Draft for Workshop of Recruitment Monitoring Program in 2006

Acoustic Index of age one southern bluefin tuna abundance by the acoustic survey in 2005/2006

2005/2006 年音響調査によるミナミマグロ 1 歳魚の加入量指数

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Summary

The acoustic monitoring survey that uses sonar provides abundance indices of southern bluefin tuna at age one which is the earliest among research surveys and fishery information. The acoustic survey continued since 1996 (1995/1996 season), suspended in 2004 and resumed in 2005. There is no feature that peculiar in 2006 in the points of survey period, survey area, species composition observed, distribution of SBT and age composition of SBT. The acoustic indices in 2006 were 6.5 tons and around 2,600 individuals. The indices have been low since 2000. On the other hand, many SBT were caught by trolling. The trolling catch index which is 33.9 schools / 100 hours in 2006 is higher than those in 2000-2002.

要約

ソナーを用いた音響モニタリング調査は、ミナミマグロの加入量指標を、全ての調査と漁業情報の中で最も若齢である 1 歳魚について提供する。1996 年から継続した音響調査は 2004 年に休止したが、2005 年に再開した。調査期間、調査海域、魚種組成、ミナミマグロの分布、ミナミマグロの年齢組成を過去 9 年間と比較したところ、2006 年に特有の特徴は認められなかった。2006 年の音響指数は 6.5 トン、約 2600 個体であり、2000 年以降継続して低レベルにある。ただし曳縄では多くの漁獲があり、曳縄指数は 33.9 群／100 時間で 2000-2002 年よりも高い値となった。

1. Introduction

To monitor recruitment level of age one southern bluefin tuna *Thunnus maccoyii* (SBT), the acoustic sonar monitoring survey have been conducted. This survey is very important because it provides an index of the recruitment level in earlier life stage than any other researches in the Recruitment Monitoring of Southern Bluefin Tuna (RMP) or any fishery information. The acoustic monitoring has been carried out every year since 1995/1996 season to 2002/2003 season, followed by the trolling

monitoring survey which had been conducted for five years between 1988/1989 and 1992/1993 and by the two years feasibility surveys. The survey was suspended in 2003/04 in order to concentrate on analyses for the review workshop held in December 2004 in Yokohama (Anon. 2003). Since the workshop concluded that the acoustic survey was a valuable research to at least provide rough measure of abundance to be used as an early warning signal, the survey was resumed in 2004/2005 season.

The survey was also carried out in 2005/2006 season. This report provides the calculated abundance indices in the survey 2005/2006 after reviewed survey period, survey area, species composition observed, distribution of SBT and age composition of SBT, compare to results in previous years.

Following terms are defined for this report. A reference year is referred to the later year of a fishing season because the acoustic survey usually conducted in January and February. For example, 2005/2006 season is referred to as 2006. One transect line is denoted as one way of a zigzag transect line from east to west (or west to east). The transect survey area is denoted as the area off south of Western Australia enclosed by six points (Northeast: 34°40.0′S-119°56.7′E, Southeast: 35°11.5′S-118°53.7′E, central South: 34°40.0′S-119°56.7′E, Southwest: 35°11.5′S-118°53.7′E, Northwest: 34°20.0′S-119°50.1′E, central North: 34°54.4′S-118°41.1′E).

2. Outline of the cruise in 2006

A transect line survey using a scanning sonar was conducted in the similar manner used in previous years. A vessel, Taikei-maru No2, which have been chartered for the acoustic survey since 2000, was chartered. The scanning sonar equipped was Furuno FSV-24 as used since 2003. The transect survey area and design of the zigzag transect line is same as those since 2003. A straight survey line off Bremer Bay, called piston line, was set as in 2005 but on slightly different positions (34°31.1′S-119°26.5′E, 34°47.4′S-119°41.4′E in 2006, 34°29.0′S-119°24.0′E, 34°48.0′S-119°41.0′E in 2005). The vessel left a zigzag transect line at a reflection point which was the closest to either end of the piston line. After reaching an end of the piston line, the vessel go and back on the piston line in the same survey manner as in the transect survey line. Then, the vessel went back to the reflection point which the vessel left the transect line and resume the transect survey on the transect line. During the survey, observations by sonar and echo sounder were conducted as well as trolling operation to catch fish and observation by eye sighting in the daytime.

The vessel left Fremantle on 10 January 2006. The vessel had conducted research from 12 January to 18 February within the transect survey area, including several times of suspend due to rough weather on 12 January (Fig. 1). The vessel returned Fremantle on 20 February and finished the research survey. A total of 12 transect lines including piston-line was surveyed. Oceanographic observations using STD were conducted at 101 points.

19 SBT schools and 1214 schools of small pelagic fish were found by sonar. 13 SBT schools were found by eye sighting. Trolling collected individuals of 633 SBT, 35 skipjack, 38 bonito, 70 albacore and 7 other species. Assuming that two occasion of trolling catches within 30 minutes are from one school, 88 schools of SBT were detected. Almost all of fish caught were measured, weighed and collected stomachs. Otolith and muscle tissue were also collected for SBT.

Total weight of SBT mortality by this survey is calculated from monthly average weight by month (N = 606 out of 633 individuals) as 1670.8 kg.

3. Review of 2006 results compare to previous years

3-1. Survey period

The number of days surveyed was 42 in 2006 (Fig. 2). This is the smallest since 1999. It is due to restriction of budget. Because most of them (38 days) were used for the transect line survey, the number of days for the transect survey were maintained as in previous several years.

