

## AN UPDATED STANDARDIZED CPUE OF BLUEFIN TUNA IN THE WESTERN ATLANTIC CAUGHT BY THE JAPANESE LONGLINE FISHERY

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## SUMMARY

Standardized CPUEs were estimated for the purpose of tuning VPA by a General Linear Model (GLM) from the Japanese longline fishery operating in the northwest Atlantic in winter. Two age-specific CPUE series were obtained; they are for 3- to 5-year old and 6- to 8-year old fish, respectively, utilizing the length frequency samples from the catch. Both series showed somewhat similar trends and moderate fluctuations in recent years.

## RESUME

La CPUE standardisée a été estimée dans le but d'ajuster les VPA à un Modèle linéaire généralisé (GLM) de la pêcherie palangrière japonaise qui pêche en hiver dans l'Atlantique nord-ouest. Deux séries de CPUE spécifiques de l'âge ont été obtenues pour les poissons de 3 à 5 ans et de 6 à 8 ans respectivement, en utilisant les échantillons de fréquences de taille provenant de la prise. Ces deux séries montrent ces dernières années une tendance plus ou moins peu semblable et des fluctuations modérées.

## RESUMEN

Se estiman las CPUE estandarizadas con le objetivo de ajustar el VPA mediante un modelo lineal generalizado (GLM) de la pesquería de palangre japonesa que opera en el Atlántico noroeste en invierno. Se obtuvieron dos series de CPUE específicas de la edad, para peces de edades 3 a 5 y 6 a 8, respectivamente, utilizando las muestras de frecuencias de tallas de la captura. Ambas series mostraron tendencias bastante similares y fluctuaciones moderadas en los años recientes.

1. Introduction

The Japanese longline fishery has covered the widest distributional area of the west Atlantic bluefin and the longest time series among major fisheries. Because of this, CPUE from this fishery has been considered very useful in the stock assessment of this species.

In this study, the same CPUE series, which were presented to the last SCRS meeting, were updated using revised 1988 data and newly added 1989 data. In addition, the attempt to incorporate the difference in the gear configuration was made.

2. Material and Method

Japanese longline catch and effort data during 1975-1989 with codes for 5° square, month and kind of bait formed the basic data (referred as "5 by 5 data"). Data for 1989 were preliminary. As for the information of gear configuration, subset of data with the number of hooks between floats (referred as "branch line data") are also used. CPUE is expressed as number of fish caught per 10<sup>6</sup> hooks.

These basic data are aged to 3 to 5 years old and 6 to 8 years old fish group by the method described by Miyabe (1990). Available length data were shown in Fig. 1.

The model includes the main effect of year, month, area and interaction between month and area. In addition, the number of hooks between floats is included when analyzing branch line data.

A fishing season from November to February was selected as the Japanese longline fleet targeted bluefin tuna only in that season in the northern winter in the northwestern Atlantic since the implementation of current regulation in 1982. It is thought the CPUE of the fishing season (November to February) represents abundance index at the beginning of the latter calendar year of the fishing season. For example, CPUE of 1985-1986 fishing season represents the abundance at the beginning of 1986.

Area division used in the model is shown in Fig. 2.

Number of observations by year, month and area were tabulated in Table 1 for 5 by 5 data and branch line data, respectively.

The multiplicative model shown below was used as were the case of past analyses (Miyabe and Suzuki 1989, Davis and Turner 1989, and Miyabe 1990).

$$\text{LOG ( CPUE )} = \mu + Y_i + M_j + A_k + M^*A_{jk} + e_{ijk}$$

where

- LOG : natural logarithm,
- CPUE : catch in number of bluefin per  $10^6$  hooks,
- $\mu$  : overall mean,
- $Y_i$  : effect of year,
- $M_j$  : effect of month (November to February),
- $A_k$  : effect of area,
- $M^*A_{jk}$  : interaction term between  $M_j$  and  $A_k$ ,
- $e_{ijk}$  : error term with  $N(0,\sigma)$ .

When branch line data is analyzed, main effect of the number of hooks between floats (5 to 13 hooks, i.e., 9 levels) are added.

### 3. Result and Discussion

In preliminary runs, it was observed that the distribution of residual was skewed to the right. Then zero catch were excluded from the analysis.

