SUMMARY OF FISHERIES INDICATORS IN 2010

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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 3, 4, 5, 6&7 age groups are above that observed in the late 1980s, which are the historically lowest levels. When looking to recent years, CPUE indices for these age classes showed increasing tendencies. 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 (RMP) 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 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. Thus, 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 3、4、5、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上にあることを示している。近年を詳しく見ると、これら年齢クラスの CPUE 指数は増加傾向を示している。その他の年齢クラスである、8-11 及び 12+は、2003 年以降、同じようなレベルを保っている傾向であった。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（RMP）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。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 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 Extended Scientific Committee (ESC) 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.

1. Japanese longline CPUE:

Nominal CPUE

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 is found in recent years because the RTMP covers more than 95% of efforts in SBT distribution.

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 (2010).

When focusing on trends for the recent five or six years, nominal CPUEs for age classes 4, 8-11, and 12+ were more or less stable, except that the 2009 (the most recent year) values for age 4 and 12+ were largely above the past 5-year averages over 2004-08. Although age classes 5 and 6&7 had declined since the early 2000s hitting the bottom in 2006, recent CPUE trends for these ages showed increasing tendencies. The 2009 values for these ages were also higher than the past 5-year averages. CPUE for age 3 was variable past several years but showed an increasing trend. The 2009 value for this age was slightly higher than the past 5-year mean. Observed 2009 high catch rates for age 4 and 5 in Statistical Area 4, 7, and 9 caused marked upturns of CPUE for these ages in the most recent year as explained below (Sakai et al. 2010).

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 (Fig. 1-2).

Overall levels of CPUE by cohort after 1990 were higher than that of cohorts recruited in pre1990 years, except for 1999, 2000, 2001, and 2002 cohorts (Fig. 1-3). The 1986-1991 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 pre1986 years and less structured management schemes at that time. The cohorts recruited from1992 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 1999-2002 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 were plotted in Fig. 1-4. Past years' data are shown for comparison. As explained in other CPUE indicators sections, it has been reported that substantial CPUE reductions of age 3 and 4 fish were detected in past, especially in Area 4 and 7 (e.g., CPUE for age 4 fish of 2006 in Fig. 1-4). These fish showing the considerable CPUE reduction corresponded to the same cohort that the acoustic monitoring survey had detected drastic declines of recruitment level since 2000 (see Fig. 3-1). The plots of Fig. 1-4 showed that many of CPUEs for age 3, 4, or 5 in those Areas had increased after the weak cohorts (e.g., CPUE for age 3 in 2007 and subsequent ages).

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 2009 (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 2010).

Looking to trends of the recent five or six years, the w0.5 and w0.8 indices for age 3 indicated increasing trends (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 (RMP) (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 2009 indices for age 3 were similar levels to the past 5-year averages over 2004-08. Trends for the age 4 indices kept the same levels between 2004 and 2006, and then increased afterwards (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 of the Recruitment Monitoring Program (RMP) 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 2009 indices for age 4 were much higher than the past 5-year means over 2004-08. The CPUE indices for 5 and 6&7 age groups steadily declined from 2004 to 2006, and then showed increasing trends (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). All indices for age classes 5 and 6&7 in 2009 were above the past 5-year means. The differences were much larger for age 5. Trends of CPUE for age 8-11 kept at the same level for last several years except for 2007 (Fig. 1-5e). The 2009 indices for this age class were almost the same levels as the past 5-year averages. The CPUE indices for age 12+ had fluctuated with small variance having kept almost the same levels since 2004. The indices in 2009 for this age group were higher than the past 5-year 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). And then there were drastic upturns observed in 2008 and 2009. The indices in 2009 for age 4+ were above the past 5-year averages over 2004-08.

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

“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. 1-6. 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 three years, the index stays at lower level than the historical low levels as in the late 1980s. The index value in 2009 was slightly below the past 5-year average over 2004-08.

"Laslett Core Area" is another concept, based upon different criteria from ST windows, 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 applying 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+ (Fig. 1-5g and Fig. 1-7). The 2009 index was much higher than the past 5-year average.

2. Australia surface fishery:

Changes of catch per efforts and age composition of Australia surface fishery catches were plotted in Fig. 2-1 and 2-2. Although interpretation of catch per efforts of the surface 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 2007/08 seasons (Fig. 2-1). This decline of juvenile 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). Both CPUEs in 2008/09 season were lower than the past 5-year means over 2004-08.

Proportions for age 1 and 2 fish aggregated for the recent five years (2005-2009) are greater than any for previous years (Fig. 2-2). Contrary, proportions for age 3 decreased for the same years except for 2008 and 2009. A small proportion for age 1 appears in 2005-2009 while there was no age 1 fish appeared during 2002-2004. In 2004-2009, proportions of age 4 are low relative to past years. Other than that, no strong signal was observed in age composition of surface catches.

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 2010, Eveson et al. 2010). 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 (RMP) 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 shows moderately declining trend throughout the survey period. The index values are more or less stable in recent years. The 2010 value was well above the past 5-year average over 2005-09. An overall trend of SAPUE appears to be increasing slightly during 2002-2010 period. The 2010 SAPUE was also well above the past 5-year average.

3. Recruitments:

Acoustic survey

Acoustic survey of the Recruitment Monitoring Program (RMP) 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 ESC 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 were apparently at the same levels of or higher than that of the late 1990's and the early 2000's (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 showed upturns (Fig. 1-5a and b), 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 RMP 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 RMP 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 and Sakai (2010). 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 (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 increased from 2005 to 2008, then declined toward 2009.

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).

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 afterwards. 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 3, 4, 5, 6&7 age groups are above that observed in the late 1980s, which are the historically lowest levels. Looking at recent years only, CPUE indices for these age classes showed increasing tendencies. 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 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 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. Thus, further careful monitoring and examining both fishery-dependent and fishery-independent indicators are continuous tasks with high priority.