Fig. 3 shows the number and weight of SBT school by five days. Peak were found during late January to middle February in the years that many SBT were found (1996-2000). Few SBT schools were found after middle February even the survey were conducted in some years. In 2006, several SBT schools were found in early February. It is not different from the result in previous years.

3-2. Survey area

Fig. 4 shows trajectories of the research vessel for 2006 as well as previous 10 years. A part of survey was conducted between the transect survey area and Esperance. The total of 12 transect lines were surveyed. Suspends were included in line 1 and 6 for 1-2 days, and in line 19 for 9 days.

3-3. Species composition

Fig. 5 shows total weight of schools of large or small pelagic species which estimated by sonar specialists in the area east of 118E. Same as in previous years, a large portion was occupied by small pelagic. Although there is no way to evaluate the accuracy of species estimation by sonar specialists, they say that it is not difficult to distinguish between large and small pelagic. Sonar specialists recognized the large influence of miss-judgement of small pelagic to the large pelagic, especially SBT. So that, they tend to be hesitated to decide a fish school to be a large pelagic. If it is the case, some of the school recorded as small pelagic were large pelagic.

Fig. 6 shows the species composition among large pelagic (which will exceed 3 kg in weight if they grow) caught by trolling of the vessel in the area east of 118E. SBT occupied the largest part in most years, followed by skipjack, bonito and albacore.

Table 1 shows proportions of SBT out of large pelagic species among individuals caught by trolling and biomass estimated by sonar specialists. Results in previous years has suggested miss-judgement of species in sonar data, however, data in 2006 are too small to be decided.

3-4. Geological distribution of SBT

Fig. 7 shows geological distributions of SBT in biomass by sonar and in number of fish caught by trolling. No specific pattern in 2006 is found. Because piston-line survey was conducted, large number of individuals caught by trolling is recorded off Bremer Bay.

3-5. Length and age of SBT

Fig. 8 shows length frequencies of SBT caught by trolling in the area east of 118E for every year. A length mode around 50 cm are observed every year. It is same in 2006.

Age was estimated based on age-length relationship used in CCSBT. The lower length of the age are defined as 42.0cm for age 1, 69.0 cm for age 2, regardless of month of the fish caught. Fig. 9 shows age composition of SBT caught by trolling in the area east of 118E. Majority of the SBT were age one as 82-100 % with average of 95 %. It was 97 % in 2006.

4. Calculation of the acoustic index

Since no feature that peculiar in 2006 were observed among above mentioned points, the abundance indices in 2006 was calculated as in previous years. Used data were only on the transect lines but piston line part, of which corresponds with the indices in previous years.

The abundance indices are calculated from following equations. The indices are standardized for all of the survey areas in 15 days.

$$\mathrm{B}io_{\mathrm{age1}} = \frac{n_{age1}}{n_{all}} \times \left(\sum_i W_i \right) \times \frac{S_{all}}{2 \times R_{effect} \times D_{trans}} \times \frac{15}{T_{survey}}$$

$$N_{age1} = 1000 \times \frac{Bio_{age1}}{w_{age1}}$$

where Bio_{age1} is the index of biomass of age 1 SBT in tons, N_{age1} is the index of the number of age 1 SBT, n_{age1} is the number of age 1 SBT caught, n_{all} is the total number of SBT caught, W_i is the weight of school *i* estimated by a sonar specialist in tons, S_{all} is the total size of the survey area in km^2, R_{effect} is the effective width in km, D_{trans} is the total distance transected in km, T_{survey} is the total net surveyed days, and $w_{age1}$is the mean body weight of age 1 SBT.

Table 2 shows parameters used for calculation. The number of SBT school found in 2006 was too small to estimate detection function, then the effective width in 2000 was used for 2006.

Fig. 10 shows the calculated acoustic indices. It is 6.5 tons and 2,600 individuals in 2006. It has been low since 2000. Since average body weights of age 1 SBT in the area were similar in all years, trends of indices bosh in biomass and in number of individuals are similar to each other.

5. Indices of trolling and eye-sighting

As same as for 2005, indices of SBT recruitment based on trolling catch and eye-sighting were also calculated in addition to the acoustic index (Itoh and Tsuji 2005). The trolling index is defined as the number of school of age one SBT in 100 search hours. Because the duration of trolling conducted was from 06:00 to 18:00, half of the total length of transect line survey using sonar was used for the calculation. Assuming that different catch within 30 minutes are from an identical SBT school. A proportion of age one SBT was estimated by the number of age one fish among all of SBT caught by the trolling, which is same as for the acoustic survey.

The index of trolling calculated was 33.9 schools / 100 hours by 53 schools found on the transect line only (exclude piston-line). It is about three times as much as that in 2005 (11.7) and much higher than those in 2000-2002 (Fig. 11). For the case of piston-line only, where many SBT schools (32 schools) were found, the trolling index was 92.5 schools / 100 hours.

The index of eye-sighting is also the number of school of age one SBT in 100 search hours. Because the duration of trolling conducted was from 06:00 to 18:00, half of the total length of transect line survey using sonar was used for the calculation. The index of eye-sighting in the transect survey area only was 5.3 schools / 100 hours, based on 9 schools (Fig. 12).

6. Discussion

Fig. 13 shows indices between 1996 and 2006 standardized with the mean of each index. Index of sonar number, which defined as the number of schools per 100 search hours, was made to compare indices that based on the number of schools including indices of trolling and eye-sighting.

