SUMMARY OF FISHERIES INDICATORS OF SOUTHERN BLUEFIN TUNA STOCK IN 2011

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Abstract : Various fisheries indicators were examined to overview the current status of southern bluefin tuna stock. The indicators suggest that current stock levels for 4, 5,and 6&7 age groups are higher than ones observed in the late 1980s, which are the historically lowest levels. When looking to recent years, CPUE indices for these age classes showed increasing trends. Standardized CPUE for age 3 increased from 2005 to 2008, and then decreased for two years in a row. Other age classes, 8-11 and 12+ tended to keep at the same level after 2003 with some variability. Current stock levels for these age groups, however, are still low similar to ones observed in past. Many indices indicated low recruitments of 1999, 2000, 2001, and 2002 cohorts. This reflects the fact that the acoustic survey indices from Recruitment Monitoring Program suggested sequential low recruitments for four years (the 2000-2003 surveys corresponding to the 1999-2002 cohorts). Agreed with these results of the surveys, longline CPUE indicators suggested considerable decline of recruitments of 1999-2002 cohorts. On the other hand, some inconsistencies in recruitment level were observed in comparisons between some fishery-dependent indicators and the results of the 2005 and 2006 acoustic surveys (corresponding to the 2004 and 2005 cohorts). In addition, while low level of recruitment for cohorts of 1999, 2000, and 2001 was observed in the acoustic survey and the trolling survey, the trolling indices for the 2002, 2004 and 2005 cohorts showed higher level of recruitment than the acoustic survey indices. The longline CPUE indices (of both nominal and standardized) for age 3 in 2007, for age 4 in 2009, and for age 5 in 2009 and 2010 showed large upturns. Whether these large positive upturns were caused by increase of stock abundance and/or the introduction of individual quota system into Japanese longline fishery is still unknown. In addition to these positive upturns of small fish CPUE observed in the longline fishery, recruitment indicators based upon the trolling survey, the aerial and commercial spotting surveys, and purse seine CPUE all suggested increases of juvenile fish in recent years. Considering uncertainty inherent in the indicators, further careful monitoring and examining both fishery-dependent and fishery-independent indicators are continuous tasks with high priority. Indices on spawning stock are difficult to interpret and thus no specific conclusion was drawn.

要旨：ミナミマグロの資源状態を概観するために各種漁業指数を検討した。指標は、現在の 4、5、及び 6&7 年齢グループの資源状態が 1980 年代後半に見られた歴史的に最低レベルより高いことを示している。近年を詳しく見ると、これら年齢クラスの CPUE 指数は増加トレンドを示している。3 歳魚の標準化 CPUE は 2005 年から 2008 年にかけて増加し、その後 2 年間続けて減少した。その他の年齢クラスである、8-11 及び 12+は、2003 年以降、ある程度の変動をともないながら同じようなレベルを保つ傾向であった。しかし、現在のこれら年齢グループの資源状態は依然として過去に見られたものと同じ低いレベルにある。多くの指標は 1999、2000、2001、2002 年級の加入が悪いことを示している。これは、加入量モニタリング調査による音響指数が 4 年間（1999-2002 年級に対応する 2000－2003 年の調査）続けて加入が低いことに対応している。音響調査の結果と一致して、はえ縄の CPUE 指標も 1999-2002 年級の加入の大きな減少を示していた。一方、いくつかの漁業指標と 2005 年及び 2006 年の音響調査結果（2004 及び 2005 年級に対応する）との間には加入レベルについて矛盾がみとめられた。また、1999-2001 年級の低い加入は音響調査及び曳き縄調査ともにみとめられたが、2002、2004 及び 2005 年級の曳き縄指数は音響調査のものより高かった。2007 年の 3 歳魚、2009 年の 4 歳魚、2009 年及び 2010 年の 5 歳魚の

はえ縄 CPUE 指数（ノミナル及び標準化の両者とも）は大きな跳ね上がりを示していた。これらの大きな正の跳ね上がりが、資源豊度の増加と日本はえ縄漁業への個別割り当て制度導入のどちらか、あるいは両方によるものなのかは分からない。はえ縄漁業で見られた小型魚 CPUE のこれらの正の跳ね上がりに加え、曳き縄調査、航空目視及び商業目視調査、まき網 CPUE に基づく全ての加入指標は若齢魚の近年の増加を示していた。指標に内在する不確実性を考慮して、今後も漁業依存の指標と漁業とは独立の指標の両者をさらに慎重にモニター及び鋭意検討することが引き続き最優先の作業である。親魚資源指標は解釈が難しく、これといった判断は行わなかった。

The 2001 Scientific Committee (SC) selected a set of fisheries indicators to overview the SBT stock status. These indicators have been revised and used in past Stock Assessment Group (SAG) and SC meetings to examine whether unexpected changes of stock status requiring urgent full stock assessment occurred. Also, the 3rd Meeting of Management Procedure Workshop in 2004 agreed to review fisheries indicators every year to monitor whether the SBT stock status stays within an expected range of uncertainty which the operating model considered. This document summarizes results of updated fishery-dependent indicators and our overall interpretations. Some fishery-independent indices based on research surveys were also presented. It should be noted that conclusions in the reports of the Japanese Market and Australian Farming Investigation Panels are not taken into account of in this summary because how to incorporate information of catch anomalies into past CPUE data is difficult. The SC agreed to use the new growth curve proposed by Australia (Polacheck et al. 2002) from the 2011 Data Exchange. All CPUE indicators in this document based on catch at age data by the new growth curve.

1. Japanese longline CPUE:

<u>Nominal CPUE</u>

Nominal CPUE data by age group of Japanese longline fishery include those of joint-venture with Australia and New Zealand (Fig. 1-1). Caution is necessary for interpretation of age 3 and 4 CPUE in 1995 and 1996 because of direct impacts of non-retention of smaller fish than 25kg occurred in these years. The most recent year's data exclusively rely on information collected by the Real Time Monitoring Program (RTMP) which covers only SBT targeting vessels. When all the other non SBT-targeting vessels' data (based on logbooks) become available and are included in the existing dataset the following year, CPUE of the most recent year tends to drop slightly (Takahashi et al. 2001). So the most recent year's CPUE must be also looked at with caution. However, those differences have decreased gradually and almost no difference has been found in recent years because the RTMP covers more than 95% of efforts in SBT distribution. There was some drop observed for all age classes in 2009 (Data were not shown).

CPUE in recent years must be further looked to carefully because Japanese longline fishery has introduced Individual Quota (IQ) system since 2006. Changes in the number of catch and the distribution pattern of effort before and after 2006 were examined and discussed in detail in Itoh (2011).

When focusing on trends for the recent five or six years, nominal CPUE for age 3 fluctuated around the past 5-year mean (Fig. 1-1). The 2010 value for this age was lower than the mean. CPUE for age 4 was more or less stable, except that the 2009 and 2010 values were largely above the past 5-year mean over 2005-09. Although age classes 5, 6&7, and 4+ had declined since the early 2000s hitting the bottom in 2006, recent CPUEs for these ages showed increasing trends. The 2010 values for these ages were also markedly higher than the past 5-year averages. Observed 2010 high catch rates for ages 4 to 7 in Statistical Area 4, 8 and 9, especially Area 7, caused marked upturns of CPUE for these ages in the most recent year as explained below (Sakai et al. 2011). Nominal CPUEs for age classes 8-11 and 12+ fluctuated around the past 5-year averages with small variations.

Trends of nominal CPUE of Japanese longline by cohort were plotted in Fig. 1-2 and 1-3. Fig. 1-2 is a comparison of nominal CPUE of juveniles among different cohorts and Fig. 1-3 compares decrease rate by cohort in the logarithmic scale. CPUE for age 3, 4 and 5 fish generally showed consistent trends, suggesting that age 3 CPUE could be used as an indicator of relative cohort strength, although a large decline of 1999 cohort (2000 acoustic survey in Fig. 3-1) was not be able to detected by age 3 CPUE and there are large variations observed in recent years (Fig. 1-2).

Overall levels of CPUE across age 3 to 11 by cohort can be grouped as the periods of 1980-1986, 1987-1992, 1993-1999, and 2000s (Fig. 1-3). Within each period, variations of the CPUE levels were small and the decease rates were similar, except for the 2000s. Since 2000, the catch rates have varied considerably and have not shown simple decreasing trends. Whether these large variations in catch rate were due to change in catchability and/or population fluctuation is unrevealed. The 1987-1991 cohorts showed more drastic declines than other cohorts, which was probably due to targeting towards smaller fish in the early 1990s caused by depleted stock status of cohorts recruited in pre1987 years and less structured management schemes at that time. The cohorts recruited from 1992 to 1999 showed slower decline rates, suggesting a reduced level of exploitation rates for these cohorts. Fig. 1-3 also indicates acute decline of age 3 fish during 2000-2002 to about the same or lower levels comparable to those experienced by the early 1980s cohorts, while showing that 2003-06 cohorts were similar to the late 1980s levels (see also Recruitments section below). Cause(s) for these weak cohorts is still unknown, whether it be a reflection of oceanographic and/or fish availability changes, or it be an indication of a consequence of fishing pressure.

