Some examination on the recruitment index of age 1 southern bluefin tuna derived from the trolling survey

曳縄調査で得られたデータによるミナミマグロ 1 歳魚の加入量指数の検討

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Summary

The trolling indices, which were recruitment indices for age one southern bluefin tuna, were calculated from the trolling survey in 2006 and 2007, as well as the trolling catch data in the acoustic survey from 1996 to 2006. The indices are in increasing trend from the 2004 year class to the 2006 class. It appears that the trolling indices can monitor the age one SBT recruitment abundance at least coarsely. Further investigation of distribution and movements of age one SBT, expanding the research area and evaluation from the fishery information that obtained for next a few years, are required.

要約

ミナミマグロ 1 歳魚の加入量指標である曳縄指数を、2006 年と 2007 年の曳縄調査ならびに 1996-2006 年の音響調査の曳縄漁獲データから求めた。曳縄指数は 2004 年級から 2006 年級にかけて増加傾向にある。曳縄指数はミナミマグロマグロの加入レベルを少なくとも大まかには反映していると思われる。1 歳魚の分布と移動の研究、調査海域の拡大、今後数年間で得られる漁業指標との比較が今後に必要である。

1. Introduction

Based on the agreement on the catch allocation of CCSBT in 2006, the largest catch of southern bluefin tuna (SBT) will come from the Australian purse seine. It means that a large part of fishing pressure will concentrate on younger age of SBT than previous years. Therefore, monitoring the recruitment level of SBT in their early life stage becomes more important for the appropriate management of the SBT stock by CCSBT. However, CCSBT does not have reliable recruitment indices yet.

One hopeful index was that from the acoustic research conducted by Japan for more than 10 years since 1996 (Itoh 2006). It predicted the low recruitments of 1999-2001 year classes. But, the survey was ceased due to budget restriction. In this paper, the recruitment index of age one SBT from another type of survey, the trolling survey, is calculated, and discussed its reliability with considering other information such as data of trolling catch in the acoustic survey and CPUE by age in Japanese longline fishery. The trolling survey is the only one survey at present that provides information of age one SBT abundance except for the CCSBT tagging. Detail of trolling survey conducted are described in other papers (Itoh and Kurota 2006, Itoh and Sakai 2007)

2. Materials and methods

Three data series were used (Table 1). The first is the data of the trolling survey in 2006 and 2007. The second is the trolling catch data of the acoustic survey on the piston line in 2005 and 2006. The third is the trolling catch data of the acoustic survey other than the piston line in 1996-2003 and 2005-2006.

In the trolling survey, in addition to the piston line survey that go and come back on the determined transect straight line, three surveys were also conducted; shelf edge survey that go and come back on lines along continental shelf edge, triangle survey that go along on triangles set on the continental shelf, and offshore survey that go and come back on a straight line that extended toward offshore from the end point of the piston line (Fig. 1). Every one way of the go and come back line or one side of a triangle was used as one line for analyses. The piston line in 2006 was between the two points of 34°31´S-119°27´E and 34°47´S-119°41´E. The piston line in 2007 was between the two points of 34°28´S-119°24´E and 34°44´S-119°38´E, extending towards inshore and shortening offshore areas compare to that of 2006 (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 in 2 km distance toward offshore. Analyses for three areas, on the continental shelf, shelf edge (between two points of 34°41.1´S-119°35.4´E and 34°42.0´S-119°36.1´E in the 2007 piston line) and offshore area, were conducted.

In the acoustic survey, the research vessel went to east or west along on zigzag lines that bounced at the northern and southern boundaries of the rectangular shaped research area. While SBT schools were searched by sonar so that the research vessels cruised all day long, trolling was conducted only in the daytime (6:00 to 18:00) and then trolling was not conducted in some portion of the lines. In the research area, SBT was distributed on continental shelf and on the shelf edge, and seldom distributed in the offshore from the shelf edge. In order to eliminate the effects of the distribution differences by area, only lines (defined as a straight line between northern and southern boundaries of the rectangle research area) that trolling was conducted whole of the line were used for the analyses. In 2003, one third of the research area (offshore side) was excluded in order to use the ship times more efficiently. Therefore, trolling indices of the acoustic survey in 1996-2002 were multiplied by 1.5 to make it consistent with indices after 2003.