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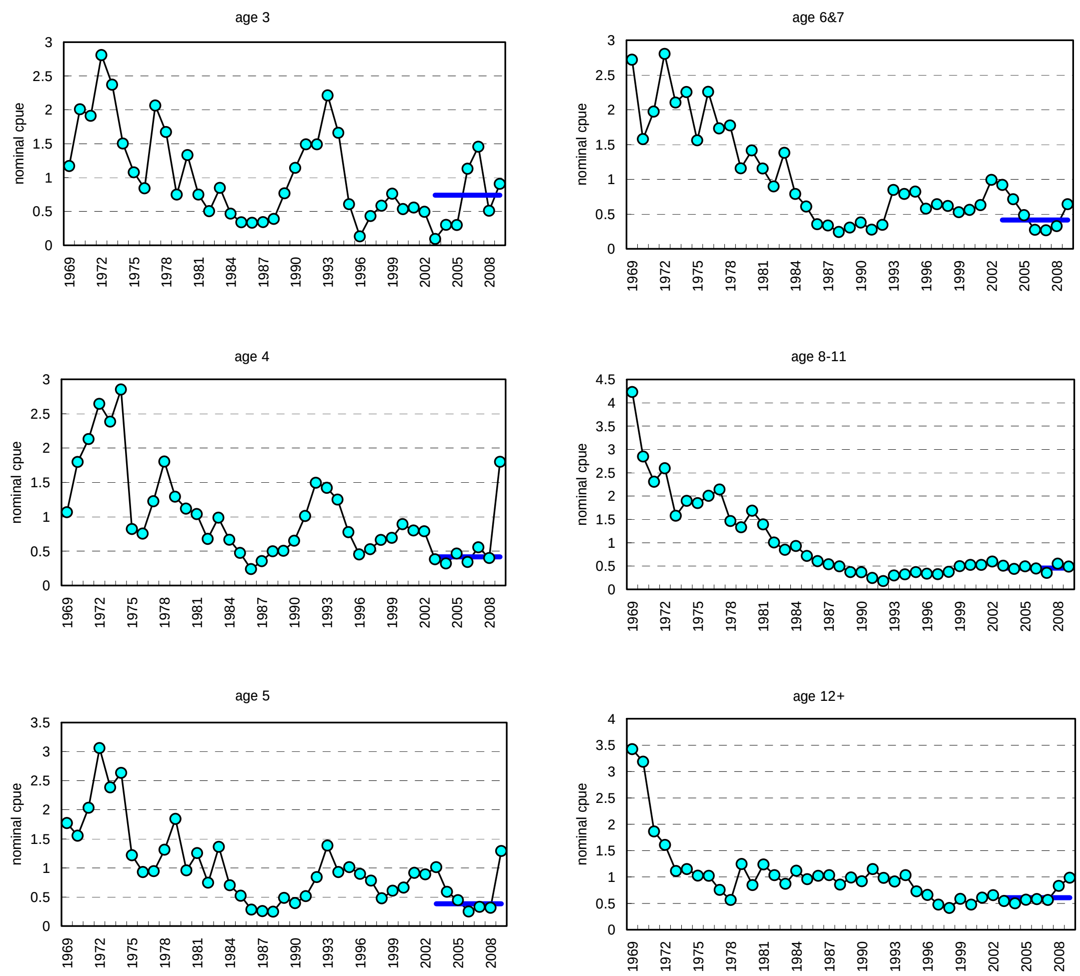


Fig. 1-1. Nominal CPUE of Japanese longline fishery by age groups. The horizontal lines indicate the past 5-year averages over 2004-08.

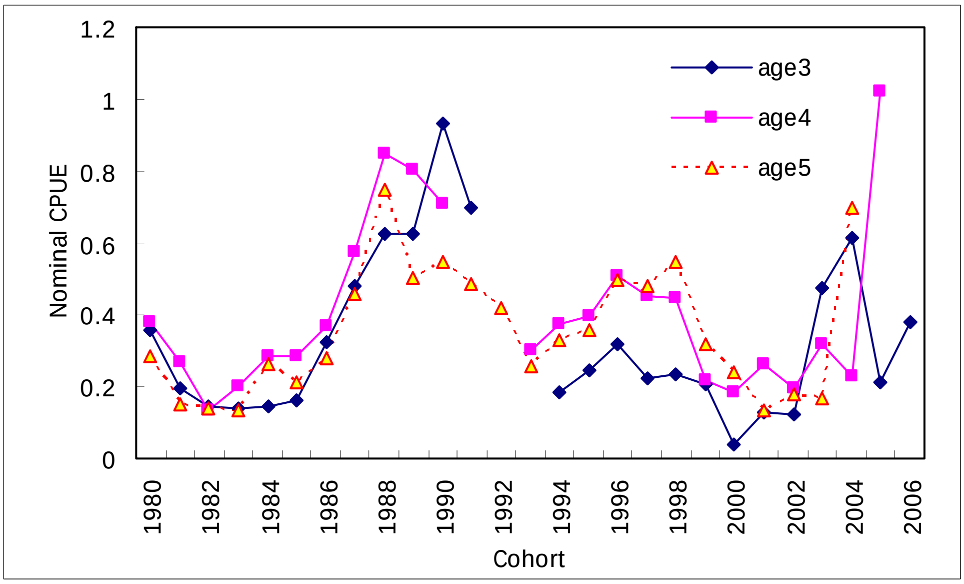


Fig. 1-2. Nominal CPUE of Japanese longline fishery by cohorts for age 3, 4, and 5.

