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Blue sharks caught by Japanese large mesh drift net fishery in the north Pacific in 1981 - 1993

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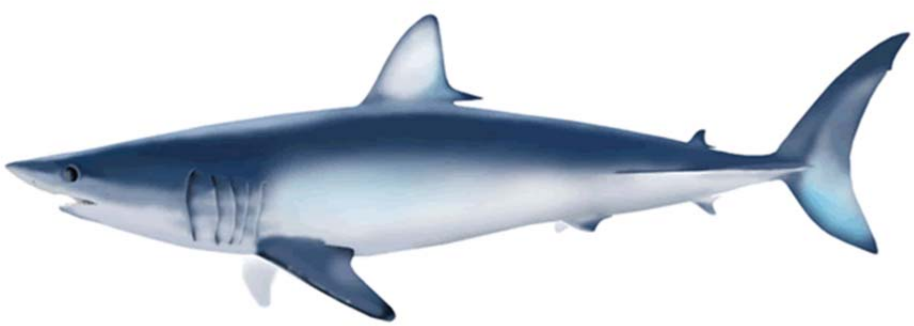

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Summary

Catch and effort data for blue shark caught by Japanese high seas large mesh drift net fishery in the period between 1981 and 1993 was reviewed and its CPUE standardized. The distribution pattern of the catch and CPUE of blue shark shows a more or less similar pattern to those of effort, with relatively higher CPUE observed in the offshore area of the northeastern side of Honshu, in the area between 160E – 180E as well as in the area around 170W. The nominal CPUE (number/km net length) of blue shark in the areas 1 and 2 shows generally the same trend over the period analyzed, but the level of the nominal CPUE is about 2 times higher in the area west of dateline than in the area east of dateline. The trend of the annual standardized CPUE was generally similar to that of the nominal CPUE, and they started to increase in the middle of the 1980s. The residual pattern was bimodal and this suggests, however, the necessity of the introduction of other factors to the model for CPUE standardization. The standardized CPUE obtained by this study could be used for the stock assessment of the north Pacific blue shark as the general trend of the standardized CPUE does not different from the nominal CPUE and this tendency would not change largely when other factors are introduced to the model.

Introduction

Large mesh drift net fishery primarily targeting billfishes and some tuna species such as albacore had been one of the Japanese main pelagic fisheries in the Pacific in the period between the end of the 1970s and 1993 when the moratorium of the open sea large scale drift net fishery introduced. The blue shark is one of main secondary targeting species for this fishery and species specific catch data were available by log-book system since the beginning of the 1980s. In the present document, catch of blue sharks by Japanese large mesh drift net fishery were reviewed and analyzed for the input of the stock assessment of blue shark in the north Pacific.

Materials and methods

Catch and fishing effort data used in this analysis were obtained from the Japanese large-mesh driftnet fishery statistics. The statistics for 1977-1993 were compiled by the National Research Institute of Far Seas Fisheries, based on logbooks. Though the log-book were started to collect in 1977, reliable species specific shark data were available since 1981, and thus, the data in 1981 – 1993 were used in this study.

These data include date, position (1x1 degree), mesh size of net (cm), length of net, and catch number by species for each set. Although log-book coverage is unknown, it is believed that the amount of data is sufficient to estimate the historical change of abundance of striped marlin in the main fishing ground of this fishery (Uosaki,1998).

Logbook data were aggregated by year, month, and 1 degree square block. Mesh size of the net is classified into three strata; <17cm, 17-19cm, and >19cm in the analysis of CPUE. Among the aggregated data, ones with less than four operations are excluded from this analysis. CPUE is calculated as catch in number per 10 km net length.

The standardization of CPUE was conducted using the GLM method and the effect of year, gear (mesh size of the net), season (quarters of year), area and their two way interactions were introduced into the analysis.

Results and Discussion

(1) Review of fishery data

For the analysis of data, the area stratification recommended by the ISC shark working group meeting in December 2011 (Fig. 1)(ISC, 2011), and subareas were developed within each area for the analysis of CPUE. Almost all efforts of Japanese large mesh drift net fishery were deployed in the subtropical and temperate area in the northwest central Pacific (Fig. 1)(areas 1 and 2) and more than 90% of efforts were obtained from the northwest Pacific (area 1). Amount of effort were fluctuated around 4 billion km of mesh length during the 1980s and increased to more than 10 billion km in the early 1990s. The annual catch number of blue shark shows similar trends as the annual amount of effort, and some notable catch were recorded from the tropical area in the northwest Pacific (area 3). The operation of the Japanese large mesh drift net fishery were conduct in all seasons with some annual variability of the ratio of effort among seasons (Fig. 2), and large number catch of blue shark were obtained in the 1st and 3rd quarters than 2nd and 4th quarters.

Higher concentrations of the amount of effort were observed in the offshore area of the northeastern side of Honshu (35N – 45N, 145E-155E) throughout the year (Fig. 4). In the pelagic area, the amount of effort longitudinally widely distributed along the 30N – 40N line with some seasonal north and south shift. The operational position goes down to most northern area in the 3rd quarter of the year and goes up to most northern area in the 1st quarter. The distribution pattern of the number of catch and CPUE of blue shark shows more or less similar pattern to those of effort, and relatively higher CPUE were observed in the offshore area of the northeastern side of Honshu, in the area between 160E – 180E as well as in the area around 170W (Fig. 4).

The seasonal CPUE distribution pattern were also described in the period when the relative catch of blue shark is lower (1984 – 1987), increasing (1988 – 1989), and higher (1991 – 1992) to obtain appropriate model structure of CPUE standardization. Among the three periods, the level of CPUE of blue shark in the "good fishing point" (the area with higher catch were obtained; the offshore area of the northeastern side of Honshu, the area between 160E – 180E, and the area around 170W) were different, and the few or no number of observations were observed in some of the good fishing points in some period-season strata.