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 the 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 the 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 the 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.

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. For the trolling survey, changes of trolling indices along with the changes of the number of piston lines conducted were examined as well as the comparisons of trolling indices among different areas or survey types. Then, the trend of the recruitment indices over 12 years between 1996 and 2007 were examined based on the three series of trolling indices.

3. Results

Figure 3 shows the five different trolling indices in 2006 and 2007. The absolute values of them vary to each other.

The trolling indices were calculated for the number of the piston line surveyed from 1 to 20. Relative values to the median of 20 lines are shown in Figure 4. Ranges of the trolling indices between 5% and 95% points are the smallest in TRI_20min and TRI_30min, followed by TRI_2km. The ranges were slightly larger in TRI_times and TRI_ind. No difference was found among indices in 2007. Along the number of lines increased, median values became stable at three lines and the ranges between the 5% and 95% points were decreased largely to seven lines and then decreased gradually. The numbers of lines conducted were 12 in 2006 and 14 in 2007, respectively, and both are appear to be sufficient.

Figure 5 shows the trolling indices (TRI_2km) by area. The trolling indices were almost same on the continental shelf and shelf edge, and no SBT were found in offshore, in 2006.

In 2007, the trolling indices was higher in the shelf edge and that in offshore was similar to that on the continental shelf.

To examine whether the area on the piston line is particular in terms of SBT distribution, the trolling indices (TRI_2km) of various surveys (the triangle survey, shelf edge survey and offshore survey) were compared to each others. Because the trolling indices differ by area as described above, comparison was made by each area. The trolling indices of various surveys were similar to each other in some cases (e.g. on the continental shelf in 2007) or differ at most about two times (Fig. 6).

Figure 7 shows the trolling indices on the piston line from the trolling survey and the acoustic survey between 2005 and 2007. Because there were no sequential detail location records (GPS time seriesdata) in the acoustic survey, TRI_30min was used. In 2006 when both surveys conducted on the same piston line, the median of the trolling indices of the acoustic survey is slightly higher but half of the ranges of the indices between 5 and 95% are corresponded. The trolling indices are in increasing trends from 2005 to 2007.

Figure 8 shows the TRI_30min from the acoustic survey on the piston line (2005-2006) or whole the rectangle research area except the piston line (1996-2006). The indices on the piston line are high 1.2-1.5 times as much as that in the whole area. Considering these, the indices are similar in 2005 and higher in 2006 compare to the 1996-1999 level.

4. Discussion

There was little difference among relative values of the five trolling indices. Among them, TRI_ind or TRI_times can be affected largely by changing the number of lines trolled or how persistently repeat trying catch to a SBT school found. TRI_20min and TRI_30min can be affected by the time required for handling of gears or treatment of sampled fish individuals. Therefore, TRI_2km is likely to be the most objective and appropriate indices among the five indices. Automatic recording system of GPS data introduced in the 2007 trolling survey allowed calculating TRI_2km much easier. There might be room for consideration whether the value of distance as 2 km is appropriate. There is also room for consideration to develop other indices.

Differences of the trolling indices by areas (on the continental shelf, shelf edge or offshore) and by surveys (piston line survey or triangle survey) were found. It arouses a caution to give too much reliability assuming the value of the trolling indices on the piston line reflects the SBT abundance distributed around the research area precisely. Additional point of consideration is that SBT school was found in offshore area in 2007 in spite of almost no catch have been made in the offshore area in the acoustic survey for more than 10 years. There is a possibility that SBT distribution in 2007 was quite different to that in previous years.

The trolling indices, which are for age one SBT, comparing to those in 1995-1998 year classes level, suggested the recruitment level of SBT in the 1999-2001 year classes were very low, the 2002 year class was similar level, the 2003 year class was unknown due to no research survey conducted, the 2004 year class was similar level, the 2005 year class was high and the 2006 year class was very high,. It was found that the 2000-2001 year classes and presumably also the 1999 year class were in very low recruitment based on various types of information in the Scientific Committee of CCSBT (Anon. 2006). This agrees with the trolling indices.

