# STANDARDIZED CPUE FOR BIGEYE CAUGHT BY THE JAPANESE LONGLINE FISHERY IN THE INDIAN OCEAN, 1952 - 1999

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**SUMMARY**

*The same methods as last year's report were applied to the updated Japanese longline data for the standardization of CPUE, in which the sub-areas for the analysis were determined by considering the distribution of longline effort and the level of bigeye CPUE. The effect of year, month, area and number of hooks between floats, and two-way interaction between month by area, and between area and number of hooks between floats were used in the model for the standardization (GLM procedure).*

*As a result of GLM, area and number of hooks between floats showed large effect. Standardized CPUE in the tropical areas were highest during 1977 to 1978 and declined gradually with fluctuations, and the values in 1999 were slightly lower than those in 1975. CPUE trend of western south area is comparatively similar to that in the tropical area, but quite different in the eastern south area. The fluctuations in the south areas, especially eastern south area, are considered to be influenced by regulation of southern bluefin tuna catch quota and fishing season and also change of the target species.*

*Seeing CPUE trend of tropical area from 1952 to 1999, CPUE showed moderate declining trend with fluctuation from about 13 around 1955 to about 5 in recent few years.*

*Based on these results, it is suggested that the standardized CPUE restricted in the tropical area is considered to be representative of more realistic abundance trend.*

## INTRODUCTION

The rapid increase of small bigeye catch by purse seine fishery has drawn the highest attention since it may inversely impact on the catch of longline fishery, which exploits medium to large fish. This increase of catch also indicates the increase of purse seine CPUE. However, due to the absence of reasonable measure of effective fishing effort, it is difficult to estimate abundance index from purse seine CPUE. Though the effect of catch by surface fishery can not be estimated by the standardization of longline CPUE, the CPUE trend let us know the relative change in the adult and sub-adult bigeye resource as far as there are enough longline effort in the area of interest.

In this paper, the same methods as in Okamoto and Miyabe (1999) were applied to the updated Japanese longline data for the standardization of CPUE, in which the sub-areas for the analysis were determined by considering the distribution of longline effort and the level of bigeye CPUE (Fig. 1). The effect of year, month, area and number of hooks between floats, and two-way interaction between month by area, and between area and number of hooks between floats were used in the model for the standardization.

## MATERIALS AND METHODS

### Data

The Japanese longline catch and effort statistics up to 1999 were used. 1999 data is preliminary. Data set from 1975 to 1999, which aggregated by month, 5-degree square and the number of hooks between floats (NHF), were used for the analyses. Similar data from 1952 to 1974 was also used, though it dose not include the information on NHF.

### Model configuration

Geographical distributions of effort (the number of hooks) and CPUE for bigeye in the Indian Ocean were shown in and Fig. 3, respectively. Considering these distributions, main fishing ground was divided into seven areas for the analysis (Fig. 1), which are same as in Okamoto and Miyabe (1999).

Frequency distribution of NHF has changed historically as shown in Table 1 and differs among the areas (ig. 4). To include the effect of NHF into the model, the number of branch lines per basket was classified into three classes (class 1: 5-9, class 2: 10-15, class 3: 16-21) (Okamoto and Miyabe, 1999).

The model used for GLM analysis (log normal error structure model) is as follows,

$$\text{Log}(\text{CPUE}_{ijkl} + \text{const}) = \mu + YR(i) + MN(j) + AREA(k) + NHFCL(l) + MN(j)*AREA(k) + AREA(k)*NHFCL(l) + e(ijkl....)$$

Where Log: natural logarithm,

CPUE: catch in number of bigeye per 1000 hooks,

Const: 10% of overall mean of CPUE μ: overall mean,

YR (i): effect of year,

MN (j): effect of fishing season (month),

AREA (k): effect of area,

NHFCL (l): effect of gear type (class of number of hooks between floats),

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

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

E (ijkl...): error term.

In order to compare the CPUE trend among the sub-areas, GLM analyses using same main effect and interaction terms were conducted for several combined sub-area, i.e., western tropical area: areas 1&3, eastern tropical area: areas 2, 4 & 5, south area: areas 6 & 7, and all area: 1-7. For the comparison in the historical trend between nominal (number of catch per 1000 hooks) and standardized CPUEs, both CPUEs are scaled by the average of nominal CPUE in each area. Moreover, to compare with the past abundance trend, the same analysis was done using data from 1952 to 1999, in which though the NHF was fixed to 6 before 1974 because deep longline gear was not used before 1970s, as is shown in ig. 4.