The nominal CPUE (n/km net distance) of blue shark in the areas 1 and 2 shows generally same trends in the period analyzed, but the level of the nominal CPUE is about 2 times higher in the area 1 than in the area 2 (Fig. 6).

(2) CPUE analysis

Based on the results of the review of the fishery data described above, the strategy of the CPUE standardization was developed. Because the results of the review of fishery data indicated that the annual and seasonal coverage of data were apparently different among area, the CPUE analysis decided to analyze by the each area, and the analysis for the area 4 and 5 is not conduct as only few data available.

Though some notable catch and effort were obtained from the area 3, the catch and effort distribution pattern clearly shows that most of catch and effort were obtained at the position “near the boundary to the area 1”, and this indicates that at least part of them were the operation spilled over from area 1 where the main fishing grounds were existed. Thus, the CPUE of area 3 supposed to be influenced by the size of main fishing ground which would be affected by the number of vessels operated in the main fishing ground as well as the environmental condition of there. Because not enough information were available to adjust these possible factors at the CPUE analysis, the analysis in the area 3 is also decided not to conduct. Thus, the analyses of CPUE of blue shark were conducted for the area 1 and area 2 only in the present study. The CPUE distribution pattern analysis indicated that the CPUE were not homogeneously occurred even within the area, subareas were decided to develop in the areas 1 and 2 for purpose of CPUE standardization.

In the area 1, the catch of blue shark was obtained throughout the year, and there were some annual fluctuations of the quarterly ratio of the catches. Referring the catch, effort and CPUE distribution pattern shown in Figs. 3 and 4, 3 subareas (subarea 1; west of 150E, subarea 2; 150E – 160E, subarea 3; east of 160E) were developed. Based on the results of review of the data, CPUE standardization were conducted by the model with main factors (year, subarea, quarter and gear (mesh size)) and interaction terms between year and quarter as well as subarea and quarter.

The results of the CPUE standardization are shown in Figs. 7 – 9, and table 1. The general trend of annual standardized CPUE was similar to those of the nominal CPUE, but smoother trend was obtained in the standardized one (Fig. 7). The standardized CPUE showed gradual decrease trend up to 1987 when it turns into steady increase trend. High CPUEs were obtained in the most near shore area (subarea 1), middle size of mesh, and 1st and 3rd quarters (Fig. 8). Residual pattern have largest mode around -0.5 – 0, and another smaller mode around 1 – 1.5 (Fig. 9). This suggests, however, the necessity of the introduction of other factors to the model of CPUE standardization, the standardized CPUE obtained by this study could be used for the stock assessment of the north Pacific blue shark as the general trend of standardized CPUE does not different with the nominal CPUE and this tendency would not change largely when other factors are introduced to the model.

In the area 2, the majority of blue shark catches were obtained by the 1st and 2nd quarters (Fig. 10). In the 3rd and 4th quarter, quite few operations were conducted (Figs. 3 and 4). Thus, the data of 1st and 2nd quarters were decided to use for the CPUE analysis in the area 2. The seasonal distribution pattern of effort indicate that the operation area were different between 1st and 2nd quarters (Fig. 3), and 2 subarea (subarea 1; west of 170W, subarea 2; east of 170W) were developed to adjust this difference. The same model structure used for the CPUE analysis in the area 1 was applied on the data of the 1st and 2nd quarter of the area 2 in the period between 1981 and 1992 (no data available in 1993). The result of the CPUE standardized CPUE produce unnatural rapid increase with wide confidence interval in 1992, and this supposed to be caused by the limited number of operations with high blue shark catch (Fig. 10). Because sudden large increase of standardized CPUE in the period between 1991 – 1992 supposed not to reflect actual change of the abundance in the area 2, CPUE standardization was re-conducted using data of 1981 – 1991 whose results are shown in Figs. 12 – 14 and Table 2. Same as the case of the area 1, the trend of the annual standardized CPUE was generally similar to that of the nominal CPUE, and they started to increase in the middle of the 1980s. The effect of the area and the quarter was not significant, but the gear effect had significant influence, especially largest mesh size had much higher CPUE than the smaller ones (Table 2, Fig. 13).

The catches of blue shark were mainly obtained by the 1st and 2nd quarters, but some notable (Fig. 7).

The catch number and amount of effort were mainly obtained in the 1st half of the year in area 1 (Fig. 4).

Figures 1-3 show the seasonal distribution pattern of CPUE, catch, and effort for the main fishing grounds of the Japanese large-mesh driftnet fishery in the north Pacific for the periods between 1977 and 1993. Based on these distribution patterns, five areas are designated (Fig. 4) for the analysis of CPUE of striped marlin: west of Kyushu area (area 1); off northeast of Honshu area (area 2); a temperate area in the northwest Pacific (area 3); a subtropical area in the north-west Pacific (area 4); and a temperate area in the north-central Pacific. Higher CPUEs are observed in the 3rd and 4th quarters in areas 2 and 3, and also area 1 all year round. Effort is distributed in all four quarters in areas 1 – 3, while most of effort in areas 4 and 5 are concentrated in the 1st and the 2nd quarters (fig. 3).

Figure 5 shows the annual catch number of striped marlin by area, and the annual amount of effort by area. More than half of all striped marlins are caught in areas 2 and 3 throughout the periods analyzed, while the amount of effort in these two areas is about 30-40% in 1984-1992. In 1993, 96% of effort is recorded in area 2, which is the results of introduction of moratorium of large scale drift net fishery in the open sea area. This drastic decrease of coverage of data observed in 1992-1993 may affect the results of the CPUE standardization.

