UPDATED STANDARDIZED CPUE OF ATLANTIC BLUEFIN CAUGHT BY THE JAPANESE LONGLINE FISHERY IN THE EASTERN ATLANTIC AND MEDITERRANEAN SEA

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1.Introduction

CPUE from the Japanese longline fishery has been one of the important abundance indices for the adult stock of the eastern bluefin since this fishery has long history of operation and covers large geographical area of this stock. The fishery data were standardized to various factors which affect CPUE of this species. The method utilized in the past was so-called General Linear Model (GLM). Although It is a very convenient, flexible and powerful tool, there are some drawbacks. For example, since we apply multiplicative model, zero catch observations cannot directly be included in the calculation. To avoid this, usually we add some small constant, but it is known that the results (i.e., estimated annual abundance) may differ according to the magnitude of the constant added to zero catch. In order to overcome this problem, catch model with Poisson distribution was applied to the longline data. Another problem which we encounter quite often is that the significance of interaction with YEAR-effect. It is difficult to extract annual abundance trend of the stock when YEAR-effect is included in the interaction term. In this paper, annual abundance was estimated by area-weighting according to the method of Nishida et al. (1994) when interaction with YEAR -effect was significant.

The fitting of Poisson distribution to model catch was done by GENMOD procedure of SAS/STAT statistical package (Ver. 6.09), which fits generalized linear model (GENMOD), as defined by Nelder and Wedderburn (1972). Under this procedure, many other distribution of exponential family such as normal, binomial, gamma and inverse Gaussian can be handled very easily. Parameters are obtained by maximum likelihood estimation with the algorithm of a ridge-stabilized Newton-Raphson method (SAS 1993).

2.Material and method

The Japanese longline catch and effort statistics for 1975-1993 were used. 1993 data is preliminary. There are two sets of data. One is aggregated data by month, 5-degree square and the number of branch lines between floats (Branch line data), which was used in the past study (Miyabe 1993), and another is set-by-set data (i.e., daily data). The former was constructed from the latter, so the difference is just the aggregation. In this paper, the later data are not thoroughly investigated due to the time constraint.

The geographical distribution of the catch and the size of the fish in the east Atlantic and Mediterranean Sea (east of 30W) were described in Miyabe (1993). Recent pattern of operation is similar except the increase of operation in the central north Atlantic (30-50N, 45-30W) since 1990 (Miyabe and Hiramatsu 1993). The time series is short though, annual abundance is estimated for this area as well as for the traditional east Atlantic-Mediterranean area. The catch data was sized to express the CPUE of 8 years old and older fish prior to the analysis as described in Miyabe (1993).

The model is similar multiplicative one but predict catch itself rather than CPUE as shown below:

$$E(C) = H \cdot \exp(\mu + Y + S + A + G + O + \text{Inter})$$

where E(C) : expectation of catch,
H : number of hooks,
μ : intercept,
Y : effect of Year,
S : effect of Season (month),
A : effect of Area,
G : effect of Gear (number of branch line between floats),
O : effect of other species caught,
Inter : two-way interaction term.

What is shown below is the summary of each main effect.

Main effect	East Atl. and Medit.	Central north Atl.
Year	1975-1993	1990-1993 (fishing year)
Season (month)	March - July	October - March
Area	5 Lat. X 10 Long. (Fig. 1)	two areas 30-40N, 40-50N (45-30W)
Gear	4 - 12 hooks	4 - 12 hooks
Other species	all other tunas (continuous variable)	all other tunas (continuous variable)

After several preliminary runs, above classifications for main effect were aggregated according to the number of available observations and difference in the parameter value. The number of observations by some of main effects were tabulated in Table 1.

In most analyses, overdispersion was observed, and so DSCALE option which estimates dispersion parameter was included. All statistics was adjusted according to the dispersion parameter appropriately.

3. Results and discussion

Factors in the final models chosen in this study are :

East and Medit. for Branch line and set-by-set data

Y+S+A+G+O+Y*S+Y*A+S*A

where the levels of main effects are
S : Mar, Apr, May, Jun+Jul,
A : 1, 2, 3+4, 5, 6+7,
G : 4-7, 8-11

Central north

Y+S+A+G+O+Y*A+S*A for Branch line data

Y+S+A+G+O+Y*S+Y*A+S*A for set-by-set data.

where the levels of main effects are
S : Oct+Nov, Dec, Jan, Feb,
A : 1, 2,
G : 4-7, 8-12.

