Statistical area 15: 20-40S, 20W-20E (see Hartog et al, 2006 for map of statistical areas).

The northern Fishery, in statistical areas 2, 14 and 15 which primarily targets albacore, shows an increase in CPUE over time since the mid-1980's (Figure 26), especially in recent years. Sizable catch rates in the Taiwanese fishery in areas 8 and 9 began in 1990. Since then the average trend in catch rates has been constant, yet the variation in individual year catch rates has been large.

The main area of effort is the southern 5 degree strip in areas 2, 14 and 15. The effort in this area has been in decline and is now 25% of the effort since 1999, while the catch in numbers is at similar levels. Effort in the northern latitudinal strip (Figure 28) is negligible. In the last two years, effort in areas 8 and 9 has increased three fold to be at the same level as that of the southern 5 degree strip of areas 2, 14 and 15.

Catch rates in the northern fishery, when split by 5 degree latitudinal strip, show that the southern strip has dominated the catch rate series (Figure 27) and the effort series (Figure 28), with the catch rates in the middle strip increasing in recent years to be at the same level as the southern strip.

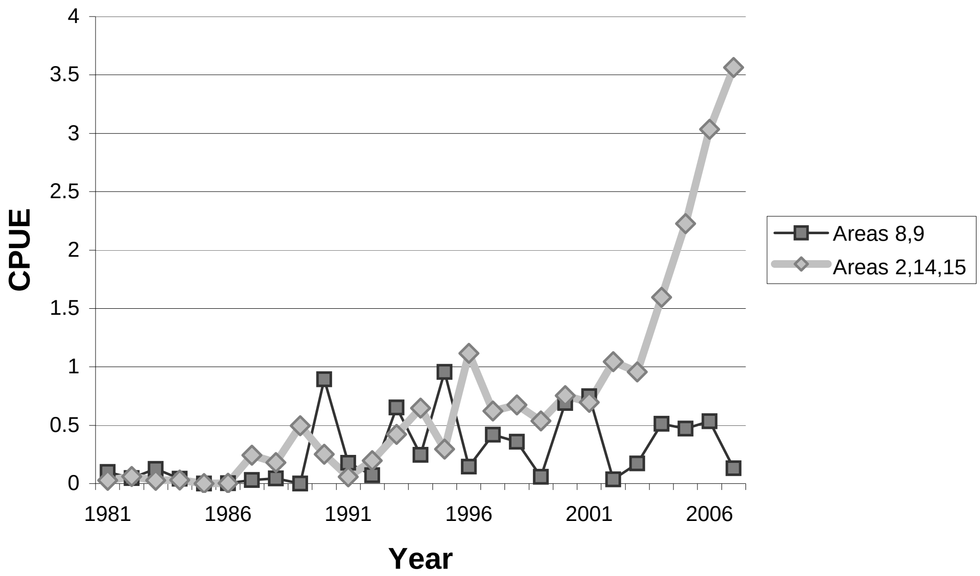

Figure 26: Estimate of nominal catch rates for SBT (number per thousand hooks) by Taiwanese longline. Catch rates have been calculated for statistical Areas 8 and 9 and for Statistical areas 2, 14 and 15 where small SBT are frequently caught by Taiwanese longline as part of their targeted albacore fishery. Both time series were calculated using data only from months 4 to 9.

