Updates of standardized CPUE of swordfish caught by Japanese offshore and distant longliners in the North Pacific[1]

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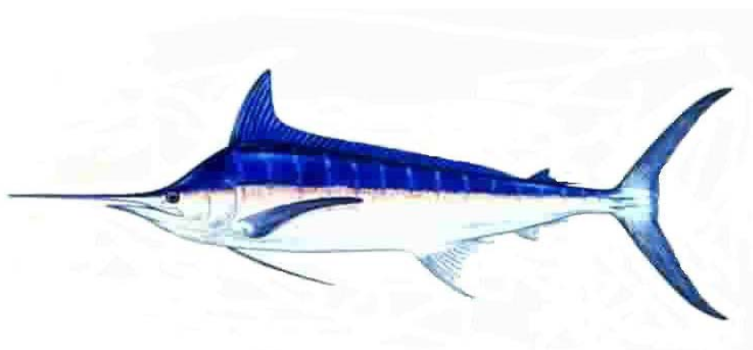

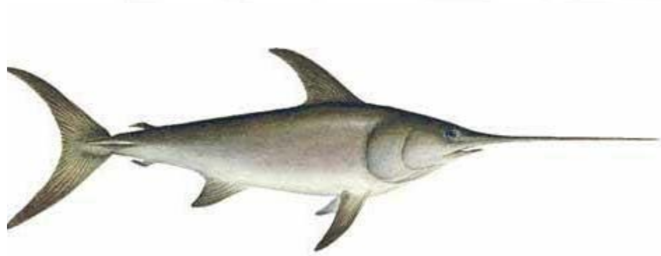

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Introduction

As for the standardization of abundance index of swordfish (SWO) in the North Pacific, many statistical models such as simple generalized liner model (Saito and Yokawa 2004) and habitat model (Yokawa 2004a), and simple generalized liner model with different definition of area stratifications (Yokawa 2004b) have been applied for increasing reliability of the results. Those studies present following implications about recent trends of swordfish stock in the North Pacific (Yokawa 2004b);

1) Trends of standardized CPUEs were different between regions south and north to 15°N, which might indicate existence of multiple sub-stocks.
2) Similar downward trends of CPUE in the main fishing ground of swordfish (the area north to 15°N) after mid 1980's regardless of area stratification and statistical models.

Yokawa (2004b) also pointed out the necessity of the careful monitoring of the status of SWO stock especially in the main fishing ground north to 15°N in recent years through the implication of this recent decreasing trend of the stock.

This document updates standardized CPUE of SWO at the main fishing ground of swordfish in the North Pacific. The method and data for standardizing CPUE were almost same as those used in the previous study by Saito and Yokawa (2004), which applies the traditional lognormal GLM method on the 5x5 aggregated data from 1975. Through this analysis, the most recent trend of SWO CPUE in 2003-2005 is investigated, and effects that can influence SWO CPUE are overviewed.

Materials and Methods

Data and area stratification

The data used in this document were from Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries. The longline data are aggregated by 5x5 degrees block, month, and number of hooks between floats from 1975 to 2005. Data points from 2003 to 2005 were newly added in this document. The set-by-set data with the information about 1x1 degree block resolution were also used for the purpose of the review of the recent pattern of the geographical distributions of CPUEs and efforts.

Methods for standardizing CPUE

We used generalized liner model (GLM) assuming log-normal error distribution for standardizing CPUE (eq. 1).

$$\ln(CPUE_{ijkl}+const)=year+quarter+area+gear+(interacteion\ term)+error \quad \text{(eq. 1)},$$

where effects of "gear" (hooks per basket) were categorized into 6 classes of 3-4, 5-6, 7-9, 10-11, 12-15 and 16-20, and effects of "quarter" into 4 of Jan-March (Qt 1), April-June (Qt 2), July-Sep (Qt 3) and Oct-Dec (Qt 3). The variable of "const" is a constant value for treating zero catch data. The parameter is set as 1/10 of the overall nominal CPUE of SWO (0.746/10). The interaction terms are considered as year*area, year*quarter, area*gear, quarter*gear and area*quarter, which are same as those used in the previous analysis in 2004. Calculation of GLM was carried out using GLM procedure by statistical software of SAS (Ver. 9.1 for SunOS 5.9 platform). We also applied catch model with negative binomial error structure to the same aggregated data set, but residuals from the catch model were skewed. In addition, estimated LS means of yearly CPUEs were not different from those from the log-normal GLM. Therefore, we present and discuss only the results from the log-normal GLM in this document.

Area definition used in this document (fig. 1) is roughly according to the definition by Saito and Yokawa (2004) and Yokawa (2004a). The previous studies categorized oceanic regions between 10° N and 40° N, and 140° E and 130° W into 5 different areas. In this document, minor change was added to the area stratification, considering recent trends of distribution of longline efforts and CPUE gradients from north to south. As shown in fig. 1, area 1 and 2 are separated into two (south and north), and area 4 is extended south to 20° N in the new area definition.