## RESULTS AND DISCUSSIONS

Standardized CPUEs from 1975 to 1999 for western tropical (area 1 & 3), eastern tropical (area 2, 4 & 5), western south (area 6) and eastern south (area 7) are shown in

***Fig. 5. Standardized and nominal CPUE in the western (left: area 1 & 3) and eastern (right: area 2, 4 & 5) tropical areas. Both CPUEs are scaled by the average of nominal CPUE in each figure.***

(tropical areas) and **Fig. 6**) (south areas) with their upper and lower 95% confidence limits and nominal CPUEs, respectively. In both tropical areas **(Fig. 5)**, standardized CPUE showed relatively similar trend, though there were some minor differences. In both tropical areas, after 1975, standardized CPUE were highest during 1977 to 1978 and declined gradually with fluctuations, and the values in 1999 were slightly lower than those in 1975.

The standardized CPUE in western south area **(Fig. 6):** left graph) showed relatively similar trends as those observed in tropical areas **(Fig.5)**

***Fig. 5. Standardized and nominal CPUE in the western (left: area 1 & 3) and eastern (right: area 2, 4 & 5) tropical areas. Both CPUEs are scaled by the average of nominal CPUE in each figure.***

, i.e., gradual decreasing trend since 1977, while larger fluctuation was observed in the last decade than those in tropical areas.

On the contrary, the CPUE in eastern south area (**Fig. 6**: right graph) was somewhat different from those in tropical areas (**Fig. 5**). It decreased from about 3.7 in 1978 to 0.9 in 1986, and increased to 5.5 in 1993, and decreased again, to 1.90 in 1999. As in the western south area (**Fig. 6**: left graph), large fluctuation was also observed in the last decade. The fluctuation of CPUE in the south areas are considered to influenced by regulation of southern bluefin tuna catch quota and fishing season and also change of the target species, as suggested in Okamoto (1998) or Okamoto and Miyabe (1999).

The results of ANOVA for tropical area (area1-5) in the model are shown in (**Table 2)**. R-square value was about 0.206. In this analysis, area and NHFCL showed large effect **(Table 3)**. The distribution of overall residual in the final model **(Fig.7)** suggested that the log normal model is appropriate.

The standardized CPUE derived from GLM analyses for tropical area was shown in Error! Reference source not found. with its upper and lower 95% confidence limits, with nominal CPUE. As observed in the analyses for western and eastern tropical areas **(Fig. 5)**, the standardized CPUE showed gradual declining trend from 1977 to 1999, and was relatively stable in the last three years.

The results for the global GLM analyses including all areas (area 1-7) were shown in

. Standardized CPUEs show the gradual decreasing trend from 1979 to 1999 with some partial fluctuations. These fluctuation are probably due to the change of target species in the south areas as mentioned before, and that in 1999 was the lowest in latest two decade, though nominal CPUE is stable since 1996, which was possibly caused by the change of longline gear, that is, sharp increase in deep longline gear (see **Table.1** and **ig.4**).

In the analysis including the past data (1952-1974), CPUE showed moderate declining trend from about 13 around 1955 to about 5 in recent few years (**Fig.10**).

Based on the results of this study and also results of the past studies by Okamoto (1998) and Okamoto and Miyabe (1999), it is suggested that the standardized CPUE restricted in the tropical area is considered to be representative of more realistic abundance trend.

## REFERENCES

OKAMOTO, H. 1998. Updated standardized CPUE of bigeye caught by Japanese longline fishery in the Indian Ocean. IPTP TWS-98, 10pp.

OKAMOTO, H. AND N. MIYABE. 1999. Standardized CPUE of bigeye caught by Japanese longline fishery in the Indian Ocean, up to 1998. IOTC WPTT-99, 8pp.

*Table 1. The number of hooks (thousand) used in the area analyzed by year and by the number of hooks between floats.*