In CPUE by age in Japanese longline fishery based on RTMP 2005 – 2007, CPUEs of age 2-3 in 2005 (2002-2003 year classes), age 2-3 in 2006 (2003-2004 year classes) and age 2-4 in 2007 (2003-2005 year classes) were higher than those in 2004 or previous years. It suggests agreement with the trolling indices in some extents. However, cautions are needed that CPUE by age varied in different areas or months and that the recruitment of SBT for Japanese longline fishery completes at age 4. It require a few more years to conclude the trolling indices reflects recruitment level at least roughly by comparison with catch information of longline fishery within a few years.

Obtaining just a coarse accuracy of the SBT recruitment level was the objection of the trolling survey from its beginning in exchange for conducting the survey with low costs. It is still not known how accurate the trolling indices reflect amount of SBT abundance distributed in the research area. If we want more improved accuracy on the indices, there are some issues that should be solved. For example, the trolling indices at present are based on the number of schools. It ignores the biomass of each school. If school biomasses change regardless of the recruitment abundance, it causes a serious problem for the accurate type of trolling indices.

It is also unknown how much SBT distributed in the research area represents whole the recruitment stock. This issue is very serious for the trolling survey, while it is common for all the scientific researches and fishery indices. At the same time of the trolling survey, we also conducted the acoustic tagging survey. The acoustic survey have been investigating distributions and movements of age one SBT off west coast and south coast of Western Australia between Fremantle and Bremer Bay for three years. In the survey, age one SBT individuals were deployed acoustic tags into their belly and released. Acoustic signals from the tags were detected by hydrophone receivers that placed on arrays off Bremer Bay. Detail of the survey is presented in another paper (Kawabe et al. 2007, Hobday et al 2007). If we seek more accurate type of indices, and if the results of the acoustic tagging survey show that SBT distributed in the research area was too much fragmental and not represented of whole the SBT recruitment stock, the area surveyed by the trolling survey have to be expanded.

In conclusion, it appears that the trolling indices can monitor the age one SBT recruitment abundance at least coarsely. However, it is still unknown how much the indices represent whole the recruitment stock. Further investigation of distribution and movements of age one SBT, expanding the research area and evaluation from the fishery information that obtained for next a few years, are required.

Reference

Anonymous (2006) Report of the eleventh meeting of the Scientific Committee. September 2006, Tokyo Japan.

Itoh, T. (2006) Acoustic index of age one southern bluefin tuna abundance by the acoustic survey in 2005/2006. CCSBT-ESC/0609/37.

Itoh, T. and Kurota, H. (2006) Report on the piston-line trolling survey in 2005/2006. CCSBT-ESC/0609/38.

Itoh, T. and Sakai, O. (2006) Report on the piston-line trolling survey in 2006/2007. CCSBT-ESC/0709/34.

Table 1 Data used for analyses

Survey	Year	Type of line	Number of lines	Remark
Trolling survey	2006	Piston line	12	Additional four on shelf and two on shelf edge.[1)]
		Triangle	12	
		Shelf edge	4	
	2007	Piston line	14	
		Triangle	12	Two lines were on shelf edge.
		Shelf edge	4	
		Offshore	2	
Acoustic survey	2005	Piston line	18	
	2006	Piston line	18	
	1996	other than piston line	23	
	1997	other than piston line	22	
	1998	other than piston line	22	
	1999	other than piston line	35	
	2000	other than piston line	26	
	2001	other than piston line	24	
	2002	other than piston line	21	
	2003	other than piston line	25	
	2005	other than piston line	17	
	2006	other than piston line	24	

Additional data from incomplete piston line were used only for the comparison among region types; four data for on shelf and two data for shelf edge.