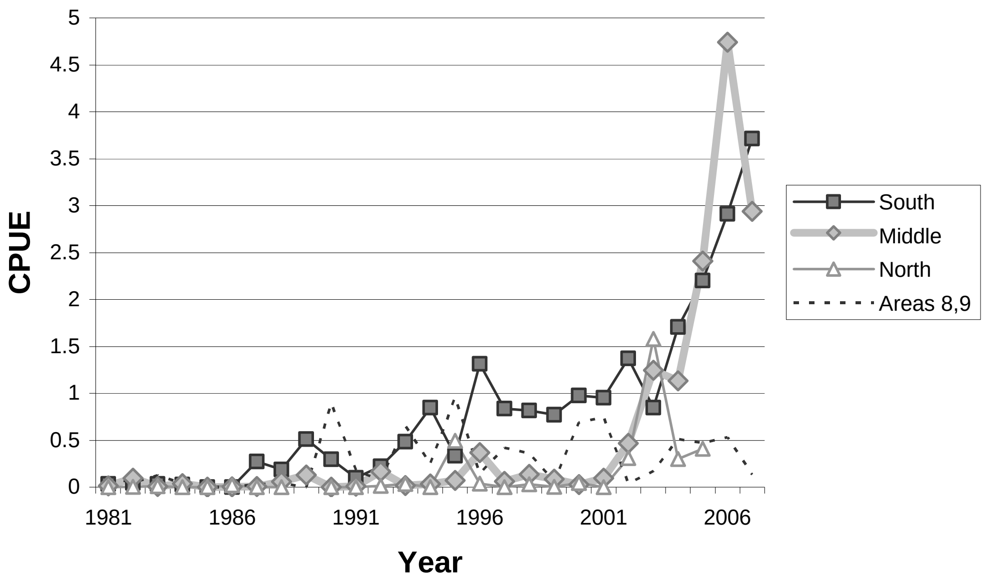

Figure 27: Estimate of nominal catch rates for SBT (number per thousand hooks) by Taiwanese longline. Catch rates have been calculated for the 5 degree latitudinal strips in statistical areas 2, 14 and 15. South is 30-35 degrees south, Middle is 25-30 degrees south and north is 20-25 degrees south. All time series were calculated using data only from months 4 to 9.

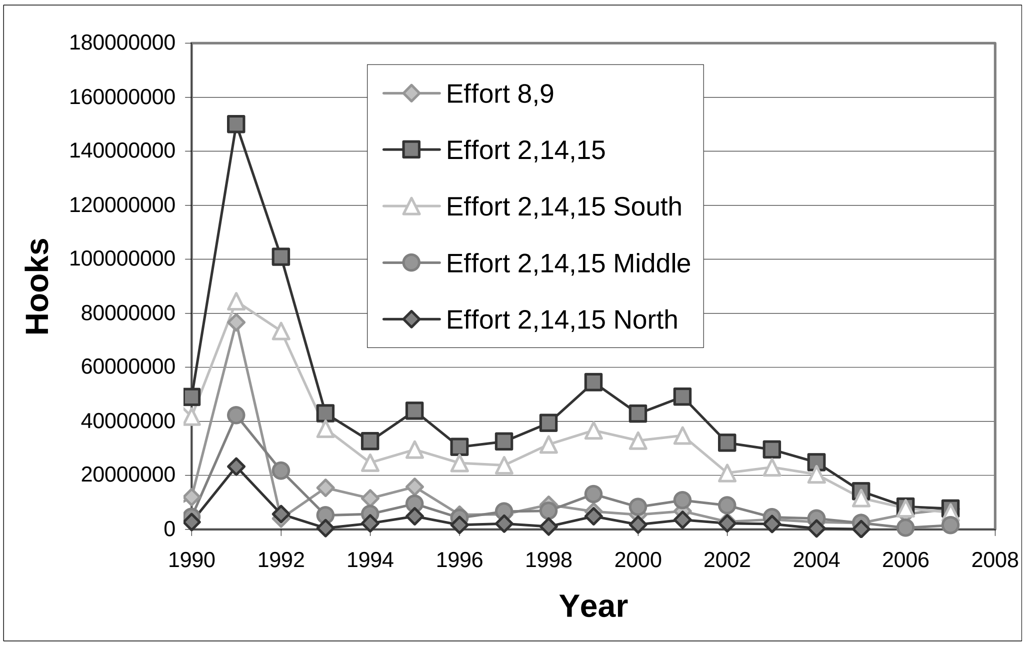

Figure 28: Yearly effort series for the last 15 years from Taiwanese longline in Areas 8 and 9, and Areas 2, 14 and 15. The effort in areas 2, 14 and 15 has also been separated by 5 degree strips as described in **Figure** 27.

Catch Size/Age Composition

Investigation of indicators related to juveniles was prompted in 2005 because of apparently very weak cohorts identified in the 2004 stock assessment. In the 2006 stock assessment (scenario modelling) the incidence of very small cohorts in recent years seems to have reduced (Basson et al. 2006).

Below, we present the age composition (via direct ageing methods or as inferred from lengths) of the different fleets. In the following, we assume that fish of size <86cm correspond to age-classes 0-2; 86-102 cm = age 3; 102-114 cm = age 4; and 114-126 cm = age 5.

Japanese Longline Fishery Catch Size/Age Composition

The Japanese longline fishery age composition data are presented below (Figure 29). The data shows an increase in the contribution of very young fish 0-2 and 3 year olds, but a decrease in the presence of 5 year olds on the catch.