Figure 6 shows nominal CPUE trends of striped marlin by area. Generally, higher CPUEs are observed in areas 1, 2, and 3. In the period between 1977 and 1982, decreasing trends of CPUE are observed more or less in all areas except for area 1.

Figure 7 shows the standardized CPUEs (number/10km) of striped marlin caught by the Japanese large mesh drift net fishery for the period between 1977-1992 and 1977-1993. CPUE decreased from 1977 to 1983, and then, it showed a gradual increasing trend. Figure 8 shows the residual patterns obtained in the results of CPUE standardization. Generally, the pattern of residuals approximate a normal distribution, although skewed patterns are observed in some strata. Increase in CPUE from 1992 to 1993 might be an artifact of the introduction of the moratorium on operations in the open sea, because most of operations in 1993 are found in area 2 where historically higher CPUE are observed. The peak of mode of the distribution pattern of residuals in 1993 shifted toward the positive side (Fig. 8, left top), which would support this.

Figure 9 shows the standardized CPUE of striped marlin by area, quarter, and mesh size class. Mesh size does not have significant impact on the CPUE of striped marlin. Higher CPUEs tend to be observed in the coastal areas of Japan (areas 1 and 2) than in offshore areas (areas 3-5). Clear seasonal patterns in CPUE are observed. Figure 10 shows seasonal pattern of CPUE by area. In areas 2, 3, and 4, the highest CPUE is observed in the 3rd quarter, while in the 1st quarter is highest in areas 1 and 5. Generally, the lowest CPUE is observed in the 2nd quarter except for in area 1 where the 4th quarter is the lowest.

In CPUE analysis of tunas and billfishes by GLM, differences in historical trend of CPUE by area are usually observed, and introduction of these differences to the estimation of an overall abundance index is an important issue. In the data set for the Japanese large scale drift net fishery for the period 1977-1993, areas 2 and 3 have a relatively large number of data available throughout the period analyzed (Fig. 5). Figure 11 shows standardized CPUE in areas 2 and 3. Trends in CPUE are different between the two areas. Figure 12 shows a comparison between the combined CPUE for areas 2 and 3, and CPUEs standardized in the original model which are shown in Figure 7. Standardized CPUEs in areas 2 and 3 are combined in two different ways: CPUE in each area is weighted by the approximate size of each area (the relative value of size of area 2 is 3.5, and area 3 is 18.0); CPUE in each area is weighted by the catch number in each area. General trend of these four estimated abundance indices are similar, but there are some differences in the values of the estimated indices at the beginning and end of the periods (1977-1978, and 1991-1993).

Conclusion

Uosaki (1998) reported that major target species of the Japanese drift net fishery in 1977-1993 were swordfish, albacore, skipjack, and striped marlin. He also reported that target species generally changed by season and area. Effect of these changes of target species was not introduced into the model of CPUE standardization used in this study because there is no information about target species in the logbook. The influence of a change in target species would be at least partly covered by the inclusion of effects for area and quarter, but because area stratification is determined arbitrary based on the average distribution of catch number and CPUE of striped marlin, the effect of change of target species would not be fully accounted for in the model used in this study. Further analysis of data is necessary to obtain better estimation of abundance indices for striped marlin in the north Pacific.

This is the first trial of CPUE standardization of striped marlin in the north Pacific caught by the Japanese large mesh drift-net fishery in the period between 1977 and 1993. Results of CPUE analysis shown in this document should be compared with the results of other studies using data from other fishery such as longline, to check its appropriateness as input to stock assessment models. Analysis of size data of striped marlin caught by the Japanese large mesh drift-net fishery would also be useful for better evaluation of the results of this study. These analyses could be effective in selecting the best method for estimating abundance indices as shown in Figure 12.

References

Uosaki, K. (1998); Standardized CPUE of north Pacific swordfish, *Xiphias gladius*, in the Japanese large-mesh driftnet fishery. NOAA Tech. Rep. NMSF 142, 125-131pp.

Table 1. Output of ANOVA in the CPUE analysis in the area 1.

Source	DF	Sum of Squares	Mean Square F	Value	Pr > F
Model	61	7990.448	130.99095	26.23	<.0001
Error	9325	46576.12	4.99476		
orrected To	9386	54566.57			
R-Square	Coeff Var	Root MSE	lcpue Mean		
0.146435	-56.62	2.234895	-3.947187		
Source	DF	Type III SS	Mean Square F	Value	Pr > F
yr	12	1112.303	92.691929	18.56	<.0001
area	2	2742.795	1371.39749	274.57	<.0001
qt	3	224.1809	74.726963	14.96	<.0001
ig	2	377.5034	188.751717	37.79	<.0001
yr*qt	36	1594.667	44.296316	8.87	<.0001
area*qt	6	91.73035	15.288392	3.06	0.0054

Table 2. Output of ANOVA in the CPUE analysis in the area 2.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	1303.53	86.90201	19.65	<.0001
Error	1862	8234.504	4.422397		
Corrected Total	1877	9538.034			
R-Square	Coeff Var	Root MSE	lcpue Mean		
0.136667	-36.0207	2.10295	-5.83817		
Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	10	714.8789	71.48789	16.16	<.0001
area	1	2.208649	2.208649	0.5	0.4798
qt	1	4.678661	4.678661	1.06	0.3038
ig	2	440.2788	220.1394	49.78	<.0001
area*qt	1	2.213381	2.213381	0.5	0.4794

