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Updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM for the period from 1960 to 2010

Hiroaki OKAMOTO

National Research Institute of Far Seas Fisheries
5 chome 7-1, Orido, Shimizu-Ku, Shizuoka-City, 424-8633, Japan

Abstract

Standardized Japanese longline CPUE for bigeye tuna was updated from 1960 up to 2010 by using GLM (CPUE-LogNormal error structured model). Method of standardization was as same as that used for bigeye assessment in 2010. NHF (Number of Hooks between Float) and material of main and branch lines were applied to standardize the change in catchability of longline gear.

In the tropical Indian Ocean, CPUE continuously decreased from around 9.3 (real scale) in 1960 to 3.2 in 2002 when it has increased to 4.2 - 4.7 in 2004 through 2008, about the same level as that in the late 1990's. However it has decreased again to about 3.3 in 2009 and 3.1 in 2010. Standardized CPUE in the south area which didn't show clear trend during the period between 1984 and 2000 (CPUE was 3.5 on average), decreased to 2.5 in 2003. It increased to 3.2 in 2004 after when it decreased to 1.3 in 2008 and increased to 1.7 in 2010. As a result, CPUE in all Indian Ocean, which had been kept in the same level around 5 to 7 until 1993 decreased to 3.0 in 2002, increased a little in 2003 and 2004 after when it decreased to about 3.0 in 2008 and 2.5 in 2009 and 2010.

1. Introduction

. Standardized Japanese longline CPUE for bigeye tuna was updated from 1960 to 2010 by GLM (CPUE-LogNormal error structured model) in order to provide abundance index to be applied for bigeye assessment in IOTC WPTT meeting in 2011. Method of standardization was the same as that used for bigeye assessment in 2010 (Okamoto and Shono, 2010).

2. Materials and methods

Area definition:

Area definition used in this study (Fig. 1) is the same as that used in the IOTC bigeye assessment in 2006 (Okamoto and Shono, 2006) which consists of seven areas. Main fishing ground of Japanese longline fishery for bigeye was divided into seven areas and CPUE standardization was done for three cases of area combinations, Aropical (areas 1-5), South (areas 6 & 7) and ALL (areas 1-7) Indian Ocean. Area 67 in the south area was not used in this study.

Environmental factors:

As environmental factors, which are available for the analyzed period from 1960 to 2009, SST (Sea Surface Temperature) was applied. The original SST data, whose resolution is 1-degree latitude and 1-degree longitude by month from 1946 to 2010, was downloaded from NEAR-GOOS Regional Real Time Data Base of Japan Meteorological Agency (JMA).

http://goos.kishou.go.jp/rrtdb/database.html

It is necessary to get password to access the data retrieving system. The original data was recompiled into 5-degree latitude and 5-latitude longitude by month from 1960 to 2010 using the procedures described in Okamoto et al. (2001), and used in the analyses.

Catch and effort data used:

The Japanese longline catch (in number) and effort statistics from 1960 up to 2010 were used. The catch and effort data set from aggregated by month, 5-degree square, NHF (the number of hooks between floats, and main line material, was used for the analysis. Data in strata in which the number of hooks was less than 5000 were not used for analyses. As the NHF information does not available for the period from 1960 to 1974, NHF was regarded to be 5 in this period. Main line material was categorized in to two, 1 = Nylon and 2 = other.

GLM (Generalized Linear Model):

CPUEs based on the number of catch was used;

The number of caught fish / the number of hooks * 1000

The model used for GLM analyses (CPUE-LogNormal error structured model) was as follows.

Model (CPUE-LogNormal error structured model):

$$\text{Log}(CPUE_{ijkl}+\text{const})=\mu+YR_{(i)}+MN_{(j)}+AREA_{(k)}+NHFCL_{(l)}+SST(m)+ML(n)+YR(i)*AREA_{(k)}+MN(j)*AREA_{(k)}+AREA(k)*NHFCL(l)+AREA(k)*SST(m)+NHFCL(l)*ML(n)+e_{(ijkl....)}$$

Where Log : natural logarithm,

CPUE : catch in number of bigeye per 1000 hooks,

Const : 10% of overall mean of CPUE

μ : overall mean (i.e. intercept),

$YR_{(i)}$: effect of year,

$MN_{(j)}$: effect of fishing season (month),

$AREA_{(k)}$: effect of sub-area,

$NHFCL_{(l)}$: effect of gear type (class of the number of hooks between floats),

$SST_{(m)}$: effect of SST,

$ML_{(n)}$: effect of material of main line,

YR (i)*AREA (k) : interaction term between year and sub-area,

MN (j)*AREA (k) : interaction term between fishing season and sub-area,

AREA (k)*NHFCL (l) : interaction term between sub-area and gear type,

AREA(k)*SST (m) : interaction term between sub-area and SST,

NHFCL(l)*ML(n) : interaction term between sub-area and MLD,

$e_{(ijkl..)}$: error term.

