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Standardized catch rate and abundance index for swordfish caught by Japanese longliner in the North Pacific in 1975 - 2000

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Introduction

Nakano (1994) analyzed stock status of the swordfish in the North Pacific by using standardized CPUE of the Japanese longline fishery and reported recent declining trend of CPUE. Yokawa (1999) improved the standardization method of swordfish CPUE in terms of the subarea stratification and the model used in GLM, and reported the stock status of swordfish in the North Pacific in the period of 1952-1997. This paper updates the standardized CPUE of Yokawa (1999) up to 1998-2000 and estimates the abundance index of swordfish in the North Pacific.

Materials and Methods

The data for this study were obtained from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries for 1952-2000. Two kinds of Databases, Databases-I and II, were existed (see, Yokawa 1999). In this paper, the data of Database-I before 1975 were used from Yokawa (1999). This study was analyzed by the new Database-II from 1975 that contains additional information for the gear configuration, i.e. the number of branch lines between floats compared to Database-I.

Designation of subareas used for the CPUE standardization were done by comparing the level and the trend of nominal CPUE value of each 5x5 block according to the method of Yokawa (1999) (Fig. 1).

CPUE was calculated as catch number per 1,000 hooks. Observations with less than

1,500 hooks per month and per 5x5 blocks were excluded from analysis. Database-II from 1975 to 2000 was used for the GLM standardization. The standardized CPUE of each area was multiplied by the relative size of the area and summed up to obtain the abundance index.

Selection of the factors included in the model as main effects were followed by Yokawa (1999). Following formula was used in the multiplicative model.

$$\ln(CPUE_{ijkl}+const)=\ln(\mu)+\ln(YR_i)+\ln(QT_j)+\ln(AR_k)+\ln(GE_l)+\ln(INTER)+\varepsilon_{ijkl}$$

where ln: natural logarithm, $CPUE_{ijk}$: nominal CPUE (catch in number per 1,000 hooks, in year i, quarter j, area k), const: 1/10 of overall mean, μ: overall mean, YR_i: effect of year i, QT_j: effect of quarter j, AR_k: effect of area k, GE_l: effect of gear l, INTER: any combination of two way interaction, and ε: normal error term. Analysis was made though the GLM procedure of computer software, "SAS Ver. 6.12". The abundance index was obtained by the standardized CPUE of the Japanese longliners and the size of subareas in the North Pacific.

Result

The standardization of CPUE was done with Database-II (1975 – 2000). The model used in Database-II is as follows,

CPUE= μ +Year+Area+Quarter+Gear+Area*Quarter+Quarter*Area+Quarter*Gear+Year*Area+e.

As Year*Area interaction was significant in Database-II, the weighted mean of CPUE in each year by the size of subareas is used as abundance index. Calculation of GLM model and analysis of variance for swordfish data are shown in Tables 1 and 2. The model in each period and area were highly significant. The distribution of standardized residuals is shown in Fig. 2. The distribution has two modes. The reason of two modes is caused by many zero catch observation.

Figure 3 shows the effect of gear configuration by area on the swordfish standardized CPUE. All the values in the figure 3 were derived from the least square mean of CPUE on gear*area effect obtained by the GLM procedure in the CPUE standardization with the Database-II. Three and four hooks between floats were recorded the highest catch rate and negative correlation was observed in standardized CPUE and number of hooks between floats.

Figure 4 shows the affect of subareas by year on the swordfish standardized CPUE. All the values in the figure 4 were derived from the least square mean of CPUE on area*year effect obtained by the GLM procedure in the CPUE standardization with the Database-II for 1975 - 2000.

High CPUE was observed for subareas 1, 3, 11 and 12 in the period of 1998 – 2000.

