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The Effect of Change of Target Species on the CPUE of Swordfish Caught by Japanese Offshore Surface Longliners Operating in the North Pacific

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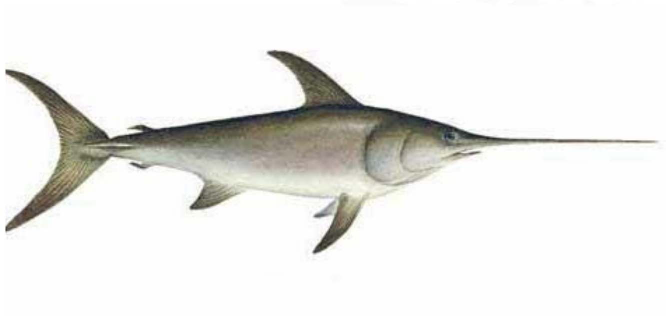

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Introduction

The Japanese offshore surface longliners has been targest primaly on swordfish in the north Pacific, but they also target tunas and blue shark seasonally. The questionriee to the union of skippers and radio operators of this fleet suggested that recently the number of operations targets on blue shark are increased and the number of operations targets on tunas are decreased mainly due to the parket prices of these species.

In this study, the result of the questionariee survey to the union is checked using their log-book data, and the effects of the change of target species on the standardized CPUE on swordfish is evaluated.

Materials and Methods

Data in the new log-book system of the Japanese offshore and distant-water longliners initiated in 1993/1994 by Japan Fishery Agency, which contains catch information of blue shark, is used in this study. In general, the coverage of the log-book is rather in the period analyzed (>95%), expect for the year of beginning and ending years (1993 and 2007).

The analysis of data is mainly conduct using set-by-set data, but also partially using the aggregated data, which is aggregated by the 5x5 block, month as well as the gear configuration defined by the number of hooks per basket (HPB). The definition of the surface longline is only limited to the sets with 3-4 hooks between floats.

The analysis of CPUE of Japanese offshore surface longliners was conducted using the traditional GLM method. Because the fishing ground of Japanese offshore and surface longliners is limited to the transition zone between the subarctic and subtropical domains in the northwestern and central Pacific, only two areas (west and east of 175E) are used in the analysis. Effect of season defined by the quarter of the year is also introduced in the analysis. The basic model of GLM analysis is;

$$\ln(CPUE_{ijkl}+\text{const})=y_i+q_j+g_k+a_l+(\text{interaction terms})+\varepsilon$$

where year (y), quarter (q), area (a), and the interaction terms between year*quarter and area*quarter.

The effect of target fishes, which is defined in by the ratio of catch number of main target species to the total catch number, is also included in the analysis as the categorical explanatory variables in some cases.

Results and Discussions

1) Outline of the fishery of the Japanese offshore surface longliners

Japanese offshore surface longliners is one of the notable longline fleet operates in the north west and central Pacific. The typical size of the boat is 119 GRT, and their main fishing ground is the transition zone between the subarctic and subtropical domains in the northwestern and central Pacific. They primary target on swordfish by the night and the surface sets, but questionnaires to the skippers indicates that tunas and blue shark is also important for them. Another typical character of this fleet is that they take a fishing strategy of "quantity before quality", e.g., using old type and cheaper gear and set the gear as much as possible in one operation (more than 3,000 hooks). Japanese common squid (*Todarodes pacificus*) and Pacific mackerel (Scomber japonicus) are their main bait, and 3 or 4 hooks per basket is their main gear configuration. They usually start gear setting in the afternoon (3 – 4 PM) and finish gear retrieving before noon (10 – 11AM). The number of boat belonging to the fleet is decreased in recent years due to the substantial rise of oil and labor costs, decrease of the fish market prices, and aging of crews, and the 27 – 28 boats are in operation recently. The skippers and the radio operators in this fleet form a union, and their unity is quite strong that they frequently exchange detailed operational information (such as position, surface water temperature, catch number of fish by species and by size class) using their own code. If one skipper makes false report, the union imposes a financial penalty on him.

In the period between 1994 and 2007, the amount of effort of the Japanese offshore surface longliners, corresponding to the amount of effort of the sets with 3 – 4 HPB, is rather stabilized at around twenty million hooks, and it occupies 40 – 60 % of the total effort in the area north of 20N (Fig. 1). This indicates that the operation by the Japanese offshore surface longliners is most popular one in the subtropical and temperate area of the north west and central Pacific. On the other hand, operation of Japanese offshore surface longliners is almost nothing in the area south of 20N. In the north Pacific, majority of swordfish and blue shark are caught by Japanese offshore surface longliners.

In the surface longline operation (3 – 4 HPB), blue shark is 1st largest catch both in number and weight, and swordfish is 2nd largest (Figs. 2 and 3). In the 4th quarter in the period before 2000, bigeye tuna and albacore occupies large part of their catch. Many skippers of Japanese offshore surface longliners indicate that they used to target tunas in late autumn and winter the price of tunas significantly increased in these period, especially in the period of the year's end. They also indicate that the increase of price of tuna in the winter time seems not apparent recently, and thus, tunas targeting operation is not so attractive for them now.

The observed increasing trend of the catch of blue shark is also supported by the report of the skippers. The price of blue shark has increased and stabilized in recent years, and this attracts skippers to target blue shark more than before. Many skippers reports that blue shark is only targeted in summer time when the catch of swordfish and tunas decreases in the period of the 1990s, but they started to target blue shark in other season than summer recently.

In the period before 2000, the ratio of sets whose CPUE of tunas higher than 5 occupied more than 40% of total and they shows steady decreasing trend (Fig. 4). The sets whose tunas CPUE higher than 10 is almost disappeared in recent years. On the contrary, the ratio of sets whose CPUE of blue shark higher than 5 increased in the recent years. There seems no particular trend in the ratio of sets by different swordfish CPUE level. These results should suggest that Japanese offshore surface longliners changes their secondary important fishes from tunas to blue shark.

2) Definition of target fish

The definition of target fish is conducted based on the species composition. In this analysis, tuna species (pacific bluefin tuna, albacore, bigeye tuna and yellowfin tuna) combined together to simplify the analysis.

To examine the species composition of the catch to define the target species, set-by-set data is aggregated into "continuous operation", which are conducted in consecutive days. This is because; most of skippers indicate they sometimes change their target fish during a single cruise, and also catch rate of swordfish in succeeded tunas targeting sets sometimes have similar catch rate of swordfish in failed swordfish targeting sets. In the analysis of species composition with the set-by-set data, these two types of sets would not be discriminated. Because operation time for one set usually quite long (more than 18 hours) for Japanese surface offshore longliners, they usually take one day off when skippers changes their fishing ground or operation style. Thus, the continuous set should indicate that fishing boats conduct operation same condition (and would be same target species).

The number of set aggregated into the one continuous operation steady diminishes in value (Fig. 5). In every year, about 20% of total sets continue only one day, and the average number of set conducted continuously is about 5 times. Largest number of set conducted continuously is 34, and the number of cruise which all sets conducted in a cruise conducted continuously is quite few.

