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STANDARDIZED CPUE FOR THE ATLANTIC SWORDFISH CAUGHT BY JAPANESE LONGLINE FISHERY

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SUMMARY

The CPUE of Atlantic swordfish by five areas was estimated using the log linear model (so-called General Linear Model). The multiplicative model was applied to the Japanese longline fishery data. CPUEs showed a slight downward trend in all three areas in the north Atlantic as well as the entire north Atlantic, whereas in the Gulf of Guinea the CPUE appeared to be stable.

RESUME

La CPUE de l'espadon de l'Atlantique a été estimée dans cinq zones en utilisant le modèle linéaire généralisé. Le modèle multiplicatif a été appliqué aux données de la pêcherie palangrière japonaise. Les CPUE indiquent une légère tendance à la baisse dans les trois zones de l'Atlantique nord ainsi que dans tout l'Atlantique nord, alors qu'elle semble être stable dans le golfe de Guinée.

RESUMEN

La CPUE del pez espada atlántico por cinco áreas se calculó utilizando el modelo lineal logarítmico (denominado Modelo Lineal Generalizado). Se aplicó el modelo multiplicativo a los datos de la pesquería de palangre japonesa. Las CPUE mostraron una tendencia ligeramente descendente en las tres áreas en el Atlántico Norte, así como en el Atlántico Norte total, mientras que en el Golfo de Guinea parecían mantenerse estables.

1.Introduction

Last year the stock status of swordfish was assessed by the technique of VPA for the first time. While there were recent improvements in the theoretical aspect of VPA, the method alone does not seem to give the correct answer particularly for the large pelagic species and needs some other information on stock status to tune the VPA such as CPUEs from the fisheries or research cruises.

In this paper, standardized CPUE series from the Japanese longline fishery operating in the whole Atlantic were updated to provide materials for the better tuning of VPA.

2.Materials and methods

Japanese longline catch and effort data compiled at the FSFRL were used. Those are essentially the same as Task II catch and effort statistics submitted to the ICCAT but have additional information on the kind of bait. There is no special intention to use records with bait information but it is simply intended to take the subset of data. In fact bait information kept in the records does not function well since only three codes are assigned for this and the fishermen often use the combination of several different baits at the same time.

At first size data were looked into whether the estimation of size specific index is feasible or not. It was found impossible to do so since length samples from the Japanese longline fishery were too few and sporadic even though the moderately larger time-area strata (quarter of the year and 10° Lat. by 10° Long. or 10° Lat. by 20° Long.) were selected.

Years covered are from 1978 to 1988 but data in 1988 are provisional. Four areas were designated (Fig. 1) to select the waters where swordfish catches were significant by the Japanese longline fishery. Those are northwest Atlantic, northeast Atlantic, mid-east (off Mauritania and Senegal), southeast(roughly the Gulf of Guinea). In the first two areas, longline fleet operated rather seasonally mainly targeting bluefin and bigeye tuna while in the others bigeye is the main target species. In addition to above four areas, entire north Atlantic (combined for the first three areas) is also set. Standardized CPUEs were calculated for each of these areas.

Besides year as a main effect, fishing season and area were considered to be in the model. Quarter of the year was chosen as fishing season. Catch and effort statistics on monthly basis were kept separately within the same quarter. With regard to area effect, subareas (10° Lat. by 10° Long.) were set as shown in Fig. 1.

CPUE was calculated as catch in number of fish per 1,000 hooks. Records with less than 10,000 hooks were excluded from the analysis but records with zero catch were retained. Histograms of the nominal CPUE by area were shown in Fig. 2. Number of observations in this analysis were shown in Table 1 by year, quarter and subarea.

Since Koido and Yonemori (1986) already pointed out that the efficiency of the deep longline gear in catching swordfish surpassed the conventional longline gear in area 4 (Fig. 1), adjustment of gear efficiency was made for fishing effort after 1979 and onward using the deployment rate (Table 2) and the efficiency rate (1.5, Koido and Yonemori op. cit.) of the deep longline gear over the conventional gear. Deployment rate in 1988 was assumed to be the same as in 1987.

Miyabe (1989) examined the best model among those which have all main effect and possible combination of two way interaction. Miyabe (op. cit.) reported that the inclusion of the interaction between fishing season and area was always significant and other interaction term was mostly insignificant.