Figure 5 shows the abundance index, nominal CPUE and the total catch (Yokawa 1999) of swordfish in the North Pacific. All the values of abundance index and nominal CPUE expressed as the relative value of the value in 1975 set at 1.0. The shape of the abundance index was flat or slightly increase with the years. The highest abundance index was obtained in 1987. The abundance index showed a consistent declining trend after 1987, but the value of 2000 is higher than that of 1975. The nominal CPUE and the abundance index were very different in the period of 1952 – 1970 while they showed similar trend after 1970. The nominal CPUE were 2 – 6 times higher than the abundance index in the period of 1952 – 1970. Large number of swordfish catch was obtained in the periods of 1957 – 1961 and 1990 – 1996.

Discussions

The abundance index of swordfish in the North Pacific increased in the period of 1998 – 2000 (Fig. 5). The level of index in 2000 was 0.6 – 1.0 times lower than that of late 1980's in which the stock level of swordfish was highest during the last 50 years. This recent trend was caused by the increase of CPUE of swordfish off the Pacific coast of Japan (subareas 1 and 3) and in the northeastern tropical Pacific (subareas 11 and 12), (Fig. 4). The value of standardized CPUE in 2000 was about 2 – 3 times higher than that in 1998 in subareas 11 and 12. The reason of this sudden increase trend is unknown, but more precise analysis included ocanographic condition such as the relationships between CPUE of swordfish and El-Nino phenomenon is required.

The surface longline fishery whose numbers of hooks between floats were 3 and 4 recorded high catch rate and occupied high percent of total catch after late 1980's (Uosaki and Takeuchi 1998). In this study, negative correlation was observed in standardized CPUE and number of hooks between floats in the period of 1975 - 2000. Because a part of the surface longline fishery whose numbers of hooks between floats are 3 – 6 sets the line for operation during night, this high CPUE might be caused by the night setting operation. The total catch of swordfish of the surface longliners was high in the periods of 1957 – 1961 and 1990 – 1996 and total catch showed a declining trend after 1993. However, there is no change in the abundance index and nominal CPUE trend during 1990's. It is suggested that the recent declining trend of total catch of swordfish in the North Pacific is caused by the decrease of the effort of Japanese longline fishery after 1990.

Further analysis about biology of swordfish, operation pattern, target species of gear form and environmental condition would contribute to obtain more accurate abundance index.

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Table 1. Calculation of GLM model of swordfish CPUE standardization.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Year	25	971.42	38.86	12.27	0.0001
Quarter	3	245.36	81.79	25.82	0.0001
Area	11	9116.67	828.79	261.64	0.0001
Gear	4	1321.47	330.37	104.29	0.0001
Area*Gear	44	10582.39	240.51	75.93	0.0001
Quarter*Area	33	12722.29	385.52	121.71	0.0001
Quarter*Gear	12	1017.14	84.76	26.76	0.0001
Year*Area	275	8018.16	29.16	9.20	0.0001

Table 2. Analysis of variance for swordfish data in the North Pacific in 1975-2000.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	407	141657.51	348.05	109.88	0.0001
Error	108662	344206.42	3.17		
Corrected Total	109069	485863.93			

