CCSBT-OMMP/1806/09
(OMMP Agenda Item 2)

ミナミマグロの MP インプット用の延縄加入量指数の開発

Development of recruitment index of SBT longline for MP input

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要約
本文書では、CCSBT の MP 開発のためのインプットデータとして延縄 CPUE に基づくミナミマグロの加入量指数を提案する。OMMP 会合で合意された、一般化線形モデルを当てはめた後に年齢分解する方法だけでなく、年齢分解した後に一般化線形モデルを実施した。また放流尾数の効果を検討した。

Summary
This document proposes recruitment indices of southern bluefin tuna based on longline CPUE as an input data to be used in developing management procedures in CCSBT. The indices were calculated not only by the suggested method from OMMP Meeting applying a generalized linear model first and then age decomposition, but also by applying age decomposition first and then did generalized linear model. It also considers effect of release/discarded fish.

Introduction

In the developing of the management procedure for southern bluefin tuna (SBT) in CCSBT, recruitment indices from longline fishery are expected. The method of calculation was agreed in the OMMP meeting in 2017 (Anon. 2017). It states that "*the meeting discussed possible forms of an index of age-4 CPUE, as a potential recruitment indicator, for inclusion in candidate MPs. The suggested formulation of such an index was the proportion of 4-year-old fish (by number) in the Core Vessel catches (relative to the 4+ catch) multiplied by the 4+ core vessels base CPUE.*" This document describes calculation of several recruitment indices not only by the suggested method. It also considers effect of release/discarded fish.

Materials and Methods

Longline abundance index (the core vessel index for age 4+) was updated by including the 2017 data. Detail is documented in different paper for the 9th OMMP meeting (CCSBT-OMMP/1806/08). The index was made by using the dataset consists of the core vessels, in CCSBT statistical area between 4 and 9, and in between April and September. Catch of fish was limited for age 4 and more (age 4+). The dataset was aggregated by year, month, 5 degree longitude, and 5 degree latitude. A generalized linear model (GLM) was applied using the Base model. The GLM result was weighted with the area weighting factor for W0.8 or W0.5.

$$log(CPUE+0.2) = Intercept + Year + Month + Area + Lat5 + BET\_CPUE + YFT\_CPUE + (Month*Area) + (Year*Lat5) + (Year*Area) + Error, \quad (1)$$

Age composition of catch was estimated. Based on the data from the CCSBT database distributed in January 2018, catch at age by Japanese longline vessels in Japan (database code is JP_ADJ), Australia (AU_AUJV), and New Zealand (NZC_LL) were extracted and combined. Data of catch-at-age in the most recent year of Japan were added. The core vessel index was decomposed by age with equation (2).

$$I_{w,age_i} = I_w \times n_{age_i} / \sum_{i=4}^{20} n_{age_i} \quad (2)$$

where, I_{w,age_i} is the recruitment index of age *i*, I_w is the abundance index of W0.8 or W0.5, n_{age_i} is the number of fish caught of age *i*. Average of two indices derived from W0.8

and W0.5 will be used. This method is defined “earlier GLM index”, here.

Another method is explored. It decomposed the data by age first (age-3, 4, and 5), and then applied GLM using the Base model. The index was area weighted for W0.8 and W0.5, then averaged (call it “later GLM index”).

It has been considered that some SBT hooked were released in Japanese longline fishery since 2006 when the individual quota system introduced. During 2006-2008, there was no framework to receive the reporting of released/discard. In 2009, a framework to receive reporting of released/discard was prepared in RTMP. Fishermen report the number of fish by life status (live or dead) by three body weight categories (<20 kg, 20-39 kg, and >=40 kg). The body weight was measured by eye. The body weight is assumed to be gilled, gutted and tail removed which is familiar to fishermen.

The proportion of age4+ in released/discard (released, here after) fish was small so that effect on CPUE age-4+ is trivial (CCSBT-OMMP/1406/08). In CPUE of single age, however, the proportion of released fish can be larger than age-4+. Age compositions of released fish were estimated in the following two cases.

Case A: It assumes that age composition of released fish in a weight category is same as that of retained fish.

Case B: It assumes that age of released fish in a weight category is same as the youngest age of the category, i.e., all fish < 20kg is age 3 (though not the youngest), all fish 20-39 kg is age 4, and all fish >= 40kg is age 5 in this assumption.

It is likely that fish was released because it was smaller. Therefore, the case A presumably overestimate the age. The case B seems to underestimate the age. The true value would be lying in the range between the two cases.