Results and discussion

<u>Geographic distribution of longline efforts and nominal CPUE of SWO in the North Pacific</u>

Recent topics about distribution of longline efforts and corresponding nominal CPUE in the North Pacific (fig. 2) are followings.

(1) Longline efforts in the area north to 35° N and east to 175° E are increasing during 2001-2005, and nominal CPUE in the area is also high in the concurrent period. However, data in the area did not used for standardizing CPUE in this document because of lack of historically sufficient number of data in the area.

(2) Distribution of longline efforts in the Eastern Pacific (east to 180° E) are relatively sparse. In addition, horizontal coverage of data in this area has largely changed by years compared with that in the Western Pacific. In particular, longline efforts in the southern part of area 5 seem to move to south during 2001-2005. This is the reason why the definition of area 5 was re-defined as it was extended to the line of 25° N in the new area definition.

The yearly changes of geographical distribution of Japanese longline efforts would make it difficult to determine appropriate area stratification especially in the Eastern Pacific, which might cause insufficient adjustment of standardized CPUE in the Eastern Pacific as abundance index of SWO.

<u>Model diagnostics and estimated effects</u>

Residual patterns derived from two models with old and new area stratifications (fig. 3 and 4, respectively) showed slightly skewed distribution especially in area 5, and bimodality in area 3. Percentages of zero catch data, which were replaced with 10% of overall mean of CPUE, to the total were 15, 18, 40, 23 and 35% for Area 1-5 of old area stratification, and 22, 11, 20, 16, 40, 23 and 41% for Area 1N, 1S, 2N, 2S and 3-5 of new area stratification, respectively. Considering the zero catch rates, the skewed and bimodal distributions of residuals would be caused from zero catch data handled in the ad hoc way. However, because total catch and CPUE of SWO by Japanese longliners are very small in area 3 and 5, it can not affect the total CPUE trend of SWO largely.

All the effects included in GLM were significant for explaining SWO CPUE (Table. 1). The estimated gear effects by area and quarter are shown in fig. 5, and effects of quarter and area are in fig. 6. The estimated effects of gear seem to be consistent with vertical habitat of swordfish preferring surface water at night. The gear effects were strong in winter of Qt1 and Qt4, and mid-latitude region between 25-35° N (area 1S, 2S and 4, fig. 5). Fig. 5 indicates a possibility that further complex model including 3rd order interaction such as quarter*gear*area would be more appropriate, although such the complex model can cause over-parameterization and did not used in this analysis.

Yearly trends of standardized CPUE

During the most recent 3 years of 2003-2005, estimated CPUE was slightly increasing in area 1, 2 and 5, but slightly decreasing in area 3 and 4 although these changes are rather minor compared with the decadal trends since 1975 (fig. 7). Redefinition of area stratification affected normalized CPUE trends only slightly. Nominal CPUE is very different from standardized especially in area 3: continuous decreasing trend of nominal CPUE disappeared in the standardized CPUE.

Any remarkable trends of overall CPUE were not observed during the last 3 years: staying at the lowest level in the period analyzed (fig. 8). This constant low CPUE levels have been observed since 1999. However, this stable trend was caused from two different CPUEs in the Western Pacific (decreasing since 2000) and the Eastern Pacific (increasing since 1998), which cancelled out each other. Standardized CPUEs during the most recent years of 2000-2005 were about 60 and 64% of those in 1985-1989 in the Western and Eastern Pacific, respectively.

Conclusion

The overall CPUE in the main fishing ground of swordfish dose not change largely during the last 10 years after continuous declining from 1985, while,CPUEs in the Western and Eastern Pacific showed rather inconsistent trends each other during the last decade. Therefore, further investigations will be needed for exploring horizontal distribution of SWO habitat between the Eastern and Western Pacific. In addition, because longline efforts in the Eastern Pacific have been changing drastically since 2000, appropriate area stratification and stock boundaries that can treat such the problem might also be needed for improving estimation of abundance index of SWO in the Eastern Pacific.

References

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Saito, H. and Yokawa, K. (2004) Estination of abundance index for swordfish caught by Japanese longliner in the North Pacific in 1956-2002. ISC/04/MARWG/ 04

Yokawa, K. (2004a) Estimation of abundance index of swordfish caught by Japanese longliners by the habitat model. ISC/04/MARWG/ 05