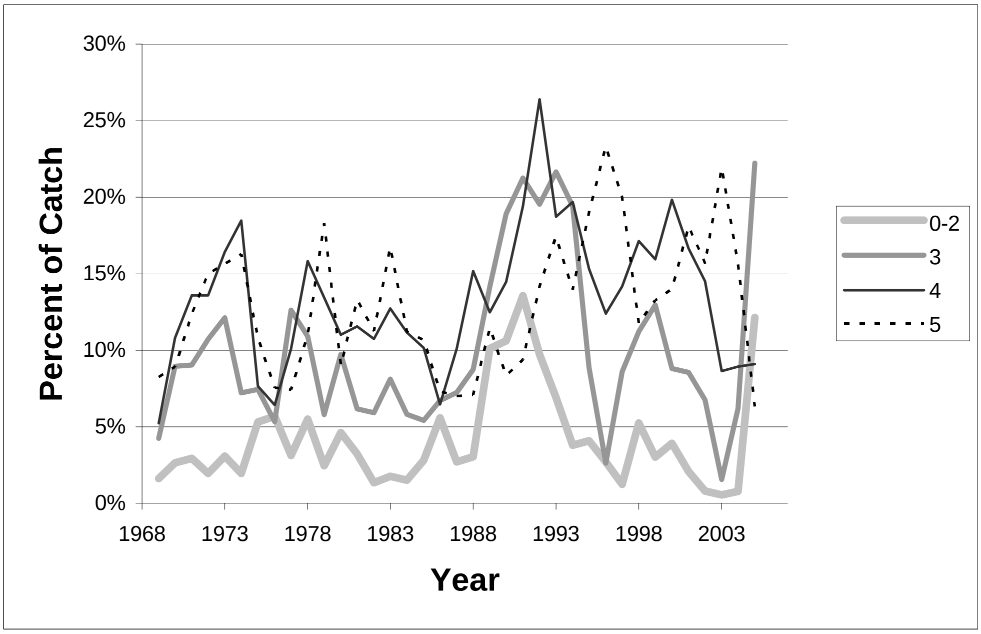

Figure 29: The percent of the SBT catch by Japanese longliners in areas 4-9 and months 4-9 which was less than or equal to 2, or age 3, 4 and 5 years of age respectively.

Korean Longline Fishery Catch Size/Age Composition

The proportion of age 3 and 4 fish in the Korean catch appears to have dropped in 2007 and is much lower than the long term average for those age classes (Figure 30). The proportion of age 5 fish has also dropped in 2007 but is in line with the long term average for that age class. Size data from Korea has not been received for 2005. Given the low effort in recent years and the lack of consistent patterns, we do not consider the Korean data to be informative about relative cohort strength.

