

日本のミナミマグロ延縄操業パターンの変化の検証：2014年漁期

Change in operation pattern of Japanese southern bluefin tuna longliners in the 2014 fishing season.

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要約

日本延縄船によるミナミマグロの漁獲データは、CCSBTにおけるミナミマグロの資源評価ならびにMPにおいて最も重要なものとして使用される。過去10年間と比較し、最近年の操業パターンの変化を検討した。漁獲量、隻数、操業のあった時空間、海区別割合、体長組成、操業の集中度を検討した結果、操業パターンの大きな変化は2014年には生じていなかった。2014年の延縄漁業のCPUEは従来と同程度に資源を反映したものとみなすことができるだろう。7海区での操業割合は、10年間継続して増加しており、これは2000年代にこの漁場を離れた漁船団が戻ったものである。2014年の漁獲枠増加に対して、操業時空間は広がらず、月・5度区画当たりの操業回数が微増した。

Summary

The Japanese longline data have been used as the most important scientific data for the stock assessment and Management Procedure of southern bluefin tuna (SBT) in CCSBT. Operation pattern of the longline fishing was examined by comparison between the most recent year and previous 10 years. No remarkable change was found in the 2014 operational pattern in terms of catch amount, the number of vessels, time and area operated, proportion by area, length frequency and concentration of operations. It can be said that the longline CPUE in 2014 represents the change of SBT stock abundance in consistently as in previous years. Continuous increasing in the proportion in Area 7 for 10 years is due to return of fleet to the Area. Due to the increase of total catch quota in 2014, the number of operations in a month and five degrees cell was increased but the number of cells was the same.

Introduction

CCSBT におけるミナミマグロ *Thunnus maccoyii* の資源評価は漁業情報に大きく依存している。漁業データは、漁業独立調査よりも比較的容易に低コストで広い時空間の情報を集めることができる長所がある。しかしそのデザインがシステマチックではないため、漁業研究者はデータを適切に解釈し、資源指標の変化の理由について資源の変化なのかまたは漁業の操業パターンの変化に起因するバイアスなのかを区別する必要がある。毎年の注意深い漁業のモニタリングは CCSBT をはじめとしたまぐろ RFMO での資源評価に不可欠な作業である。

CCSBT においてそうした操業パターン変化の検証は、ミナミマグロに関連する全ての漁業について毎年実施すべきである。中でも日本延縄船によるミナミマグロの漁獲データは、CCSBT におけるミナミマグロの資源評価において最も重要なものとして使用されてきたこと、ならびに 2011 年に運用を開始した管理方策 MP では、TAC を決定するインプットデータであることから、注意深いモニタリングが必要である。よって我々は毎年、検証文書を提出してきた (Itoh 2014)。本文書は、2014 年末までのアップデートであり、過去 10 年間との比較で 2014 年の操業パターンの変化を検討する。

The stock assessment of southern bluefin tuna *Thunnus maccoyii* (SBT) in CCSBT relies on data from various fisheries. Fishery data have a crucial advantage that a large amount of information from a large scale in time and space can be easily collected without expensive cost compare to fishery independent researches. However, because its design is not systematic, fishery scientists need to interpret the data properly and distinguish the reason of any changes in stock indices from previous years is whether by changes in stock itself or by bias caused by any operational pattern changes in fishery. Careful monitoring of fishery every year is an essential task for stock assessment and management of fish in tuna RFMOs, including CCSBT.

Such a careful examination of fishing operational pattern should be carried out every year for each of the fishing fleets whose data can be used for the stock assessment of SBT in CCSBT. Particularly, it is important for catch data of Japanese longliners, because it has been used as the most important data for the stock assessment of SBT for a long period of years and it is a major input datasets of the Management Procedure which implemented CCSBT in 2011. We have been evaluating operational pattern of Japanese longline for SBT every year (e.g. Itoh 2014). This paper is the update of it up to the end of 2014.

Material and method

二つのデータセットを解析した。一つ目のデータセットは 2004 年から 2014 年までの RTMP データである。Logbook が公式統計ではあるが、Logbook データにはミナミマグロを対象としない操業も含まれ、また使用可能となるまでに 2 年程度の遅れがあることから、最近年のデータと同じ条件で比較することができない。なお、RTMP はミナミマグロを対象として出漁する日本延縄船の全てが報告しており、日本が CCSBT 統計海区の 4-9 海区において漁獲するミナミマグロ漁

獲尾数全体の過去においては90%以上(2001-2005年の平均値は93%)、近年は100%がRTMPに含まれていることから、日本延縄船のミナミマグロ操業を十分に反映している(Sakai et al. CCSBT/0909/SBT Fisheries-Japan)。2014年以前の10年間(2004年-2013年)を比較対象とした。ある月の緯度5度、経度5度区画をセルと称し、解析の単位とした。

別データセット(日本タイプ延縄操業別データと称す)も解析に用いた。このデータセットはコア船CPUEを求めるために作成した、コア船を抽出する前のもので、日本のlogbookデータを含み(最近年はRTMP主体)、NZジョイントベンチャーや豪州枠のRTMP船操業も含むshot-by-shotデータから構成される(Itoh et al. CCSBT-ESC/1509/31)。

日本タイプ延縄操業別データを使用してセル数を、全操業並びにSBT(4歳以上魚)が漁獲された操業について集計した。また同じデータセットを使用して、5度区画・月内において操業のあった1度区画の数も集計した。これは一種の操業海域の集中を示す情報である。

操業海域の集中の度合いは別途開発したインデックスでも示した(Attachment 1)。この集中指数はDr. Hillaryが計算方法を提供したもので、操業緯経度の平均位置に対する分散を指標化したものである。集中指数は日本タイプ延縄操業別データセットに適用し、4-9海区、4月-9月のデータにおける釣钩数とミナミマグロ尾数(4歳以上魚)の両方について求めた。

Two data sets were used for analyses in this paper. One dataset used was the RTMP (RealTime Monitoring Program) data between 2004 and 2014. While logbook data are the Japanese official catch-and-effort data, logbook data, which includes longline operations targeting for other tuna species and requires about two years to be available, does not allow comparison with the most recent year to previous years in same condition. RTMP data fully represents Japanese SBT longline operation because it includes all of longline operations targeting for SBT. The data includes more than 90% of total SBT catch of Japan in CCSBT statistical area (Area) 4-9 in the past (mean of 2001-2005 is 93%) (CCSBT/0909/FisheriesJapan), and 100% of the catch in recent years. Various statistics of the data in 2014 were compared to previous 10 years, 2004-2013. Five degree longitude, five degree latitude in a month is defined as one "cell".

Another dataset ("Japanese-type longline shot-by-shot dataset") was also used. This dataset was made for the CPUE of core vessels which comprised of Japanese logbook data (mostly RTMP data in the most recent year), RTMP data from Australia in the 1990s, and New Zealand charter vessel data (Itoh et al. CCSBT-ESC/1509/31). Data of all vessels, before extract the core vessels, were used for analysis.

The numbers of cells were calculated for the Japanese-type longline shot-by-shot dataset in two cases, all operations and operations with catch of SBT age 4+. In addition, the number of one degree square operated within five degrees square, a kind of indicator for operational concentration, was calculated using this dataset.

Concentration of operation was also calculated as another index (Attachment 1). The

concentration index was derived from variance to the mean latitude and longitude of operations, and the method was provided by Dr. Hillary in CSIRO. The index was calculated in two cases, all operations and operations with catch of SBT age 4+ by using the Japanese-type longline shot-by-shot dataset in Areas 4 to 9 in April-September.