Three cases were set for each age group as follows:

- Case 1 : uses all 5 by 5 data,
- Case 2 : excludes some deviated observations,
- Case 3 : uses all branch line data.

In Case 3, observations were too few to apply GLM in the full model. To avoid this, 9 areas in Fig. 2 were restructured into 3 larger areas. Those are 1 to 3, 4 to 7 and 8 to 9 area, respectively.

The results of ANOVA, estimated parameters and CPUEs and the distribution of standardized residual in the GLM are shown in Table 2, 3 and Fig. 3, respectively. The model itself and all effects in the model are significant ( $F > 2.0$ ) in the final run.  $R^2$  ranges 0.40 - 0.76 which is rather higher than the last year's analysis. It is thought this is ascribed to the exclusion of zero catch from the analysis.

The overall distribution of standardized residual (Fig. 3) is very close to normal curve, especially in

Case 2 for both age groups.

As for branch line data, the frequency distribution of the annual number of hooks by the number of hooks between floats are illustrated in Fig. 4. As it is clear, the proportion of deep longline (more than 10 hooks between floats) gear has been very minor, although the most frequently used number of hooks between floats shifted from 5 to 7 hooks between floats during the 1980s. This tendency can also be seen in Table 1.

In Fig. 5 and Table 3 standardized CPUE are shown. All three cases for both age groups indicated somewhat similar annual change though the difference was larger in the earlier years and most recent year. CPUE for 3-5 age group was fairly high in 1976 to 1978 indicating that 1973 year class was dominant. CPUE was high in 1980 and 1985 and low in 1979, 1983 and 1986. The abundance for 6-8 age fish was high during 1977 to 1981, in 1985, 1988 and 1989. The low is observed in 1976, 1982, 1983 and 1986. A overall trend in CPUEs for both age groups are similar for the years after 1981.

### References

- Davis K. S. and S. C. Turner 1989 : Standardized catch rates of bluefin tuna from the Japanese longline fishery in the United States Exclusive Economic Zone for 1983-1987, ICCAT, CVSP, Vol. 30(2), 311-317.
- ICCAT 1989 : Report for biennial period, 1988-89. Part I(1988).
- Miyabe, N. 1990 : Standardized CPUE of bluefin tuna in the western Atlantic caught by Japanese longline fishery, ICCAT, CVSP, Vol. 32(2), 255-261.
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Table 1. Number of observations for CPUE analysis by month and area. Numbers letter "A" and that of letter "B" express area and the number of hooks between flows, respectively.

5 BY 5 DATA

Year	Nov	Dec	Jan	Feb	A1	A2	A3	A4	A5	A6	A7	A8	A9	Total
75-76	9	12	7	5	8	7	4	2	1	5	5	0	0	33
76-77	13	16	11	8	6	7	8	9	4	4	4	6	0	48
77-78	15	14	13	4	4	7	10	9	4	7	1	4	0	46
78-79	17	15	21	5	5	8	9	10	4	8	5	6	3	58
79-80	17	11	17	7	6	3	8	9	8	8	2	5	3	52
80-81	17	28	20	13	7	11	10	11	9	8	5	8	9	78
81-82	19	21	11	5	4	9	6	6	6	6	6	8	5	56
82-83	12	13	10	14	5	4	9	9	6	6	4	5	1	49
83-84	10	12	13	8	3	3	7	8	6	5	5	4	2	43
84-85	11	12	15	11	6	4	6	8	6	8	5	5	1	49
85-86	0	0	15	6	4	2	2	4	1	2	2	3	1	21
86-87	14	15	12	0	6	2	6	6	6	6	4	5	0	41
87-88	12	15	8	8	12	3	4	8	8	4	2	2	0	43
88-89	13	16	16	9	6	1	8	6	6	4	7	8	8	54
Total	179	200	195	111	78	71	101	105	75	86	57	73	39	685

