STANDARDIZATION OF CPUE FOR SWORDFISH AND BILLFISHES CAUGHT BY JAPANESE LONGLINE FISHERY IN THE INDIAN OCEAN

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INTRODUCTION

The CPUEs of longline are one of the valuable sources of information on the historical changes in stock abundance for swordfish and billfishes vulnerable to longliners. However, there are many factors which seem to affect CPUE such as environmental (season, area, water temperature, salinity, depth, current, moon phase, and so on), biological (maturation, migration, food availability), and operational (gear configuration, soaking time, target species, regulation, kind of bait, hook size, and so on). In addition, these factors may have changed through the history of fishery. Therefore, standardization becomes essential for the purposes of monitoring the stock abundance using the CPUE. However, the data availability on such factors generally is very limited and it is possible to incorporate some of these factors into analyses in the present study.

The Japanese longline fishery has caught swordfish and billfishes (striped marlin, blue marlin, black marlin, sailfish, and spearfish), but these species are secondary target species or by-catch species, except for the early period of the fishery in the 1950s and 60s, when some of the Japanese longline fishery targeted billfishes (mainly striped and black marlins) in the Indian Ocean. Since the early 1970s, the Japanese longline fishery has targeted mainly bigeye, yellowfin, and southern bluefin in the Indian Ocean. So, there are large discrepancies in distribution between billfishes and fishing effort. Furthermore, it is likely that the some operational (gear configuration), and social (200 mile EEZ) factors introduce some biases in the CPUE trend, if these factors are not properly accounted in the standardization. This probability may be much higher in billfishes than tunas due to the distribution pattern of these species.

In the present analysis, CPUEs of swordfish and billfishes are standardized with fine scale statistics to eliminate some possible biases in the CPUE trend, which may be introduced by the factors mentioned above.

DATA AND METHODS

Catch and Effort Data

The catch and effort data for the present analysis were obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries for 1967-1997. The database is sample statistics composed of catch (number) and effort (number of hooks) from 1967 to 1997, aggregated by month, and also one-degree area. Since 1975, the item of the number of branch lines per basket, which approximates the gear configuration for regular and deep longlines, has added in this database.

The catch number of sailfish and spearfish had not been collected separately until 1994. There are only species combined catch data for sailfish and spearfish until 1994.

Standardization

Multiplicative model is used in the standardization with the assumption that error structure belongs to a log-normal distribution. Year, season, area, and gear configuration were incorporated as the main effects. The gear configuration is only used in the latter period from 1975-97.

Quarter-of-the-year was selected as season. Based on the distribution of efforts and CPUE of swordfish and billfishes, 13 subareas were selected as shown in Figure 1. The area used in the present study is very limited due to change of fishing ground (details is discussed in the latter section). Fishing operations within the 200 mile EEZ in Subareas 1-8, 11, and 13 were excluded in the present analysis to avoid any biases introduced by regulations and to keep consistency of the data. With regard to the gear configuration, 5 to 20 hooks between floats were observed in the most cases in the statistics used. This range was arbitrarily categorized to 6 levels (5, 6, 7-8, 9-10, 11-13, and 14-20 hooks between floats). Observations (1x1 block in a month with a gear class) with less than 6,000 hooks were excluded from the analysis.

The fitting for the CPUE and catch models with log-normal distribution was done using GLM procedure of SAS/STAT statistical package (Ver. 6.11).

The multiplicative CPUE model with log-normal distribution is :

$$\log(CPUE_{ijkl}+\text{Constant})=\mu+YR_i+QT_j+Area_k+Bran_l+Interactions+e_{ijkl} \quad \text{.................} \quad (1)$$

where log : natural logarithm

$CPUE_{ijkl}$: nominal CPUE (catch in number per 1000 hooks, in year i, quarter j, subarea k, and effect of gear l), **μ** : overall mean, **YR_i** : effect of year i, **QT_j** : effect of quarter j, **$Area_k$** : effect of subarea k, **$Bran_l$** : effect of gear l, **Interactions** : two-way interactions for all main factors, **e_{ijkl}** : normal error term.

0.1*mean CPUE, which was recommended by the bluefin tuna species working group, was used for the constant in each period for each species (ICCAT, 1997).

In this analysis, it is assumed that there is a single stock in the Indian Ocean for each species, because there is no sufficient analysis which suggests the stock structure for each species.

Results and Discussions

Area stratification

Distribution of swordfish and billfishes

The fishing grounds of the Japanese longline fishery have changed in the long history mainly due to the change of target species and social factors such as 200 mile EEZ. The difference in CPUE between the area inside and outside 200 EEZ was analyzed by the GLM using the area shown in Fig. 2 during the period of 1967 to 1975 when the operations were carried out freely inside and outside 200 mile EEZ. Year, area, quarter, and EEZ (inside or outside) were incorporated as main effects. The effect of EEZ and interaction between EEZ and area are highly significant for all species (swordfish, striped marlin, blue marlin, black marlin, and sailfish+spearfish). The ratio of CPUE inside EEZ vs. outside EEZ was calculated for each area by species using least square means that were obtained by the GLM procedure (Table 1). Table 1 shows clearly that CPUEs of marlins are generally higher in the coastal waters than the offshore waters. This trend is clearer for black marlin and sailfish+spearfish than swordfish and blue marlin. The trend of striped marlin is intermediate one.

