STANDARDIZATION OF CATCH PER UNIT OF EFFORT FOR SWORDFISH AND BILLFISHES CAUGHT BY THE JAPANESE LONGLINE FISHERY IN THE INDIAN OCEAN

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Introduction

The catches per unit of effort (CPUEs) of the longline fishery are a valuable source of information on historical changes in stock abundance for swordfish and billfishes exploited by longliners. However, there are many factors which seem to affect CPUE, environmental (season, area, water temperature, salinity, depth, current, moon phase, etc.), biological (maturation, migration, food availability), and operational (gear configuration, soak time, target species, regulation, kind of bait, hook size, etc.). 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 CPUE. However, the availability of data on such factors is generally very limited, but it was 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 bycatch 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. There are therefore large discrepancies in distribution between billfish catches and fishing effort. Furthermore, it is likely that the some operational (gear configuration) and political (EEZ) factors introduce some biases in the CPUE trend, if they are not properly accounted for in the standardization. This probability may be much higher for billfishes than for tunas due to the different distribution patterns 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 for 1967-1997 compiled at the National Research Institute of Far Seas Fisheries. The database contains sample statistics composed of catch (number of fish) and effort (number of hooks) from 1967 to 1997, aggregated by month and by one-degree area. Also, since 1975 the number of branch lines per basket, which approximates the gear configuration for regular and deep longlines, has been included in this database.

The catches of sailfish and spearfish were not separated by species until 1994, so there are only combined catch data for these two species for the period prior to 1995.

Standardization

A multiplicative model was used in the standardization, with the assumption that the error structure has a log-normal distribution. Year, season, area, and gear configuration were incorporated as the main effects. The gear configuration is only used in the period from 1975-97. Year quarters were selected as season. Based on the distribution of effort and CPUE of swordfish and billfishes, 13 sub-areas were selected, as shown in Figure 1. The area used in the present study is very limited due to change of fishing ground (see Discussion). Fishing operations within the EEZs in sub-areas 1-8, 11, and 13 were excluded from the present analysis to avoid any biases introduced by regulations and to keep the data consistent. With regard to the gear configuration, 5 to 20 hooks between floats were observed in most cases in the statistics used. This range was arbitrarily categorized into 6 levels (5, 6, 7-8, 9-10, 11-13, and 14-20 hooks between floats). Any 1x1 degree block-month-gear class stratum with less than 6,000 hooks was excluded from the analysis.

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

The multiplicative CPUE model with log-normal distribution is :

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

where log: natural logarithm; $CPUE_{ijkl}$: nominal CPUE (catch in number per 1,000 hooks, in year i, quarter j, sub-area 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 sub-area k; $Bran_l$: effect of gear l; $Interactions$: two-way interactions for all main factors; e_{ijkl}: normal error term.

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

In this analysis, it is assumed that there is a single stock of each species in the Indian Ocean, because there is no adequate analysis of 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 their long history, mainly due to the change of

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target species and to political factors such as EEZs. The differences in CPUE inside and outside the EEZ were analysed with the GLM, using the area shown in Figure 2 during the 1967-1975 period, when there were no restrictions on operations related to EEZs. 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 *versus* outside EEZ was calculated for each area by species, using least-square means obtained from the GLM procedure (Table 1). Table 1 shows clearly that CPUEs of marlins are generally higher in coastal waters than offshore waters. This trend is clearer for black marlin and sailfish+spearfish than for swordfish and blue marlin. The trend for striped marlin is intermediate.

Figures 3 and 4 show mean annual CPUE distribution for swordfish and billfishes in the 1967-1975 period, when the effort of the Japanese longline fishery was most widely distributed in the Indian Ocean. Figure 4 also shows the CPUE distribution of sailfish and spearfish separately, based on data after 1995. These figures also visually support the results of Table 1. Figure 4 shows that the distribution of spearfish in the northern Indian Ocean is very sparse and more oceanic, and the CPUE is much lower than for sailfish. This means that the CPUE ratio of the two species combined for Areas A-E and I may reflect the distribution pattern of sailfish rather than of spearfish.

Distribution of fishing effort

Figure 5 shows the distribution of fishing effort, in five-year periods in the late 1960s, 1970s, and mid-1990s. In the early period (Figure 5, top panel) the fishing effort was distributed widely in the Indian Ocean, except for the central southern Indian Ocean between 10º and 30ºS, where there was little effort. In the late 1970s and early 1980s, fishing effort was distributed mainly in the southern ocean, targeting southern bluefin tuna, and off Somalia, targeting bigeye tuna. In the later period the area of distribution became a little larger than in the early period, but there was little fishing effort in coastal waters, especially in the northern Indian Ocean.

Fishing effort of the Japanese longline fishery occurred only in the thirteen areas shown in Figure 1 throughout the period from 1967 to 1997. Furthermore, in Areas 1-8 there was little fishing effort after 1977 in coastal waters inside EEZs, where the CPUE of billfishes is significantly higher than in offshore waters (Table 1).

The sub-areas for the standardization of CPUE were selected based on the results of the observations above (Figure 1). This area stratification shows that there is a relatively small area in which fishing effort has occurred continuously from 1967 to 1997. Furthermore, a comparison of the area shown in Figure 1 and the distribution of billfish catches in Figures 3 and 4 shows clearly that the area used for standardization does not cover the area where high CPUEs of billfishes are observed, especially striped marlin, black marlin and sailfish.