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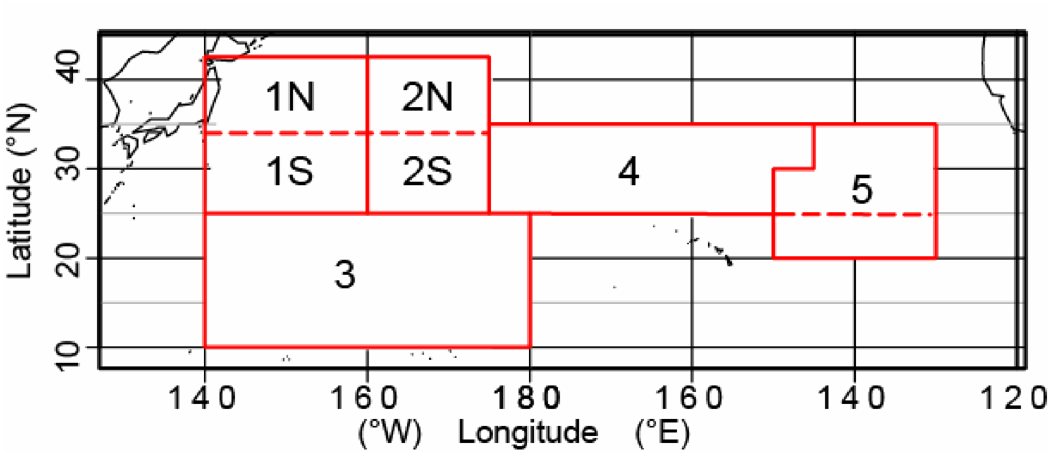


Fig. 1. Area definiton used in standardizing CPUE. The numbered regions represent the new area definition. The definition is rougly according to Saito and Yokawa (2004), but area 1 and 2 are separated into two (south and north), and area 4 is extended south to 20˚N in the new area definiton.

Fig. 2 is shown in the next page (p. 6).

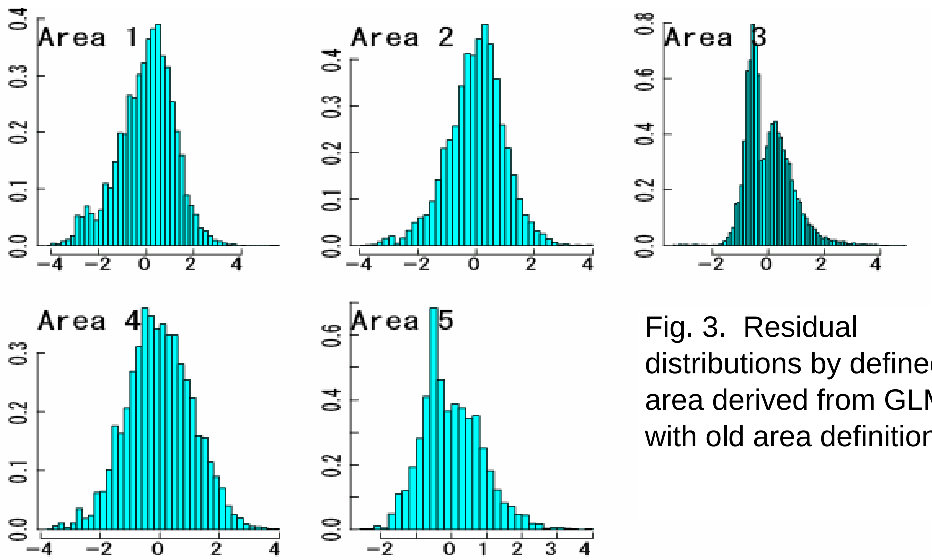


Fig. 3. Residual distributions by defined area derived from GLM with old area definition.