BRANCH LINE DATA

YEAR	NOV	DEC	JAN	FEB	A1	A2	A3	B5	B6	B7	B8	B9	B10	B11	B12	B13	TOTAL
75-76	4	9	8	3	15	9	0	16	8	0	0	0	0	0	0	0	24
76-77	11	8	9	1	11	14	4	17	12	0	0	0	0	0	0	0	29
77-78	9	4	6	4	13	6	4	14	9	0	0	0	0	0	0	0	23
78-79	8	8	17	5	16	15	7	22	13	2	0	0	1	0	0	0	38
79-80	7	7	3	10	10	8	9	13	12	2	0	0	0	0	0	0	27
80-81	23	18	12	12	25	27	13	21	20	8	1	7	8	0	0	0	65
81-82	3	23	13	11	8	31	11	14	14	6	2	1	6	6	1	0	50
82-83	18	13	11	15	18	34	5	20	18	3	7	0	8	0	1	0	57
83-84	6	14	6	9	13	16	6	14	11	4	0	1	4	0	1	0	35
84-85	14	15	20	14	18	38	7	3	23	24	0	3	3	1	4	2	63
85-86	9	19	19	4	10	29	12	2	16	13	9	0	4	1	0	6	51
86-87	8	22	11	1	16	16	10	3	13	13	9	2	2	0	0	0	42
87-88	16	12	13	14	19	26	10	0	7	26	19	0	0	0	0	3	55
88-89	22	17	0	0	9	24	6	0	10	15	4	0	7	3	0	0	39
TOTAL	158	189	148	103	201	293	104	159	186	116	51	14	43	11	7	11	598

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Table 2. Results of ANOVA from the General Linear Model for western Atlantic bluefin. For explanation of Case, see text.

3 - 5 AGE FISH

Case #	Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R <sup>2</sup>
1	Model	1194.0895	48	24.8769	13.99	0.56
	Error	949.8082	534	1.7787		
	Total	2143.8977	582			
2	Model	1160.1663	48	24.1701	30.14	0.76
	Error	376.1192	469	0.8020		
	Total	1536.2855	517			
3	Model	756.2166	32	23.6318	14.09	0.51
	Error	717.6934	428	1.6769		
	Total	1473.9100	460			

6 - 8 AGE FISH

Case #	Source of variation	Sum of square	Degree of freedom	Mean Square	F statistics	R <sup>2</sup>
1	Model	936.1412	48	19.5029	11.61	0.51
	Error	896.6614	534	1.6791		
	Total	1832.8025	582			
2	Model	836.9547	48	17.4366	20.94	0.68
	Error	393.9268	473	0.8328		
	Total	1230.8816	521			
3	Model	481.3419	32	15.0419	8.92	0.40
	Error	721.5056	428	1.6858		
	Total	1202.8475	460			

Table 3. Parameter estimates for main effect of year in the GLM analysis for the western Atlantic bluefin tuna. "STD ERROR", "LSMEAN" and "CPUE" mean standard error, least squares mean of CPUE in log scale and that in the original scale, respectively.

AGE 3 - 5, CASE 1				AGE 6 - 8, CASE 1			
PARAMETER	STD ERROR	LSMEAN	CPUE	PARAMETER	STD ERROR	LSMEAN	CPUE
INT 6.8001862	0.4666080			INT 3.4064226	0.4533654		
76 0		6.40719	605.19	76 0		4.07966	59.126
77 0.9806801	0.3761562	7.38787	1615.26	77 1.6219295	0.3654808	5.70159	299.344
78 0.2067902	0.3829780	6.61398	744.44	78 1.6880850	0.3721089	5.76775	319.817
79 -1.366830	0.3751994	5.04036	153.53	79 1.8268198	0.3645511	5.90648	367.412
80 -0.219079	0.3752228	6.18811	485.92	80 1.7376565	0.3645738	5.81732	336.071
81 -0.482424	0.3585718	5.92476	373.19	81 1.4490104	0.3483954	5.52868	251.810
82 -1.033305	0.3817421	5.37388	214.70	82 0.4689477	0.3709081	4.54861	94.501
83 -1.890785	0.3945430	4.51640	90.51	83 0.2017643	0.3833457	4.28143	72.344
84 -0.766945	0.3882347	5.64024	280.53	84 1.1623071	0.3772165	5.24197	189.043
85 -0.598281	0.3748245	5.80891	332.25	85 1.5238996	0.3641868	5.60356	271.392
86 -1.381995	0.4411003	5.02519	151.20	86 0.8632824	0.4285817	4.94295	140.183
87 -0.777866	0.3893868	5.62932	277.47	87 1.4604585	0.3783359	5.54012	254.709
88 -0.663011	0.3698009	5.74418	311.37	88 1.7159908	0.3593058	5.79566	328.868
89 -0.638808	0.3892342	5.76838	319.02	89 1.4489602	0.3781876	5.52863	251.797