Age compositions of nominal CPUE obtained from RTMP in 2011 were plotted in Fig. 1-4. Past years' data are shown for comparison. CPUEs for about age 4 to 7 fish of recent two or three years were higher than that of the previous years. This occurred in most Area/month strata. These fish corresponded to cohorts come after the weak recruitments of which the acoustic monitoring survey had detected drastic declines between 1999 and 2002 (see Fig. 3-1). Corresponding to these weak cohorts, substantial CPUE reductions of age 4 to 11 fish were detected, especially in Area 4 and 7 (e.g., CPUEs for age 5 to 8 fish of 2007, CPUEs for age 6 to 9 of 2008 in Fig. 1-4).

Standardized CPUE

Two GLM standardized CPUE indices of w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) were updated (Fig. 1-5) using the same method as described in Takahashi et al. (2001; see also Takahashi 2008 for correction of editorial errors in the formulae for calculating the indices). The standardization model used was the same as that of Nishida and Tsuji (1998). Estimates of CPUE indices for 2010 (the most recent year) were based on RTMP data only not on logbook, and thus should be looked at with caution as described above (Takahashi et al. 2001). These estimates may be changed when logbook data become available the subsequent year. Further, as mentioned above, recent years' CPUE must be examined carefully because Japanese longline fishery has introduced IQ system since 2006 (Itoh 2011).

Looking to trends of the recent five or six years, the w0.5 and w0.8 indices for age 3 showed increasing trends from 2005 to 2008, and then decreased for two years in a row (Fig.1-5a). Upturns for this age in 2007 and 2008 inconsistently corresponded to low recruitments of 2004 and 2005 cohorts observed respectively in the 2005 and 2006 acoustic survey of the Recruitment Monitoring Program (see Fig. 3-1), but were more or less consistent to results from the trolling survey in 2005 and 2006 (see Fig. 3-2). The 2010 indices for age 3 were lower levels than the past 5-year averages over 2005-09. The indices for the age 4 continuously increased from 2006 to 2009, and then decreased slightly in 2010 (Fig. 1-5b). Low index values for age 4 observed in 2004-2006 correspond to low recruitments (2000, 2001, and 2002 cohorts) observed in the acoustic survey conducted in 2001-2003, respectively (see Fig. 3-1). The acoustic survey was not conducted in 2004 corresponding to the 2003 cohort (Fig. 3-1). However, index values for age 3 in 2006 and for age 4 in 2007 suggested a possibility that, although its recruitment level was still low, 2003 cohort was not so weak as that of 1999-2002, showing some upturns (Fig. 1-5a and b). Furthermore, the similar upturn patterns were observed for age 4 in 2008 and 2009 corresponding to the 2004 and 2005 cohort (Fig. 1-5b) while the acoustic surveys conducted in 2005 and 2006 show low indices (Fig. 3-1). Similar increasing trend was also observed in the trolling survey in 2005 and 2006 (Fig. 3-2). The 2010 indices for age 4 were higher than the past 5-year means over 2005-09. The CPUE indices for 5 and 6&7 age groups steadily declined from 2004 to 2006, and then have shown uninterrupted increasing trends afterward (Fig. 1-5c and d). The low recruitments observed in the 2000, 2001, 2002, and 2003 acoustic survey (1999, 2000, 2001, and 2002 cohorts) corresponded to these low index values in 2004-2007 (see Fig. 3-1). Cohorts which have shown the steady increases agree with ones after these weak cohorts. All indices for age classes 5 and 6&7 in 2010 were much above the past 5-year means. The differences were much larger for age 5. CPUE index values for age 8-11 more or less kept at the same level for last several years except for 2007 (Fig. 1-5e). The 2010 indices for this age class were almost the same level as the past 5-year average for w0.8 and slightly lower than the average for w0.5. The CPUE indices for age 12+ had fluctuated around the past 5-year averages with small variances. The indices in 2010 for this age group were lower than the averages (Fig. 1-5f).

The CPUE indices for age 4+ group continuously decreased from 2004 to 2007 toward the lower level than the historical low levels observed in the late 1980s (Fig. 1-5g). Then the indices have uninterruptedly increased since 2007. The indices in 2010 for age 4+ were much higher than the past 5-year averages over 2005-09.

Fig. 1-6 shows trends of the CPUE indices for age 4+ calculated using the Core Vessel data and the standardization models agreed in the CPUE modeling Group (CCSBT 2010). The "Base" series is the one used for the operating model (OM) conditioning and management procedure (MP) inputs in the SC. Other two series, namely "Reduced Base" and "Base with SxS," will be used for monitoring to check if there is any unexpected thing happened to both SBT and the fishery along with the Base series. The trends of these indices had patterns similar to that of the CPUE indices using the Nishida and Tsuji model and all vessel data presented above (Figs. 1-5g and 1-6).

<u>Spatial-Temporal (ST) windows CPUE and Laslett Core Area CPUE for age 4+</u>

“Spatial-temporal (ST) windows” CPUE index for age 4+ (Takahashi et al. 2002) was also updated using the new method as described in Takahashi (2006). “ST windows” represents Area 9/May and June, and Area 8/September and October. By inspecting historical Japanese longline catch/effort data, these spatiotemporal strata were so defined as to persistently observe substantial effort of the longline fishery. A trend of the “ST windows” is shown in Fig. 1-7. The updated index more or less has kept the same level ranging between 0.5-1.0 index values the past 20 years. For the last five years, the index stays at levels lower than or same as the historical low levels observed in the late 1980s. The index value in 2010 was same as the past 5-year average over 2005-09.

“Laslett Core Area” applies another concept, based upon different criteria from ST windows, that is to define and extract spatiotemporal strata in which longline fishing has consistently been occurred, and CPUE data for these strata are used to derive abundance indices by utilizing smoothing splines (Laslett 2001). Trend of the Laslett Core Area CPUE showed almost the identical pattern to that of w0.5 and w0.8 indices for age 4+ (Figs. 1-5g, 1-6, and 1-8). The 2010 index was higher than the past 5-year average.

Both ST windows and Laslett Core Area series have been used for robustness tests of MP development in the SC and would be used for monitoring purposes because the two series can be considered as an envelope for the "Base" series (see above), given they have formed the recent upper and lower bounds of other CPUE-based series (CCSBT 2010).

2. Australia purse seine fishery:

Changes of catch per efforts and age composition of Australia purse seine fishery catches were plotted in Fig. 2-1 and 2-2. Although interpretation of the CPUE of this fishery is contentious, monitoring changes of the CPUE merits having some insight into status of juvenile fish. Both catch per shot and catch per searching hours appear to be gradually declining from 1999/00 to 2008/09 seasons (Fig. 2-1). In part, this decline of juvenile fish probably corresponds to recent low recruitments that were observed in the acoustic survey index and Japanese longline CPUE (see Fig. 1-1, 1-4, and 1-5 for the longline, and Fig.3-1 for the acoustic survey). There were large upturns of the CPUE observed in last two seasons. Both CPUEs in 2009/10 season were higher than the past 5-year means over 2005-09.

Proportions for age 1 and 2 fish combined between 2004 (03/04 season) and 2009 (08/09 seasons) were greater than any for previous years (Fig. 2-2). Contrary, proportions for age 3 and 4 decreased for the same years. In 2010, the age compositions decreased for age 1 and 2, and increased for age 3 and 4. Other than that, no strong signal was observed in age composition of the purse seine catches. It should be noted that applying cut points of the new growth curve made almost all age 1 fish proportions disappear from the age composition chart. This is because fish being classified as age 1 by the previous growth curve are now categorized as age 2 by the new growth curve.

Trends of both the aerial and commercial spotting (SAPUE) survey indices in the Great Australian Bight (GAB) are shown in Fig. 2-3 (Farley and Basson 2011, Eveson et al. 2011). These indices monitor surface abundance of age 2-4 fish combined distributed in the GAB region. The aerial surveys have been conducted by Australia under the Recruitment Monitoring Program since 1993. Full scale line transect aerial surveys were suspended between 2001 and 2004. Although a limited number of lines was continued to be surveyed during this period, it was concluded that the indices of limited scale survey were not able to provide information comparable to the full scale aerial survey. Overall the aerial survey index showed moderately declining trend from 1993 to the early 2000s. The index values were more or less stable in the rest of the 2000s. The index increased in 2010 and 2011, two years in a row. The 2011 value was well above the past 5-year average over 2006-10 and the similar level to the 1993 estimate. An overall trend of SAPUE appears to be increasing during 2004-2011 period. The 2011 SAPUE was also well above the past 5-year average.

3. Recruitments:

<u>Acoustic survey</u>

Acoustic survey of the Recruitment Monitoring Program is aimed to monitor changes in relative abundances of age 1 fish moving through the survey area in the southwestern coast of Australia. This index represents the age 1 fish abundance within the survey area standardized with 15 days' survey period. The index showed a drastic decline in 2000 and stayed at very low level in 2002 with a very slight upturn from 2001 level, then became non-estimative level because of lack of records identified as SBT with a certain estimated biomass with sonar (Fig. 3-1). No field activities were conducted in 2003/2004 season, and the survey ended in the 2005/2006 season.

