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AN UPDATED STANDARDIZED CPUE FOR ATLANTIC SWORDFISH CAUGHT BY THE JAPANESE LONGLINE FISHERY

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SUMMARY

CPUEs of Atlantic swordfish from the Japanese longline fishery by five areas were standardized by log linear model (so-called General Linear Model) for fish 5 years old and older. In general, CPUEs showed a downward trend during 1978 to 1989 in all three areas in the North Atlantic as well as in the entire North Atlantic, although CPUEs in recent years in Area 3 (mid-east) and total North Atlantic were stable. CPUEs are slightly decreasing in the Gulf of Guinea with moderate fluctuations.

RESUME

La CPUE de l'espadon de l'Atlantique pour la pêcherie palangrière japonaise en cinq zones a été standardisée par le modèle logarithmique linéaire (dénommé modèle linéaire généralisé) pour les poissons de 5 ans et plus. En général, la CPUE montre une tendance à la baisse de 1978 à 1989 dans les trois zones nord-atlantiques, ainsi que dans l'ensemble de l'Atlantique nord, bien que la CPUE des années récentes dans la zone 3 (centre-est) et dans l'ensemble de l'Atlantique nord soit stable. La CPUE est légèrement en baisse dans le golfe de Guinée avec des fluctuations modérées.

RESUMEN

Por medio del modelo lineal (denominado Modelo Lineal Generalizado) se estandarizaron las CPUEs de pez espada del Atlántico, de la pesquería japonesa de palangre, por cinco zonas y para peces de 5 años y más. En general, estas CPUEs mostraban una tendencia descendente en el periodo 1978-1989 en las tres zonas del Atlántico norte y en todo el Atlántico norte, si bien eran estables en años recientes en la zona 3 (este central) y en el Atlántico norte total. En el golfo de Guinea las CPUEs presentan un ligero descenso con fluctuaciones moderadas.

1.Introduction

One of the main drawbacks in Virtual Population Analysis (VPA) is that VPA can not give unique solution without external information on the stock. At the ICCAT, as an index of the stock CPUEs mostly from commercial fishery have been used for this purpose.

Compared with other fish such as demersal fish, large pelagic fish differs in many points. For example, its distribution is vast often oceanwide and it makes long distance migration. These characteristics sometime prevent from getting information on the stock status which is easily obtained in other species by research trawl cruise or larval survey. Accordingly it is essential to analyze data from the commercial fishery in the case of large pelagic species.

In this paper, standardization was done for age specific CPUE from the Japanese longline fishery operating in the whole Atlantic in order to provide materials for the tuning process in VPA.

2.Materials and methods

2.1 Basic data.

The basic input data for CPUE analysis were obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries (NRIFSF) for 1978-1989. The compilation of data in

1989 are still underway thus they are provisional. Catch and effort data are almost the same as Task II catch and effort statistics submitted to the ICCAT in which single operation data are aggregated to month and 5-degree area. The difference between ICCAT Task II and this dataset is that the latter has additional information on the kind of bait. This code has three categories; i.e. saury, squid and others, and was originally introduced to classify the target species in the early period of fishery (1960's). But the mode of operation and the kind of bait used have changed since then, and now this code is not so meaningful. Considering this nature, bait information was not incorporated to the model but they are treated as replicated data.

Four fishing areas were designated (Fig. 1) to select the waters where swordfish catches were significant by the Japanese longline fishery. Those are northwest Atlantic (Area 1), northeast Atlantic (Area 2), mid-east (off Mauritania and Senegal, Area 3), southeast (roughly the Gulf of Guinea, Area 4). 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.

CPUE was calculated as catch in number of fish per 10^6 hooks. Records with less than 5,000 hooks in month-subarea-bait stratum were excluded from the analysis.

2.2 Development of age-specific CPUE.

To get relevant information on the stock trend from the CPUE, it is considered necessary that cpue should be size-specific. In doing so, however, the length data being collected were too few to be matched with catch in fine scale such as by month and 5-degree square. In this analysis, catch-at-size for the Japanese fishery by ICCAT area was used. The original length data are also compiled at the NRIFSF. After checking the length frequency for this fishery, it was decided the CPUE were calculated for fishes equal and older than 5 years old (5+). The ratio of the fish age 5+ were calculated by ICCAT area, year and quarter, and was multiplied to each basic data in the same strata.

2.3 Adjustment for the difference in gear efficiency.

Koido and Yonemori (1986) reported that the efficiency of the deep longline gear in catching swordfish was higher than the conventional longline gear in Area 4. Then adjustment of gear efficiency was made for fishing effort after 1979 and onward as in the same manner of Miyabe (1990) using the deployment rate (Table 1) and the efficiency rate (1.5) of the deep longline gear over the conventional gear (Koido and Yonemori op. cit.). Deployment rate in 1989 was assumed to be the same as in 1988.