Result

1. 2014年の漁獲、努力量、サイズの概要 Summary of the catch, effort and size in 2014

図1に、CCSBT 統計海区 4-9 海区における、毎年の隻数、使用鈎数、ミナミマグロ漁獲尾数を、2004年から2013年までの平均値に対する相対値で示す。2005年から2008年または2010年まで減少してからは、5年間以上にわたって横ばいで安定している。

図2に、隻数、使用鈎数、ミナミマグロ漁獲尾数の統計海区別組成を示す。漁獲尾数では、7海区の割合が継続して増加し、4海区と8海区が減少した。

図3にミナミマグロの体長組成を示す。2014年の体長組成は145cmFLにピークを持っていた。2013年の体長組成と比較してほぼ同様で、150cm付近の頻度を見るとわずかに大型化していることが分かる。小型魚の部分は放流による影響も受けている点に留意すべき (Itoh et al. 2014 CCSBT-OMMP/1406/08)。

Figure 1 shows relative values of the numbers of vessels, hooks used and SBT caught to the mean values between 2004 and 2013 in the Areas 4 to 9. The values decreased from 2005 to 2008 or 2010 followed by stable period for more than 5 years.

Figure 2 shows the compositions of numbers of vessels, hooks used and SBT caught by Area. The number of SBT has been increasing in Area 7 while decreasing in Area 4 and Area 8.

Figure 3 shows fork length frequency of SBT by year. In 2014, it has a peak at 145cmFL. The shape of length frequency in 2014 is similar to that in 2013, though slightly larger as seen around 150 cmFL. Note that frequencies in small fish are affected from small fish release and discards (Itoh et al. 2014 CCSBT-OMMP/1406/08).

2. 操業時空間の変化 Changes of the time and space operated

図4に、RTMP 船データセットにおける4-9海区内の操業のあったセル (5x5度・月単位) 数の変化を示す。合計セル数は2006年の165セルから減少傾向にあり、2014年には94セルとなった。

表1に、セル数を年、月、海区別に示す。表2には、その操業回数を示す。過去5年間または10年間と比較して2014年の操業時期、海域はほぼ同様であった。詳細に見ると、全海区、一年

間に対する海区、月別の操業割合は、7海区で3月と4月に増加し6月は減少した。8海区では4月から6月が増えて9月から12月が減少した。9海区では5月、8月に減少した。各海区の中心時期は8海区の8月、9海区の6月のように同じか、7海区が5月から4月になったようにやや早くなった。すなわち、2014年には各海区で漁獲時期が早く始まり、早く終了する傾向があった。

図5にRTMP船データセットにおける1セル当たりの操業回数を示す。日本の総漁獲枠が半分以下に減少し、漁期撤廃に伴ってセル数が増加したことの結果として、1セル当たりの操業回数は2005年の114.3回/セルから2010年に20.7回/セルにまで減少した。その後2014年の38.7回/セルまでわずかな増加が継続している。

図6は日本タイプ延縄操業別データセットを使って求めた4-9月、4-9海区内の操業セル数である。RTMPに基づく図4よりも長期データであるが、RTMPデータが主体となる最近年(2014年)とそれ以前との一貫性には注意が必要である。SBTが漁獲されなかった操業も含めた全操業で見ると、操業セル数は1980年代から次第に減少し、2002年、2003年に低くなった後に2006年にかけて増加したが、その後はまた減少している(Fig. 6a 上図)。セルの定義を5度区画・月から1度区画・月に変更しても傾向は変わらない(Fig. 6a 中図)。5度区画・月の1セル当たりの操業回数(Fig. 6の白丸)は1986年から2005年まではほぼ一定であったが、その後は減少し、2007年以降は横ばいである。2010年以降はわずかに増加傾向である。セル数の減少は特定の海区だけでなく、全ての海区で生じていた。

データをミナミマグロ4歳以上魚が漁獲された操業に限定しても、全操業で見られたものと傾向に違いはなかった(Fig. 6b)。

Figure 4 shows the change of the number of cells (five degree square and month) in Area 4-9 in the RTMP data. The total number of cells has been decreasing from 165 in 2006 to 94 in 2014.

Table 1 shows the number of cells by year, month and Area. Table 2 shows the number of operations. Fishing season and area in 2014 were similar to those in previous five or 10 years in general. Seeing in detail, it increased in March and April and decreased in June in Area 7 in terms of the proportions in the number of operations by Area and month to the total number of operations in Area 4-9 and Month 4-9 in 2014. In Area 8, it increased between April and June and decreased between September and December. In Area 9, it decreased in May and August. The main fishing periods were same as previous years like in Area 8 (September) or Area 9 (June), or slightly earlier like in Area 7 which sifted from May to April. Thus, there was a tendency that the fishing year in 2014 started and finished slightly earlier in each Area.

Figure 5 shows the number of operations per cell in the RTMP dataset. Because the allocation of TAC to Japan was reduced to less than half and the number of cell operated was increased with the lift of seasonal area closure, the number of operations per cell has decreased to 20.7 times per cell in 2010 from 114.3 times per cell in 2005. Since then,

slight increase has continued, and it reached 38.7 times per cell in 2014.

Figure 6 shows the number of cells operated in Area 4-9 and month 4-9 in the Japanese-type longline shot-by-shot dataset. While the time series was longer than the RTMP dataset, it should be noted that most recent year (2014) was based on RTMP and may have inconsistency to previous years. In all operations including SBT zero catch, the number of cells decreased since the 1980s to 2002 and 2003 followed by slight increase until 2006, and then decreasing further (Fig. 6a upper panel). No difference was found in the case that the cell was defined as one degree square and month (Fig. 6a middle panel). The number of operations per cell in five degree (line with open circle in Fig. 6) had been stable between 1986 and 2005, then decreased and has been stable since 2007, but has been slightly increasing since 2010. Decrease of the number of cells was observed in all Areas.

No difference was found when the data was limited in operations with catch of SBT 4+ only, instead of all operations (Fig. 6b).

3. 操業の集中度 Concentration of area operated

ある5度区画内で操業のあった1度区画の数(全数は25)は、1986-2006年の平均値は6.9個、2007-2014年にはやや低下してほぼ横ばいとなり、その平均値は5.2個であった(Fig. 6a 下図)。データをミナミマグロ4歳以上魚が漁獲された操業に限定しても、全操業で見られたものと傾向に違いはなかった(Fig. 6b 下図)。

集中度指数は海域別に求めた。値が高いことは操業海域の拡散を、また低いことは操業海域の集中を意味する。経年的には8海区、9海区は安定的に推移し、5海区、6海区、7海区は変動が大きかった。8海区では2013年と2014年に、漁獲尾数では集中しているが努力量の分布は拡散している。操業位置を詳細に検討したところ、6海区は2005年以前には近年よりも北側および南側に操業海域が広がっていたが、それらがなくなっていたことで指数が増加した。7海区は、2003年まではタスマニア島の東西両方で操業があったが、2004年以降は東側でしか操業していないことで指数が増加した。8海区の釣数の指数増加は、北の海域での操業割合がわずかに増えたことによる。

The number of one degree square operated within five degree square (total is 25) was 6.9 in the average of 1986-2005 and 5.2 in the average of 2006-2014 (Fig. 6a bottom panel). No difference was found when the data was limited in operations with SBT 4+ only, instead of all operations (Fig. 6b).

