

Report of the piston-line trolling monitoring survey for the age-1 southern bluefin tuna recruitment index in 2010/2011

ミナミマグロ 1 歳魚の加入指標のためのピストンライン曳縄モニタリング調査 2010/2011 の結果報告

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Summary

In January 2011, the trolling research survey that provides the recruitment index of age-1 southern bluefin tuna with low cost was carried out in similar manner since 2006. In the survey, a chartered Australian vessel goes and back on the same straight line (piston-line) off Bremer Bay in the southern coast of Western Australia using trolling for a total of 6 times (12 lines). The adjacent area of the piston-line and the area between Esperance and Albany were also surveyed. In the cruise, a total of 263 SBT individuals were caught and 34 of them were tagged and released with CCSBT conventional tags and archival tag. The trolling index, the number of SBT age one school per 100 km searched, was 5.7 with a 90% confidence range of 4.1-7.4. The index was higher in the 2005-2010 year classes than the 1995-1998 year classes by taking into account of both the trolling survey and the trolling catch data in the acoustic survey.

要約

ミナミマグロ 1 歳魚の加入指数を低コストで求める曳縄調査を、2011 年 1 月に、2006 年以降と一貫した方法で実施した。この調査では、豪州船を用船し、西オーストラリア州南岸の Bremer Bay 沖に設定した単一ライン（ピストンライン）上を曳縄をしながら 1 日に一往復、合計 6 往復（12 ライン）を調査した。ピストンラインの周辺海域及び Esperance -Albany 間の海域のミナミマグロ分布状況も調査した。航海を通じて漁獲したミナミマグロは 263 個体で、その内 34 個体には CCSBT 標識及びアーカイバルタグを装着して放流した。探索 100km 当りの群れ数である曳縄指数は 5.7（90%信頼範囲は 4.1-7.4）であった。音響調査による曳縄データも含めて考慮すると、2005-2010 年級は 1995-1998 年級レベルより高いレベルであった。

1. Introduction

Recruitment level is a crucial information on stock management of southern bluefin tuna (*Thunnus maccoyii*, SBT). Since 2006, Australia has the largest national allocation of TAC of SBT in CCSBT (Anon. 2006). Most of the Australian catch, used for farming, is mainly age three with a range between two and four, which is the earliest age of SBT fished compared to other nations' fisheries. Given high fishing pressure in their younger life stage, monitoring the recruitment level of SBT becomes much more important than in previous years.

Several research activities have been attempted for the recruitment monitoring of SBT. Since 1989, Japan has been conducted a series of recruitment monitoring surveys within a cooperative research framework with Australian scientists. Japan carried out a trolling and pole-and-line catch monitoring survey from 1989 to 1993, and then carried out an acoustic monitoring survey using sonar and echo sounder from 1995 to 2006, for age-1 SBT distributed off the southern coast of Western Australia (Itoh 2006). These researches had been providing the recruitment indices of age-1 SBT to CCSBT for years. Australia carried out the scientific aerial survey in the Great Australian Bight in South Australia since 1993 and also provided the recruitment indices, as aerial survey index, to CCSBT (Eveson et al. 2006). However, because the aerial survey index is for SBT age three which is the same age of the Australian purse seine catch, it gives little time to consideration to regulate the fishery based on the results of the research survey. Catch information of SBT age-1 off the southern coast of Western Australia had been provided by the CCSBT tagging since 2001, but the areas surveyed by the cruise were limited and the tagging was suspended in 2007.

The acoustic index derived from the acoustic monitoring survey predicted the low recruitment levels of the 1999-2001 year classes of SBT so that it was likely to be a reliable index. However, the survey was ceased after the final survey in 2006 due to the budget restriction. Alternatively, a type of survey that can be done with lower cost was sought. Since 2006, we have carried out a monitoring survey that a chartered Australian vessel go-and-back on a single straight transect line and find SBT schools by catching with trolling (Itoh and Kurota 2006, Itoh and Sakai 2007, 2008, 2009a, 2010). In January 2011, we carried out the 6th trolling monitoring survey and the results of the survey are presented in this paper.

2. Materials and methods

Cruise of the piston line trolling survey

An Australian vessel, St Gerard M with 18 m in total length, was chartered (Fig.1).

The vessel was also used in the surveys for last five years. Two researchers including the authors, and two Australian crew members were on board.