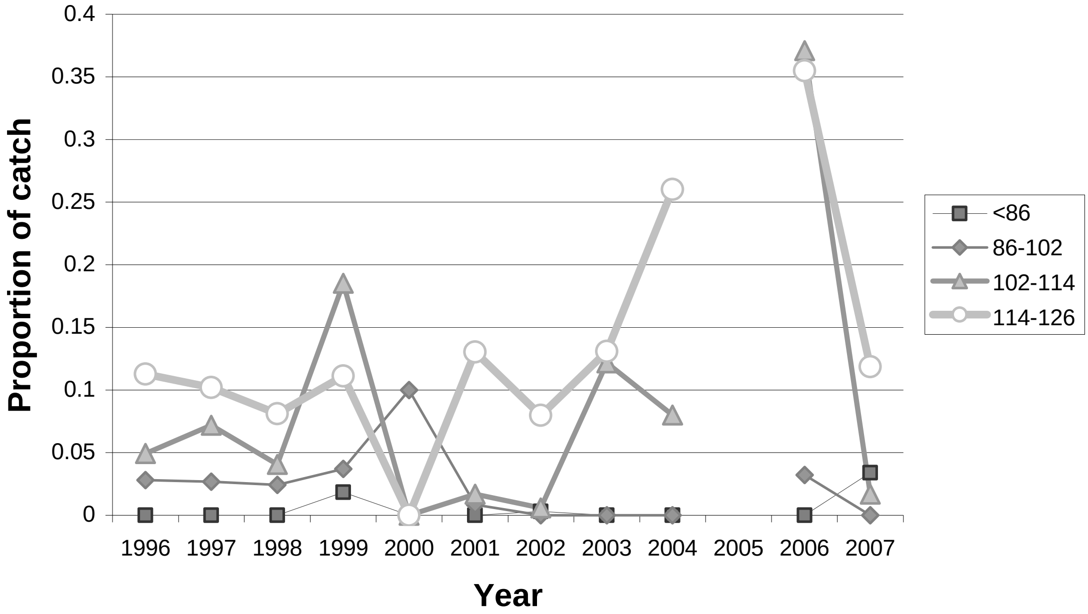

Figure 30: The percentage of the catch reported to be less than 86 cm (ages 0-2), 88-102cm (age 3), 102-114cm (age 4), and 114-126cm (age 5) in the Korean longline catches.

Taiwanese Longline Fishery Catch Size/Age Composition

The Taiwanese fishing in areas 2, 14 and 15 which primarily targets albacore has generally had a high proportion of juveniles (age < 5). The proportion aged three or less (ages 0-3) has declined since 2001, while the proportions of 4 and 5 year olds (102-114cm and 114-126cm) has increased (Figure 31). Additional data comparing Taiwanese data with port sampling results from Mauritius (last surveyed in 2004) is generally consistent with these results (Figure 32).

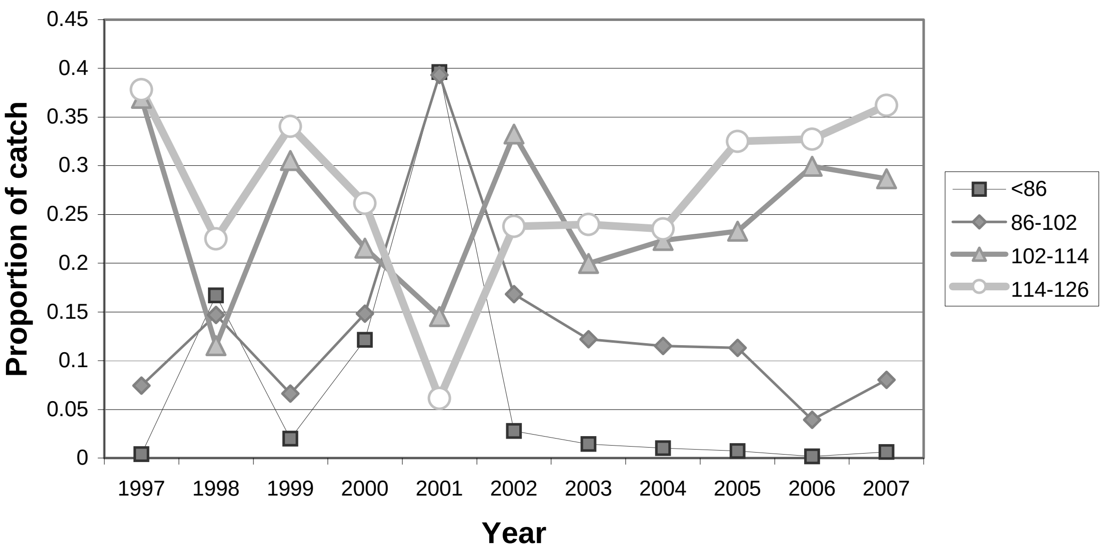

Figure 31: Taiwanese longline catches in the northern fishery (statistical areas 2, 14 and 15). We assume that fish of size <86cm correspond to age-classes 0-2; 86-102 cm = age 3; 102-114 cm = age 4 and 114-126 cm = age 5.