As explained above, cohorts showing extreme low abundance levels in the 2000, 2001, 2002, 2003, 2005, and 2006 surveys are now available to Japanese longline fishery and mostly showing substantially low CPUE (see Fig. 1-1, 1-4 , and 1-5). It has been common understanding in the CCSBT SC that the recruitment trend detected by the acoustic surveys reflected the real situation, and we have seen at least four years' low longline CPUEs coming in sequence which were resulted from low recruitments of 1999, 2000, 2001, and 2002 cohorts (corresponded to cohorts detected by the 2000-2003 surveys). This has caused devastative impacts on both SBT stock and longline fishery. However, there is some inconsistency observed for 2004 and 2005 cohorts. CPUE indices for age 3 in 2007 and 2008, for age 4 in 2008 and 2009, and for age 5 in 2009 and 2010 were apparently at the same levels of or higher than that of the late 1990s and the early 2000s (Fig. 1-5a, b, and c) whereas the 2005 and 2006 acoustic surveys indices indicated low recruitments (Fig. 3-1). Further, although we tend to assume that 2003 cohort (not acoustic-surveyed) was similarly weak because the acoustic survey indices of previous and following years' indicate low recruitments (Fig. 3-1), corresponding CPUEs for age3 in 2006, for age 4 in 2007, for age 5 in 2008, and for 6&7 age class in 2009 and 2010 showed upturns (Fig. 1-5a, b, c and d), suggesting that the 2003 cohort may not be so weak as the previous ones. Thus, considering such uncertainty about recruitment we need to monitor these indicators synthetically and carefully for next several years.

The Recruitment Monitoring acoustic survey ended in the 2005/2006 season due to budget matter and is replaced by much lower-cost trolling survey to monitor relative abundance of age 1 fish (see below).

Trolling survey

Since a vast amount of costs was necessary for conducting the Recruitment Monitoring acoustic surveys, a recruitment index of age 1 fish estimated from results of much lower-cost trolling surveys has been currently being developed. Details of survey design, estimation method, results and its interpretation are documented in Itoh (2007) and Itoh et al (2011). Fig. 3-2 illustrates trends of the trolling catch indices. Cohorts of 1999, 2000, and 2001 (2000, 2001, and 2002 surveys) showed considerably low levels of recruitment. These low recruitment levels were consistent with the ones observed in results of the acoustic surveys (see Fig. 3-1). In contrast, the trolling indices for 2002, 2004, and 2005 cohorts (2003, 2005, and 2006 surveys) inconsistently showed higher levels of recruitment than the acoustic survey did. However, increased levels of the 2004 and 2005 cohorts were compatible with upturns observed in longline CPUE indices for age 3 fish in 2007 and 2008, for age 4 in 2008 and 2009, and for age 5 in 2009 and 2010 (see Fig. 1-5a, b, and c). No survey was conducted in 2004, so any speculation on recruitment status of 2003 cohort could not be drawn from the trolling catch index. Median trend of the trolling catch indices of bootstrap sampling increased from 2005 to 2008, declined toward 2010, and then upturned in 2011 although bootstrapped 5% and 95% quantiles estimates were quite wide.

Levels of trolling indices are consistent with that of other indices (e.g., acoustic indices, Japanese longline CPUE) for some years. Thus, some usefulness of the indices to monitor age 1 recruitment is recognized. Reliability of the trolling indices is still being verified and it is necessary to compare these indices with CPUE for corresponded cohorts recruited into longline fishery for further verification. The trolling indices may not be used as rigorous quantitative indicators for recruitment. However, they can be used as indicators to detect some qualitative signals of the recruitment level, indicating one such as “high”, “medium”, or “low.”

4. Indonesian Catch (Spawning ground fishery) :

Indonesian SBT catch both in number and weight as well as catches by two age groups, age 8-16 and age 17 and older, changed between years (Fig. 4-1).

Catches for age class 17+ were higher than ones for 8-16 ages throughout the 1990s. In contrast, many of yearly catches for the 17+ group have become similar to or lower than ones for 8-16 ages since 2000/01 season. A marked increase of catch in 2001/02 season may mainly be due to large increase of younger age classes. Then, catches drastically decline in 2002/03 and 2003/04 seasons without change in the age composition pattern for 2001/02. No information available to conclude whether this decline reflected changes in fish abundance or changes in fishing practices. In 2004/05 season, another large increase of catch occurred, similar to that observed in 2001/02. Again catch dropped in 2005/06 and kept more or less stable afterward. Low levels of the older portion of spawning stock in recent years and potentially low reproduction give some concerns.

5. Overall Conclusion:

Fisheries indicators examined generally support a view that current stock levels for 4, 5, and 6&7 age groups are higher than ones observed in the late 1980s, which are the historically lowest levels. Looking at recent years only, CPUE indices for these age classes showed increasing trends. Standardized CPUE for age 3 increased from 2005 to 2008, and then decreased for two years in a row. Other age classes, 8-11 and 12+

tended to keep at the same level after 2003 with some variability. Current stock levels for these age groups, however, are still low similar to ones observed in past. Many indicators suggested considerable low recruitments in past years but differ in indication of how low they were. The acoustic indices suggested continuous low recruitments for four years (the 2000-2003 acoustic surveys corresponding to the 1999-2002 cohorts). Agreed with these results of the surveys, longline CPUE indicators suggested considerable decline of recruitments of 1999-2002 cohorts. However, there are some inconsistencies in recruitment level observed in comparisons between some indicators and the results of the 2005 and 2006 acoustic surveys (corresponding to the 2004 and 2005 cohorts). In addition, while low level of recruitment for cohorts of 1999, 2000, and 2001 was observed in the acoustic survey and the trolling survey, the trolling indices for the 2002, 2004 and 2005 cohorts showed higher levels of recruitment than the acoustic survey indices. The longline CPUE indices (of both nominal and standardized) for age 3 in 2007, for age 4 in 2009, and for age 5 in 2009 and 2010 showed large upturns. Whether these large positive upturns were caused by increase of stock abundance and/or the introduction of individual quota system into Japanese longline fishery is still unknown. In addition to these positive upturns of small fish CPUE observed in the longline fishery, recruitment indicators based upon the trolling survey, the aerial and commercial spotting surveys, and purse seine CPUE all suggested increases of juvenile fish in recent years. Considering uncertainty inherent in the indicators, further careful monitoring and examining both fishery-dependent and fishery-independent indicators are continuous tasks with high priority.

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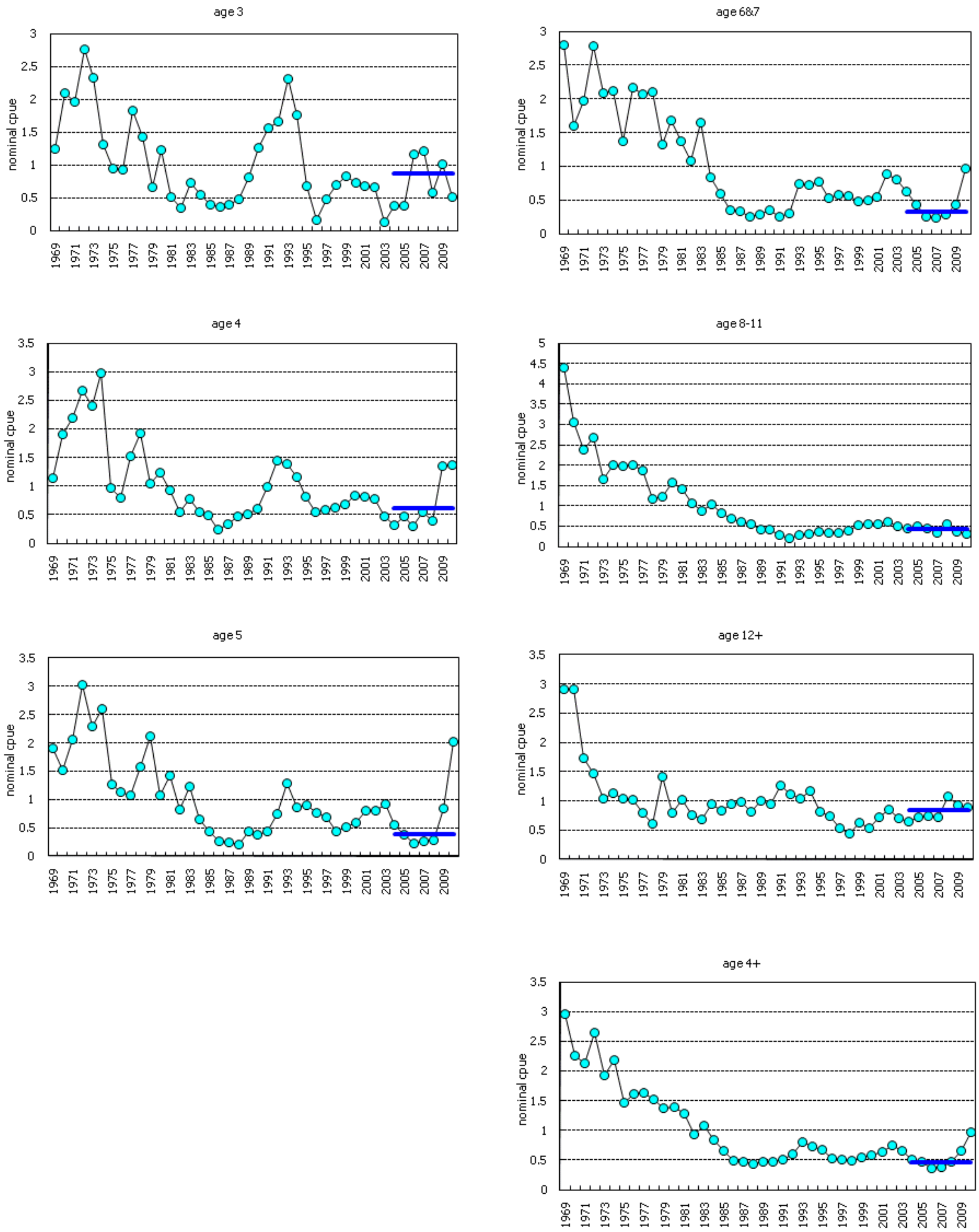


Fig. 1-1. Nominal CPUE of Japanese longline fishery by age groups. The horizontal lines indicate the past 5-year averages over 2005-09.