| Year | Number of hooks between floats (NHF) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** |
| **1975** | 692 | 17637 | 11110 | 1679 | 785 | 590 | 275 | 444 | 242 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1976** | 419 | 13815 | 4883 | 575 | 150 | 335 | 9 | 144 | 63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1977** | 43 | 9933 | 3512 | 306 | 530 | 587 | 456 | 685 | 738 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1978** | 35 | 8387 | 4999 | 1489 | 256 | 2960 | 3237 | 2426 | 2523 | 1681 | 98 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1979** | 4 | 5421 | 5566 | 1515 | 408 | 1391 | 1902 | 1193 | 1218 | 296 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1980** | 0 | 5776 | 6497 | 1604 | 959 | 2112 | 2336 | 2130 | 918 | 308 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1981** | 19 | 6585 | 8767 | 3458 | 792 | 1945 | 5510 | 3236 | 739 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1982** | 67 | 9772 | 9301 | 2497 | 224 | 1624 | 6647 | 7613 | 2261 | 470 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1983** | 0 | 5531 | 10680 | 2917 | 458 | 1157 | 5541 | 11660 | 5068 | 2344 | 112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1984** | 28 | 5271 | 14077 | 3737 | 628 | 339 | 6395 | 9787 | 6047 | 1723 | 219 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1985** | 19 | 1588 | 17618 | 6813 | 705 | 708 | 7298 | 12856 | 7789 | 2320 | 97 | 214 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1986** | 0 | 2270 | 21516 | 5394 | 667 | 446 | 4051 | 9974 | 6608 | 3146 | 305 | 353 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1987** | 0 | 1163 | 17358 | 8861 | 903 | 452 | 1174 | 6268 | 10552 | 2204 | 304 | 418 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1988** | 0 | 897 | 12628 | 4840 | 998 | 701 | 1781 | 3703 | 11410 | 2177 | 44 | 543 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1989** | 0 | 173 | 15483 | 2932 | 729 | 303 | 2468 | 1714 | 6453 | 1543 | 166 | 716 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| **1990** | 0 | 738 | 8600 | 6333 | 997 | 136 | 2394 | 1179 | 4362 | 4301 | 353 | 531 | 128 | 188 | 26 | 0 | 0 | 0 | 0 |
| **1991** | 0 | 329 | 11890 | 9205 | 2840 | 697 | 957 | 1304 | 2964 | 3647 | 1232 | 402 | 113 | 63 | 451 | 0 | 31 | 0 | 0 |
| **1992** | 7 | 409 | 15949 | 8391 | 2023 | 932 | 1581 | 593 | 1993 | 2001 | 306 | 784 | 83 | 258 | 726 | 36 | 781 | 0 | 0 |
| **1993** | 0 | 211 | 9695 | 10433 | 3090 | 1449 | 3919 | 839 | 2228 | 1294 | 929 | 393 | 473 | 705 | 321 | 153 | 1876 | 346 | 0 |
| **1994** | 4 | 49 | 5918 | 15395 | 6930 | 4803 | 11952 | 1196 | 2406 | 1614 | 948 | 784 | 765 | 496 | 1845 | 351 | 2081 | 524 | 0 |
| **1995** | 4 | 32 | 2606 | 14690 | 8925 | 9286 | 20813 | 2313 | 2952 | 2672 | 634 | 1152 | 868 | 972 | 1647 | 585 | 2766 | 597 | 0 |
| **1996** | 0 | 0 | 469 | 6441 | 8216 | 12793 | 26548 | 1920 | 4746 | 2567 | 1509 | 3995 | 1521 | 1082 | 2922 | 786 | 4174 | 801 | 42 |
| **1997** | 0 | 3 | 197 | 1921 | 5108 | 13310 | 31009 | 3490 | 5617 | 2155 | 1930 | 3010 | 3678 | 2749 | 6970 | 2072 | 5747 | 1048 | 0 |
| **1998** | 0 | 1 | 2 | 532 | 1639 | 9496 | 26412 | 3461 | 4345 | 869 | 984 | 2371 | 2524 | 3807 | 8204 | 2221 | 8242 | 2387 | 7 |
| **1999** | 0 | 0 | 0 | 123 | 266 | 1547 | 14382 | 4305 | 2979 | 304 | 650 | 2342 | 2322 | 989 | 2049 | 741 | 5726 | 858 | 3 |

*Table 2. Result of ANOVA from the General Linear Model for bigeye in the tropical area (AREA 1, 2, 3, 4 and 5) in the Indian Ocean, 1975-1999.*

| Source of Variation | Degree of Freedom | Some of Squares | Mean Square | F Value | Pr > F | R-Square |
|---|---|---|---|---|---|---|
| | YR + MN + AREA + NHFCL + MN*AREA + AREA*NHFCL | | | | | |
| **Model** | 93 | 1982.677 | 21.31911 | 45.98 | 0.0001 | 0.206177 |
| **Error** | 16464 | 7633.727 | 0.463662 | | | |
| **Total** | 16557 | 9616.405 | | | | |

*Table 3. Result of F-test of the GLM analyses (full model) (YR+MN+AREA+NHFCL+MN*AREA+AREA*NHFCL).*

| Source | Degree of Freedom | Sum of Square | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| **YEAR** | 24 | 750.0 | 31.2 | 48.4 | 0.0001 |
| **MONTH** | 11 | 79.6 | 7.2 | 11.2 | 0.0001 |
| **AREA** | 6 | 1279.1 | 213.2 | 330.3 | 0.0001 |
| **NHFCL** | 2 | 261.4 | 130.7 | 202.5 | 0.0001 |
| **MN*AREA** | 66 | 1441.1 | 21.8 | 33.8 | 0.0001 |
| **AREA*NHFCL** | 12 | 197.3 | 16.4 | 25.5 | 0.0001 |