Figure 7 shows the concentration index by Area. Smaller and larger values indicate more and less concentrated operation respectively. The time series have been stable in Area 8 and Area 9, and fluctuated largely in Area 5, Area 6 and Area 7. In Area 8 in

2013 and 2014, it was less concentrated in terms of hooks while it was still concentrated in catch. Detailed examination of operated area brought following findings; In Area 6, area of fished was extended further north and south up to 2005 but shrank and resulted in the increase of the concentration index. In Area 7, there were operations both the east and west of Tasmania Island before 2003, but only in the east since 2004 and resulted in increase of the index. In Area 8, the operations increased slightly in the northern area and resulted in the increase of index in hooks in 2013 and 2014.

4. 船の一貫性 Vessel consistency

表 3 に、2014 年の RTMP 参加船（かつミナミマグロを漁獲した船）が過去とどれほど共通しているかを示す。2014 年の 90 隻中、72 隻は 2001-2005 年に RTMP においてミナミマグロ操業を実施したことがあり、2001-2005 年に 4 年間または 5 年間実施した船が 53 隻（59%）と依然として大きな割合を占めており、船は一貫したものが多いことが分かる。

Table 3 shows the consistency of the vessels that participated the RTMP in 2014 (and caught any SBT) with those in 2001-2005. Among 90 vessels in 2014, 72 vessels caught SBT in 2001-2005 RTMP and still a large part of them (53 vessels, 59%) caught SBT in four or five years in 2001-2005 RTMP.

Discussion

漁獲量、隻数、操業のあった時空間、海区別割合、体長組成、操業の集中度を検討した結果、操業パターンの大きな変化は 2014 年には生じていなかった。2014 年の延縄漁業の CPUE は従来と同程度に資源を反映したものとみなすことができるだろう。

7 海区での操業割合は、10 年間継続して増加している。低水準であった 2000 年級が加入したころ、タスマン海ではミナミマグロの漁況が悪く、日本延縄船が 7 海区での操業を避けていた。新たな増加というよりはそれらの漁船団が戻ったものである（Itoh et al 2015 CCSBT-ESC/1509/SBT Fisheries -Japan）。

日本の漁獲枠は 2013 年の 2703 トンから 2014 年の 3403 トンに 1.26 倍となった。これに対して操業回数は 1.11 倍にしか増えなかった。そして操業セル数は増えず、一セルあたりの操業回数が増加した。以前の年より若干、早期に漁場へ入り、高い CPUE によって早期に IQ を満たし、早期に漁場を離脱したことで、各漁場の後半のセルは増えず、後半の操業回数は減った。2015 年には 4737 トン（2013 年の 1.75 倍）へと増加する。操業回数の増加に伴って操業時空間がどう拡大するのかが注目される。

No remarkable change was found in the 2014 operational pattern in terms of catch amount, the number of vessels, time and area operated, proportion by area, length frequency and concentration of operations. It can be said that the longline CPUE in 2014 represents the change of SBT stock abundance in consistently as in previous years.

Proportion of operation in Area 7 has been increasing in last 10 years. In the early 2000s,

many Japanese longline fleets escaped from Area 7 with its low CPUE probably due to the weak cohort around the 2000 year classes (Itoh et al. 2015 CCSBT-ESC/1509/ SBT Fisheries-Japan). Observed increase in Area 7 appears return of the fleet rather than increase of vessels participating fishing in the area.

TAC allocation of Japan in 2014 (3403 tones) was 1.26 times of that in 2013 (2703 tones). However, the factor in the number of operations in 2014 was smaller as 1.11 times of 2013. The number of cells operated did not increase. Instead, the number of operations per cell increased. Starts of fishing season were earlier in 2014 in each Area. However, their operations finished earlier by filling their IQ quickly with high CPUE. They left the SBT fishing area earlier and the number of cells, as well as the number of operations, did not increase in the later season. TAC allocation of Japan in 2015 (4737 tones) will further increase to 1.75 times of that in 2013. It would deserve attention how operation areas expand spatio-temporally associated with increase of catch and the number of operations.

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Table 1. Number of 5x5 degree square where longline operations conducted by year, month and area.

| Area | Month | Year | | | | | | | | | | | | | |
|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|----|
| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | |
| 4 | 2 | | | | | | | | | 1 | | | 1 | | |
| | 3 | | | | | | | 3 | | 2 | 1 | 1 | 3 | 2 | |
| | 4 | | | 1 | 2 | 2 | | 2 | 4 | 2 | 2 | 2 | 3 | 1 | 2 |
| | 5 | | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 5 | 3 | 4 | 4 | 2 | 3 |
| | 6 | | 3 | 4 | 5 | 5 | 3 | 5 | 5 | 5 | 6 | 6 | 3 | 4 | 3 |
| | 7 | | 6 | 4 | 6 | 6 | 4 | 6 | 5 | 2 | | 2 | | 2 | 1 |
| | 8 | | | | 3 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | | 2 | 2 |
| | 9 | | | | | | | | 1 | 1 | 1 | 2 | 1 | 1 | |
| | 10 | | | 4 | | | | 1 | 2 | | | 1 | | | 1 |
| | 11 | | | 4 | | | | | | | | | | | |
| | 12 | | | 4 | | | | | | | | | | | |
| | 5 | 7 | | | | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |
| 8 | | | | | | | 3 | 3 | 2 | 2 | | 2 | | 2 | |
| 9 | | | | | | | | 2 | 2 | | | 1 | | | |
| 10 | | | | | | | | | 1 | | | 1 | | | |
| 12 | | | | | | | | | | | | 2 | | | |
| 6 | 4 | | | | | | | 2 | | | | | | | |
| | 5 | | | | | | | 2 | | | | | | | |
| | 6 | | | | | | 1 | 1 | | | | | | | |
| | 7 | | | | | | | | | | | | | | |
| 7 | 2 | | | | | | | 2 | | | | | | | |
| | 3 | | | | | | | | | 2 | | | | 2 | |
| | 4 | | | | | | | | | 1 | 2 | 2 | 2 | 2 | |
| | 5 | | 5 | 6 | 2 | 2 | | 2 | 2 | 2 | 2 | 3 | 2 | 2 | |
| | 6 | | 6 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| | 7 | | 3 | 2 | 2 | 2 | 2 | 2 | | | | | | | |
| | 9 | | 6 | 1 | | | 1 | | | | | | | | |
| 10 | | | 2 | | | 2 | | | | | | | | | |
| 11 | | 3 | 1 | 1 | | | | 1 | | | | | | | |
| 8 | 1 | | 3 | | 1 | | | 1 | | | | | | | |
| | 2 | | | | | | | 1 | 2 | 2 | | 6 | | 1 | |
| | 3 | | | | | | | | 2 | | | | | 1 | 1 |
| | 4 | | | | | | | | 2 | | 3 | 1 | 1 | 4 | 4 |
| | 5 | | | 1 | 3 | 5 | 1 | | 3 | | 7 | 4 | | 5 | 3 |
| | 6 | | | | 4 | 5 | | | | | 2 | 2 | 3 | 2 | 3 |
| | 7 | | | | | | 5 | 8 | 6 | 4 | 2 | 1 | 5 | 3 | 2 |
| | 8 | | | | | | 8 | 8 | 6 | 6 | 4 | 5 | 7 | 5 | 3 |
| | 9 | | 12 | 11 | 13 | 5 | 7 | 6 | 5 | 4 | 2 | 3 | 2 | 3 | 2 |
| | 10 | | 13 | 13 | 9 | 7 | 8 | 8 | 8 | 8 | 2 | 6 | 2 | | |
| | 11 | | 13 | 9 | 9 | 8 | 8 | 7 | 7 | 6 | 3 | 4 | 1 | 1 | 2 |
| | 12 | | | 7 | 8 | 4 | 7 | 6 | 4 | 6 | 1 | 1 | | | 2 |
| 9 | 2 | | | | | | | | | 1 | | | | | |
| | 3 | | | | | | | | 3 | | 7 | 5 | 5 | 2 | 3 |
| | 4 | | | | | | | 5 | 7 | 8 | 15 | 8 | 13 | 6 | 6 |
| | 5 | | 17 | 14 | 19 | 25 | 21 | 16 | 14 | 8 | 20 | 15 | 13 | 5 | 10 |
| | 6 | | 14 | 17 | 23 | 20 | 18 | 18 | 15 | 10 | 14 | 13 | 12 | 12 | 11 |
| | 7 | | 11 | 15 | 19 | 19 | 21 | 16 | 16 | 12 | 12 | 11 | 9 | 8 | 10 |
| | 8 | | | | 12 | 13 | 15 | 8 | 11 | 9 | 9 | 9 | 6 | 5 | 6 |
| | 9 | | | | | | 11 | 5 | 5 | 3 | 5 | 6 | 4 | 6 | 3 |
| | 10 | | | | | | 7 | 4 | 6 | 1 | 3 | 2 | 3 | 4 | 1 |
| | 11 | | | | | | 4 | 2 | 2 | | 2 | | 1 | 2 | |
| | 12 | | | | | | | | | 1 | 1 | 1 | | | |