Released fish by age was converted to nominal CPUE by year, month, and area, then multiplied to hooks of the core vessel data, and obtained the number of released fish by age. For data in 2006-2008 when detail number of released fish was not available, average of 2009-2017 was used.

In total, 45 CPUE series were produced.

Earlier GLM: 2 ages (age4, age5), 3 released (only retained fish, caseA, case B), 3 weightings (W0.8, W0.5, average) = 18 series.

Later GLM: 3 ages (age 3, age4, age5), 3 released (only retained fish, caseA, case B), 3 weightings (W0.8, W0.5, average) = 27 series.

Results

Recruitment index of age 4 and age 5

Age composition used for simpler method (earlier GLM) is shown in Fig. 1. It produced the recruitment indices of age 4 and age 5 (Table1. Fig 2, black lines in the left panels).

The recruitment indices of age-3, 4, and 5 in the later GLM are shown in Table 2 and Fig. 2 (red lines in the left panel) and Fig. 4 (black lines in lower panels). Note that the series were adjusted to the mean of the earlier GLM during 1986-2008 in each panel of Fig. 2 and Fig. 4. General trends were similar to each other, except 2016 in age5 series where it dropped moderately in the earlier GLM series but dropped sharply in the later GLM series.

Effect of released/discarded

The annual number of released fish are shown in Table 3. Age compositions of retained fish by three body weight categories used for released fish (< 20kg, 20-39kg, > 40kg) are shown in Fig. 3 and Table 2. Fish in the < 20kg class was mainly consisted of age-2 and age-3 with a small portion of age 4. Fish in the class of 20-39kg was mainly consisted of age-4 and age-5. Fish in the > 40kg class was mainly consisted of age between 6 and 8. Annual catch-at-age and CPUE in case-B are shown in Table 5.

Effect of including released fish on CPUE is shown in Fig. 4 and Table 6. There was a large effect in age 3 recruitment index. (Slight decreasing during 1986-2005 was due to adjacent to the mean of 1986-2008 value.) In the later GLM CPUE to the CPUE only for retained fish, the case-A had a raising effect of 98% in age-3 fish, 19% in age-4 fish, and 14% in age-5 fish. The case-B in the later GLM had larger effect that raised 138% in age-3 fish, and 36% in age-4 fish. However, it was only 6% in age-5 fish because the increase of denominator by including released fish decreased the composition ratio of age-5 fish.

In the case of the earlier GLM, the raising effect was slightly lowered. The raising effects were 7% in age-4 and 5% in age-5 in the case-A, and 16% in age-4 and -1% in age-5 in the case-B.

Discussion

By the present analysis, despite its simplicity, the method of earlier GLM, which applied GLM for fish >= age-4 aggregated initially and then age decomposition, provided similar index to the method of later GLM, which age decomposition initially and then applied GLM. This is probably because young fish such as age-4 and age-5 are dominating the trend because of the large number of individuals even in the data aggregate as age-4+. However, it should be noted that the trend was different in 2015 at age-4.

Therefore, as agreed, when using the index from the earlier GLM method, it is recommended to use the index obtained by the later GLM for sensitivity analysis.

Instead of age-4, there is also a choice to use CPUE of age-5 fish which is hardly affected by releasing. At present, there was no difference in trends between earlier and later GLM indices.

CPUE of age-3 was not suitable for decomposing by age composition because it did not include age-3 fish in the earlier GLM method. Also, it was strongly influenced by releasing, and careful consideration is required for use as a recruitment index, and its use cannot be recommended.

Consideration of released fish would not be necessary for CPUE of age-5 fish. Among age-4 fish CPUEs, case A is an intermediate value for age-4 fish, so either CPUE not including released fish or CPUE including released fish in the case B is recommended as the base case for one and the sensitivity/robustness test for the other.

References

Anonymous (2017) Report of the eighth operating model and management procedure technical meeting. pp32.

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Itoh, T. and N. Takahashi (2018) Update of the core vessel data and CPUE for southern bluefin tuna in 2018. CCSBT-OMMP/1806/08.

Table 1 Recruitment index by age for the earlier GLM case

The weight is the mean of W0.8 and W0.5.