The species composition is analyzed for the data aggregated by the continuous set. The ratio of the aggregated data with lower percentage of tunas (<5%) shows steady increasing trend since 2000 (Fig. 6). On the contrary, the ratio of the data with higher percentage to blue shark (>50%) increased since 2000. The ratio of the aggregated data with lower percentage of swordfish is also increased in recent years.

The number of the aggregated data with the higher percentage of tunas catch (>50%) are clearly observed in the period between 1993 and 1999, but the number of these data become negligible in the period after 2000 (Fig. 7). The histogram of the number of the aggregated data by the ratio of the catch number of swordfish to the total has the peak of the mode in the level of 5-10% or 10-15% in the period between 1993 and 1999, while it has the peak in the level of 0-5% or 5-10% in the period of 2000 – 2007 (Fig. 8). The histogram of the number of the aggregated data by the ratio of the catch number of blue shark used to have the peak of the mode in the 0-5% and 85-90%, but in the period after 2000, the highest peak was observed in 100% (Fig. 9).

These results of the analysis clearly indicates that the ratio of tunas targeting sets decreased and the ratio of blue shark targeting sets increased in the period after 2000. Increasing trend of the ratio of the aggregated data of the low swordfish catch ratio may reflect the fact that the decrease of the abundance level of swordfish and the decrease of relative importance of swordfish for Japanese offshore surface longliners. The decrease of the ratio of drop down blue shark when crews bring in it as a result of the careful handling of blue shark due to the increase of its market price may also have the effect on the result show in Figs. 8 and 9.

3) CPUE analysis

In the analysis of species composition of the catch of Japanese offshore surface longliners described above, it becomes apparent that this fleet change its secondary target species from tunas to blue shark in the period analyzed. To examine the effect of this change of secondary target species, GLM analysis of CPUE is conducted. In this analysis, tuna targeting operation is defined arbitrarily as the ratio of the number of catch of tunas in the aggregated data is larger than 60%. This is because in the same catch ratio among swordfish (first targeting species) and tunas, skippers would target swordfish. The blue shark operation is also defined arbitrarily as the ratio of the blue shark catch number in the aggregated data is larger than 95%. This is simply due to that fact that market price of one blue shark is roughly one twentieth of one swordfish.

The results of GLM analysis is shown in Fig. 10. The estimated trend of CPUE of swordfish is stable is the period analyzed. CPUE of swordfish in the blue shark targeting operation is estimated to be only 25% of that of the swordfish targeting operation, and the CPUE is estimated to be 60% of that of the swordfish. As a result of this, the annual trend of the swordfish standardized CPUE becomes more optimistic than the trend of the CPUE, which standardized without the effect of targeting (Fig. 11).

The ratio of the blue shark targeting operation from less than 10% of total in 1996 to more than 30% in 2007 (Fig. 12). Large increasing of the ratio of the blue shark targeting operation is observed in 2^{nd} and 3^{rd} quarters. The ratio of the tuna targeting operation decreased from 20% in 1996 to less than few percent in 2007, and decreasing trend of the ratio of the tuna targeting operation is most obvious in 4^{th} quarter.

Exclusion of the effect of blue shark targeting operations (these operations categorized into swordfish operation) in the CPUE standardization produced quite similar output as the trend of CPUE standardized without the effect of targeting (Fig. 13). Exclusion of the effect of tuna targeting operations produced similar result as the CPUE standardization with the effect of targeting. This result would mainly be due to the fact that the difference of the standardized CPUE of swordfish between tuna and swordfish targeting operations is not so large as the one between swordfish and blue shark (Fig. 10).

Because the effect of the inclusion of the blue shark targeting operation on the trend of standardized CPUE of swordfish, the effect of the change of the criterion to decide the blue shark targeting operation is examined. When the ratio of the blue shark catch number becomes larger in the selection of the blue shark targeting operation, more optimistic result is obtained (Fig. 14), but lowest value (80%) in the selection of the blue shark targeting operation still produced more optimistic result than the one by no effect of targeting. As the lower percentage for the selection of the blue shark targeting operations of the aggregated data, the difference of CPUE values between swordfish targeting and blue shark targeting operations becomes smaller.

Conclusions

The result of this study clearly indicates following two things;

a) Japanese offshore surface longliners catches blue shark and tunas as their secondary targeting species with surface set (HPB is 3 -4). The impotence of tunas for this fleet as the secondary targeting spices becomes lower in the period of analyzed. Instead of tunas, importance of blue shark as the secondary targeting species becomes larger in recent years.
b) This change of secondary targeting species form tunas to blue shark should cause underestimate of the most recent abundance level of swordfish in the subtropical and temperate areas in the northwest and north central Pacific, derived by the CPUE standardization using data of Japanese offshore and distant-water longliners using traditional GLM method. This is because in the subtropical and temperate areas in the northwest and north central Pacific, operation by Japanese offshore surface longliners occupies large part of the total effort as well as the total catch of swordfish. For the improvement of the estimation of the abundance index of swordfish, method to include the information about the change of targeting should be necessary.

The inclusion of the species composition into the CPUE standardization of swordfish as the indicator of the target species has been used in the analysis of swordfish CPUE of Canadian coastal surface longliners target swordfish and tunas in the east coast of Canada (Paul and Neilson, 2007). In this study, catch and effort data is analyzed by the trip base, and trips with the more than half catch number of tunas among major target species are classified into tuna targeting trips.

Using information of the species composition as the indicator of the target species would cause some problems in the analysis when the annual trends of abundances of species used in the calculation of the species composition largely changes one from the other. This is because the different pattern of change of abundance trend among species analyzed would affect on the species composition of the catch (Maunder and Punt, 2004).

In the present study, all tuna catch is aggregated in the calculation of the species composition, mainly to simplify the method, and this may soften the effect of the difference in the annual trend of abundance level among different tuna species. Further study should be necessary to eliminate this effect from the estimation of species composition of the catch.

In the present study, set-by-set data is aggregated by the continuous operations. This is mainly because the fact that the cruise data of Japanese offshore longliners is relatively longer (30 – 40 days per one cruise) than Canadian coastal surface longliners and they sometimes change their target even in a single cruise. The number of days aggregated into one continuous operation becomes wide range from one day to more than 30 days. Because this wide range of the aggregated set would give affect on the CPUE standardization, it should be better to be examined.

Definition of the criteria to determine the target fish is another important thing in the CPUE analysis. In this study, the criteria is determine arbitrary by limited information. Further analysis of data should be necessary to decide the optimal criteria.

References

Maunder, M.N. and Punt, A.E., 2004: Standardizing catch and effort data: a review of recent approaches. Fisheries Research, Vol. 70, p141-159.

Paul, Stacey D. and John D. Neilson, 2007: Updated sex– and age-specific CPUE from the Canadian swordfish longline fishery, 1988-2005. Col. Vol. Sci. Pap. ICCAT, 60(6), 1914-1942.