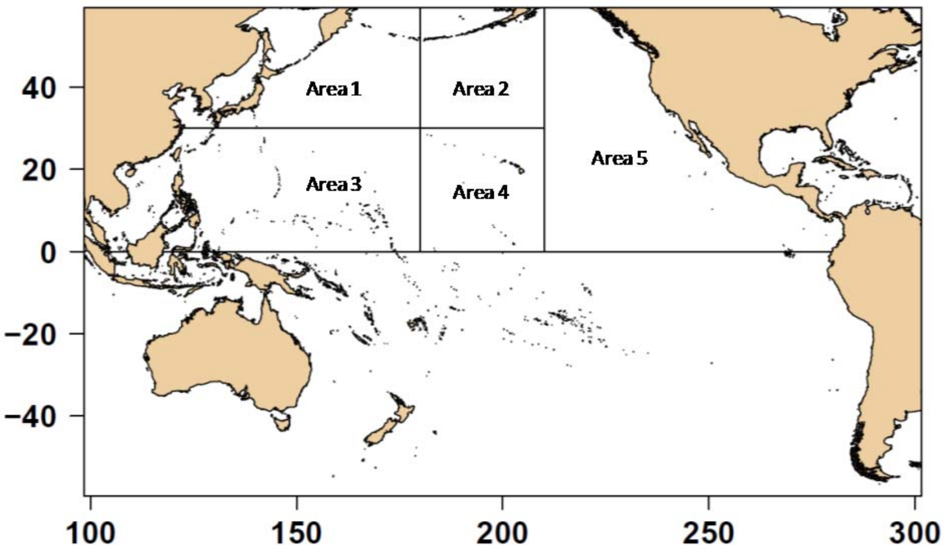


Fig. 1. Area stratification used in the data analysis.

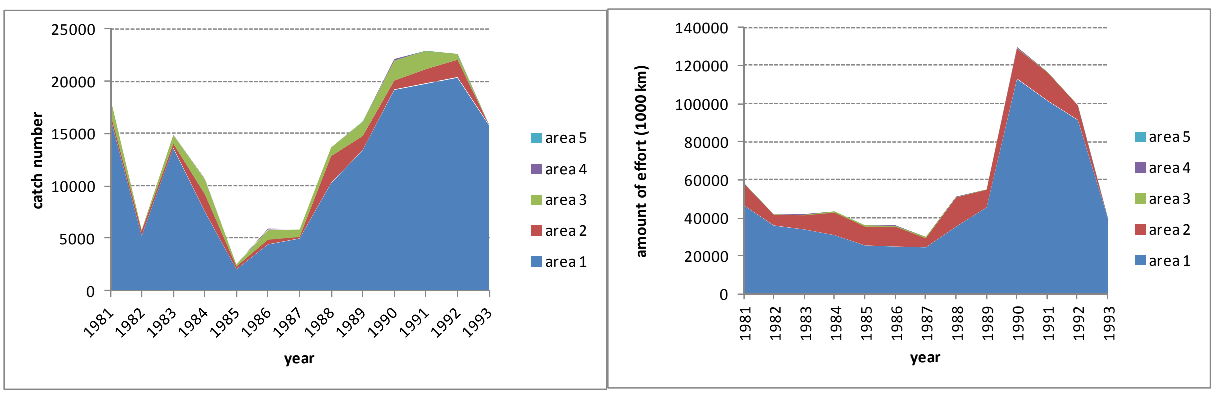
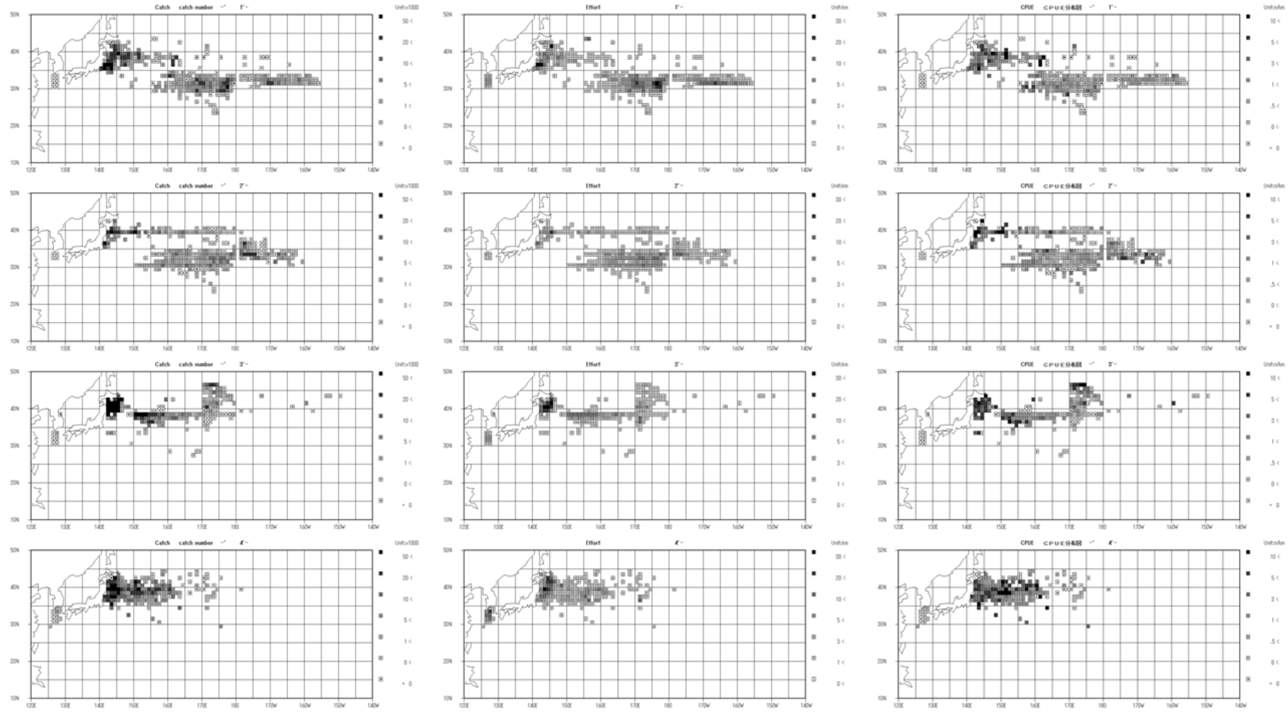
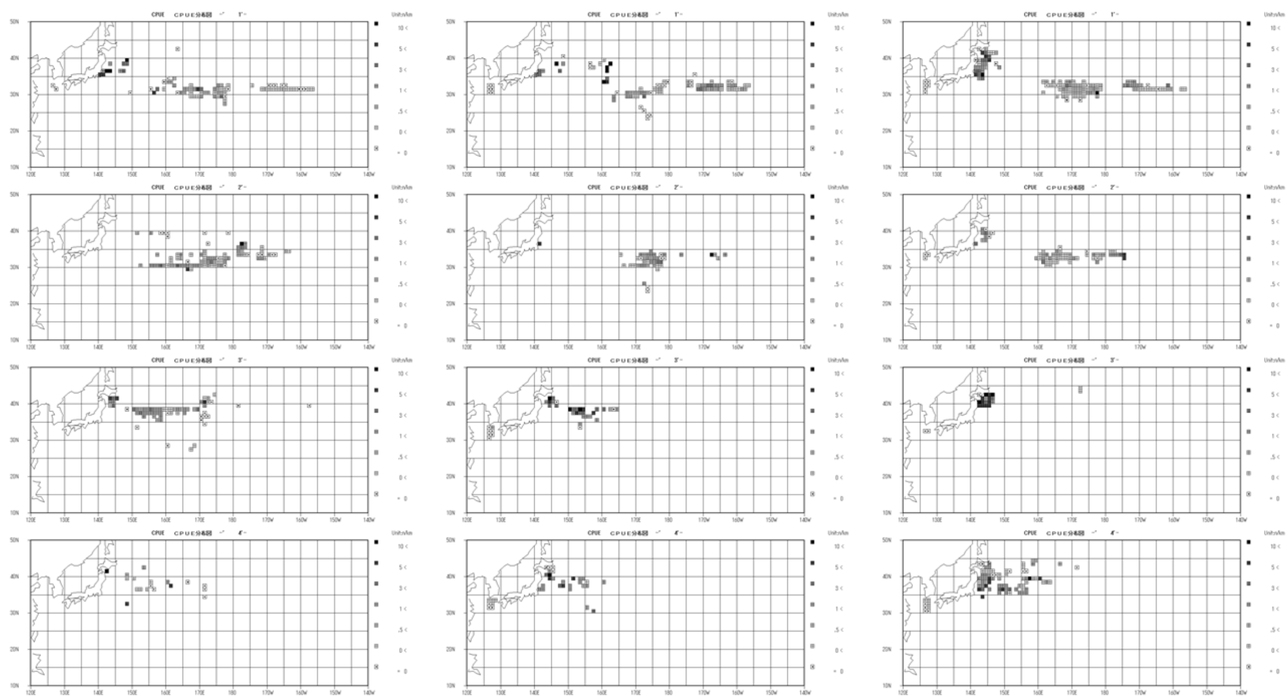