Age Release	4 No	5 No	4 A	5 A	4 B	5 B
1969	0.9688	1.5637	0.9557	1.5517	0.9387	1.5656
1970	2.0399	1.5833	2.0123	1.5711	1.9766	1.5852
1971	2.2916	2.0878	2.2606	2.0717	2.2204	2.0902
1972	2.3262	2.5472	2.2946	2.5276	2.2538	2.5502
1973	2.4613	2.2605	2.4279	2.2431	2.3848	2.2632
1974	2.7482	2.3263	2.7109	2.3084	2.6627	2.3291
1975	1.0223	1.2975	1.0085	1.2875	0.9905	1.2990
1976	0.9850	1.3311	0.9717	1.3209	0.9544	1.3327
1977	1.6337	1.1145	1.6116	1.1059	1.5829	1.1158
1978	1.8455	1.4626	1.8204	1.4513	1.7879	1.4643
1979	0.9567	1.8594	0.9438	1.8452	0.9270	1.8617
1980	1.2793	1.0809	1.2620	1.0726	1.2394	1.0822
1981	0.9822	1.4521	0.9689	1.4409	0.9516	1.4539
1982	0.6375	0.9289	0.6288	0.9218	0.6176	0.9300
1983	0.7580	1.1592	0.7477	1.1503	0.7344	1.1606
1984	0.7179	0.8026	0.7082	0.7964	0.6956	0.8035
1985	0.6746	0.5891	0.6655	0.5845	0.6536	0.5898
1986	0.3332	0.3479	0.3287	0.3452	0.3228	0.3483
1987	0.4880	0.3408	0.4814	0.3381	0.4728	0.3412
1988	0.6284	0.2567	0.6199	0.2548	0.6088	0.2570
1989	0.5302	0.4458	0.5230	0.4424	0.5137	0.4463
1990	0.7058	0.4212	0.6962	0.4179	0.6838	0.4217
1991	0.8958	0.3904	0.8837	0.3874	0.8679	0.3909
1992	1.3757	0.6772	1.3570	0.6720	1.3328	0.6780
1993	1.2422	1.1270	1.2253	1.1183	1.2033	1.1284
1994	1.0543	0.7674	1.0399	0.7614	1.0211	0.7683
1995	0.9100	0.9396	0.8976	0.9323	0.8815	0.9407
1996	0.6169	0.8297	0.6084	0.8233	0.5975	0.8307
1997	0.5913	0.6691	0.5833	0.6639	0.5728	0.6699
1998	0.7394	0.4940	0.7293	0.4902	0.7163	0.4946
1999	0.7243	0.5277	0.7144	0.5236	0.7016	0.5283
2000	0.7585	0.5101	0.7481	0.5061	0.7347	0.5107
2001	0.7678	0.7286	0.7574	0.7230	0.7438	0.7295
2002	0.9125	0.9102	0.8999	0.9031	0.8837	0.9113
2003	0.4557	0.8571	0.4495	0.8504	0.4414	0.8581
2004	0.3996	0.6696	0.3941	0.6644	0.3870	0.6704
2005	0.5100	0.3884	0.5030	0.3854	0.4940	0.3888
2006	0.2977	0.2082	0.3451	0.2434	0.4072	0.2031
2007	0.3898	0.1792	0.4091	0.1990	0.4407	0.1758
2008	0.4377	0.2995	0.4881	0.3376	0.5537	0.2966

Table 1 (continued)

Age	4	5	4	5	4	5
Release	No	No	A	A	B	B
2009	1.4018	0.8420	1.4241	0.8640	1.4719	0.8111
2010	1.2954	1.7257	1.3179	1.7272	1.3702	1.6904
2011	1.0589	1.2781	1.0684	1.2778	1.0747	1.2873
2012	0.9691	1.0289	1.0386	1.0631	1.1146	1.0178
2013	0.7518	0.9542	0.8015	0.9750	0.8492	0.9482
2014	0.8416	1.1324	0.9133	1.1693	1.0034	1.1320
2015	0.9091	1.4663	0.9782	1.4963	1.0655	1.4783
2016	0.5573	1.1954	0.6285	1.2267	0.7113	1.2118
2017	1.1215	0.9447	1.1482	0.9665	1.1842	0.9572

Table 2 Recruitment index by age for the later GLM case

The weight is the mean of W0.8 and W0.5.