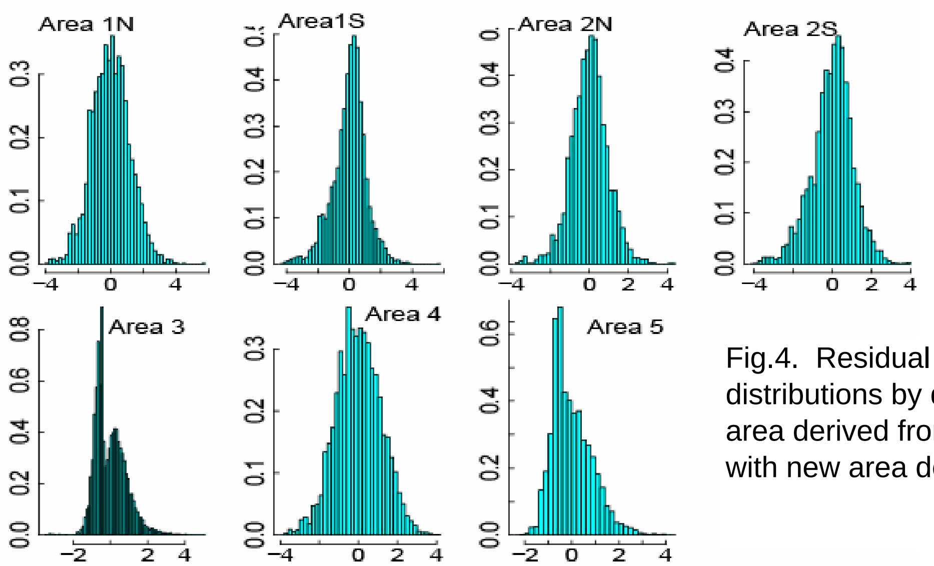
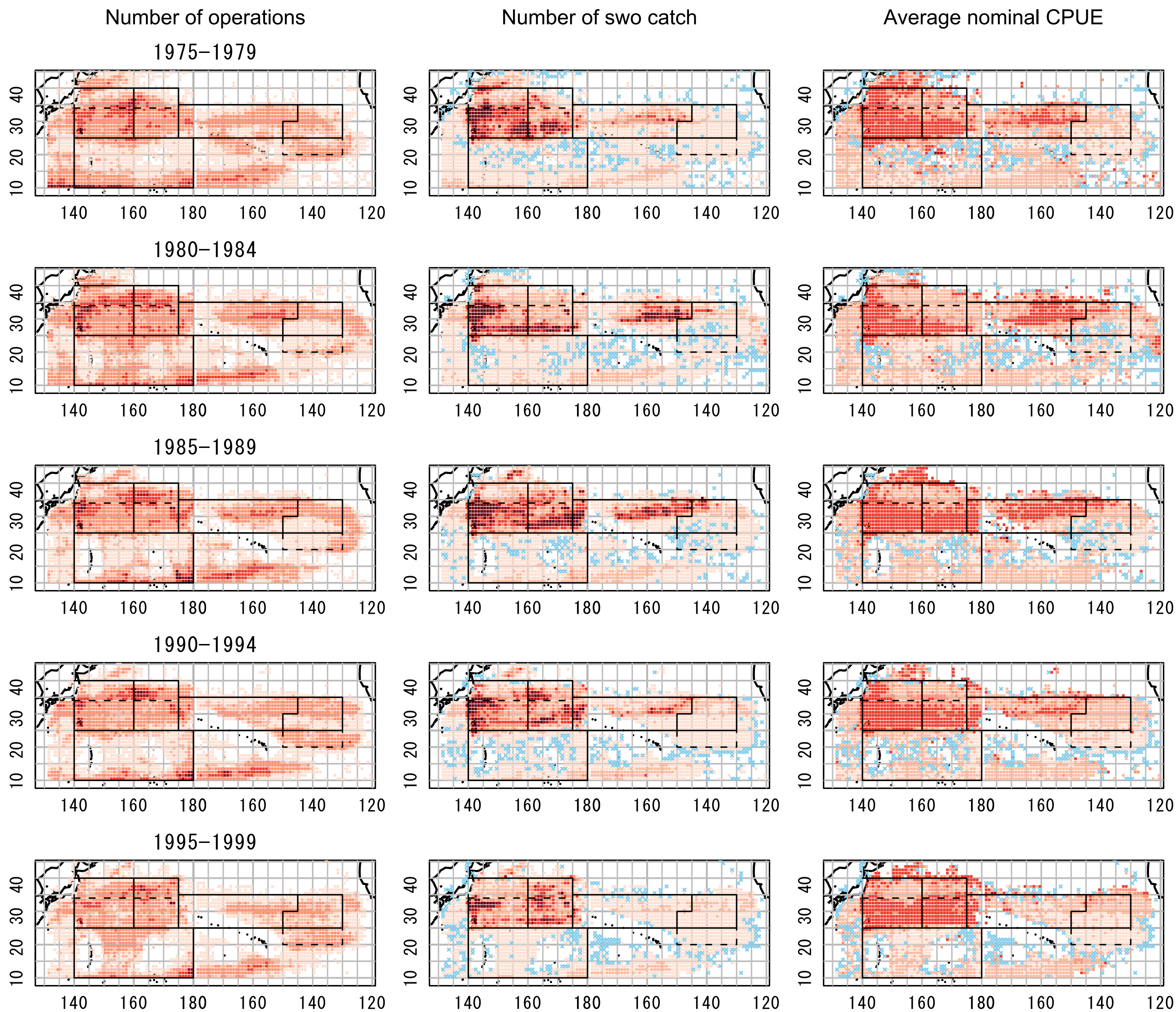


Fig.4. Residual distributions by defined area derived from GLM with new area definition.



N of operations
- >150
- 100-150
- 50-100
- 10-50
- 5-10
- <5
- No effort

N of swo catch
- >300
- 200-300
- 100-200
- 50-100
- 10-50
- <10
- No effort
- Zero catch

CPUE (/1000 hooks)
- >10
- 5-10
- 1-5
- 0.5-1
- 0.1-0.5
- <0.1
- No effort
- Zero catch

Fig. 2. Number of operations and swordfish catch by Japanese longlines, and nominal CPUE by 1x1 degree. The numbers of longline efforts and swo catch were average yearly total.

