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THE CPUE TREND FOR ATLANTIC BLUE MARLIN CAUGHT BY JAPANESE LONGLINE FISHERY

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SUMMARY

CPUEs of Atlantic blue marlin (Makaira nigricans) caught by Japanese longline fishery were standardized by General Linear Model (GLM) and Honma method. Both CPUEs of GLM and Honma method showned a downward trend until 1978 then a upword trend gradually. The effort of gear configuration was also considered in the analysis.

RESUME

La CPUE du makaire bleu (Makaira nigricans) capturé par la pêcherie palangrière japonaise a été standardisée au moyen du modèle linéaire généralisé (GLM) et de la méthode de Honma. La CPUE du GLM et la méthode de Honma montraient toutes deux une tendance décroissante jusqu'en 1978, puis une tendance graduelle à la hausse. L'analyse tenait également compte de la configuration des engins.

RESUMEN

Las CPUEs de aguja azul (Makaira nigricans) capturadas por la pesquería de palangre japonesa, se normalizaron por medio del Modelo Lineal Generalizado (GLM) y el método Honma. Tanto la CPUE del GLM como la del método Honma mostraban una tendencia descendente hasta 1978 y a partir de entonces, una tendencia gradual hacia el alza. En el análisis se consideró también el esfuerzo de configuración del arte.

1. INTRODUCTION

The Atlantic blue marlin was caught by Japanese longline fishery incidentally as other billfishes. This fishery covers from the tropical to temperate waters and partly overlapped the distribution of blue marlin. However fishing ground were changed drastically because of taget species change (Uozumi and Nakano SCRS/92/65). The longline CPUEs for this species have been provided by Honma method (Kikawa and Honma 1980, 1983 and Watanabe et al. 1989). In this paper, standardized CPUE series for blue marlin were provided using General Linear Model (GLM) and Honma method.

2. MATERIALS AND METHODS

2.1 Basic data.

The basic data for this study were obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries (NRIFSF) for 1956-1989.

We used same type of two data sets as Nakano and Uozumi (SCRS/92/63). The data set 1 is sampling data with gear configuration and the data set 2 is same as Task II catch and effort data

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submitted to the ICCAT. CPUE was calculated as catch in number of fish per 1000 hooks. Observations with less than 5,000 hooks and 0 catch were excluded from the analysis.

2.2 Adjustment for the difference of gear efficiency.

The difference of gear efficiency in catching Swordfish and billfishes by the Japanese longline fishery were reported by Koido and Yonemori (1986) in the Atlantic and Suzuki et al. (1977) in the Pacific, respectively. Then gear efficiency parameter was included in the GLM model analysis using data set 1.

2.3 Selection of the model.

For the analysis of data set 1, year, fishing season, fishing area and gear configuration were included as main effects in the model. Years ranged from 1975 to 1989. Quarter-of-the-year were selected as fishing season. Areas were selected same as Nakano and Uozumi (SCRS/92/63) because distribution of blue marlin is similar to white marlin (Fig.1). The gear configuration were categorized to 3 levels (4-8, 9-11 and 12-15 hooks between the floats) according to the report of Uozumi et al. (1992) and results of preliminary runs in which all 12 levels of gear were kept separately without any interaction term. The 0 catch observations were dropped from the analysis with same reason of white marlin (Nakano and Uozumi SCRS/92/63).

The multiplicative model was selected. The model is:

$$LOG\ (CPUE_{ijkl}) = \mu + Y_i + Q_j + A_k + G_l + Interaction + e_{ijkl}$$

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,

Y_i: effect of year i,

Q_j: effect of quarter j,

A_k: effect of area k,

G_l: effect of gear l,

Interaction: any combination of two way interaction except for year term.

LOG ($CPUE_{ijkl}$) = ì@+ Y_i + Q_j + A_k + G_l + Interaction + e_{ijkl}

The best model was selected by AIC among the tested models. AIC is:

AIC = X log(MSE) + 2 Y

where X is the number of observations, MSE is mean square error and Y is number of parameters to be estimated.

CPUEs were estimated for four units where are Total Atlantic (Areas 1-11 in Fig.1), North Atlantic (Areas 1-7), South Atlantic (Areas 8-11) and North-west Atlantic (Areas 1-4) considering the stock structure.

For the analysis of data set 2, same parameters were included as main effects in the model except gear effect. Years covered from 1960 to 1989. Fishing season were same as data set 1. Areas were selected as Fig.5 and outsides of these areas were not included for analysis because of small number of observation. The 0 catch observations were dropped from the analysis. CPUE was only estimated for Total Atlantic.

Calculation was performed through computer software, 'SAS Ver. 6.03' on the UNIX workstation HP425t.

2.4 Honma method

For comparison of the results, the Honma method (Honma 1974) was adopted for the analysis. CPUEs were calculated for each North, South and total Atlantic unit using time series data of 1956-1989. 0 catch records were included for analysis. The "average years period" were calculated with 1965-1989.

After 1978, the data with the US 200 mile area were excluded from calculation because Japanese fishermen were not allowed to keep billfish by the US regulation.

3. RESULTS AND DISCUSSION

For data set 1, number of observations fitted to the final model were shown in Table 1 by main effect. The model with all the two way interaction was determined to be the best for Total, North, North-west and South Atlantic. In each unit area, it was found that some interaction term was not significant ($F < 2.0$). The model with some interaction term including YEAR was not estimated least square mean of LN(CPUE) because of not enough observation.

For the Total unit, the model with QUARTER*AREA, QUARTER*GEAR and AREA*GEAR in addition to all main efforts was selected (Table 2). For North unit, the model with four 2 way interaction was selected. For North-west and South unit, the same model with QUARTER*AREA, QUARTER*GEAR and AREA*GEAR in addition to all main efforts were selected.

The overall histograms of normalized residual from the final model were shown in Fig. 2. The distribution is close to normal distribution in most cases. In Fig. 3, also shown are the histograms of normalized residual by year. These histograms are close to normal distribution in most cases. The results of ANOVA indicated all models in Table 2 were statistically significant. The rate of variability explained by the final models (i.e., R^2) were in the range of 0.33-0.67.

Relative gear efficiency were estimated as 1.00, 1.46 and 0.99 for gear type 1, 2 and 3 (i.e. 4-7, 8-11 and 12-15 hooks per basket), respectively.

Estimated parameters, their standard error and standardized CPUEs were shown in Table 3. In Fig. 4, the standardized CPUEs were shown with lower and upper 95% confidence limits. All CPUE series indicate almost same upward trend except North-west unit.

For data set 2, number of observations fitted to the final model were shown in Table 4 by main effect. Three models were estimated from the data set. The model with two 2way interaction (QUARTER*AREA) was selected (Table 5).

The overall histograms of normalized residual from the final model were shown in Fig. 6. The distribution is fairy close to normal distribution. In Fig. 8, also shown are the histograms of normalized residual by year. The results of ANOVA indicated all models in Table 5 were statistically significant. The rate of variability explained by the final model(i.e., R^2) was 0.54.

Estimated parameters, their standard error and standardized CPUEs were shown in Table 6. In Fig. 7, the standardized CPUEs were shown with lower and upper 95% confidence limits. The CPUE series indicate down trend until 1977 and up gradually.

The results of Honma methods were shown in Table 7 and Fig.9 which indicate almost same trends of GLM model. It showed less effect of deep longline gear after 1978 using the gear efficiency obtained from GLM analysis.

Although no difference was shown in CPUE trend estimated by GLM and Honma method, we suggest the results of GLM analysis be better estimates because of statistical superiority. The CPUE trend of blue marlin was better estimated than white marlin because of larger number of observation (Nakano and Uozumi SCRS/92/63). However it should be interpret carefully because of the difference between distribution of fish and effort.

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Table. 1. Number of observations in the final models of blue marlin by main effect including gear effect.