Dotted line shows 2006 when the individual quarter system started.

Table 2. Number of operations by year, month and area

| Area | Month | Year | | | | | | | | | | | | %10Y | %5Y | 2014% | | | |
|------|-------|------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|-------|--------|--------|--------|------|
| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | | | | 2014 | | |
| 4 | 2 | | | | | | | | | 4 | | | 8 | 0.0% | 0.1% | 0.0% | | | |
| | 3 | | | | | | | | | 33 | 3 | 2 | 31 | 5 | 0.1% | 0.4% | 0.1% | | |
| | 4 | | | 2 | 23 | 13 | | | 39 | 45 | 47 | 60 | 30 | 34 | 2 | 38 | 0.4% | 1.0% | 1.0% |
| | 5 | 56 | 347 | 447 | 731 | 530 | 55 | 140 | 203 | 139 | 131 | 149 | 38 | 64 | 3.6% | 3.9% | 1.8% | | |
| | 6 | 1017 | 1015 | 1179 | 1122 | 457 | 324 | 147 | 46 | 52 | 74 | 8 | 55 | 52 | 4.9% | 1.4% | 1.4% | | |
| | 7 | 807 | 911 | 1110 | 732 | 115 | 75 | 49 | 35 | | 72 | | 39 | 14 | 3.1% | 0.9% | 0.4% | | |
| | 8 | | | 10 | 1 | 3 | 2 | 1 | 3 | 15 | 5 | | 34 | 16 | 0.1% | 0.3% | 0.4% | | |
| | 9 | | | | | | | 12 | 4 | 4 | 35 | 4 | 3 | | 0.1% | 0.3% | 0.0% | | |
| | 10 | | 96 | | | | 2 | 6 | | | | | | 1 | 0.0% | 0.0% | 0.0% | | |
| | 11 | | 120 | | | | | | | | 2 | | | | 0.0% | 0.0% | 0.0% | | |
| | 12 | | 47 | | | | | | | | | | | | 0.0% | 0.0% | 0.0% | | |
| | 5 | 7 | | | 2 | 6 | 11 | 22 | 17 | 8 | 25 | 4 | 1 | 10 | 0.1% | 0.3% | 0.0% | | |
| 8 | | | | | | 27 | 34 | 23 | 11 | | 65 | | 10 | 0.2% | 0.5% | 0.0% | | | |
| 9 | | | | | | | 17 | 7 | | | 20 | | | 0.1% | 0.1% | 0.0% | | | |
| 10 | | | | | | | | 2 | | | 3 | | | 0.0% | 0.0% | 0.0% | | | |
| 12 | | | | | | | | | | | | 10 | | 0.0% | 0.1% | 0.0% | | | |
| 6 | 4 | | | | | | | 13 | | | | | | 0.0% | 0.0% | 0.0% | | | |
| | 5 | | | | | | | 31 | | | | | | 0.0% | 0.0% | 0.0% | | | |
| | 6 | | | | | 1 | 22 | | | | | | | 0.0% | 0.0% | 0.0% | | | |
| | 7 | | | | | | | | | | | | | 0.0% | 0.0% | 0.0% | | | |
| | 7 | 2 | | | | | | 2 | | | | | | 0.0% | 0.0% | 0.0% | | | |
| 7 | 3 | | | | | | | | | 7 | | | 54 | 0.0% | 0.0% | 1.5% | | | |
| | 4 | | | | | | | | | 33 | 25 | 102 | 14 | 500 | 0.2% | 1.0% | 13.7% | | |
| | 5 | 842 | 648 | 530 | 603 | | 27 | 181 | 189 | 290 | 449 | 547 | 522 | 276 | 4.7% | 11.7% | 7.6% | | |
| | 6 | 1731 | 1032 | 646 | 397 | 180 | 352 | 183 | 64 | 61 | 118 | 48 | 399 | 14 | 3.4% | 4.0% | 0.4% | | |
| | 7 | 588 | 254 | 2 | 3 | 66 | 92 | | | | | | | | 0.2% | 0.0% | 0.0% | | |
| | 9 | 44 | 1 | | | 46 | | | | | | | | | 0.1% | 0.0% | 0.0% | | |
| | 10 | | 47 | | | 6 | | | | | | | | | 0.0% | 0.0% | 0.0% | | |
| | 11 | 369 | 1 | 6 | | | 1 | | | | | | | | 0.0% | 0.0% | 0.0% | | |
| | 8 | 1 | 183 | 13 | | | 2 | | | | | | | | 0.0% | 0.0% | 0.0% | | |
| | 2 | | | | | | 1 | 2 | 4 | 60 | | 2 | | | 0.1% | 0.4% | 0.0% | | |
| | 3 | | | | | | | 30 | | | | | 7 | 6 | 0.1% | 0.0% | 0.2% | | |
| 4 | | | | | | | 5 | | 34 | 3 | 16 | 129 | 206 | 0.3% | 1.1% | 5.7% | | | |
| 5 | | 1 | 411 | 651 | 12 | | 26 | | 55 | 26 | | 180 | 246 | 1.9% | 1.5% | 6.8% | | | |
| 6 | | | 104 | 13 | | | | | 88 | 16 | 33 | 17 | 154 | 0.4% | 0.9% | 4.2% | | | |
| 7 | | | | | 76 | 103 | 177 | 33 | 4 | 15 | 55 | 47 | 17 | 0.7% | 0.9% | 0.5% | | | |
| 8 | | | | | 407 | 773 | 921 | 988 | 259 | 197 | 425 | 461 | 600 | 6.2% | 13.6% | 16.5% | | | |
| 9 | 1335 | 961 | 489 | 551 | 270 | 630 | 482 | 251 | 13 | 214 | 156 | 76 | 58 | 4.4% | 4.2% | 1.6% | | | |
| 10 | 755 | 842 | 589 | 687 | 343 | 379 | 131 | 163 | 8 | 68 | 7 | | | 3.3% | 1.4% | 0.0% | | | |
| 11 | 321 | 825 | 904 | 821 | 518 | 750 | 362 | 357 | 95 | 125 | 16 | 13 | 32 | 5.6% | 3.5% | 0.9% | | | |
| 12 | | 316 | 618 | 488 | 259 | 115 | 177 | 280 | 2 | 39 | | | 17 | 2.8% | 1.9% | 0.5% | | | |
| 9 | 2 | | | | | | | | | 1 | | | | 0.0% | 0.0% | 0.0% | | | |
| | 3 | | | | | | | 23 | | 68 | 44 | 66 | 19 | 12 | 0.3% | 1.2% | 0.3% | | |
| | 4 | | | | | | 66 | 111 | 46 | 298 | 155 | 196 | 107 | 113 | 1.4% | 4.7% | 3.1% | | |
| | 5 | 2314 | 2564 | 2383 | 1897 | 905 | 160 | 220 | 184 | 473 | 459 | 359 | 241 | 236 | 10.2% | 10.0% | 6.5% | | |
| | 6 | 2362 | 2672 | 2826 | 2537 | 1163 | 575 | 792 | 394 | 443 | 468 | 534 | 504 | 476 | 14.4% | 13.7% | 13.1% | | |
| | 7 | 325 | 586 | 2832 | 2802 | 1513 | 683 | 1032 | 436 | 222 | 270 | 351 | 179 | 349 | 14.5% | 8.5% | 9.6% | | |
| | 8 | | | 522 | 1261 | 1738 | 755 | 623 | 266 | 115 | 86 | 116 | 31 | 25 | 7.7% | 3.6% | 0.7% | | |
| | 9 | | | | | 1033 | 623 | 224 | 34 | 22 | 121 | 38 | 33 | 55 | 3.0% | 1.5% | 1.5% | | |
| | 10 | | | | | 262 | 183 | 105 | 50 | 22 | 26 | 16 | 55 | 1 | 1.0% | 1.0% | 0.0% | | |
| | 11 | | | | | 24 | 5 | 30 | | 35 | | 7 | 11 | | 0.2% | 0.3% | 0.0% | | |
| | 12 | | | | | | | 5 | 1 | 1 | | | | | 0.0% | 0.0% | 0.0% | | |
| | Total | | 13049 | 13288 | 15646 | 15316 | 9965 | 6911 | 6323 | 4097 | 3041 | 3368 | 3298 | 3275 | 3637 | 100.0% | 100.0% | 100.0% | |