The indices of sonar, both in biomass and in the number of school, have been low level since 2000. The trolling index is higher in 2003 and 2005 than in 2001-2002, and much higher in 2006. The trolling indices since 2003 are in the same level in 1996-1999. Index of eye-sighting is higher in 2005-2006 than in 2001-2003, but lower than in 1996-1999.

At present, it is difficult to decide the reason of the different trends of indices among various methods to detect SBT schools. One interpretation is that the recruitment level since 2003 has increased (probably slightly) but made a number of small schools, which below the lowest level of biomass that sonar specialists can detect. The 2002 year class was observed as a high index of trolling in 2003 survey. They will be caught by Australian purse seine at age three in 2005 and by Japanese longline at age four in 2006. Catch data in those fisheries would provide good information to consider.

Acknowledgement

All crew of No. 2 Taikei-maru, Taikei Gyogyo Company and field researchers are greatly appreciated. Staffs in Fisheries Agency of Japan, Fisheries Research Agency, JAMARC, NRIFE and NRIFSF are acknowledged.

Reference

Anonymous (2004) SBT Recruitment Monitoring Review Workshop: The role and constraints of scientific monitoring for stock management – brain storming using southern bluefin tuna experiences as an example. 15-17 December 2004, Yokohama, Japan

Itoh, T, and T. Tsuji (2005) Other indices for age one southern bluefin tuna recruitment derived from data of the acoustic transect survey. RMWS/05/05.

Table 1. Proportion of southern bluefin tuna in large pelagic species between trolling catch and schools found by sonar in the area east of 118E

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Trolling catch in number	SBT	98	118	160	248	50	92	27	67		284	625
	Large pelagic	100	138	229	300	133	222	79	123		396	771
	%SBT	98	86	70	83	38	41	34	54		72	81
School biomass in ton by sonar	SBT	1,102	831	450	994	126	2	21	6		54	5
	Large pelagic	1,102	836	451	994	136	10	31	6		55	5
	%SBT	100	99	100	100	92	18	68	98		99	100

Table 2. Parameters for the acoustic index

Subjects	Unit	1996	1997	1998	1999	2000	2001	2002	2003	2005	2006
Basic information											
Number of transect line completed	line	12	8	10	12	12	11	10	9	10	12
Survey period		Jan.26–Fe b.12	Jan. 28– Feb. 21	Jan.22– Feb.20	Jan.25– Mar.11	Jan.19– Mar. 10	Feb.5 – Mar. 10	Feb.4 – Mar. 11	Dec.28 – Jan.27	Jan.14 – Feb.14	Jan.12– Feb.18
Actual survey hours (days) for transect line completed (**).	hours(days)	199h (8.3d)	180.8h (7.5d)	242.7h (10.1d)	299.5h (12.5d)	303.3h (12.6d)	267.8h (11.2d)	246.4h (10.3d)	262.9h (11d)	249.1h (10.4d)	326.8h (13.6d)
Number of schools found	no.	57	101	146	208	57	6	13	0	12	10
Total school size	ton	1,049	664	346	744	100	1.0	16.6	0.0	36.0	2.1
Size of the survey area	Km^2					9,828					
Search range by sonar (radius)	m					0 – 600					
Detection function											
Interval of perpendicular distant	m					0–200–250–300–350–400–500–600					
Best detection function selected		Half–normal	Hazard rate	Hazard rate	Half–normal	Hazard rate					
f(0): probability to find school in the edge of the effective width.		0.002338 (CV=11.7%)	0.003479 (CV=3.7%)	0.003087 (CV= 4.4%)	0.003142 (CV=34.9%)	0.002878 (CV=5.0%)					
Effective width	m	428 (CV=11.7%)	287 (CV=3.7%)	324 (CV=4.4%)	318 (CV=34.9%)	347 (CV=5.0%)	347	347	347	347	347
Estimation (all ages pooled)											
Density (type A)	kg/Km^2	431.0	410.0	154.6	274.3	33.9	0.373	6.831	0.000	12.918	0.625
Density (type B)	kg/km^2/survey	51.98	54.42	15.29	21.98	2.68	0.03	0.67	0.00	1.24	0.05
Nominal biomass (in real survey days)	tons	4,235	4,030	1,519	2,696	333	3.7	67.1	0.0	127.0	6.1
Standardized biomass (I)(in terms of 15 survey days)	tons	7,662	8,022	2,254	3,241	395	4.9	98.1	0.0	183.5	6.8
Estimation (Age 1)											
Composition of age 1	%	86.2	100.0	97.3	99.5	98.0	95.7	84.6	97.0	97.4	95.7
Average weight	kg	3.1	3.07	3.28	2.92	2.86	3.48	2.87	2.44	2.81	2.47
Density (type B)	kg/Km^2/survey	44.81	54.42	14.88	21.87	2.63	0.03	0.56	0.00	1.21	0.04
Nominal biomass	ton	3,651	4,030	1,478	2,682	326	3.5	56.8	0.0	123.6	5.9
Nominal number of fish	(x1000)	1,178	1,313	451	919	114	1.0	19.8	0.0	44.1	2.4
Standardized biomass (I) (in terms of 15 survey days)	ton	6,605	8,022	2,193	3,225	387	4.7	83.0	0.0	178.6	6.5
Standardized number of fish (I)(in terms of 15 survey	(x1000)	2,131	2,613	669	1,104	135	1.4	28.9	0.0	63.7	2.6