Unit	Total Atlantic	North	North-west	South
Main Effect	No. of Observation	No. of Observation	No. of Observation	No. of Observation
Year 75	249	192	99	57
76	187	174	124	13
77	126	95	59	31
78	104	78	12	26
79	161	74	38	87
80	332	161	23	171
81	381	243	83	138
82	641	396	85	245
83	315	136	39	179
84	527	195	61	332
85	765	297	53	468
86	425	177	48	248
87	326	138	53	188
88	623	184	41	439
89	860	373	56	487
QT 1	1490	528	120	962
2	985	596	164	389
3	1744	1003	345	741
4	1803	786	245	1017
Gear 1	1418	989	568	429
2	2435	1334	277	1101
3	2169	590	29	1579
Area 1	231	231	231	
2	134	134	134	
3	338	338	338	
4	171	171	171	
5	329	329		
6	918	918		
7	792	792		
8	498			498
9	690			690
10	618			618
11	1303			1303
Total	6022	2913	874	3109

Table. 2. Results of ANOVA for GLM analysis applied to Atlantic blue marlin caught by the Japanese longline fishery.

Total Atlantic

Model	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F Value	R-Square	AIC
Y+Q+A+G	Model	29	2995.46	103.29	121.62	0.371	-953.661
	Error	5992	5089.06	0.85			
	Total	6020	8084.52				
Y+Q+A+G +Q*A	Model	59	3628.26	61.5	82.28	0.449	-1639.282
	Error	5962	4456.26	0.75			
	Total	6021	8751.21				
Y+Q+A+G +Q*G	Model	35	3144.07	89.83	108.84	0.389	-1120.133
	Error	5986	4940.45	0.83			
	Total	6021	8084.52				
Y+Q+A+G +A*G	Model	49	3125.19	63.78	76.8	0.387	-1069.16
	Error	5972	4959.33	0.83			
	Total	6021	8084.52				
Y+Q+A+G +Q*G+A*G	Model	55	3262.76	59.92	73.4	0.404	-1226.563
	Error	5966	4821.77	0.81			
	Total	6021	8084.52				
Y+Q+A+G +Q*A+A*G	Model	79	3724.14	47.14	64.24	0.461	-1784.259
	Error	5942	4360.38	0.73			
	Total	6021	8084.52				
Y+Q+A+G +Q*A+Q*G	Model	65	3667.1	56.42	73.06	0.454	-1733.989
	Error	5956	4417.43	0.74			
	Total	6021	8084.52				
Y+Q+A+G +Q*A+Q*G +A*G	Model	85	3750.73	44.13	60.44	0.464	-1809.094
	Error	5936	4333.79	0.73			
	Total	6021	8084.52				

North Unit

Model	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F Value	R-Square	AIC
Y+Q+A+G	Model	25	2456.33	98.25	102.01	0.469	-83.517
	Error	2887	2780.59	0.96			
	Total	2912	5236.92				
Y+Q+A+G +Q*A	Model	43	2751.38	63.99	73.86	0.525	-374.281
	Error	2869	2485.53	0.87			
	Total	2912	5236.92				
Y+Q+A+G +Q*G	Model	31	2583.11	83.33	90.46	0.493	-207.458
	Error	2881	2653.81	0.92			
	Total	2912	5236.92				
Y+Q+A+G +A*G	Model	37	2529.78	68.37	72.61	0.483	-137.497
	Error	2875	2707.14	0.94			
	Total	2912	5236.92				
Y+Q+A+G +Q*A+A*G	Model	55	2825.05	51.36	60.84	0.539	-437.925
	Error	2857	2411.87	0.84			
	Total	2912	5236.92				
Y+Q+A+G +Q*A+Q*G	Model	49	2924.4	57.64	68.4	0.539	-449.136
	Error	2863	2412.52	0.84			
	Total	2912	5236.92				
Y+Q+A+G +Q*G+A*G	Model	43	2646.8	61.55	98.18	0.505	-254.225
	Error	2869	2590.11	0.9			
	Total	2912	5236.92				
Y+Q+A+G +Q*A+Q*G +A*G	Model	61	2883.25	47.27	57.25	0.551	-497.079
	Error	2851	2353.67	0.83			
	Total	2912	5236.92				

Table 2. Continued..

Northwest Unit

Model	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F Value	R-Square	AIC
Y+Q+A+G	Model	22	1704.69	77.49	56.13	0.592	304.431
	Error	851	1174.7	1.38			
	Total	873	2879.39				
Y+Q+A+G +Q*A	Model	31	1815.98	58.58	46.38	0.631	235.439
	Error	842	1063.41	1.27			
	Total	873	2879.39				
Y+Q+A+G +Q*G	Model	28	1791.46	63.98	49.69	0.622	249.364
	Error	845	1087.93	1.29			
	Total	873	2879.39				
Y+Q+A+G +A*G	Model	28	1751.57	62.56	46.87	0.608	280.837
	Error	845	1127.82	1.33			
	Total	873	2879.39				
Y+Q+A+G +Q*A+Q*G	Model	37	1888.35	51.04	43.05	0.656	185.839
	Error	836	991.04	1.19			
	Total	873	2879.39				
Y+Q+A+G +Q*A+A*G	Model	37	1864.72	50.4	41.52	0.648	206.434
	Error	836	1014.67	1.21			
	Total	873	2879.39				
Y+Q+A+G +Q*G+A*G	Model	34	1819.28	53.51	42.35	0.632	238.719
	Error	839	1060.1	1.26			
	Total	873	2879.39				
Y+Q+A+G +Q*A+Q*G +A*G	Model	43	1916.55	44.57	38.42	0.666	172.603
	Error	830	962.83	1.16			
	Total	873	2879.39				

South Unit

Model	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F Value	R-Square	AIC
Y+Q+A+G	Model	22	833.67	37.89	58.79	0.295	-1342.441
	Error	3086	1989.16	0.64			
	Total	3108	2822.83				
Y+Q+A+G +Q*A	Model	31	901.68	29.09	46.59	0.319	-1432.602
	Error	3077	1921.15	0.62			
	Total	3108	2822.83				
Y+Q+A+G +A*G	Model	28	857.51	30.63	48	0.304	-1367.928
	Error	3080	1965.32	0.64			
	Total	3108	2822.83				
Y+Q+A+G +Q*G	Model	28	863.99	30.86	48.52	0.306	-1378.204
	Error	3080	1958.84	0.64			
	Total	3108	2822.83				
Y+Q+A+G +Q*A+A*G	Model	37	920.53	24.88	40.16	0.326	-1451.27
	Error	3071	1902.29	0.62			
	Total	3108	2822.83				
Y+Q+A+G +Q*G+A*G	Model	34	894.24	26.3	41.92	0.318	-1414.584
	Error	3074	1928.59	0.63			
	Total	3108	2822.83				
Y+Q+A+G +Q*A+Q*G +A*G	Model	43	940.65	21.88	35.62	0.333	-1472.318
	Error	3063	1882.18	0.61			
	Total	3108	2822.83				

Table. 3. Standardized CPUE for Atlantic blue marlin, 1975-1989.

	TOTAL ATLANTIC			NORTH ATLANTIC			NORTHWEST ATLANTIC			SOUTH ATLANTIC		
Year	Parameter	Standard Error	Standar-dized CPU	Parameter	Standard Error	Standar-dized CPU	Parameter	Standard Error	Standar-dized CPU	Parameter	Standard Error	Standar-dized CPU
75	-1.8719	0.0755	0.1538	-1.8059	0.1034	0.1643	-1.1000	0.2034	0.3329	-1.7917	0.1182	0.1667
76	-2.0046	0.0831	0.1347	-1.9586	0.1042	0.1411	-1.4733	0.1920	0.2292	-2.3722	0.2291	0.0933
77	-2.4081	0.0945	0.0900	-2.4423	0.1245	0.0870	-1.9422	0.2262	0.1434	-2.1459	0.1569	0.1170
78	-2.2932	0.0975	0.1009	-2.3084	0.1270	0.0994	-1.9411	0.3573	0.1435	-1.9577	0.1724	0.1412
79	-2.0815	0.0825	0.1247	-2.2157	0.1272	0.1091	-1.9749	0.2388	0.1388	-1.7471	0.1031	0.1743
80	-1.9996	0.0632	0.1354	-1.9404	0.0987	0.1437	-1.5520	0.2832	0.2118	-1.9588	0.0699	0.1410
81	-2.0801	0.0598	0.1249	-2.2742	0.0872	0.1029	-2.2226	0.1938	0.1083	-1.6809	0.0758	0.1862
82	-1.8477	0.0519	0.1576	-1.8599	0.0781	0.1557	-1.5931	0.1874	0.2033	-1.7245	0.0595	0.1783
83	-1.9172	0.0628	0.1470	-1.8203	0.1017	0.1620	-1.7041	0.2283	0.1819	-1.8291	0.0671	0.1606
84	-1.8640	0.0548	0.1550	-1.7517	0.0910	0.1735	-1.5519	0.1983	0.2119	-1.7737	0.0547	0.1697
85	-1.8231	0.0504	0.1615	-1.8798	0.0828	0.1526	-1.6341	0.2072	0.1951	-1.6345	0.0482	0.1950
86	-1.9966	0.0579	0.1358	-2.0633	0.0939	0.1270	-2.1477	0.2168	0.1668	-1.7920	0.0601	0.1666
87	-1.8967	0.0622	0.1501	-2.1371	0.1007	0.1180	-2.5485	0.2085	0.0782	-1.5665	0.0669	0.2088
88	-1.8620	0.0539	0.1554	-1.8802	0.0942	0.1526	-2.2302	0.2231	0.1075	-1.6807	0.0512	0.1863
89	-1.7524	0.0502	0.1733	-1.8536	0.0813	0.1567	-1.7327	0.2034	0.1768	-1.5266	0.0496	0.2173