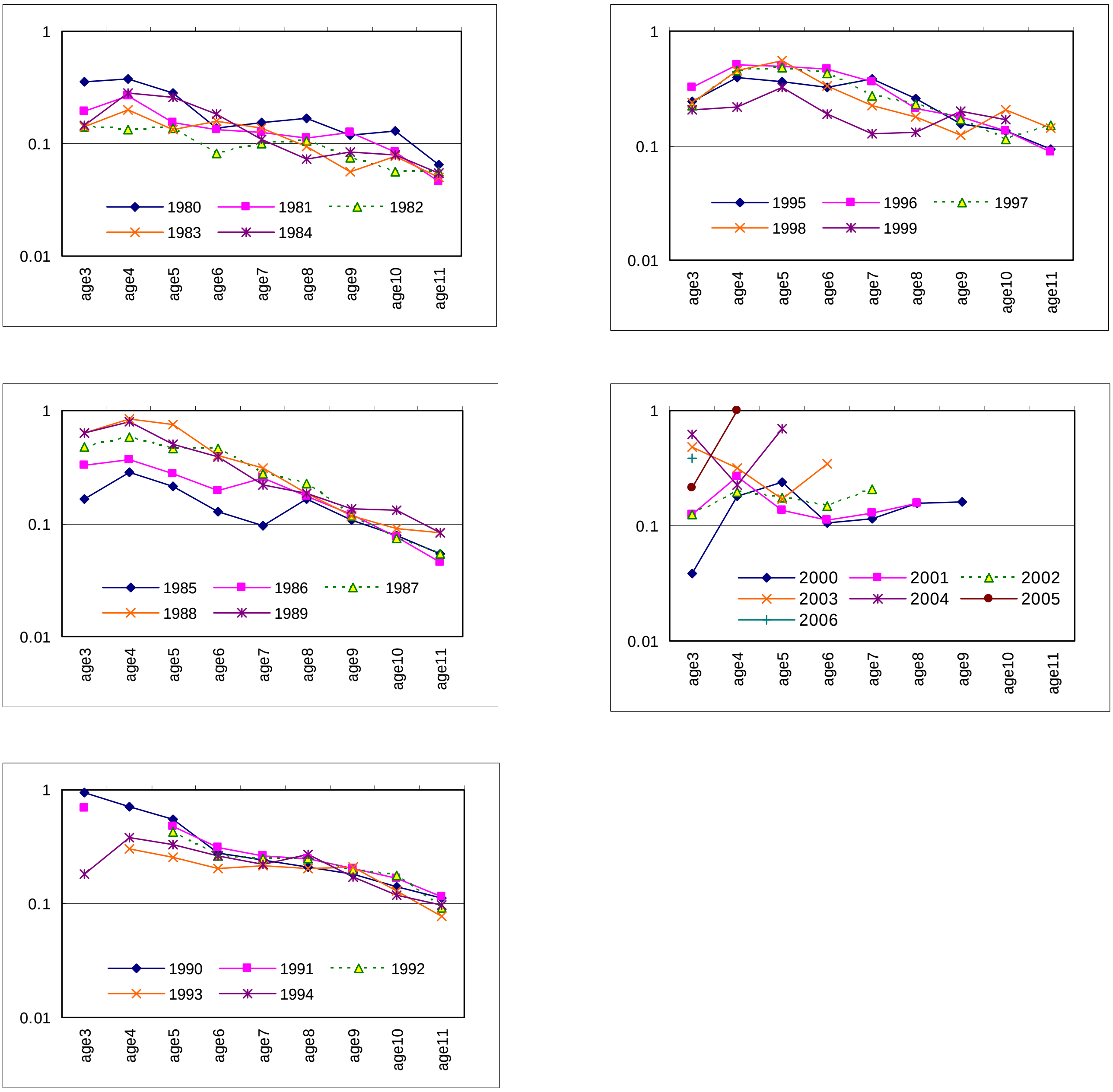


Fig. 1-3. Nominal CPUE of Japanese longline fishery by cohorts in log-scale.

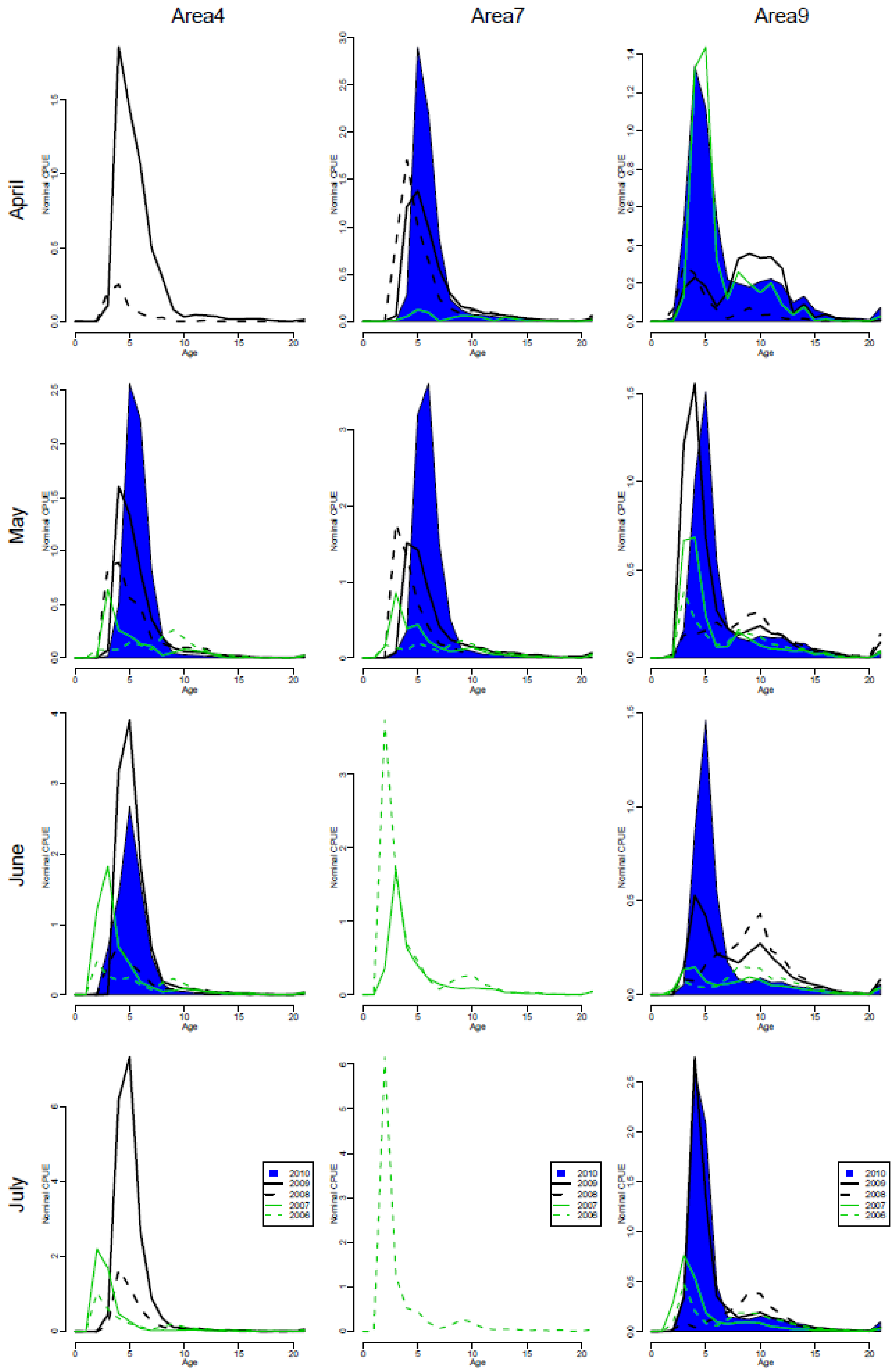


Fig. 1-4. Age composition of nominal CPUE of RTMP data for recent five years by month and areas.