Age	3	4	5	3	4	5	3	4	5
Releas	No	No	No	A	A	A	B	B	B
1985	0.9874	1.0863	0.8930	0.9155	1.0949	0.9019	0.8879	1.1009	0.8982
1986	0.4283	0.3938	0.3933	0.3590	0.3856	0.3896	0.3336	0.3783	0.3962
1987	0.4795	0.5289	0.4053	0.4105	0.5209	0.4019	0.3831	0.5117	0.4063
1988	0.4918	0.6093	0.3019	0.4143	0.5980	0.2974	0.3847	0.5859	0.3050
1989	0.5901	0.5591	0.4742	0.4980	0.5478	0.4695	0.4625	0.5368	0.4766
1990	1.0808	0.6759	0.4723	0.9206	0.6670	0.4687	0.8536	0.6554	0.4790
1991	0.8200	0.8238	0.4559	0.7075	0.8127	0.4519	0.6594	0.7988	0.4589
1992	0.9130	1.2276	0.6500	0.7933	1.2144	0.6439	0.7401	1.1930	0.6437
1993	1.2287	1.1257	1.0346	1.0950	1.1186	1.0296	1.0272	1.1021	1.0286
1994	1.2506	1.0170	0.6769	1.0544	0.9996	0.6703	0.9759	0.9808	0.6825
1995	0.8173	1.0360	0.8906	0.6954	1.0236	0.8858	0.6459	1.0064	0.8961
1996	0.2758	0.7692	0.8158	0.2286	0.7551	0.8089	0.2128	0.7401	0.8202
1997	0.4294	0.5563	0.6277	0.3646	0.5466	0.6223	0.3393	0.5361	0.6283
1998	0.7021	0.7125	0.5450	0.5954	0.7016	0.5407	0.5525	0.6887	0.5499
1999	0.8044	0.7330	0.5486	0.6834	0.7237	0.5453	0.6345	0.7116	0.5536
2000	0.5605	0.6871	0.4878	0.4739	0.6758	0.4831	0.4396	0.6624	0.4907
2001	0.6055	0.7983	0.7134	0.5168	0.7882	0.7086	0.4807	0.7744	0.7135
2002	0.5298	0.8277	0.9006	0.4573	0.8187	0.8944	0.4256	0.8035	0.8936
2003	0.2138	0.5727	0.8331	0.1755	0.5637	0.8261	0.1628	0.5522	0.8287
2004	0.4098	0.4595	0.6884	0.3636	0.4562	0.6862	0.3418	0.4498	0.6883
2005	0.3968	0.5260	0.3832	0.3613	0.5221	0.3792	0.3420	0.5134	0.3734
2006	0.5467	0.2984	0.2178	0.8236	0.4059	0.2950	0.9510	0.5237	0.2419
2007	0.4272	0.4663	0.2501	0.6823	0.5742	0.3222	0.7980	0.6863	0.2712
2008	0.5379	0.5820	0.3699	0.8001	0.6918	0.4454	0.9195	0.8058	0.3862
2009	0.5898	1.1493	0.8009	1.0236	1.3517	0.9283	1.1661	1.5313	0.7951
2010	0.3837	0.9773	1.4576	0.5932	1.1246	1.5660	0.6536	1.2827	1.4745
2011	0.6680	0.9252	1.1715	0.8297	0.9650	1.1926	0.8957	0.9795	1.1805
2012	0.7329	0.9741	0.9765	1.3105	1.1380	1.0743	1.5252	1.2455	0.9978
2013	0.3924	0.8362	0.7557	0.7545	0.9109	0.7989	0.9138	0.9600	0.7804
2014	0.3794	0.9162	1.0851	0.8893	1.1010	1.1845	1.0912	1.2580	1.1334
2015	0.2076	1.0940	1.3986	0.5695	1.3109	1.5754	0.6885	1.5263	1.5400
2016	0.1688	0.5250	0.7183	0.5620	0.6673	0.8152	0.7428	0.7921	0.8134
2017	0.1921	0.7438	0.8545	0.4856	0.8536	0.9519	0.6075	0.9698	0.9392

Table 3 Number of released/discarded fish by body weight class

Year	under 20kg	over 20kg	over 40kg	Total
2009	7,847	1,895	12	9,754
2010	1,866	1,368	111	3,345
2011	2,641	651	154	3,446
2012	7,570	1,801	198	9,569
2013	8,243	1,642	217	10,102
2014	6,905	2,933	545	10,383
2015	7,472	2,802	812	11,086
2016	7,510	3,519	734	11,763
2017	5,605	2,291	403	8,299

Table 4 Estimated number and CPUE at age of released/discarded fish in the case A (age of retained fish)