R-Square = 0.291558

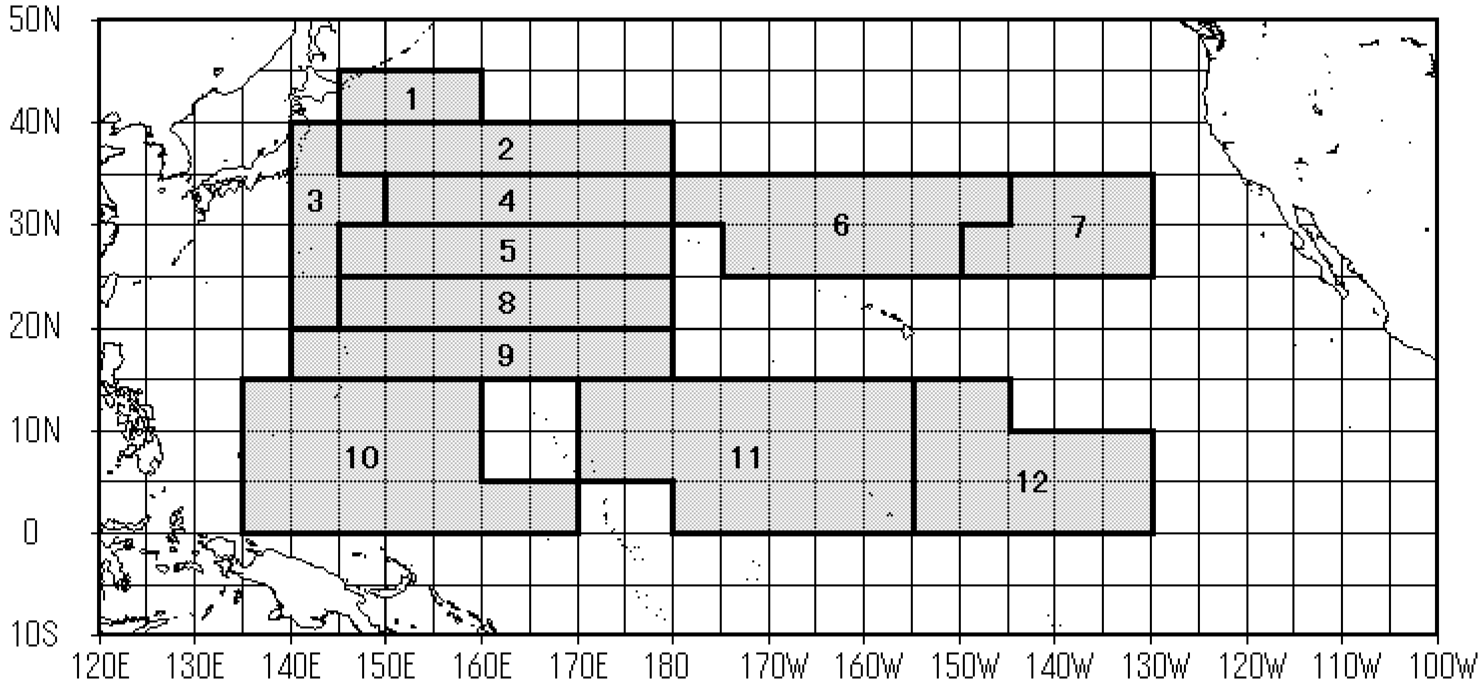

Fig. 1. The designation of the subarea used in the CPUE standardization by swordfish data in the North Pacific.