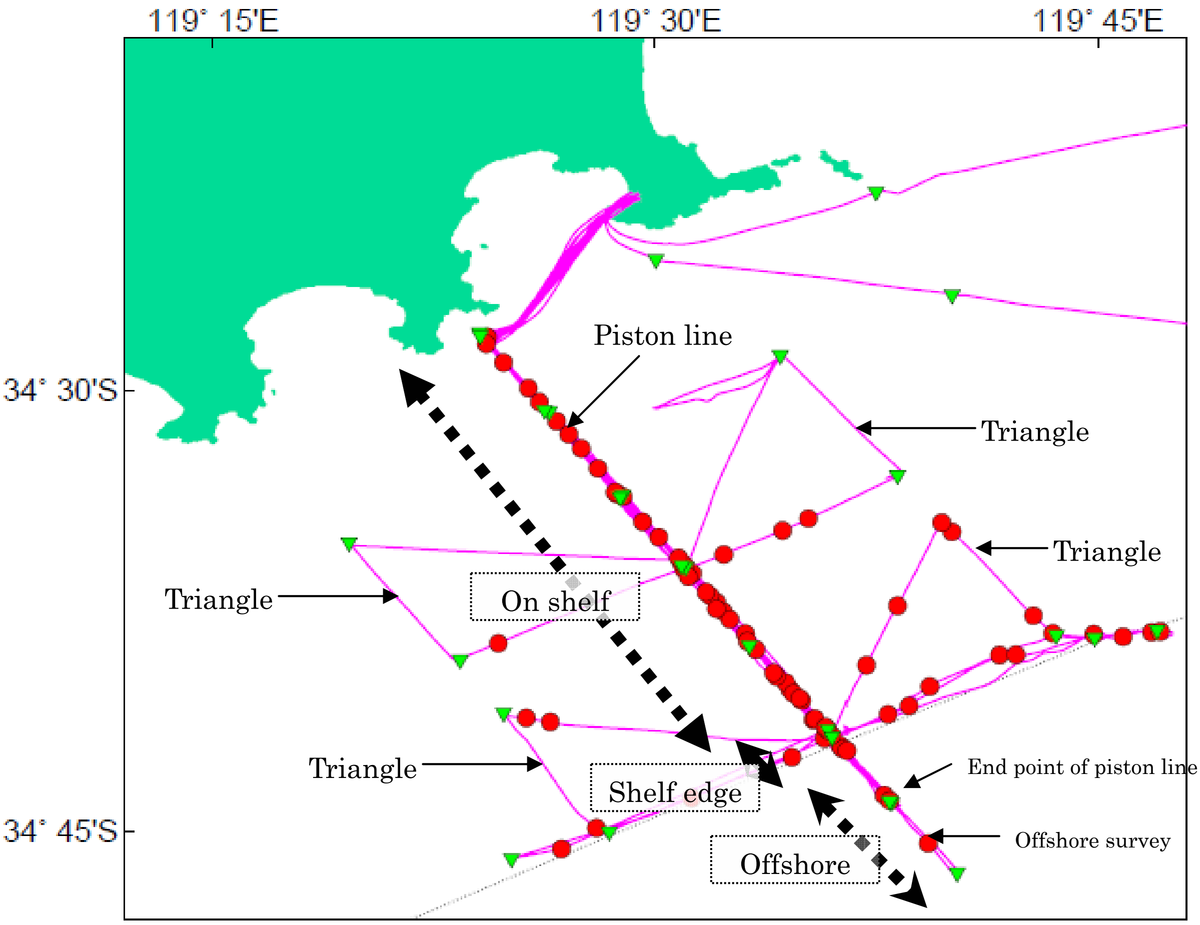

Fig. 1 Out line of the trolling survey in 2007. Area categories and name of surveys are shown. Lines are trajectories of the research vessel. Circles and triangles denote locations where southern bluefin tuna were caught and oceanographic observations were made, respectively. Dotted line is 200m isobath.