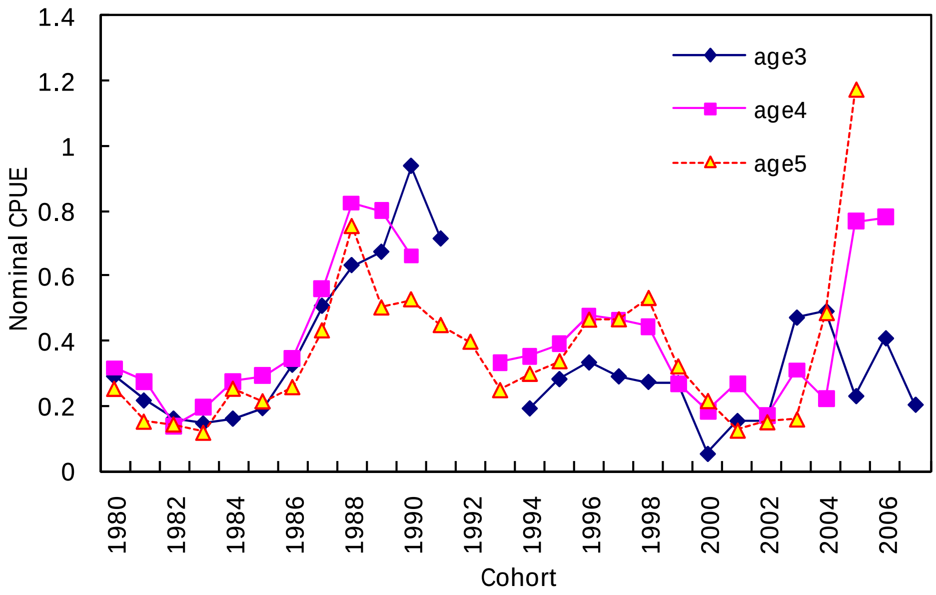


Fig. 1-2. Nominal CPUE of Japanese longline fishery by cohorts for age 3, 4, and 5.

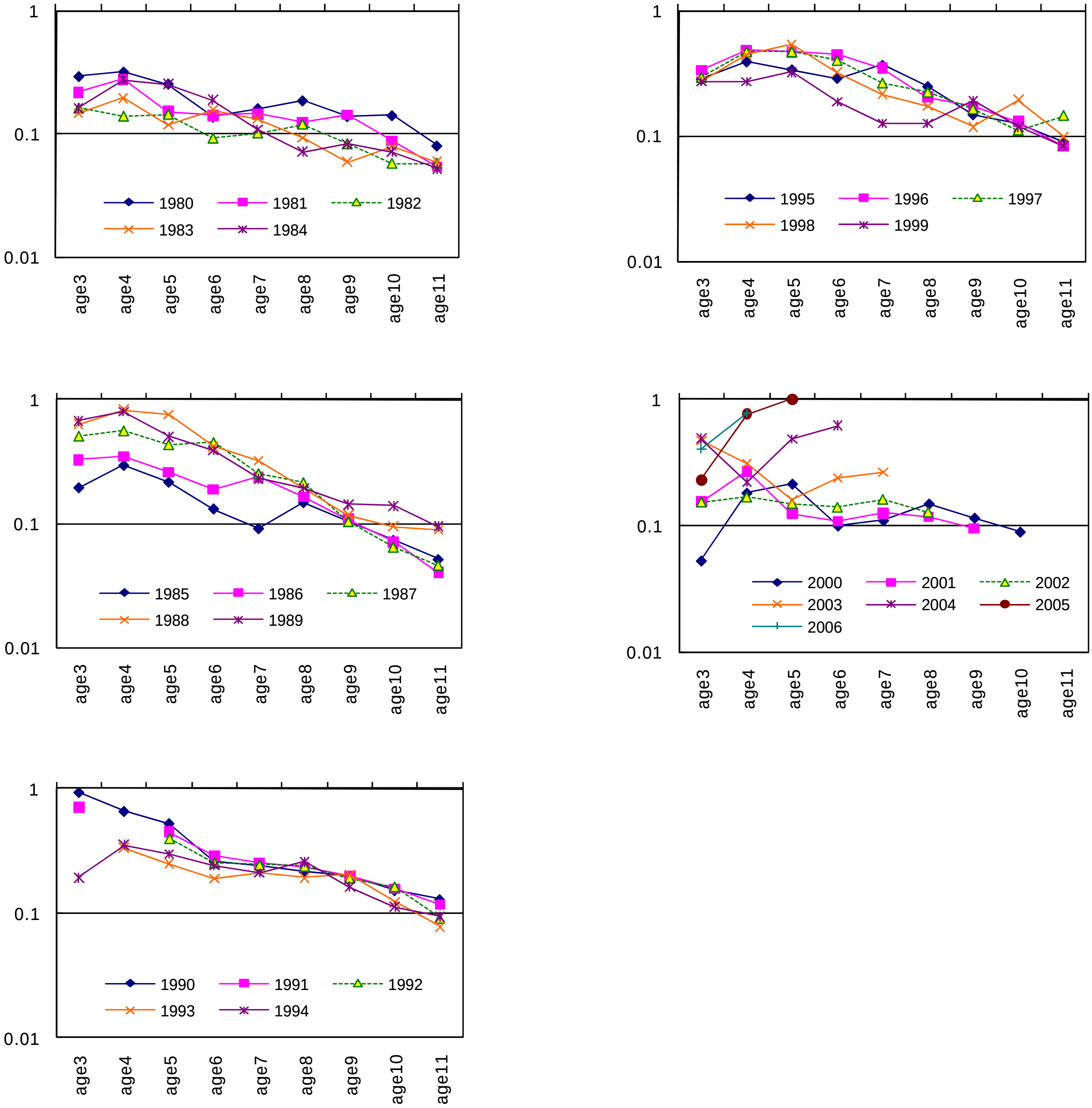


Fig. 1-3. Nominal CPUE of Japanese longline fishery by cohorts in log-scale.

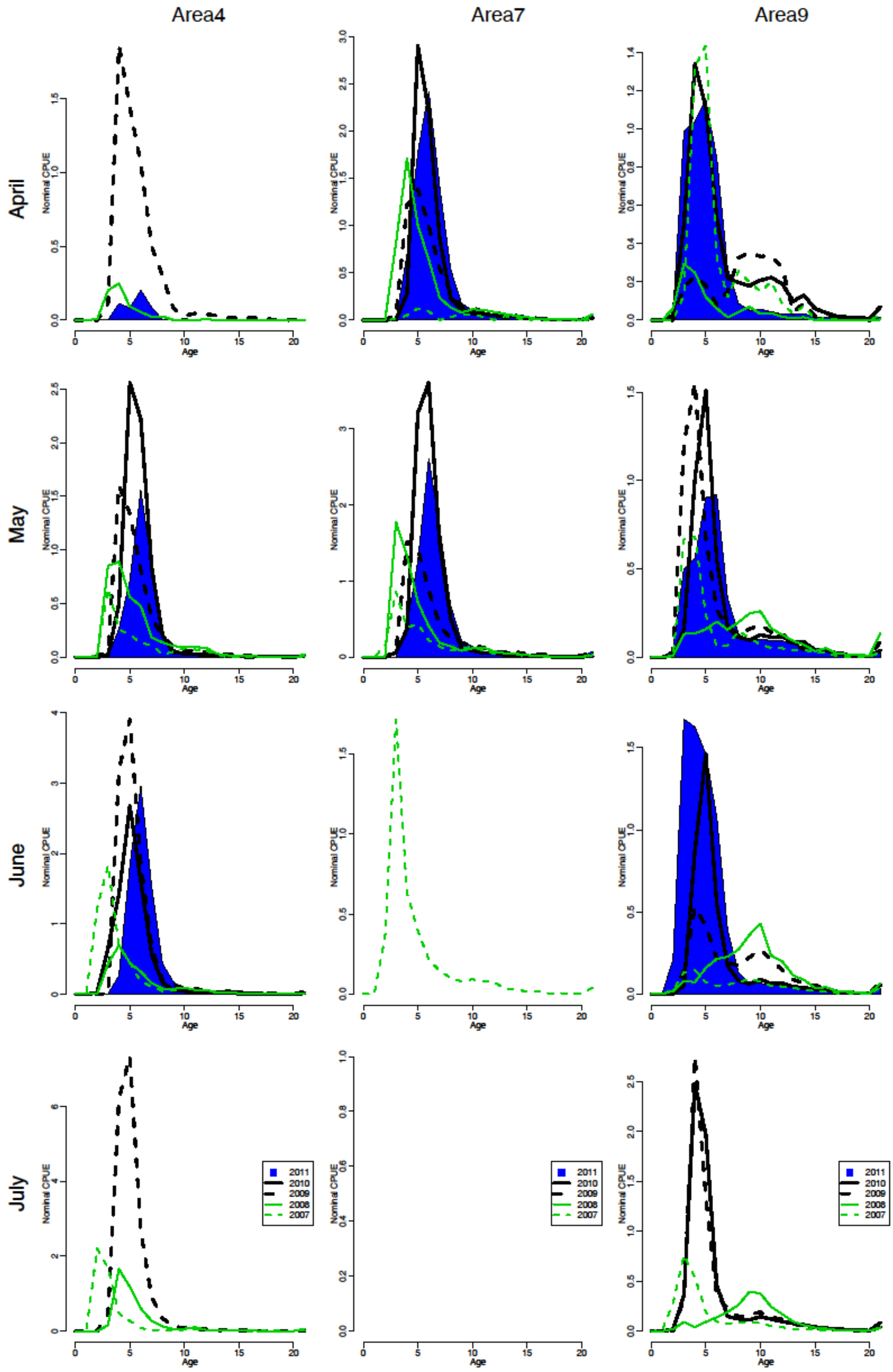


Fig. 1-4. Age composition of nominal CPUE of RTMP data for recent five years by month and areas.