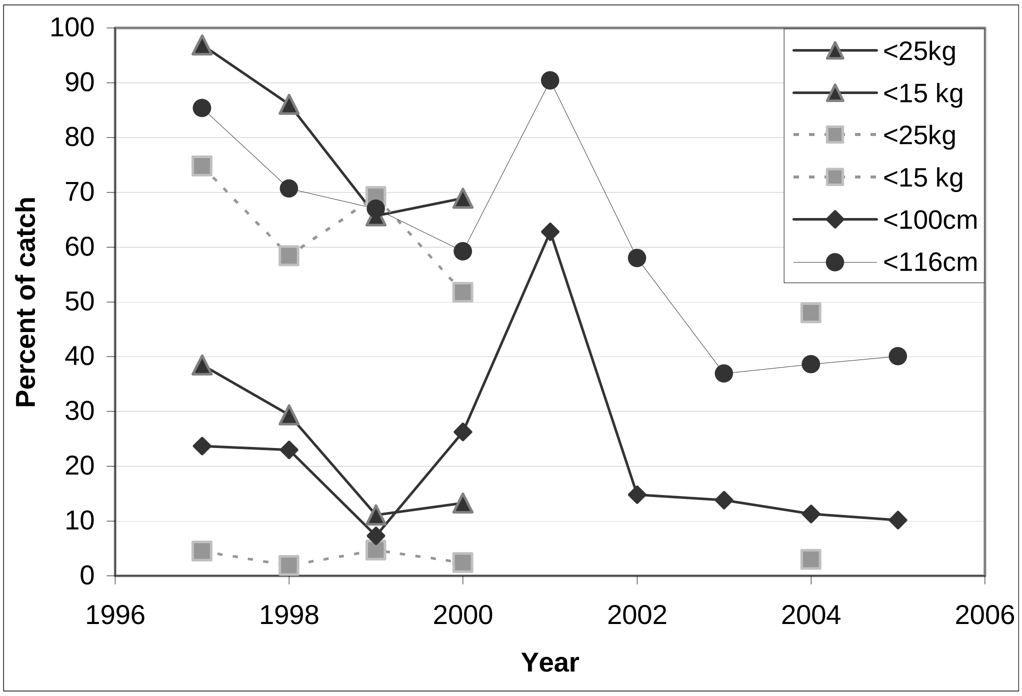

Figure 32: The percent of the catch less than 15kg and 25kg in Taiwanese catches based on log book sampling in Mauritius (both summer and winter) compared with the percent less than 100cm (diamond) and 116cm (circle) in data reported to CCSBT. The dotted lines and squares indicate sampling from the summer fishery, solid lines and triangles are from the winter fishery. Note that 100cm and 116cm correspond approximately to the estimated weight of a 15kg and 25kg fish (processed weight).

Australian Surface Fishery Catch Age Composition

The Australian Farm Review panel was unable to resolve whether there were biases in the 40 fish sampling program, which would affect the age/size composition (Fushimi et al 2006). An increased number of small fish less than 10kg (2 years old or less), have been sampled as part of the 40 fish quota monitoring process in recent years (Sahlquist et al, 2006). Figure 33 shows relatively low numbers of older fish (ages 4+) in the surface fishery in recent years. The tag return data from the surface fishery catches contain relatively larger proportions of older fish than would be expected given the size distributions shown in Figure 33 . There are several different reasons why this could be the case (see Polacheck and Eveson 2007), and at this stage it is unclear what has caused this difference.