AGE 3 - 5, CASE 2				AGE 6 - 8, CASE 2			
PARAMETER	STD ERROR	LSMEAN	CPUE	PARAMETER	STD ERROR	LSMEAN	CPUE
INT 7.4949205	0.3485165			INT -0.787699	0.3951604		
76 0		6.73179	838.65	76 0		4.30616	74.156
77 0.5003111	0.2669747	7.23210	1383.12	77 1.4069626	0.2769568	5.71313	302.816
78 -0.200587	0.2781051	6.53120	688.22	78 1.0722996	0.2954973	5.37846	216.689
79 -0.970573	0.2728365	5.76121	317.73	79 1.6117964	0.2760699	5.91796	371.653
80 -0.145943	0.2697791	6.58585	724.76	80 1.5153800	0.2753618	5.82154	337.493
81 -0.686294	0.2561962	6.04549	422.21	81 1.5547222	0.2673011	5.86089	351.035
82 -1.546654	0.2724950	5.18513	178.60	82 0.5336636	0.2874585	4.83983	126.448
83 -2.492287	0.2779279	4.23950	69.37	83 -0.178112	0.2945797	4.12805	62.057
84 -0.889494	0.2772466	5.84229	344.57	84 1.1047849	0.2870508	5.41095	223.844
85 -0.764759	0.2661569	5.96703	390.34	85 1.5016658	0.2763606	5.80783	332.896
86 -1.759103	0.3135751	4.97268	144.41	86 0.6448046	0.3245082	4.95097	141.312
87 -1.169635	0.2720920	5.56215	260.38	87 1.2340798	0.2834198	5.54024	254.740
88 -1.003659	0.2603130	5.72813	307.39	88 1.5132268	0.2714342	5.81939	336.767
89 -0.559900	0.2779539	6.17189	479.09	89 1.6780181	0.2902825	5.98418	397.098

AGE 3 - 5, CASE 3				AGE 6 - 8, CASE 3			
PARAMETER	STD ERROR	LSMEAN	CPUE	PARAMETER	STD ERROR	LSMEAN	CPUE
INT 7.3436644	0.7163141			INT 3.9112997	0.718214		
76 0		6.29457	541.63	76 0		3.63640	37.955
77 0.8311902	0.4276839	7.12576	1243.60	77 1.6277050	0.4288183	5.26411	193.274
78 -0.165877	0.4521571	6.12870	458.84	78 1.3743973	0.4533564	5.01080	150.025
79 -1.427857	0.4138709	4.86672	129.89	79 1.9166018	0.4149686	5.55300	258.012
80 -0.085498	0.4487878	6.20908	497.24	80 2.1063539	0.4499781	5.74276	311.923
81 -0.268702	0.3971439	6.02587	414.00	81 1.8347728	0.3981972	5.47118	237.740
82 -1.146433	0.4179803	5.14814	172.11	82 0.9413172	0.4190889	4.57772	97.292
83 -1.375385	0.4100504	4.91919	136.89	83 0.8784047	0.4111380	4.51481	91.360
84 -0.540699	0.4249555	5.75388	315.41	84 1.4988482	0.4260826	5.13525	169.907
85 -0.632278	0.4135343	5.66230	287.81	85 1.7338476	0.4146312	5.39025	219.258
86 -1.043673	0.4984655	5.25090	190.74	86 1.6193513	0.4997875	3.25575	191.666
87 -0.683959	0.4380707	5.61061	273.31	87 1.8973481	0.4392326	5.53375	253.092
88 -0.478599	0.4375979	5.81597	335.62	88 2.2778537	0.4387586	5.91426	370.279
89 -0.234434	0.4471915	6.06014	428.44	89 2.0417045	0.4483775	5.67811	292.396