Taking this result into consideration, following multiplicative model was applied:

$$\mathrm{LOG}\ (\mathrm{CPUE} + 1.0) = \mu + Y_i + Q_j + A_k + QA_{jk} + e_{ijk}$$

where LOG : natural logarithm,
CPUE : nominal CPUE (catch in number of swordfish divided by the number of hooks and multiplied by 1,000), in year i, quarter j and subarea k,
μ : overall mean,
Y_i : effect of year i,
Q_j : effect of quarter j,
A_k : effect of subarea k,
QA_{kj} : interaction term between Q_j and A_k,
e_{ijk} : error term, $N(0,\sigma)$.

Constraints ($\Sigma Y_i = \Sigma Q_j = \Sigma A_k = 0$) were also incorporated in order to reduce the number of parameters to be estimated. Design matrix was constructed using dammy variable with 1, 0, -1 codes.

Calculation was performed through computer software, ('Universal Mathematical Software System') on NEC computer ACOS930.

3.Results and Discussion

The histogram of normalized residual was shown in Fig. 3. Although the center part is slightly peaked in all areas, the distribution is very close to normal curve especially for Area 3, 4 and entire North Atlantic. The rate of variability explained by the model(i.e., R square) was rather low ranging 0.22 to 0.43 among areas. This means that the model could not explain the variation of CPUE very well, but it seems there are very few factors which can be incorporated to the model from a standpoint of data availability.

Estimated CPUEs were shown in Fig. 4 and Table 4. In general, all the areas in the north Atlantic (areas 1-3) showed a moderate decreasing trend until around 1985. It continued to decline in Area 2, but it went up in 1987 and 1988 and reached 1979-80 level in Area 3. In Area 1 it remained the same level. CPUE in Area 4 was stable and indicated almost no trend except the sudden drop in 1987. In the entire north Atlantic, CPUE was in slight downward trend but after 1986 it was almost stable. CPUE in 1988 was about 60 % of 1978 and 79 % of 1979.

The 95% confident limits of the standardized CPUE were narrow. The reason of this is attributable to the fact that SS (sum of squares) is very small compared to the bluefin (Miyabe 1989b). In other word, it can be said swordfish tends to be caught very consistently.

References

Koido, T. T. Yonemori 1986: Trend in hook rate of Atlantic swordfish. ICCAT, CVSP. Vol. XXVI:396-401.

Miyabe, N. 1989a: Estimation of standardized CPUE for the Atlantic swordfish using the data from the Japanese longline fishery. ICCAT, CVSP. Vol. XXIX:183-194.

Miyabe, N. 1989b: Standardized CPUE of bluefin tuna in the western Atlantic caught by Japanese longline fishery. ICCAT, SCRS/89/85.

Table 1. Number of observations used in this analysis by main effect.

Area 1

Main effect	No. of obs.
1978	38
1979	59
1980	60
1981	63
1982	48
1983	46
1984	34
1985	41
1986	42
1987	18
1988	8
Q1	111
Q2	69
Q3	118
Q4	159
Subarea 1	189
Subarea 2	158
Subarea 3	110

Area 2

Main effect	No. of obs.
1978	25
1979	18
1980	18
1981	30
1982	24
1983	26
1984	20
1985	15
1986	16
1987	11
1988	5
Q1	73
Q2	101
Q3	19
Q4	15
Subarea 1	96
Subarea 2	112

Area 3

Main effect	No. of obs.
1978	55
1979	29
1980	56
1981	81
1982	103
1983	58
1984	57
1985	69
1986	48
1987	25
1988	13
Q1	199
Q2	153
Q3	125
Q4	117
Subarea 1	17
Subarea 2	111
Subarea 3	73
Subarea 4	160
Subarea 5	156
Subarea 6	77

Area 4

Main effect	No. of obs.
1978	25
1979	43
1980	75
1981	67
1982	70
1983	53
1984	77
1985	69
1986	58
1987	25
1988	12
Q1	173
Q2	86
Q3	145
Q4	190
Subarea 1	66
Subarea 2	77
Subarea 3	68
Subarea 4	80
Subarea 5	139
Subarea 6	164

North Atlantic

Main effect	No. of obs.
1978	118
1979	106
1980	134
1981	174
1982	255
1983	130
1984	117
1985	125
1986	106
1987	54
1988	26
Q1	383
Q2	323
Q3	262
Q4	291
Subarea 1	189
Subarea 2	158
Subarea 3	110
Subarea 4	96
Subarea 5	112
Subarea 6	17
Subarea 7	111
Subarea 8	73
Subarea 9	160
Subarea 10	156
Subarea 11	77

Table 2. Deployment rate of deep longline gear by quarter and subarea in area 4.