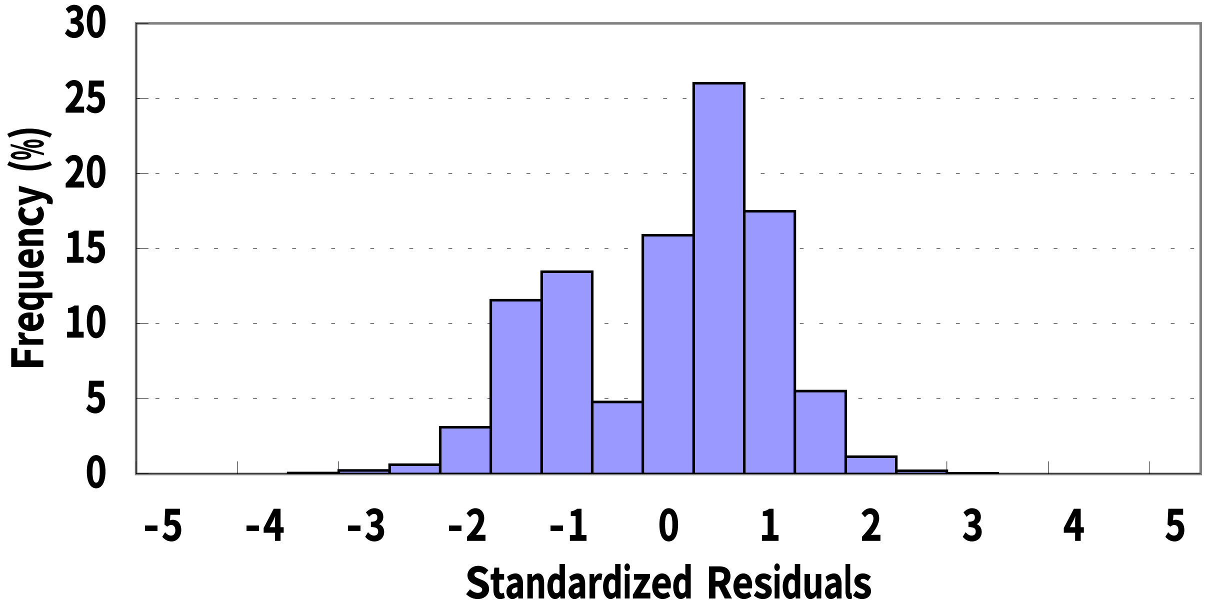

Fig. 2. Overall histgrams of standardized residuals from the final model in the North Pacific.

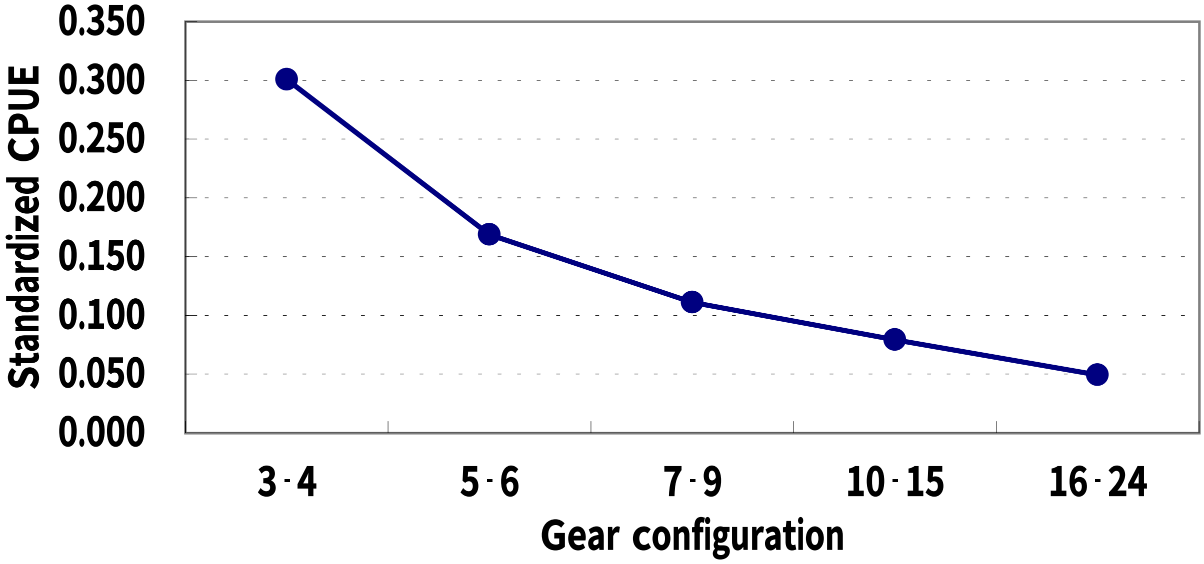

Fig. 3. The values of the standardized CPUE by gear configuration in the North Pacific.