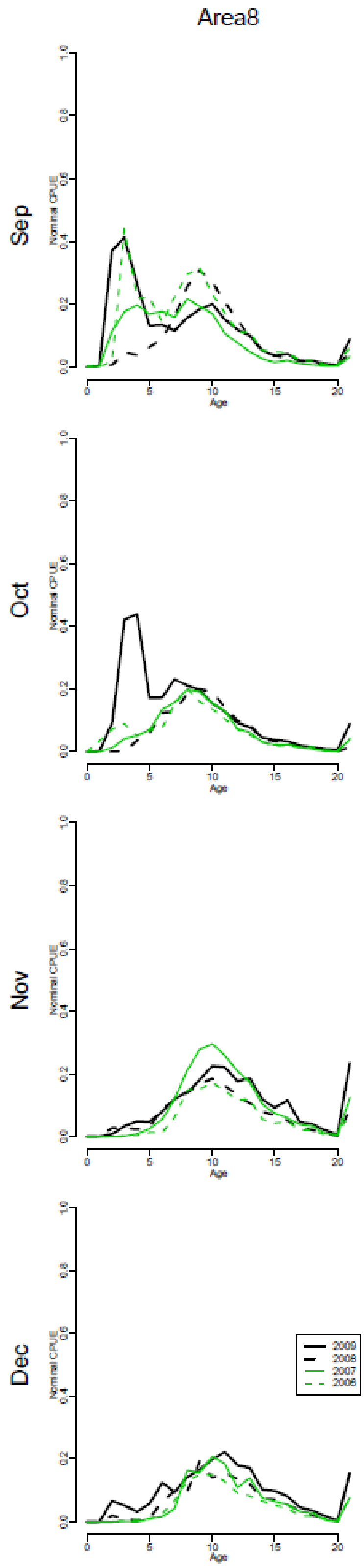
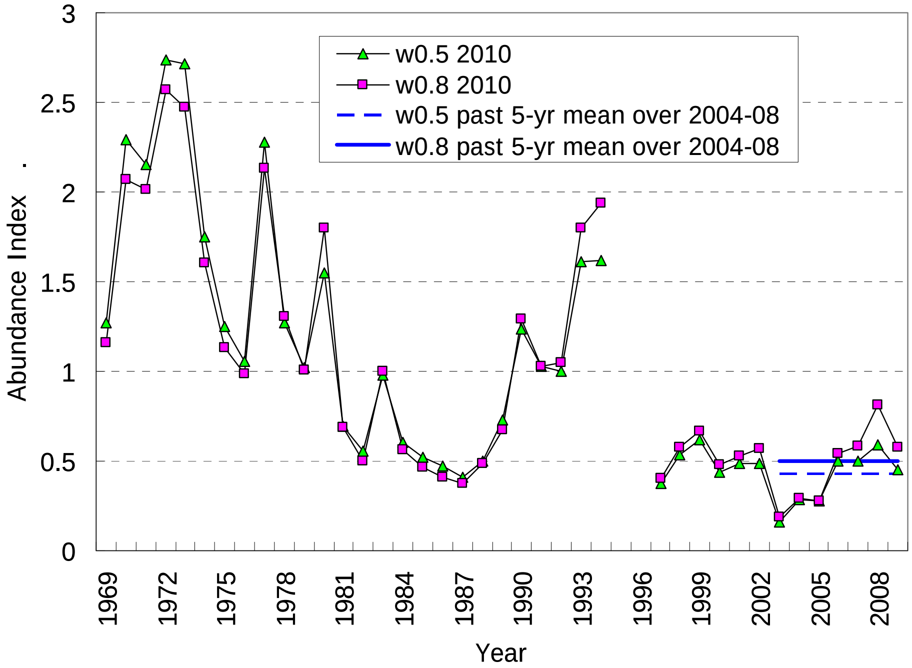


Fig. 1-4 (cont'd). Age composition of nominal CPUE of RTMP data for recent four years by month and areas.

(a) Age 3



(b) Age 4

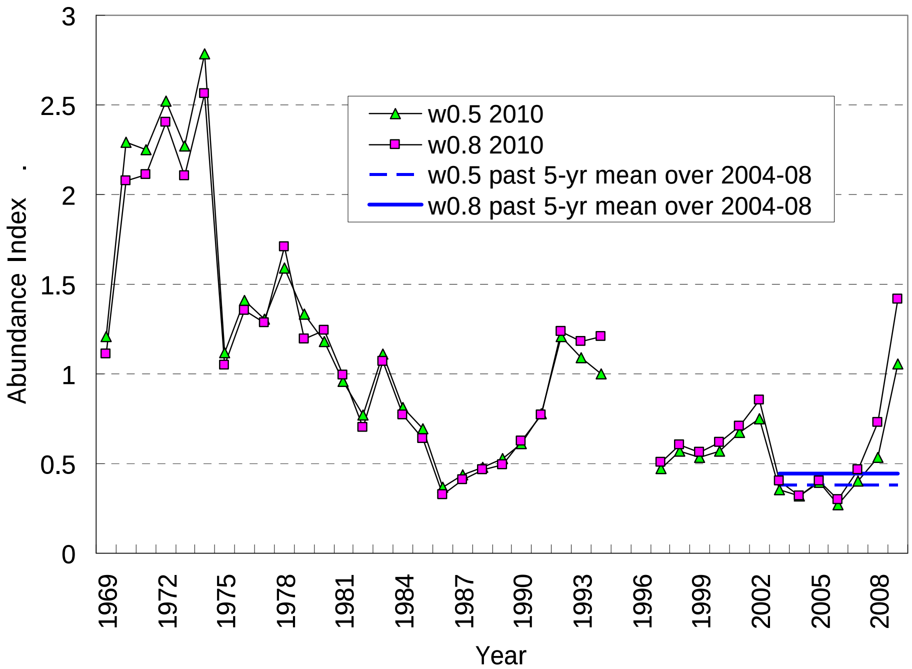
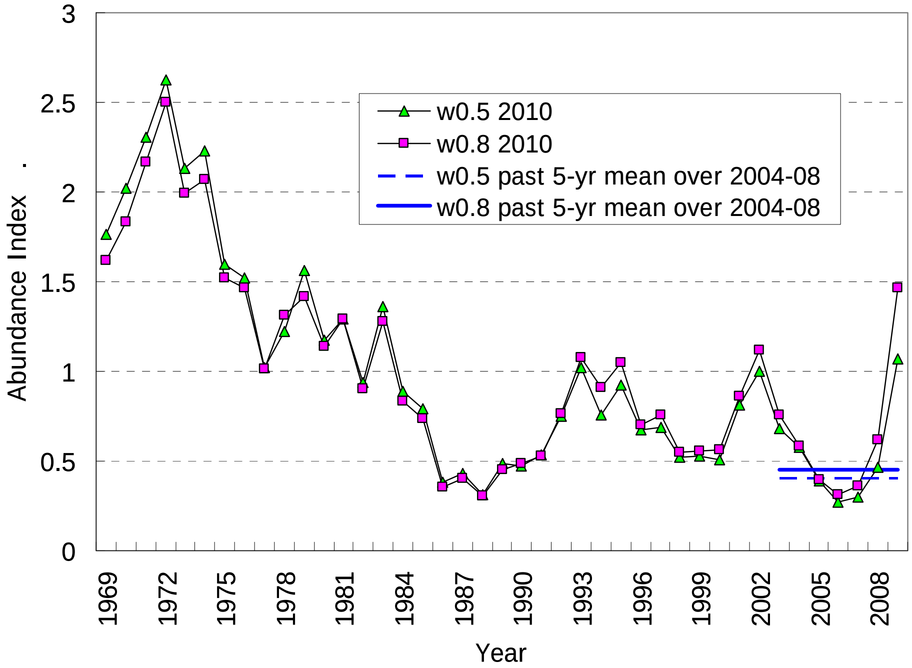


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices.