2.4 Construction of the model.

As main effect, year, fishing season and fishing area were considered. Years covered are from 1978 to 1989. Month and quarter of the year were selected as fishing season. After several preliminary runs, it turned out that parameters were not be estimable when month was introduced to the model. As for fishing area, quadrate in 10° Lat. by 10° Long. (Fig. 1) was adopted mostly taking consideration on data availability and data handling on the statistical procedure.

Miyabe (1989) examined the best model among those which have all main effect and possible combination of two way interaction, and reported that the inclusion of the interaction between fishing season and area was always significant and other interaction terms were mostly insignificant. It is also observed that there is very few difference in the parameter estimates in the preliminary runs.

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

$$LOG(CPUE_{ijk} + 1.0) = \mu + Y_i + Q_j + A_k + Q_j{*}A_k + e_{ijk}$$

where LOG : natural logarithm,

$CPUE_{ijk}$: nominal CPUE (catch in number per 10^6 hooks, 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,

$Q_j{*}A_k$: interaction term between Q_j and A_k,

e_{ijk} : error term, $N(0,\sigma)$.

Calculation was performed through computer software, 'SAS Ver. 6.03' on the UNIX workstation HP360. In the General Linear Model procedure on 'SAS', standards at the main effects are placed on the last year, area and quarter.

3.Results and Discussion

Number of observations in this analysis were shown in Table 2 by year, quarter and subarea.

Records with zero catch were not retained in the final model. The reason for that is zero catch formed a small peak at the lower tail of residual in the preliminary analyses.

The histogram of normalized residual was shown in Fig. 2. The distribution is close to normal curve in all areas. The results of ANOVA are indicated in Table 3. In all areas model as well as variables are statistically significant. The rate of variability explained by the model(i.e., R square) was rather low ranging 0.24 to 0.53 among areas.

Estimated CPUEs were shown in Fig. 3 and Table 4. In Fig. 3, lower and upper 95% confidence limits are also drawn together. Confidence limits at the standard year express confidence limits for overall mean (intercept). In all areas in the north Atlantic (areas 1-3) trends of CPUE were downward particularly in Area 2. High peaks are seen in 1978 and 1982 in Area 1, and 1978 and 1980 in Area 2. CPUE of 1978 in Area 3 and total north Atlantic is also quite high compared to later years. It appears the trend is stable in these 2 areas except 1978. CPUE in area 4 showed a moderate fluctuation in every 3 years. The recent level (1987-1989) of CPUE relative to the initial years (1978-1980) of this period are 38%, 21%, 59%, 83% and 44%, for Areas 1-4 and total north Atlantic, respectively.

References

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

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

Table 1. Quarterly deployment rate of deep longline gear in Area 4.

Subarea 12	Quarter of the year 1	2	3	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
1988	0.98	1.00	1.00	0.96

Subarea 15	Quarter of the year 1	2	3	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
1988	0.92	1.00	1.00	0.98

Subarea 13	Quarter of the year 1	2	3	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
1988	1.00	1.00	0.95	0.97

Subarea 16	Quarter of the year 1	2	3	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
1988	0.98	1.00	0.98	0.94

Subarea 14	Quarter of the year 1	2	3	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
1988	1.00	1.00	0.82	0.98

Subarea 17	Quarter of the year 1	2	3	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
1988	1.00	1.00	0.70	0.45

Table 2. Number of observations in the final model by main effect.

Area 1

Main effect	No. of obs.
1978	47
1979	72
1980	79
1981	88
1982	59
1983	57
1984	45
1985	72
1986	63
1987	59
1988	75
1989	47
Q1	235
Q2	79
Q3	134
Q4	315
Subarea 1	235
Subarea 2	328
Subarea 3	200

Area 2

Main effect	No. of obs.
1978	50
1979	33
1980	36
1981	55
1982	38
1983	48
1984	49
1985	26
1986	34
1987	28
1988	29
1989	16
Q1	137
Q2	243
Q3	41
Q4	21
Subarea 4	162
Subarea 5	280

Area 3

Main effect	No. of obs.
1978	88
1979	52
1980	102
1981	127
1982	212
1983	100
1984	109
1985	159
1986	100
1987	77
1988	110
1989	118
Q1	392
Q2	333
Q3	350
Q4	279
Subarea 6	35
Subarea 7	243
Subarea 8	105
Subarea 9	406
Subarea 10	416
Subarea 11	150

Area 4

Main effect	No. of obs.
1978	43
1979	97
1980	158
1981	133
1982	182
1983	128
1984	192
1985	219
1986	135
1987	124
1988	221
1989	144
Q1	392
Q2	333
Q3	350
Q4	279
Subarea 12	200
Subarea 13	234
Subarea 14	166
Subarea 15	220
Subarea 16	395
Subarea 17	561