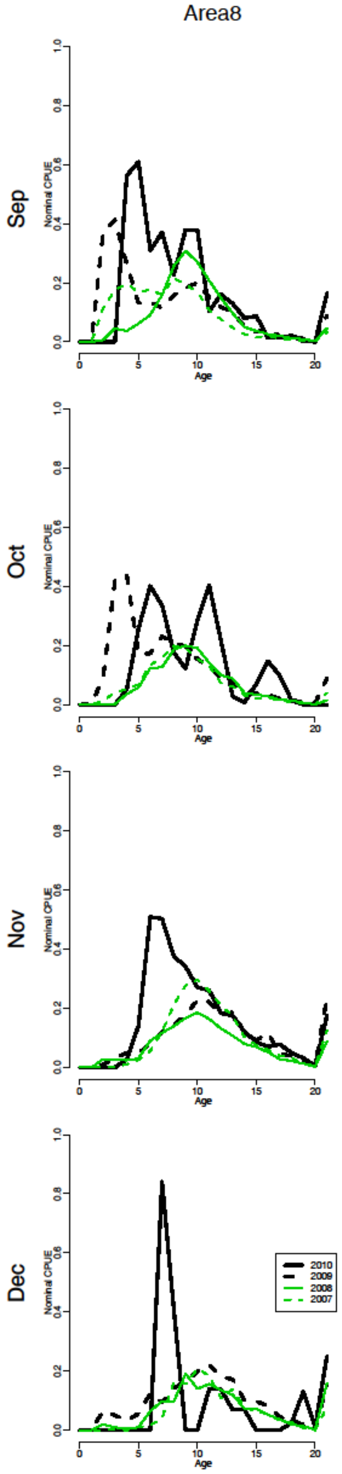
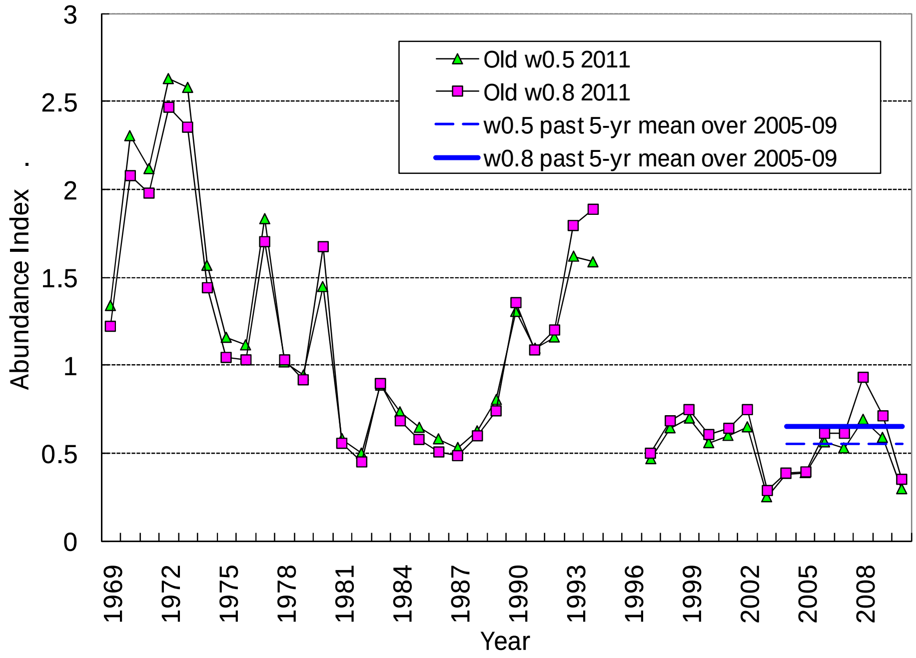


Fig. 1-4 (cont'd). Age composition of nominal CPUE of RTMP data for recent four years by month and areas.

(a) Age 3



(b) Age 4

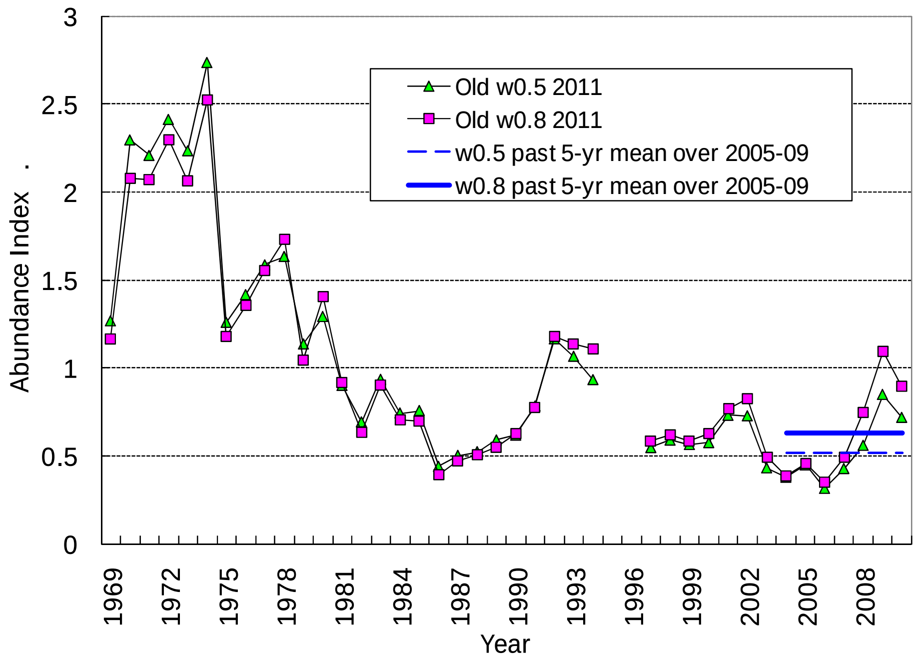
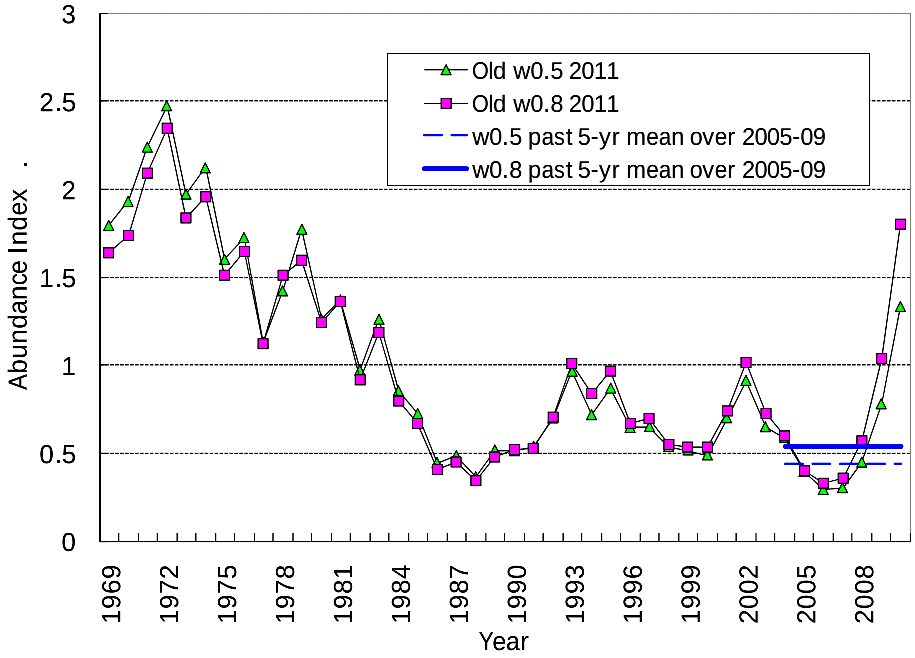


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998).