(c) Age 5



(d) Age 6&7

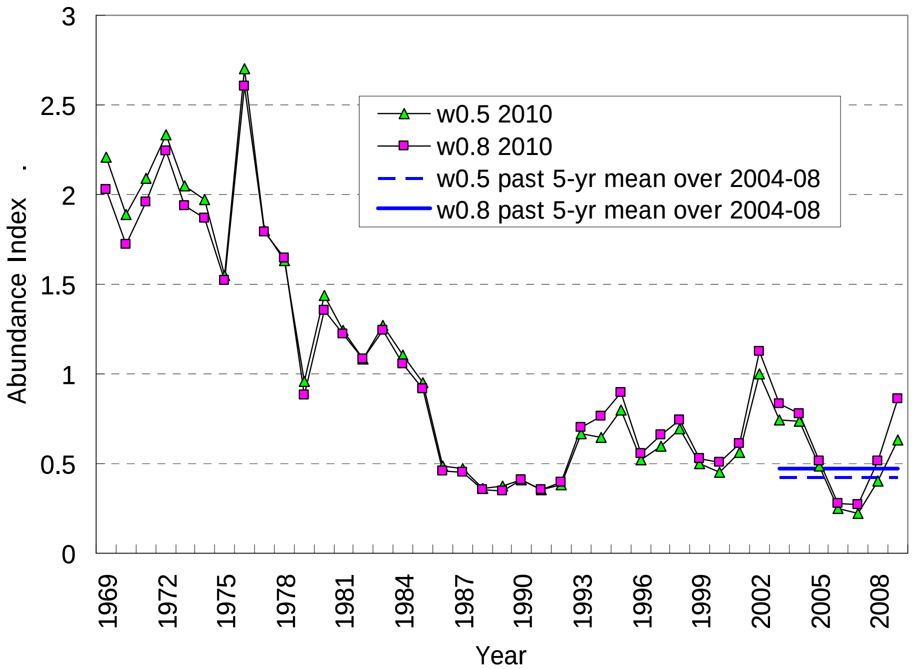
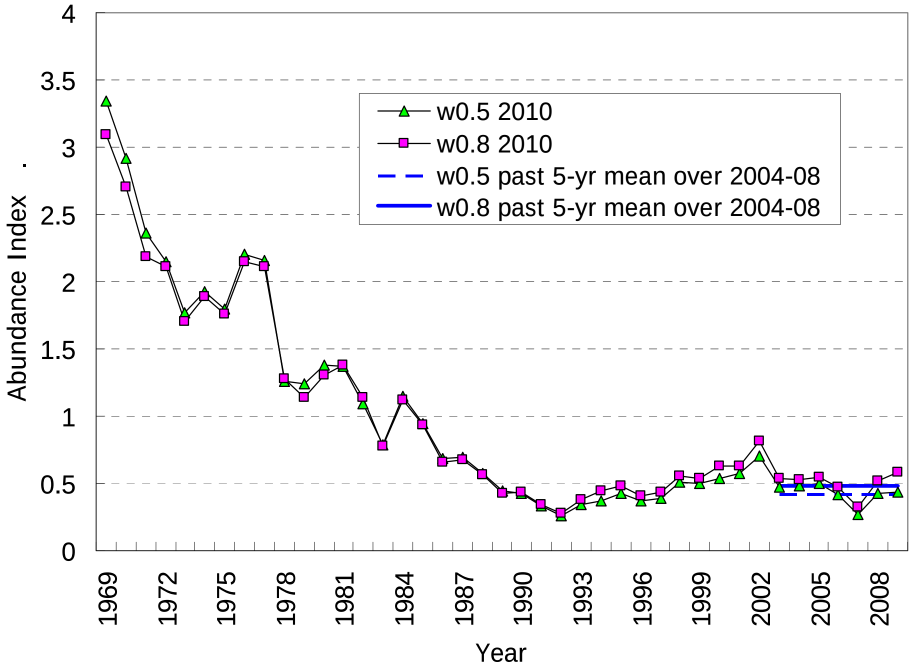


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. (cont'd)

(e) Age 8-11



(f) Age 12+

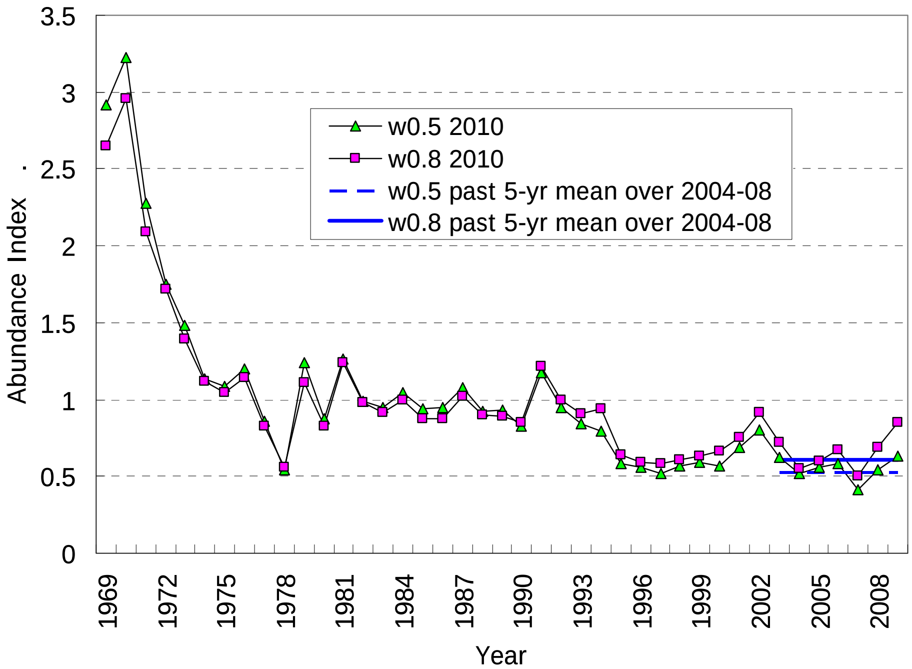


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. (cont'd)