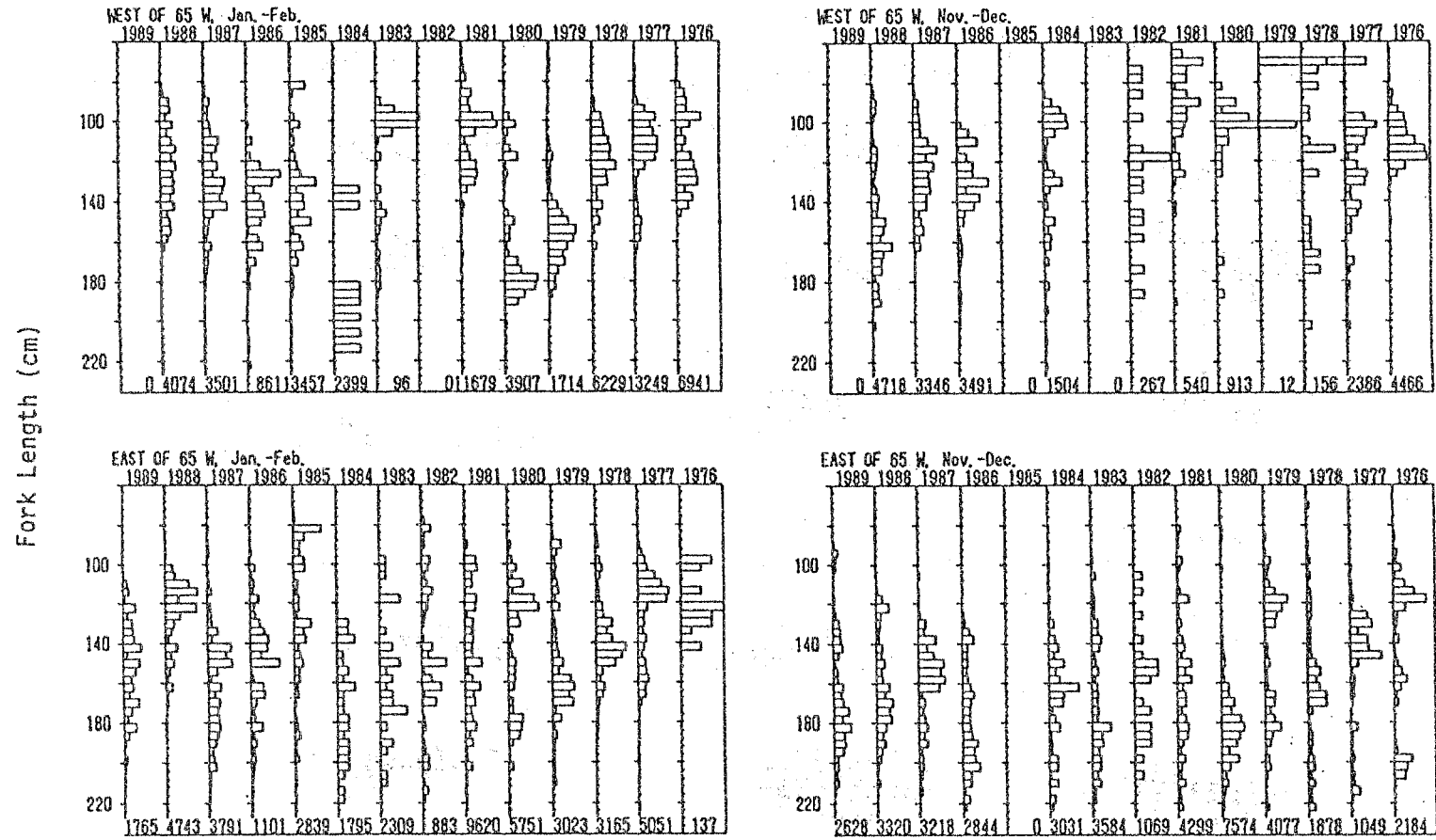


Fig. 1 Sample length frequency of bluefin in the northwestern Atlantic by area (east and west of 65 W) and two months interval (Nov.-Dec. and Jan.-Feb.) for years 1976 - 1989.