Figs 3 and 4 show mean annual CPUE distribution for swordfish and billfishes in the period of 1967 to 1975 when the fishing effort of the Japanese longline fishery was most widely distributed in the Indian Ocean. Fig. 4 also shows the CPUE distribution of sailfish and spearfish separately using the data after 1995 when the catch data began to be collected separately for these two species. These figures also visually supported the results of Table 1. Fig 4 shows the distribution of spearfish in the north Indian Ocean is very sparse and more oceanic, and CPUE is much lower than sailfish. This means that the CPUE ratio for areas A to E and I may reflect the distribution pattern of sailfish. Fig. 4 also shows the distribution of spearfish is mainly in the offshore waters compared with the distribution pattern of sailfish.

Distribution of fishing effort

Fig 5 shows the distribution of fishing effort in particular five years periods in late 60s, 70s, and middle 90s. In the early period (the top figure in Fig. 5), the fishing effort was distributed widely in the Indian Ocean, except for the central part in the southern Indian Ocean between 10 and 30 degree south, where a few fishing efforts were occurred. In the late 1970s and early, the fishing efforts were distributed mainly in the Southern Ocean which targeted southern bluefin tuna, and in the waters off Somalia which targeted bigeye tuna. In the latest period the distribution area became a little bit greater than the former period, but there was few fishing effort in the coastal water, especially in the northern Indian Ocean.

The fishing efforts of the Japanese longline fishery have continued to occur only in the thirteen areas shown in Fig. 1 throughout the period from 1967 to 1997. Furthermore, in the areas 1 through 8, there was little fishing effort in the coastal waters inside of 200 EEZ in the later period after 1977 where the CPUE of billfishes is significantly higher than offshore waters as shown in Table 1.

Based on the results of the observations mentioned above, the Subareas for the standardization of CPUE are selected as shown in Fig. 1. This area stratification shows that there are relatively small area in which the fishing efforts have continued to be occurred from 1967 to 1997. Furthermore, The comparison between the area shown in Fig. 1 and the distribution of billfishes in Figs. 3 and 4 shows clearly that the area used for standardization does not cover the area where the high CPUEs of the billfishes are observed, especially for striped marlin, black marlin, and sailfish.

Standardization of CPUE

Model used for the standardization

The standardization of CPUE was carried out for the two periods, 1967-75 and 1975-97, respectively, because there was no information on gear configuration in the earlier period. The model in each period includes all main effect and two-way interaction terms with no missing cell.

The model used in each period is as follows,

For the period of 1967 to 1975:

CPUE=μ+Year+Area+Quarter+Area*Quarter+Year*Area+e.

For the period of 1975 to 1997;

CPUE=μ+Year+Area+Quarter+Gear+Area*Quarter+Quarter*Gear+Year*Area+e.

The weighted mean of CPUE in each year by the size of subareas is used as expected CPUE in each year, because Year*Area interaction is significant in both periods for all species concerned. The results of ANOVA are shown in Appendix Tables. The models for all species in each period are highly significant. The distribution of residuals for each species in the later period (1975-97) is shown in Fig. 6. The shapes of residual distributions in the period of 1967-75 is very similar to those in the period of 1975-97. The shapes of distributions for all species are not close to the normal distribution, especially for blue and black marlins and sailfish+spearfish. The residual distributions of these species are not symmetric ones. These results show the fitting of the model is not so good and suggests that there may be other important factors, which affect on the CPUE of these species substantially.

Gear effect for each species

The introduction of deep longlining is effective for the species distributed in deeper water column, but ineffective for the species in shallower waters. The deep longlining was introduced in the Indian Ocean since the mid-1970s to target bigeye in the tropical waters. This introduction of deep longlining likely affect negatively on CPUEs of billfishes, which are distributed in the shallower water column.

Fig. 7 shows the effect of gear configuration on the CPUEs of billfishes. The least square mean of CPUE on gear effect which was obtained in GLM procedure is used for this Figure. The gear with 7 to 10 branch lines between two floats is most effective for stripe, blue and black marlins. Other shallower and deeper longlining are less effective for these species. CPUEs by the gear with 7 to 10 branch lines are about 20 to 45% higher than the other gears for these species. For sailfish and spearfish combined, the gear with 6 branch lines is most effective one, but deeper longline has lesser effective for these species. On the contrary, Fig. 7 shows the deeper longlining is more effective for swordfish. CPUE of swordfish by the gear with 14-20 branch lines is about 50% higher than it by the gear with 5-6 branch lines. These results are consistent with the other observations by bio-teremetory experiments.

Standardized CPUE of swordfish

Fig. 8 shows the standardized and nominal CPUEs of swordfish. Standardized CPUE was relatively in higher level before 1975. The CPUE decreased in the mid 1970s, and then became stable during the 1980s. The standardized CPUE decreased in the late 1980s, but increased to similar level of the mid 1980s in the late 1990s. Nominal CPUE shows the gradual increase trend since the late 1970s. It is suggested that this increase trend in nominal CPUE may caused by the introduction of deep longlining.

Standardized CPUE of striped marlin

Fig. 9 shows the standardized and nominal CPUEs of striped marlin. The standardized CPUE showed the substantial increase in the mid 1970s and decrease in the late 1970s. This phenomenon was observed in almost all areas observed, but the level of change was larger in north-east Indian Ocean than south-west Indian Ocean. After this change, the CPUE decreased gradually in the 1980s. In the 1990s the CPUE has become stable. The level of the present CPUE is about 50% of it in the previous period, except for the high peak period in the mid-1970s. Decrease trend of CUE is much larger in nominal one than the standardized one, especially in the later period. This may be caused by the change of gear configuration and fishing grounds.