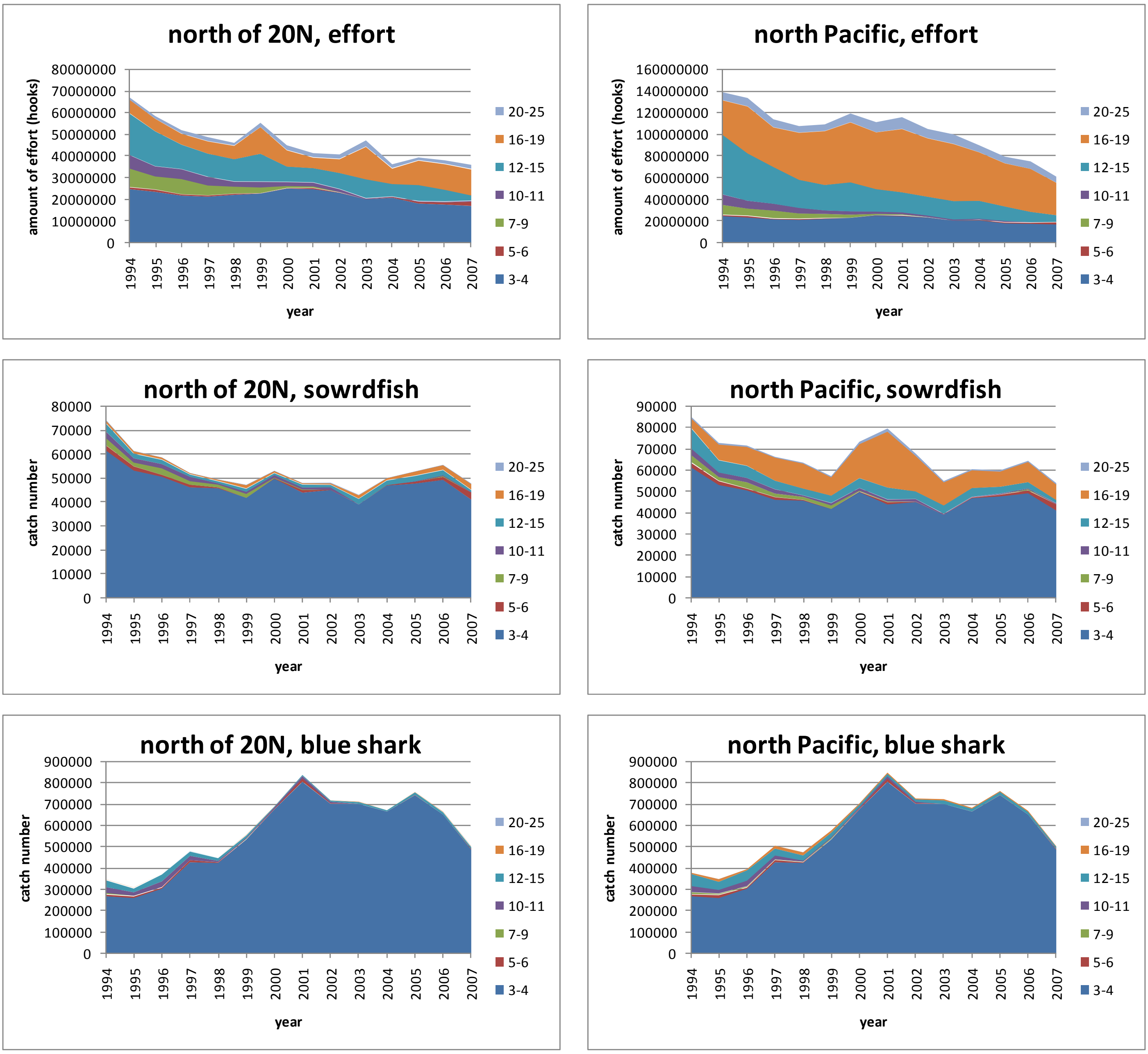
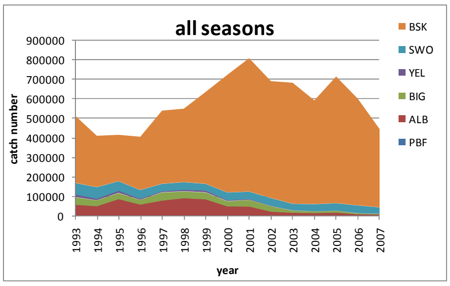


Fig. 1. Amount of effort, catch number of swordfish and blue shark of Japanese offshore and distant-water longliners by the gear configuration in the north of 20N in the north Pacific, and in the north Pacific.



Abbreviations; BSK, blue shark; SWO, swordfish; YEL, yellowfin tuna; BIG, bigeye tuna; ALB, albacore; PBF, pacific bluefin tuna

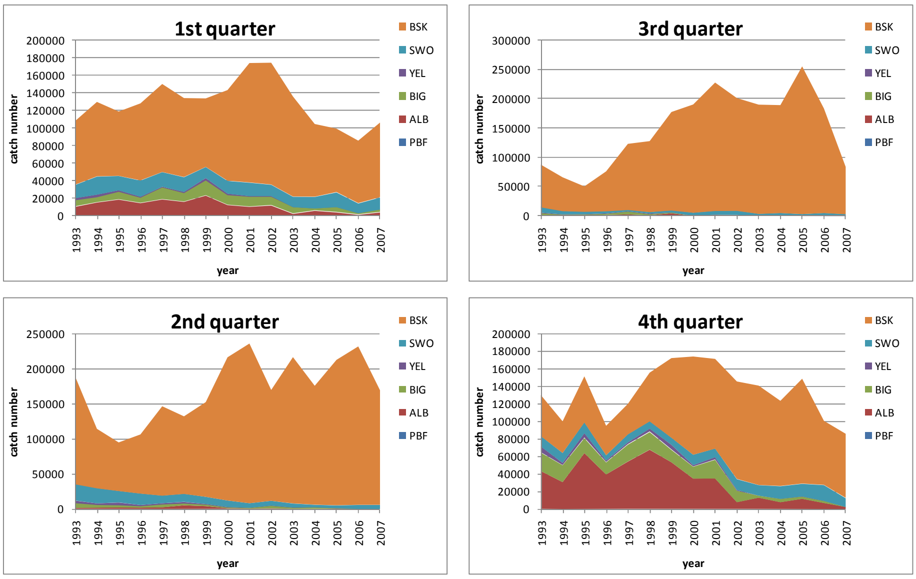
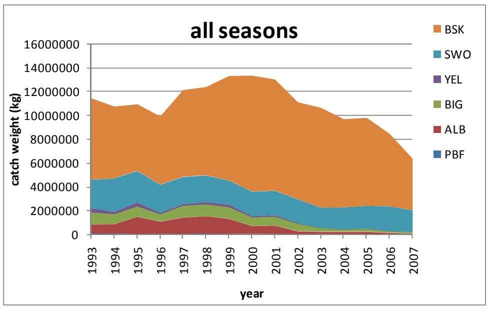


Fig. 2. Catch number by species of the operations of Japanese offshore surface longliners with 3-4 HPB.