“%10Y” and “%5Y” are the proportion of the Area and month to the sum of 10 years (2004-2013) and 5 years (2009-2013), respectively. “2014%” is the proportion of the Area and month to the sum of 2014 data. Shadow and line enclosing denotes 2014% is much larger or lower than %10Y and %5Y, respectively

Table 3. Number of vessels that caught SBT in RTMP between 2006 and 2014 by the number of

years participated in RTMP in past years (2001-2005).

| Number of years participate in the RTMP during 2001–2005 | | | | | | |
|--|--------|--------|--------|--------|--------|--------|
| | 0 year | 1 year | 2 year | 3 year | 4 year | 5 year |
| 2006 | 5 | 7 | 15 | 9 | 20 | 67 |
| 2007 | 5 | 10 | 16 | 10 | 22 | 74 |
| 2008 | 11 | 8 | 16 | 8 | 22 | 61 |
| 2009 | 13 | 4 | 13 | 6 | 15 | 49 |
| 2010 | 9 | 4 | 12 | 5 | 14 | 42 |
| 2011 | 8 | 6 | 12 | 6 | 12 | 39 |
| 2012 | 11 | 6 | 13 | 6 | 14 | 43 |
| 2013 | 13 | 4 | 11 | 4 | 14 | 42 |
| 2014 | 18 | 3 | 10 | 6 | 13 | 40 |

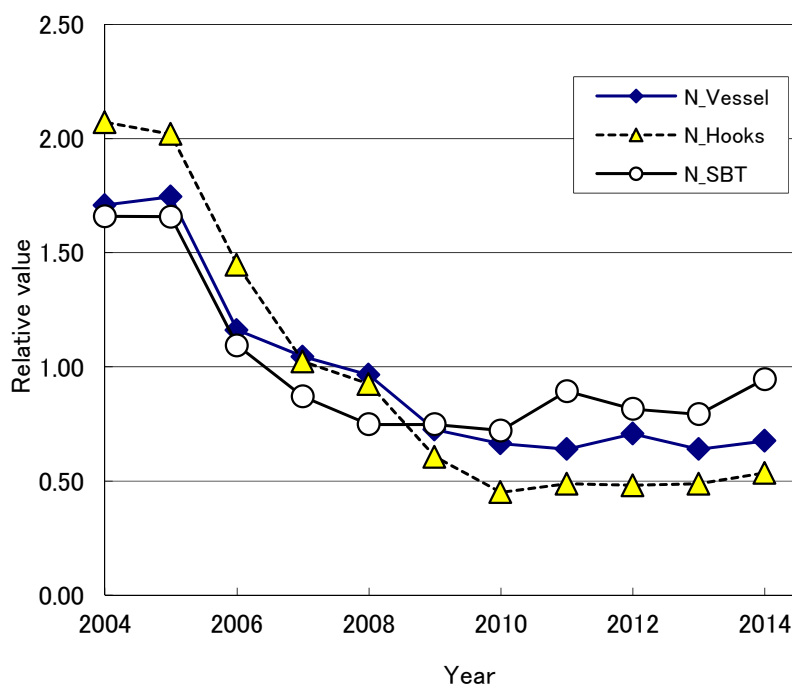


Fig.1. Changes in the number of operation, the number of vessels and the number of SBT caught in Area 4-9 in 2014 and previous 10 years. Y axis is the relative value to the average of previous 10 years.

