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Report of the piston-line trolling monitoring survey for the age-1 southern bluefin tuna recruitment index in 2019/2020
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 2019/2020 の結果報告

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要約

ミナミマグロ *Thunnus maccoyii* 1 歳魚の加入指数を求める曳縄調査を、2020 年 1 月から 2 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 10 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 226 個体で、その内 118 個体にはアーカイバルタグを装着して放流した。

Summary

In January and February 2020, the trolling survey that provides the data for recruitment index of age-1 southern bluefin tuna *Thunnus maccoyii* (SBT) was carried out in a similar manner since 2006. In the survey, a chartered Australian vessel went and back on the same straight line (piston-line) off Bremer Bay on the southern coast of Western Australia using trolling for a total of 10 lines. The adjacent area of the piston-line and the area between Albany and Esperance were also surveyed. During the survey, a total of 226 SBT individuals were caught. Among them, 118 fish were implemented archival tags and released.

1. Introduction

Recruitment level is crucial information on stock management of fish, including southern bluefin tuna (*Thunnus maccoyii*, SBT). Several research activities have been attempted for the recruitment monitoring of SBT. Since 1989, Japan has conducted a series of recruitment monitoring survey 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). The recruitment index derived from the acoustic monitoring survey predicted the low recruitment levels of the 1999-2001 year classes of SBT which was confirmed several years later by the model-based assessment 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, we have carried out a trolling survey since 2006. Australia had carried out a scientific aerial survey in the Great Australian Bight in South Australia since 1993 and provided the recruitment indices, as the aerial survey index, to CCSBT (Eveson et al. 2006). The aerial survey was discontinued after 2017 because of budgetary reason and logistical problems. Since 2016, pilot Gene Tagging (GT) project has been started instead of the aerial survey. GT estimates the absolute amount of resources of age-2 SBT for the next Management Procedure (MP).

The trolling survey is a reasonable way to know the recruitment status of age-1 SBT. The recruitment index of age-1 SBT from this survey have provided to CCSBT as a fishery independent indicator and robustness test for MP. This survey finds SBT schools by trolling off southwestern Australia. Additionally, we set the single straight transect line in the survey area and are investigating intensively each year on this line (Itoh and Kurota 2006). This survey is a long-term survey covering 14 years from 2006 to 2019 (Itoh and Kurota 2006, Itoh and Sakai 2007, 2008, 2009a, 2010, Itoh et al. 2011, 2012a, 2013, Itoh and Tokuda 2014, Itoh and Tsuda 2016, Tsuda and Itoh 2017a, 2018a, 2019a). The long time series data can be expected to detect not only the interannual fluctuation of recruitment of age-1 SBT but also a medium-term trend of it. Additionally, the recruitment index from this survey become available immediately in the same year of the survey carried out, i.e. the time-lag from the survey to data become available is 0 year. On the other hand, the GT data has provide a short time series. The estimated absolute age-2 SBT abundance from GT has the time-lags of 2 years from sampling to the data become available. Therefore, in order to find recruitment failure, if it occurred, as quick as possible and understand the recruitment trend roughly, it is necessary to continue the trolling survey for the age-1 SBT.

In January and February 2020, we carried out the 14th trolling monitoring survey. This paper describes the general results of the survey. The trolling index calculated from this survey data is described in another paper (Itoh and Tsuda 2020 CCSBT-ESC/2008/20).

2. Materials and methods

An Australian vessel, *The Southern Conquest* with 17 m in total length, was chartered (Fig. 1). Two researchers and two Australian crew members were on board.

The survey area was off the southern coast of Western Australia between off Esperance (123E) and east of Albany (117E), including off Bremer Bay (Fig. 2). The area covers about 450 km x 60 km. The continental shelf of about 70 m in depth extended largely from the coast, and then dropped sharply at shelf-edge to deeper than 500 m in depth within 2 km distance. The piston-line laid between the two points almost same as previous years; one was at 34°29′12″S - 119°23′15″E and the other was at 34°45′00″S - 119°36′44″E so that the piston-line covered a range from the continental shelf to offshore through shelf-edge in distance of 35.76 km.

The vessels engaged in the survey from 5:00 to 17:00 and anchored in the calm bay at night. The vessel operated trolling at speed of 7-8 knots. Eight trolling lines at maximum were trolled. Each line has one hook with a plastic lure. The specifications of the trolling gears were consistent with those used in the last year survey. Because the trolling index derived from the survey is based on the number of SBT schools, not the total number of SBT individuals caught, we did not try to maximize the number of fish caught.