Standardization of CPUE

Model used for the standardization

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

The model used in each period is as follows,

1967-1975:

$$CPUE=\mu+Year+Area+Quarter+Area*Quarter+Year*Area+e.$$

1975-1997:

$$CPUE=\mu+Year+Area+Quarter+Gear+Area*Quarter+Quarter*Gear+Year*Area+e.$$

The mean of the CPUE in each year weighted by the size of the sub-areas was used as expected CPUE in each year, because the year*area interaction is significant in both periods for all species concerned. The results of the ANOVA are shown in Table 3. The results 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 Figure 6. The shapes of the distributions of residuals during the early period are very similar to those for the late period. The shapes of the residual distributions for all species are asymmetrical, not close to a normal distribution, especially for blue and black marlins and sailfish+spearfish. These results show that the fit of the model is not very good and suggest that there may be other important factors which affect the CPUE of these species substantially.

Gear effect by species

Deep longlining is effective for species distributed deeper in the water column, but ineffective for species in shallower waters. Deep longlining was introduced in the Indian Ocean in the mid-1970s to target bigeye in tropical waters. This introduction of deep longlining probably had a negative effect on the CPUEs of billfishes, which are distributed in shallower waters.

Figure 7 shows the effect of gear configuration on the CPUEs of billfishes. The least mean square of CPUE on gear effect obtained with the GLM procedure was used for this figure. A gear configuration with 7 to 10 branch lines between floats is most effective for striped, blue and black marlins. Both shallower and deeper longlines are less effective for these species with CPUEs about 20 to 45 % higher than those of other configurations. For sailfish and spearfish combined, gear with 6 branch lines is most effective and deeper longlines are less effective. On the other hand, Figure 7 shows that deeper longlines are more effective for swordfish. The CPUE of swordfish for gear with 14-20 branch lines between floats is about 50 % higher than that for 5-6 branch lines. These results are consistent with observations from bio-telemetry experiments.

Standardized CPUE of swordfish

Figure 8 shows the standardized and nominal CPUEs of swordfish. Standardized CPUE was relatively higher 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 in the late 1990s to a level similar to that of the mid-1980s. Nominal CPUE shows a gradually increasing trend since the late 1970s. It is suggested that this trend may be caused by the introduction of deep longlining.

Standardized CPUE of striped marlin

Figure 9 shows the standardized and nominal CPUEs of striped marlin. The standardized CPUE showed a substantial increase in the mid-1970s and a decrease in the late 1970s. This phenomenon was observed in almost all areas observed, but the level of change was greater in the north-eastern Indian Ocean than in the south-western Indian Ocean. The CPUE then decreased gradually in the 1980s and stabilised in the 1990s. The level of the present CPUE is about 50 % of that of the previous period, except for the high peak period in the mid-1970s. The decreasing trend is much greater for nominal CPUE than for standardized CPUE, especially in the later period. This may be caused by the changes of gear configuration and fishing grounds.

Standardized CPUE of blue marlin

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

Standardized CPUE of black marlin

Figure 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. It then became stable until the mid-1980s and has decreased gradually since then. The present level of CPUE is about 50 % of the average for the 1970-1989 period. The relationship between nominal and standardized CPUEs is very similar to that observed for striped marlin.

Standardized CPUE of sailfish and spearfish combined

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

The species composition in this CPUE index is unknown before 1995 but, since then, species-specific statistics have been obtained. The recent distribution of CPUE shown in Figure 4 suggests that the major trend of this CPUE index may reflect the abundance of sailfish, especially in the northern Indian Ocean, but it is still unknown whether the decreasing trend in the earlier period reflected the abundance of sailfish.

Discussion

Because the Japanese longline fishery did not target swordfish and billfishes in the Indian Ocean, except for a short period in its 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 (area of high abundance), especially in the later period. This situation may make it very difficult to monitor the abundance of these stocks using the CPUE of this fishery, as suggested by the results of the standardization such as distribution of residuals.

The present results 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. In particular, the effect of coastal waters inside the EEZ cannot be assessed by statistics aggregated in large areas such as by 5º x 5º. The present analysis shows that both of these factors affect the CPUE of billfishes negatively: the decreasing trend of CPUE would be overestimated if these factors were not considered.

The GLM analysis shows that the year*area interaction is significant for all species concerned. This means that the annual trend of CPUE is different among areas. This result suggests that there may be some possibility that the species concerned have more than one stock in the Indian Ocean. This possibility has already been pointed out in previous work on sailfish, striped and black marlin (FAO, 1980).

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

References

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. Ratios of CPUE in coastal waters to CPUE in offshore waters in each area shown in Figure 2.

	Striped marlin	Swordfish	Blue marlin	Black marlin	Sailfish + 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

Coastal waters are defined as the area inside a 200-mile EEZ and offshore waters as the areas outside such EEZs. The ratio was calculated by the least mean squares obtained by the GLM procedure for each species. Shaded cells indicate that the ratio is greater than 1, which means that the CPUE in coastal waters is higher than in offshore waters.

Table 2. Japanese catches as percentages of the total catch of the Indian Ocean

Year	Swordfish	Striped marlin	Blue marlin	Black marlin	Sailfish + 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: sub-area, Bran: number of branch lines between floats).

Swordfish 1967-75

Source	DF	um 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	um 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	um 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	um 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

Appendix Table continued.