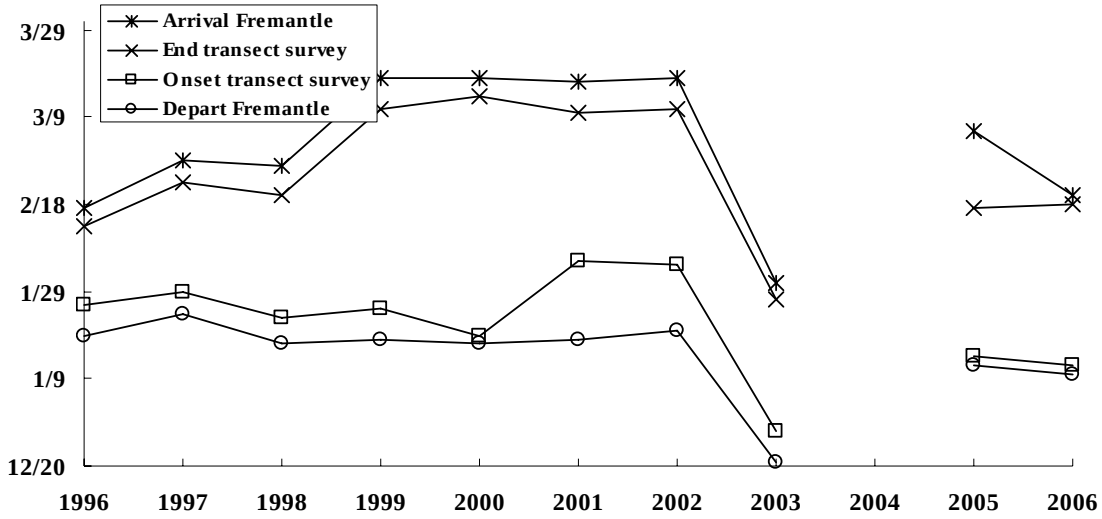

Fig. 1. Date of survey by year

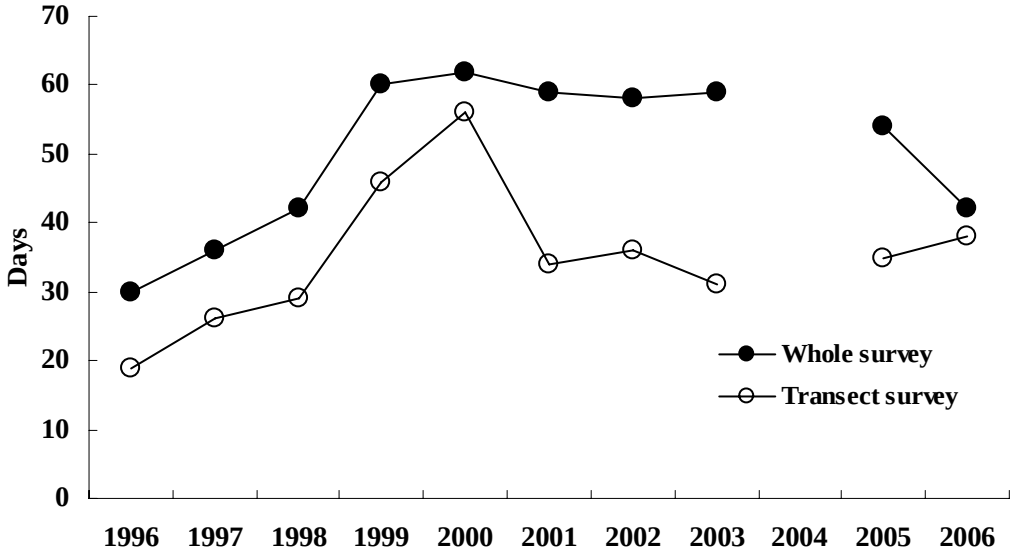

Fig. 2. Number of days surveyed

Whole survey is the duration from departure and arrive at Fremantle.