Individual fish caught of any species were measured by its length. SBT in good condition were tagged with an archival tag (Lotek Inc., LAT2810L) and released without conventional tags. Some other SBT individuals were weighed and taken biological samples (stomach contents, otoliths, and muscle tissue). There were some SBT individuals only its fork length (FL) measured and released.

Oceanographic observation for vertical profile of temperature and salinity (conductivity) was carried out at 14 points using the Conductivity-Temperature-Depth profiler (JFE Advantech Co. ltd., CTD RINKO-Profiler) to just above sea bottom or 200 m in depth. GPS position data were recorded every second.

3. Results

The trolling survey started on 30 January 2020 off Esperance in south Western Australia. The vessel moved to the west after 1-day survey off Esperance and we surveyed off Bremer Bay from 1 to 2 February. The vessel moved to further west to Albany on 3

February and we surveyed for 2 days, in addition to two days of strong winds without research. The vessel went back to Bremer Bay on 8 February. After we surveyed off Bremer Bay again for 3 days, the vessel went back to Esperance and we surveyed again off Esperance from 13 to 15 February. The piston-line off Bremer Bay was surveyed in 5 days for 10 lines.

During the survey, a total of 333 fish were hooked, including 226 SBT, 8 skipjack *Katsuwonus pelamis*, 27 yellowtail kingfish *Seriola lalandi*, 52 oriental bonito *Sarda orientalis* and 20 unidentified and escaped fish far from the vessel. 118 out of 226 SBT were implemented archival tags into their body cavities. 93 SBT were killed for biological sampling. Total weight of SBT killed was 238.6 kg.

Length frequency of SBT caught in the 2020 survey is shown in Figure 3. There are four components of SBT in this area: age-0.3 in 30-35 cmFL, age-1.0 having mode at around 48 cmFL, age-1.3 in 57-63 cmFL, and age-2 in 65-80 cmFL (Itoh et al. 2012b). There are two sub-cohorts in age-1 presumably doe to different spawning peaks exists in October and January/February. (Age is estimated from fork length in the following description.) Last survey in 2019, we observed age-1.0 and age-2 fish in almost the same numbers, which was unusual compare to previous years. In 2020, age-1.0 fish was dominant, which is a usual pattern in previous years. Small number of age-2 is corresponds with the result of small proportion of age-1 fish in 2019. The number of fish in age-0.3 was relatively large in 2020.

In SBT distribution in this area, there area tow patterns. One is distributed mainly o the continental shelf and few in shelf-edge. This pattern is frequently observed in recent years. The other is substantial fish are distributed in shelf-edge, which was observed in the early 2010s. In either of patterns, many fish are distributed in topographic features (lumps) and few fish are distributed offshore of shelf-edge. In 2020, SBT in age-1 distributed on continental shelf and few in shelf-edge. In the case of age-0.3 SBT, most of they were caught near shelf-edge. Age-1 SBT were observed anywhere between Esperance and Albany. SBT of age-1 of 10 fish were caught on the piston-line.

4. Discussion

Fishery data are basic information to assess the current stock status of SBT in CCSBT. Especially, CPUE of Japanese longline, which covers wide area, season and SBT age range that based on detailed information reported from fishermen, is a long time series index more than 40 years for SBT stock status. The aerial survey was also valuable research. It covered a wide area in a short duration of time in the Great Australian Bight (GAB) by using airplane and data of school biomass is derived as an estimation of a spotter. However, there is no index that directly reflects the status of SBT stock in whole ranges in both age and geographical distribution. Therefore, we need to collect a variety of information as many as possible to decide stock status appropriately. Trolling survey provides important information of age-1 SBT abundance.

The design of the trolling survey corresponds to the temporal and spatial distribution of age-1 SBT, although its survey period and geographic area are limited. A majority of age-1 SBT is thought to be distributed in the coastal area of Western Australia in austral summer (Itoh and Sakai 2009b). Then the age-1 SBT widely migrates to east and west at the end of the summer, although the majority of the SBT move to the GAB. SBT of age-2 and older are distributed so widely in the area between off New Zealand and off Cape, and the fish returns to GAB by the following year is not always. Therefore, the recruitment survey targeting age-1 SBT in the southern coast of Western Australia may have a potential to provide abundance index that represents whole the stock at age-1 SBT.

To derive accurate year trend in an index of recruitment level, we need to exclude other factors that fluctuate by year. Carrying out the survey in a consistent method for all years is a good way for this. We have not changed the gear specification used, and general research method for 14 years. We changed the survey vessel at the 10^{th} and 12^{th} survey, but the type and size of the vessels were consistent all the survey. The survey area has been consistent for 14 years where the main survey area has been off Bremer Bay and carried out the piston-line survey. Such consistent survey design is expected to facilitate to obtain an index that reflects only for annual SBT recruitment change. Additionally, the trolling is robust survey method against environmental factors, including wind, wave, and swell. There were a few days that suspended the research during the cruise due to rough sea condition in 14 years. We did not find a tendency that SBT were less caught in rough weather condition (see Tsuda and Itoh 2017c CCSBT-ESC/1708/24).