Year	Age3	Age4	Age5	Age4 plus	CPUE_ age3	CPUE_ age4	CPUE_ age5	CPUE_ age4+
2009	4,756	986	654	1,867	0.32	0.06	0.04	0.12
2010	1,262	599	475	1,336	0.13	0.06	0.04	0.13
2011	1,603	337	230	790	0.15	0.03	0.02	0.07
2012	4,584	940	628	1,964	0.44	0.09	0.06	0.18
2013	4,947	897	575	1,867	0.47	0.08	0.05	0.18
2014	4,366	1,37	1,029	3,259	0.37	0.11	0.08	0.28
2015	4,671	1,33	994	3,431	0.35	0.10	0.07	0.26
2016	4,795	1,62	1,237	3,967	0.32	0.11	0.08	0.27
2017	3,531	1,07	803	2,529	0.27	0.08	0.06	0.19

Table 5 Estimated number and CPUE at age of released/discarded fish in the case B (the minimum age)

Year	Age3	Age4	Age5	CPUE_ age3	CPUE_ age4	CPUE_ age5
2009	7,847	1,895	12	0.535	0.129	0.001
2010	1,866	1,368	111	0.193	0.141	0.011
2011	2,641	651	154	0.252	0.062	0.015
2012	7,570	1,801	198	0.730	0.174	0.019
2013	8,243	1,642	217	0.793	0.158	0.021
2014	6,905	2,933	545	0.599	0.254	0.047
2015	7,472	2,802	812	0.565	0.212	0.061
2016	7,510	3,519	734	0.511	0.239	0.050
2017	5,605	2,291	403	0.428	0.175	0.031

Table 6 Change of CPUE by including released/discarded

Relative value to CPUE of retained only. The weight is the mean of W0.8 and W0.5.

GLM	Earlier	Earlier	Earlier	Earlier	Later	Later	Later	Later	Later	Later
Age	4	5	4	5	3	4	5	3	4	5
Release	A	A	B	B	A	A	A	B	B	B
Mean	**1.068**	**1.049**	**1.155**	**0.993**	**1.981**	**1.186**	**1.143**	**2.375**	**1.360**	**1.057**
2006	1.159	1.169	1.368	0.975	1.506	1.360	1.354	1.740	1.755	1.111
2007	1.049	1.110	1.131	0.981	1.597	1.231	1.288	1.868	1.472	1.084
2008	1.115	1.127	1.265	0.990	1.487	1.189	1.204	1.709	1.385	1.044
2009	1.016	1.026	1.050	0.963	1.735	1.176	1.159	1.977	1.332	0.993
2010	1.017	1.001	1.058	0.980	1.546	1.151	1.074	1.703	1.312	1.012
2011	1.009	1.000	1.015	1.007	1.242	1.043	1.018	1.341	1.059	1.008
2012	1.072	1.033	1.150	0.989	1.788	1.168	1.100	2.081	1.279	1.022
2013	1.066	1.022	1.130	0.994	1.923	1.089	1.057	2.329	1.148	1.033
2014	1.085	1.033	1.192	1.000	2.344	1.202	1.092	2.876	1.373	1.045
2015	1.076	1.020	1.172	1.008	2.744	1.198	1.126	3.317	1.395	1.101
2016	1.128	1.026	1.276	1.014	3.330	1.271	1.135	4.401	1.509	1.132
2017	1.024	1.023	1.056	1.013	2.528	1.148	1.114	3.163	1.304	1.099