(c) Age 5



(d) Age 6&7

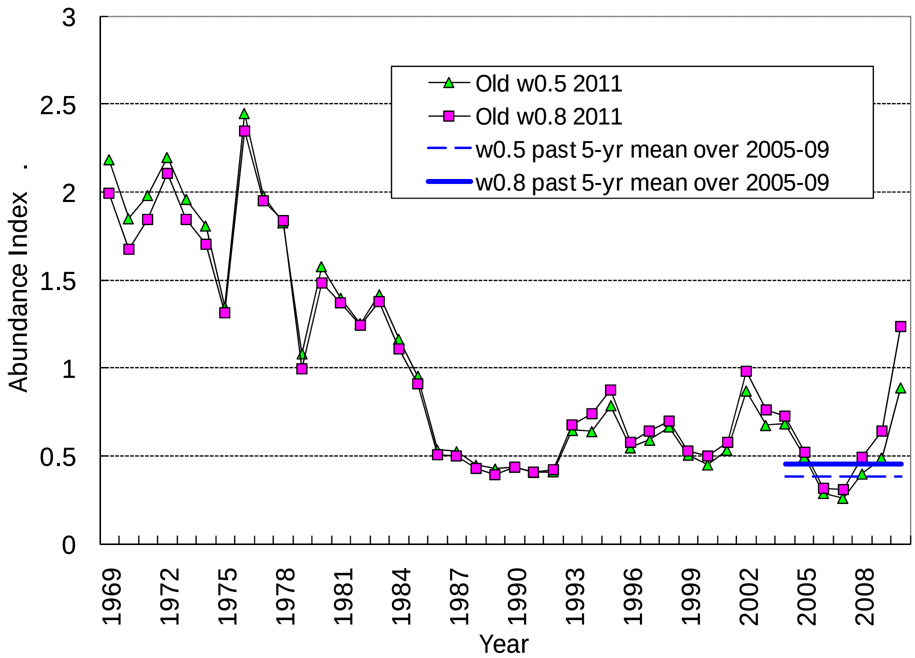
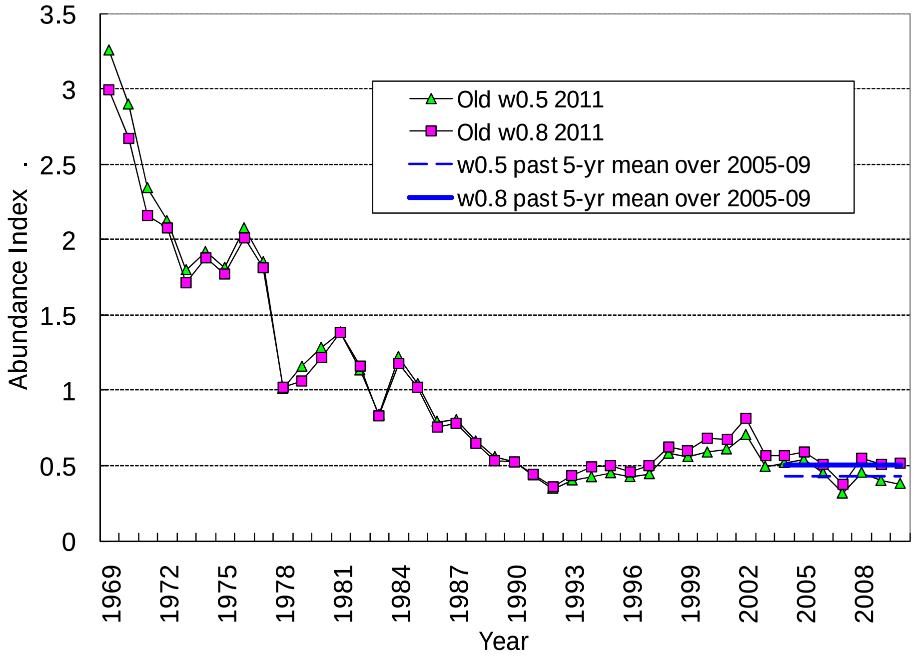


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)

(e) Age 8-11



(f) Age 12+

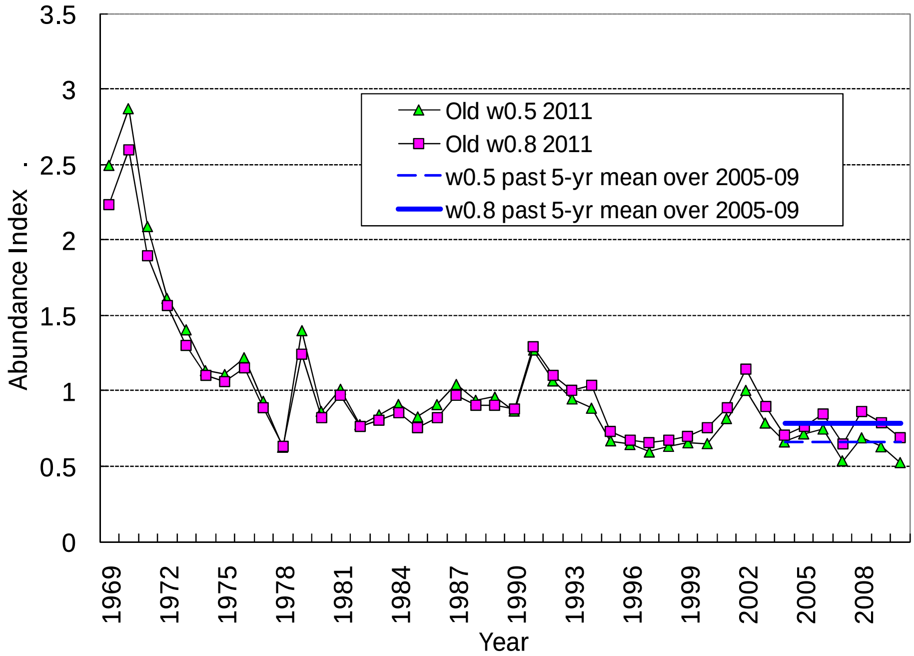


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)

(g) Age 4+

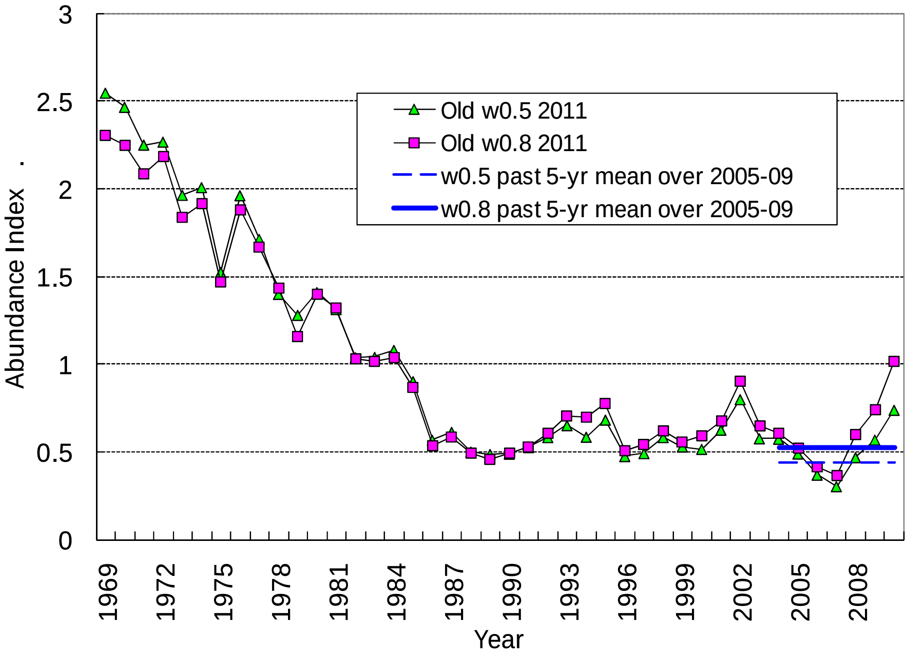
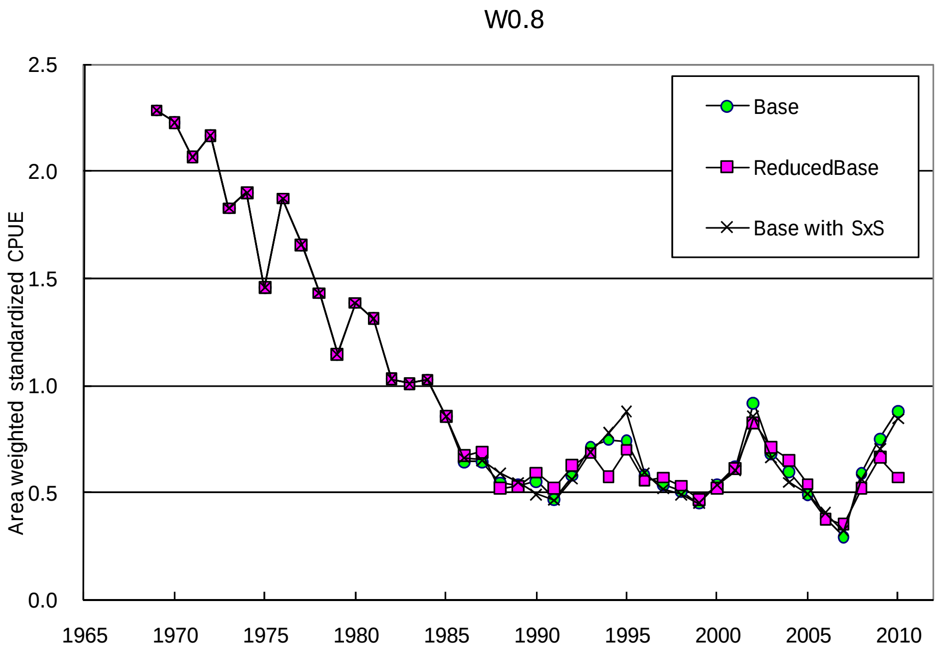


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. The standardization model used was the same as that of Nishida and Tsuji (1998). (cont'd)