Standardized CPUE of blue marlin

Fig. 10 shows the standardized and nominal CPUEs of blue marlin. The standardized CPUE was stable until the mid 1980s, and then decreased about 50% during the late 1980s. In the 1990s, the CPUE was stable again with some fluctuations. The relationship between nominal and standardized ones is very similar to it observed in striped marlin.

Standardized CPUE of black marlin

Fig. 11 shows the standardized and nominal CPUEs of black marlin. The standardized CPUE shows a clear decreasing trend in the late 1960 to early 1970s. Then it became stable until the mid 1980s, and started again to decrease gradually since then. The present level of CPUE is about 50% of the average for the early period from 1970 to 1989. The relationship between nominal and standardized ones is very similar to it observed in striped marlin.

Standardized CPUE of sailfish and spearfish combined

Fig. 12 shows the standardized and nominal CPUEs of sailfish and spearfish combined. The standardized CPUE continued to decrease from 1967 to the end of 1980s. In the latest several years a slight increasing trend was observed. The present level of CPUE is about 30% of the average for the period from 1967 to 1975. The relationship between nominal and standardized ones is very similar with striped marlin.

The species composition in this CPUE index is unknown before 1995, but in the recent several years the species-specific statistics have obtained. The recent distribution of CPUE shown in Fig. 4 suggests that the major trend of this CPUE index may reflect the abundance of sailfish, especially in the north Indian Ocean. But it is still unknown whether the decrease trend in the earlier period reflected the abundance of sailfish or not.

GENERAL DISCUSSION

Because the Japanese longline fishery does not target swordfish and billfishes in the Indian Ocean, except for the short period in the early stage, the distribution pattern of fishing effort is completely different from the billfish distributions, especially for striped marlin, black marlin, and sailfish. This fishery does not cover the main distribution area (high abundance area), especially in the later period. This situation may make it to be very difficult to monitor the abundance of these stocks by the CPUE through this fishery as suggested in the results of the standardization such as distribution of residuals.

The present results also shows that the horizontal and vertical distribution of fishing effort (area stratification and gear configuration) is important for the standardization of CPUE using the statistics of the Japanese longline fishery. Especially the effect of coastal water inside 200 mile EEZ can not be assessed by the larger scale statistics such as 5x5 degree basis. The present analysis showed that both of these factors affect negatively CPUE of billfishes, namely the decrease trend of CPUE was overestimated, if these factors were not be taken care.

The GLM analysis showed that the Year*Area interaction is significant for all species concerned. This mean the annual trend of CPUE is different among the areas. This result suggests that there may be some possibilities that the species has more than one stock in the Indian Ocean. This possibility has already pointed out in the previous works for sailfish, striped marlin, and black marlin (FAO, 1980).

The percentage of the Japanese catch in the total Indian Ocean for billfishes clearly decreased since 1981 and less than 20 % in the recent years (Table 2). This means that catch mainly occurred in the different waters from the main fishing ground of the Japanese longline fishery historically exploited. It is probable that the statistics of the Japanese catch may not reflect the total exploitation of the billfish stocks appropriately, especially for sailfish which is mainly distributed in the coastal waters. In the recent years the billfish catches increased significantly, and this increase may occurred in the coastal waters which is the main distribution area of the billfishes, except for swordfish and blue marlin. The CPUE of Japanese longline fishery can monitor the abundance in the peripheral distribution area of the billfishes and more refinement of CPUE analysis is required. In the same time, the development of abundance indices for billfishes based on the coastal fisheries is highly desirable.

LITERATURE CITED

ICCAT 1997: Report of the bluefin tuna methodology session. ICCAT Coll. Vol. Pap. Vol XLVI(1), 187-212.

FAO 1980: State of selected stocks of tuna and billfish in the Pacific and Indian Ocean. FAO Fish. Tech. Pap. No.200, 88pp.

Table 1. CPUE ratio between coastal and off-shore waters in each area shown in Fig. 2. Coastal waters is defined as the water inside 200 mile zone and off-shore waters is defines as out side of the coastal waters in a area. The ratio was calculated by the least square means obtained by GLM procedure for each species. Shaded cell shows the ratio is larger than one which means that CPUE in coastal water is higher than off-shore water.

	Striped marlin	Swordfish	Blue marlin	Black marlin	Salifish&Spearfish
Average	1.31	1.16	1.15	1.67	1.49
A	0.83	1.14	1.02	2.13	1.65
B	1.39	0.90	0.64	1.74	1.13
C	0.94	0.83	0.56	1.01	1.03
D	1.00	1.34	1.36	2.29	1.37
E	0.81	1.00	0.52	1.07	1.27
F	3.31	0.85	5.13	1.85	6.14
G	2.65	1.82	5.95	5.82	1.17
H	6.08	1.19	3.28	10.12	1.54

Table 2. Percentages of the Japanese catch in the total catch of the Indian Ocean.

	Swordfish	Striped marlin	Blue marlin	Black marlin	Sailfish and Spearfish
1981	53.8	29.3	50.4	40.8	26.2
1982	47.5	30.8	52.2	42.9	24.9
1983	45.4	24.2	41.7	46.9	24.3
1984	56.8	37.1	50.7	39.9	24.7
1985	62.1	19.7	38.3	42.7	6.6
1986	35.6	21.6	21.2	30.4	9.3
1987	32.7	18.2	23.5	20.0	4.6
1988	25.6	11.2	9.9	11.4	1.3
1989	21.3	6.9	7.6	7.4	1.0
1990	20.1	9.0	5.4	4.6	0.6
1991	17.2	8.9	4.6	3.1	0.2
1992	18.1	9.2	3.9	3.9	0.4
1993	13.8	2.8	2.0	4.4	0.1
1994	25.7	8.2	13.8	6.5	0.3
1995	7.7	7.6	16.3	17.8	0.8

APPENDIX TABLE.