Agreements of trends were observed between the trolling survey indices derived from this survey and several recruitment indices from the CCSBT stock assessment, e.g. recruitment output from the Operating Model and nominal CPUE of age-4 SBT in Japanese longline (Itoh 2014). Up to now, the trolling survey appeared to succeed in providing data for the recruitment index that represents the whole age-1 SBT stock. Then, there is no need to change the current survey design so far.

However, it does not guarantee the survey design to be appropriate in the future. There are several points of concerns to be pointed out relating representativeness of the research data against the whole age-1 stock. SBT distribution within the survey area may change by year. For example, although many SBT were caught on the shelf-edge in 2006, 2007 and 2009, few SBT were caught there in recent years (2012-2020). To reflect such annual distribution changes on the abundance index, we are intensively conducting the trolling on the piston-line covered from shore to offshore and developing a grid-type trolling index covering all survey area (Itoh 2014, Tsuda and Itoh 2017b, 2018b, 2019b, Itoh and Tsuda 2020).

Another concern is the residence time of age-1 SBT in the survey area. Although the survey period from January to early February overlaps the residence time of juvenile SBT in the survey area, the peak of migration through the survey area may be varied. The previous study showed the temporal patterns of residence times of juvenile SBT in the survey area related to these spatial migration pathways in 2004-2007 (Fujioka et al. 2010). The inshore-migrating SBT were left progressively from the survey area in the early month of each summer (Dec-Feb) in 2005/06 and the shelf migrating SBT remained on the shelf over a longer period (Dec-Apr) in 2004/05 and 2006/07. The abundance index may be affected by the proportion of the age-1 SBT population migrating in the survey area. The mechanism for the temporal and spatial movement patterns must be considered related to oceanographic conditions. Electronic tagging would be an effective way to know the movement pattern of age-1 SBT on the environmental condition.

The sub-cohort structure is also of concern. All the years, age-1.0 fish were the primary component. In several years, e.g. 2011, 2012, 2013 and 2016, a significant part of age-1.3 SBT was large that corresponding to age-1, such as 42% in 2011, 55% in 2012, 36% in 2013 and 20.8% in 2016. Only a fraction of age-1.3 fish was observed in 2020. Its effect on the research design or index should be considered.

Such uncertainties on the potential existence of age-1 SBT outside of the survey area and season may harm the representativeness of the trolling indices. However, it would be a little effect if the proportion of the outside fish was negligible or such a proportion was stable over the years. If such a proportion changed largely by year probably due to the fluctuation of oceanic conditions, it may give a large impact on the trolling indices. Although we should be careful about such potential concerns, there is no actual information to support any of the concerns so far.

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Figure 1 The Southern Conquest, used for the 2020 survey.