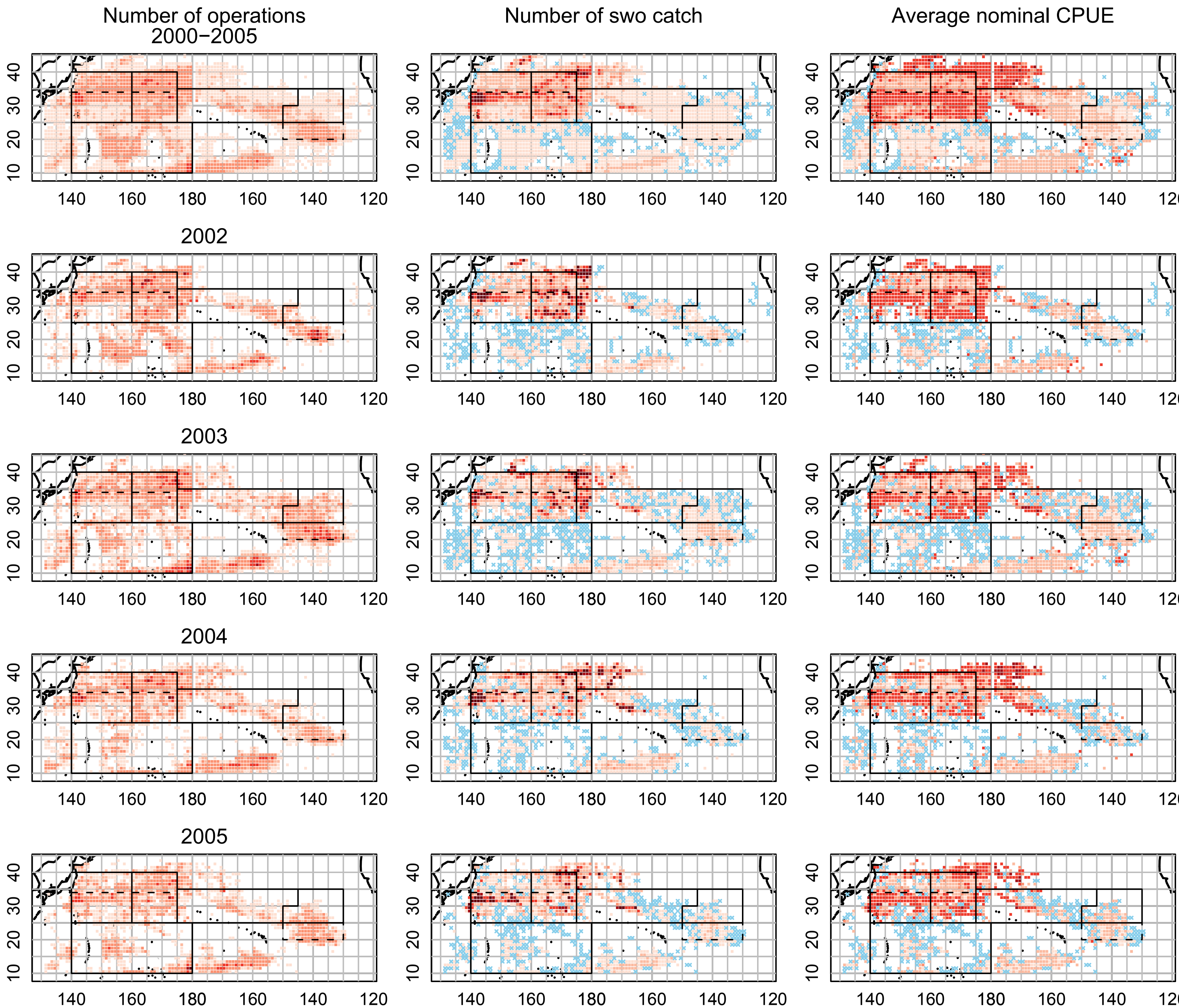


Fig. 2.
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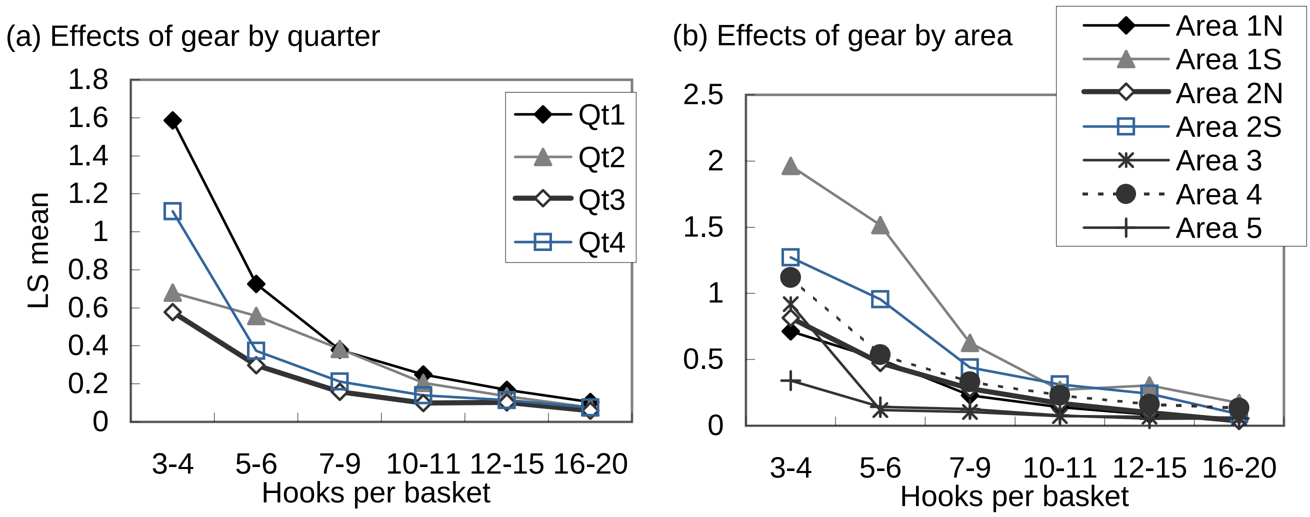