Table. 4. Number of observations in the final models by main effect without deep longline parameter

Main Effect	No. of Observation	Main Effect	No. of Observation
Year 60	157	82	297
61	242	83	176
62	272	84	246
63	373	85	340
64	482	86	235
65	563	87	189
66	357	88	295
67	296	89	402
68	255	QT 1	1568
69	236	2	1742
70	245	3	2258
71	341	4	1858
72	194	Area 1	486
73	141	2	852
74	125	3	811
75	190	4	479
76	136	5	1007
77	93	6	925
78	65	7	1284
79	110	8	1582
80	171		
81	202	Total	7426

Table 5. Results of ANOVA for GLM analysis without gear effect applied to Atlantic blue marlin caught by the Japanese longline fishery without gear effect.

TOTAL ATLANTIC

Model	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F Value	R square	AIC
Y+Q+A	Model	39	6848.31	175.6	166.15	0.467	416.604
	Error	7386	7805.89	1.06			
	Total	7425	14654.2				
Y+Q+A +Q*A	Model	60	7604.16	126.74	132.4	0.519	-316.525
	Error	7365	7050.04	0.96			
	Total	7425	14654.2				

Table. 6. Standardized CPUE of Atlantic blue marlin for total Atlantic, 1960-1989 without gear effect.

Year	Stan Parameter	Standard Error	Standar-dized CPUE	Year	Sta Parameter	Standard Error	Standar-dized CPUE
60	-0.5114	0.0799	0.5996	75	-2.0048	0.0723	0.1347
61	-0.0914	0.0649	0.9126	76	-2.0347	0.0855	0.1307
62	-0.1842	0.0610	0.8318	77	-2.6059	0.1026	0.0738
63	-0.4869	0.0522	0.6145	78	-2.5220	0.1223	0.0803
64	-0.7384	0.0459	0.4779	79	-2.2387	0.0947	0.1066
65	-1.2356	0.0423	0.2907	80	-2.1682	0.0759	0.1144
66	-1.2033	0.0532	0.3002	81	-2.2638	0.0696	0.1040
67	-1.4363	0.0581	0.2378	82	-1.7811	0.0578	0.1685
68	-1.3153	0.0625	0.2684	83	-1.8420	0.0745	0.1585
69	-1.2155	0.0647	0.2966	84	-1.7480	0.0631	0.1741
70	-1.3913	0.0636	0.2487	85	-1.6435	0.0544	0.1933
71	-1.7849	0.0538	0.1678	86	-2.0003	0.0650	0.1353
72	-1.8777	0.0713	0.1529	87	-1.8183	0.0723	0.1623
73	-1.9474	0.0840	0.1426	88	-1.8219	0.0585	0.1617
74	-1.6872	0.0891	0.1850	89	-1.7271	0.0505	0.1778

Table. 7. Standardized CPUE of Atlantic blue marlin for North, south and total Atlantic units, with gear effect (above) and without gear effect (below) using Honma method.

Year	NORTH			SOUTH			TOTAL		
	C	X	U	C	X	U	C	X	U
WITH GEAR EFFECT									
1978	409	1061	0.039	153	438	0.035	562	1579	0.036
1979	694	1620	0.043	559	1681	0.033	1253	3105	0.040
1980	1627	3135	0.052	988	5054	0.020	2615	7483	0.035
1981	3780	6556	0.058	1221	5075	0.024	5001	11726	0.043
1982	7156	14434	0.050	4503	19094	0.024	11659	30656	0.038
1983	2516	5472	0.046	2280	11420	0.020	4796	14427	0.033
1984	3960	6518	0.061	4224	16922	0.025	8184	20033	0.041
1985	4745	9579	0.050	6366	23685	0.027	11111	28461	0.039
1986	1849	4259	0.043	3194	14911	0.021	5043	15522	0.032
1987	752	2382	0.032	3415	12885	0.027	4167	11715	0.036
1988	2094	4434	0.047	5804	24368	0.024	7898	22702	0.035
1989	6982	13351	0.052	9364	32893	0.028	16346	40350	0.041
WITHOUT GEAR EFFECT									
1956	96	29	0.327	404	204	0.198	500	191	0.261
1957	1130	343	0.330	7574	4040	0.187	8704	3465	0.251
1958	3399	3939	0.086	6568	5742	0.114	9967	8817	0.113
1959	6347	5570	0.114	16260	13927	0.117	22607	16741	0.135
1960	5829	5536	0.105	21251	19149	0.111	27080	19730	0.137
1961	4213	2686	0.157	38788	23772	0.163	43001	19901	0.216
1962	51958	22864	0.227	59677	48295	0.124	111635	58907	0.190
1963	51838	37302	0.139	43855	47585	0.092	95693	74801	0.128
1964	49922	53110	0.094	33672	57320	0.059	83594	99851	0.084
1965	27239	41486	0.066	17627	45387	0.039	44866	79195	0.057
1966	11240	21662	0.052	10232	31047	0.033	21472	45934	0.047
1967	5038	8843	0.057	5567	15744	0.035	10605	21098	0.050
1968	4771	8765	0.054	4274	10810	0.040	9045	17308	0.052
1969	9880	13986	0.071	3740	9181	0.041	13620	22291	0.061
1970	8897	15026	0.059	2466	6728	0.037	11363	21690	0.052
1971	16352	31621	0.052	1773	5084	0.035	18125	40823	0.044
1972	4350	9808	0.044	954	2866	0.033	5304	13325	0.040
1973	3284	5677	0.058	1362	2910	0.047	4646	8676	0.054
1974	3389	6245	0.054	204	446	0.046	3593	7516	0.048
1975	8248	17009	0.048	587	1705	0.034	8835	20436	0.043
1976	3298	8398	0.039	39	206	0.019	3337	9590	0.035
1977	1269	3677	0.035	166	568	0.029	1435	4935	0.029
1978	409	1040	0.039	153	438	0.035	562	1555	0.036
1979	694	1532	0.045	559	1658	0.034	1253	2987	0.042
1980	1627	2931	0.056	988	4162	0.024	2615	6575	0.040
1981	3780	6075	0.062	1221	4221	0.029	5001	10524	0.048
1982	7156	12331	0.058	4503	15518	0.029	11659	25681	0.045
1983	2516	4189	0.060	2280	9446	0.024	4796	11513	0.042
1984	3960	5206	0.076	4224	14295	0.030	8184	16537	0.049
1985	4745	7926	0.060	6366	20383	0.031	11111	24114	0.046
1986	1849	3575	0.052	3194	12280	0.026	5043	12873	0.039
1987	752	2149	0.035	3415	10676	0.032	4167	9930	0.042
1988	2094	3755	0.056	5804	21431	0.027	7898	19807	0.040
1989	6982	11613	0.060	9364	28332	0.033	16346	34919	0.047

* C: catch, X: effective effort (x1000), U: CPUE(C/1000 hooks)