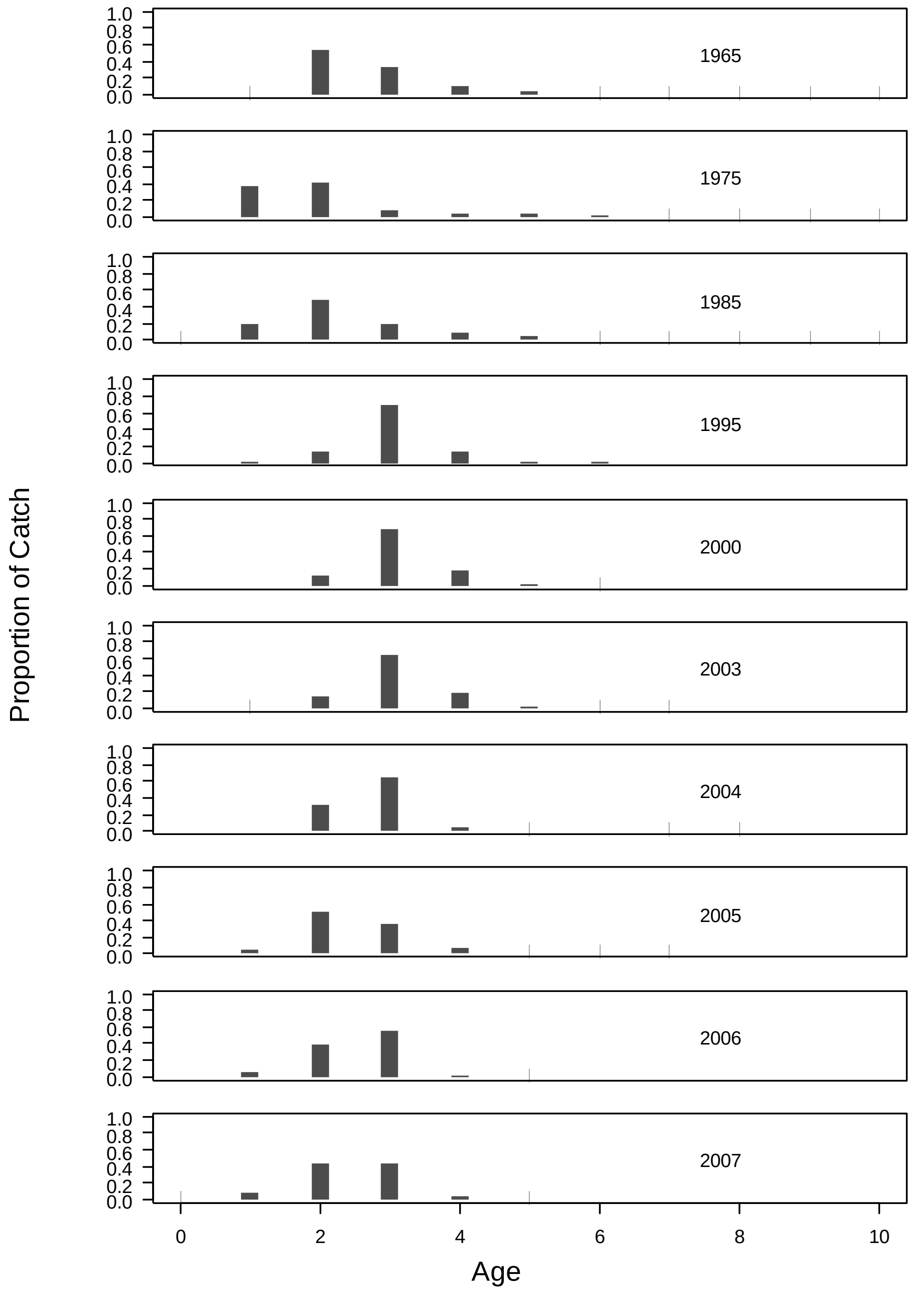

Figure 33. Estimated age composition of the Australian surface fishery, taken from the Operating Model Input data prepared as part of the CCSBT data exchange.

Concluding Remarks

This paper provides an update of the 2007 indicators using data from the CCSBT data exchange. Only a subset of these indicators are unaffected by the Japanese market review and Australian Farm review results on over-catch of SBT. The interpretation of the unaffected indicators is not markedly different from last year. The unaffected indicators are summarised in Table 4. We restrict our comments on recent trends and apparent cohort strength to this subset of indicators.

The indicators continue to suggest that:

1. There have been 2-5 very weak cohorts in 1999-2003.
2. Subsequent cohorts may be stronger, but still appear to be weak compared with average cohort strength in the mid-1990s.
3. There is limited information available on the fully recruited (to the fishery) and spawning components of the stock biomass, however what do we have suggests little change over the last few years.

Table 4: 2008 qualitative summary of recent fishery indicators. Negative indicators (-) suggests that the trend in the indicator over the time interval is generally declining or that the year class strength is substantially below the recent ~5-10 year average. Positive (+) indicates the opposite; 0 indicates a neutral indicator. Missing values are not thought to be informative with respect to the particular category (because the indicator is irrelevant or we have strong reasons not to believe it).

Indicator	relevant SBT ages	indicator interpretation trend over last 1-3 years	indicator interpretation last 5-10 years	Cohort Strength (age 0)							
				1999	2000	2001	2002	2003	2004	2005	2006
Catch Rates											
[1,2]New Zealand CPUE	4+	0	0/-								
[1,2]Indonesian Fishery School CPUE	8+										
Catch Size / Age Composition											
[2]New Zealand	5-	+	-								
[2]Indonesia	8+	0	0								
Other											
Acoustic Survey	1	0/-	-								
[3]GAB Aerial survey	2-4	0	0			-	-	-	-	-	0/-
[3]Commercial spotting SAPUE	2-4	0/+	0	0	-	-	0	0	0	+	
[4]SRP Tag Returns	6-			-	-	-	-	-	-		
[5]Total Indonesian Catch	8+	0/-	0								
[6]SBT as proportion of Indonesian Catch	8+	+	0/+								
[7]SBT growth rates	6-		0/-								