Fig. 2. Catch number of blue shark (left panel) and amount of effort (1,000 km)(right panel) of Japanese large mesh drift net by area reported by log-book in the north Pacific in the period of 1981 – 1993.



Catch number of blue shark **CPUE of blue shark** **Amount of effort**

Fig. 3. Seasonal average distribution pattern of reported catch number (left row) of blue shark, CPUE (n/km) of blue shark (middle row) and amount of effort (1,000 km) of Japanese large mesh drift net fishery in the period of 1981 – 1993. First to forth lines indicate patterns of 1st to 4th quarter respectively.



Catch number of blue shark **CPUE of blue shark** **Amount of effort**

Fig. 4. Seasonal average CPUE (n/km) distribution pattern of blue shark caught by Japanese large mesh drift net fishery in the period of 1984 – 1987 (left row), 1988 – 1989 (middle row), and 1991 – 1992 (right row). These three periods corresponding to the period of low, middle and high nominal CPUE. First to forth lines indicate patterns of 1st to 4th quarter respectively.

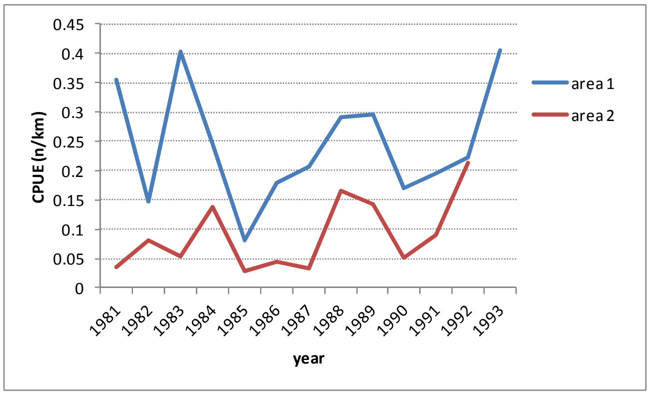


Fig. 5. Nominal CPUE (n/km) trend of blue shark caught by Japanese large mesh drift net fishery in the north Pacific in areas 1 and 2 in the period of 1981 – 1993. No data available in 1993 in the area 2.