Subarea 1	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	-	-	-	-
1981	0.69	0.68	-	0.79
1982	0.65	0.83	-	0.86
1983	1.00	-	-	0.83
1984	1.00	0.47	0.92	0.91
1985	1.00	0.99	0.96	1.00
1986	1.00	-	1.00	0.94
1987	1.00	0.90	1.00	1.00

Subarea 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	-	-	-	-
1981	0.83	0.97	1.00	0.57
1982	0.87	0.55	-	0.78
1983	0.95	1.00	-	0.88
1984	0.93	-	1.00	0.98
1985	0.99	0.97	1.00	1.00
1986	0.96	0.62	1.00	1.00
1987	1.00	0.99	1.00	1.00

Subarea 2	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	0.26	1.00	0.80	0.84
1981	1.00	-	1.00	0.66
1982	0.80	0.74	1.00	0.98
1983	1.00	-	-	0.69
1984	0.89	1.00	0.83	0.99
1985	1.00	0.97	0.94	0.93
1986	1.00	1.00	0.96	0.97
1987	1.00	0.25	1.00	0.96

Subarea 5	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	0.68	0.75	0.71	0.81
1981	0.72	0.82	0.56	0.53
1982	0.91	1.00	0.73	0.87
1983	0.95	-	-	0.66
1984	0.88	-	0.66	1.00
1985	0.97	1.00	0.93	0.90
1986	1.00	1.00	0.71	0.92
1987	0.99	0.91	-	0.92

Subarea 3	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	0.54	-	0.92	0.87
1981	1.00	-	0.87	0.78
1982	1.00	-	0.90	0.93
1983	1.00	-	0.53	0.82
1984	1.00	1.00	0.74	1.00
1985	-	1.00	0.96	0.93
1986	-	1.00	0.91	1.00
1987	1.00	-	1.00	1.00

Subarea 6	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1980	0.48	0.62	0.61	0.29
1981	0.71	0.53	0.30	0.34
1982	0.74	0.44	0.61	0.32
1983	1.00	-	0.18	0.24
1984	0.96	0.69	0.57	0.48
1985	0.92	0.94	0.85	0.46
1986	1.00	0.85	0.55	0.05
1987	1.00	0.93	0.60	0.51

Table 3. Results of ANOVA from the General Linear Model for Atlantic swordfish.

Area	Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R^2
Area 1	Regression	15.8357	21	0.7541	14.00	0.40
	Residual	23.4290	435	0.0539		
	Total	39.2648	456			
Area 2	Regression	6.8466	17	0.4027	8.41	0.43
	Residual	9.0940	190	0.0479		
	Total	15.9406	207			
Area 3	Regression	9.0259	33	0.2735	4.65	0.22
	Residual	32.9482	560	0.0588		
	Total	41.9741	593			
Area 4	Regression	17.2670	33	0.5232	11.04	0.39
	Residual	26.5446	560	0.0474		
	Total	43.8115	593			
North Atlantic	Regression	45.1822	53	0.8525	15.05	0.40
	Residual	68.2708	1205	0.0567		
	Total	113.4529	1258			

Table 4. Standardized CPUE of Atlantic swordfish, 1978-1988.

Year	Area 1	Area 2	Area 3	Area 4	North Atlantic
1978	0.7438	0.6587	1.2043	0.6473	0.9612
1979	0.5114	0.7119	0.8810	0.9594	0.7409
1980	0.4120	0.5679	1.0080	0.9905	0.7070
1981	0.4671	0.5644	0.8526	1.0160	0.6866
1982	0.6274	0.3247	0.7770	1.1373	0.6537
1983	0.3792	0.4099	0.7388	1.0623	0.5696
1984	0.4765	0.4703	0.6550	1.2296	0.5776
1985	0.3704	0.3189	0.6749	1.0394	0.5243
1986	0.3445	0.3015	0.6122	0.9134	0.4836
1987	0.3313	0.1832	0.8015	0.5964	0.5283
1988	0.3416	0.0831	0.9485	1.0274	0.5720