The research area was off the south coast of Western Australia between Esperance (122E) and Albany (118E), including off Bremer Bay (Fig. 2). Within the research area, continental shelf of 70 m in depth extended largely and then dropped sharply to deeper than 500 m in depth at shelf edge within 2 km distance toward offshore. The piston-line laid between the two points same as last year; one was at 34°29.2'S-119°23.1'E and the other was at 34°44.9'S-119°36.9'E so that the piston-line covered a range from continental shelf to offshore through shelf edge. In addition to the piston-line, adjacent areas, east, west or south (offshore) of the piston-line as well as the area west to off Albany, were also surveyed so that examine whether the piston-line is a representative area in regard to SBT distribution (Fig. 2).

The vessel operated trolling at speed of 7-8 knots. Eight trolling lines at maximum were trolled. The specifications of the trolling gears were consistent with those used in the last year survey.

Because the index derived from the survey is based on the number of SBT schools, not the number of SBT individuals caught, we did not try to maximize the number of fish caught. When catch was succeeded and reach 10 individuals presumably from single school, trolling was suspended and the vessel went forward around 1.0 mile without using trolling lines so that left from the school, in order to minimize mortality by the survey.

Individuals caught of any species were measured its length. SBT in good condition were tagged and released with an archival tag (Lotek Inc., LAT2810) and two CCSBT conventional tags following the CCSBT tagging procedure. Other SBT individuals were weighed and taken biological samples (stomach contents, otoliths and muscle tissue).

Vertical profile of temperature and salinity (conductivity) were measured down to just above sea bottom or 200 m in depth using a CTD (JFE ALEC co. ltd., CTD RINKO-Profilier). Temperatures of sea surface were recorded successively using the miniature temperature recorder (JFE ALEC co. ltd., MDS-MkV/T). GPS positions data were recorded every ten seconds.

Underwater video images were taken during trolling conducted out of the piston-line. One or two digital cameras in waterproof cases were towed and placed 20-30 m behind of the vessel and 2-3 m below the sea surface. The camera took image toward below and behind direction. The images taken were observed on monitor of PC and SBT presence was checked later in laboratory.

Calculation of Trolling Index

Five types of trolling indices were calculated as follows.

- (1) The number of schools of age one SBT per 100 km search distance. A catch of age one SBT that apart from 2 km in distance from last catch of age one SBT is defined as a different school. TRI_2km.
- (2) The number of schools of age one SBT per 100 km search distance. A catch of age one SBT that apart from 20 minutes in time from last catch of age one SBT is defined as a different school. TRI_20min.
- (3) The number of schools of age one SBT per 100 km search distance. A catch of age one SBT that apart from 30 minutes in time from last catch of age one SBT is defined as a different school. TRI_30min.
- (4) The number of times of catch of age one SBT per 100 km search distance. All the catches even it was likely to be from the same school were counted. TRI_times.
- (5) The number of age one SBT individuals per 100 km search distance. TRI_ind.

Confidence intervals of the trolling indices were calculated from data sampled 1000 times by bootstrap methods, and the results were shown by box plots or median, 5% and 95% points. The indices were calculated for the following three data series and compared over 16 years between 1996 and 2011; 1) piston-line trolling survey from 2006 to 2011, 2) trolling catch on the piston-line in the acoustic (sonar) survey from 2005 to 2006, and 3) trolling catch in other area of the piston-line in the acoustic (sonar) survey from 1996 to 2006 (Itoh, 2007).

3. Results

The vessel departed Esperance on 25 January 2011, which was six days later than the survey in 2010. The vessel surveyed off Bremer Bay from 26 to 29 January, and then went further west and surveyed an area between Bremer Bay and Albany from 30 January to 6 February. The vessel came back and surveyed off Bremer Bay again from 7 to 8 February. The vessel left off Bremer Bay and surveyed west of Esperance, near Investigator Island and West Group, from 9 to 10 February and back to Esperance on 11 February in which the research survey was finished.

Usually, the vessels engaged in the research survey from 6:00 to 18:00 and anchored in calm bay at night. While there were a few days in rough sea, we could carry out the surveys all the 18 days except two days (5 and 6 February). The piston-line was surveyed off Bremer Bay in six days for 12 lines.