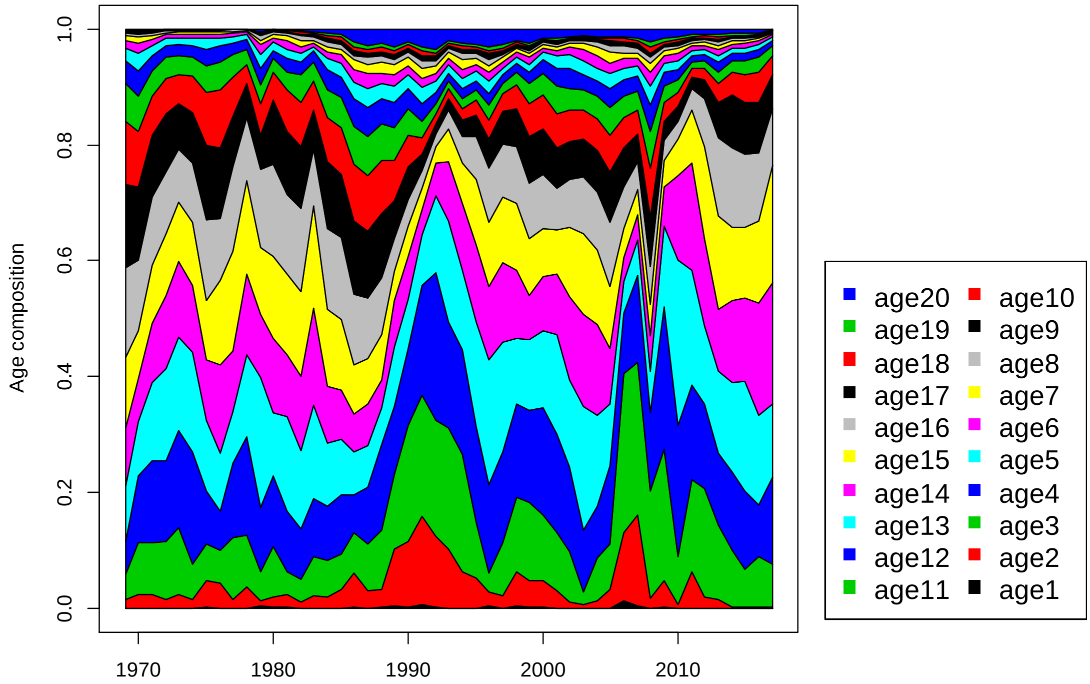

Fig. 1 Age composition of SBT retained

Data were from Japanese longline and joint venture with Australia and New Zealand.