The number of hooks between float (NHF) was divided into 6 classes (NHFCL 1: 5-7, NHFCL 2: 8-10, NHFCL 3: 11-13, NHFCL 4: 14-16, NHFCL 5: 17-19, NHFCL 6: 20-21) as later explanation.

Effect of year was obtained by the method used in Ogura and Shono (1999) that uses lsmean of Year-Area interaction as the following equation.

$$CPUE_i = \Sigma\ W_j * (\exp(\text{lsmean}(Year\ i*Area\ _j))-\text{constant})$$

Where $CPUE_i$ = CPUE in year i,

W_j = Area rate of Area j , ($\Sigma W_j = 1$),

lsmean($Year*Area_{ij}$) = least square mean of Year-Area interaction in Year i and Area j,

constant = 10% of overall mean of CPUE.

Time period of standardization was 1960-2009 for both of annual and quarter CPUE.

3. Results and discussion

CPUE standardizations by GLM:

The bigeye CPUE (catch in number per 1000 hooks) was standardized by GLM (CPUE-LogNormal error structured model) for each of three area categories, Tropical (Areas 1 – 5), South (Areas 6 & 7) and All Indian Ocean (Areas 1 – 7) for three periods 1960-2010 as described in the materials and method section.

Trends of CPUE in each region category (Tropical, South and All Indian Ocean) were shown in Fig. 2 overlaying Nominal CPUE in real scale and relative scale. In the tropical Indian Ocean, CPUE continuously decreased from around 9.3 (real scale) in 1960 to 3.2 in 2002 when it has increased to 4.2 - 4.7 in 2004 through 2008, about the same level as that in the late 1990's. However it has decreased again to about 3.3 in 2009 and 3.1 in 2010. Standardized CPUE in the south area which didn't show clear trend during the period between 1984 and 2000 (CPUE was 3.5 on average), decreased to 2.5 in 2003. It increased to 3.2 in 2004 after when it decreased to 1.3 in 2008 and increased to 1.7 in 2010. As a result, CPUE in all Indian Ocean, which had been kept in the same level around 5 to 7 until 1993 decreased to 3.0 in 2002, increased a little in 2003 and 2004 after when it decreased to about 3.0 in 2008 and 2.5 in 2009 and 2010. Results of ANOVA and distributions of the standard residual in each analysis were shown in Table 1 and Fig. 3, respectively. Distributions of the standard residual did not show remarkable difference from the normal distribution. Annual values of standardized CPUE by region were listed in Appendix Table 1.

Standardized CPUE of each month and each NHFCL by material were compared for tropical and temperate area in Fig. 4 and 5, respectively. In the temperate (south), CPUE was highest in summer (Jun–Aug) and lowest in winter (Nov-Feb). Although the seasonal trend in tropical was not so clear, that in winter was highest in winter and lowest in March. Regarding the combination of NHFCL with non-nylon main line materials, larger NHFCL shows higher CPUE in the South Indian Ocean, while smallest (NHFCL1) and largest (NHFCL 6) classes were rather low in CPUE than other NHFCL 2 – 5 which were about the same level each other in the Tropical Indian Ocean. As for the nylon mainline, CPUE in Tropical Indian Ocean was lowest for NHFCL 2 or 3, while those of other NHFCL (1, and 4-6) are the same level. Nylon material CPUE of South Indian Ocean did not show large difference between NHFCL although highest value was observed for largest NHFCL.

4. Recerences

Shono, H. and M. Ogura, M. (1999): The standardized skipjack CPUE including the effect of searching devices, of the Japanese distant water pole and line fishery in the Western Central Pacific Ocean. ICCAT-SCRS/99/59. 18p

Okamoto, H., Miyabe, N., and Matsumoto, T. (2001): GLM analyses for standardization of Japanese longline CPUE for bigeye tuna in the Indian Ocean applying environmental factors. IOTC-2001/TTWP/21, 38p.