Fig. 5. Effects of hooks per basket by quarter and area estimated in the model with new area definition.

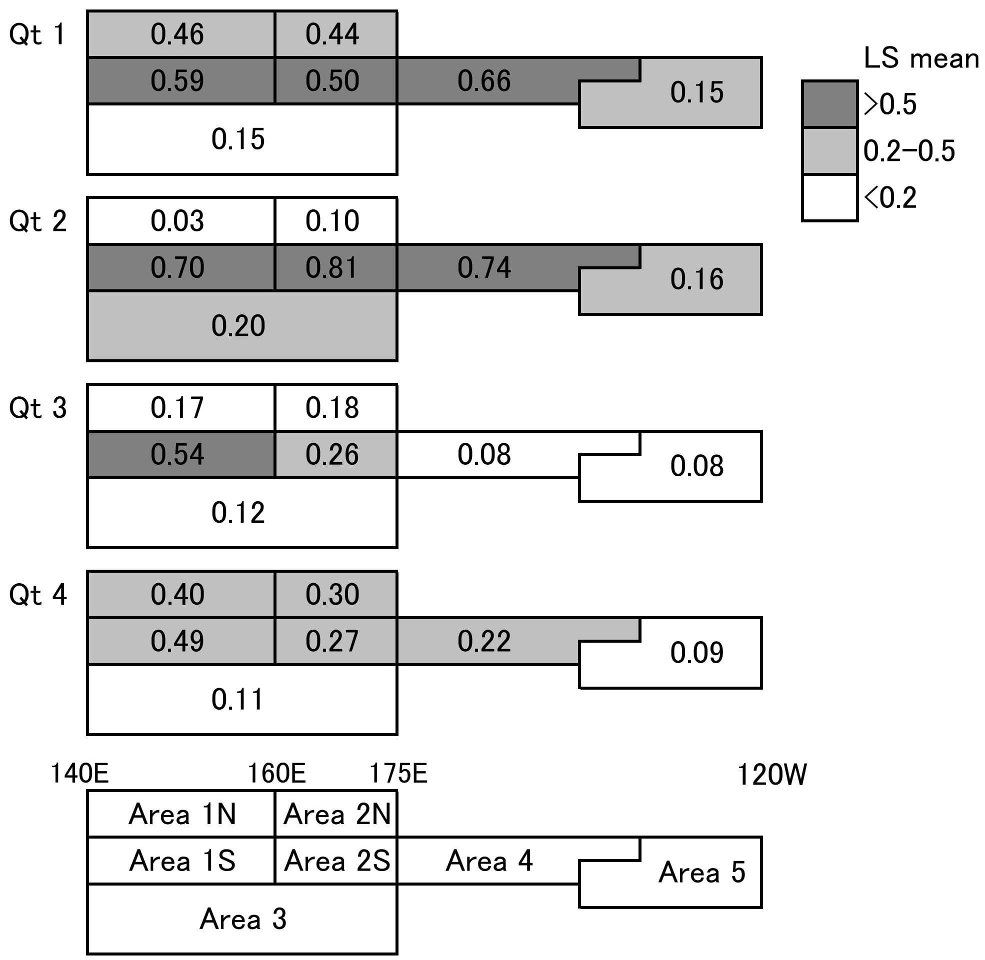
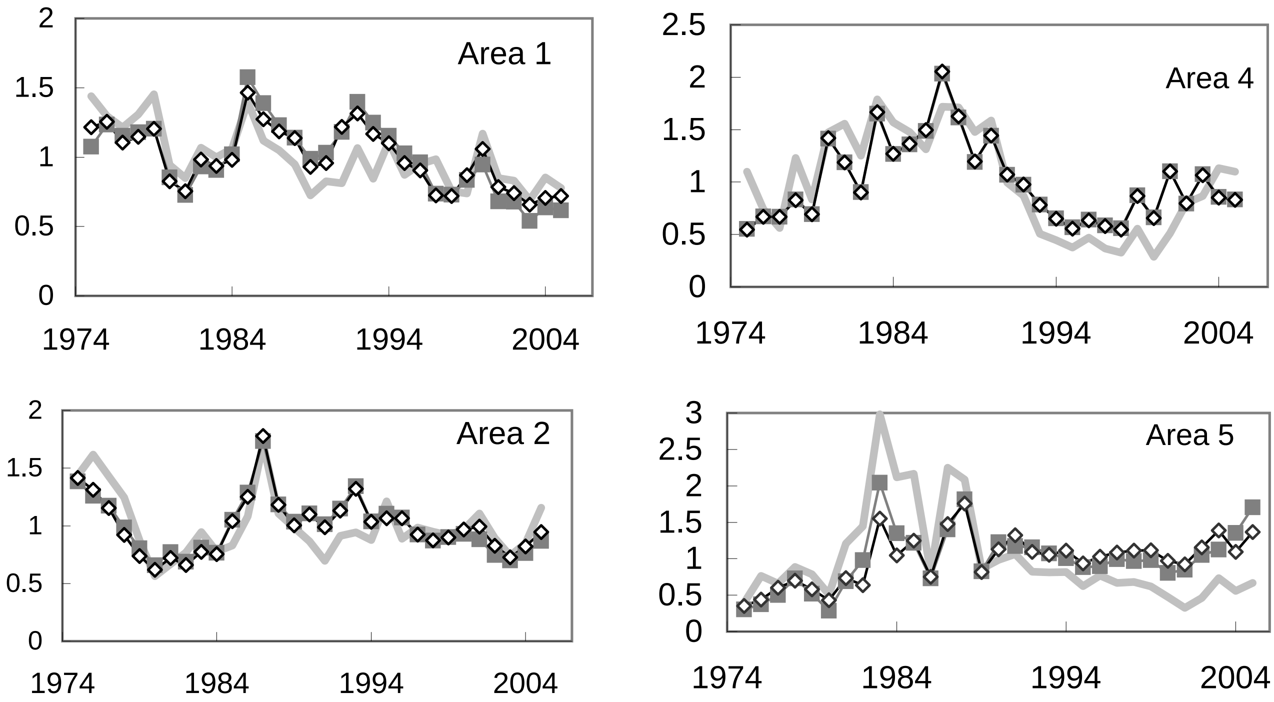