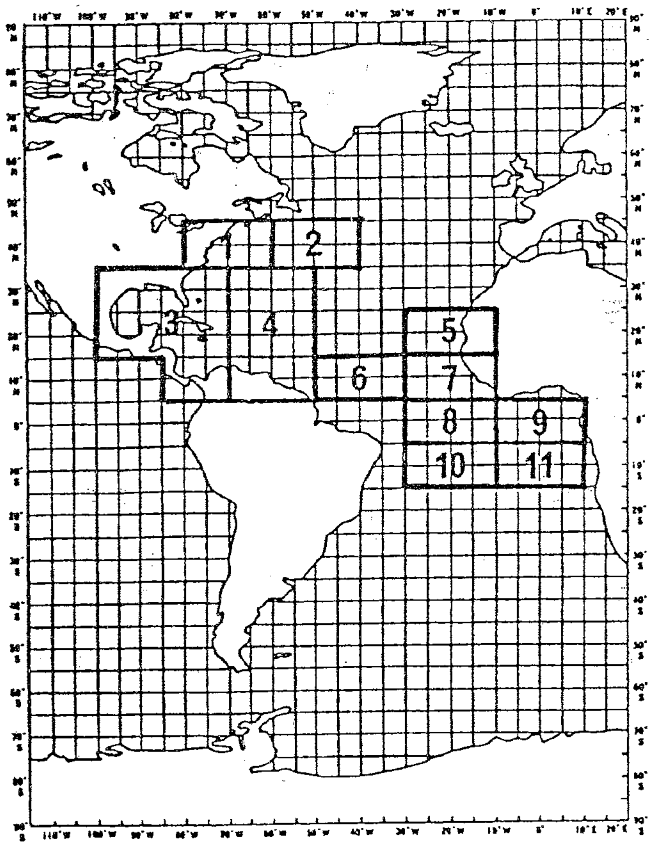

Figure 1. Area division used for GLM analysis with data set 1 for Atlantic blue marlin caught by the Japanese longline fishery.

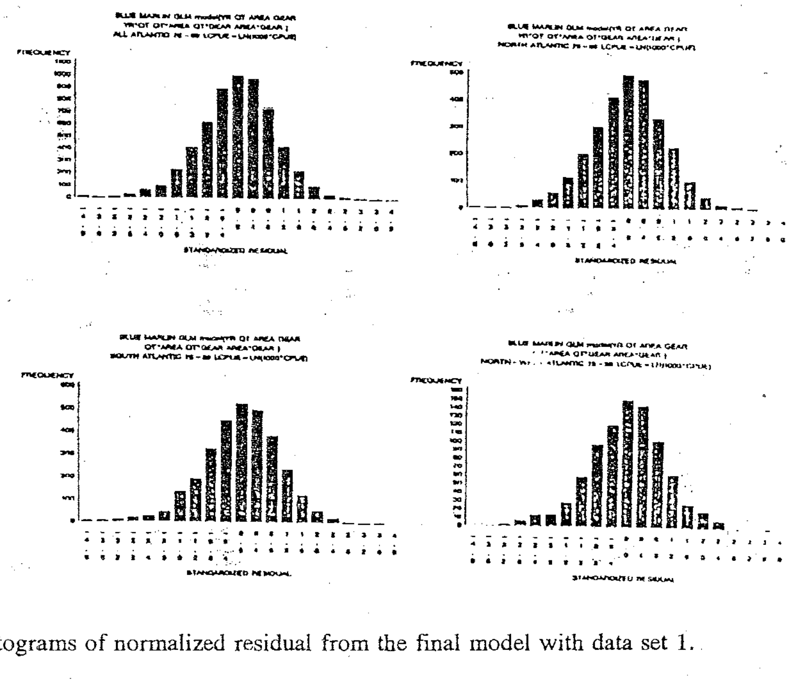

Figure 2. Overall histograms of normalized residual from the final model with data set 1.

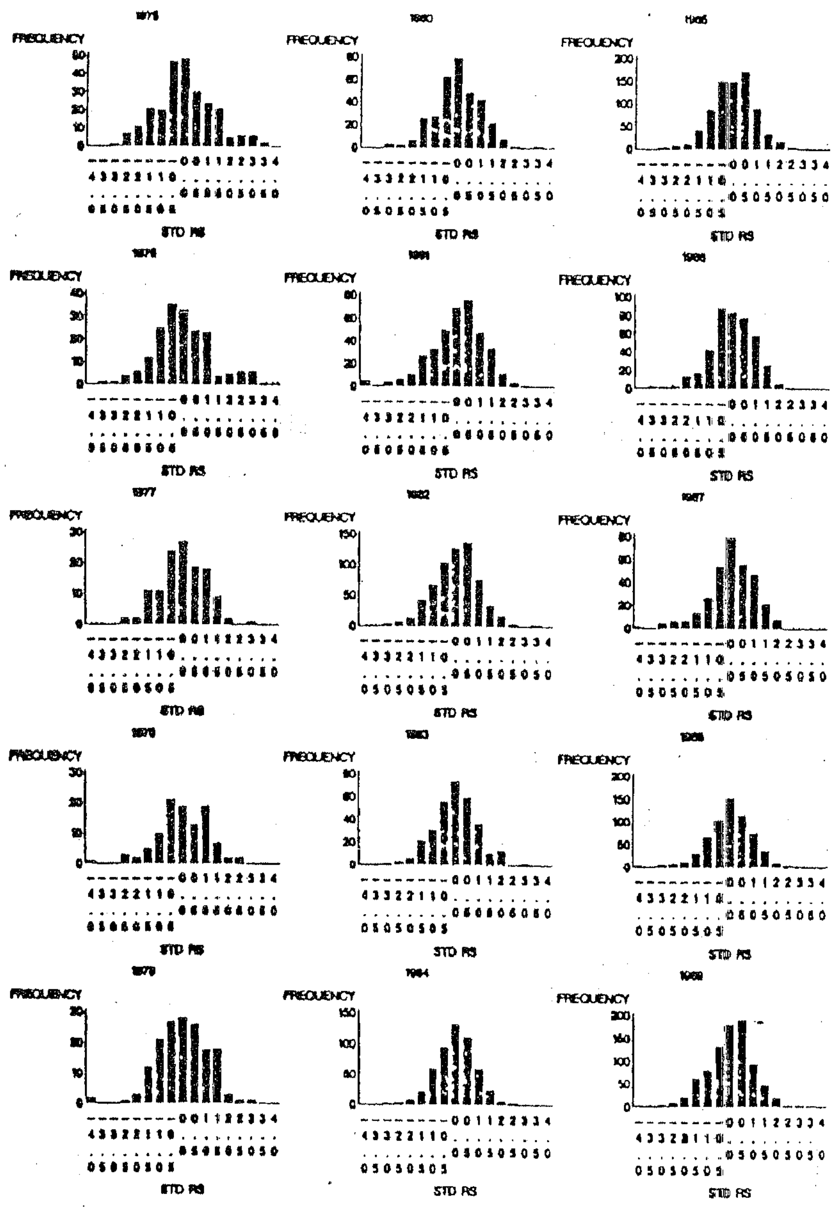

Figure 3. Histograms of normalized residual plotted by year with data set 1. All Atlantic unit.