Sailfish+Spearfish 1967-75

Source	DF	um 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	um 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

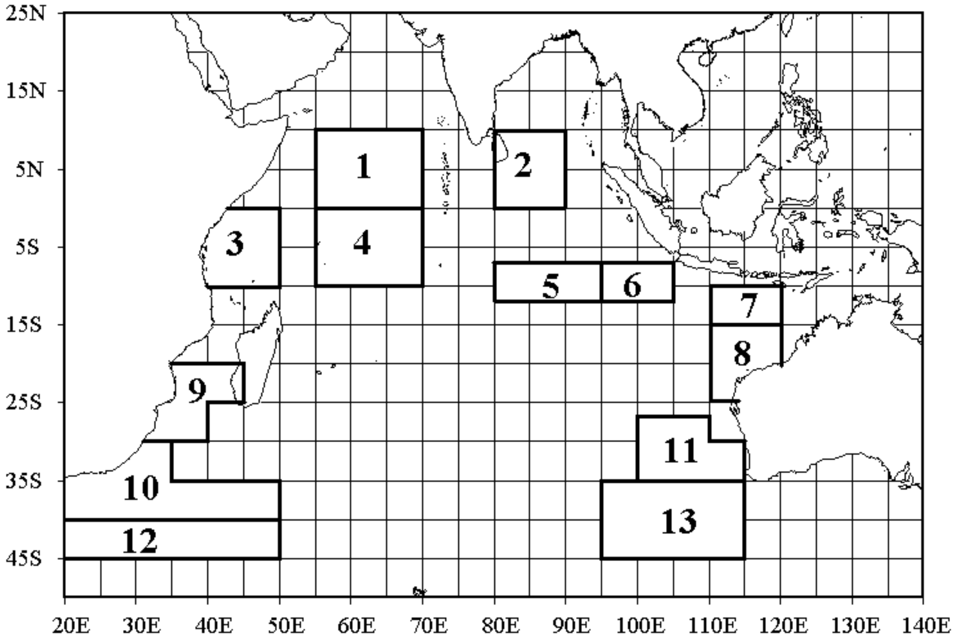


Figure 1. Area stratification used for the standardization of CPUE for swordfish and billfishes.

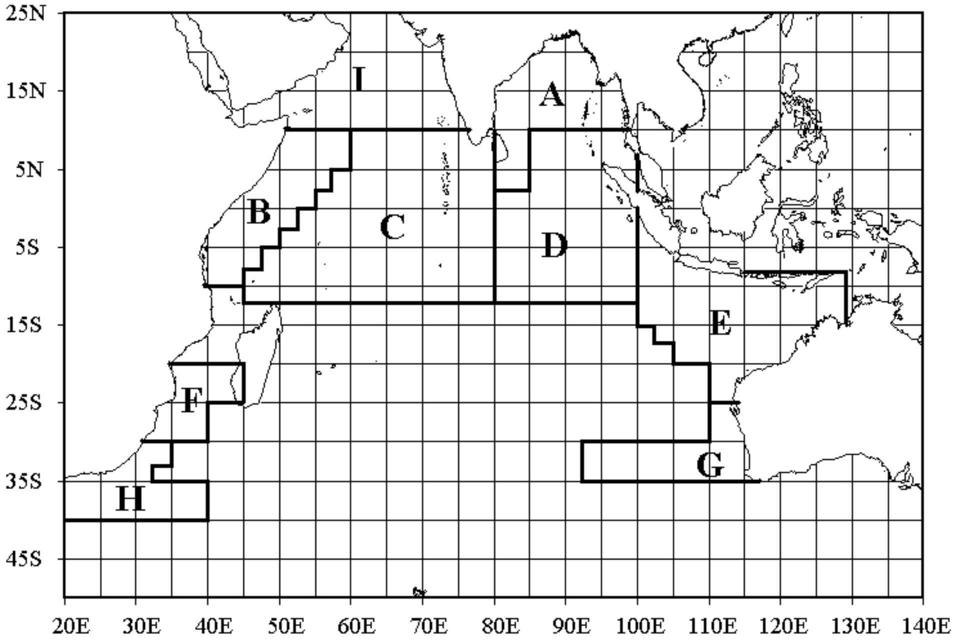
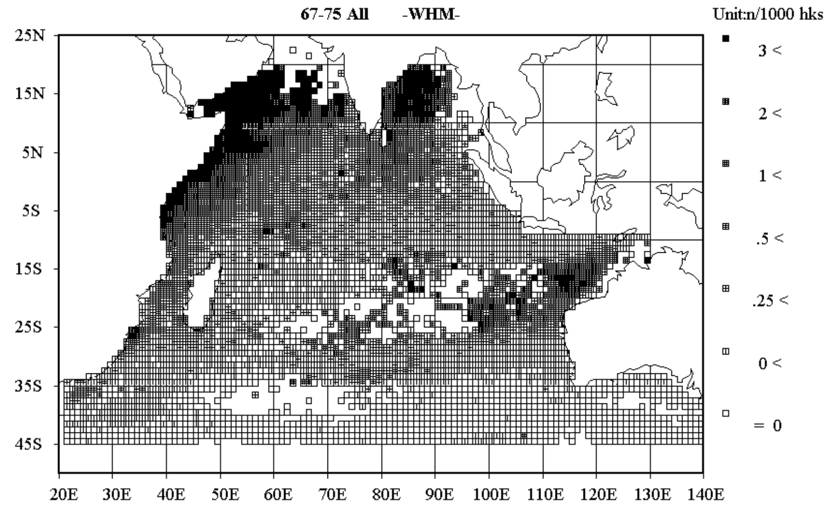