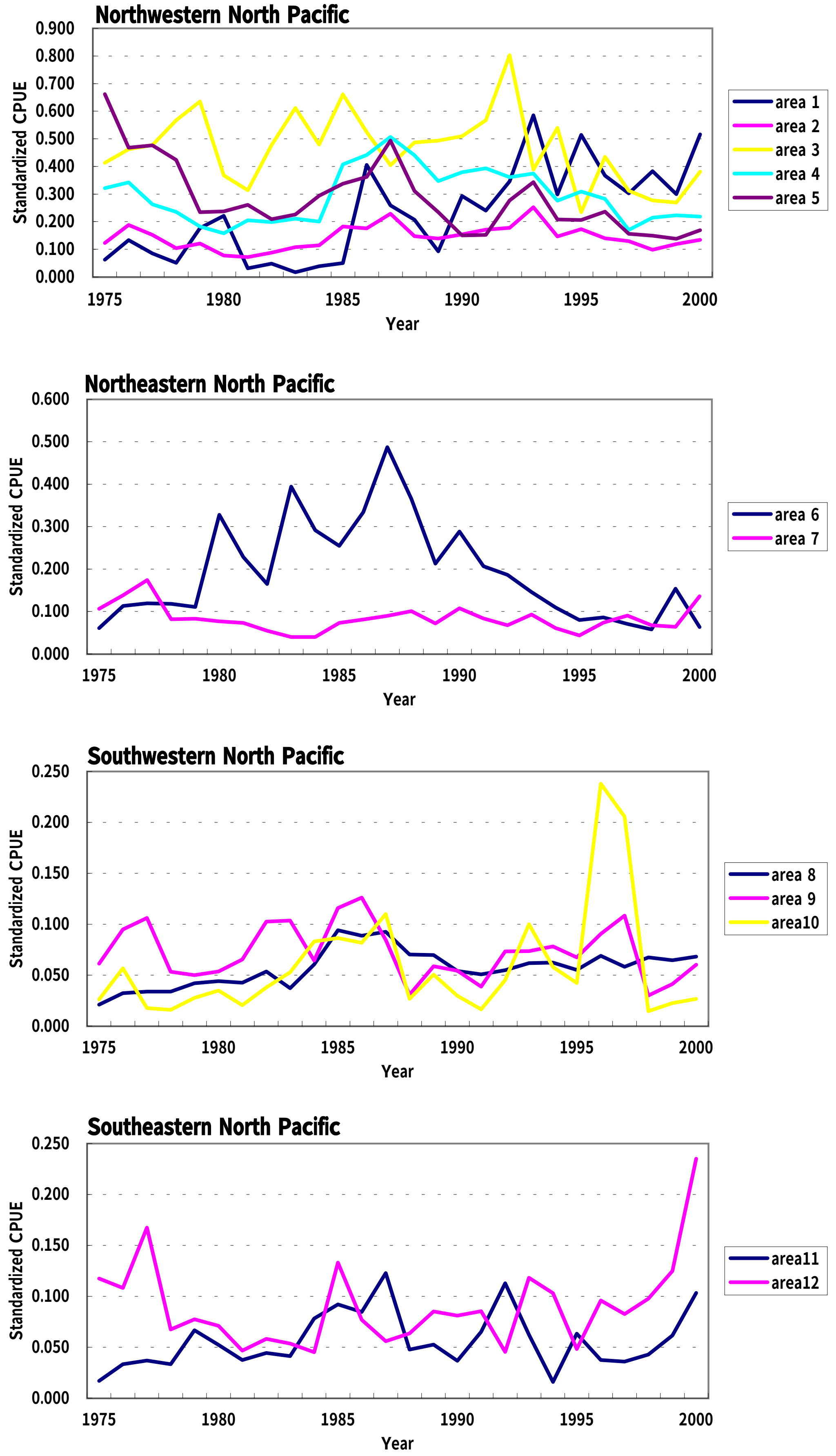

Fig. 4. The standardized CPUE by the designated area of the swordfish caught by the Japanese distant water and offshore longliners in the North Pacific.