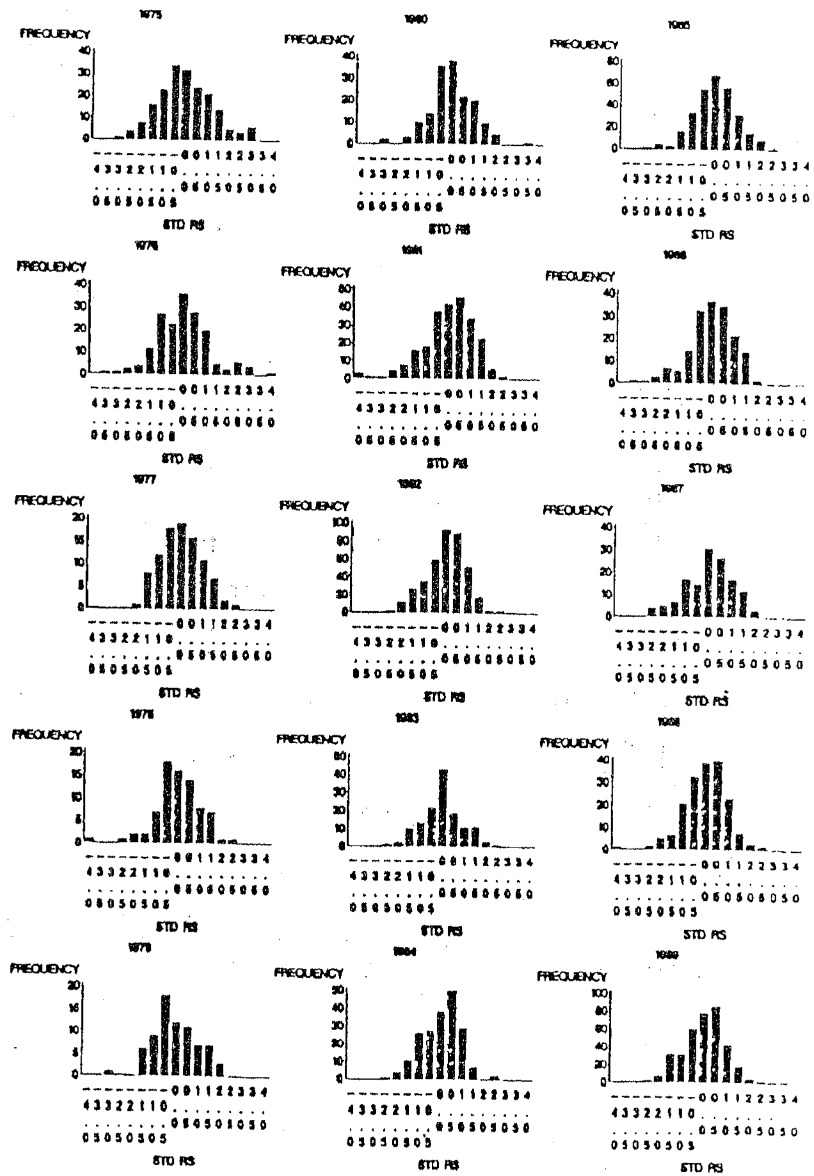

Figure. 3. Continued. North unit.

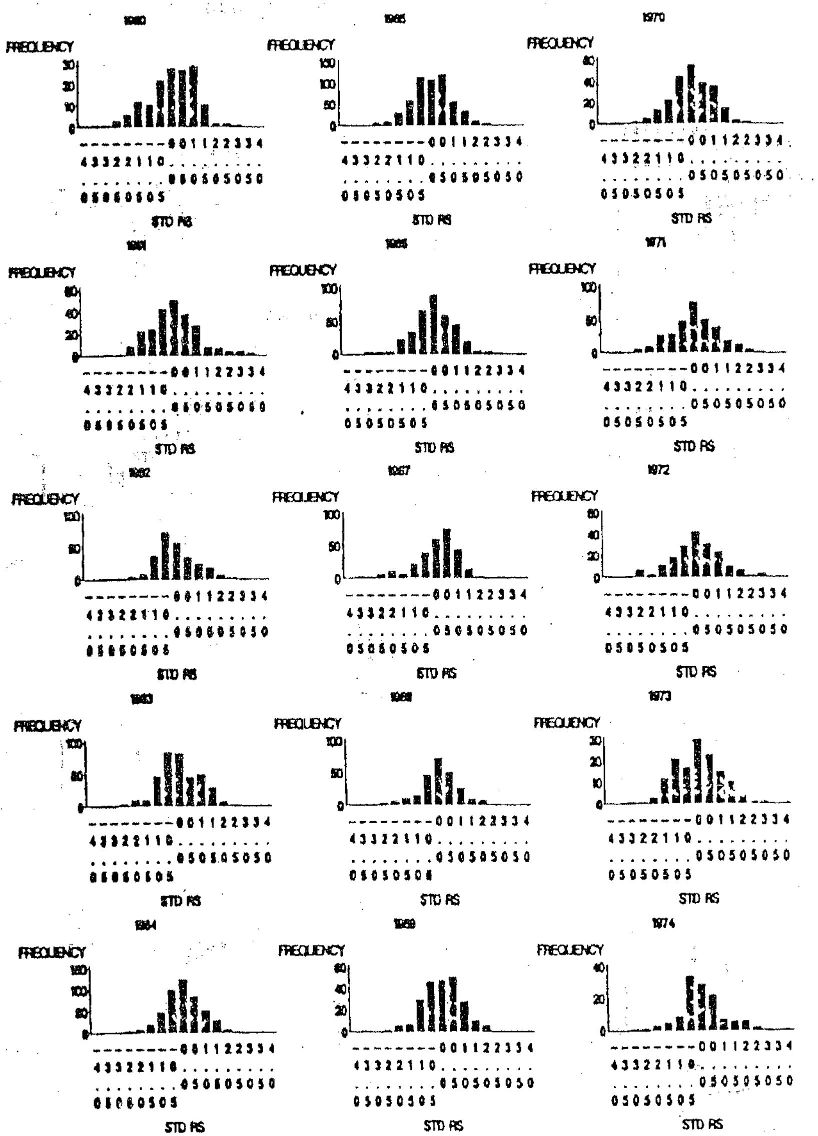

Figure 3. Histograms of normalized residual plotted by year with data set 2.

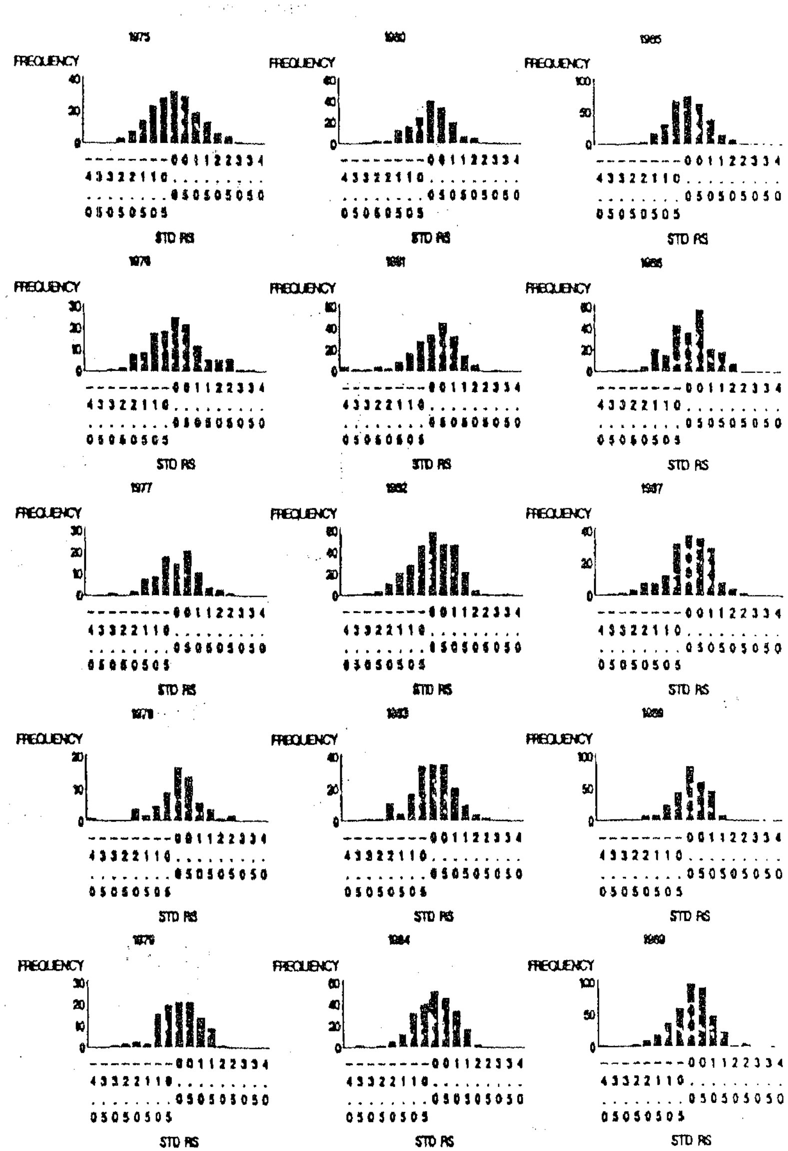

Figure. 3. Continued.