Figure 2 Area stratification used for the observation of CPUE of swordfish and billfishes between coastal and off-shore waters (inside and outside of 200 mile EEZ) in the Indian Ocean.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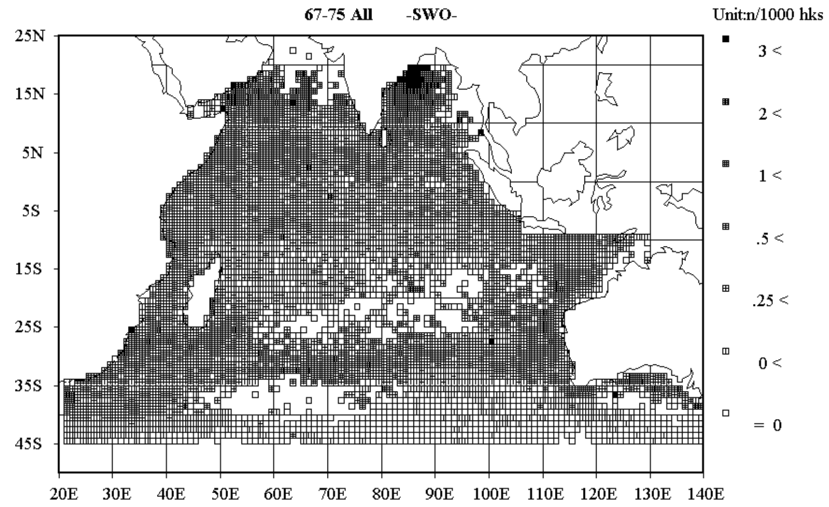
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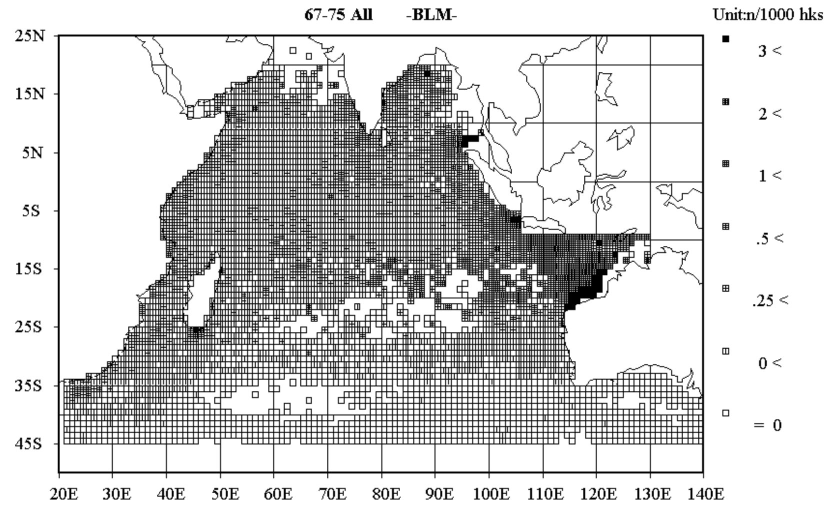
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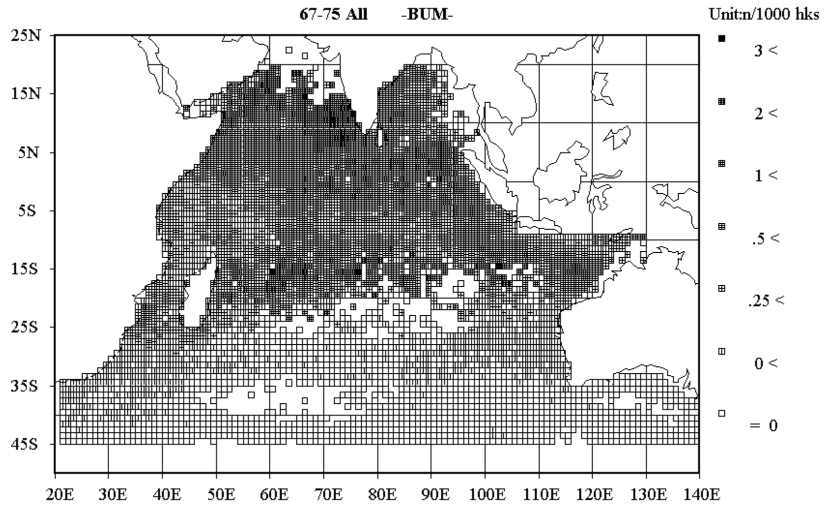
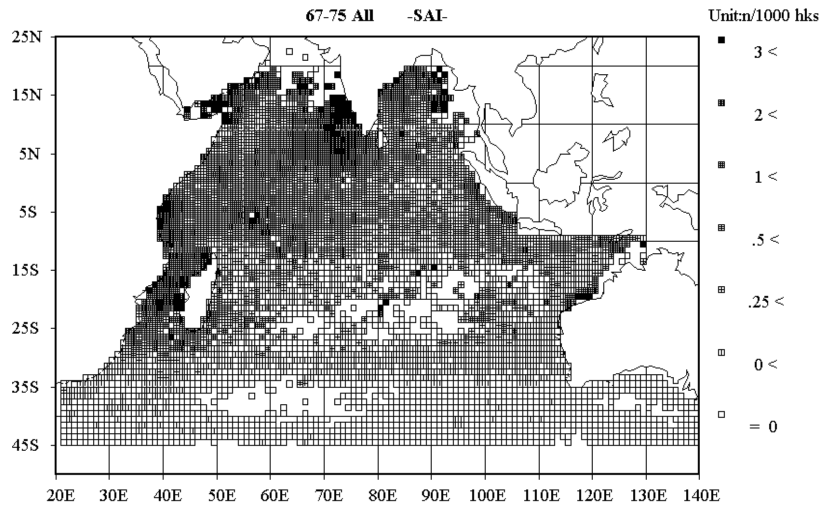
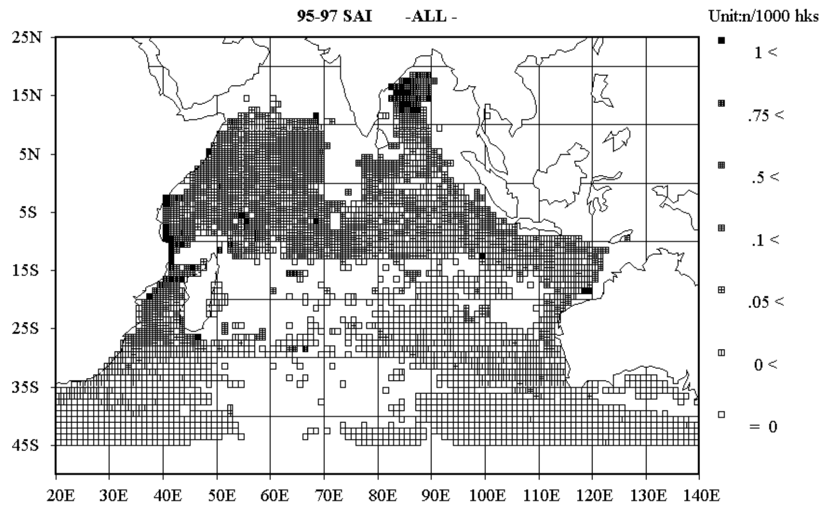