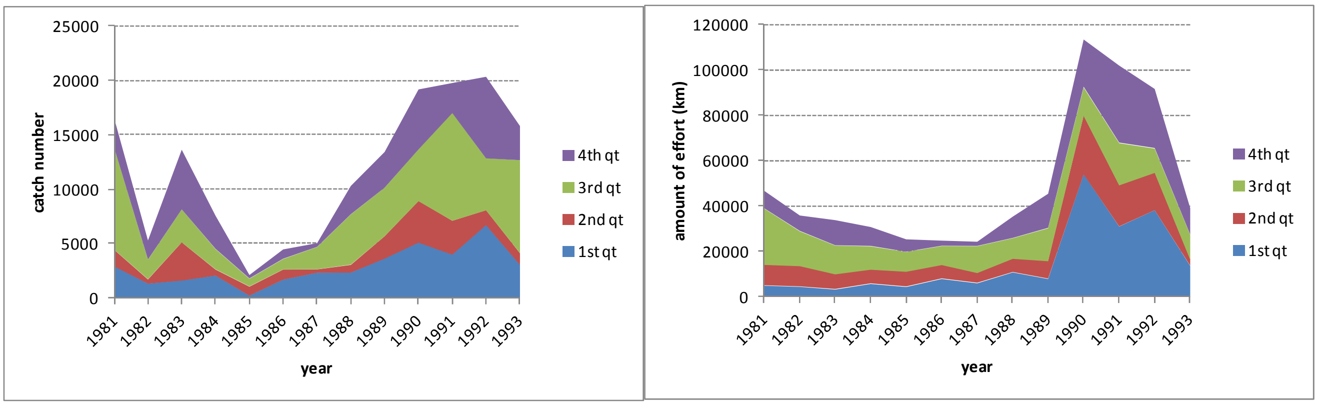


Fig. 6. Seasonal Catch number of blue shark (left panel) and amount of effort (km)(right panel) in area 1 of Japanese large mesh drift net reported by log-book in the north Pacific in the period of 1981 – 1993.

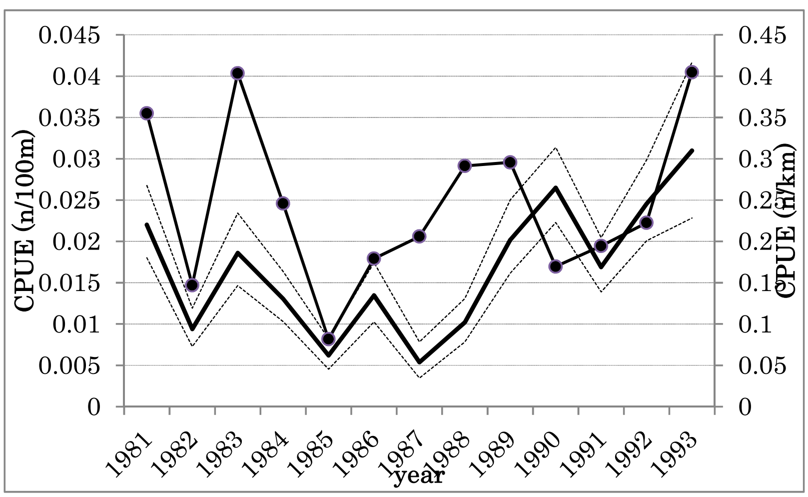


Fig. 7. Annual trend of the standardized CPUE (n/ 100 m) and its confidence interval of blue shark caught by Japanese large mesh drift net fishery in the period of 1981 – 1993 in the area 1. The nominal CPUE (n/km) are also shown with the standardized CPUE by year with closed circle.

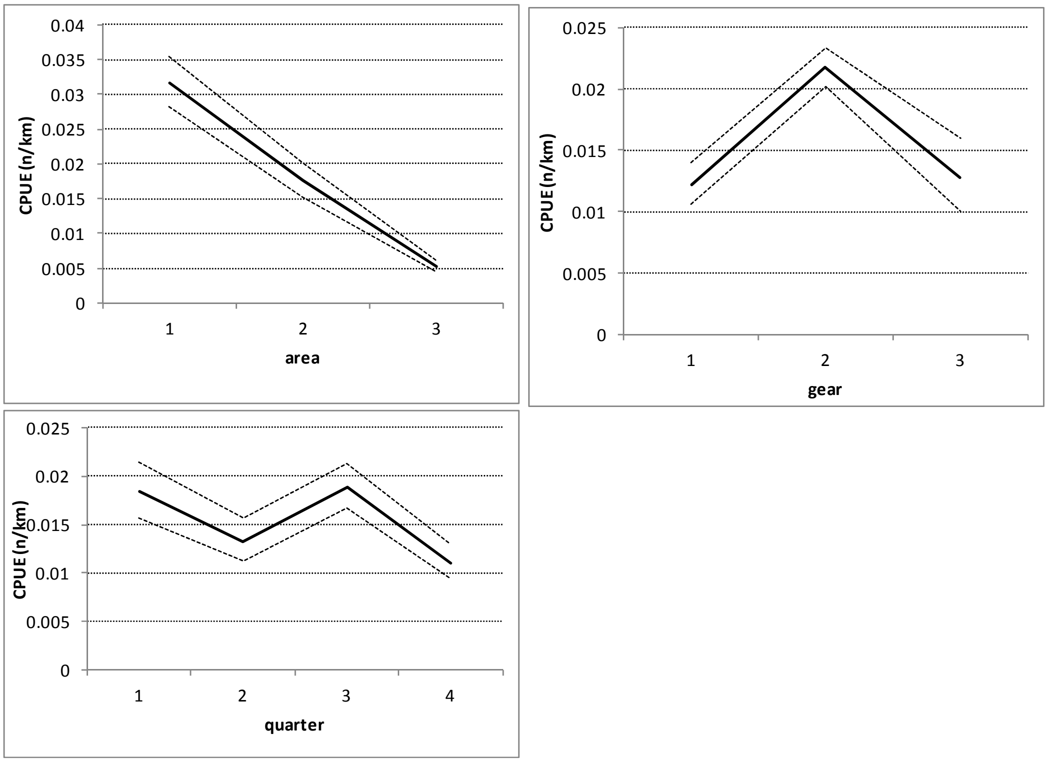


Fig. 8. Standardize CPUE (n/km) by area (left top), by gear (right top), and by quarter (left, bottom) in the CPUE analysis in the area 1..