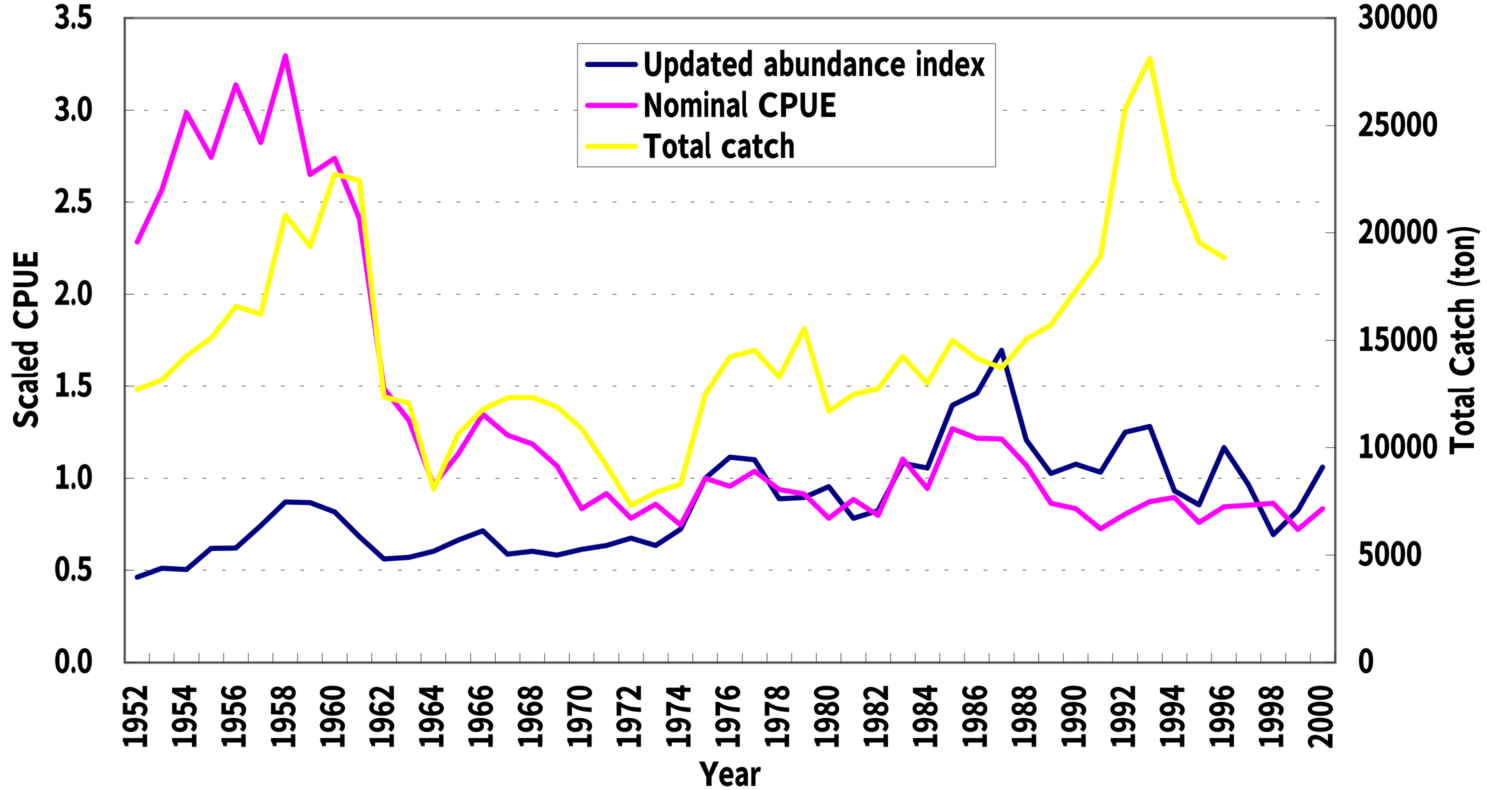

Fig. 5. The trend of the abundance index and nominal CPUE of the swordfish caught by the Japanese distant water and offshore longliners in the North Pacific and estimated total catch (ton) in the northwest and north central Pacific (north of 0 ° N), (data of abundance index and nominal CPUE before 1975 and total catch from Yokawa 1999).
All the values of the abundance index and nominal CPUE scaled to that in 1975 which set at 1.0.