Key assumptions implicit in the qualitative interpretation:
1) CPUE proportional to abundance
2) selectivity constant over time
3) ages 1-3 represented in equal proportions in the Great Australian Bight
4) tags well mixed
5) effective fishing effort constant among years
6) targeting and non-SBT species composition constant over time
7) density-dependent growth rates from intra-specific competition

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Appendix 1. The 1988 SBT Stock Status Indicators

Thirteen fishery indicators were used to justify the 1988 tri-lateral meeting recommendation that "…*Global SBT catch limits* <u>*be immediately reduced*</u> *in all sectors of the fishery substantially below current catch levels. Because of the severity of the decline in the SBT population…*" (Anon. 1988):

Indicator #1: Reduction of unexploited biomass to less than 25%.

Indicator #2: Reduction in hook rate in the Japanese longline fishery between 1983 and 1986 of 50%.

Indicator #3: Contraction in the area of Japanese fishing effort to two of the nine fishing areas

Indicator #4: Reduction of the peak Japanese longline catch to less than 20%.

Indicator #5: Reduction in the abundance of 4-7 year old fish in the longline fishery from 1972-86 to 10%

Indicator #6: Reduction in the abundance of 8-10 year old fish in the longline fishery since 1980 to about 30%.

Indicator #7: Reduction in the hook rate in the Japanese longline fishery off New Zealand between 1980 and 1987 to 33%.

Indicator #8: Disappearance of small fish from the Japanese longline fishery in New Zealand waters.

Indicator #9: Reduction from the peak New Zealand handline/troll fishery catches to less than 25%.

Indicator #10: Sudden and continued absence of SBT from NSW coast.

Indicator #11: Continued contraction in the area of occurrence of juvenile SBT in the Australian waters to 40%

Indicator #13: Progressive reduction in the availability of large fish to the Australian fishery since 1982-83.

Appendix 2. Stock status summary table reproduced from Polacheck et al (2004)

For each indicator an overall assessment was made of the performance of that indicator over the last 10 to 14 years and over the last 3 to 4 years. A label of negative is meant to indicate either that the indicator suggested an overall negative trend with respect to the stock or suggested potential concern relative to exploitation or stock status. A label of positive is meant to indicate that the indicator suggested an overall positive trend or improvement in the indicator relative to 1986. Neutral is meant to indicate that the indicator suggested no change over the period or no net improvement or deterioration. NA signifies that the indicator is no longer relevant, or that data are not available or are not interpretable.

Indicator	Last 10-14 years	Last 3-4 years
Parental Biomass estimates	Negative	NA (awaiting 2004 Assessment results)
Catch rate trends for the Japanese fishery	Positive/neutral	Neutral
Fishing effort spatial distribution	Negative	Negative
Catch Levels - Japan	NA	NA
Korea	NA	Negative
Indonessia	NA	Negative
Abundance of ages 4-7 in Japanese longline fishery	Positive	Neutral
Abundance of ages 8-11 in Japanese longline fishery	Positive	Neutral
Catch Rates off New Zealand (Japanese longline)	Positive	Neutral/negative
Small Fish in the Japanese longline Fishery off NZ	Positive/neutral	Negative
Trends in New Zealand Handline/Troll Fishery	NA	NA
Trends in New Zealand Domestic longline	Neutral	Neutral (?negative)
Surface Schools of Juvenile SBT off the NSW coast	Neutral	Neutral
Area of occurrence of SBT in Australian Waters	Neutral	Neutral
Juvenile exploitation rates –conventional tagging	Negative ?	NA
Juvenile exploitation rates – archival tagging	Negative	Negative
Large fish in Australian Fishery	NA	NA
Small fish in pelagic longline catches: Japan	NA	Negative
Korea	NA	Negative
Taiwan	NA	Negative
Small fish in NZ domestic fishery catches	Neutral (?positive)	Negative
Catch rate for 12 plus	Negative	Neutral
Korean Longline CPUE trends	Negative	Neutral/negative
Taiwan Longline CPUE trends	NA	NA
Juvenile abundance estimates from tagging	Negative	NA
Spawning ground Catch Age/Size distributions	Positive	Positive (?Negative)
Growth rate change	Negative	NA
Catch Rate trends by cohort	Positive	Positive
Aerial Survey	Negative	NA
Acoustic Survey	Negative	Negative
Commercial aerial spotting	NA	Negative