Fig. 6. Distribution of LS means of SWO CPUE by area and quarter. Values in the columns represent the calculated LS mean by each region and quareter. The colums are corresponding to the new area definition, which is roughly described in the bottom figure.



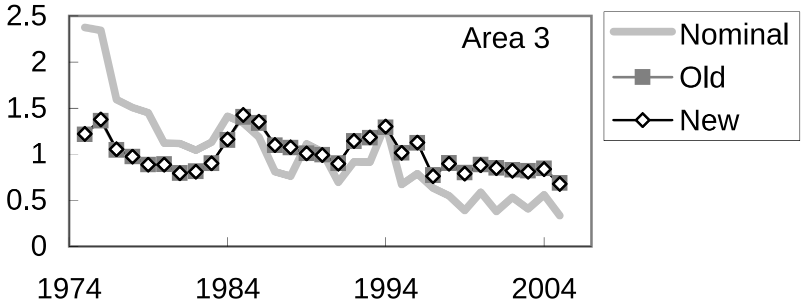


Fig. 7. Comparison of nominal and standardized CPUEs. Two standardized CPUEs are shown using old area definition ("Old") and new ("New"). All indices are normalized to set their average as 1.

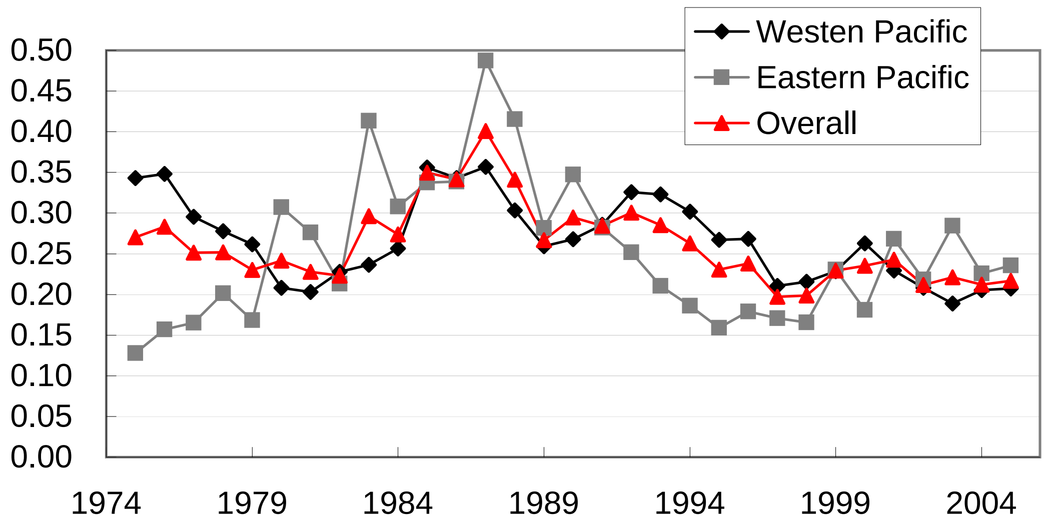


Fig. 8. Area weighted LS mean of standardized swo CPUE in the overall, Western and Eastern North Pacific. The indices were calculated from LS means of regional CPUEs and area weighted factors shown in Table 2.