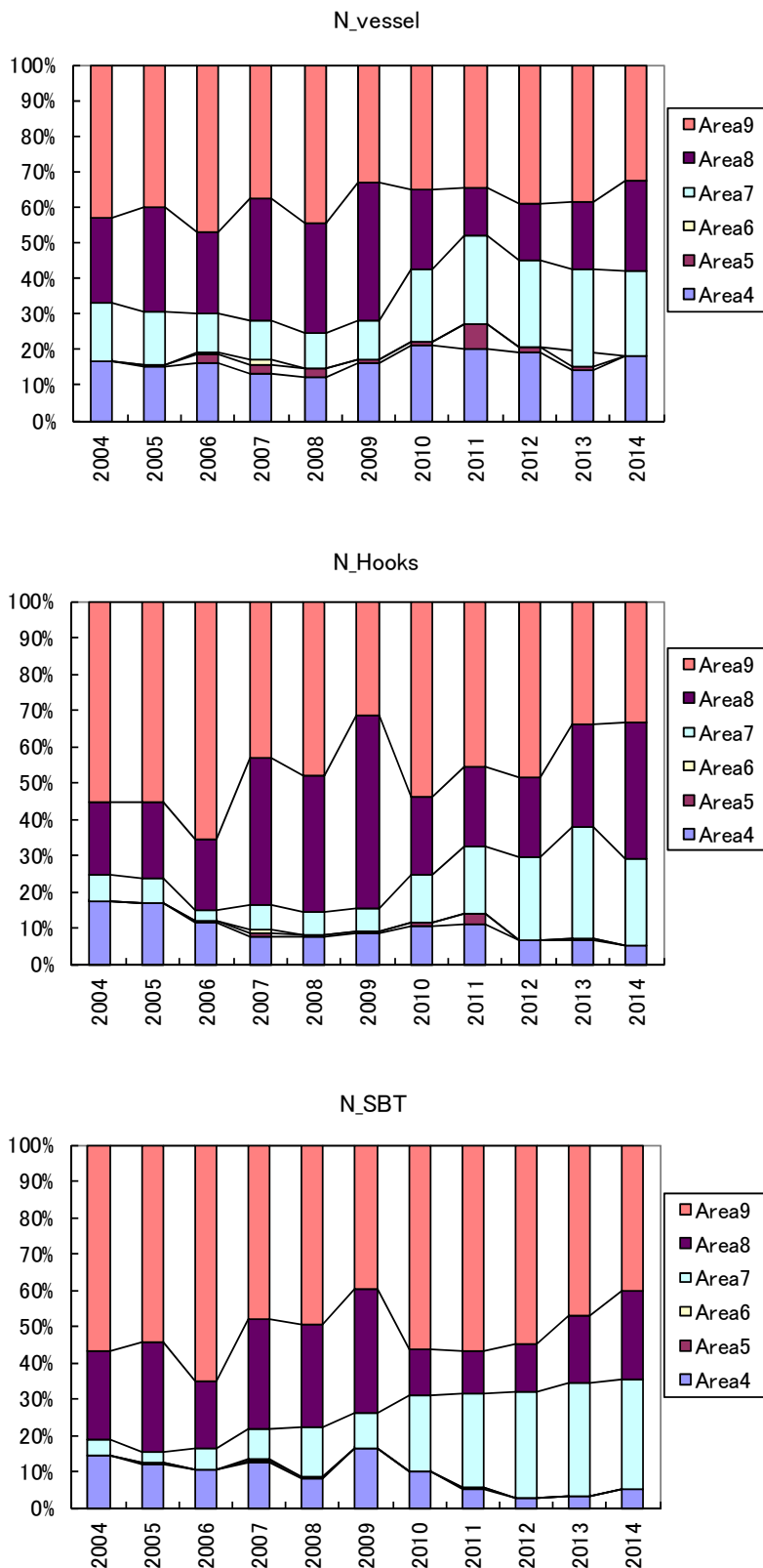


Fig.2. Proportions of Area in the number of vessels, the number of hooks used and the number of SBT caught in 2014 and previous 10 years.

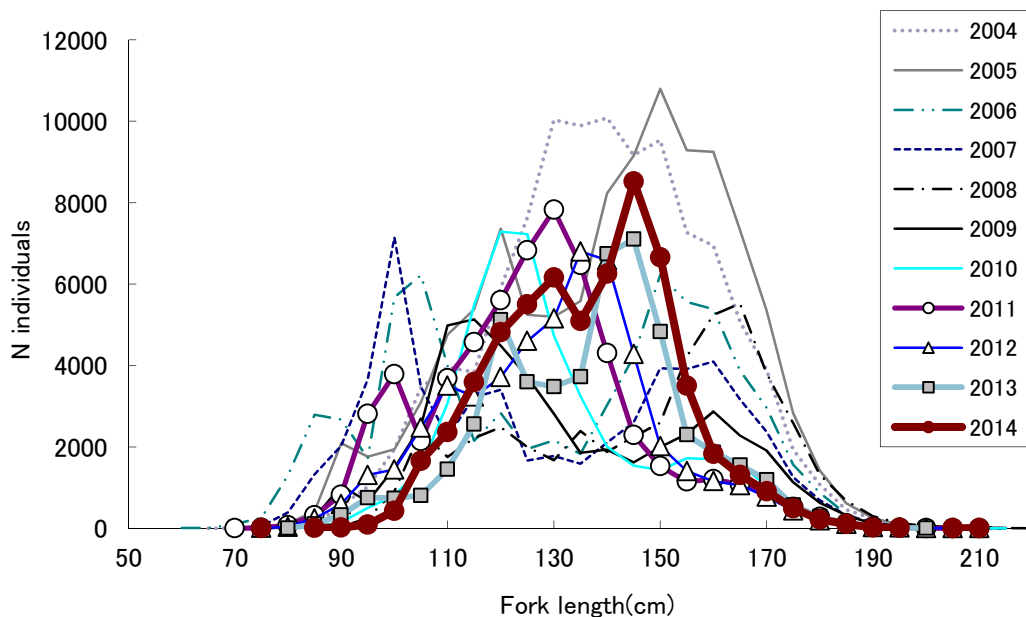


Fig.3. Length frequency distributions of SBT by year in 2014 and previous 10 years.

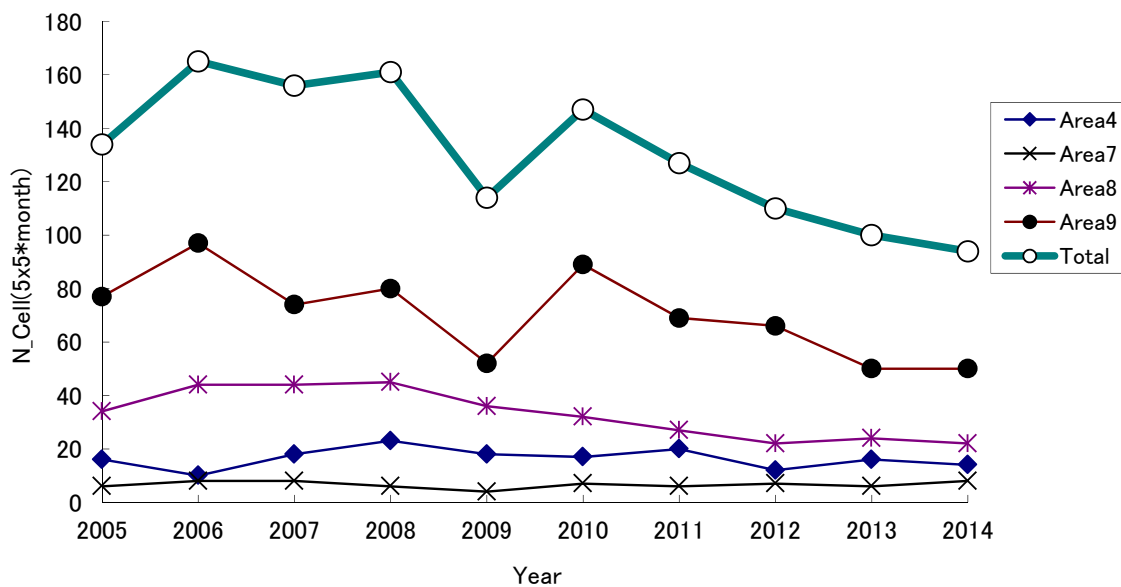


Fig.4. Changes of the number of cells (5 degrees latitude and longitude and month) operated in 10 years in Area 4-9.

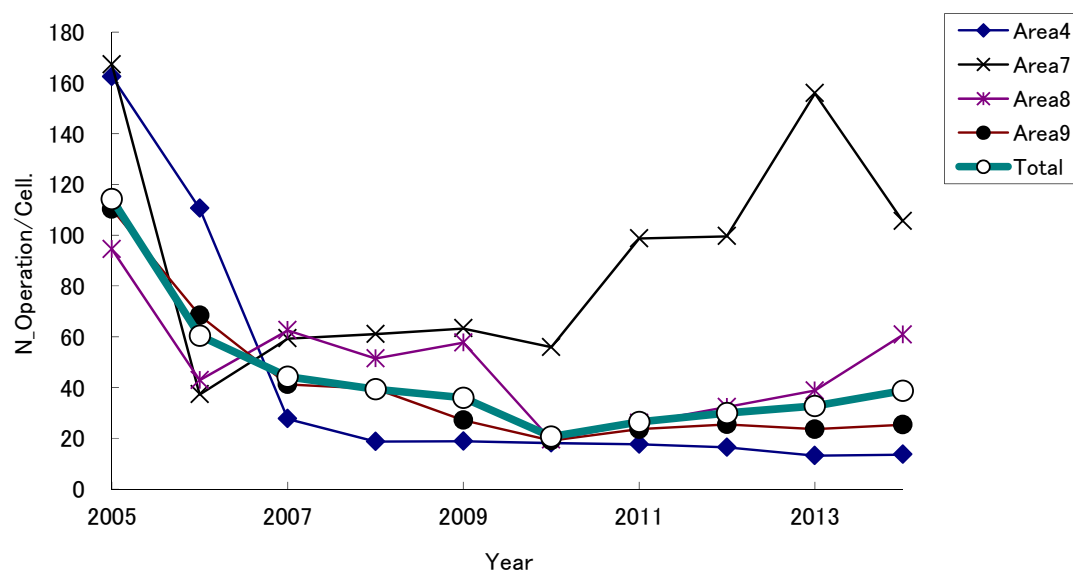


Fig.5. Changes of the number of longline operations per cell (5 degrees latitude and longitude and month) in 10 years in Area 4-9.