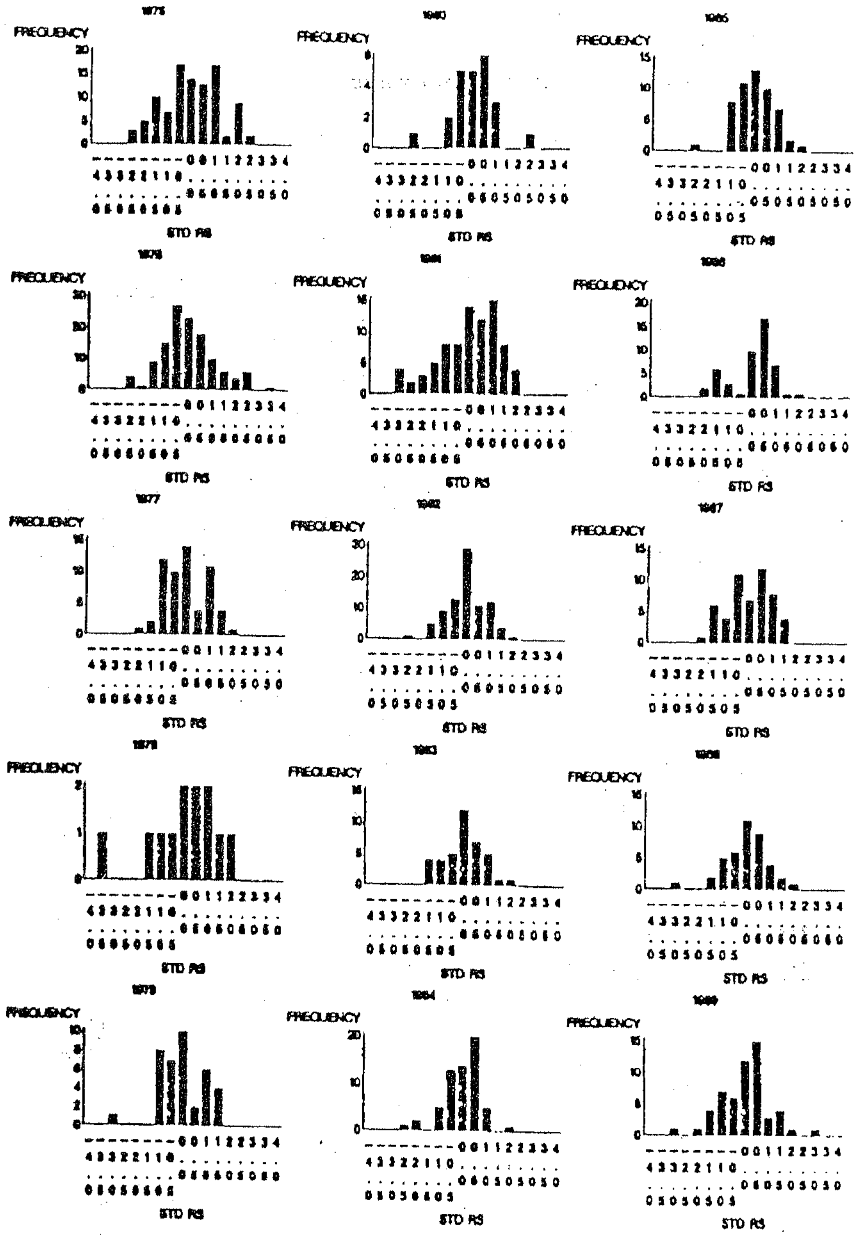

Figure 3. Continued. Northwest unit.

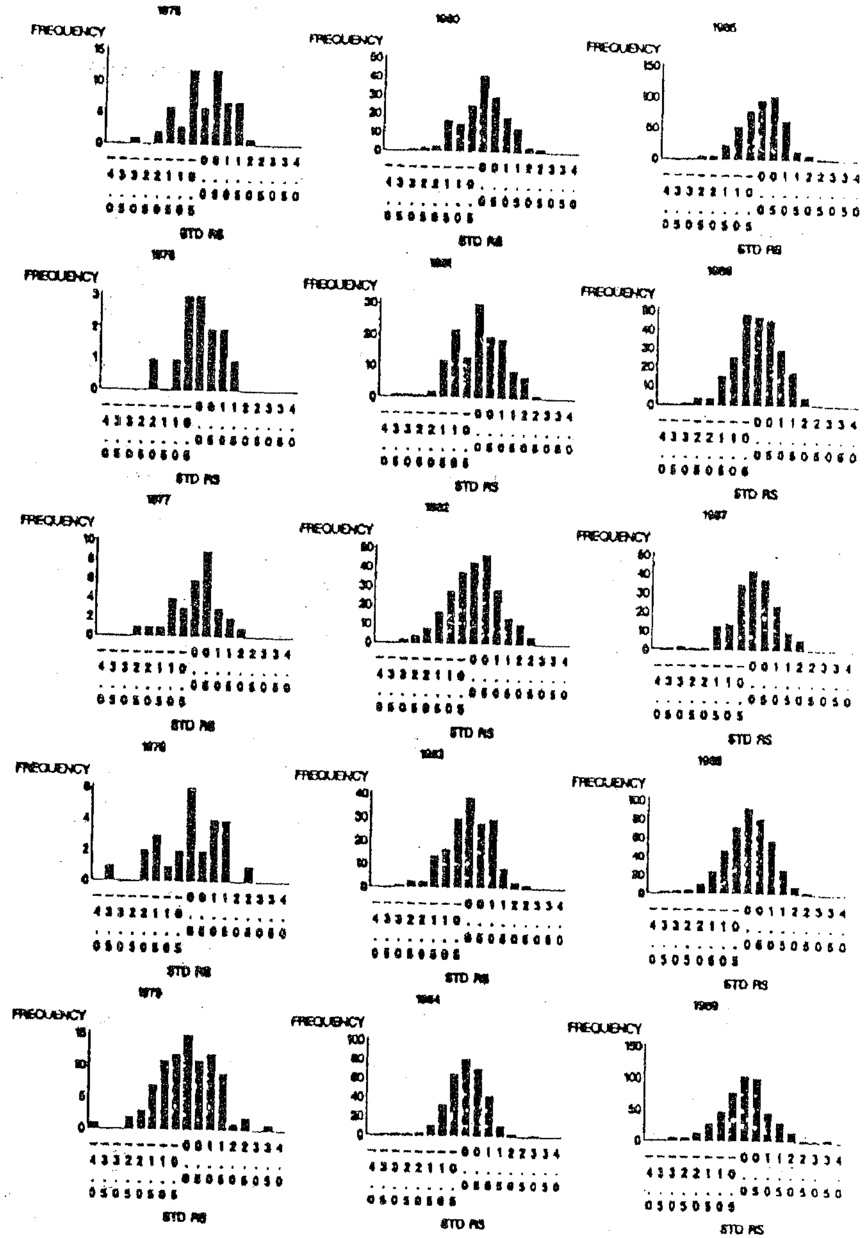

Figure. 3. Continued. South unit.

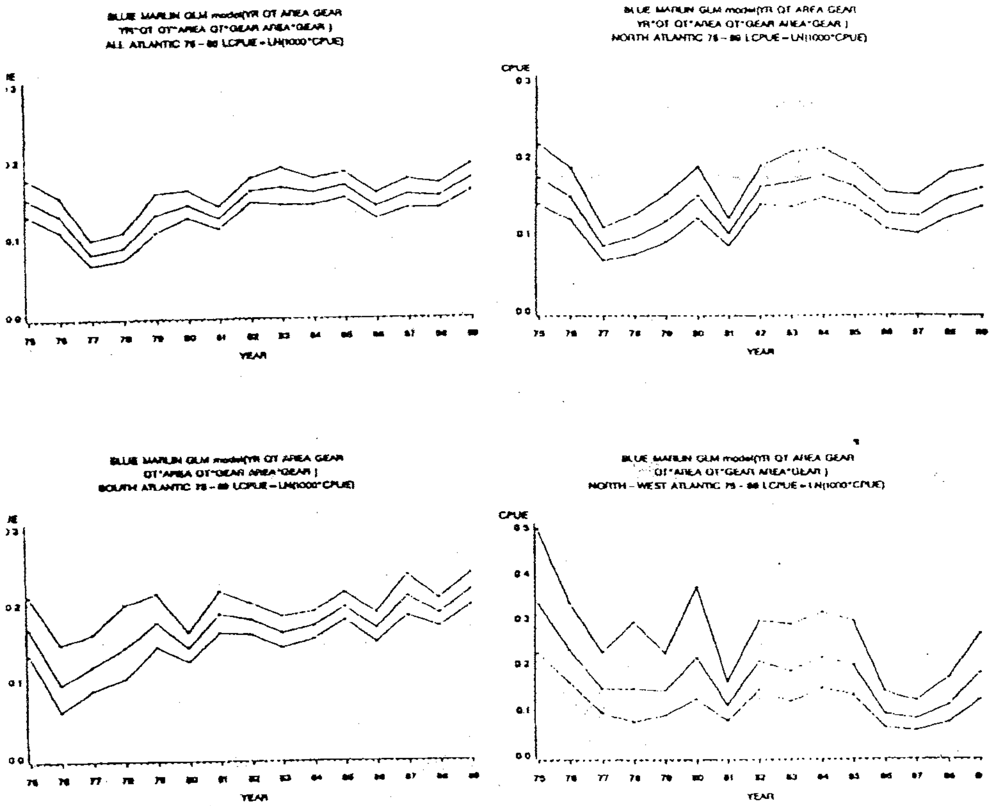

Figure 4. Annual change of standardized CPUE with data set 1. Upper and lower line indicates 95% confidence limits.