The goodness of fit is shown in Table 2. Deviance (twice the difference between the maximum achievable log likelihood and the log likelihood at the maximum likelihood estimates) is much larger than the degree of freedom, so there are some room to improve fitting. The overall distribution of standardized residual (deviance residual) is shown in Fig. 2. It looks that the fitting is good for Branch line data but slightly skewed towards right for set-by-set data. This phenomena may lead to other optional model for bluefin catch such as negative binomial. In Table 3, likelihood ratio statistics is shown to see the significance of effects.

Since interaction term with YEAR main effect is significant in the final models, area-weighted annual abundance was calculated as follows.

$$E(CPUE_y) = \Sigma_y \Sigma_s \Sigma_a (P(CPUE_{ysa}) \cdot \text{Area index}_a)$$

where $E(CPUE_y)$: area weighted annual abundance,

$P(CPUE_{ysa})$: predicted CPUE by the model,

Area index : index of area which excludes land and adjusted to latitude.

The scaled annual abundance is presented in Fig. 3 and Table 4. There are very minor difference in the annual trends between the two data sets for both east Atlantic and Mediterranean and central north Atlantic areas. The estimate obtained by General Linear Model (GLM : Miyabe 1993) is also superimposed in the same graph. The overall trend is similar but the estimated annual abundance by GENMOD shows smaller fluctuation than the one by GLM.

The abundance trend for the age 8 and older fish stock in the eastern Atlantic has been decreasing, to about one third in the recent years, although the recent five year's index stayed stable. Time series in the central area is very short with aberant with 1993 data. As shown in Table 1, the number of observation in 1993 is very small and high season for fishing in that year was different from the previous years. Therefore 1993 index appears to need more detailed analysis when data processing is completed.

References

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Table 1. Number of observations used in GENMOD.

East BR

YEAR	MAR	APR	MAY	JUN	JUL	A1	A2	A3	A4	A5	A6	A7	TOTAL
75	13	21	26	18	9	18	29	2	9	14	9	6	87
76	11	24	25	6	11	11	25	0	10	14	10	7	77
77	9	11	24	12	9	7	26	0	11	13	7	1	65
78	14	17	18	9	2	21	15	2	13	4	5	0	60
79	13	8	12	9	5	7	9	7	14	3	6	1	47
80	11	17	19	2	1	11	17	1	7	6	6	2	50
81	19	14	10	2	0	12	12	0	10	8	2	1	45
82	10	14	23	18	13	3	9	6	37	11	11	1	78
83	17	24	24	7	14	16	9	7	30	11	11	2	86
84	24	28	25	20	9	18	22	2	33	11	12	8	106
85	2	15	22	6	4	5	7	0	17	5	10	5	49
86	11	17	19	9	3	5	13	4	20	7	7	3	59
87	16	21	25	3	2	5	19	2	12	16	9	4	67
88	16	16	18	6	3	1	17	1	15	12	9	4	59
89	14	23	31	2	1	2	27	3	24	8	4	3	71
90	18	30	35	13	1	18	24	9	28	9	8	1	97
91	16	26	26	19	7	22	13	17	28	9	5	0	94
92	18	28	30	16	12	23	12	17	33	10	5	4	104
93	6	29	29	17	18	30	4	13	26	8	8	10	99
TOTAL	258	383	441	194	124	235	309	93	377	179	144	63	1400

East set-by-set

YEAR	MAR	APR	MAY	JUN	JUL	A1	A2	A3	A4	A5	A6	A7	TOTAL
75	272	768	1606	207	251	828	1359	8	231	294	267	117	3104
76	147	765	761	118	266	114	938	3	81	390	267	264	2057
77	134	219	502	388	203	121	721	0	172	268	157	7	1446
78	317	304	205	126	12	340	216	33	308	21	44	2	964
79	133	201	223	165	48	47	365	47	202	36	63	10	770
80	206	387	323	18	4	268	444	7	39	61	103	16	938
81	309	352	179	27	0	267	245	0	209	112	30	4	867
82	78	319	573	485	335	27	172	43	948	332	264	4	1790
83	196	675	782	726	220	139	365	76	1516	224	266	13	2599
84	360	946	1042	561	275	232	621	23	1361	329	500	118	3184
85	41	693	672	57	41	36	192	0	400	71	715	90	1504
86	143	699	716	122	16	63	517	41	519	157	336	63	1696
87	232	590	429	93	7	107	587	6	197	179	229	46	1351
88	360	909	679	113	25	5	779	8	762	227	220	85	2086
89	212	635	401	63	12	14	737	21	370	43	93	45	1323
90	310	772	612	250	5	213	778	84	696	72	102	4	1949
91	159	739	779	532	60	360	328	338	984	156	102	1	2269
92	184	801	819	774	156	654	188	353	1201	184	122	32	2734
93	189	751	685	448	124	746	45	315	673	61	184	173	2197
TOTAL	3982	11525	11988	5273	2060	4581	9597	1406	10869	3217	4064	1094	34828

Table 1. Number of observations used in GENMOD, continued.