Abbreviations; BSK, blue shark; SWO, swordfish; YEL, yellowfin tuna; BIG, bigeye tuna; ALB, albacore; PBF, pacific bluefin tuna

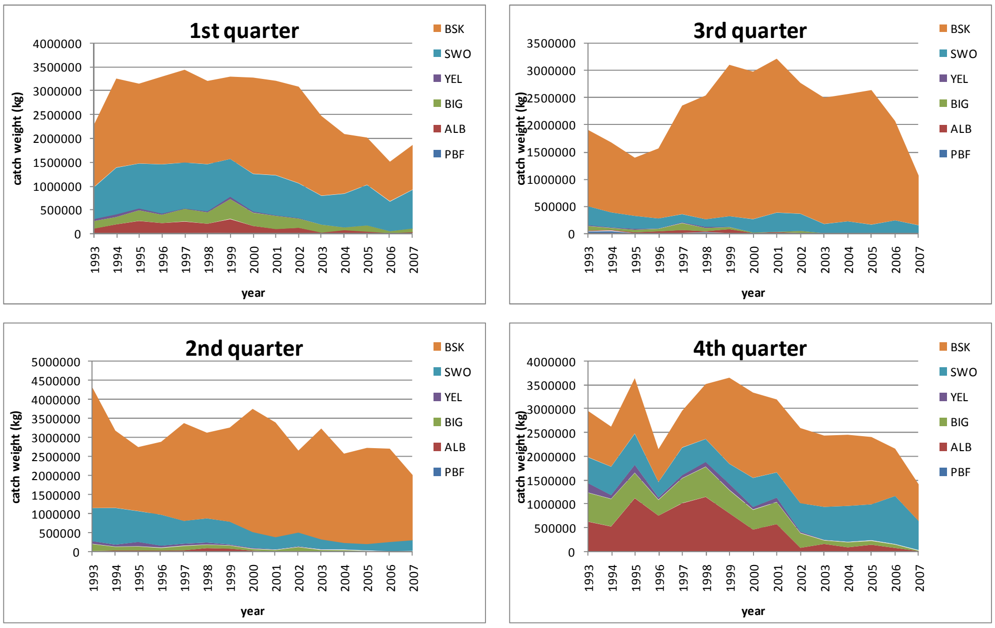


Fig. 3. Catch weight (kg) by species of the operations of Japanese offshore surface longliners with 3-4 HPB.

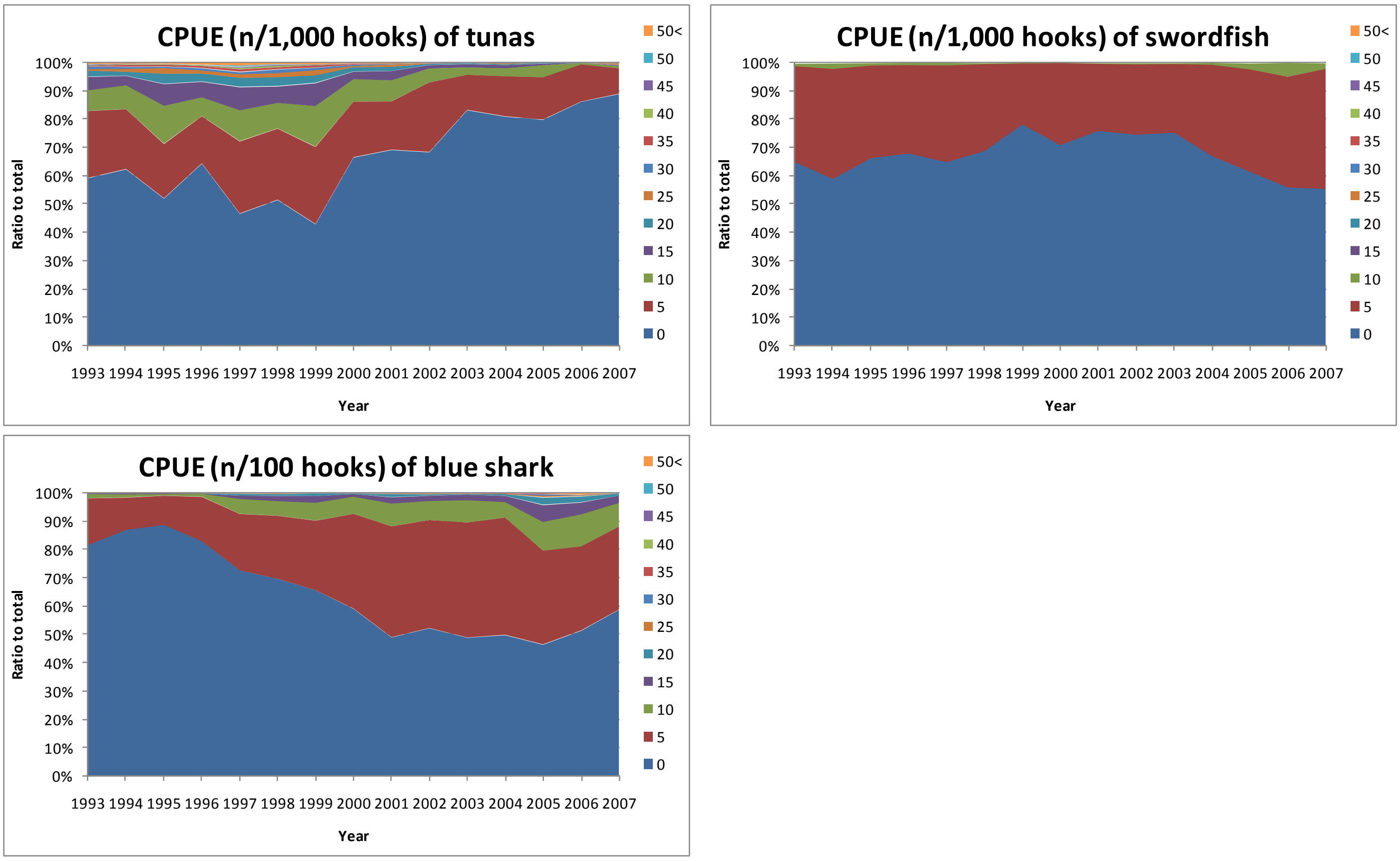


Fig. 4. Annual change of the ratio of sets with different level of CPUE of the tunas (sum total of bluefin tuna, albacore, bigeye tuna and yellowfin tuna), swordfish and blue shark caught by Japanese offshore surface longliners in the north Pacific in 1993 – 2007. The data of sets with 3-4 HPB is used.