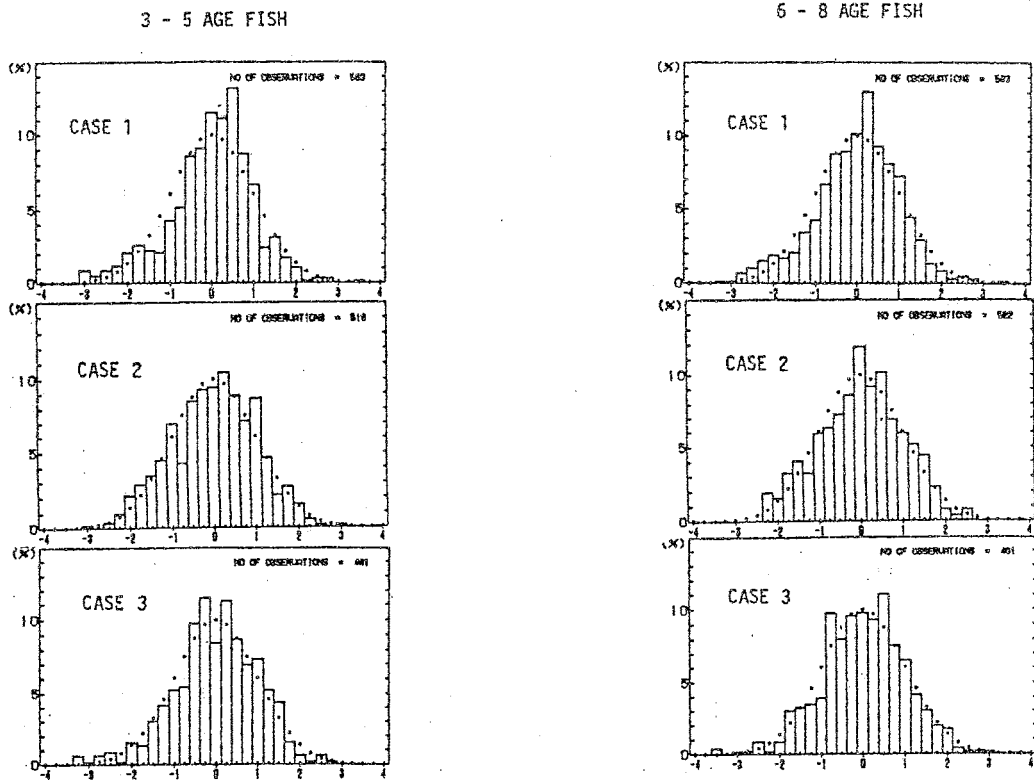


Fig. 3 Histograms of standardized residual. Bars show frequency of residual and solid circles show expected normal distribution.

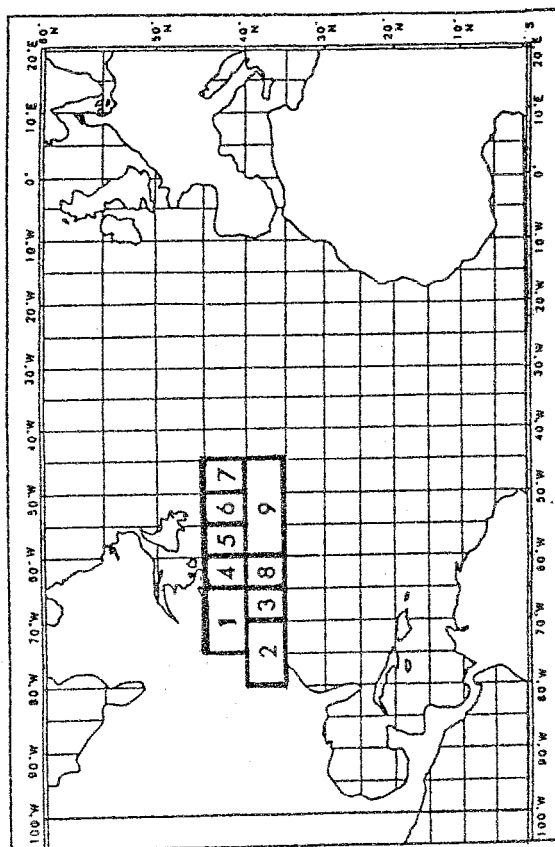


Fig. 2 Area division used in this analysis.