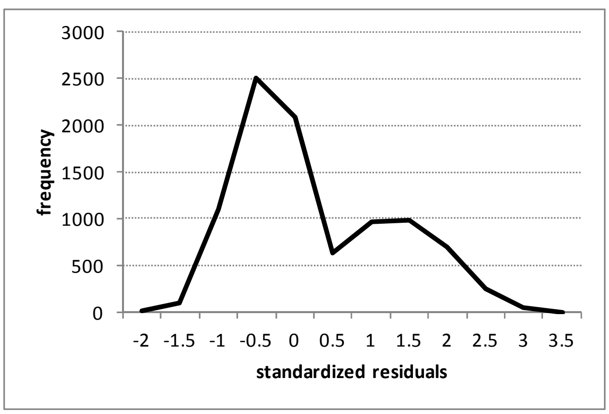


Fig. 9. Distribution pattern of residuals in the analysis of CPUE in the area 1.

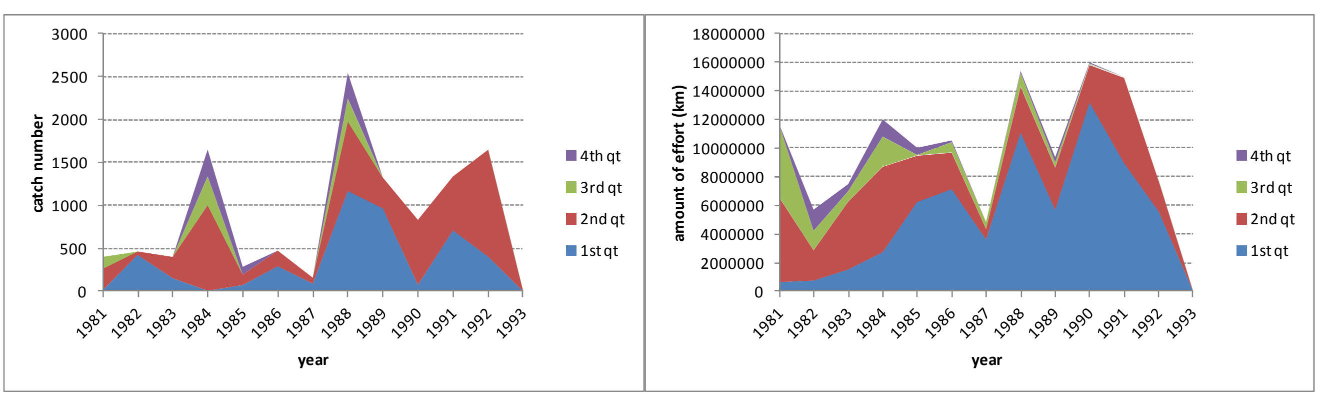


Fig. 10. Seasonal Catch number of blue shark (left panel) and amount of effort (km)(right panel) in area 2 of Japanese large mesh drift net reported by log-book in the north Pacific in the period of 1981 – 1993.

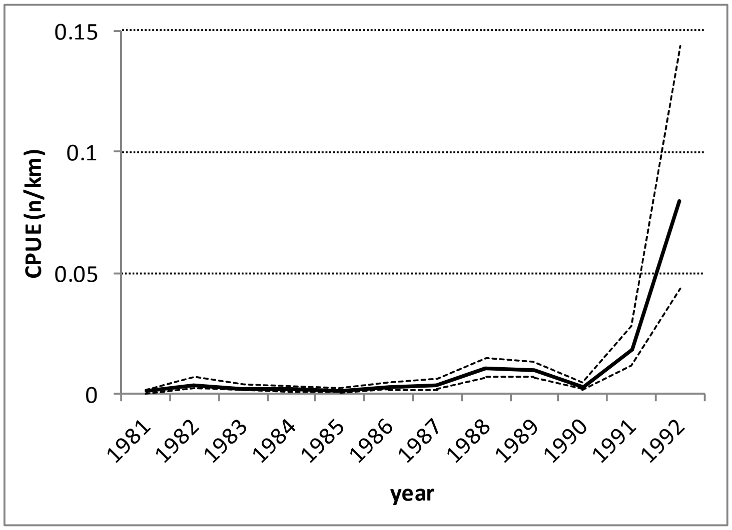


Fig. 11. Annual trend of the standardized CPUE (n/ 100 m) and its confidence interval of blue shark caught by Japanese large mesh drift net fishery in the period of 1981 – 1992 in the area 2

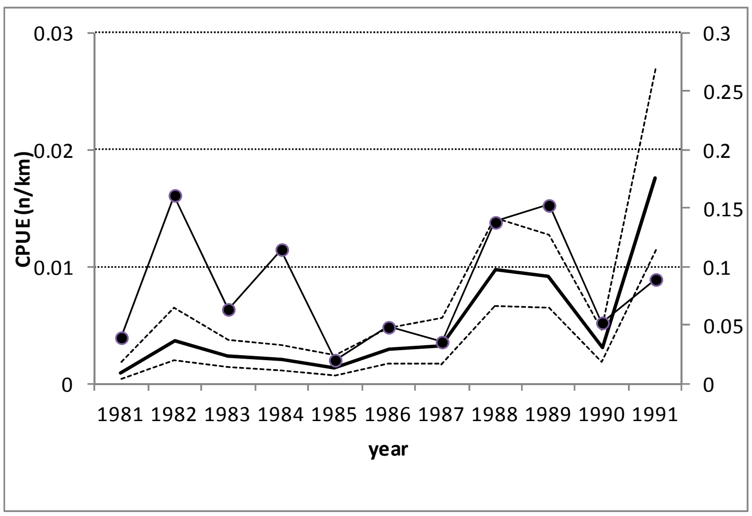


Fig. 12. Annual trend of the standardized CPUE (n/ 100 m) and its confidence interval of blue shark caught by Japanese large mesh drift net fishery in the period of 1981 – 1991 in the area 2. The nominal CPUE (n/km) are also shown with the standardized CPUE by year with closed circle.