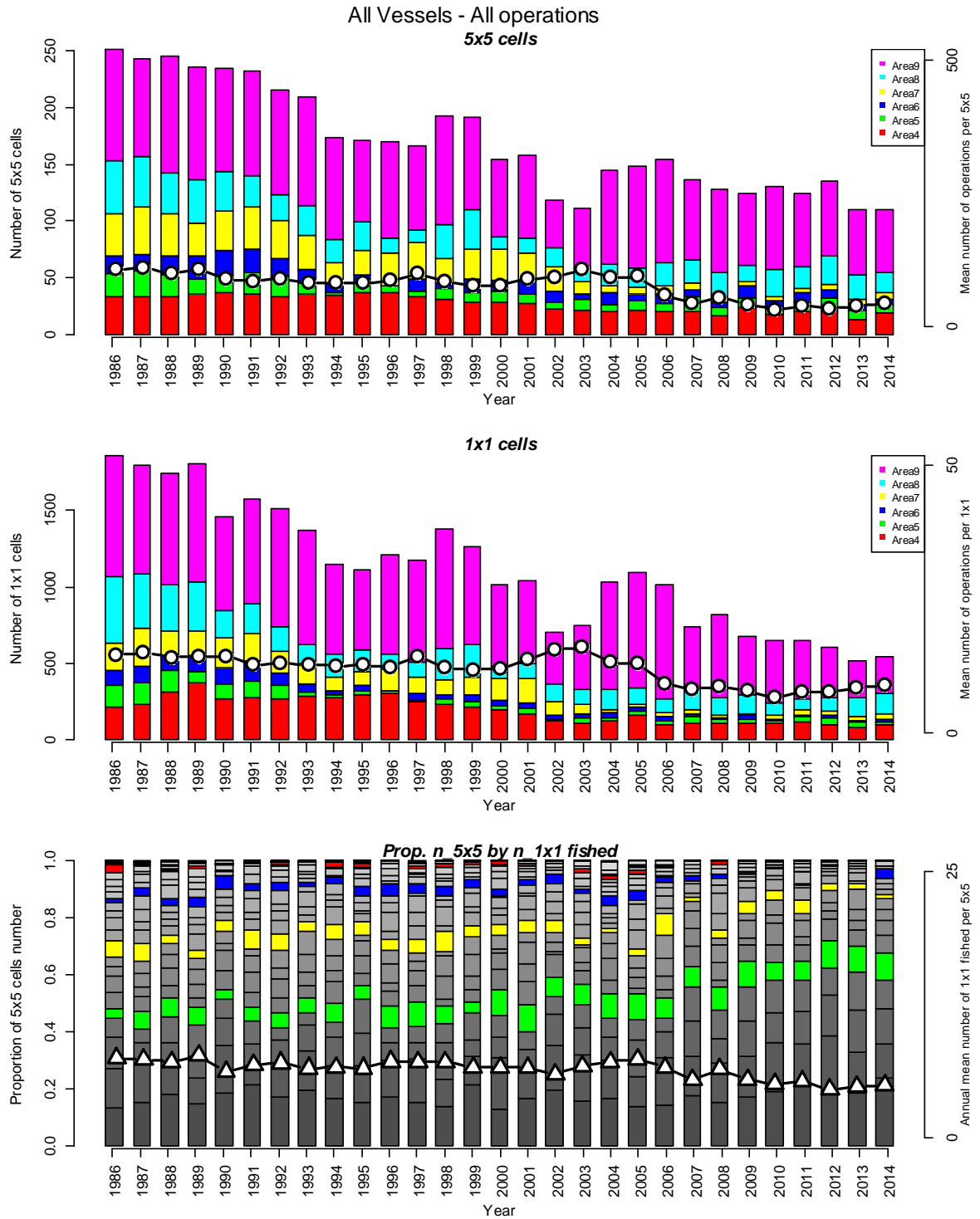


Figure 6a. Number of cells in the Japanese-type longline dataset for all operations.

(Top panel) Bar represents the number of 5x5 degrees square and month (cell) where fishing operated by CCSBT statistical area and refer to left side y-axis. Line with circle plot represents the mean annual number of operations per cell and refer to right side y-axis. (Middle panel) Bar represents the number of 1x1 degree square and month (cell) where fishing operated by CCSBT statistical area and refer to left side y-axis. Line with circle plot represents the mean annual number of operations per cell and refer to right side y-axis. (Bottom panel) Composition of frequency for the number of 1x1 degree square and month cells operated in a 5x5 degree squares and month cell. Refer to left side y-axis. The grey band is one of 25 cells and that at top is 25 of 25 cells, and every five is colored. Line with triangle represents the mean number of 1x1 month cells operated in a 5x5 month cell and refer to right side y-axis.