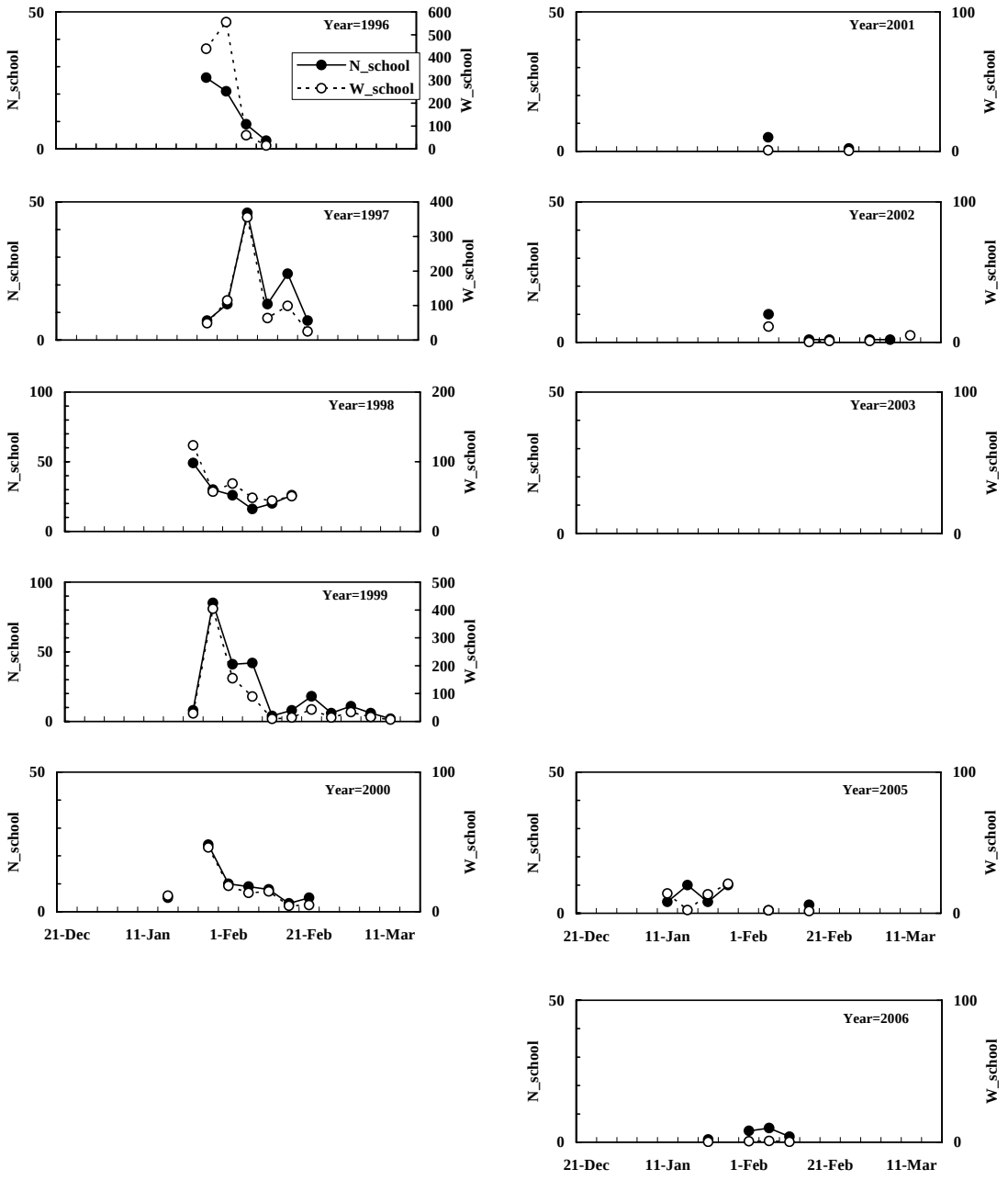

Fig. 3. Number and weight of southern bluefin tuna school found in the transect survey by every five days

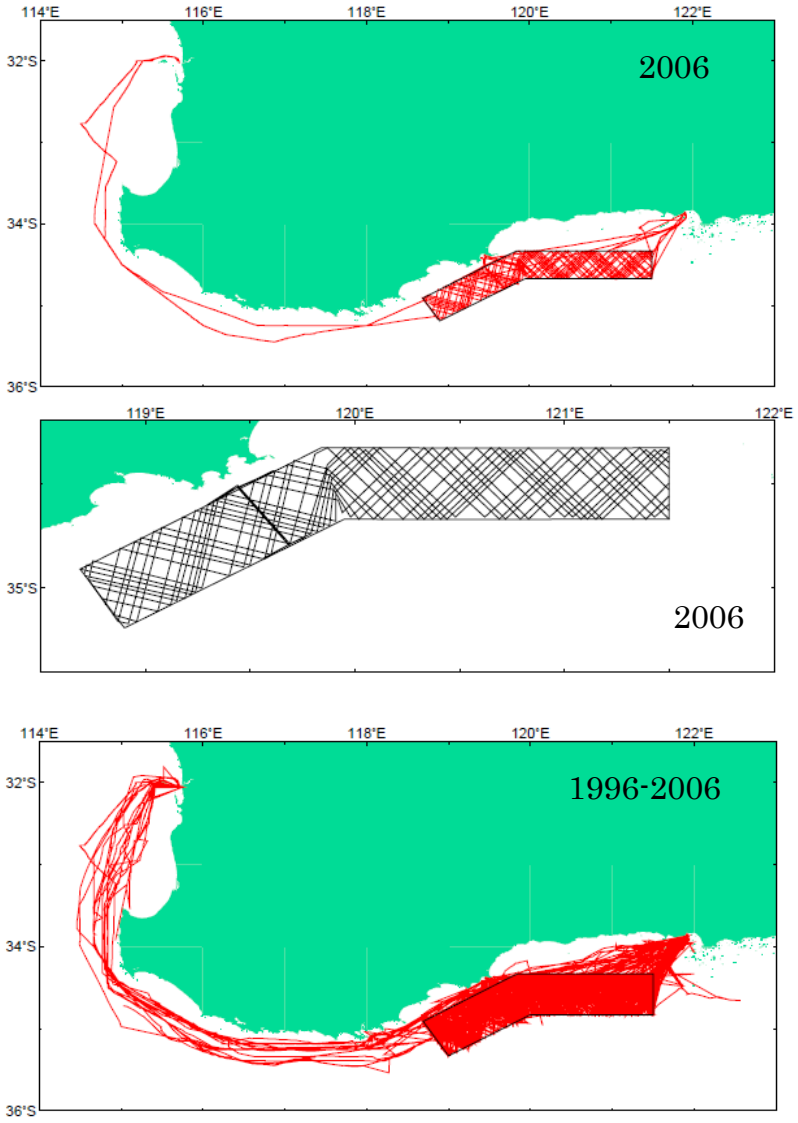

Fig. 4. Trajectories of Taikei-maru No2 in 2006 and all years since 1996

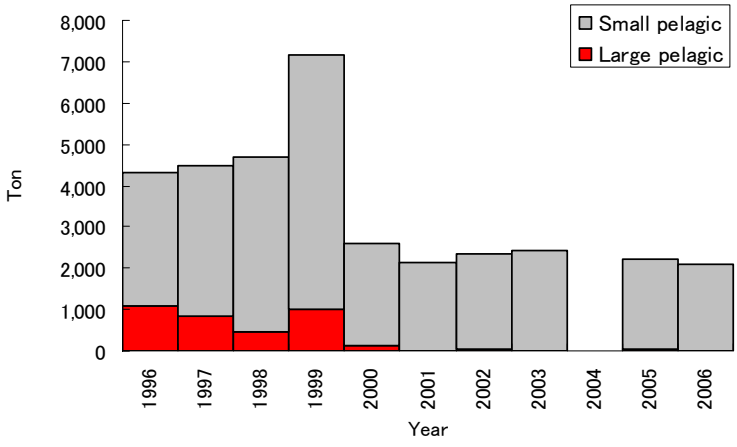

Fig. 5. Biomass of large and small pelagic species estimated by sonar specialists