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Table 1. ANOVA table of GLM for standardization of Annual CPUE.

Tropical			1960-2010 Year base			
Source	DF	Type III SS	Mean Square	F Value	Pr > F	R-Square=
Model	344	5283.470	15.359	48.270	<.0001	0.364881
						CV =
yr	50	601.110	12.022	37.790	<.0001	31.0073
mn	11	114.910	10.446	32.830	<.0001	
area	4	109.683	27.421	86.180	<.0001	
nhfcl	5	38.681	7.736	24.320	<.0001	
sst	1	11.873	11.873	37.320	<.0001	
ml	1	1.763	1.763	5.540	0.0186	
yr*area	199	510.723	2.566	8.070	<.0001	
mn*area	44	174.638	3.969	12.470	<.0001	
area*nhfcl	20	60.309	3.015	9.480	<.0001	
sst*area	4	101.071	25.268	79.420	<.0001	
nhfcl*ml	5	56.694	11.339	35.640	<.0001	

South			1960-2010 Year base			
Source	DF	Type III SS	Mean Square	F Value	Pr > F	R-Square=
Model	140	4962.816	35.449	61.210	<.0001	0.360569
						CV =
yr	50	899.331	17.987	31.060	<.0001	75.69804
mn	11	641.428	58.312	100.680	<.0001	
area	1	40.011	40.011	69.080	<.0001	
nhfcl	5	50.302	10.060	17.370	<.0001	
sst	1	221.571	221.571	382.570	<.0001	
ml	1	1.926	1.926	3.330	0.0682	
yr*area	50	231.563	4.631	8.000	<.0001	
mn*area	11	83.508	7.592	13.110	<.0001	
area*nhfcl	5	27.370	5.474	9.450	<.0001	
nhfcl*ml	5	17.424	3.485	6.020	<.0001	
sst*area						

All Indian Ocean			1960-2010 Year base			
Source	DF	Type III SS	Mean Square	F Value	Pr > F	R-Square=
Model	480	14247.129	29.682	77.320	<.0001	0.456952
						CV =
yr	50	925.618	18.512	48.220	<.0001	39.69301
mn	11	110.241	10.022	26.110	<.0001	
area	6	116.689	19.448	50.660	<.0001	
nhfcl	5	59.572	11.914	31.040	<.0001	
sst	1	4.206	4.206	10.960	0.0009	
ml	1	0.266	0.266	0.690	0.4054	
yr*area	299	1268.256	4.242	11.050	<.0001	
mn*area	66	685.734	10.390	27.070	<.0001	
area*nhfcl	30	114.780	3.826	9.970	<.0001	
sst*area	6	122.681	20.447	53.260	<.0001	
nhfcl*ml	5	44.482	8.896	23.170	<.0001	