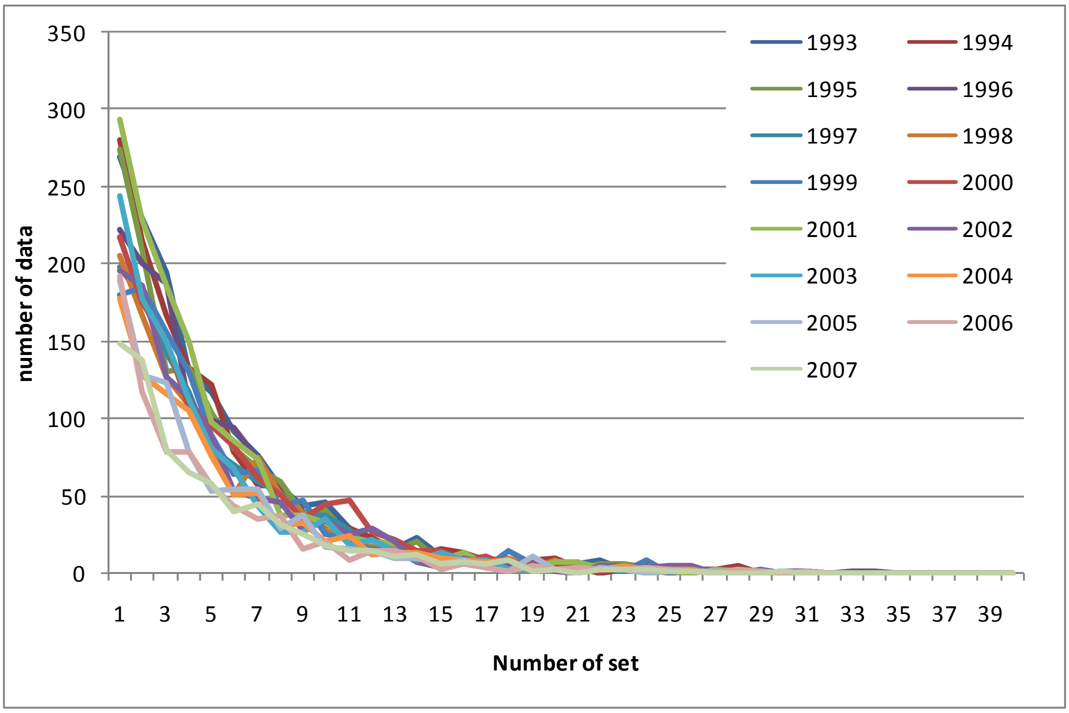


Fig. 5. Number of the data by the aggregated sets. Sets continuously conducted are aggregated into single data for the analysis. The continuous sets can be considered as a group of sets targets same species with the same fishing condition. The set-by-set data of Japanese offshore surface longliners operating with

3-4 HPB are used.

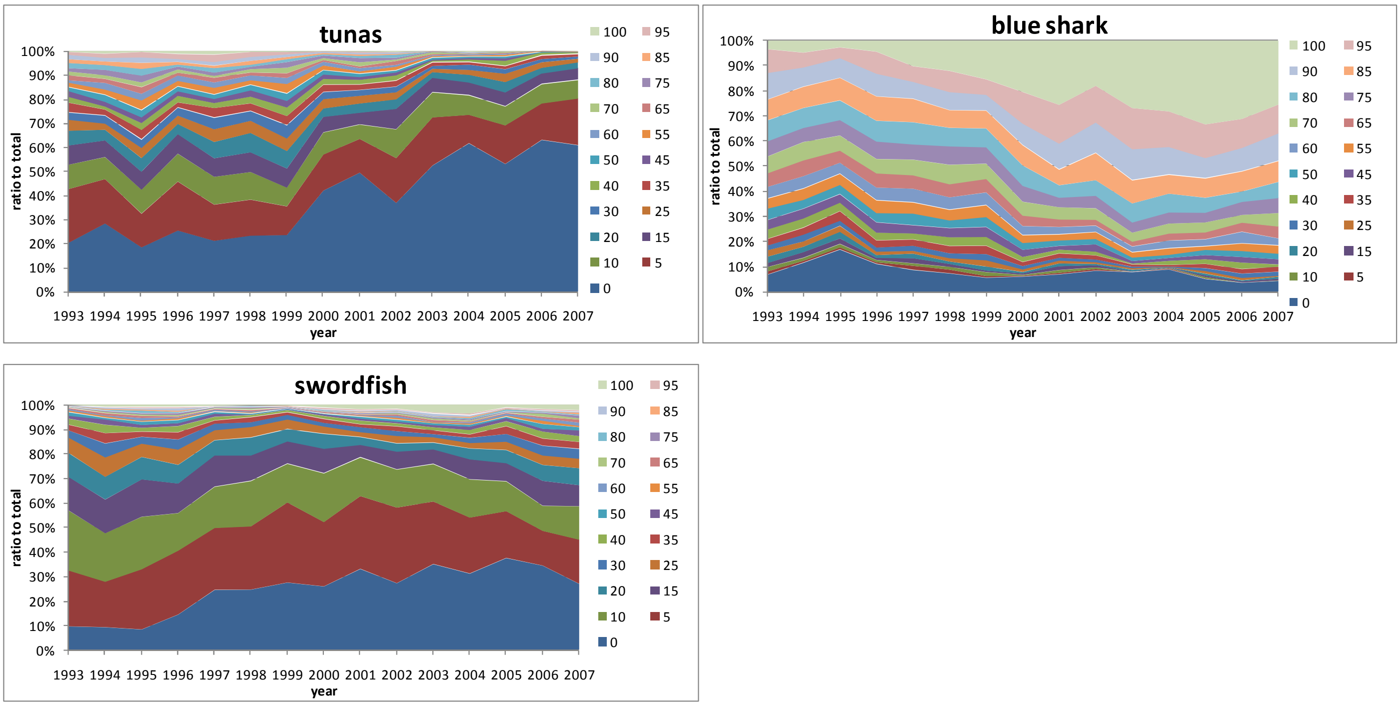


Fig. 6. Ratio of the aggregated data with catch number of the tunas occupied 0 – 100 percent of the total catch (sum of tunas, swordfish and blue shark) in the period of 1993 – 2007. The data of sets with 3-4 HPB of Japanese offshore surface longliners is used.