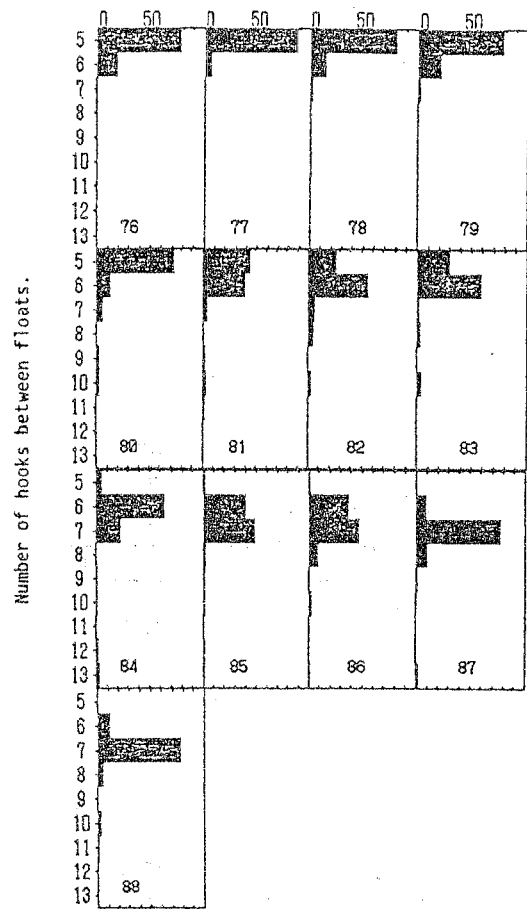


Fig. 4 Frequency distribution of fishing effort (in hooks) by the number of hooks between floats, for years 1976 - 1988.

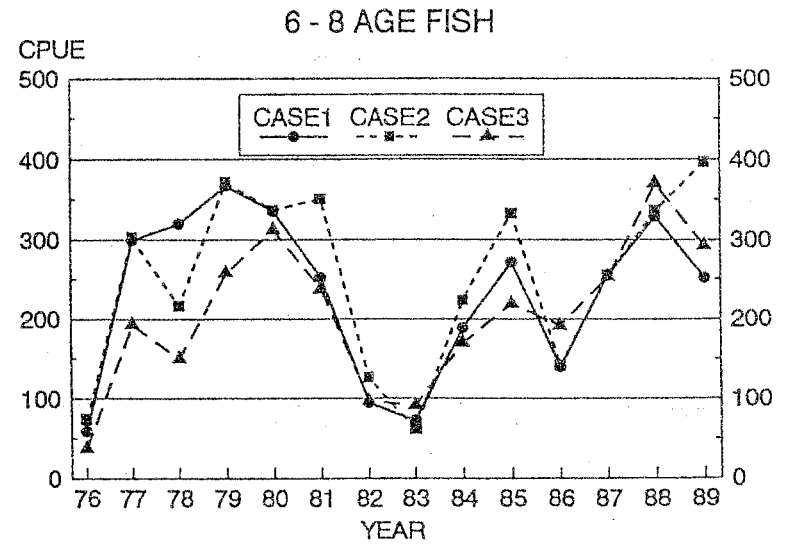
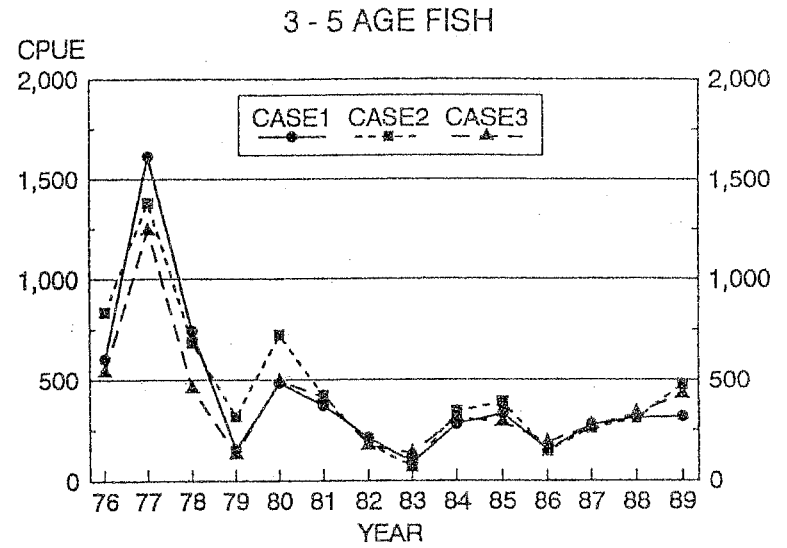


Fig. 5 Estimated least square mean in the General Linear Model for northwest Atlantic bluefin. The explanation of "CASE" is given in the text.