Figure 3. Mean CPUE distribution of swordfish (left top), striped marlin (left bottom), blue marlin (right top), and black marlin (right bottom) caught by the Japanese longline fishery in the Indian Ocean during 1967 to1975.





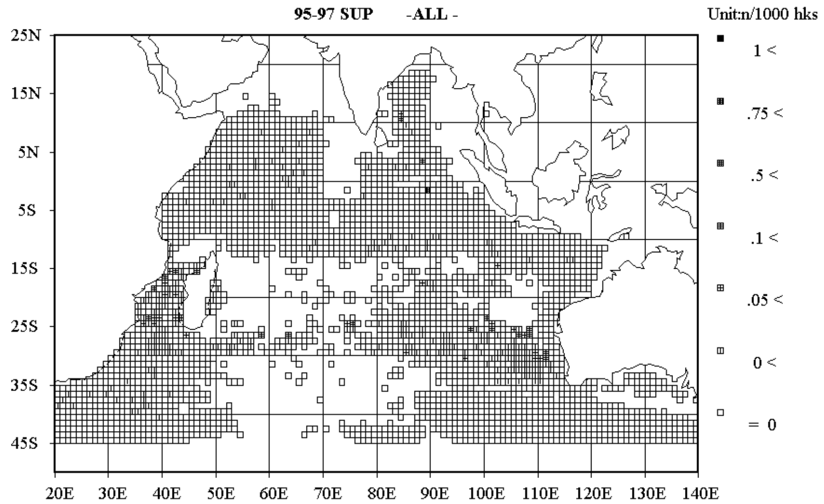
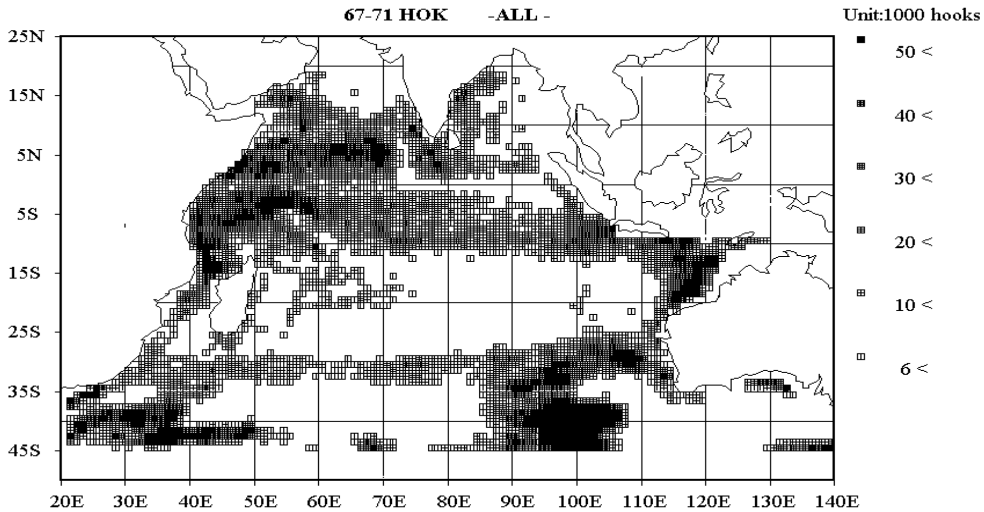
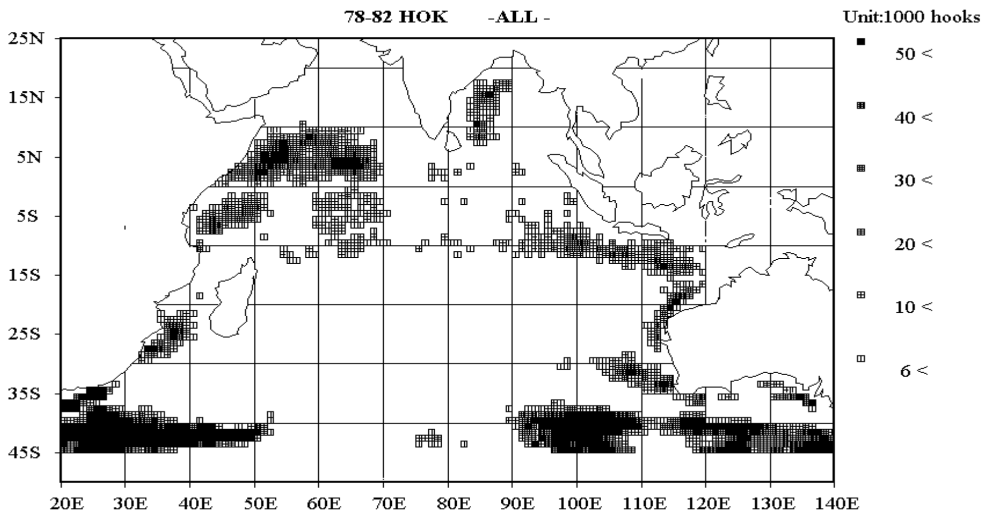