Total North Atlantic

Main effect	No. of obs.
1978	185
1979	157
1980	217
1981	270
1982	309
1983	205
1984	203
1985	257
1986	197
1987	164
1988	214
1989	181
Q1	481
Q2	257
Q3	493
Q4	545
Subarea 1	235
Subarea 2	328
Subarea 3	200
Subarea 4	162
Subarea 5	280
Subarea 6	35
Subarea 7	243
Subarea 8	105
Subarea 9	406
Subarea 10	416
Subarea 11	150

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

Area	Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R^2
Area 1	Model	277.856	22	12.630	20.42	0.38
	Error	457.754	740	0.619		
	Total	735.610	762			
Area 2	Model	279.079	18	15.504	26.04	0.53
	Error	251.866	423	0.595		
	Total	530.945	441			
Area 3	Model	210.430	34	6.189	12.44	0.24
	Error	656.251	1319	0.498		
	Total	866.680	1353			
Area 4	Model	300.368	34	8.834	20.54	0.29
	Error	748.872	1741	0.430		
	Total	1049.241	593			
Total North Atlantic	Model	930.301	54	17.228	28.32	0.38
	Error	1523.508	2504	0.608		
	Total	2453.809	1258			

Table 4. Standardized CPUE of age 5+ group for Atlantic swordfish, 1978-1989.

Year	Area 1	Area 2	Area 3	Area 4	Total North Atlantic
1978	301.877	391.472	669.220	709.675	500.867
1979	150.921	202.840	225.763	553.961	213.168
1980	148.217	341.411	408.518	528.510	290.337
1981	147.147	146.151	222.801	737.550	190.455
1982	312.920	99.719	288.581	341.260	240.168
1983	101.149	136.449	155.605	503.653	139.652
1984	131.467	192.228	214.858	581.742	190.876
1985	126.967	108.692	182.334	382.906	151.554
1986	151.090	93.776	182.590	513.624	158.753
1987	76.511	47.102	223.068	563.086	123.663
1988	83.695	116.171	282.300	432.845	168.946
1989	66.937	33.522	260.267	482.406	145.643

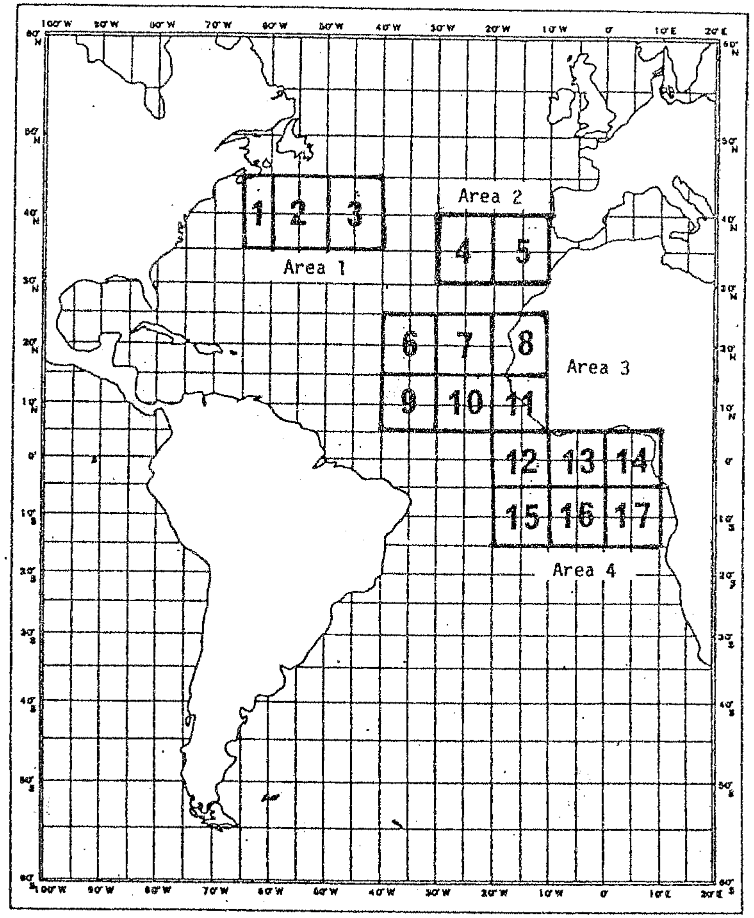


Fig. 1 Area and subarea used in the standardization of CPUE for Atlantic swordfish. Numbers in the square indicate subarea.