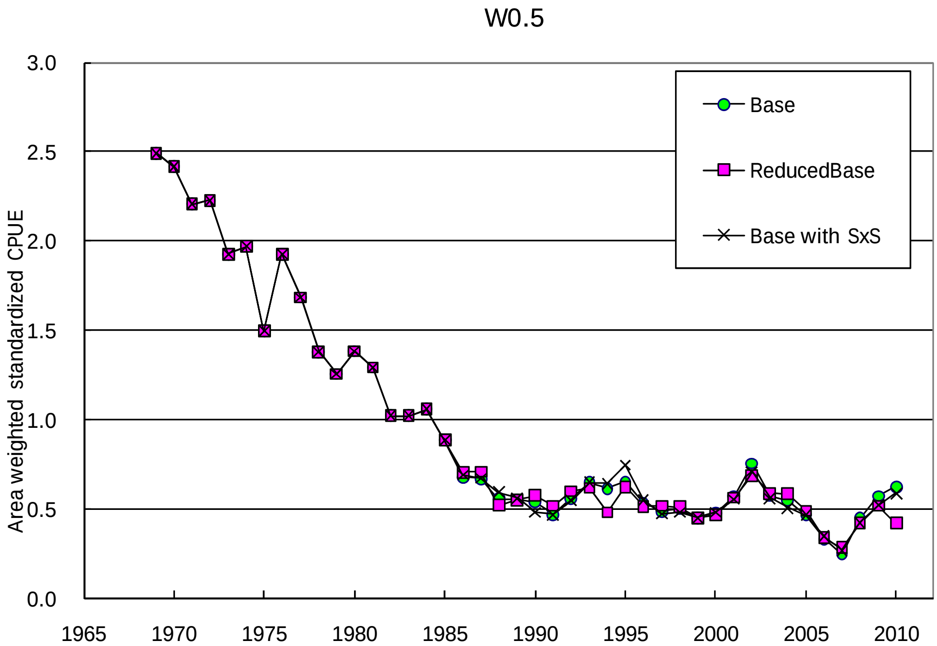


Fig. 1-6. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices using the Core Vessel data. The standardization models used were the ones agreed in the CPUE Modeling Group (CCSBT 2010).

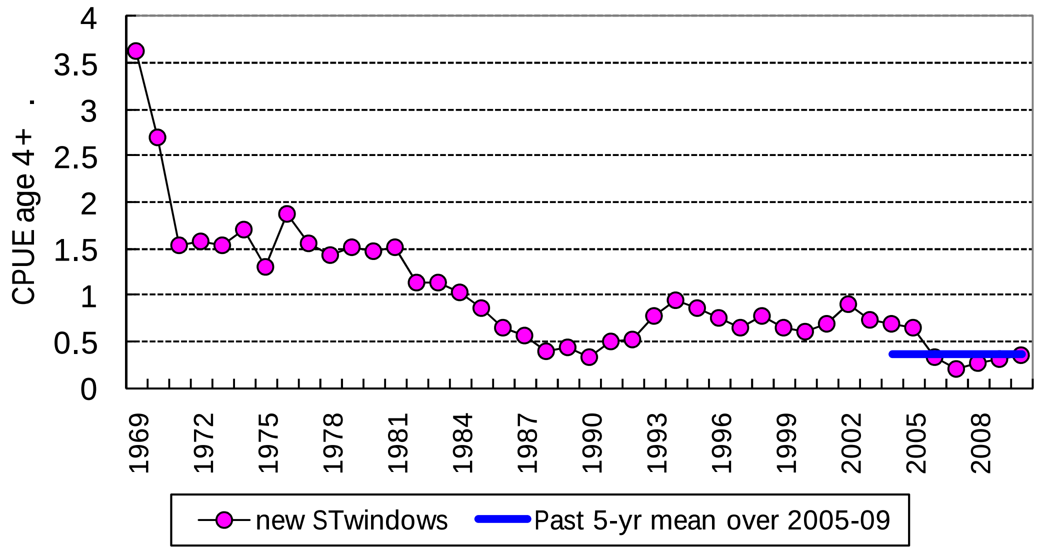


Fig. 1-7. Trend of normalized “ST Windows” index for age 4+ fish by the new calculation method.

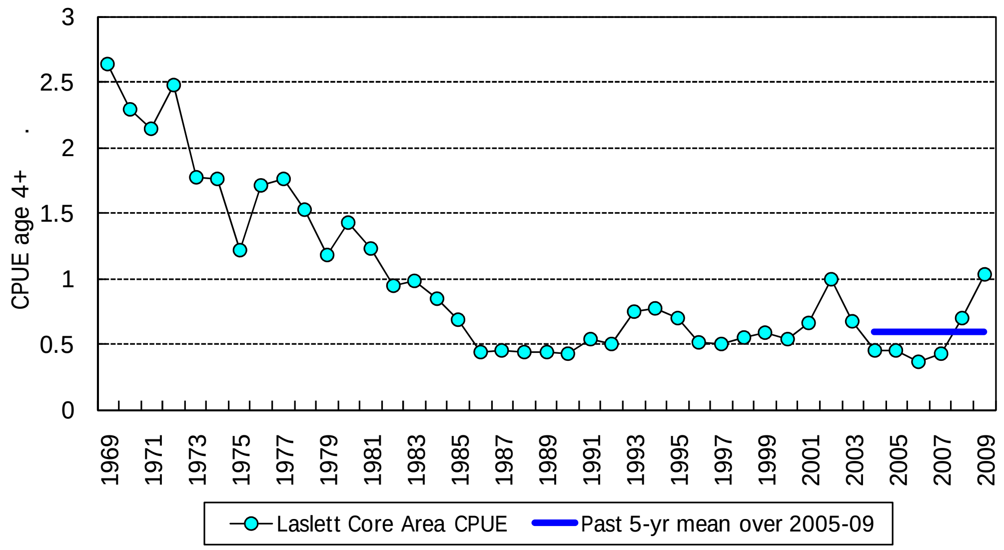


Fig. 1-8. Trend of normalized Laslett Core Area CPUE index for age 4+ fish.

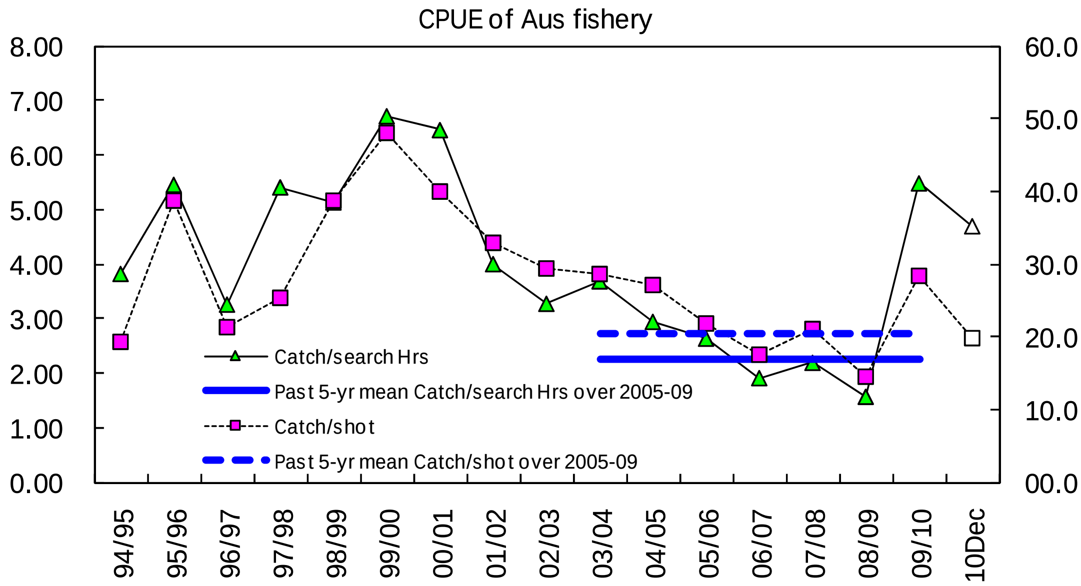


Fig. 2-1 Catch by efforts for Australia purse seine fishery.

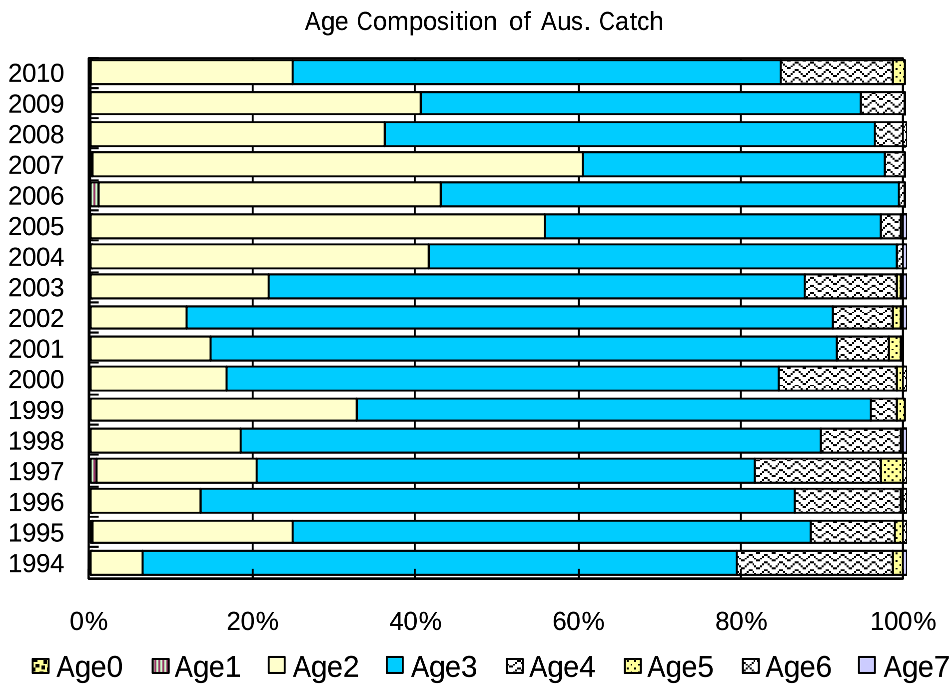


Fig. 2-2 Changes in age composition of Australia purse seine catches.