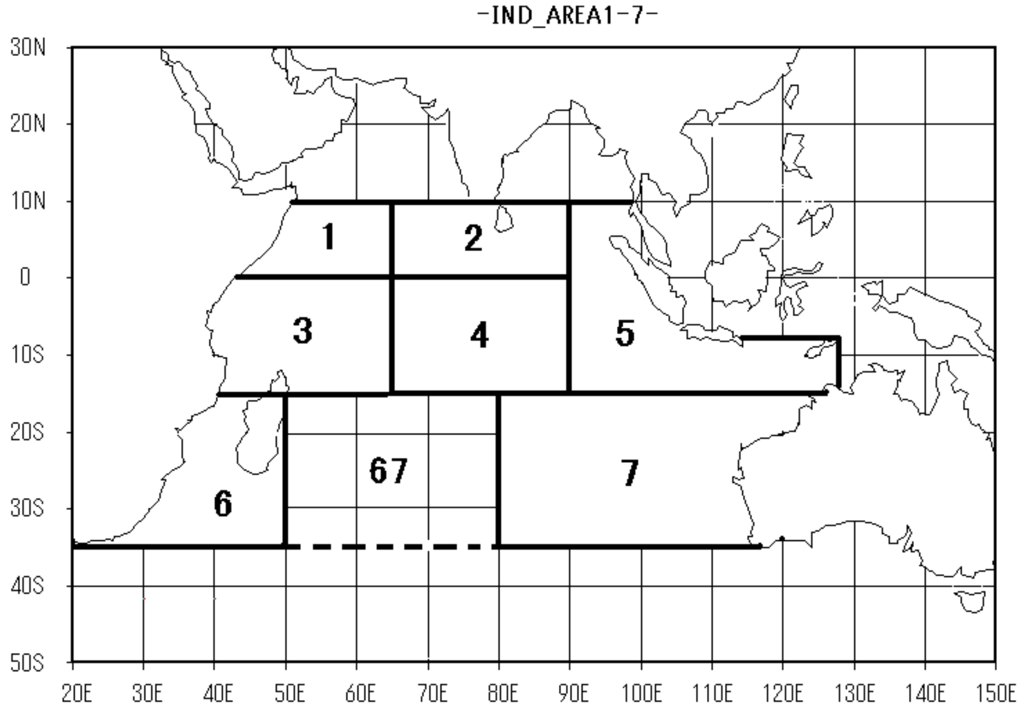

Fig. 1 Definition of sub-areas used in this study. TROPICAL, SOUTH and ALL INDIAN area categories in this paper consist of areas 1-5, areas 6-7 and areas1-7, respectively. Area67 was not used in this study.