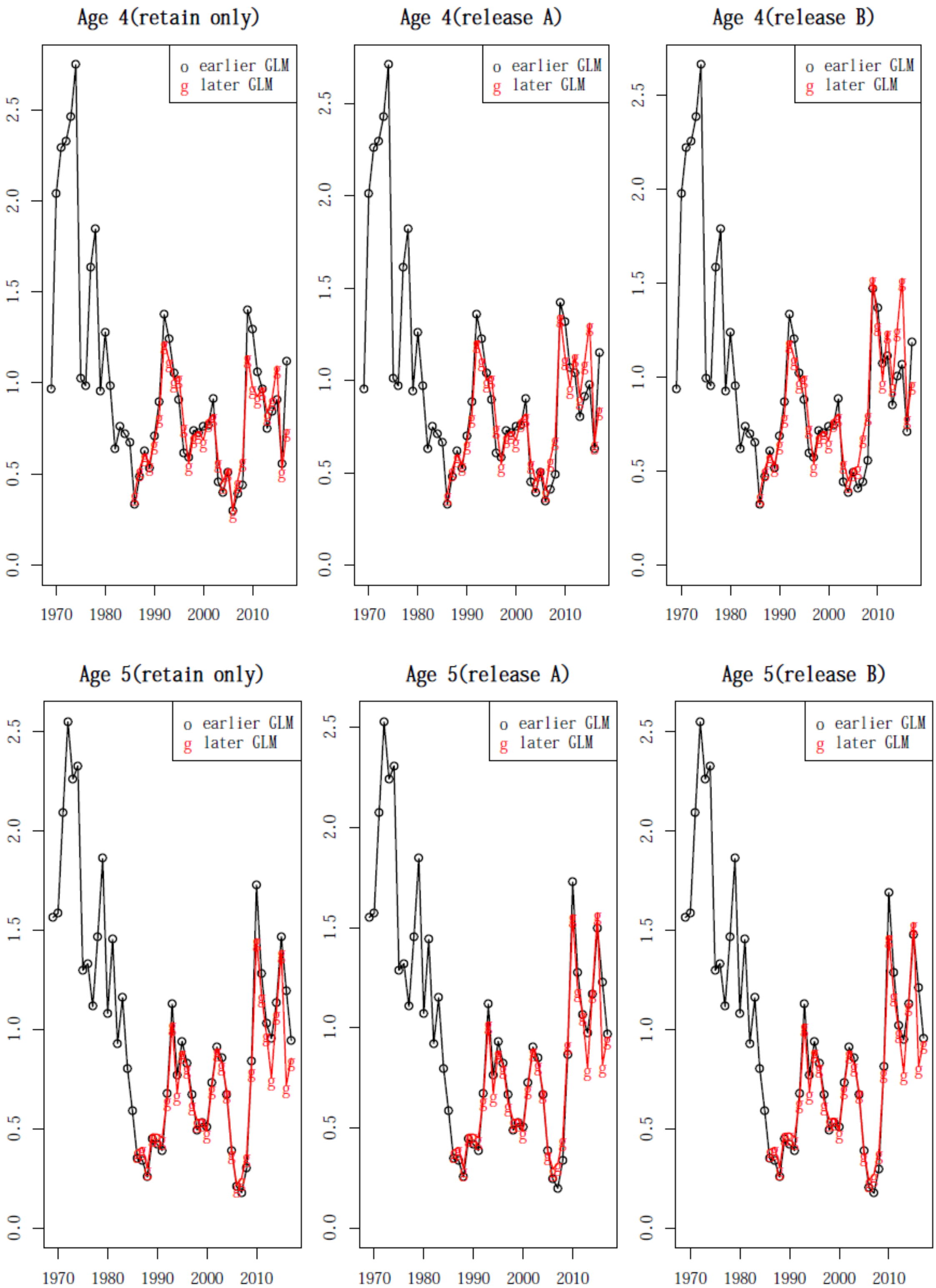

Fig. 2 Comparison between earlier GLM series and later GLM series

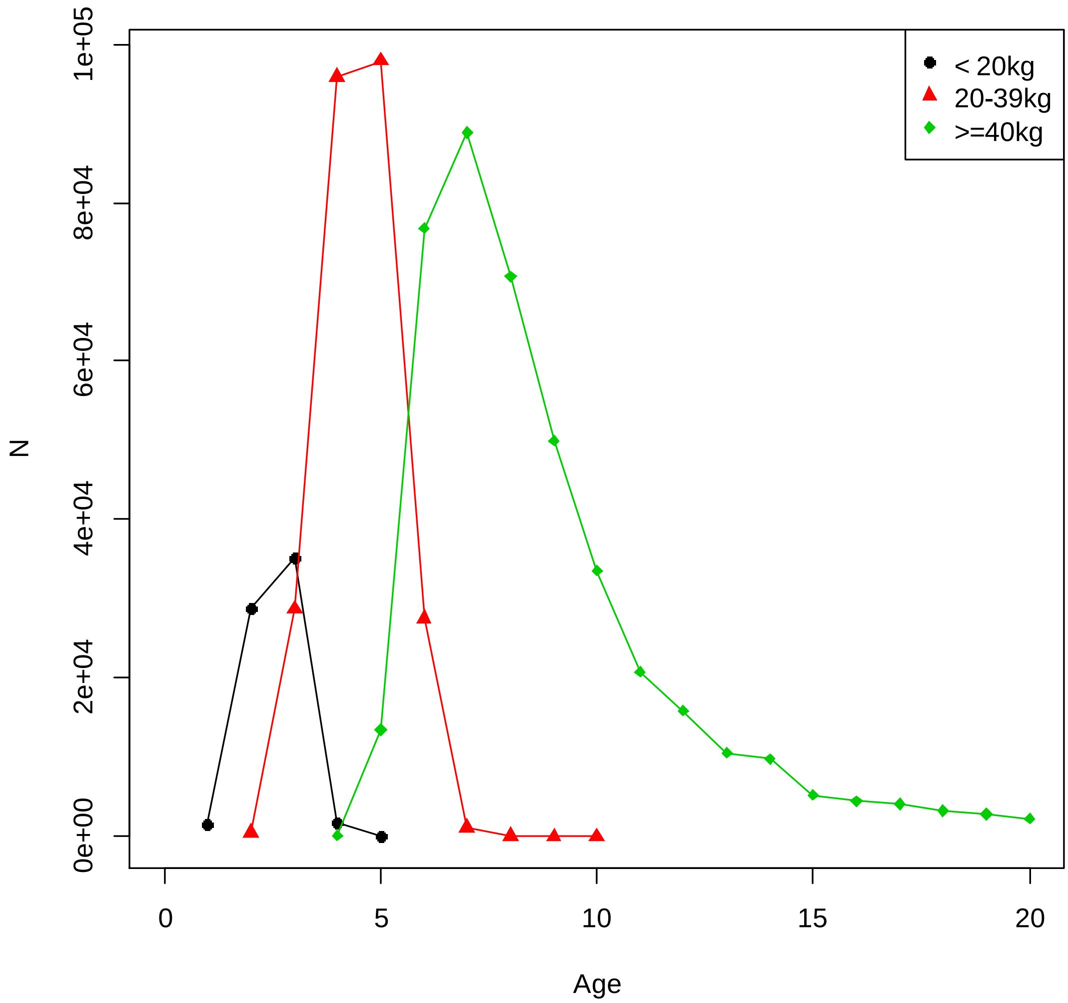

Fig. 3　Age composition of three body weight categories by retained fish.