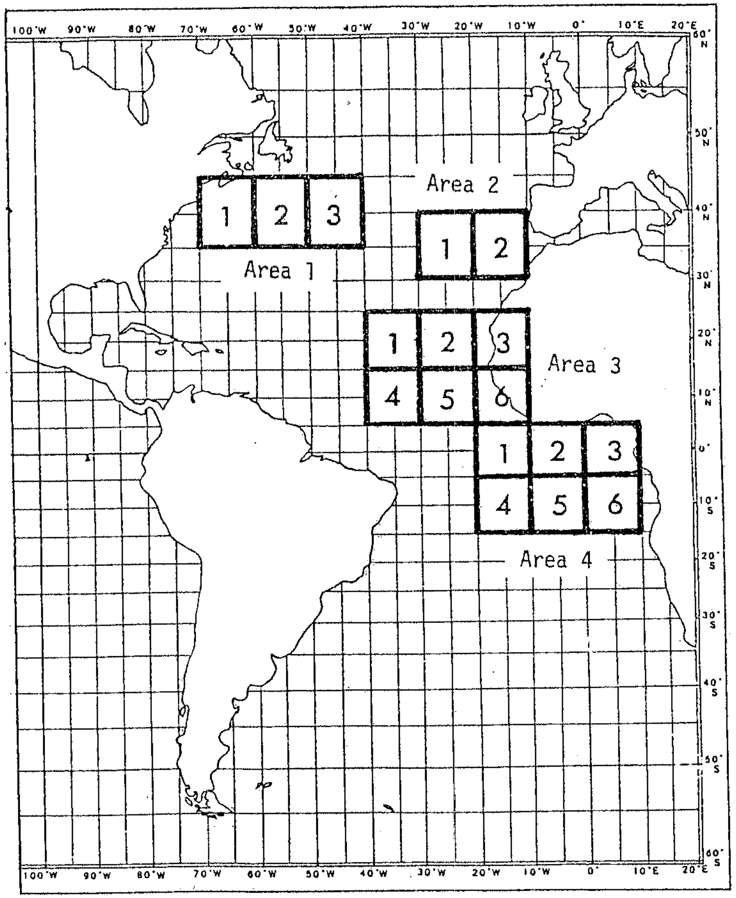

Fig. 1 Area and subarea division used to estimate standardized CPUE for Atlantic swordfish. Numbers in the square indicate subarea in each area.