Figure 4. Mean CPUE distribution of sailfish and spearfish. Top figure shows the species combined CPUEs for the two species during 1967 to 1975. Bottom left and right figures show the CPUE distributions of sailfish and spearfish during 1995 to 1997, respectively.





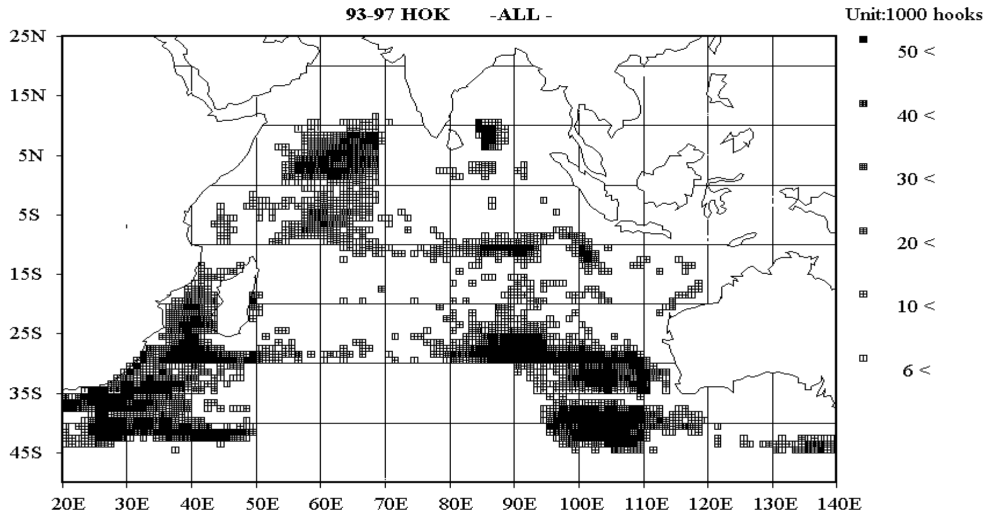


Figure 5. Mean annual distribution of fishing effort (number of hooks) in a particular five years period. Top figure shows the distribution in 1967 to 71, middle one in 1978 to 1982 and bottom one shows one in 1993 to 1997.

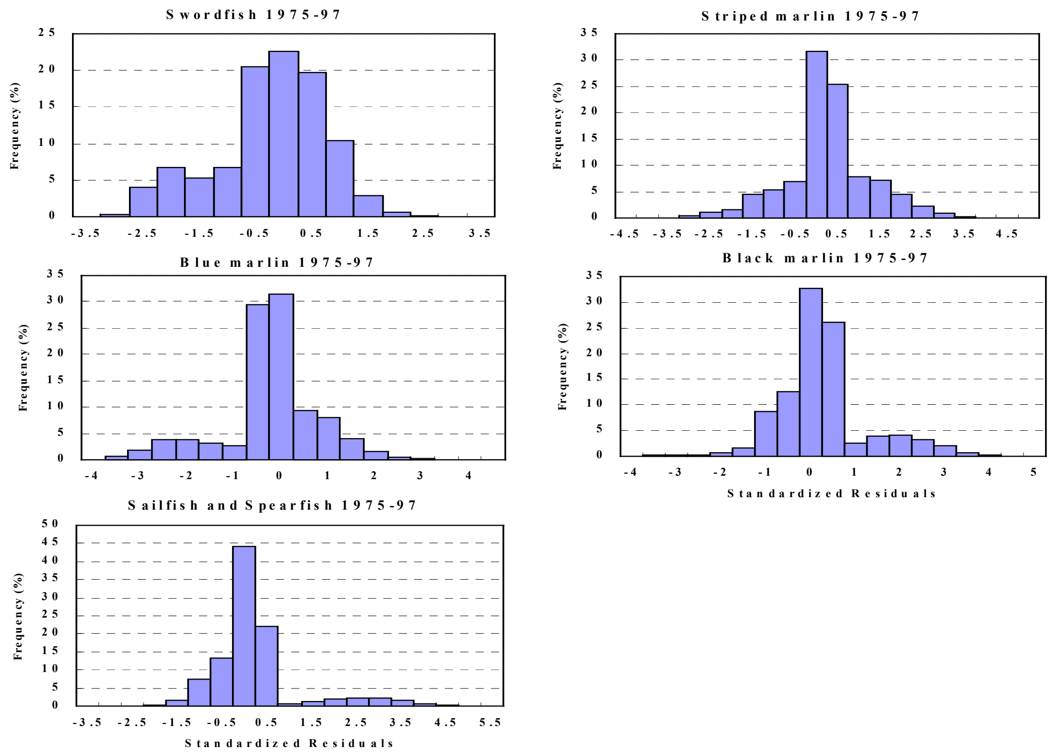


Figure 6. The distribution of standardized residuals of CPUE in the period of 1975 to 1997.