Results of ANOVA for standardization of CPUE.YR: year, QT: quarter, AR: subarea, Bran: number of branch lines between floats.

Swordfish 1967-75

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	155	30619.645	197.546	78.68	0.0001
Error	21940	55087.208	2.511		
Corrected Total	22095	85706.853			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	8	142.684	17.836	7.1	0.0001
QT	3	325.709	108.570	43.24	0.0001
AR	12	14055.151	1171.263	466.49	0.0001
YR*AR	96	1679.990	17.500	6.97	0.0001
QT*AR	36	911.773	25.327	10.09	0.0001

Swordfish 1975-97

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	318	129095.576	405.961	155.73	0.0001
Error	74269	193608.444	2.607		
Corrected Total	74587	322704.020			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	19	793.532	41.765	16.02	0.0001
QT	3	165.801	55.267	21.2	0.0001
AR	12	21316.735	1776.395	681.43	0.0001
BRAN	5	455.465	91.093	34.94	0.0001
YR*AR	228	7371.963	32.333	12.4	0.0001
QT*AR	36	2920.942	81.137	31.12	0.0001
QT*BRAN	15	318.335	21.222	8.14	0.0001

Striped marlin 1967-75

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	155	57642.725	371.889	205.47	0.0001
Error	21940	39710.249	1.810		
Corrected Total	22095	97352.974			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	8	321.993	40.249	22.24	0.0001
QT	3	513.270	171.090	94.53	0.0001
AR	12	22038.232	1836.519	1014.68	0.0001
YR*AR	96	2003.193	20.867	11.53	0.0001
QT*AR	36	8107.841	225.218	124.43	0.0001

Striped marlin 1975-97

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	318	143722.499	451.958	290.15	0.0001
Error	74269	115686.447	1.558		
Corrected Total	74587	259408.946			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	19	3584.378	188.651	121.11	0.0001
QT	3	364.083	121.361	77.91	0.0001
AR	12	23529.708	1960.809	1258.81	0.0001
BRAN	5	156.255	31.251	20.06	0.0001
YR*AR	228	11870.316	52.063	33.42	0.0001
QT*AR	36	10123.122	281.198	180.52	0.0001
QT*BRAN	15	291.109	19.407	12.46	0.0001

Blue marlin 1967-75

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	155	57151.971	368.722	239.11	0.0001
Error	21940	33833.461	1.542		
Corrected Total	22095	90985.432			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	8	190.500	23.813	15.44	0.0001
QT	3	559.656	186.552	120.97	0.0001
AR	12	29314.005	2442.834	1584.11	0.0001
YR*AR	96	1404.606	14.631	9.49	0.0001
QT*AR	36	1470.834	40.856	26.49	0.0001

Blue marlin 1975-97

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	318	148516.566	467.033	302.51	0.0001
Error	74269	114661.748	1.544		
Corrected Total	74587	263178.314			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	19	1168.427	61.496	39.83	0.0001
QT	3	605.994	201.998	130.84	0.0001
AR	12	30625.606	2552.134	1653.07	0.0001
BRAN	5	43.276	8.655	5.61	0.0001
YR*AR	228	4918.670	21.573	13.97	0.0001
QT*AR	36	3668.522	101.903	66.01	0.0001
QT*BRAN	15	277.688	18.513	11.99	0.0001

Black marlin 1967-75

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	155	43883.313	283.118	170.37	0.0001
Error	21940	36458.486	1.662		
Corrected Total	22095	80341.798			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	8	606.412	75.802	45.62	0.0001
QT	3	273.860	91.287	54.93	0.0001
AR	12	20552.956	1712.746	1030.7	0.0001
YR*AR	96	1865.451	19.432	11.69	0.0001
QT*AR	36	1952.387	54.233	32.64	0.0001

Black marlin 1975-97

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	318	50154.913	157.720	142.97	0.0001
Error	74269	81928.513	1.103		
Corrected Total	74587	132083.426			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	19	984.769	51.830	46.98	0.0001
QT	3	73.289	24.430	22.15	0.0001
AR	12	6875.962	572.997	519.43	0.0001
BRAN	5	75.743	15.149	13.73	0.0001
YR*AR	228	3013.874	13.219	11.98	0.0001
QT*AR	36	3356.889	93.247	84.53	0.0001
QT*BRAN	15	386.597	25.773	23.36	0.0001

Sailfish+Spearfish 1967-75

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	155	48225.748	311.134	160.87	0.0001
Error	21940	42434.385	1.934		
Corrected Total	22095	90660.133			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	8	632.886	79.111	40.9	0.0001
QT	3	600.717	200.239	103.53	0.0001
AR	12	24078.093	2006.508	1037.43	0.0001
YR*AR	96	2346.867	24.447	12.64	0.0001
QT*AR	36	1026.048	28.501	14.74	0.0001