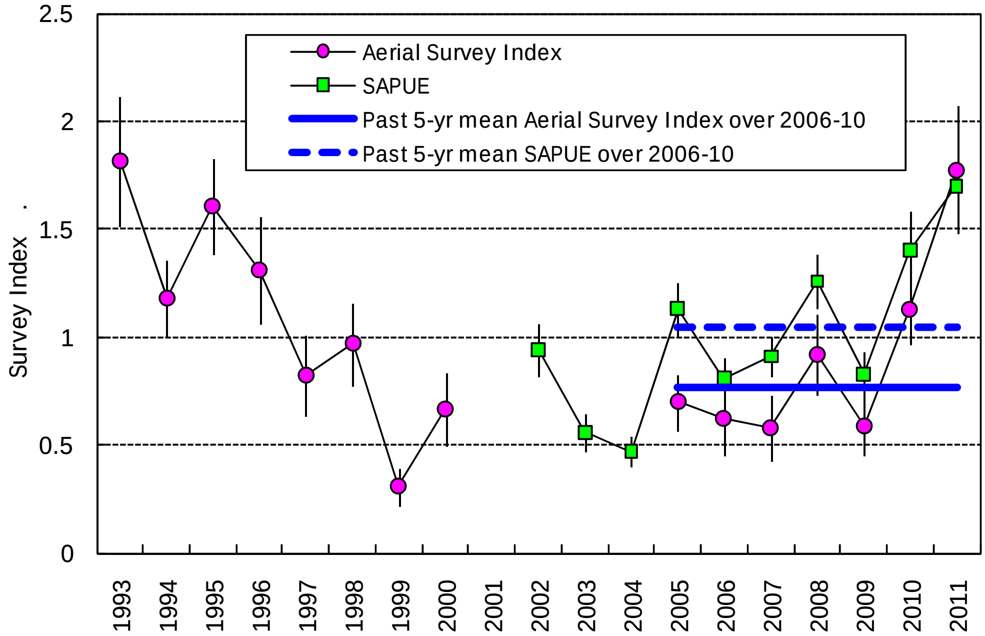


Fig. 2-3 Changes in aerial and commercial spotting (SAPUE) indices in the Great Australian Bight. Vertical bars indicate standard errors.

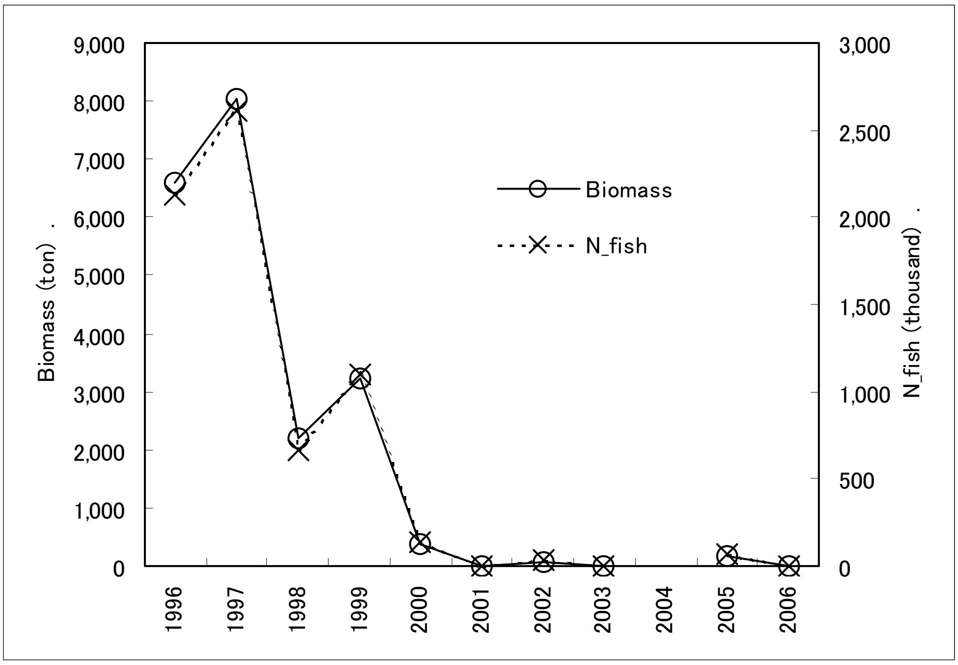


Fig. 3-1. Trends of acoustic index of age 1 SBT in the Western Australia. The acoustic survey ended in the 2005/2006 season (shown as “2006” in the figure).

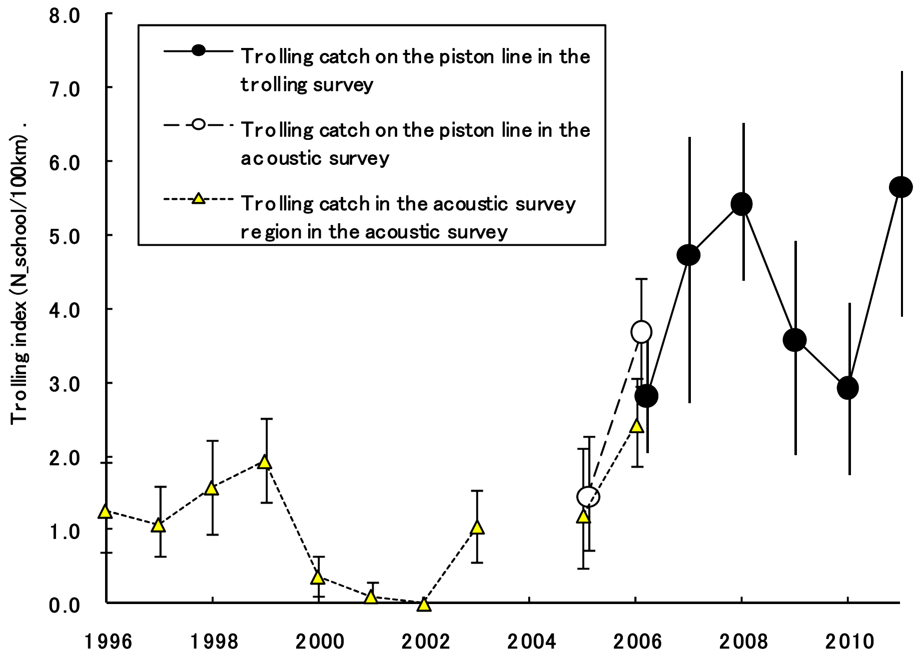


Fig. 3-2. Trends of trolling catch index of age 1 SBT in the Western Australia.

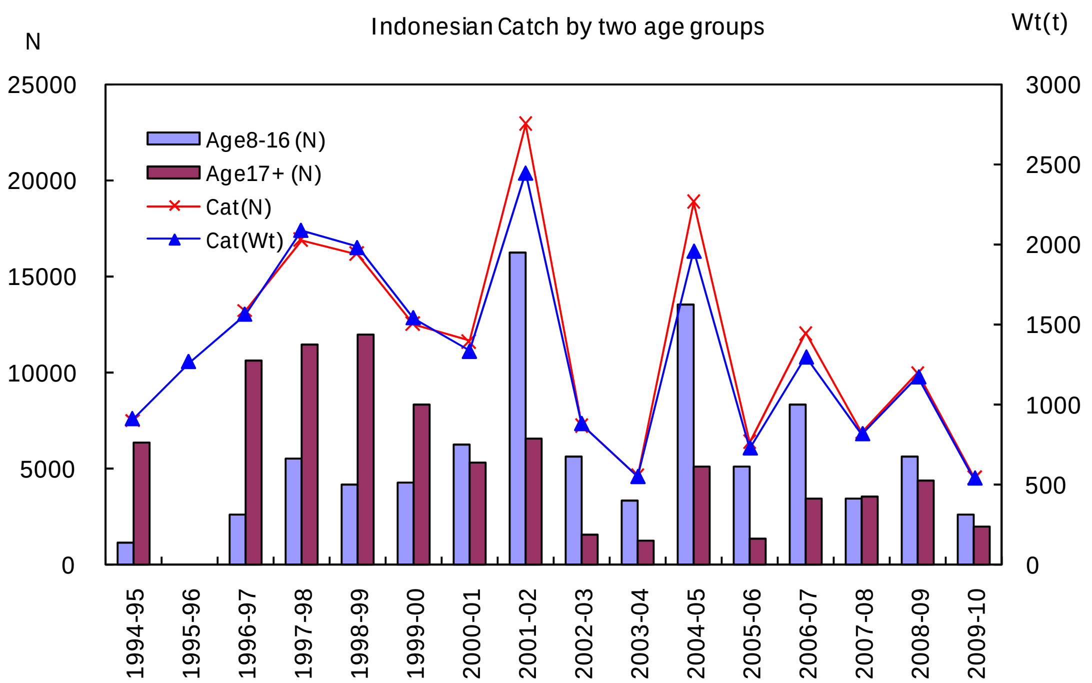


Fig. 4-1. Trends of Indonesian catches with proportion of two age groups occurrences.