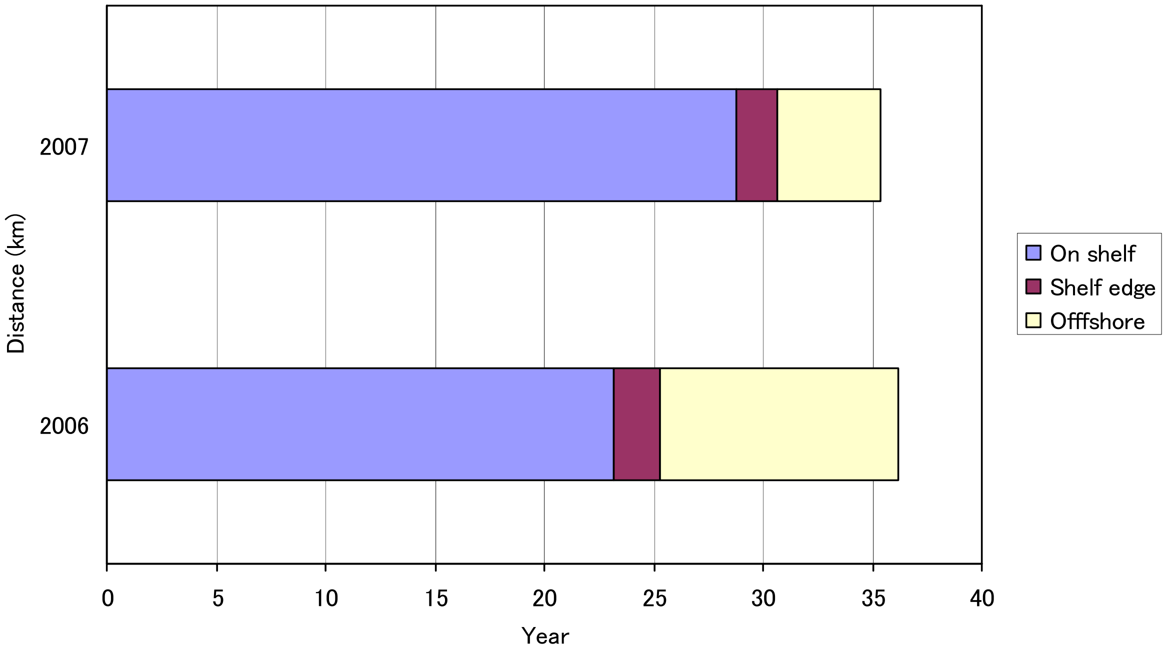

Fig. 2　Distance of the piston line by area category

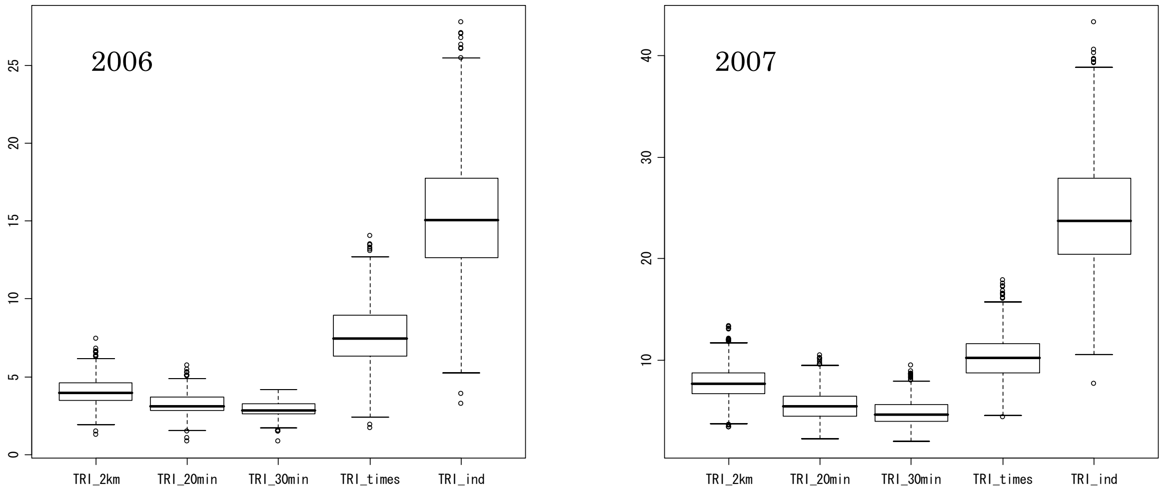

Fig. 3　Absolute values of the five types of trolling indices derived by bootstrap.