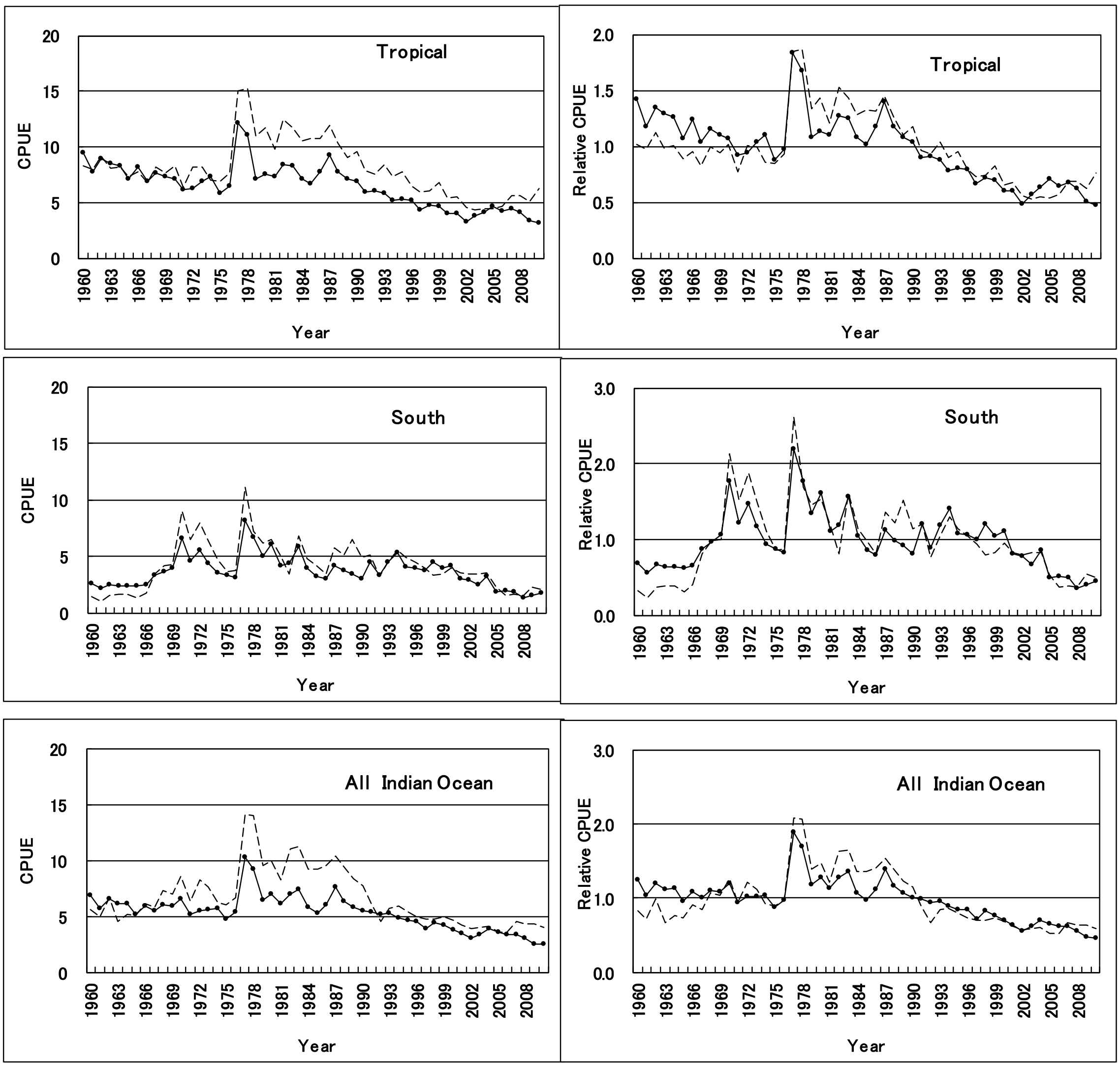

Fig. 2. Standardized CPUEs in real (left) and relative (right) scales for Tropical (top), South (middle) and ALL (bottom) Indian Ocean.