(g) Age 4+

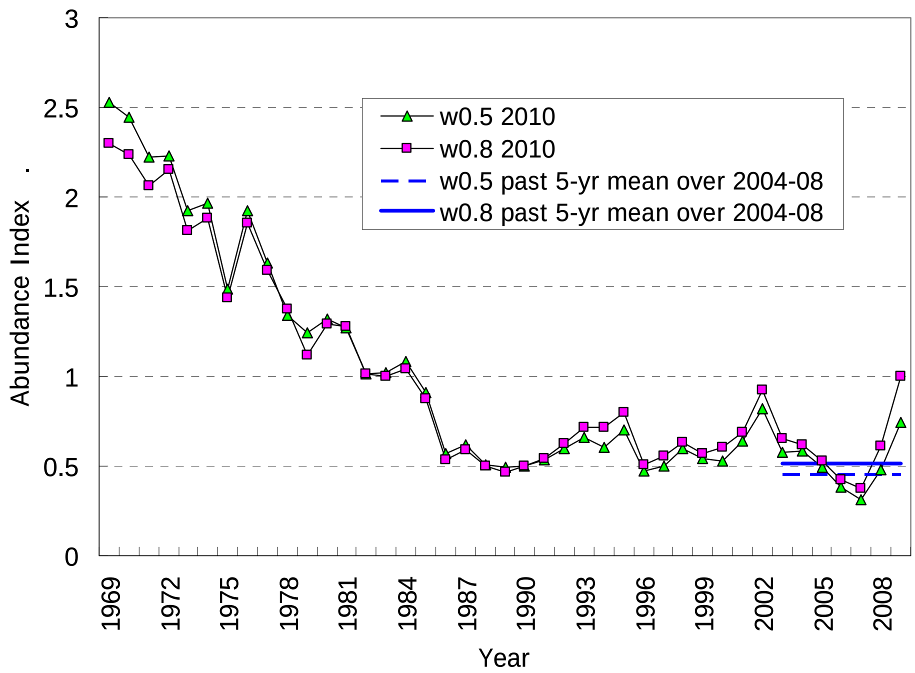


Fig. 1-5. Trends of normalized w0.5 (B-ratio proxy) and w0.8 (Geostat proxy) abundance indices. (cont'd)

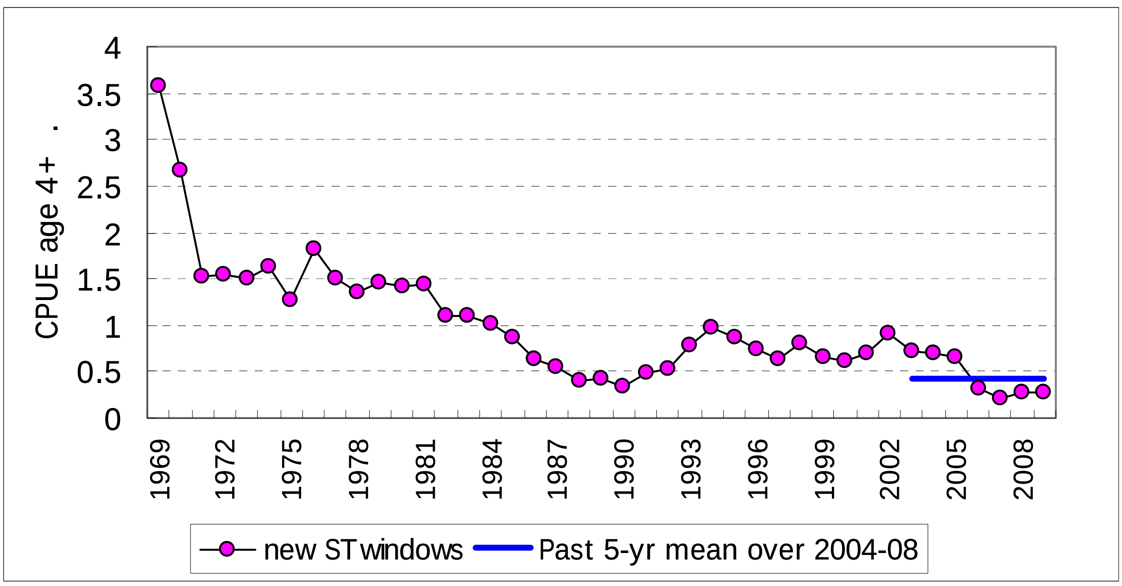


Fig. 1-6. Trend of normalized "ST Windows" index for age 4+ fish by the new calculation method.

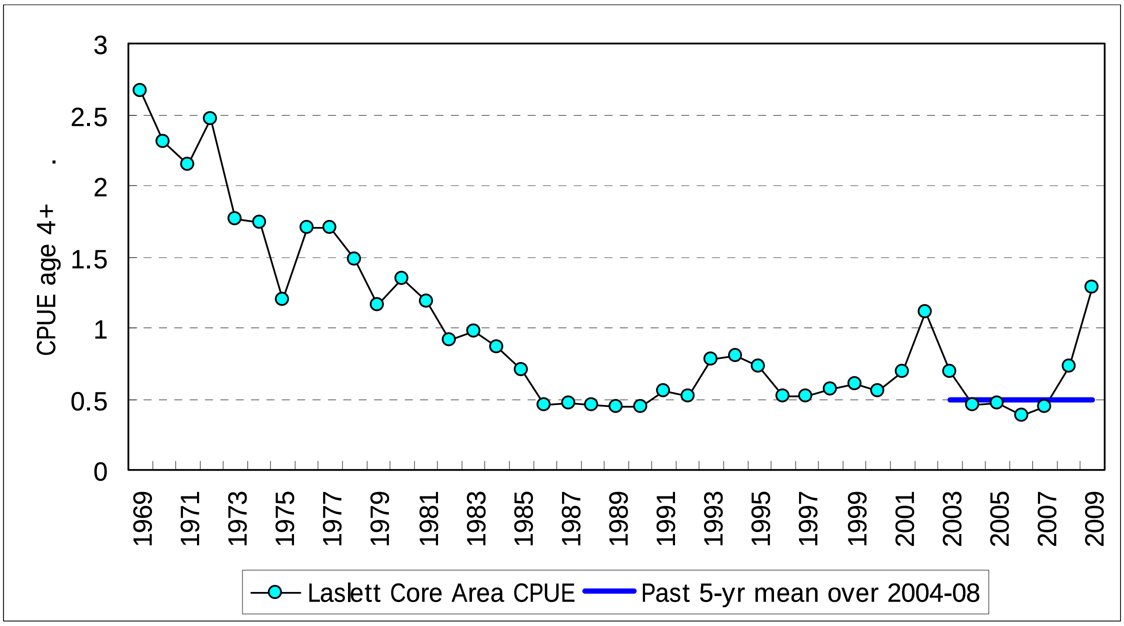


Fig. 1-7. Trend of normalized Laslett Core Area CPUE index for age 4+ fish.