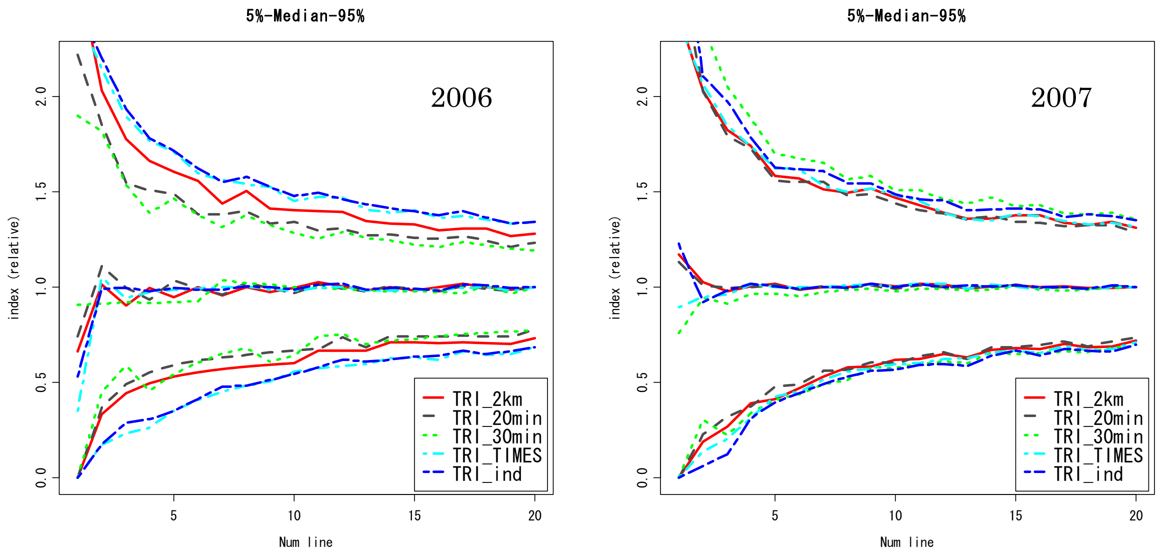

Fig. 4 Bootstrap simulation for the five types of trolling indices and for the number of line surveyed. Relative values of median, and 5% and 95 % points to the median at 20 lines of each trolling indices are shown.

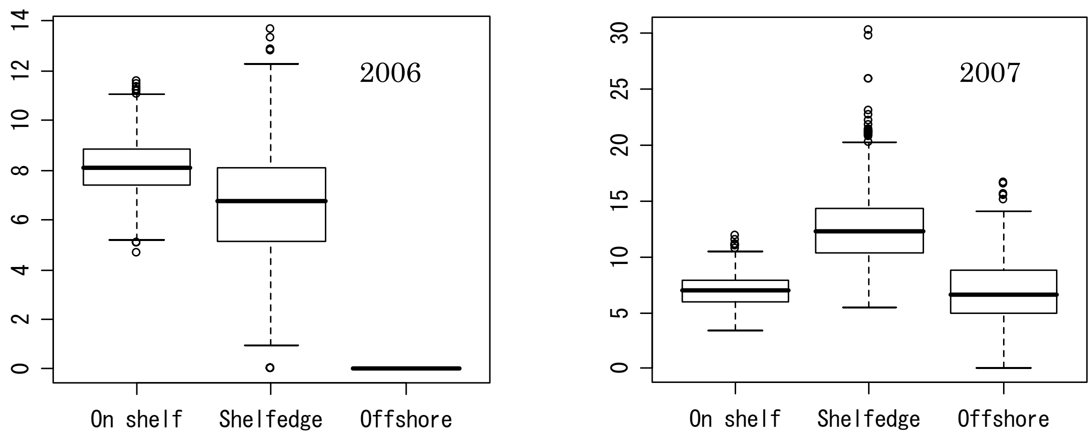

Fig. 5 Comparison of trolling indices (TRI_2km) among area categories. All of the surveys were bundled.

