Reexamination of arrangement and standardization of CPUE for Japanese longline fishery for applying SS3 to north Pacific albacore[1]

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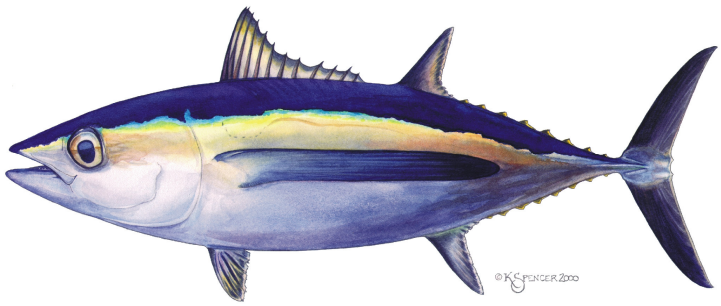

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SUMMALY

Reexamination of arrangement for Japanese large and small longline fisheries (L-LL and S-LL) in the north Pacific was conducted for SS3 analyses. Due to concentration of longline effort and albacore catch in the northwest Pacific and sudden decrease in effort and CPUE in the northeast Pacific, Japanese longline fishery is aggregated into two or three based on area and season in which only northwest and southwest areas were used. Trends of CPUE are similar among fisheries defined except for a part of period.

1. INTRODUCTION

Recently, stock synthesis (SS: SS2 or SS3) models along with VPA-2BOX are used for stock assessment of north Pacific albacore at ISC meetings. Abundance indices of Japanese longline fishery are very important input data to these models. Arrangements of Japanese longline fishery for SS models are concern of the ISC Albacore Working Group for Stock Assessments at the moment. Ichinokawa (2009a; 2009b) reported rearrangement of data from Japanese large (distant water and offshore) and small (coastal) longline fisheries by dividing these fisheries based on area/season with similar fish size. As a result, large and small longline fisheries were divided into up to six and three, respectively. That brought improvements in that analyses by SS3 model have got more stable. However, there still remains a concern that abundance indices differ depending on the way in which fisheries are defined. Therefore, in this study, reexamination of arrangement of Japanese longline fishery data (large and small longline) was considered for SS3 analyses.

2. MATERIALS AND METHODS

2.1. Catch and effort data

Catch and effort data used in this study were obtained from the statistics for Japanese large longline (distant water and offshore, L-LL) and small longline (coastal, S-LL) fisheries compiled at NRIFSF. Logbook data aggregated by 5×5 degrees latitude/longitude block, month and number of hooks per basket were used for analyses in this study. Data for 1966-2008 were used, but statistics for small longline are available only for 1994-2008. Information on number of hooks per basket is not available for the period of 1966-1974 and it was assumed 5 hooks per basket during that period.

2.2.Length data

Length of albacore caught by longline fishery was measured at the landing ports or onboard and the data have been collected and complied by National Research Institute of Far Seas Fisheries (NRIFSF) up to 2008. Length frequencies were created by summing up length data in the areas defined above, and were used to understand fish size in a certain area and to consider selectivity for each fishery.

2.3. Arrangement of longline fishery

Arrangement of Japanese longline data was conducted according to the following procedures and criteria.

(1) As reported by Matsumoto (2010), sudden decrease in CPUE by Japanese longline fishery in the northeast Pacific (25-40˚N, 120-170˚W) was observed and the decrease is mainly due to the shift of operation area because less effort was deployed in the area where albacore CPUE is normally high. Therefore, we considered that it is better not to include CPUE in the northeast area for the analyses of the stock of north Pacific albacore.

(2) Large and small longline fisheries were merged because abundance indices of both fisheries are similar in the same area (Ichinokawa, 2009b) and both fisheries are considered to be virtually the same.

(3) Abundance indices in the main albacore fishing areas are considered to represent the entire north Pacific abundance index of albacore, and hence only areas in which albacore catch, CPUE, and proportion in the total are above a certain level (albacore is considered to be targeted) were selected and used.