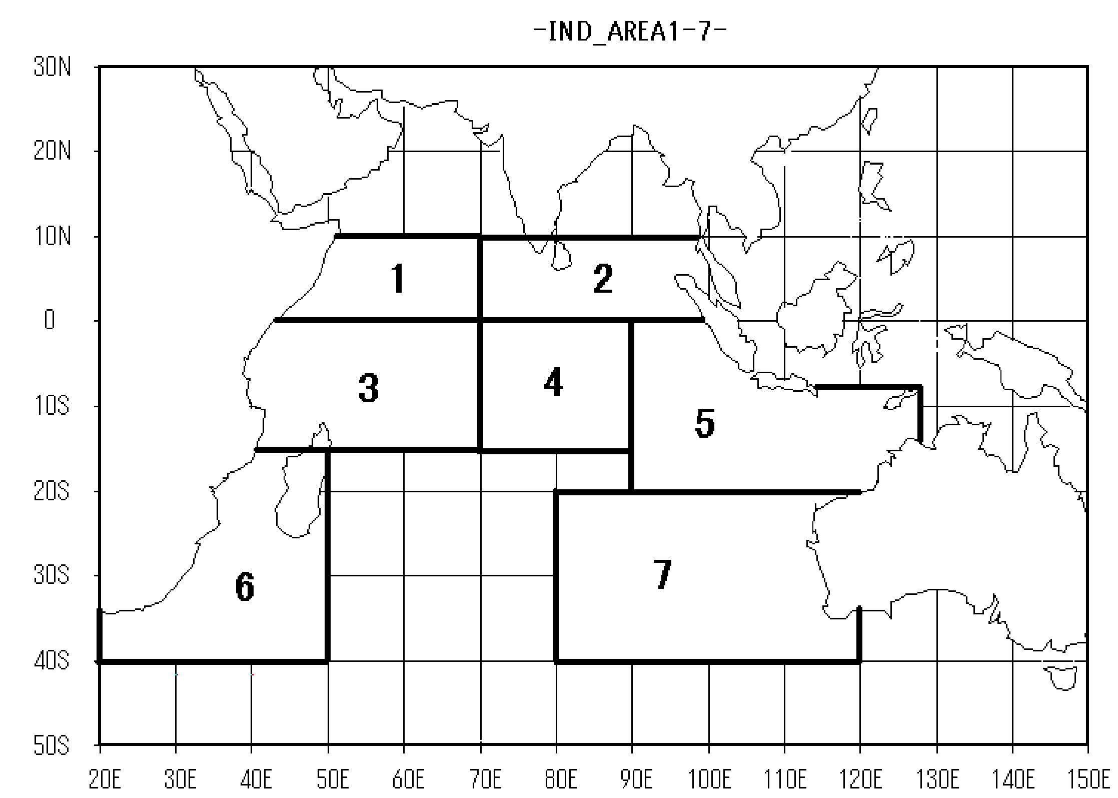



***Fig. 1. Area definition used in the GLM analysis.***

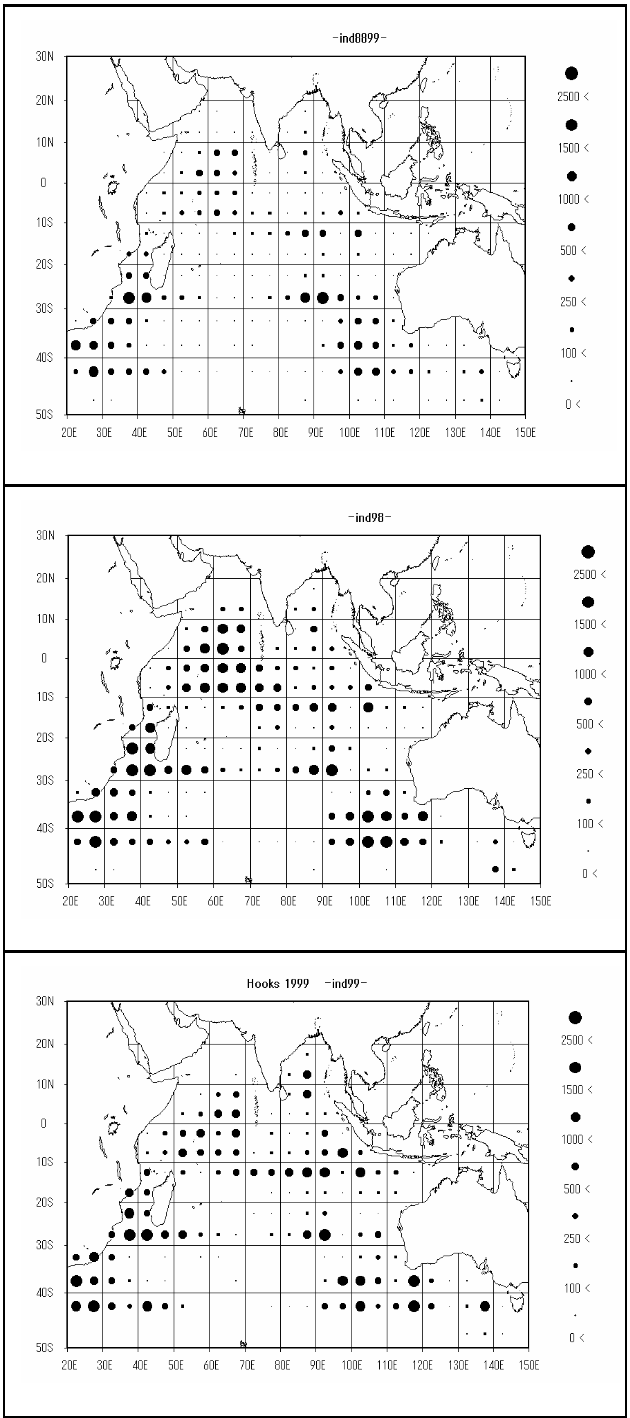



*Fig. 2. Geographical distribution of Japanese longline effort (in 1000 hooks). Top figure shows annual average distribution of hooks during 1988-1999. Bottom two figures show annual distribution of hooks in 1998 and 1999, respectively.*