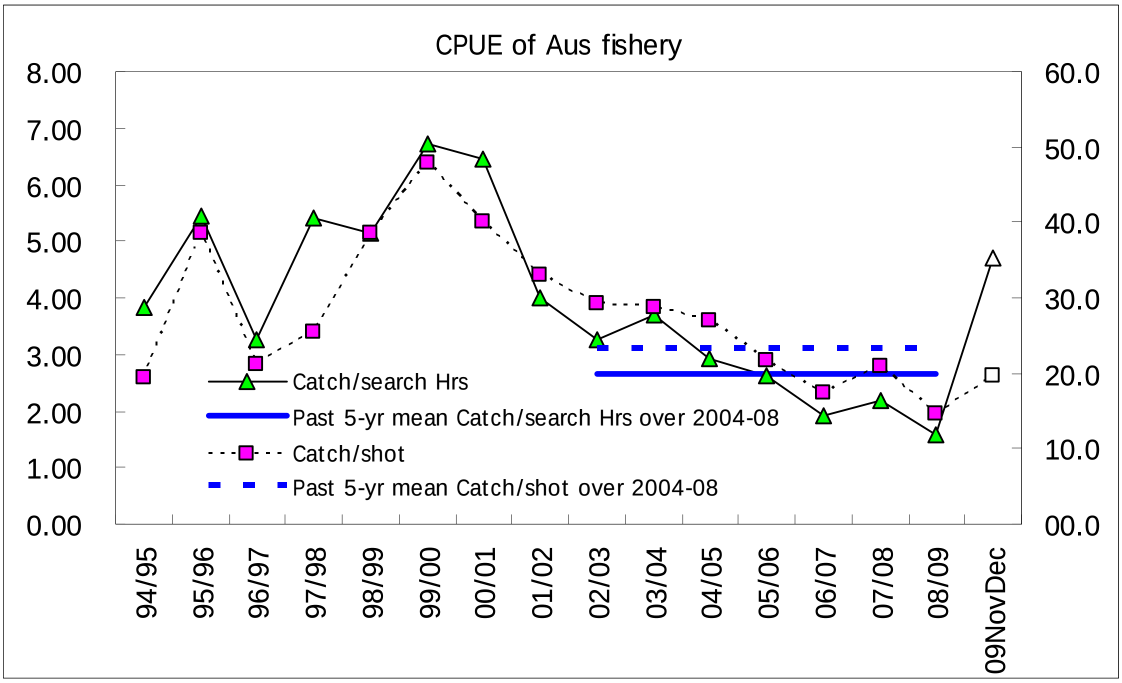


Fig. 2-1 Catch by efforts for Australia surface fishery.

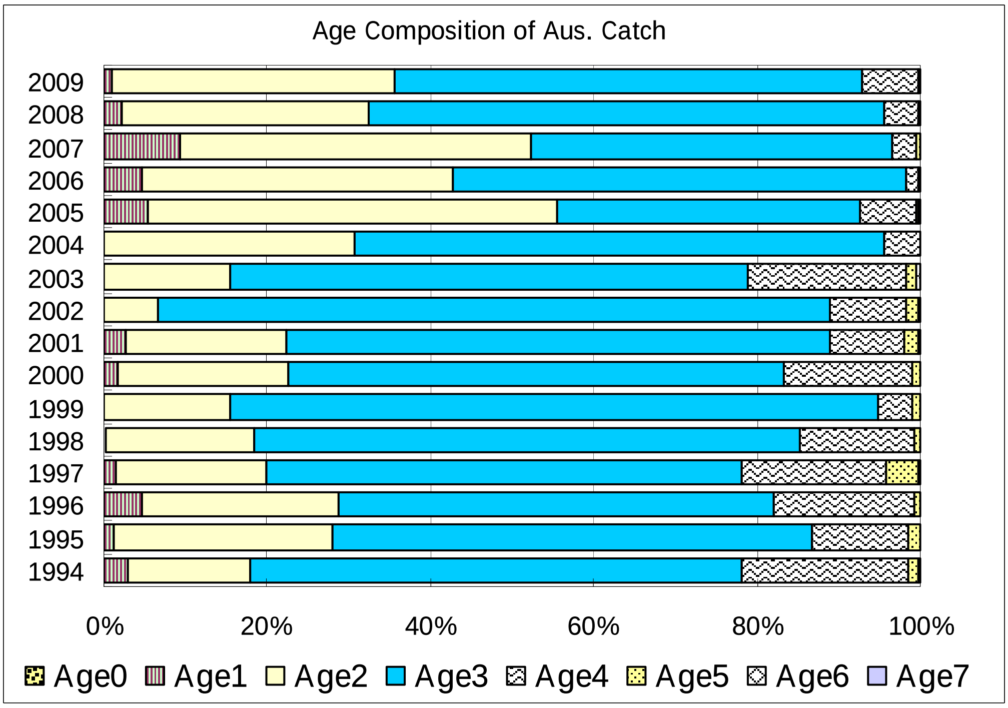


Fig. 2-2 Changes in age composition of Australia surface catches.

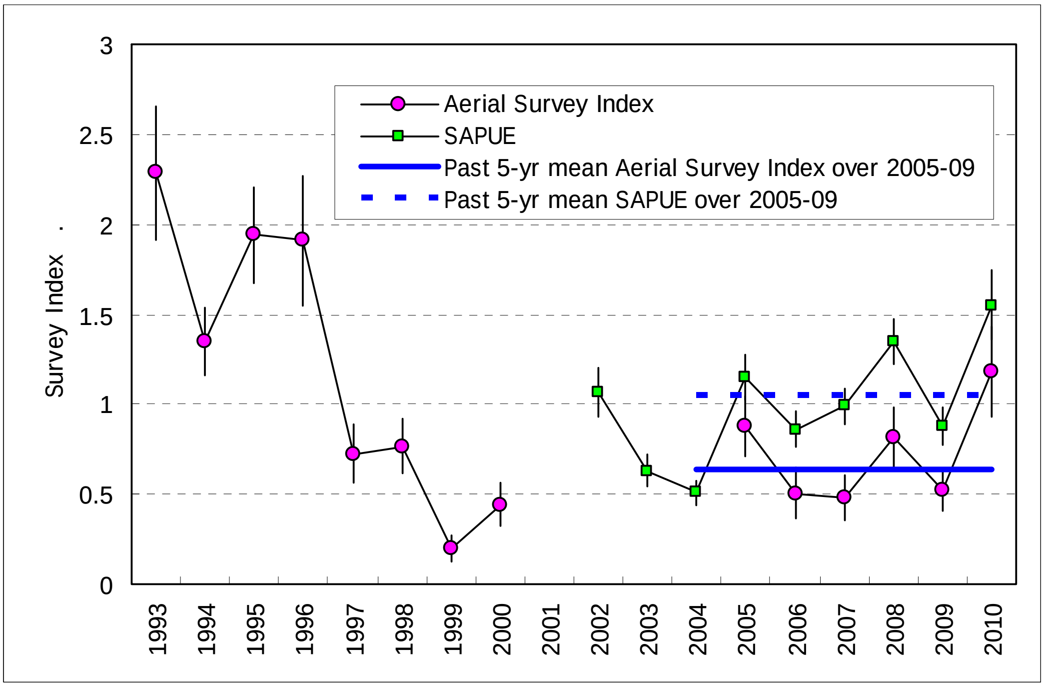


Fig. 2-3 Changes in aerial and commercial spotting (SAPUE) indices in the Great Australian Bight. Vertical bars indicate standard errors.