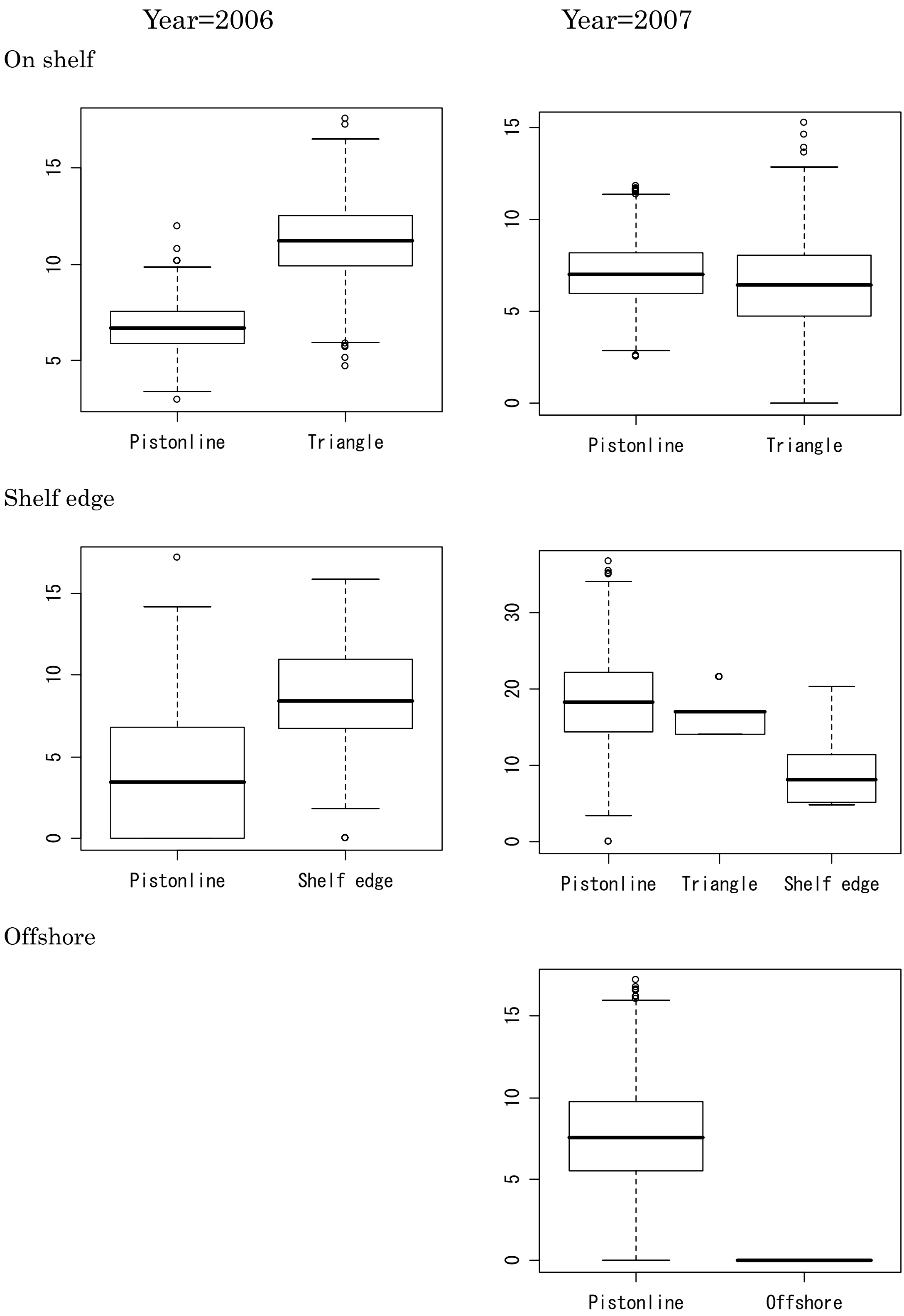

Fig. 6 Comparison of the trolling indices (TRI_2km) by survey type in each area category.