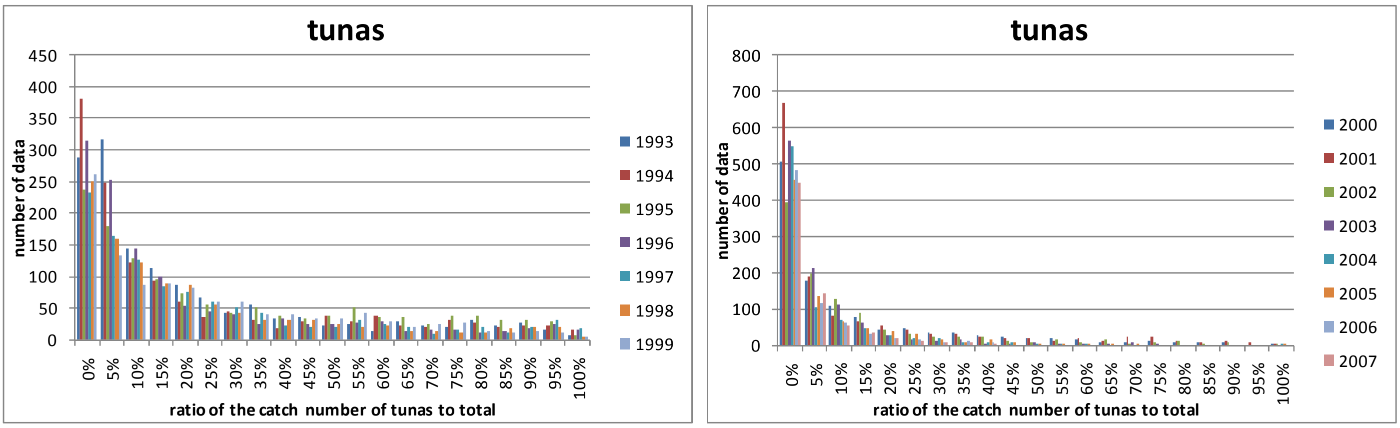


Fig. 7. Number of aggregated data by the different level of the ratio of catch number of tunas to the total catch (sum of tunas, swordfish and blue shark) in the period of 1993 – 1999 (left panel) and in the period of 2000 – 2007 (right panel).

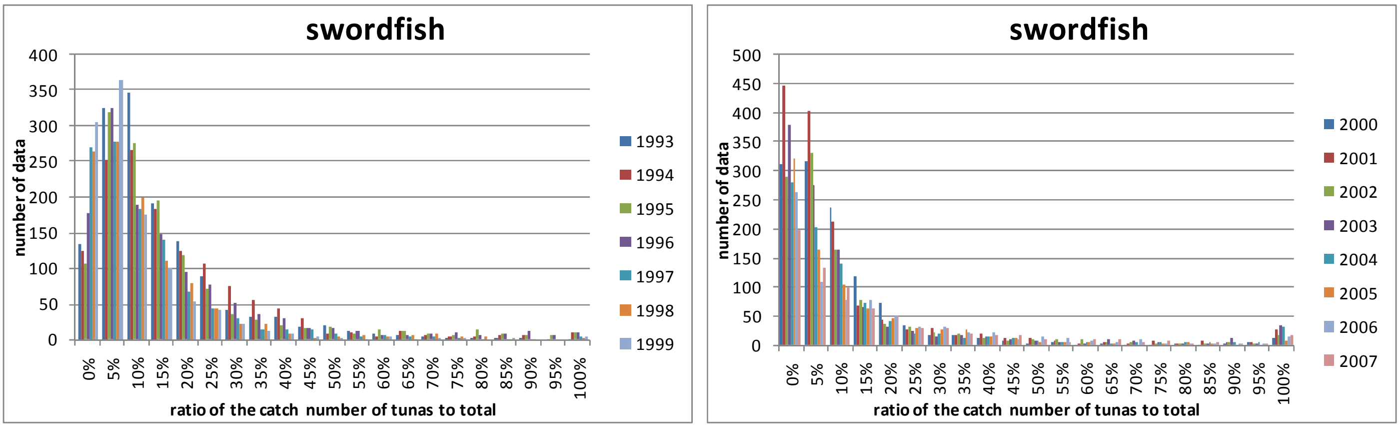


Fig. 8. Number of aggregated data by the different level of the ratio of catch number of swordfish to the total catch (sum of tunas, swordfish and blue shark) in the period of 1993 – 1999 (left panel) and in the period of 2000 – 2007 (right panel).

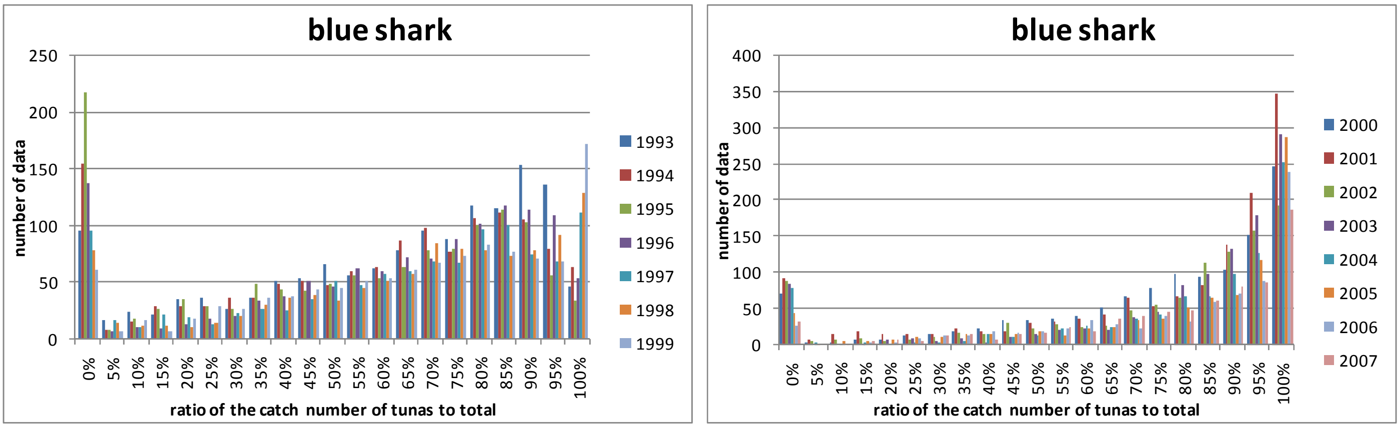


Fig. 9. Number of aggregated data by the different level of the ratio of catch number of blue shark to the total catch (sum of tunas, swordfish and blue shark) in the period of 1993 – 1999 (left panel) and in the period of 2000 – 2007 (right panel).

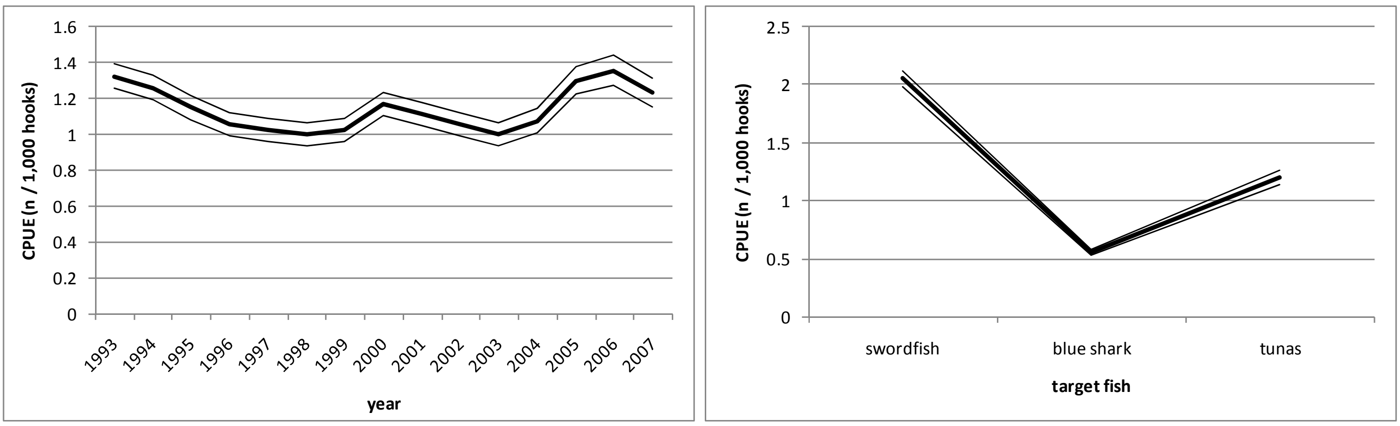


Fig. 10. Standardized CPUE (n / 1,000 hooks) of swordfish caught by the surface sets (HPB is 3 - 4) of Japanese offshore surface longliners by year (left panel) and by target fish (right panel). Standardization of CPUE was conducted by including the effect of target fishes.