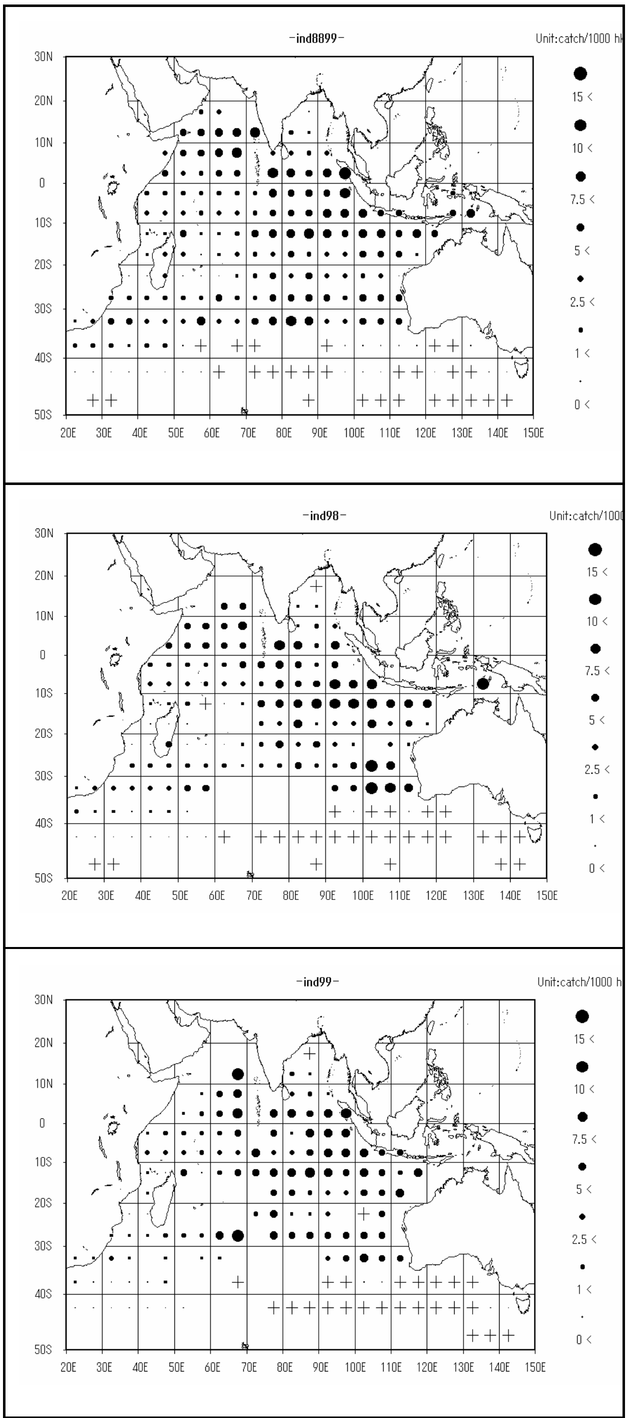
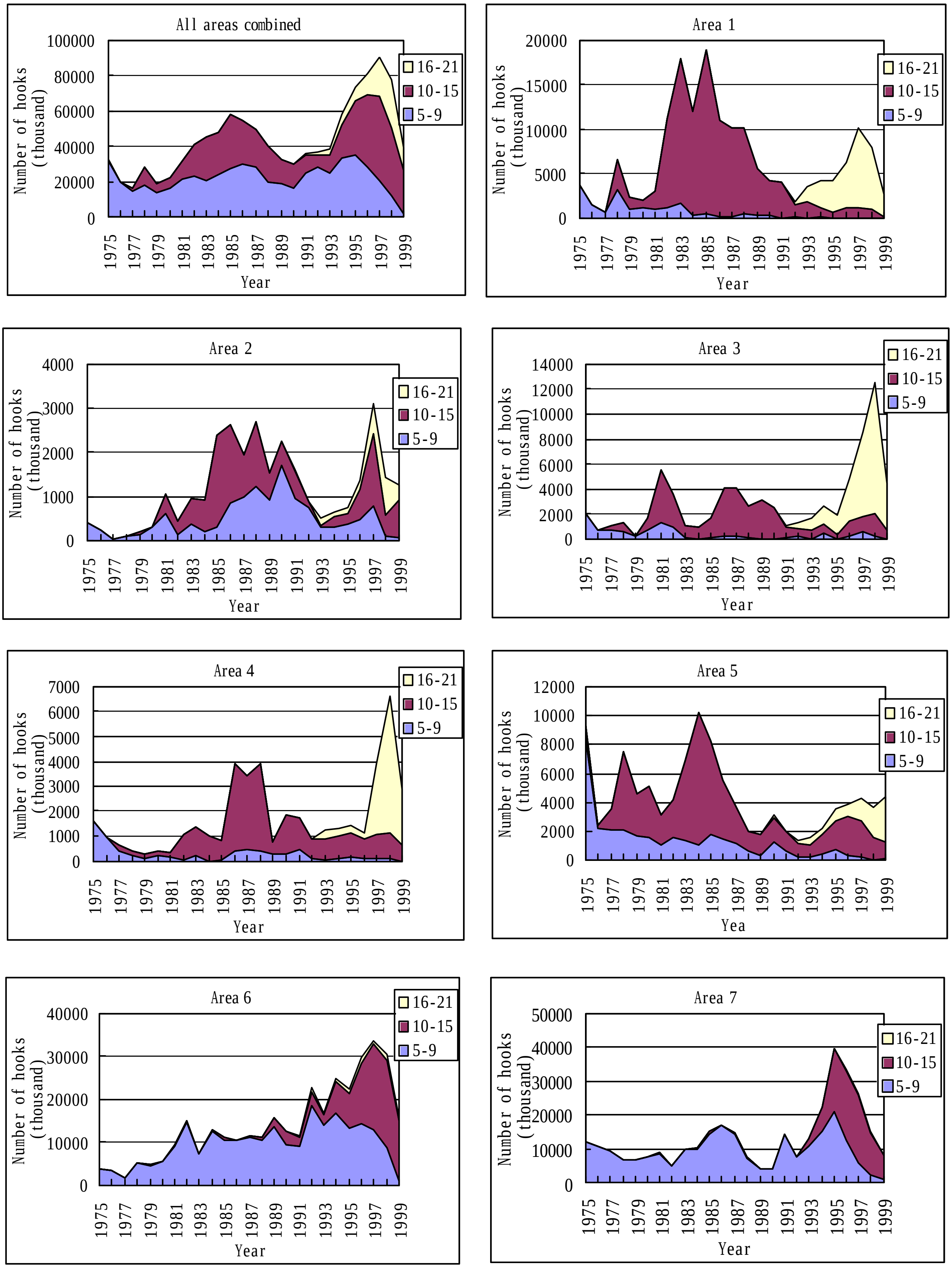



***Fig. 3. Nominal CPUE (catch number per 1000 hooks) for bigeye in the Indian Ocean. Top figure shows the average distribution of CPUE during 1988-1999. Bottom two figures show annual distribution of CPUE in 1998 and 1999, respectively. "+" means CPUE=0.***




***ig. 4. Annual changes of fishing efforts (number of hooks) by number of hooks between floats (NHF) in each area. NHF is classified into the three groups such as 5-9 hooks between floats, 10-15, and 16-21, which is used in the standardization of CPUE in this paper.***