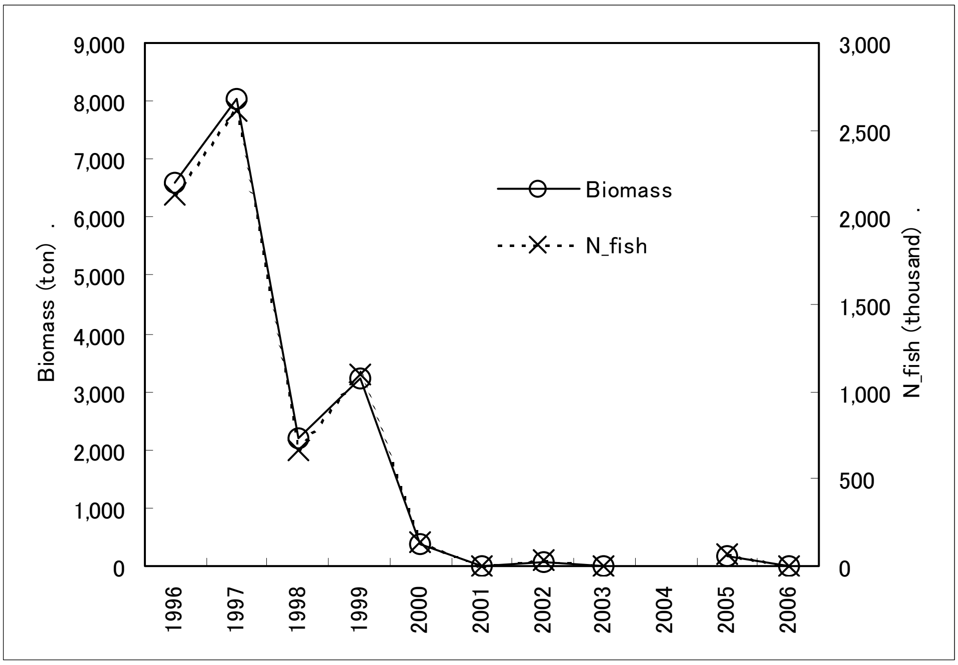


Fig. 3-1. Trends of acoustic index of age 1 SBT in the Western Australia. The acoustic survey ended in the 2005/2006 season (shown as "2006" in the figure).

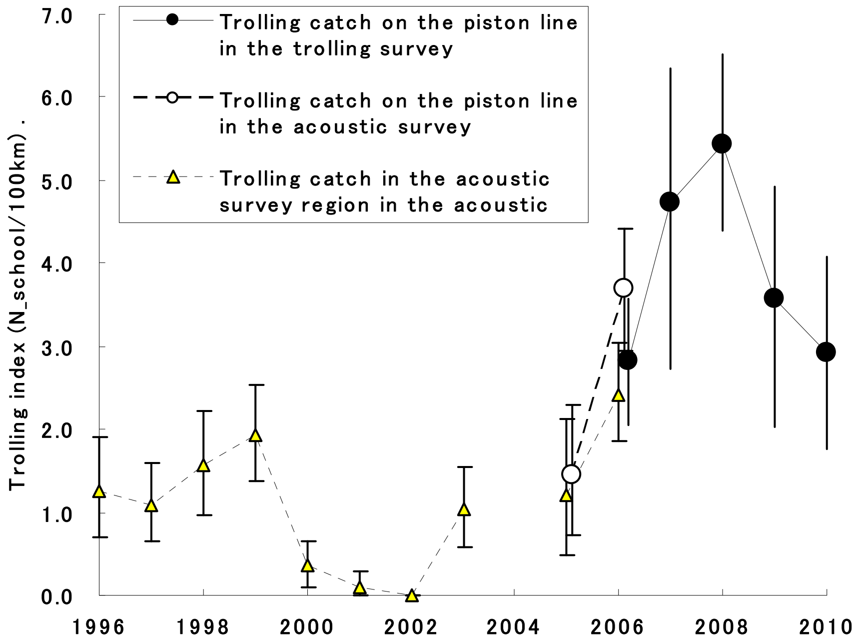


Fig. 3-2. Trends of trolling catch index of age 1 SBT in the Western Australia.

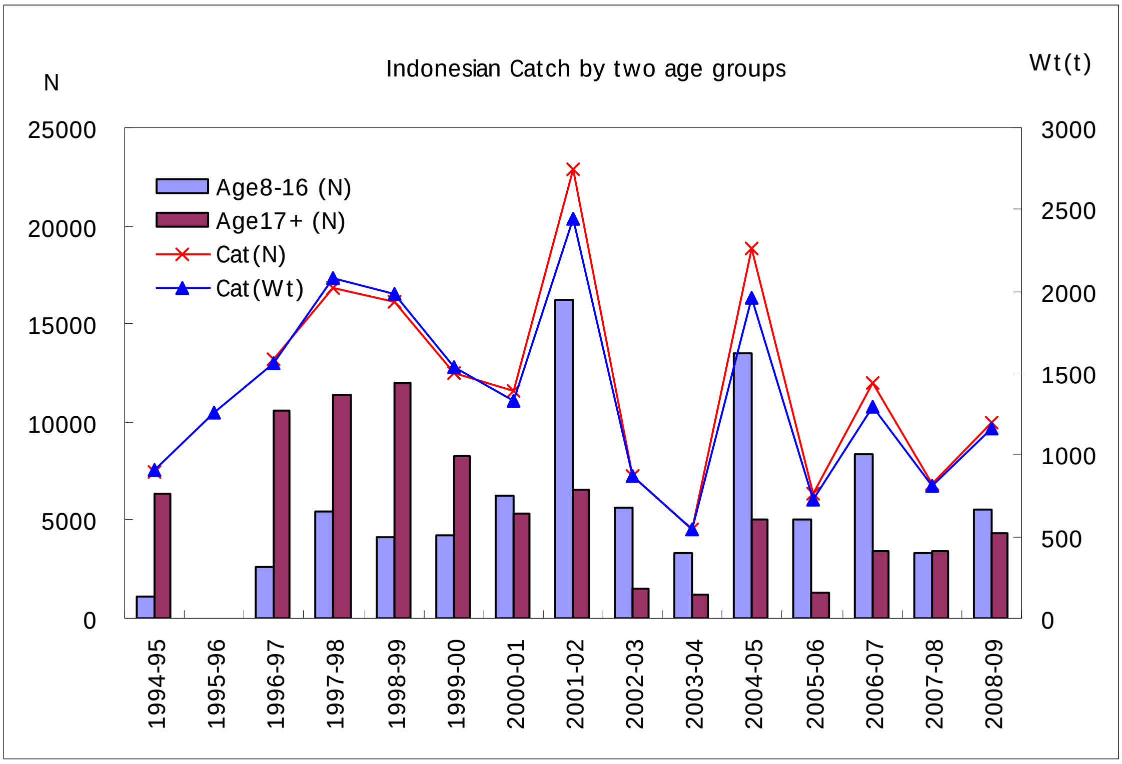


Fig. 4-1. Trends of Indonesian catches with proportion of two age groups occurrences.