Sailfish+Spearfiash 1975-97

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	318	21068.423	66.253	64.46	0.0001
Error	74269	76336.911	1.028		
Corrected Total	74587	97405.335			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	19	674.627	35.507	34.54	0.0001
QT	3	100.408	33.469	32.56	0.0001
AR	12	4785.460	398.788	387.99	0.0001
BRAN	5	28.835	5.767	5.61	0.0001
YR*AR	228	4199.893	18.421	17.92	0.0001
QT*AR	36	730.330	20.287	19.74	0.0001
QT*BRAN	15	103.137	6.876	6.69	0.0001

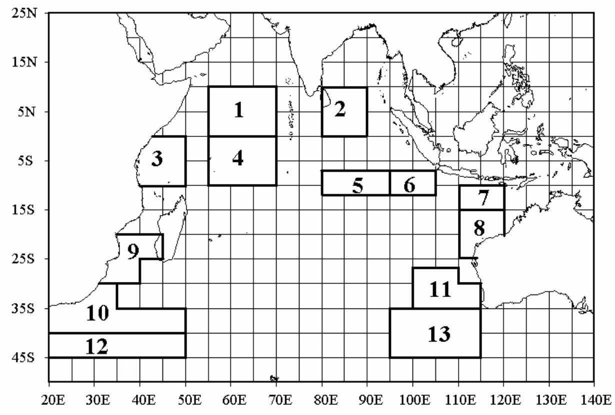


Fig. 1. Area stratification used for the standardization of CPUE for swordfish and billfishes.

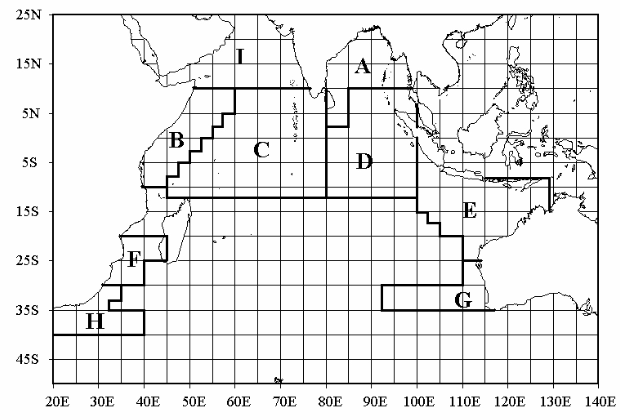


Fig. 2 Area stratification used for the observation of CPUE of swordfish and billfishes between coastal and off-shore waters (inside and outside of 200 mile EEZ) in the Indian Ocean.

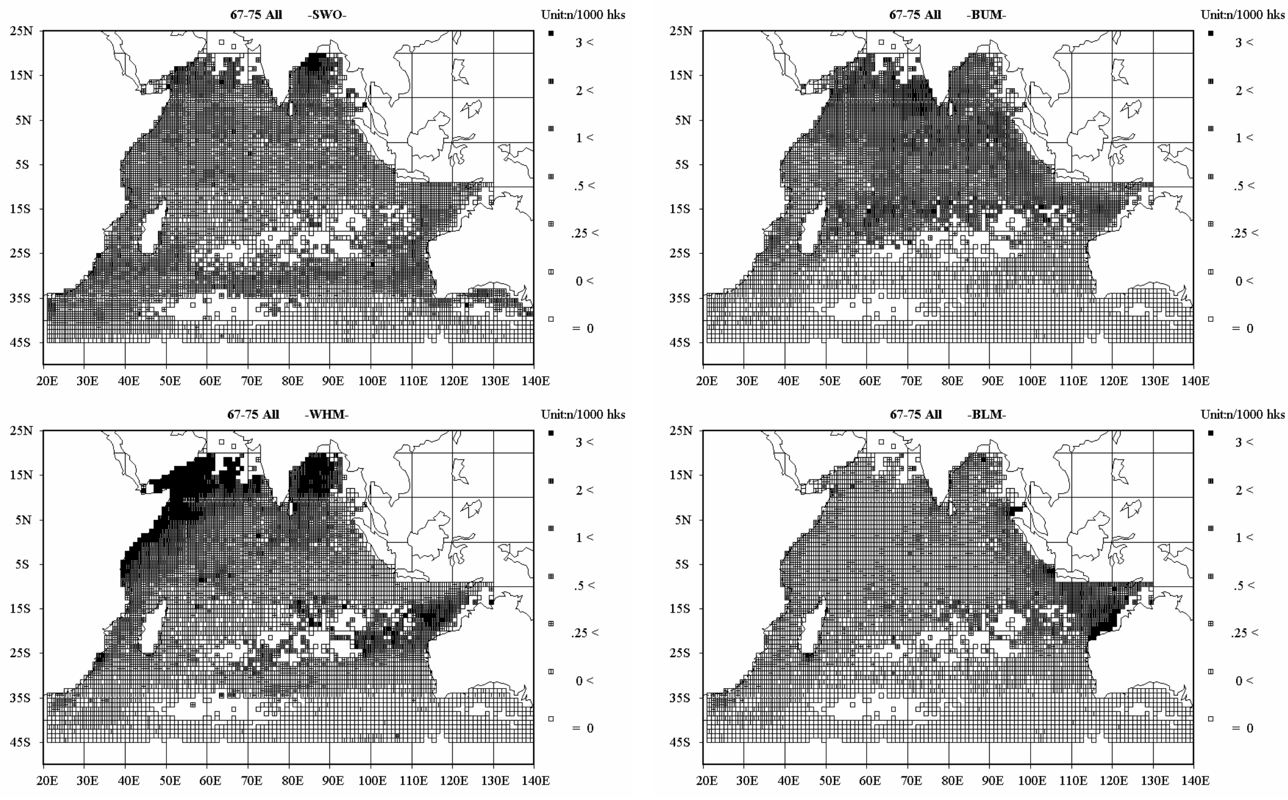
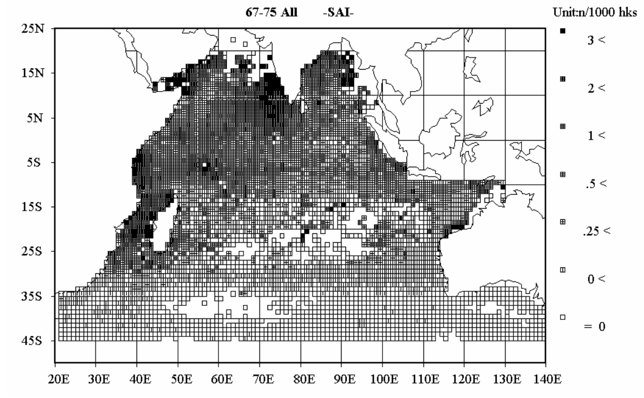
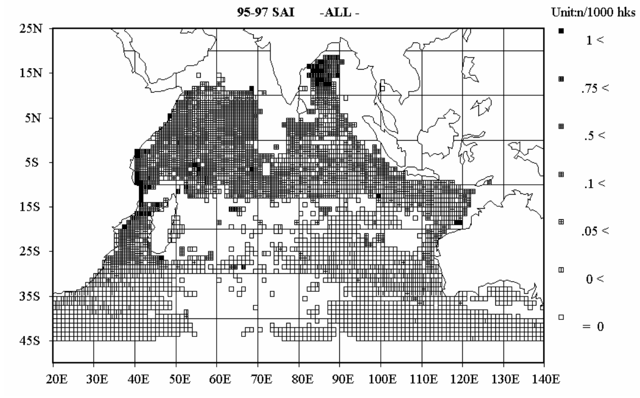