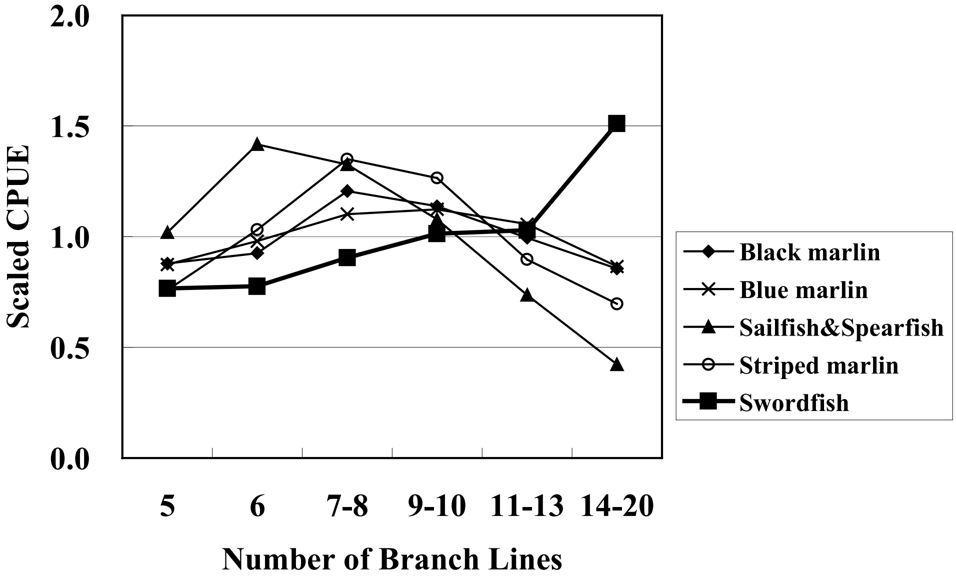


Figure 7. Relationship between CPUE and gear configuration for swordfish and billfishes. CPUE of each species is scaled to the mean CPUE.

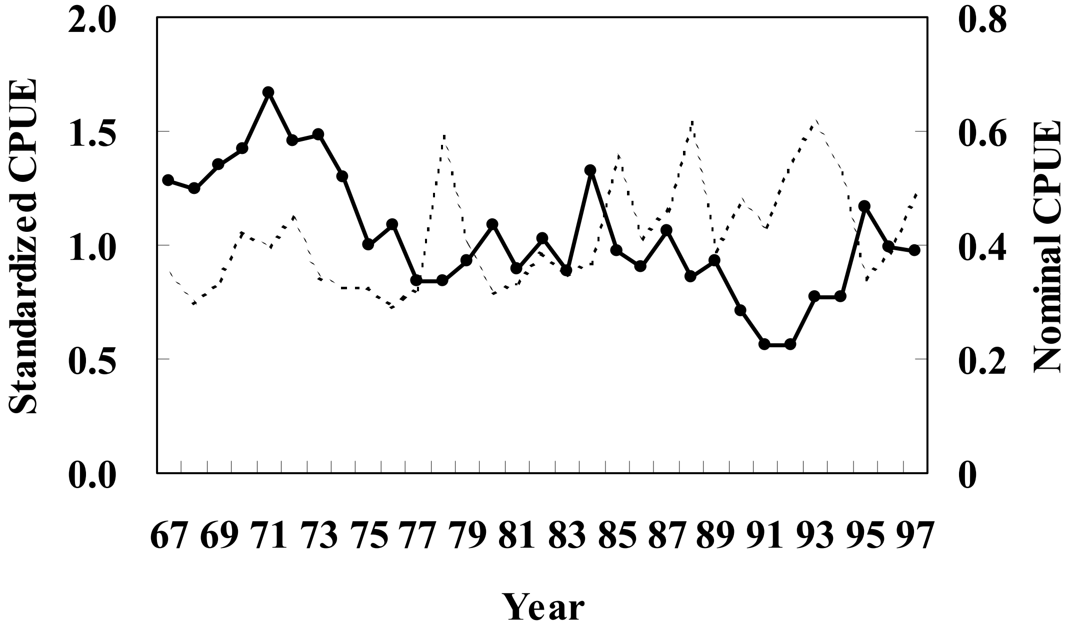


Figure 8. Standardized CPUE of swordfish by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