Center Branch

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	OT-B	TOTAL
90	17	21	18	14	6	1	0	0	22	29	11	5	7	0	0	0	3	77
91	17	23	29	18	15	8	0	6	24	25	17	9	14	7	1	0	7	110
92	26	30	32	25	13	7	8	8	30	32	15	3	10	0	4	1	22	133
93	7	9	6	19	4	3	0	0	25	12	1	2	2	0	5	0	1	48
TOTAL	67	83	85	76	38	19	8	14	101	98	44	19	33	7	10	1	33	342

Center set-by-set

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	OT-B	TOTAL
90	175	376	397	226	147	17	0	0	406	637	132	54	91	0	0	0	18	1338
91	250	742	1147	360	174	63	0	87	932	1019	376	77	125	55	4	0	61	2736
92	772	1817	1315	577	289	50	79	172	2153	1592	447	28	107	0	36	2	204	4820
93	125	181	39	326	60	28	0	0	506	152	7	20	11	0	53	0	10	759
TOTAL	1322	3116	2898	1489	670	158	79	259	3997	3400	962	179	334	55	93	2	293	9653

Table 2. Criteria for assessing goodness of fit.

East BR

Criterion	DF	Value	Value/DF
Deviance	1068	211923.5730	198.4303
Scaled Deviance	1068	1068.0000	1.0000
Pearson Chi-Square	1068	213023.7535	199.4604
Scaled Pearson X2	1068	1073.5444	1.0052
Log Likelihood	.	45222.7133	.

East set-by-set

Criterion	DF	Value	Value/DF
Deviance	33E3	1210504.2964	36.6831
Scaled Deviance	33E3	32999.0000	1.0000
Pearson Chi-Square	33E3	1629083.4032	49.3677
Scaled Pearson X2	33E3	44409.6922	1.3458
Log Likelihood	.	101778.4141	.

Center BR

Criterion	DF	Value	Value/DF
Deviance	318	100022.1936	314.5352
Scaled Deviance	318	318.0000	1.0000
Pearson Chi-Square	318	111342.3908	350.1333
Scaled Pearson X2	318	353.9902	1.1132
Log Likelihood	.	2759.6324	.

Center set-by-set

Criterion	DF	Value	Value/DF
Deviance	9333	274169.7461	29.3764
Scaled Deviance	9333	9333.0000	1.0000
Pearson Chi-Square	9333	508059.1916	54.4369
Scaled Pearson X2	9333	17294.8201	1.8531
Log Likelihood	.	9043.6630	.

Table 3. Likelihood ratio statistics for type 3 analysis.

East BR

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
MONTH	3	1068	14.5937	.0000	43.7811	0.0000
AREA	4	1068	35.8061	.0000	143.2242	0.0000
BR	1	1068	58.6493	.0000	58.6493	0.0000
OTH	1	1068	10.0275	.0016	10.0275	0.0015
YEAR*MONTH	54	1068	3.8466	.0000	207.7173	0.0000
YEAR*AREA	72	1068	3.4820	.0000	250.7061	0.0000
MONTH*AREA	11	1068	6.7148	.0000	73.8628	0.0000

East set-by-set

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YEAR	18	33E3	26.9141	.0000	484.4545	0.0000
MONTH	3	33E3	62.8862	.0000	188.6585	0.0000
AREA	4	33E3	95.1894	.0000	380.7576	0.0000
BR	1	33E3	161.9096	.0000	161.9096	0.0000
OTH	1	33E3	1141.2243	.0000	1141.2243	0.0000
YEAR*MONTH	54	33E3	21.4642	.0000	1159.0665	0.0000
YEAR*AREA	72	33E3	15.9716	.0000	1149.9562	0.0000
MONTH*AREA	12	33E3	28.2220	.0000	338.6635	0.0000