Table 1. Stasistical results of GLM.

	(1) Model from simple GLM and old area definition according to Saito and Yokawa (2004)					(2) Model from simple GLM and new area definition				
Effects	DF	Type III SS	Mean Square	F value	Pr>	DF	Type III SS	Mean Squar	F value	Pr>
year	30	610	20	23.9	<.0001	30	622	21	26.4	<.0001
area	4	2275	569	669.1	<.0001	6	3410	568	724.3	<.0001
quarter	3	2148	716	842.5	<.0001	3	817	272	347.0	<.0001
gear	5	1912	382	449.8	<.0001	5	3483	697	887.6	<.0001
year*area	120	1118	9	11.0	<.0001	180	1376	8	9.7	<.0001
area*gear	20	1019	51	59.9	<.0001	30	1229	41	52.2	<.0001
quarter*gear	15	668	45	52.4	<.0001	15	635	42	53.9	<.0001
area*quarter	12	1548	129	151.7	<.0001	18	3014	167	213.4	<.0001

R-Square= 0.513 R-Square= 0.557

Table 2. LS means calculated from GLM with new area definiton including 7 areas.

Area	Western Pacific 1N	1S	2N	2S	3	Eastern Pacific 4	5	Westen Pacific	Eastern Pacific	Overall
Area weighting factor	7	8	6	6	24	15	11			
1975	0.12	0.86	0.33	0.61	0.17	0.19	0.04	0.34	0.13	0.27
1976	0.24	0.77	0.34	0.52	0.19	0.23	0.05	0.35	0.16	0.28
1977	0.22	0.67	0.27	0.50	0.15	0.23	0.07	0.30	0.17	0.25
1978	0.20	0.72	0.18	0.43	0.14	0.29	0.08	0.28	0.20	0.25
1979	0.38	0.60	0.13	0.35	0.12	0.24	0.07	0.26	0.17	0.23
1980	0.18	0.48	0.11	0.30	0.13	0.50	0.05	0.21	0.31	0.24
1981	0.08	0.53	0.14	0.33	0.11	0.42	0.09	0.20	0.28	0.23
1982	0.11	0.68	0.15	0.28	0.11	0.31	0.08	0.23	0.21	0.22
1983	0.11	0.64	0.18	0.33	0.13	0.58	0.18	0.24	0.41	0.30
1984	0.19	0.60	0.18	0.32	0.16	0.44	0.12	0.26	0.31	0.27
1985	0.27	0.92	0.24	0.44	0.20	0.48	0.15	0.36	0.34	0.35
1986	0.29	0.74	0.29	0.54	0.19	0.52	0.09	0.34	0.34	0.34
1987	0.26	0.70	0.44	0.74	0.15	0.72	0.17	0.36	0.49	0.40
1988	0.23	0.69	0.25	0.53	0.15	0.57	0.21	0.30	0.42	0.34
1989	0.19	0.56	0.22	0.45	0.14	0.42	0.10	0.26	0.28	0.27
1990	0.24	0.53	0.28	0.45	0.14	0.50	0.13	0.27	0.35	0.29
1991	0.26	0.72	0.22	0.43	0.13	0.37	0.16	0.29	0.28	0.28
1992	0.28	0.78	0.24	0.51	0.16	0.34	0.13	0.33	0.25	0.30
1993	0.32	0.63	0.33	0.54	0.17	0.27	0.12	0.32	0.21	0.29
1994	0.23	0.66	0.24	0.44	0.18	0.23	0.13	0.30	0.19	0.26
1995	0.25	0.53	0.23	0.47	0.14	0.19	0.11	0.27	0.16	0.23
1996	0.22	0.51	0.24	0.46	0.16	0.22	0.12	0.27	0.18	0.24
1997	0.21	0.38	0.24	0.37	0.11	0.20	0.13	0.21	0.17	0.20
1998	0.17	0.41	0.21	0.37	0.13	0.19	0.13	0.22	0.17	0.20
1999	0.21	0.50	0.22	0.38	0.11	0.30	0.13	0.23	0.23	0.23
2000	0.26	0.59	0.25	0.39	0.12	0.23	0.11	0.26	0.18	0.24
2001	0.19	0.45	0.29	0.37	0.12	0.39	0.11	0.23	0.27	0.24
2002	0.24	0.36	0.21	0.34	0.12	0.28	0.14	0.21	0.22	0.21
2003	0.26	0.27	0.18	0.30	0.11	0.37	0.16	0.19	0.28	0.22
2004	0.20	0.37	0.23	0.31	0.12	0.30	0.13	0.21	0.23	0.21
2005	0.14	0.45	0.26	0.36	0.10	0.29	0.16	0.21	0.24	0.22