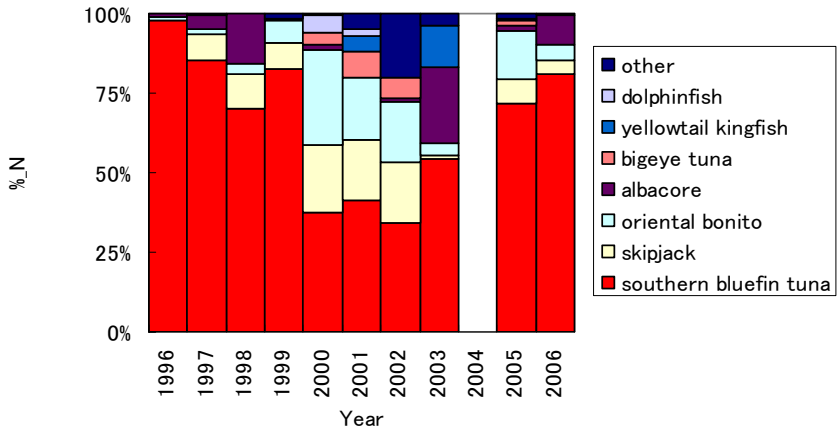

Fig. 6. Species composition in the number of large pelagic caught by trolling

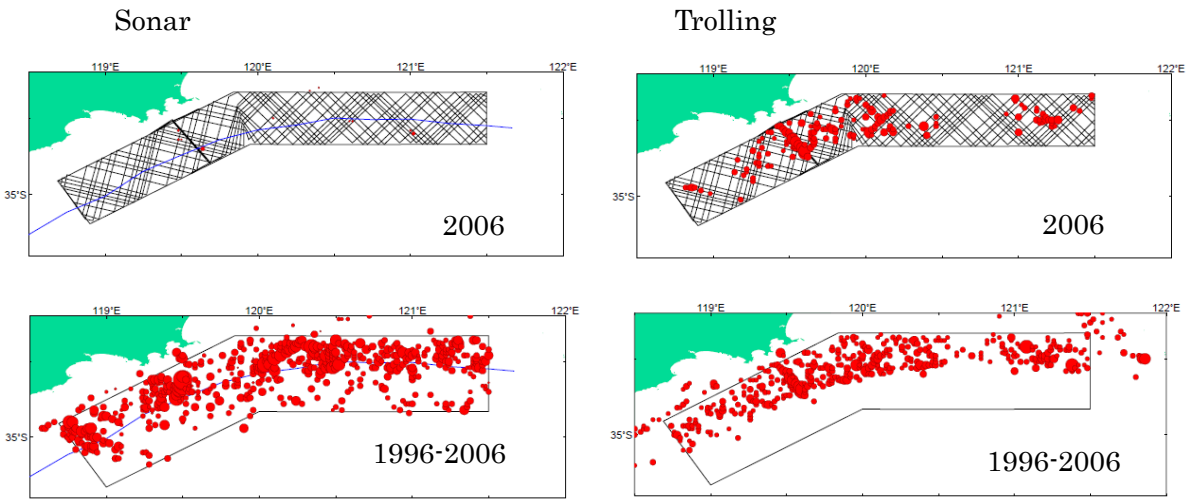

Fig. 7. Distribution of southern bluefin tuna by sonar in ton (left) and by trolling catch in number (right) for the 2006 survey (upper) and total of between the 1996 and 2006 surveys (lower)

Sum of 0.2 degree square.