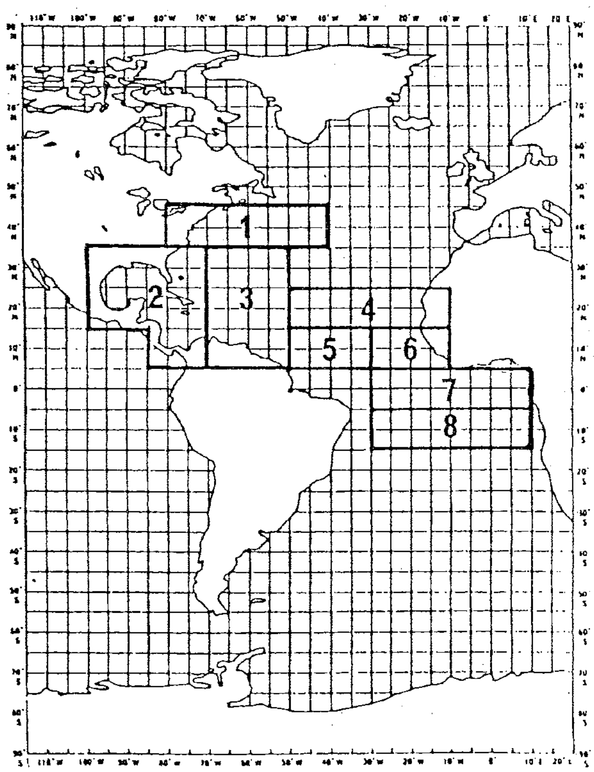

Figure 5. Area division used for GLM analysis with data set 2 for Atlantic blue marlin caught by the Japanese longline fishery.

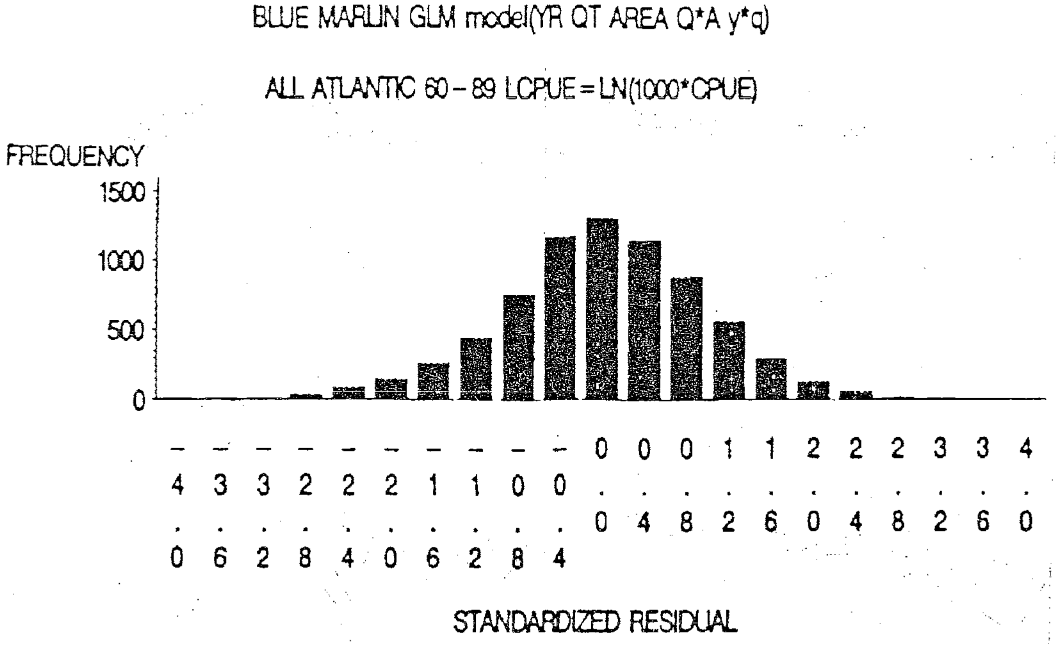

Figure 6. Overall histograms of normalized residual from the final model with data set 2.

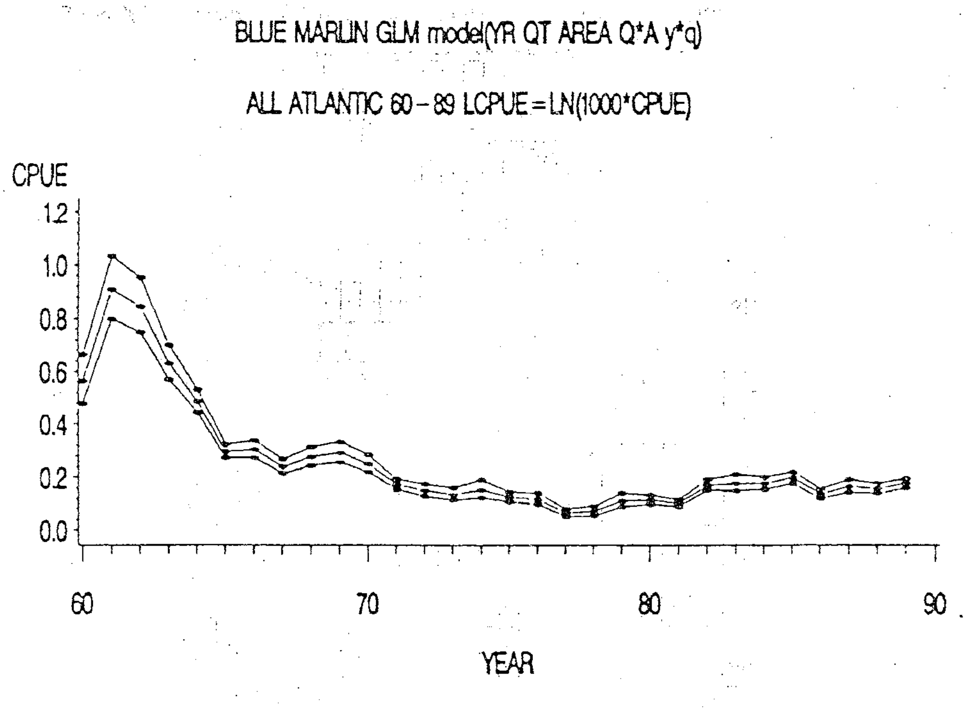

Figure 7. Annual change of standardized CPUE with data set 2. Upper and lower line indicates 95% confidence limits.