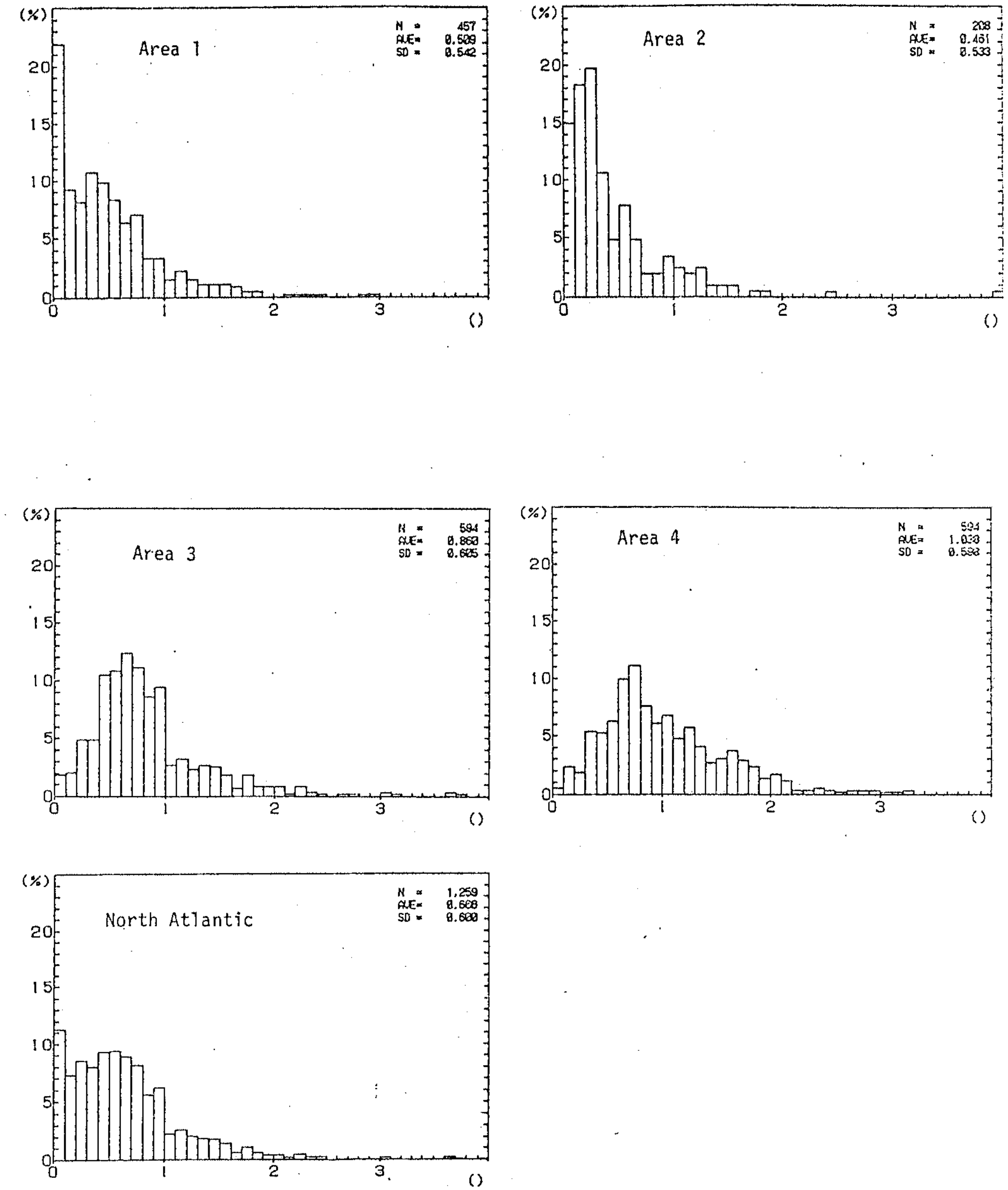

Fig. 2 Histgrams of nominal CPUE (catch per 1,000 hooks) by area.