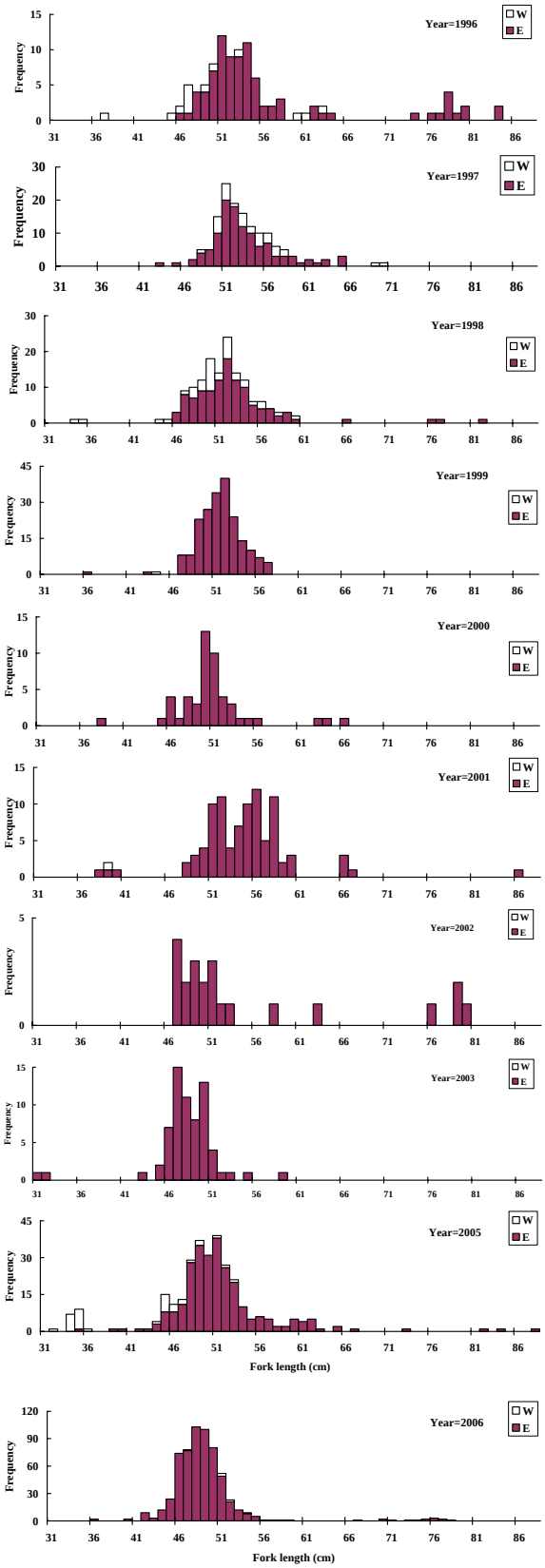

Fig. 8. . length frequency of SBT caught by trolling

W and E denote west and east of 118E.