Fig. 3. Mean CPUE distribution of swordfish (left top), striped marlin (left bottom), blue marlin (right top), and black marlin (right bottom) caught by the Japanese longline fishery in the Indian Ocean during 1967 to1975.





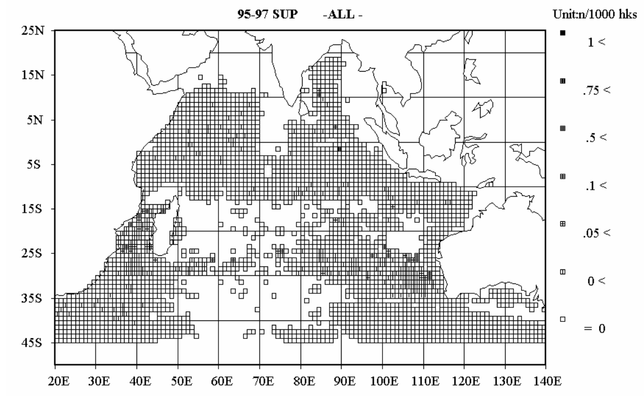
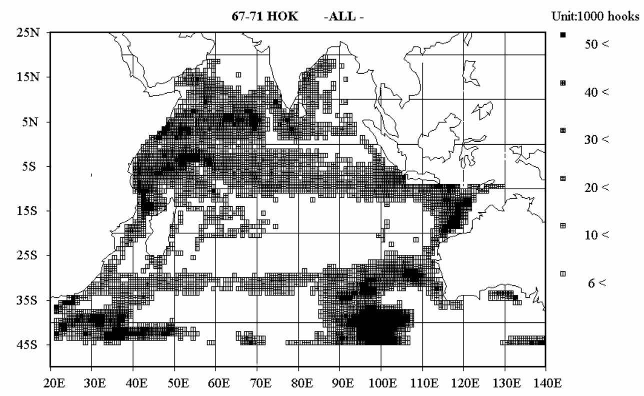
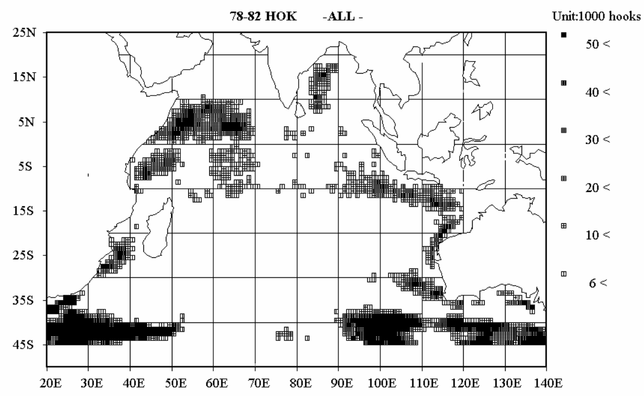


Fig. 4. Mean CPUE distribution of sailfish and spearfish. Top figure shows the species combined CPUEs for the two species during 1967 to 1975. Bottom left and right figures show the CPUE distributions of sailfish and spearfish during 1995 to 1997, respectively.