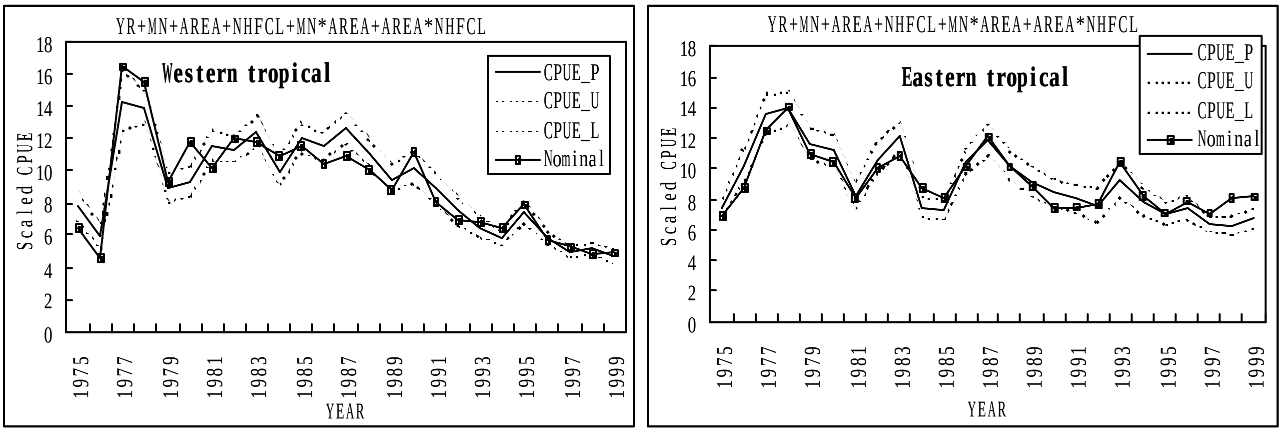



***Fig. 5. Standardized and nominal CPUE in the western (left: area 1 & 3) and eastern (right: area 2, 4 & 5) tropical areas. Both CPUEs are scaled by the average of nominal CPUE in each figure.***

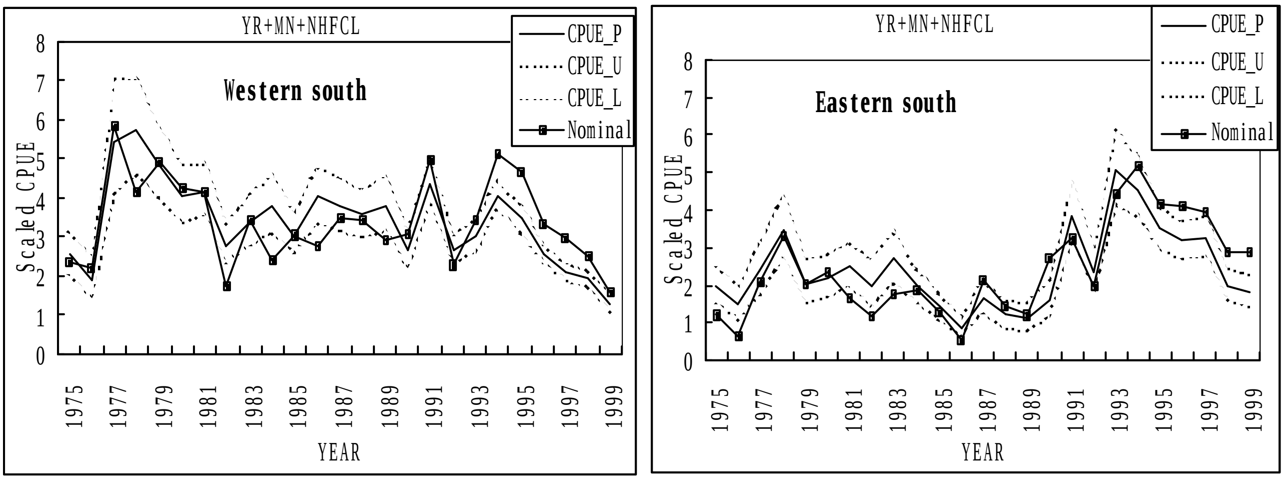



***Fig. 6. Standardized and nominal CPUE in the south area (left: area 6, right: area7). Both CPUEs are scaled by the average of nominal CPUE in each figure.***