During the cruise, a total of 344 fish individuals were hooked, including 263 SBT, 19 skipjack *Katsuwonus pelamis*, 3 bonito *Sarda orientaris*, 1 blue mackerel *Scomber australasicus*, 11 yellowtail kingfish *Seriola lalandi*, 13 barracouta *Thyrsites atun* and 34 unidentified individuals which escaped far from the vessel. Among the 263 SBT individuals, 34 SBT were tagged with CCSBT conventional tags and also implemented archival tags. 222 SBT were killed for biological sampling and 7 were escaped near the vessel. Total weight of SBT sampled was 793.2 kg of 222 individuals.

Many SBT were caught off Bremer Bay not only on the piston-line but also in adjacent areas (Fig. 2). Few SBT were caught offshore area from self edge on the piston-line. Compare to previous years, fewer SBT were caught near shelf edge this year.

Length frequencies of SBT caught are shown in Figure 3. SBT caught ranged from 34 to 76 cmFL. Most of fish caught were estimated as age-1 fish from its length. SBT larger than regular age-1 size (e.g. 55-65 cm FL) were frequently caught this year. They were caught off Albany and west of Esperance, but few off Bremer Bay. The SBT age-1 off Bremer Bay including the piston-line was regular size as in previous years. There is a difficulty to decide such a larger size fish as age-1. However, SBT individuals caught from every school on the piston line included at least one SBT individual less than 55 cm FL. Then, age assignment for the school to be age-1 was not affected by the presence of relatively larger size SBT this year.

Underwater video images were taken 61 times, up to 32 minutes long each time. Those footages were under observation.

On the 12 piston lines, the total number of age-1 SBT school was 20 and 24 when the successive SBT catches more than 30 minutes and 2 km are defined from different schools, respectively. The total distance searched on the piston line was 352 km. The mean trolling indices are calculated as 5.7 school/100 km (30 minutes school definition) or 6.8 school/100 km (2 km school definition).

Figure 4 shows the five different trolling indices produced by 1000 times bootstrap sampling to the number of lines. The indices were standardized to its median at 12 lines. Along the number of lines increased, median values become more stable larger than two lines and the confidence interval between 5% and 95% points were decreased largely to five lines and then decreased gradually. 12 lines actually carried out this year was appear to be sufficient.

Figure 5 shows three series of trolling indices. Because there were no sequential detail location records (GPS time series data) in the acoustic survey and TRI_2km was not available, TRI_30min was used for comparison. Although each index was derived from different methods (vessel or area) and should be careful, it allows interpretation of

the recent index within the longer time series of 16 years. Indices in 2005 and 2006 provide calibration among the three indices. Generally, indices of the three series were in similar values to each other in each of the two years. Median of indices of the acoustic survey on the piston-line were 1.2 (2005) and 1.5 (2006) times higher than that in the whole area, respectively. Median of index of the acoustic survey on the piston-line were 1.3 times higher than that of the trolling survey in 2006. It is better that the indices from the acoustic survey in the whole area during 1996-2006 was as 1.2-1.5 times high that shown in the figure, when compare to the indices from the trolling survey since 2006.

Considering these, the indices were similar level between 1996 and 1999, decreased to very low level between 2000 and 2002, increased again in 2003 and 2006 (research was not carried out in 2004) to the same level during 1996-1999, and further increased between 2007 and 2008. After decreasing in two years of 2009 and 2010 to the same level during 1996-1999, the index increased in 2011 with median of 5.7 shoals/100 km (4.1-7.4 in the 90% confidence interval). Note that cohort (year class) is one year before mentioned above.

4. Discussion

The results obtained from the piston-line trolling survey and trolling data in the acoustic survey show that the recruitment level of the 1999-2001 year classes are low, those of the 2002 and 2004 year classes are same level of the 1995-1998 year classes, and those of the 2005-2010 year classes are high. It is consistent with that the 1999-2001 year classes are low level in various fishery data and scientific researches (Anon., 2006). For the subsequent year classes, aerial survey index and fishery data from longline in Japan and New Zealand suggests that the 2002 and 2008 year classes are in relatively high level, which also consistent with trend of the trolling index. Information of the year classes after 2009 has not been obtained from other sources.

Fishery data are basic information to estimate current stock status of SBT in CCSBT. Especially, CPUE of Japanese longline, which cover wide area and season and wide age range and based on detailed information reported from fishermen, is a long time series index more than 40 years for SBT stock status. Aerial survey is also a valuable research. It covers wide area in a short duration in the Great Australian Bight by using airplane and data of school biomass is derive as an estimation of spotter. Aerial survey index is thought to be a valuable index and used for MP testing. However, there is no index that directly reflect the status of whole the stock perfectly. Therefore, as many as possible information is required to decide stock status appropriately. Trolling survey provide an important information of which some part is unique among various sources.