Center BR

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YEAR	3	318	6.5289	.0003	19.5868	0.0002
MONTH	3	318	27.7955	.0000	83.3864	0.0000
LAT	1	318	42.6205	.0000	42.6205	0.0000
BR	1	318	37.3951	.0000	37.3951	0.0000
OTH	1	318	3.1668	.0761	3.1668	0.0752
YEAR*LAT	3	318	4.5023	.0041	13.5068	0.0037
MONTH*LAT	3	318	7.1463	.0001	21.4388	0.0001

Center set-by-set

Source	NDF	DDF	F	Pr>F	ChiSquare	Pr>Chi
YEAR	3	9333	36.9517	.0000	110.8550	0.0000
MONTH	3	9333	122.9022	.0000	368.7066	0.0000
LAT	1	9333	195.1767	.0000	195.1767	0.0000
BR	1	9333	333.2576	.0000	333.2576	0.0000
OTH	1	9333	241.4665	.0000	241.4665	0.0000
YEAR*MONTH	9	9333	19.6011	.0000	176.4095	0.0000
YEAR*LAT	3	9333	26.9572	.0000	80.8715	0.0000
MONTH*LAT	3	9333	23.6841	.0000	71.0524	0.0000

Table 4. Scaled abundance indesx.

Year	East-BR	East-SET	Cent-BR	Cent-SET
75	1.000	1.000		
76	0.814	0.837		
77	1.110	1.160		
78	0.544	0.561		
79	0.438	0.480		
80	0.679	0.792		
81	0.794	0.733		
82	0.787	0.875		
83	0.535	0.524		
84	0.430	0.426		
85	0.499	0.582		
86	0.448	0.454		
87	0.651	0.729		
88	0.429	0.566		
89	0.289	0.287		
90	0.360	0.383	1.000	1.000
91	0.367	0.397	0.739	0.688
92	0.334	0.331	0.896	0.810
93	0.302	0.303	0.302	0.259

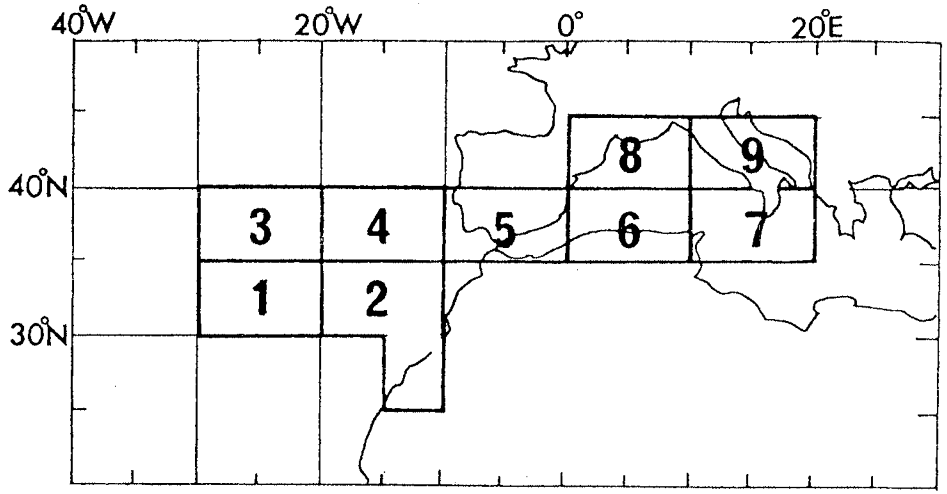

Fig. 1. Area division for east Atlantic and Mediterranean Sea used in the GENMOD analysis.