1960-2010

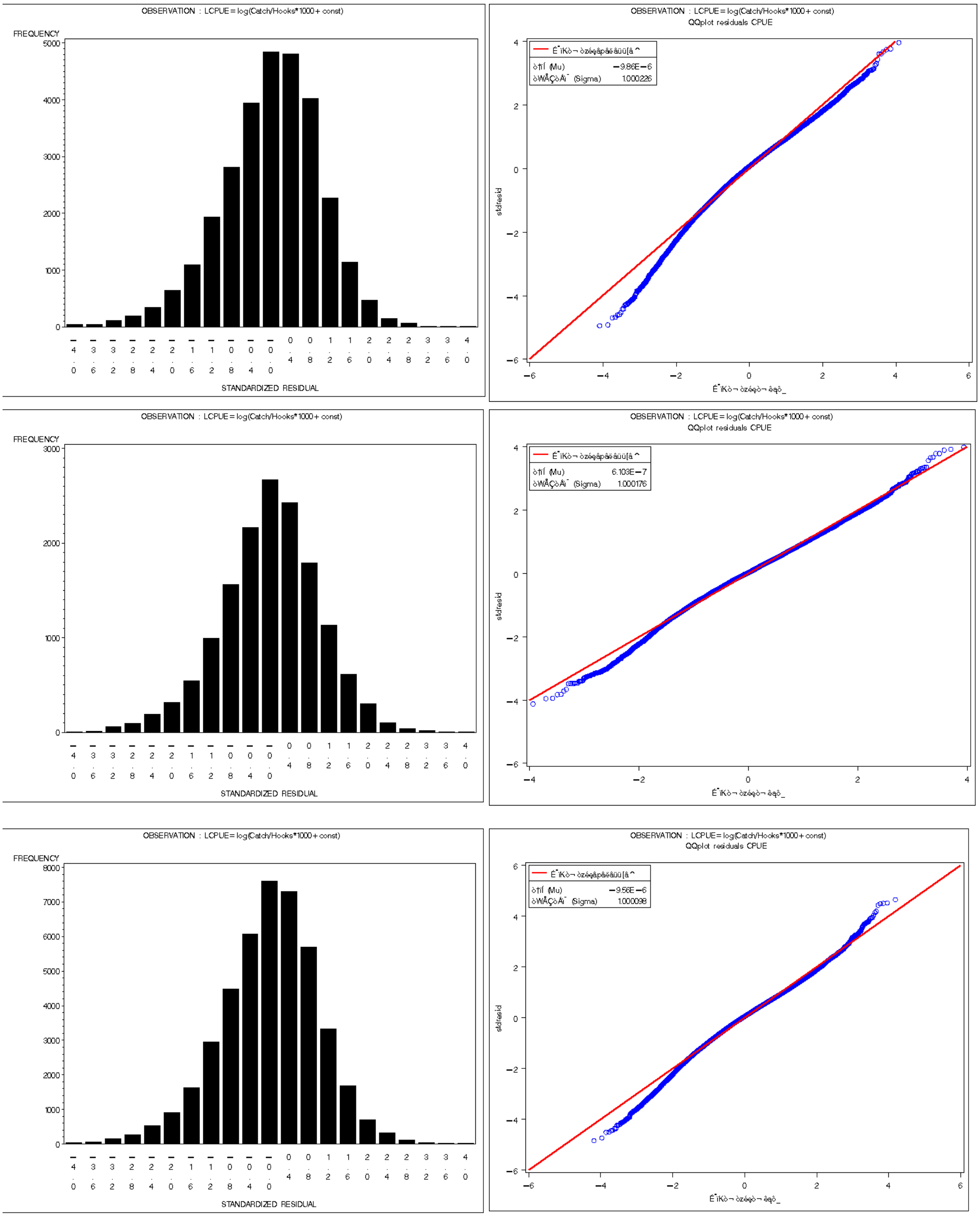

Fig. 3. Standardized residuals of year based standardization for each region expressed as histograms (upper figures) and QQ plots (bottom figures).

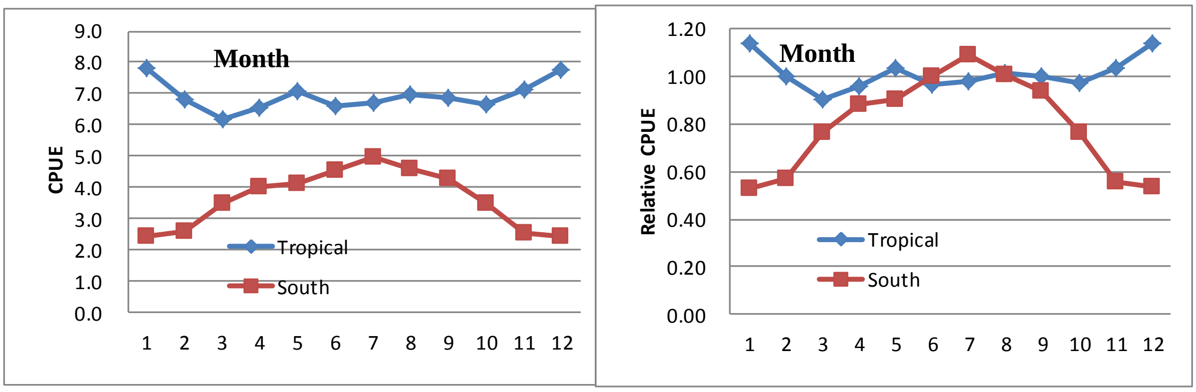

Fig. 4. Standardized CPUE in real scale by month for Tropical and Temperate Indian Ocean. Unit of CPUE is catch in number per 1000 hooks.