The trolling survey is a robust research against wind, wave and swell. There was few

days that suspended the research during the cruise due to rough sea condition in six years. We did not find a tendency that SBT were less caught in rough sea condition. In addition, species identification and size of SBT are actual data in the trolling survey. These are advantages of the trolling survey compared to the acoustic survey and the aerial survey.

SBT of age 3 and more are distributed so widely in the area between off New Zealand and off Cape that a fraction of the whole stock is the subject of the aerial survey in the Great Australian Bight and Taiwanese and Japanese longliners. In contrast, it is believed that SBT age-1 is distributed in the coastal area of Western Australia (Itoh and Sakai 2009b). A recruitment index derived from SBT age-1 in Western Australia has a potential that represents whole the stock at an age.

The objective of trolling survey has been to obtain a rough recruitment index with low cost. Index on the piston-line which become stable around 4-7 lines in six years suggests that four days or more is sufficient for the piston-line survey. Indices between on the piston-line and on adjacent areas, as well as those between off Bremer Bay and off Albany were not different very much (Itoh, 2007, Itoh and Sakai 2008, 2009a). However, unfortunately, these differences were not small. We should recognize that the trolling index, which based only on the number of school and ignore the biomass of the SBT school, is a rough recruitment index. Even if the number of days for survey or the number of vessels were increased, the resolution of the index is not likely to be increased largely. In order to obtain such a rough recruitment index, the research design has already established.

The recruitment monitoring is needed to be continued further at least in similar scale in the consistent procedure. In addition, to determine the robustness of the index obtained, more data of the dynamics of distribution of SBT age 0-1 in Western Australia should be collected (Itoh and Sakai 2009b).

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Table 1. Statistics of trolling index.

| Survey | Year | N_line | Area | Minimum | 5% | Median | 95% | Maximum |
|----------|------|--------|---------------------------|---------|-------|--------|-------|---------|
| Acoustic | 1996 | | Not including piston line | 0.365 | 0.711 | 1.260 | 1.912 | 2.955 |
| Acoustic | 1997 | | Not including piston line | 0.317 | 0.644 | 1.075 | 1.604 | 2.361 |
| Acoustic | 1998 | | Not including piston line | 0.423 | 0.958 | 1.576 | 2.215 | 2.949 |
| Acoustic | 1999 | | Not including piston line | 0.819 | 1.373 | 1.932 | 2.528 | 3.127 |
| Acoustic | 2000 | | Not including piston line | 0.000 | 0.092 | 0.367 | 0.658 | 1.068 |
| Acoustic | 2001 | | Not including piston line | 0.000 | 0.000 | 0.101 | 0.301 | 0.716 |
| Acoustic | 2002 | | Not including piston line | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Acoustic | 2003 | | Not including piston line | 0.161 | 0.570 | 1.046 | 1.554 | 2.270 |
| Acoustic | 2005 | | Not including piston line | 0.128 | 0.483 | 1.196 | 2.120 | 3.390 |
| Acoustic | 2006 | | Not including piston line | 1.309 | 1.859 | 2.420 | 3.052 | 3.738 |
| Acoustic | 2005 | 18 | Piston line only | 0.142 | 0.718 | 1.442 | 2.284 | 3.158 |
| Acoustic | 2006 | 18 | Piston line only | 2.500 | 2.951 | 3.682 | 4.422 | 5.015 |
| Trolling | 2006 | 12 | Piston line only | 1.490 | 2.057 | 2.817 | 3.584 | 4.172 |
| Trolling | 2007 | 14 | Piston line only | 1.493 | 3.100 | 4.723 | 6.712 | 8.576 |
| Trolling | 2008 | 10 | Piston line only | 3.388 | 4.326 | 5.426 | 6.467 | 7.567 |
| Trolling | 2009 | 9 | Piston line only | 1.298 | 2.236 | 3.578 | 5.119 | 6.613 |
| Trolling | 2010 | 11 | Piston line only | 0.872 | 1.755 | 2.918 | 4.071 | 4.954 |
| Trolling | 2011 | 12 | Piston line only | 2.773 | 4.068 | 5.653 | 7.393 | 9.066 |

Unit of index was $N_{\text{school}}/100 \text{ km}$. School definition was >30 minutes between two catches.