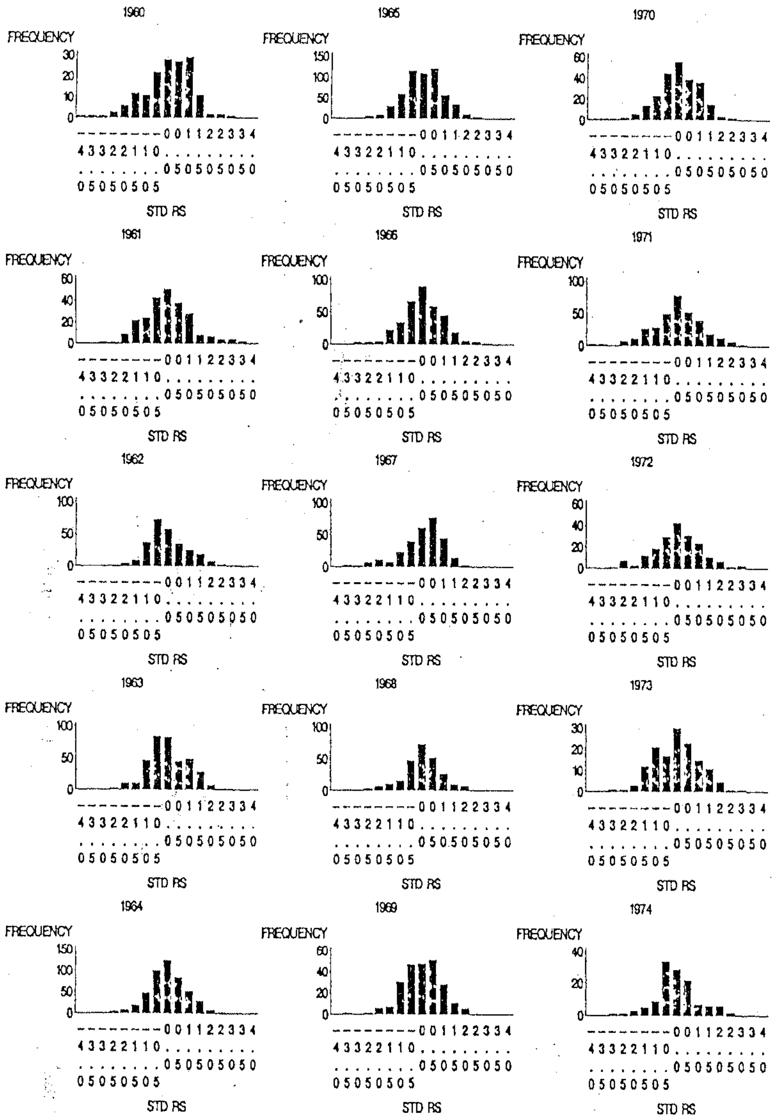

Fig. 8. Histograms of normalized residual plotted by year with data set 2.

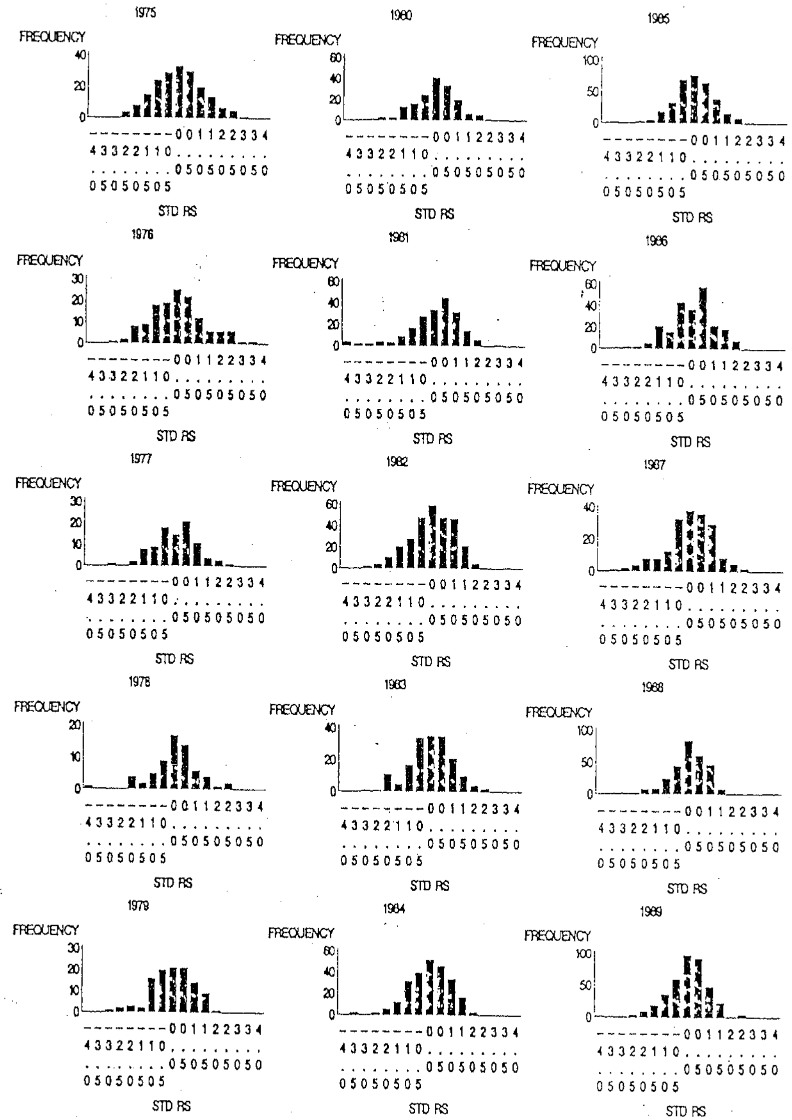

Fig. 8. Continued.

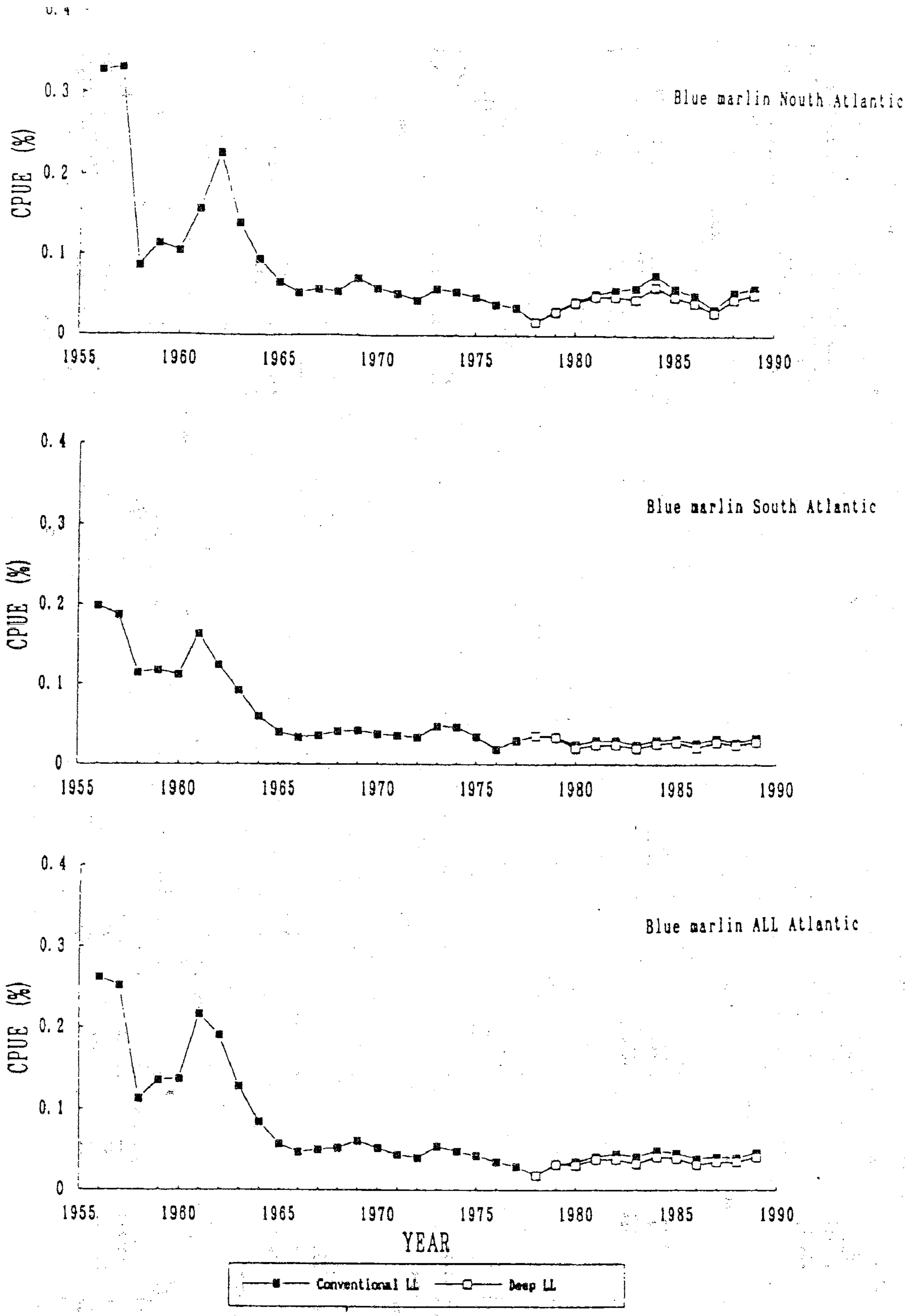

Figure 9. Annual change of standardized CPUE using Honma method.