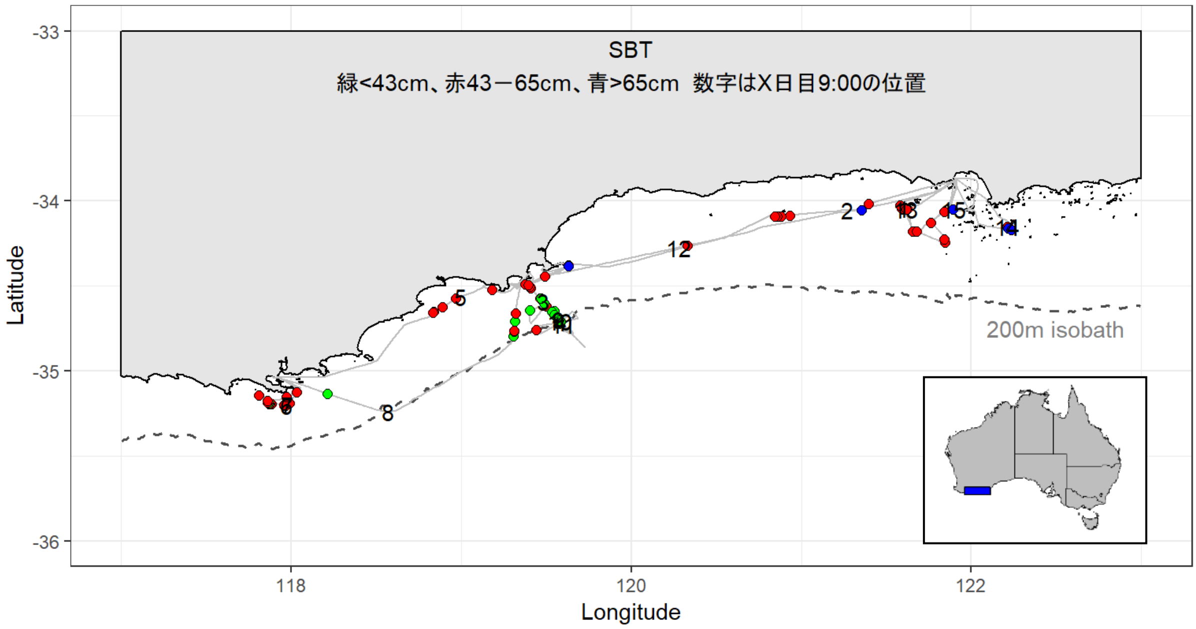

Figure 2 The trajectory of the vessel (line) and locations of southern bluefin tuna caught (circles) in the 2020 survey.

Circles in green, red and blue represents fish size as < 43 cmFL, 43-65 cmFL, >65 cm FL, respectively. The numbers are the location at 9AM on i^{th} day.

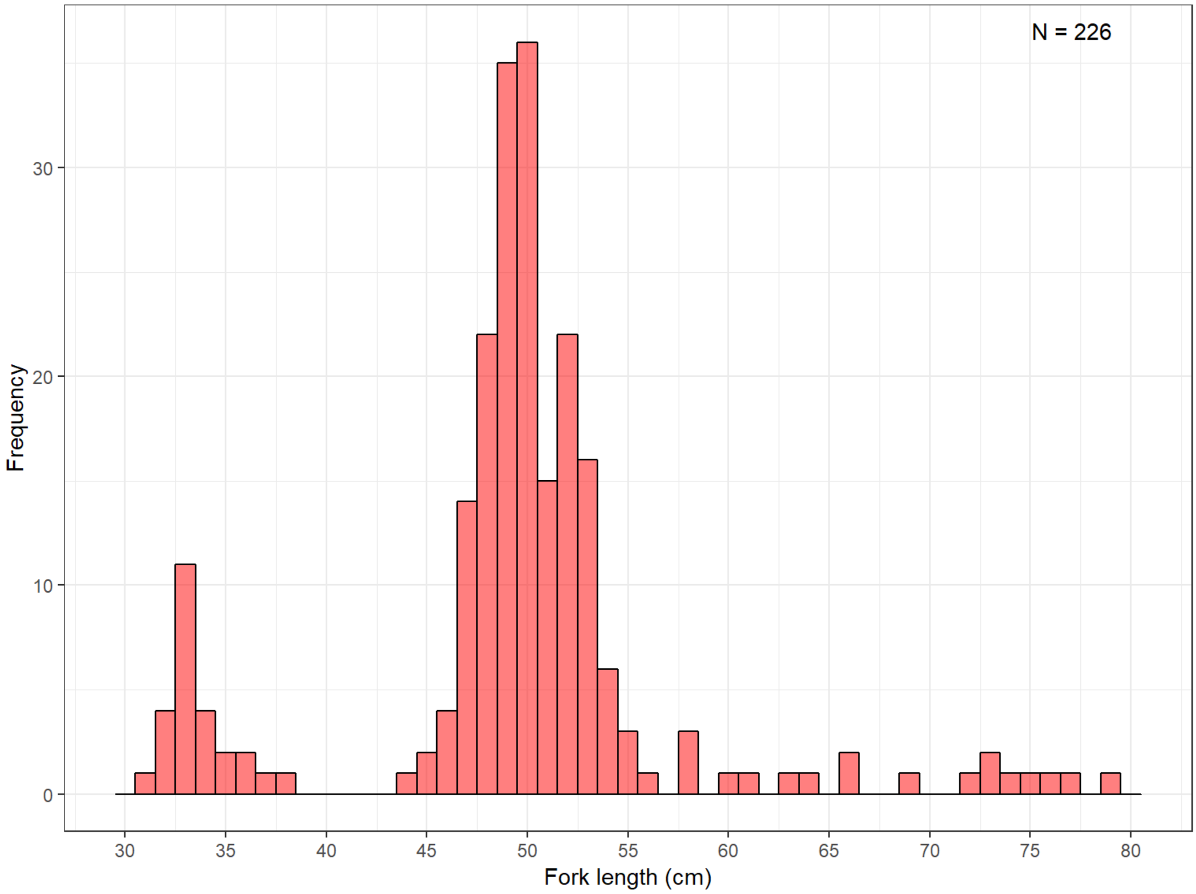

Figure 3 Fork length frequency distribution of southern bluefin tuna caught in the 2020 survey.