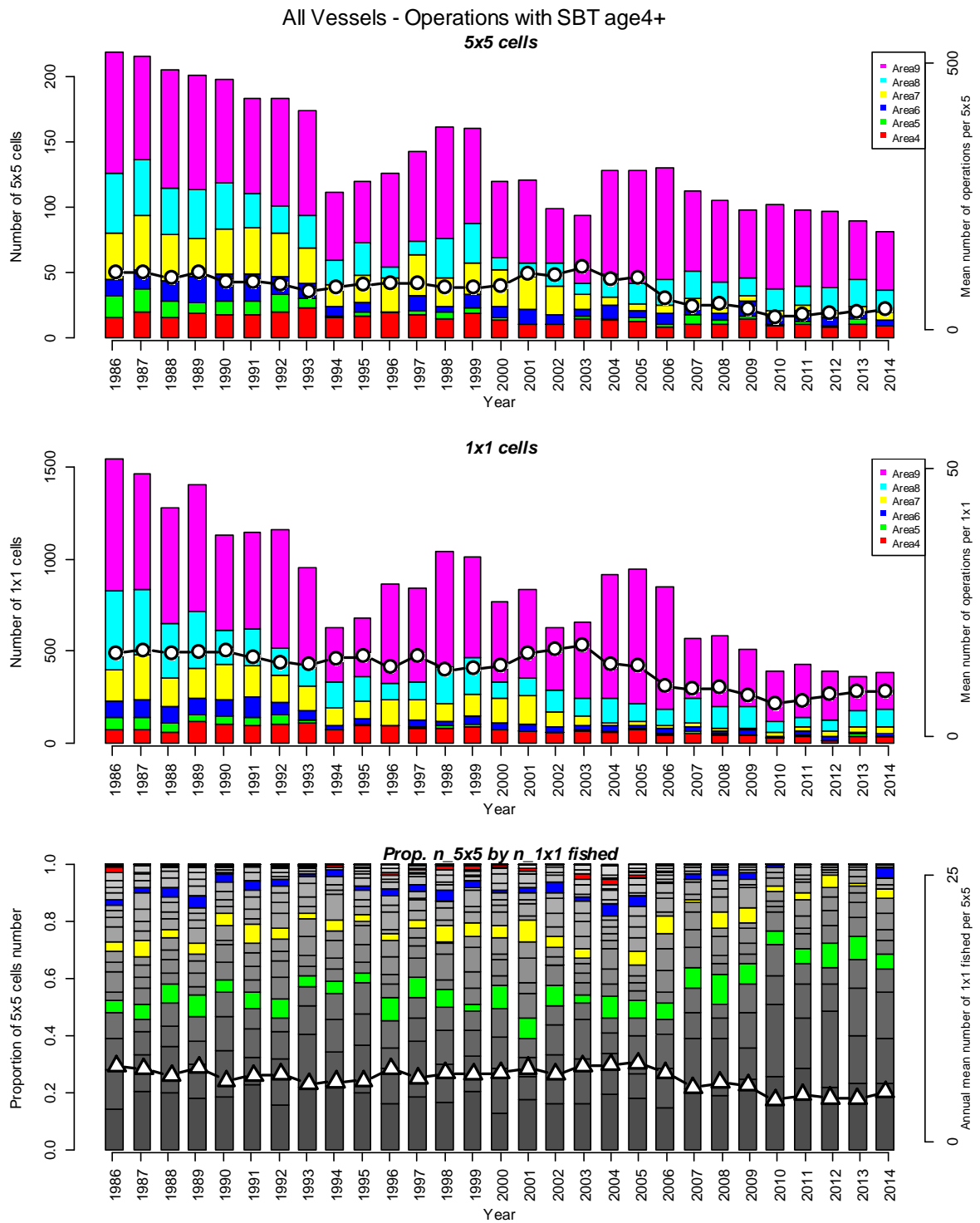


Figure 6b. Number of cells in the Japanese-type longline dataset for operations of SBT 4+ catch positive. See explanation in Fig. 6a.

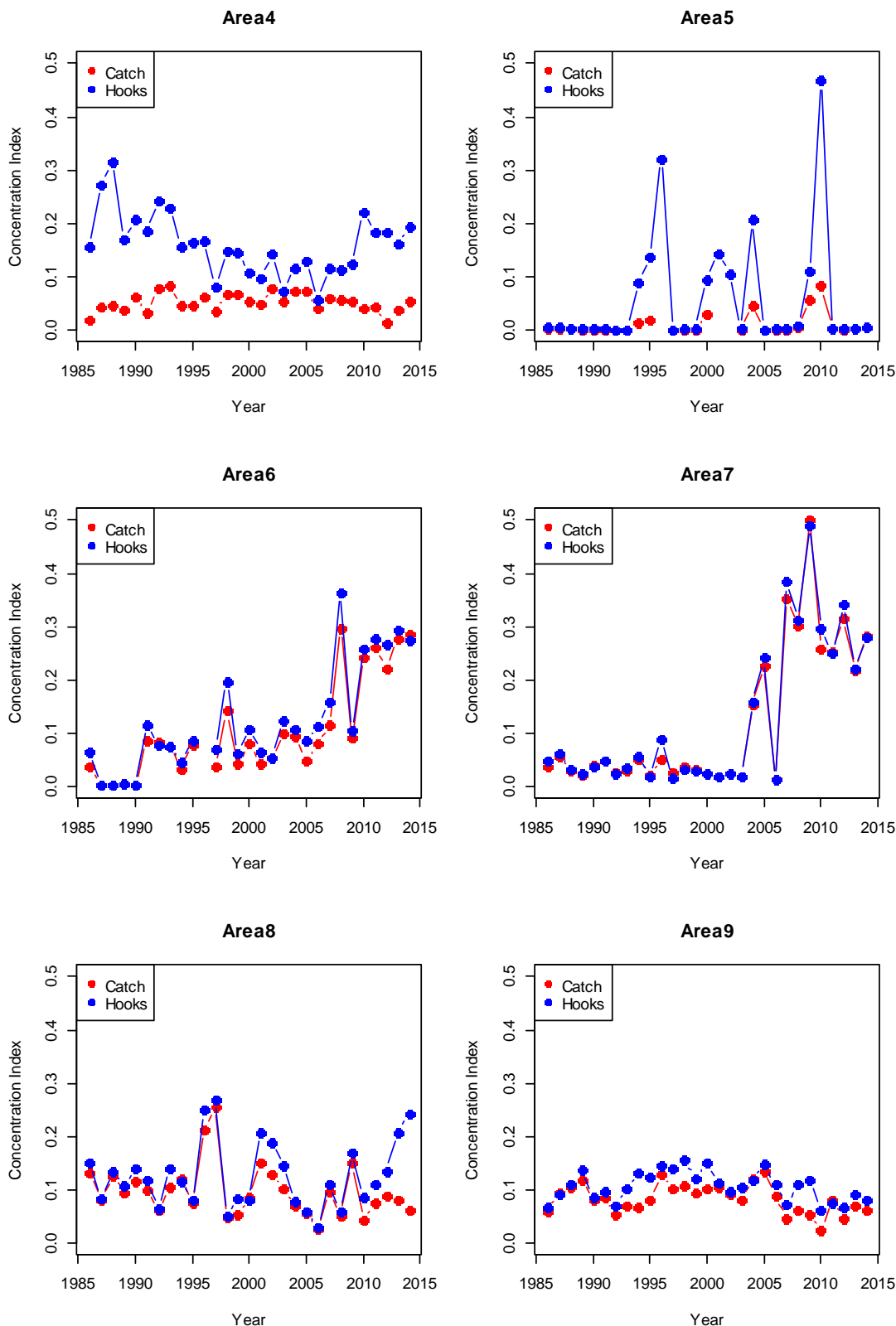


Figure 7. Concentration index in the Japanese-type longline dataset for catch (age 4+) or hooks to years by CCSBT statistical area
Smaller/larger values relate to more/less aggregated.

Attachment 1

SBT exploratory data analysis Idea

In conjunction with usual analyses done for the indicators paper there are some potentially revealing but simple things we can do to be primed for the upcoming assessment of SBT.

CPUE data

This obviously really refers to the LL_1 CPUE data that will form the basis of the main abundance index in the OM. While that will work with the standardised CPUE there are several things we can look it in the raw data. In terms of a reasonably detailed spatial analysis, by area and 5×5 square there are some basic spatial statistics we can look at, henceforth, I_{ijk} denotes the raw CPUE (over a given length/age range) for year i , in region j , in square k . To look at a rough trend in how the average fishing location as changed in each area over time we can simply compute the centre of mass, R_{ij} of the CPUE in a given year i and region j :

$$R_{ij} = \frac{\sum_{k \in j} \rho_k I_{ijk}}{\sum_{k \in j} I_{ijk}}, \quad (1)$$

where ρ_k denotes the physical location of square k in area j (i.e. lat and long) and then the square center of mass of that region in a given year is the square containing R_{ij} . A secondary measure is to see how the density of either effort, catch or CPUE changes over time and in each area. This can be calculated by first estimating the discrete mass density of the given quantity of interest, X_{ijk} , in a given region at a given time:

$$\mu_{ijk} = \frac{X_{ijk}}{\sum_{k \in j} X_{ijk}}, \quad (2)$$

and from this we can estimate the (relative) aggregation, α_{ij} , of the quantity X_{ij} fairly easily:

$$\alpha_{ij} = \frac{E^k(\mu_{ijk})^2}{E^k(\mu_{ijk}^2)} \quad (3)$$

where $\alpha_{ij} \in [N_j^{-2}, 1]$ (where N_j is the number of squares in region j) and smaller/larger values of α relate to more/less aggregated spatial quantities. Even spread it is equal to 1 and all in one square it is equal to N_j^{-2} .