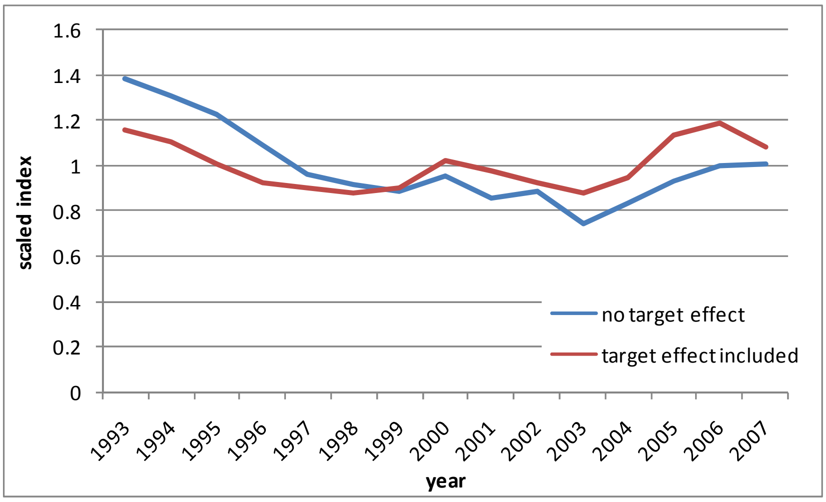


Fig. 11. Comparison of the trend of CPUEs of swordfish standardized by the two different models, which are the model with/without the effect of target fish. All CPUE values scale to their average set at

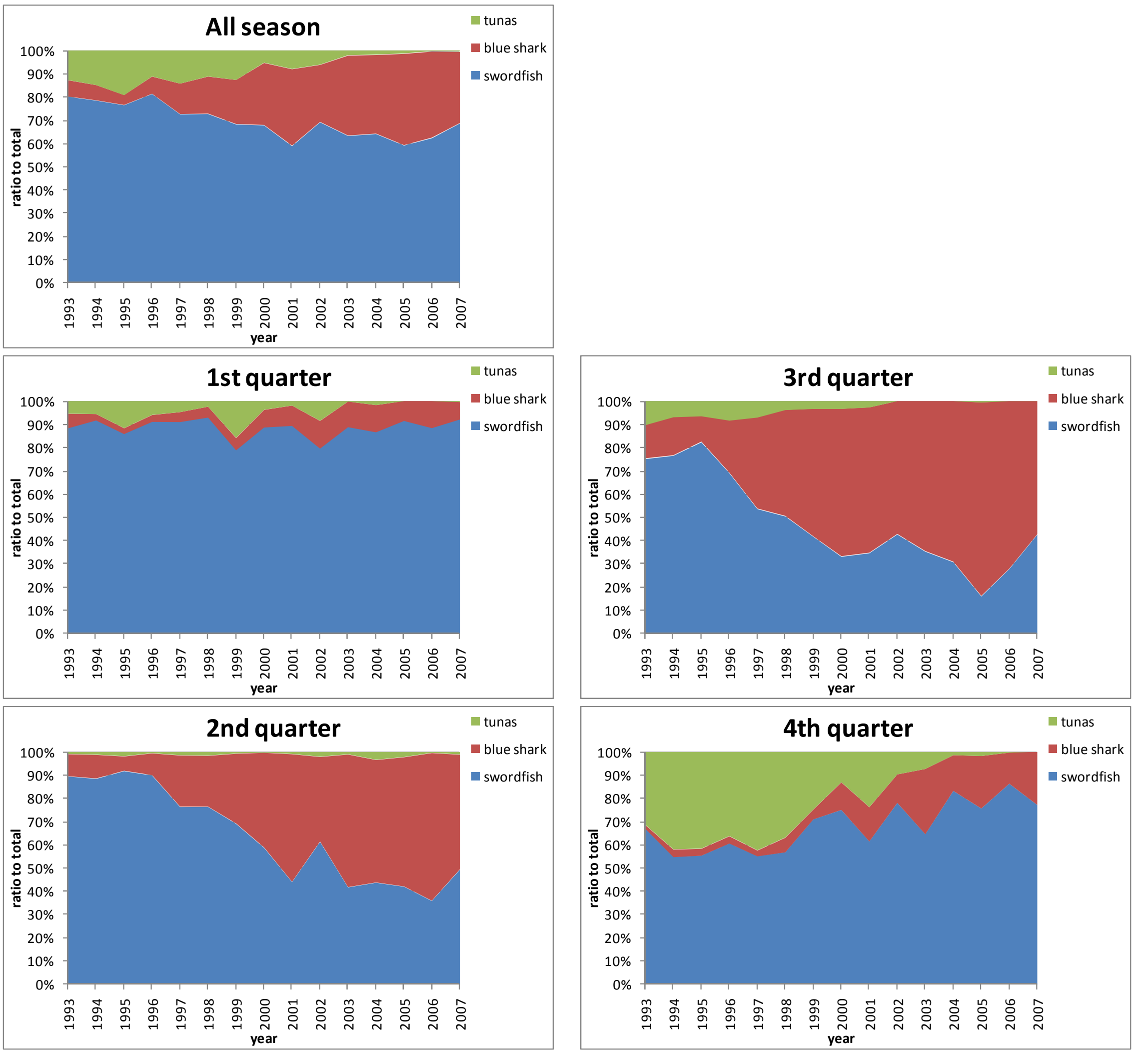


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Fig. 12. Ratio of aggregated data classified into the tunas, blue shark and swordfish targeting operation. The data of sets with 3-4 HPB of Japanese offshore surface longliners is used. The data with the ratio of tunas catch number to the total is larger than 60% is classified into the tunas targeting operation, the one with the ratio of blue shark catch number is larger than 95% is classified into the blue shark targeting operation, and other data is classified into the swordfish targeting operation.