(4) Difference of fish size among season and/or area was used for defining the fishery.

2.4. Standardization of CPUE

GLM was used for CPUE standardization for the fisheries defined by procedures and criteria mentioned above. The model includes main effects (year, season, area, fishery and fishing gear) and interaction terms. Month and quarter were examined as the effect of fishing season, and number of hooks per basket (hereafter, NHB) was used as gear effect. Small and large longline fisheries were distinguished and used as the effect of fishery. Area stratification was done based on distribution of catch and effort. The model was selected based on AIC. The final model for standardization of CPUE was,

$$LOG\ (CPUE + Const) = \mu + Y + M + A + B + F + (interaction\ terms) + e$$

where *LOG* is the natural logarithm, *CPUE* is the catch in number of fish per 1000 hooks, *Const* =10% of overall mean of nominal CPUE, μ is the intercept, *Y* is the effect of year, *M* is the effect of fishing season (month), *A* is the effect of area, *B* is the effect of fishing gear (NHB divided into five categories), *F* is the effect of fishery (small or large longline) and *e* is the error term with $N(0,\sigma)$. NHB was categorized as 3-4, 5-6, 7-9, 10-14 and 15-20 hooks per basket. Analyses were done through the statistic package program "SAS version 9.1.3".

Area weighting method for calculating overall CPUE is the same as that in Ichinokawa (2009a). That is, as for the GLMs including the interaction term of year and area (Y*A), overall CPUE was calculated using area weighting factors for each subarea *a* (f_a, a=1, 2, …, A) and predicted CPUE in year *y* and subarea *a* ($SCPUE_{ya}$) with the following equation (Punt, 2004).

$$SCPUE_y = \sum_{k=1}^{A} f_k \cdot SCPUE_{yk}, \text{ where } \sum f_k = 1$$

The parameter of $SCPUE_{yk}$ is the least squares mean (a.k.a., population marginal mean) of CPUE estimated in year y at subarea k. The area weighting factors of f_k is the ratio of the number of 5x5 degree blocks with ≥1 longline operations in area k to the total number of 5x5 degree blocks considered.

3. RESULTS AND DISCUSSIONS

General aspects of Japanese longline fishery in the north Pacific

Distribution of effort, albacore catch and CPUE is shown in Fig. 1. Distribution of species composition of catch

by Japanese longline fishery in the Pacific Ocean is shown in Fig. 2.

As shown in Fig. 1 (top), most of the effort of Japanese longline fishery in the north Pacific is concentrated in the northwest area except for equatorial area. Albacore catch is also distributed mostly in the northwest area especially around Japanese coastal area (Fig. 1, middle). CPUE is high both in the northwest and northeast areas (Fig. 1, bottom), but cumulative catch in the northeast area is not as large as that in the northwest area. Therefore, it seems that northwest area is the main fishing ground for the Japanese albacore longline fishery, the abundance index in that area being important for analyses of north Pacific albacore. According to the distribution of species composition of the catch (Fig. 2), it seems that albacore is the main target in the temperate area, while bigeye and yellowfin tuna are the main target in the tropical area.

Selection of area

Data from the northeast area (east of 180˚, between 25˚N and 40˚N) was not used due to the reason mentioned in the section of materials and methods. Since albacore catch, CPUE and its proportion in the total catch were low in the southeast area (east of 180˚, south of 25˚N), this area was also not used. Regarding western area (west of 180˚, between 10˚N and 40˚N), both albacore catch and CPUE were at a certain level and proportion of albacore in the catch was comparatively high. Therefore, western area was selected for using in SS3 model.