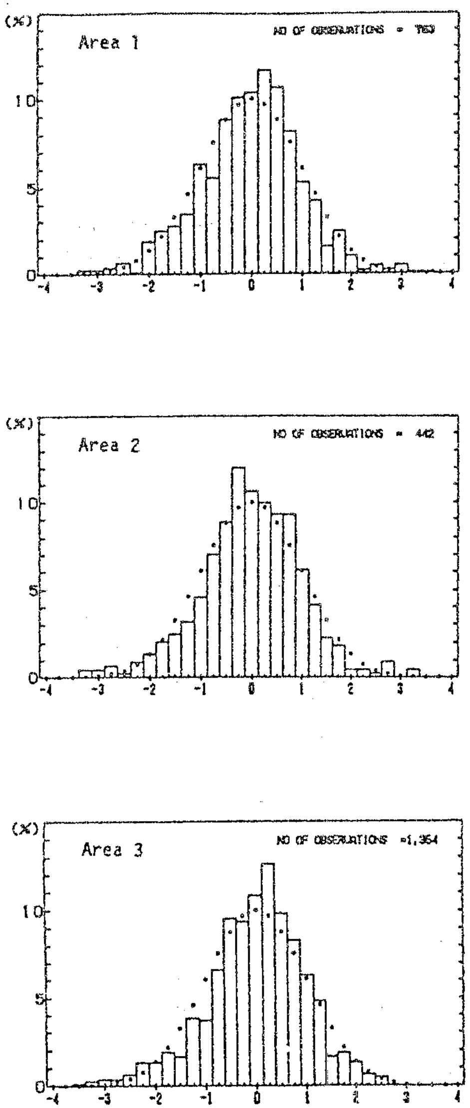
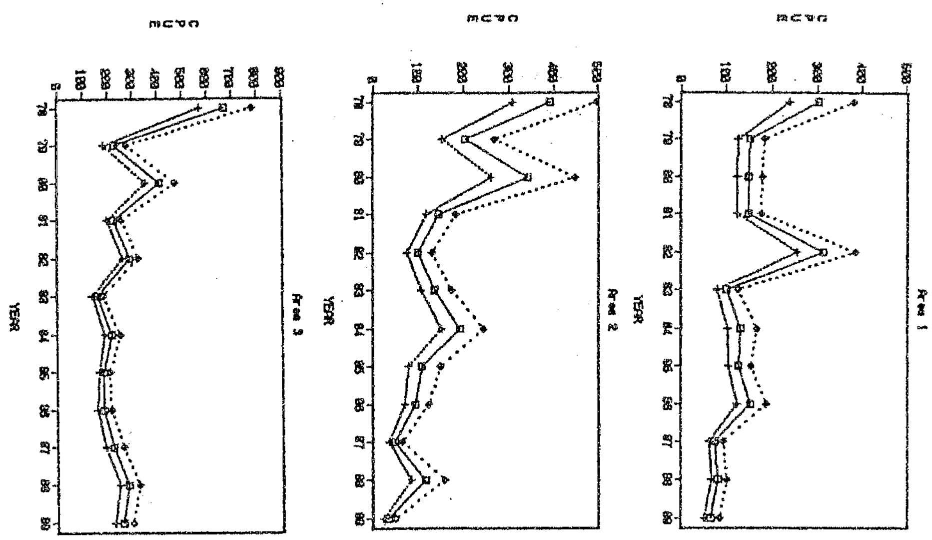


Fig. 2 Histograms of the normalized residual. Small dots show the expected frequency from normal distribution.



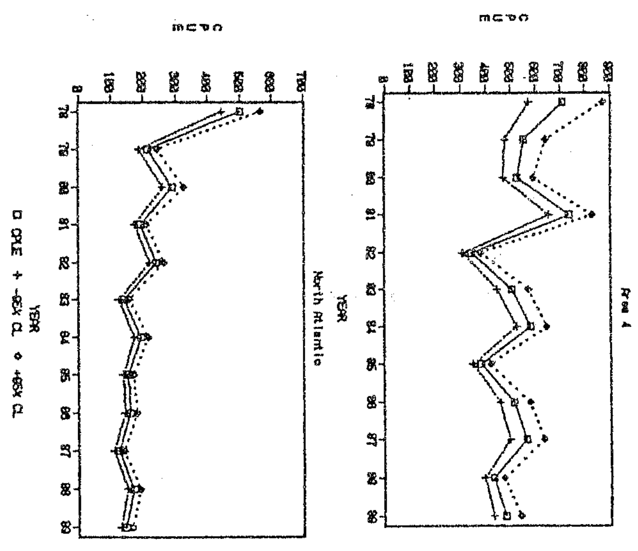


Fig. 3 Standardized CPUE of Atlantic swordfish for age 5+ group. Solid line and dotted lines show annual CPUE and its upper and lower 95% confidence limits, respectively.