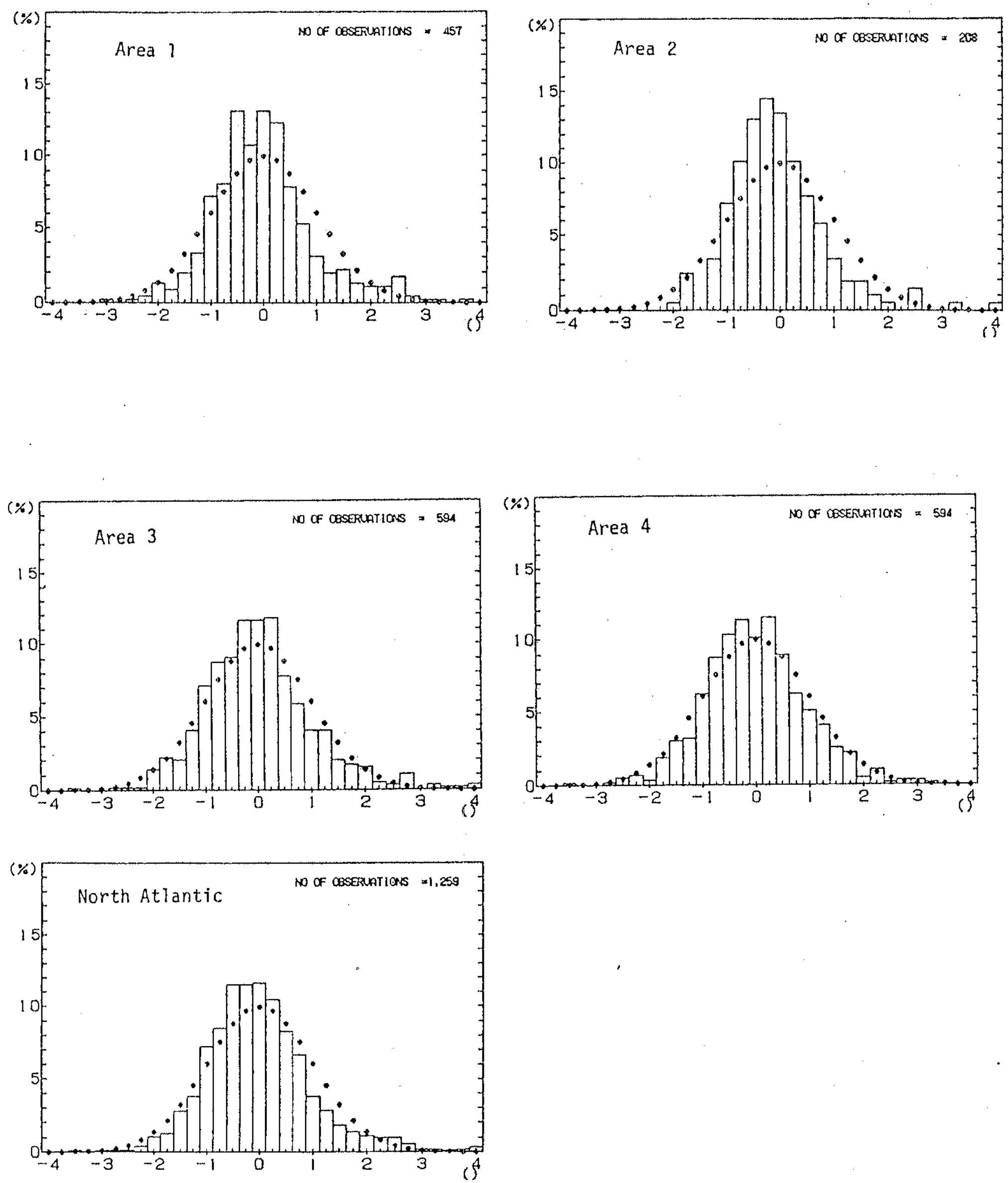

Fig. 3 Histograms of the normalized residual from the model. Dots show the expected frequency from normal distribution.

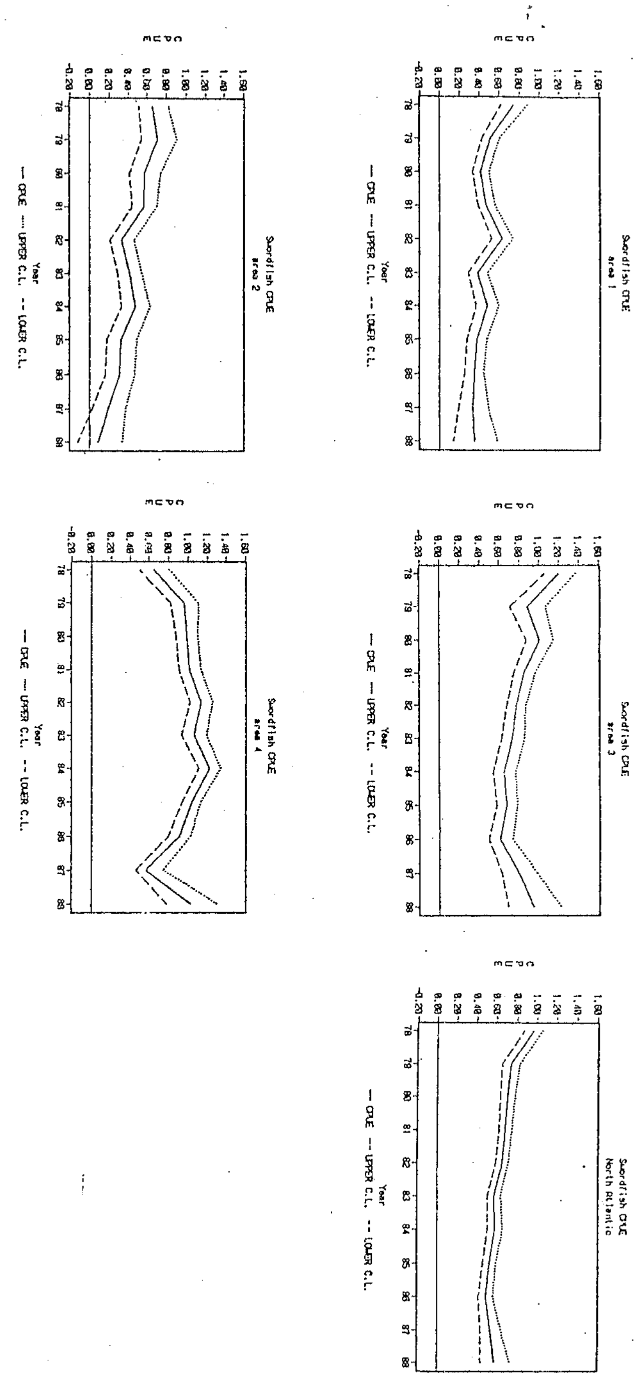

Fig. 4 Standardized CPUE of Atlantic swordfish. Solid line, dotted line and broken line show annual CPUE and its upper and lower 95% confidence limits, respectively.