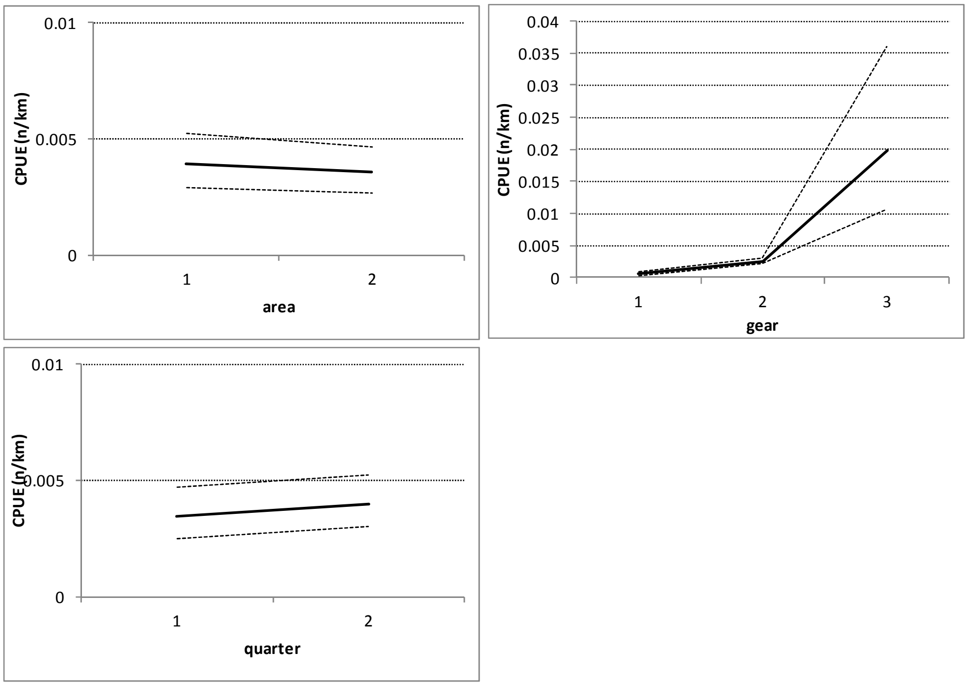


Fig. 13. Standardize CPUE (n/km) by area (left top), by gear (right top), and by quarter (left, bottom) in the CPUE analysis in the area 2.

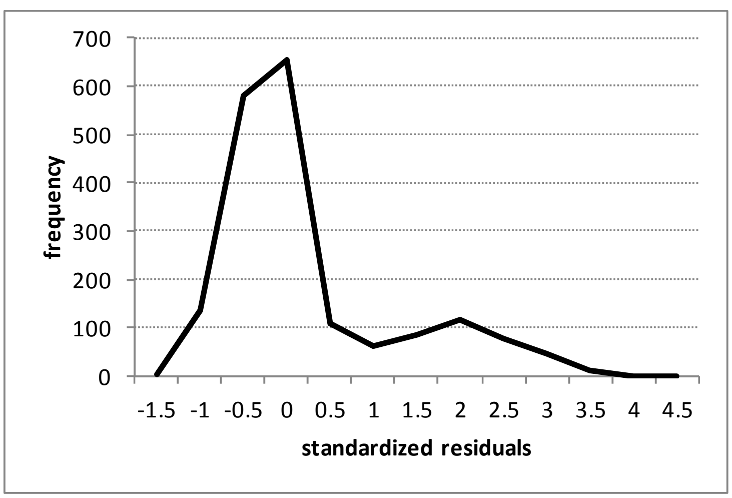


Fig. 14. Pattern of the standardized residuals and the output of ANNOVA table of the CPUE analysis in the area 2.

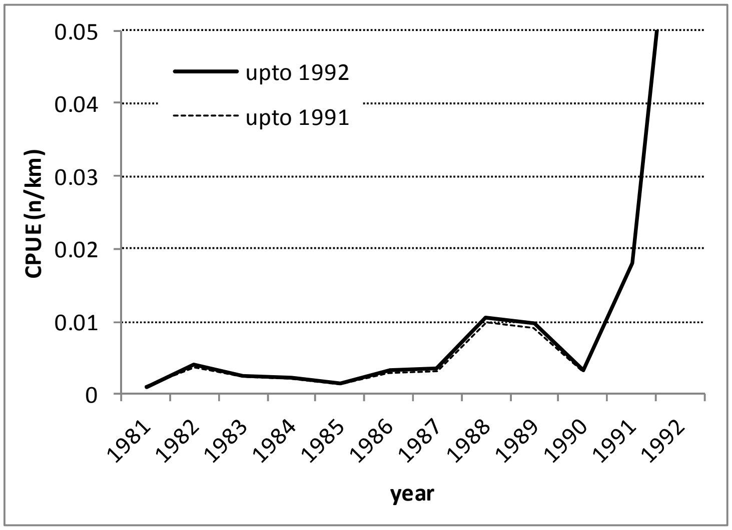


Fig. 15. Comparison of the annual trend of CPUE in the area 2 standardized using data of 1981 – 1991 and 1981 – 1992.