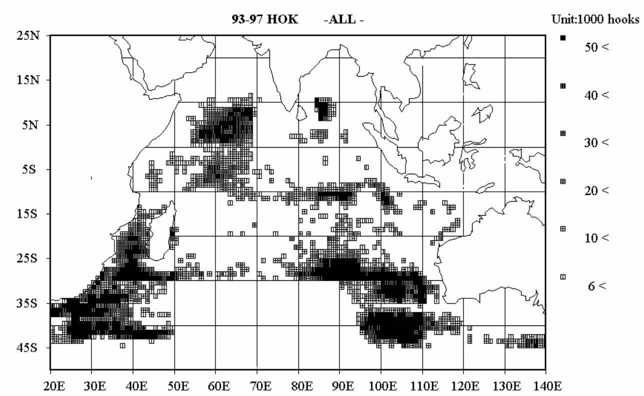


Fig. 5. Mean annual distribution of fishing effort (number of hooks) in a particular five years period. Top figure shows the distribution in 1967 to 71, middle one in 1978 to 1982 and bottom one shows one in 1993 to 1997.

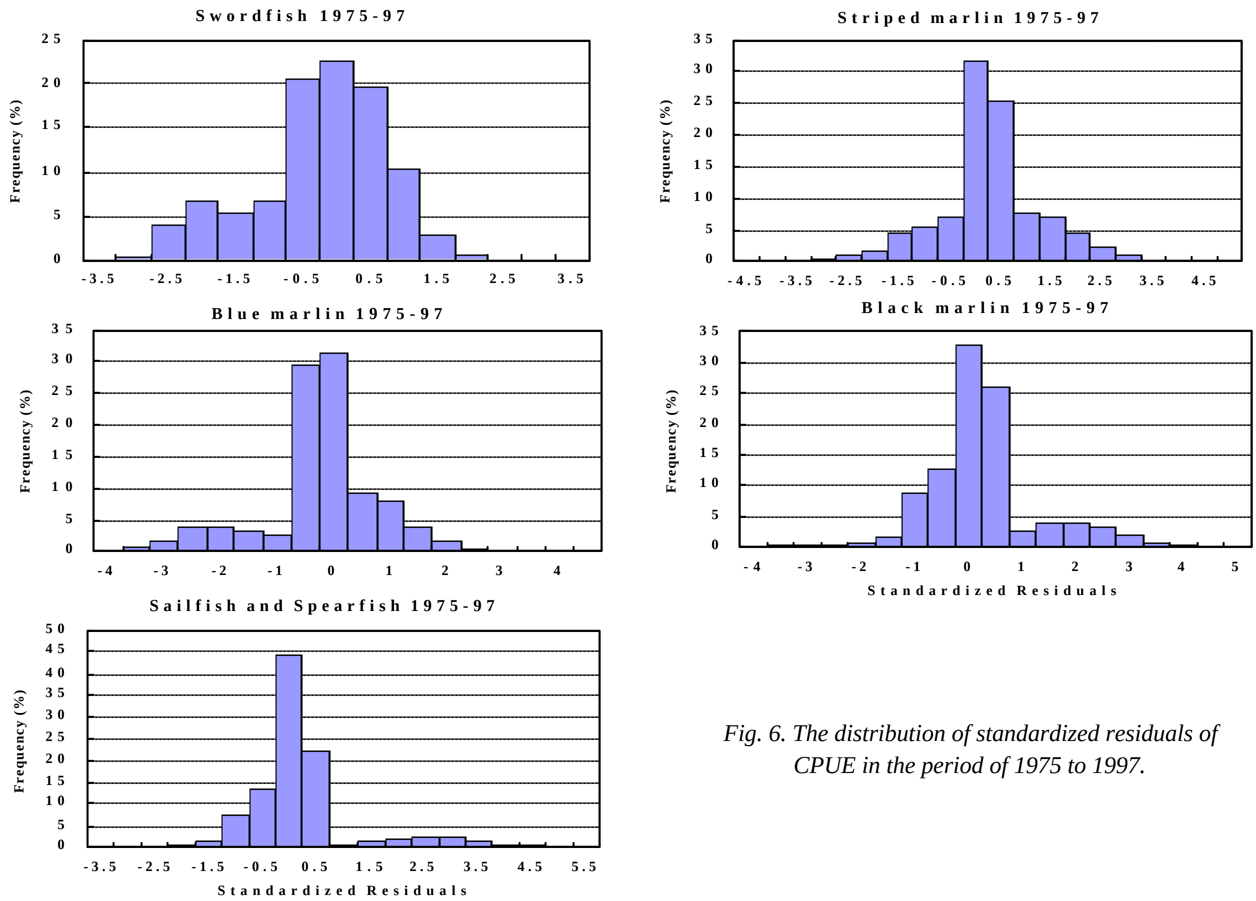


Fig. 6. The distribution of standardized residuals of CPUE in the period of 1975 to 1997.