Minimum, 5%, median, 95%, and maximum points were calculated from 1000 times bootstrap samplings.



Figure 1 St Gerard M, used for the research

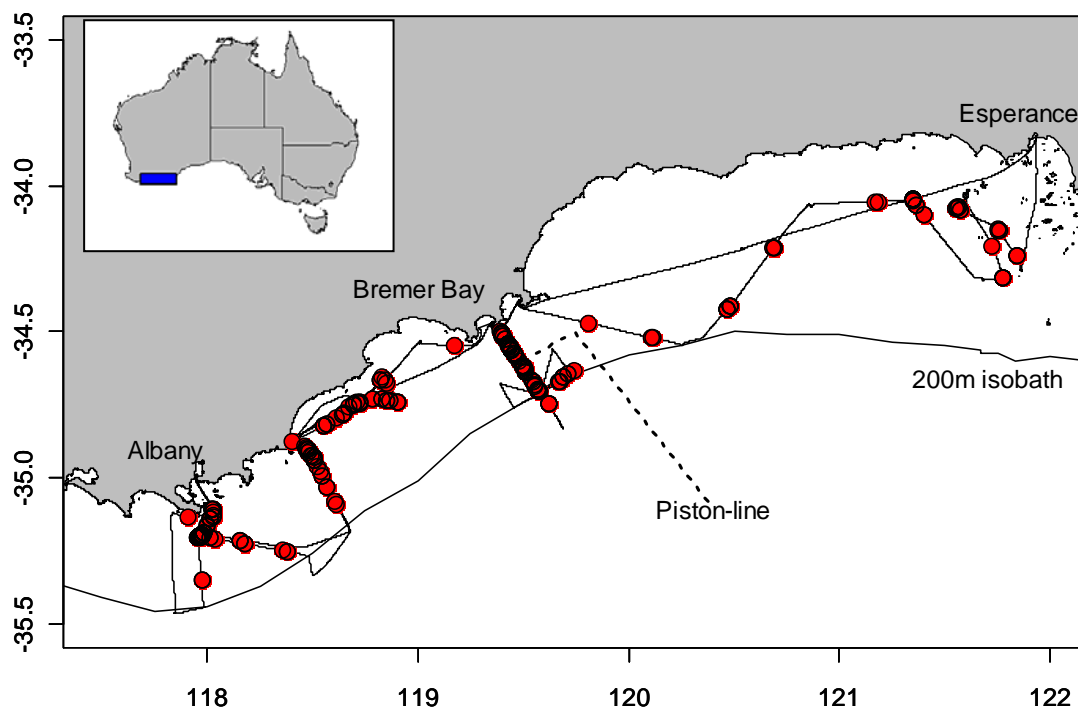


Figure 2 Trajectory of the vessel and location of SBT caught (circles) in the 2011 trolling survey.

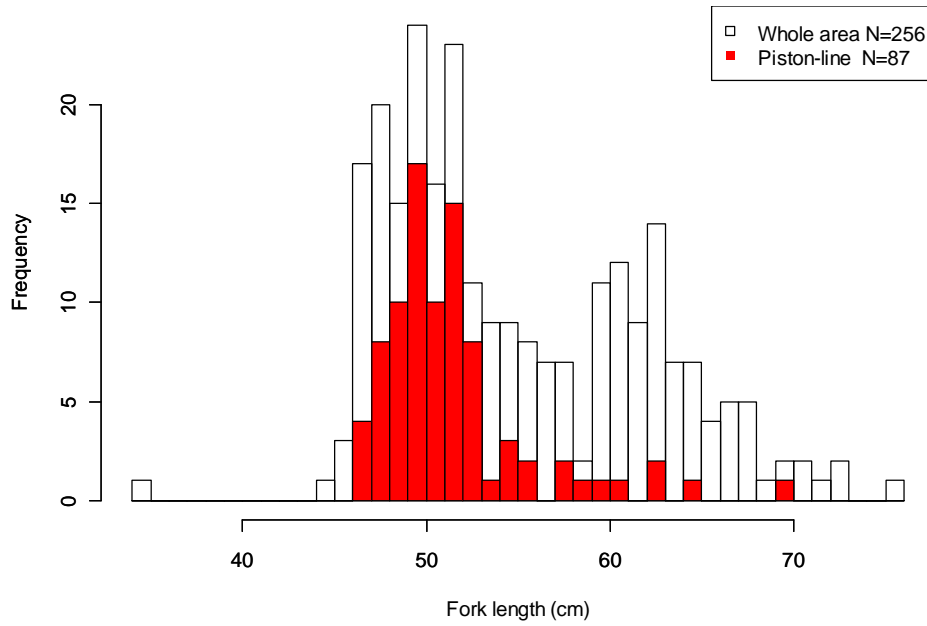


Figure 3 Fork length frequency distributions of southern bluefin tuna caught in the 2011 cruise. That of fish caught off Bremer Bay (119E-120E) is also show as Piston-line.