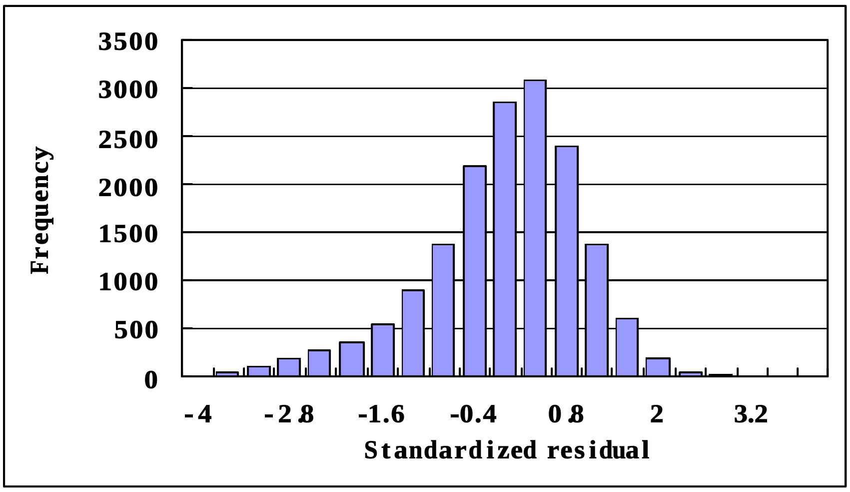



***Fig. 7. Histogram of standardized residuals in the tropical area (area 1-5), 1975-1999.***

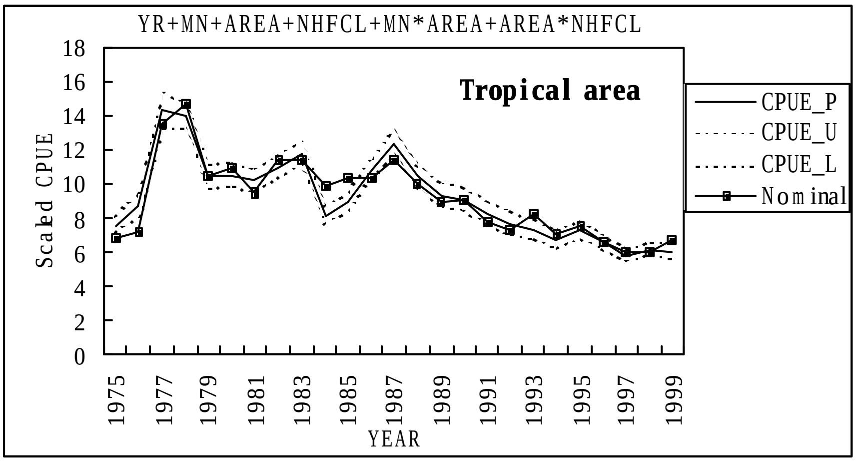



*Fig. 8. Annual change of standardized (upper and lower broken lines indicate 95% confidence limits) and nominal (solid line with square mark) CPUE in the tropical area (area 1-5).*

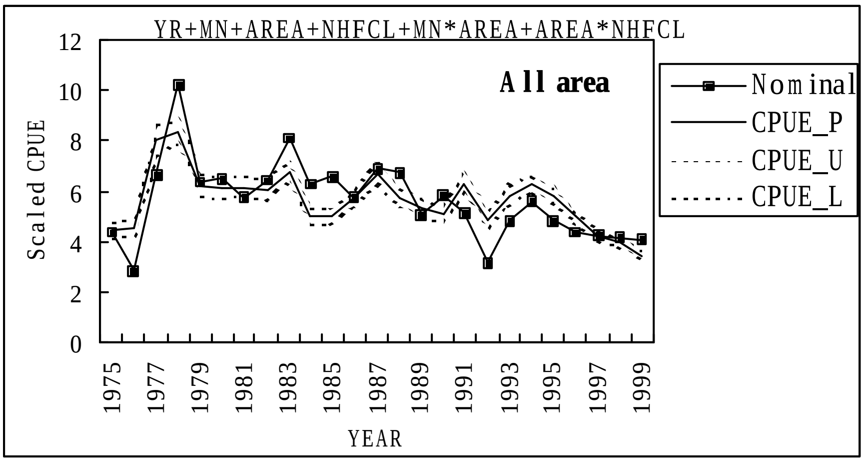



*Fig. 9. Standardized and nominal CPUE of all area included (area 1-7).*

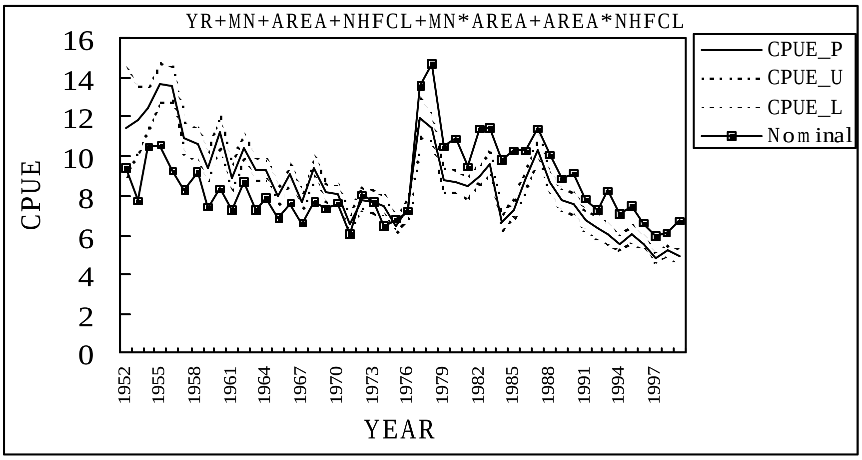



*Fig. 10. Standardized and nominal CPUE of tropical area (area 1-5) from 1952 to 1999.*