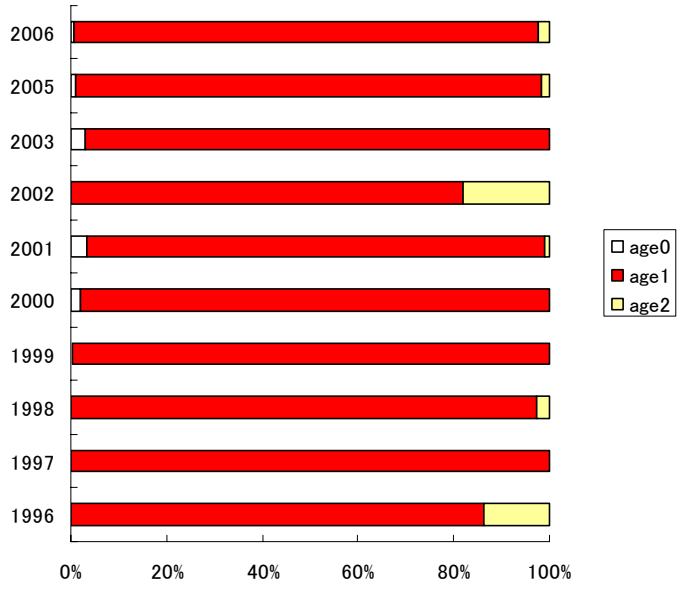

Fig. 9. Age composition of SBT caught by trolling

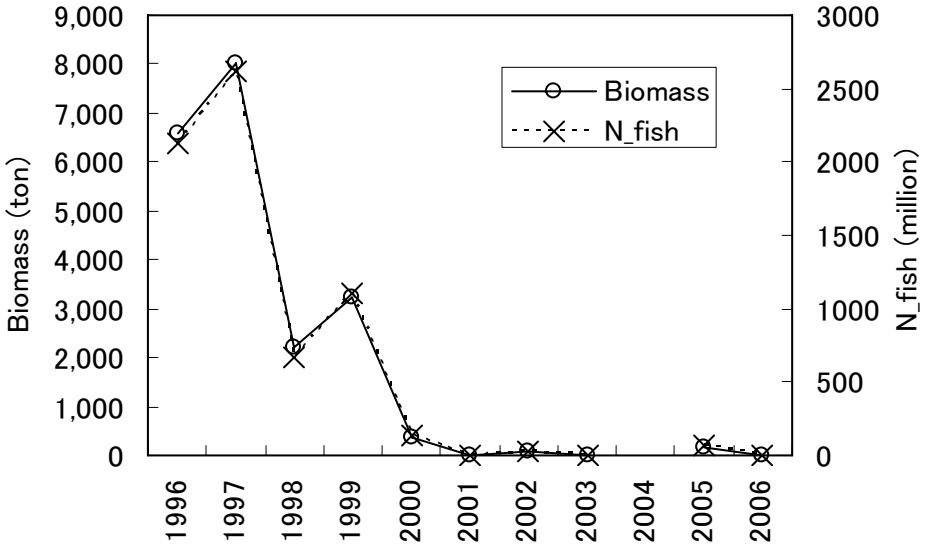

Fig. 10. Acoustic index for age one SBT

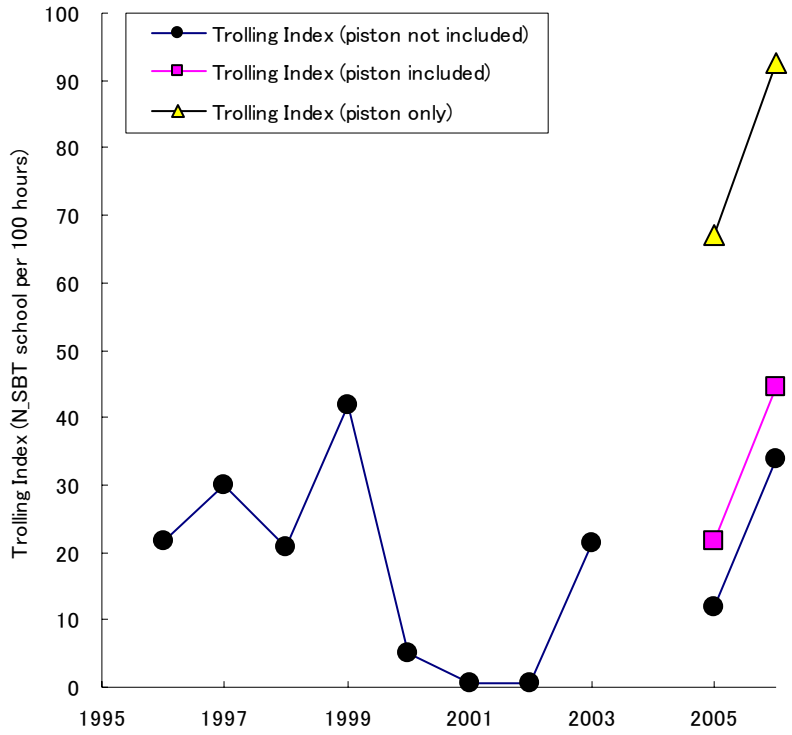

Fig. 11. Trolling index for age one SBT

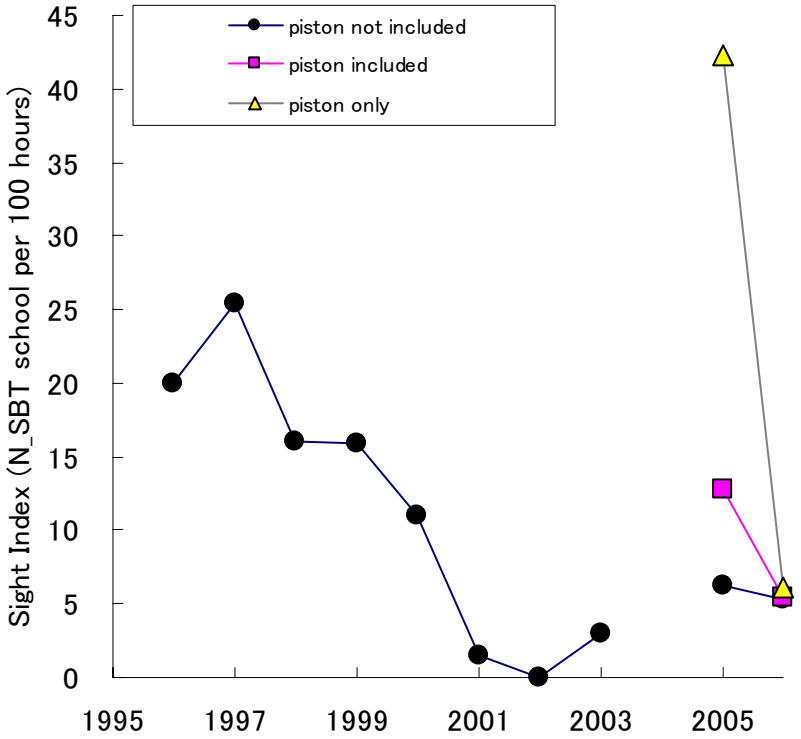

Fig. 12. Eye-sighting index for age one SBT

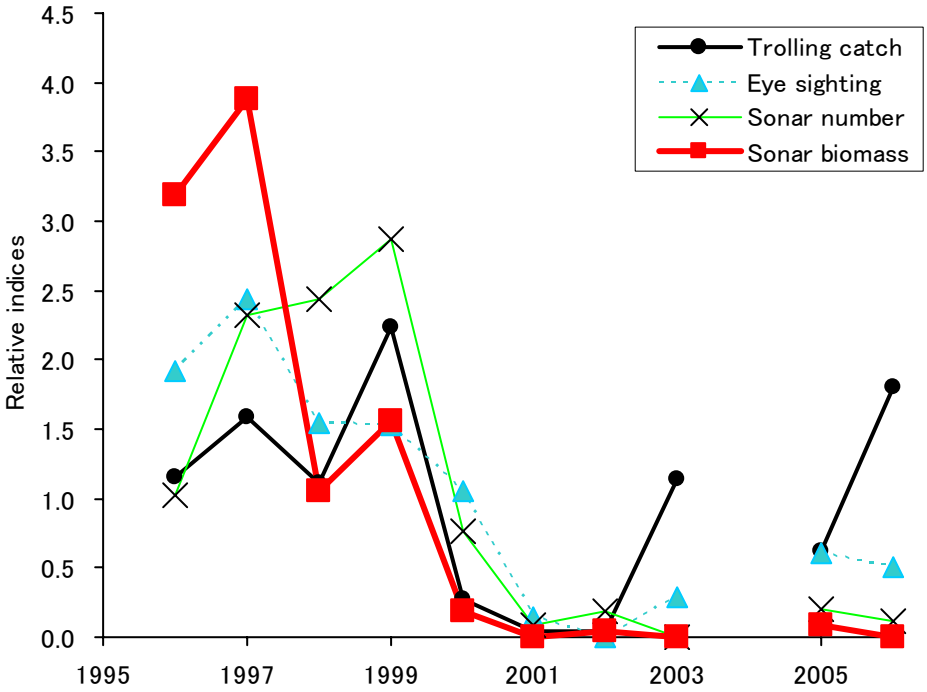

Fig. 13. Recruitment indices for age one SBT

Standardized with mean of each series of index.