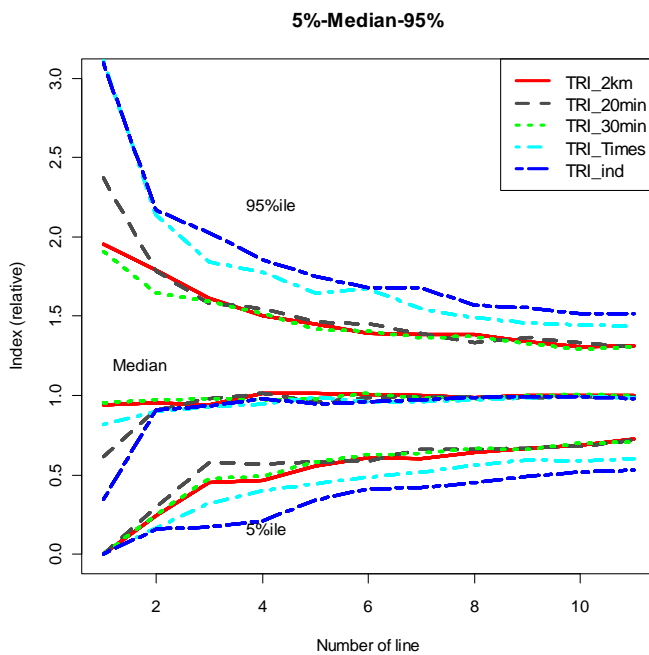


Figure 4 Bootstrap simulation for the five types of trolling indices to the number of line surveyed in 2011. Relative values of median, and 5 percentile and 95 percentile points to the mean of each trolling indices are shown.

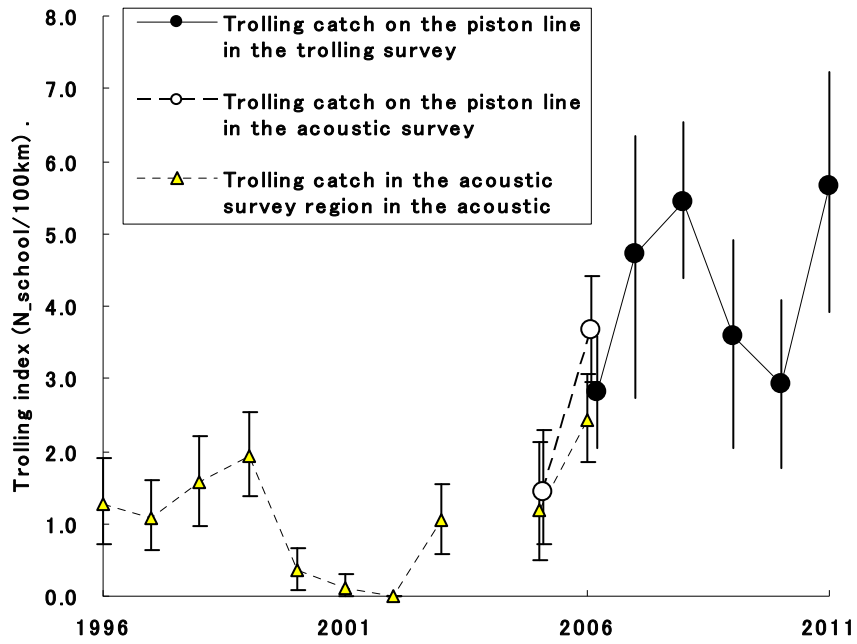


Figure 5 Trolling indices (TRI_30min) from the troling survey on the piston line (2006-2011), from the acoustic survey on the piston line (2005-2006) and from the acoustic survey in whole the rectangle research area except the piston line (1996-2006). Marks and bars denote median and 5% and 95% points from 1000 times bootstrap samplings, respectively.