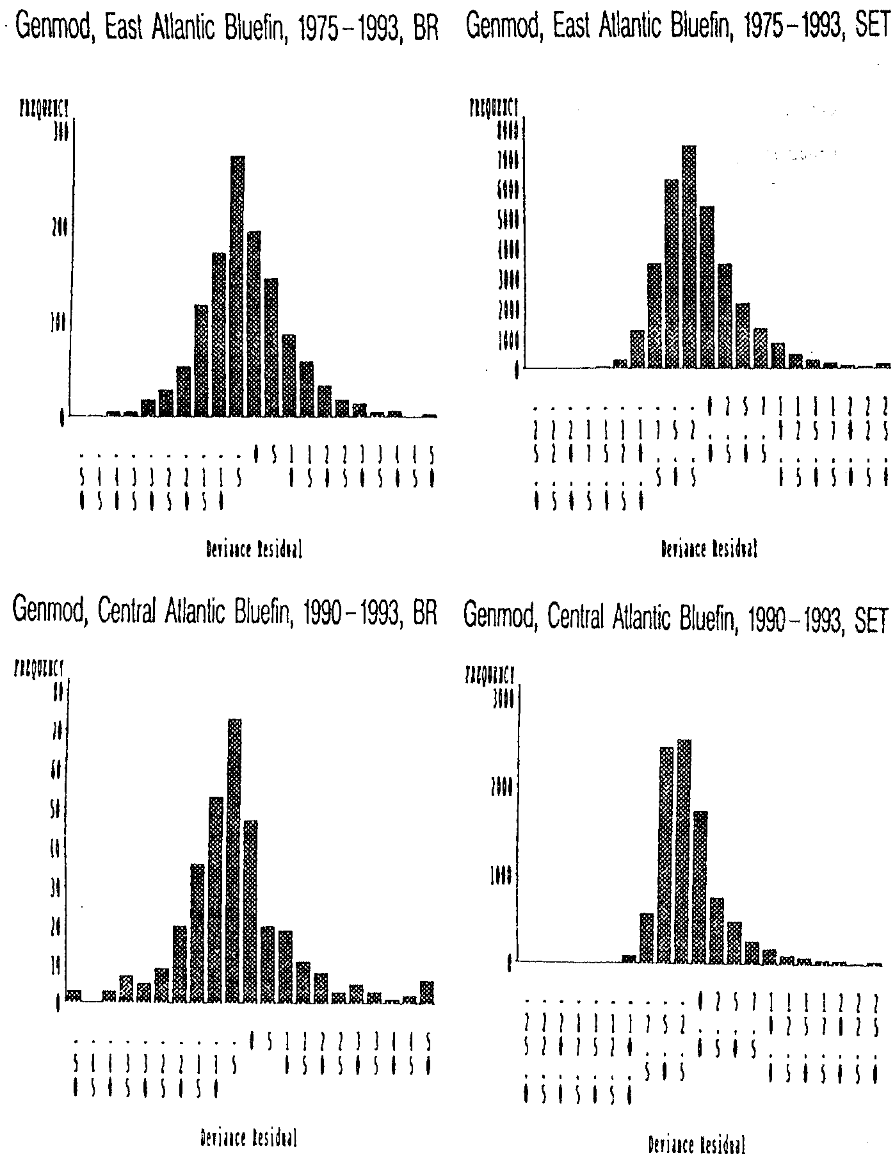

Fig. 2. Overall distribution of deviance residual in the GENMOD analysis.

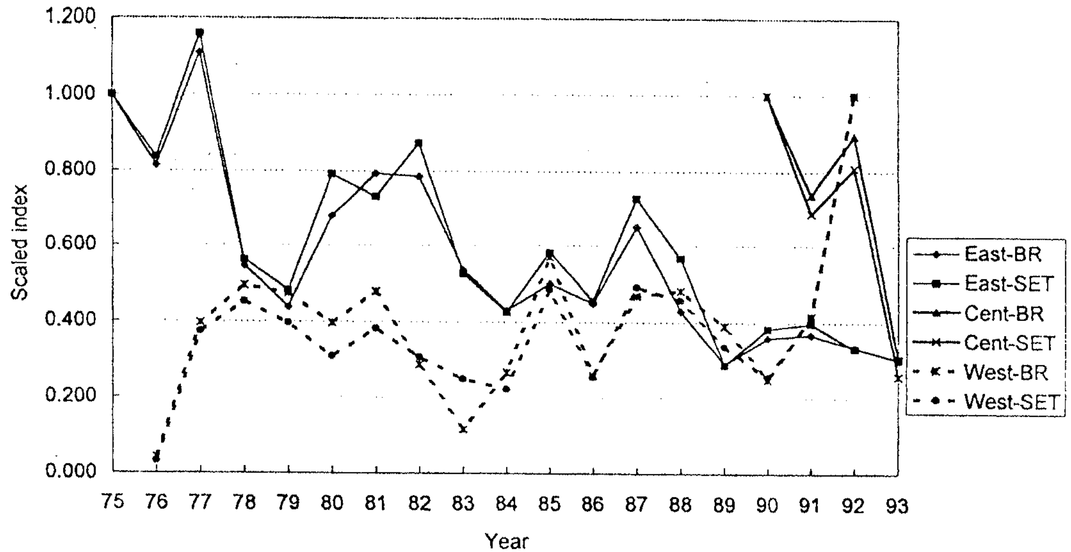

Fig. 3. Scaled index of abundance for east Atlantic bluefin stock, age 8 and older.