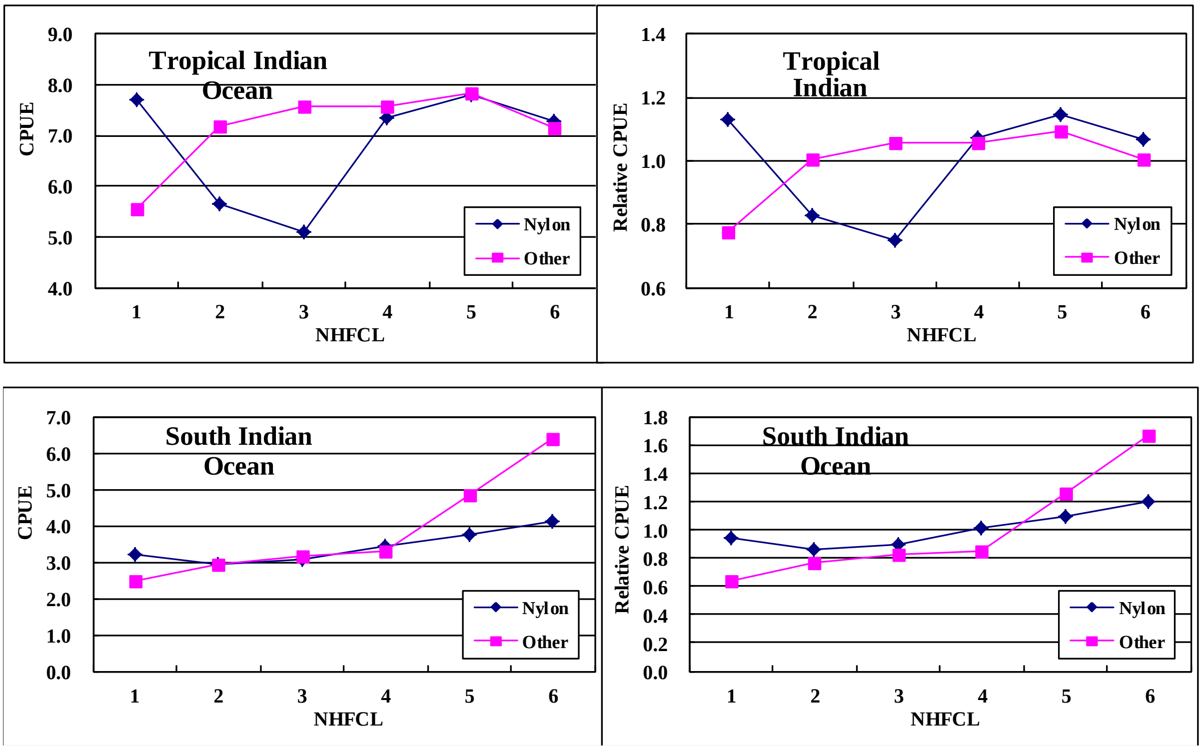

Fig. 5. Standardized CPUE expressed in real (left) and relative (right) scale by NHFCL and mainline materials for Tropical (top) and South (bottom) Indian Ocean. Unit of CPUE is catch in number per 1000 hooks.

Appendix Table 1. Annual value of standardized Bigeye CPUE in Tropical, South and All Indian Ocean from 1960-2010 expressed in real and relative scale in which the average from 1960 to 2010 is 1.0, with deviation.

Tropical 1960-2010

year	CPUE	dev_t	Relative CPUE
1960	9.4307	0.0013	1.4236
1961	7.7739	0.0014	1.1735
1962	8.9104	0.0010	1.3451
1963	8.5396	0.0012	1.2891
1964	8.3380	0.0012	1.2587
1965	7.1073	0.0010	1.0729
1966	8.2113	0.0009	1.2395
1967	6.8834	0.0009	1.0391
1968	7.6369	0.0012	1.1528
1969	7.3245	0.0010	1.1057
1970	7.0753	0.0013	1.0680
1971	6.1312	0.0011	0.9255
1972	6.2259	0.0016	0.9398
1973	6.8739	0.0017	1.0376
1974	7.3066	0.0015	1.1030
1975	5.8183	0.0012	0.8783
1976	6.4736	0.0022	0.9772
1977	12.1259	0.0028	1.8305
1978	11.1043	0.0013	1.6762
1979	7.1291	0.0030	1.0762
1980	7.5328	0.0017	1.1371
1981	7.2867	0.0010	1.1000
1982	8.4102	0.0008	1.2696
1983	8.2590	0.0010	1.2467
1984	7.1199	0.0012	1.0748
1985	6.7113	0.0010	1.0131
1986	7.7838	0.0007	1.1750
1987	9.2924	0.0008	1.4027
1988	7.7706	0.0010	1.1730
1989	7.1415	0.0011	1.0780
1990	6.8674	0.0010	1.0367
1991	5.9532	0.0012	0.8987
1992	6.0457	0.0017	0.9126
1993	5.8436	0.0012	0.8821
1994	5.1448	0.0010	0.7766
1995	5.3437	0.0008	0.8067
1996	5.2184	0.0006	0.7877
1997	4.3767	0.0004	0.6607
1998	4.7566	0.0005	0.7180
1999	4.6410	0.0005	0.7006
2000	3.9786	0.0004	0.6006
2001	3.9803	0.0006	0.6008
2002	3.2193	0.0005	0.4860
2003	3.7922	0.0011	0.5724
2004	4.1657	0.0007	0.6288
2005	4.6680	0.0013	0.7047
2006	4.2703	0.0005	0.6446
2007	4.4645	0.0004	0.6739
2008	4.1428	0.0004	0.6254
2009	3.3174	0.0006	0.5008
2010	3.1315	0.0011	0.4727