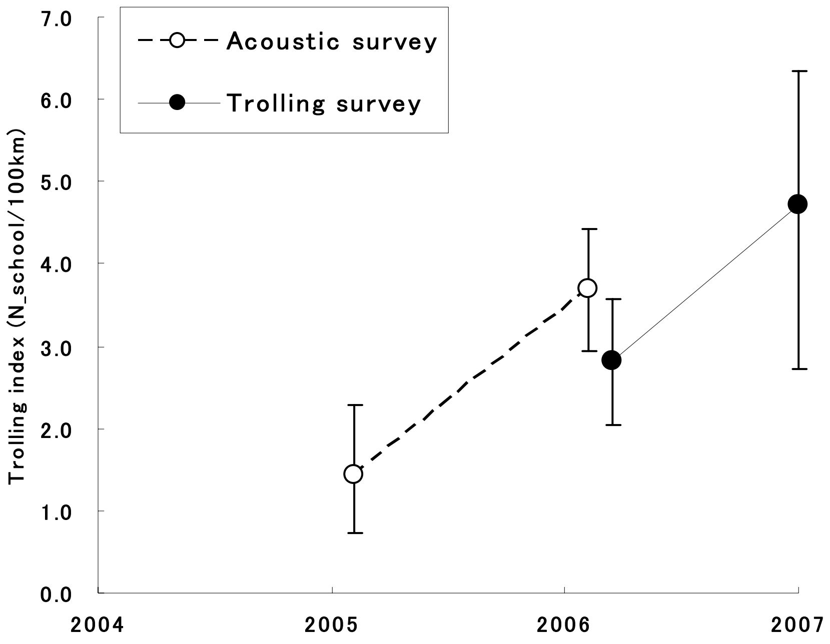

Fig. 7 The trolling indices (TRI_30min) on the piston line from the trolling survey and the acoustic survey between 2005 and 2007. Marks and bars denote median and 5% and 95% points from 1000 times bootstrap samplings, respectively.

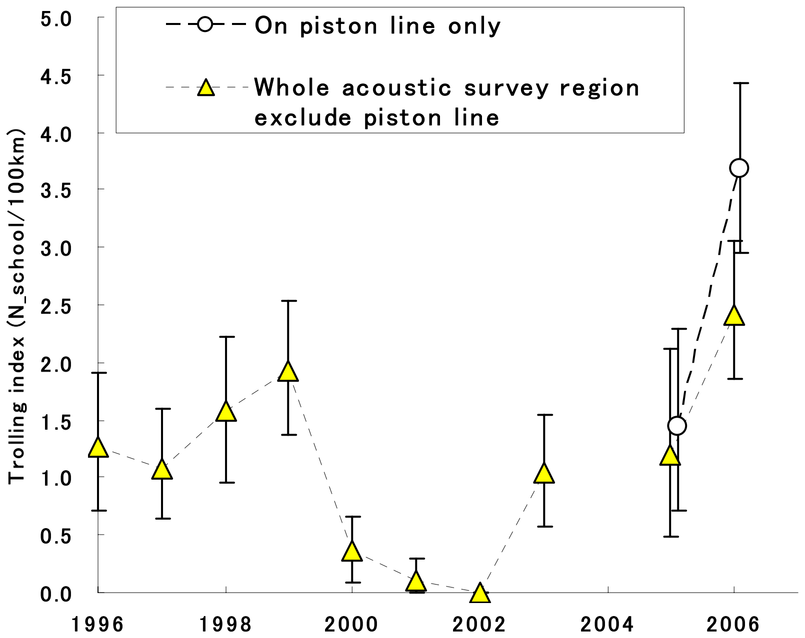

Fig. 8 Trolling indices (TRI_30min) from the acoustic survey on the piston line (2005-2006) or whole the rectangle research area except the piston line (1996-2006). Marks and bars denote median and 5% and 95% points from 1000 times bootstrap samplings, respectively.