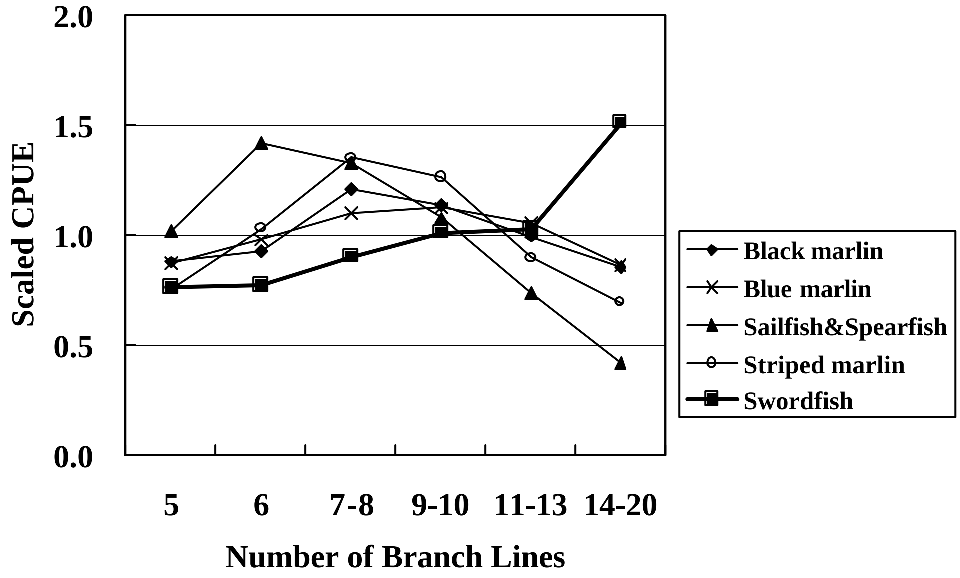


Fig. 7. Relationship between CPUE and gear configuration for swordfish and billfishes.

CPUE of each species is scaled to the mean CPUE.

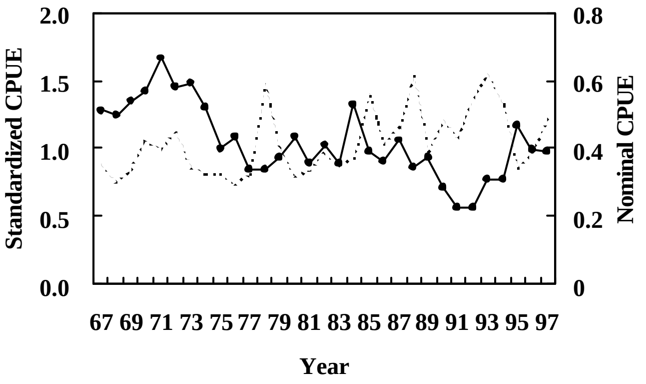


Fig. 8. Standardized CPUE of swordfish by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

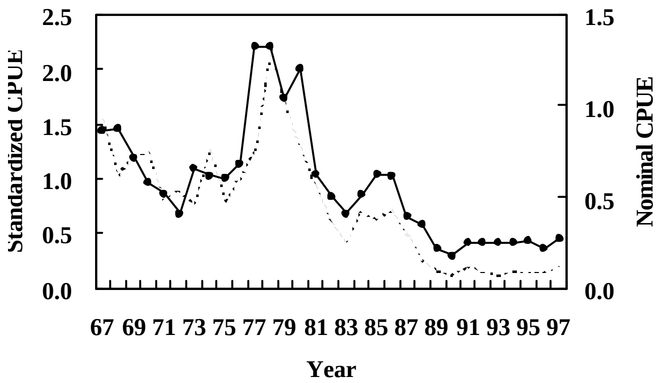


Fig. 9. Standardized CPUE of striped marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

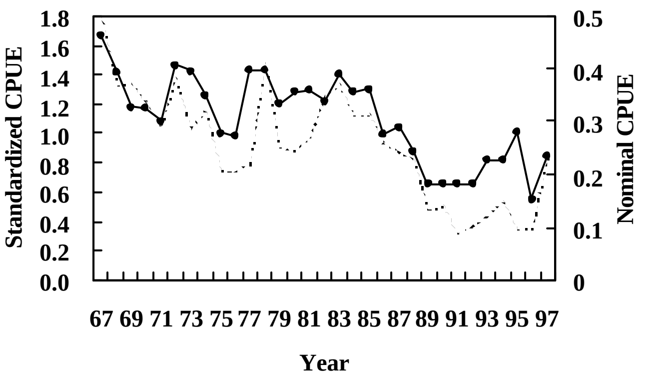


Fig. 10. Standardized CPUE of blue marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

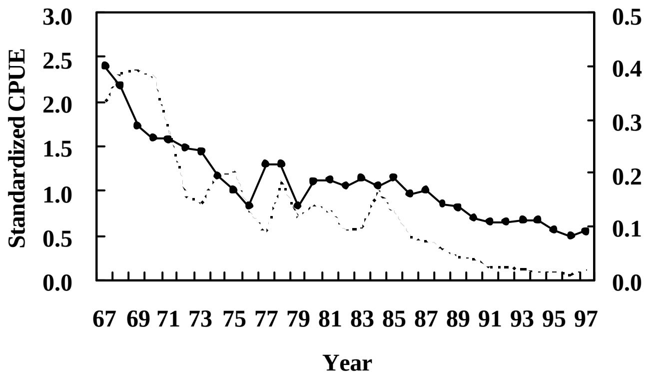


Fig. 11. Standardized CPUE of black marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

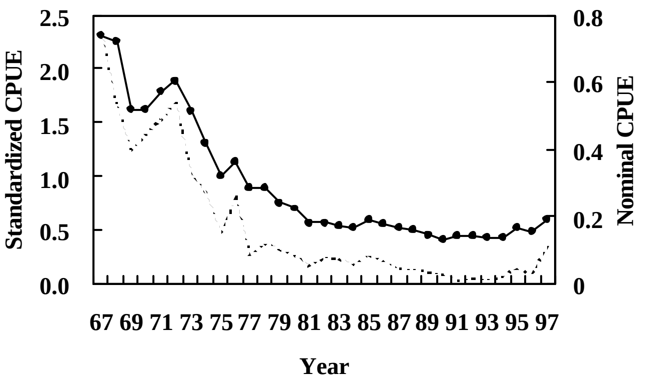


Fig. 12. Standardized CPUE of sailfish and spearfish combined by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.