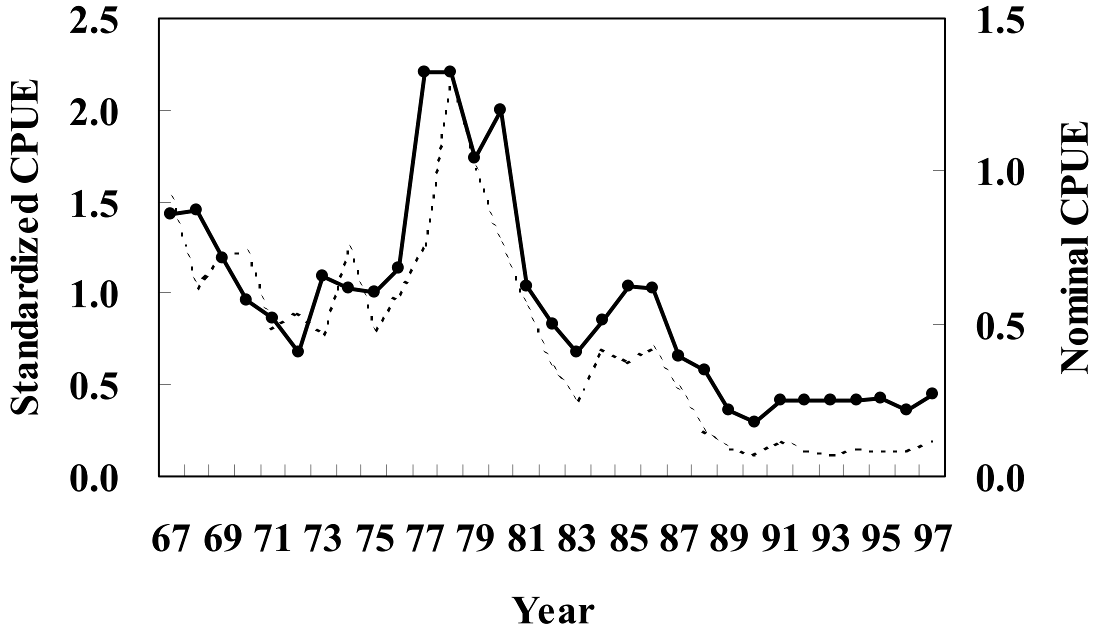


Figure 9. Standardized CPUE of striped marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

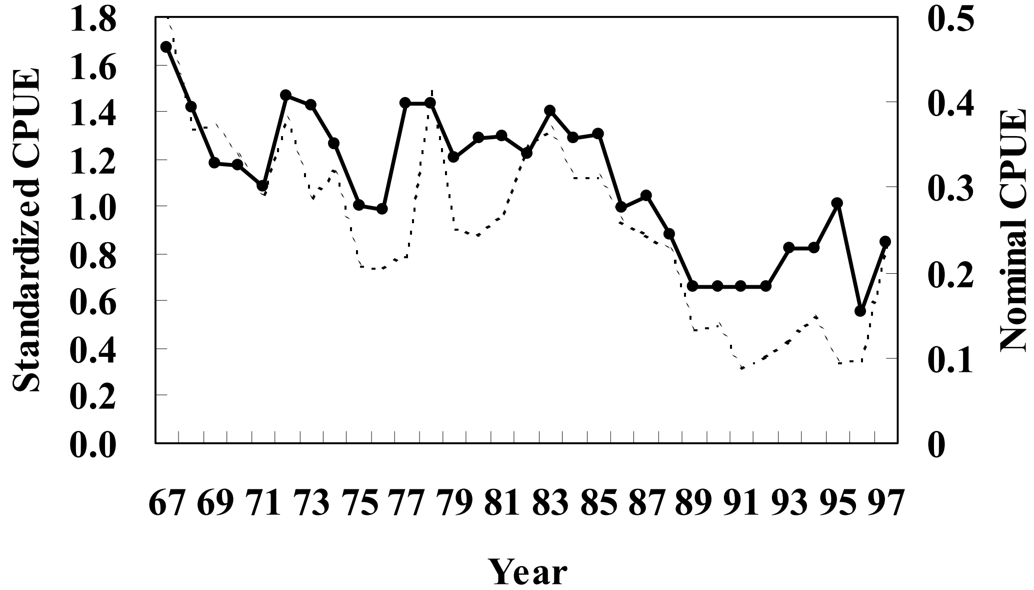


Figure 10. Standardized CPUE of blue marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.

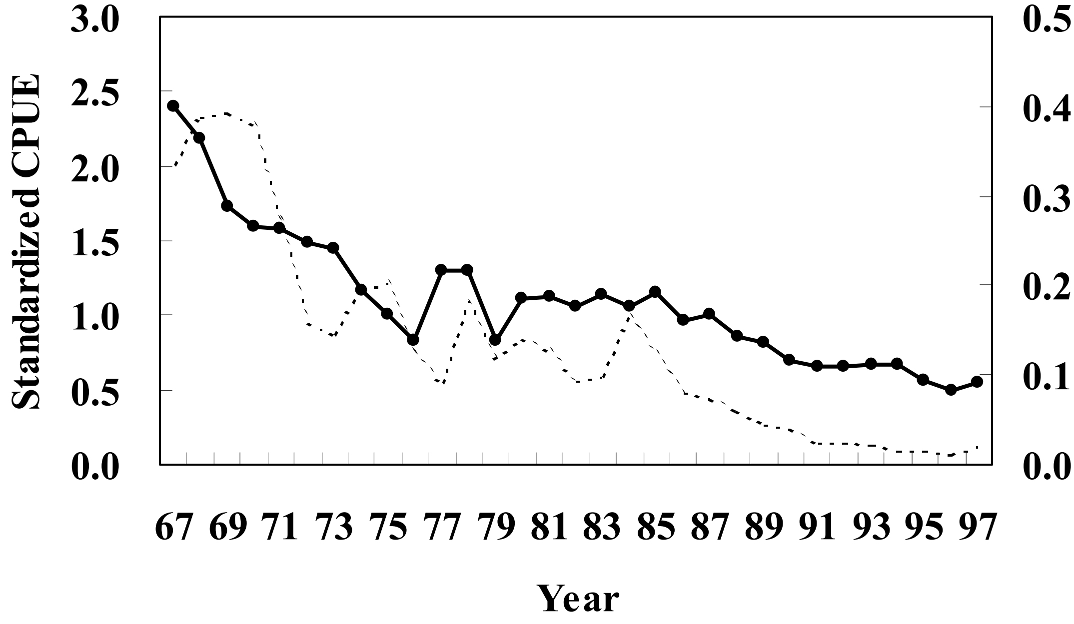


Figure 11. Standardized CPUE of black marlin by the Japanese longline fishery in the Indian Ocean. Solid line shows the standardized CPUE, which is scaled by adjusting the value in 1975 to 1.0. Dotted line shows the nominal CPUE.