South 1960-2010

year	CPUE	dev_t	Relative CPUE
1960	2.5553	0.0091	0.6814
1961	2.1086	0.0066	0.5623
1962	2.4827	0.0056	0.6620
1963	2.4087	0.0052	0.6423
1964	2.3724	0.0052	0.6326
1965	2.3522	0.0046	0.6273
1966	2.4267	0.0051	0.6471
1967	3.2867	0.0032	0.8764
1968	3.6253	0.0035	0.9667
1969	3.9816	0.0041	1.0617
1970	6.6030	0.0045	1.7608
1971	4.5366	0.0044	1.2097
1972	5.5086	0.0081	1.4689
1973	4.3758	0.0067	1.1669
1974	3.4894	0.0047	0.9305
1975	3.2941	0.0045	0.8784
1976	3.0664	0.0112	0.8177
1977	8.2061	0.0171	2.1882
1978	6.6537	0.0065	1.7743
1979	5.0345	0.0063	1.3425
1980	6.0194	0.0060	1.6051
1981	4.1815	0.0045	1.1150
1982	4.4209	0.0073	1.1789
1983	5.8440	0.0056	1.5584
1984	3.9025	0.0036	1.0406
1985	3.2295	0.0038	0.8612
1986	2.9606	0.0052	0.7895
1987	4.1913	0.0045	1.1177
1988	3.6920	0.0071	0.9845
1989	3.4656	0.0072	0.9241
1990	3.0259	0.0048	0.8069
1991	4.5005	0.0023	1.2001
1992	3.3009	0.0036	0.8802
1993	4.4298	0.0023	1.1813
1994	5.2680	0.0013	1.4048
1995	4.0413	0.0009	1.0777
1996	3.9824	0.0010	1.0620
1997	3.7281	0.0012	0.9941
1998	4.5008	0.0022	1.2002
1999	3.9037	0.0020	1.0410
2000	4.1282	0.0015	1.1008
2001	3.0361	0.0011	0.8096
2002	2.9043	0.0013	0.7745
2003	2.5239	0.0027	0.6730
2004	3.2290	0.0029	0.8611
2005	1.8516	0.0031	0.4937
2006	1.9420	0.0028	0.5178
2007	1.8594	0.0027	0.4958
2008	1.3225	0.0019	0.3527
2009	1.5076	0.0022	0.4020
2010	1.6890	0.0020	0.4504

All Indian Ocean 1960-2010

year	CPUE	dev_t	Relative CPUE
1960	6.8139	0.0015	1.2497
1961	5.6707	0.0013	1.0400
1962	6.5349	0.0011	1.1985
1963	6.0840	0.0011	1.1158
1964	6.1249	0.0011	1.1233
1965	5.1922	0.0009	0.9523
1966	5.9057	0.0010	1.0831
1967	5.5014	0.0008	1.0090
1968	5.9828	0.0009	1.0973
1969	5.9343	0.0009	1.0884
1970	6.5446	0.0011	1.2003
1971	5.1404	0.0010	0.9428
1972	5.5232	0.0016	1.0130
1973	5.5412	0.0015	1.0163
1974	5.6408	0.0012	1.0345
1975	4.7618	0.0010	0.8733
1976	5.3308	0.0021	0.9777
1977	10.2461	0.0030	1.8791
1978	9.2351	0.0013	1.6937
1979	6.4690	0.0021	1.1864
1980	6.9683	0.0014	1.2780
1981	6.1356	0.0010	1.1253
1982	6.9589	0.0011	1.2763
1983	7.4119	0.0011	1.3594
1984	5.8254	0.0010	1.0684
1985	5.3011	0.0009	0.9722
1986	6.0466	0.0009	1.1090
1987	7.5631	0.0009	1.3871
1988	6.3636	0.0012	1.1671
1989	5.7971	0.0012	1.0632
1990	5.4933	0.0010	1.0075
1991	5.3706	0.0009	0.9850
1992	5.1241	0.0012	0.9398
1993	5.2471	0.0009	0.9623
1994	4.8692	0.0007	0.8930
1995	4.5944	0.0006	0.8426
1996	4.5550	0.0005	0.8354
1997	3.9149	0.0004	0.7180
1998	4.4666	0.0005	0.8192
1999	4.1745	0.0005	0.7656
2000	3.8115	0.0004	0.6990
2001	3.4636	0.0005	0.6352
2002	2.9984	0.0004	0.5499
2003	3.3598	0.0009	0.6162
2004	3.8455	0.0007	0.7053
2005	3.5768	0.0010	0.6560
2006	3.3428	0.0006	0.6131
2007	3.3871	0.0005	0.6212
2008	3.0293	0.0005	0.5556
2009	2.5443	0.0006	0.4666
2010	2.5229	0.0009	0.4627