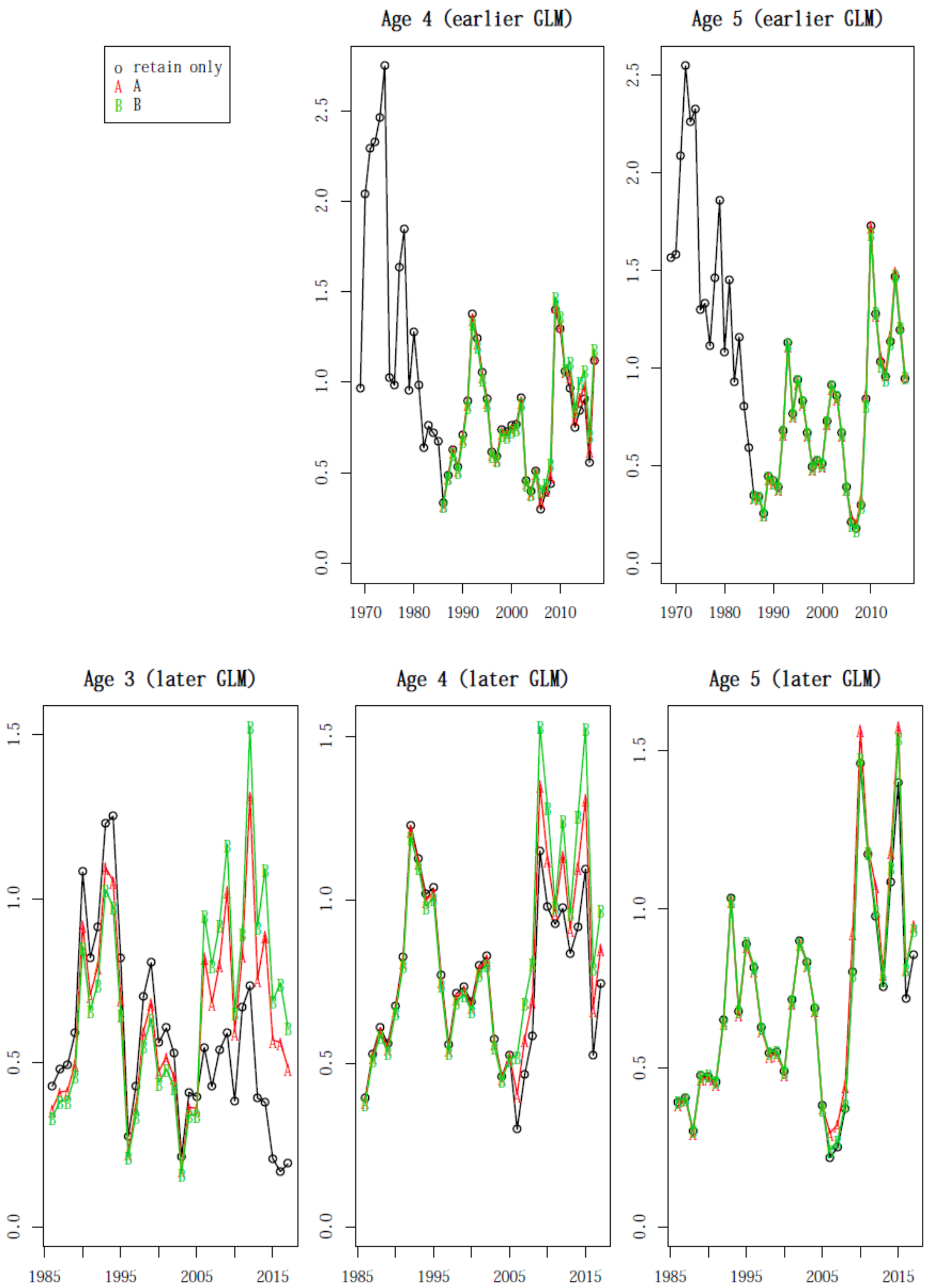

Fig. 4 Effect of released/discarded fish on CPUE series.

A and B are based on the age composition of retained fish and the minimum age of weght categories, respectively.