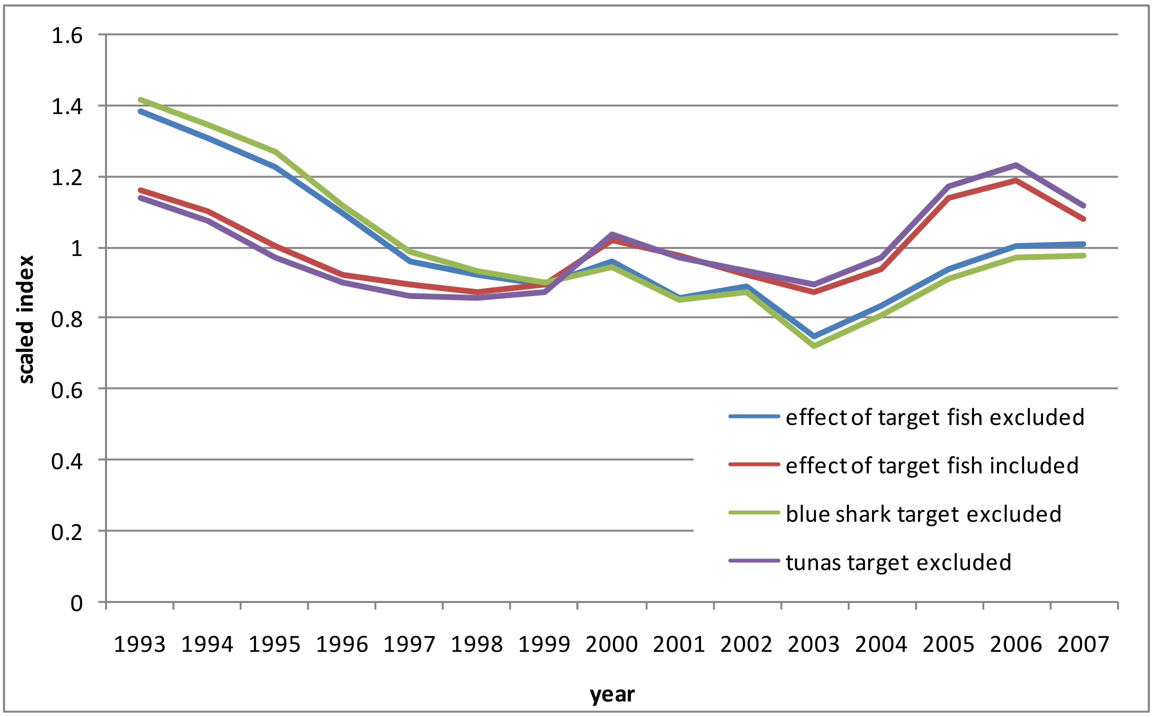

Fig. 13. Comparison of the trend of CPUEs of swordfish standardized by the four different models, which include, exclude or partially include the effect of target fish.

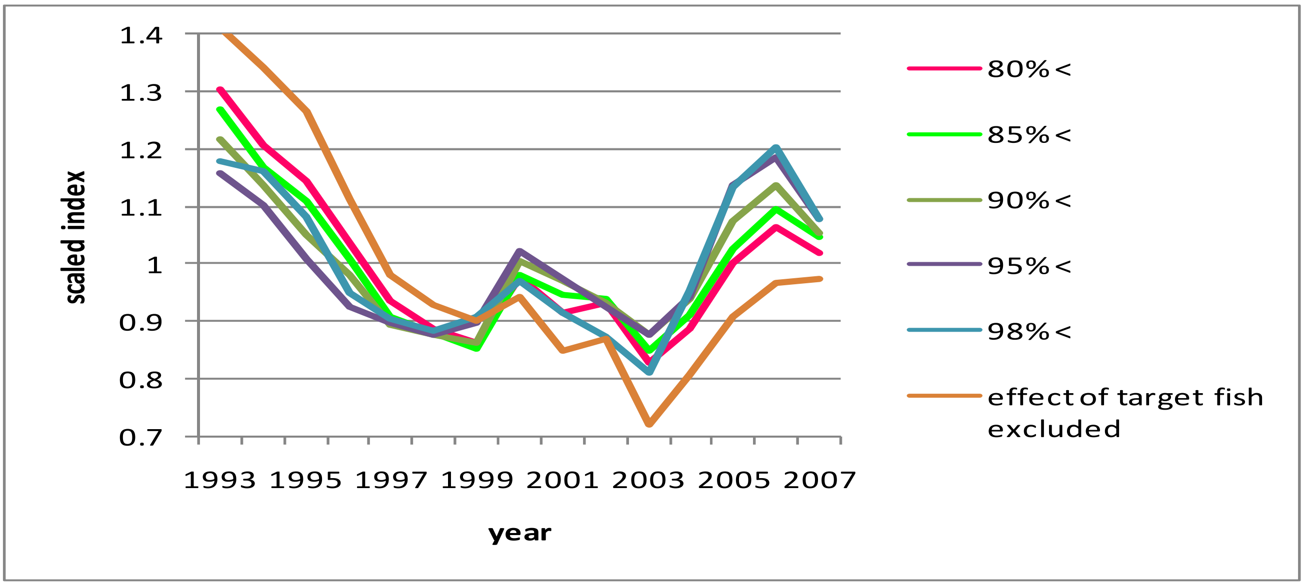

Fig. 14. Comparison of the trend of CPUEs of swordfish by the change of criteria of the selection of the blue shark target data. The trend of CPUEs without the effect of target fish is also added for the comparison.

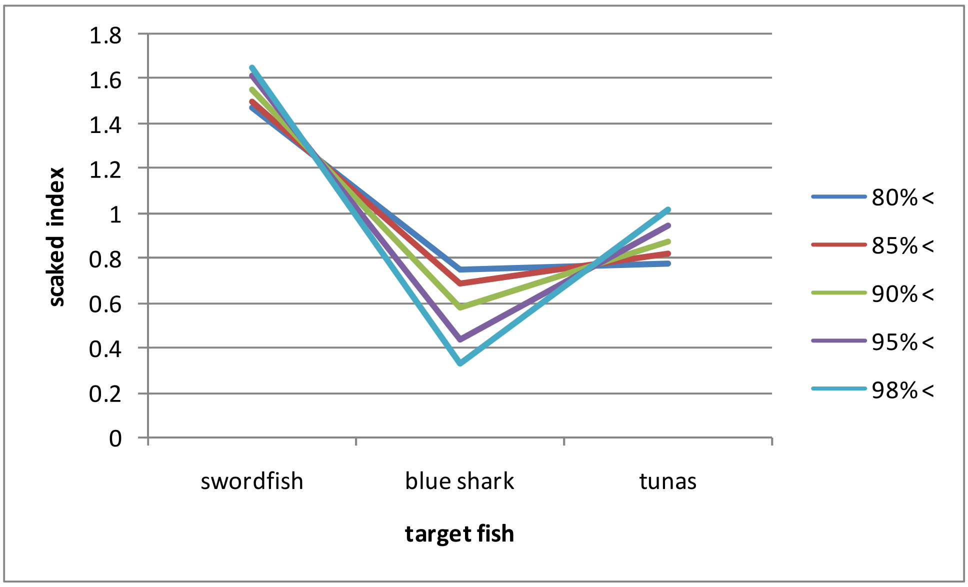

Fig. 15. The trend of standardized CPUE by the change of the criterion for the selection of the blue shark targeting operation.