Fish size

Length frequencies of the catch in the northwest (north of 25˚N) and southwest (south of 25˚N) area are shown in Fig. 3. Both small (around 75cm FL) and large (around 100cm) fish are caught in the northwest Pacific. On the other hand, mainly large (around 105cm) fish are caught in the southwest Pacific. Seeing fish size in the northwest Pacific by season, fish are small (mainly around 75cm) in the first to second quarters and are large (around 100cm) in the third and forth quarters.

Arrangement of longline fishery

According to the results mentioned above, two scenarios were selected for arrangement of longline fishery. One is that longline fishery was divided into two by area (northwest and southwest). The other is that, northwest area was further divided into two by season (1^{st} to 2^{nd} quarter and 3^{rd} and 4^{th} quarter) based on fish size shown in Fig. 3. Area definition is shown in Fig. 4. List of the scenarios is shown in **Table 1**

Standardization of CPUE

Standardization of CPUE was conducted based on the fishery defined above. Final models for standardization of CPUE selected based on AIC are shown in Table 2. Interaction of M*A and A*B were selected for all the fisheries. Trends of abundance index for each fishery are shown in Fig. 5. Abundance index in the northwest Pacific (all season, scenario 1) declined during 1966-1971, was almost constant during 1970s-1980s, increased during 1992-1997, and decreased from 1999 onward. Trends of index in the southwest Pacific were similar to those in the northwest Pacific, but the index in the southwest Pacific did not show any decline during 1960s.

The indices in the northwest Pacific in the 1^{st} to 2^{nd} quarters sharply declined in the late 1960s, gradually declined in the 1970s-1980s, increased in 1993, and declined again with fluctuation. On the other hand, the index in the northwest Pacific in the 3^{rd} to 4^{th} quarter were almost constant during 1966-1991, increased in 1992, was high until 1999, declined sharply in 2000 and has been at a low level since then. Generally, trends of abundance index for scenario 2 were similar in that they increased during early or middle 1990s and declined around 2000.

Results of last year's studies

Appendix figures 1-4 show the results of arrangement of fishery data (or definitions of fisheries) and CPUE standardization adopted in 2009 studies (Ichinokawa, 2009a; 2009b), which divided longline fisheries based on area and season with similar fish size. These studies, along with the present study, offer the source of discussions on rearrangement of Japanese longline fishery for SS3 analyses.

4. Literature cited

Ichinokawa M. 2009a. Rearrangement of Japanese fisheries for applying length-based SS-3 to the stock of North Pacific albacore I: offshore longline. ISC/09-1/ALBWG/02. 11pp.

Ichinokawa M. 2009b. Rearrangement of Japanese fisheries for applying length-based SS-3 to the stock of North Pacific albacore II: coastal longline. ISC/09-1/ALBWG/03. 8pp.

Matsumoto, T. 2010. Recent change in the operation of Japanese longline fishery in the northeast Pacific. ISC/10-1/ALBWG/02. 12pp.

Punt, A.E., Walker, T.I. and Pribac, F. 2000. Standardization of catch and effort data in a spatially-structured shark fishery. Fish. Res. 45, 129-145.

Table 1. List of the scenarios of aggregation and disaggregation of Japanese longline fisheries.

No.	Year		L-LL, S-LL*	Number of fisheries	Area	Area stratification by season
	L-LL*	S-LL*				
1	1966-2008	1994-2008	Combined	2	Northwest, southwest	No
2	1966-2008	1994-2008	Combined	3	Northwest, southwest	Qt1-2 and Qt3-4 for northwest

* L-LL: large (distant water and offshore) longline, S-LL: small (coastal) longline.

Table 2. Models for standardization of CPUE for each scenario and fishery.

Scenario	Fishery	Area	Season	Interaction terms used*	Number of subareas
1	L-LL and S-LL	Northwest	All season	Y*A, M*A, A*B, Y*M, M*B	6
	L-LL and S-LL	Southwest	All season	Y*A, M*A, A*B, Y*M, M*B	3
2	L-LL and S-LL	Northwest	Qt1-2	Y*A, M*A, A*B, Y*M, M*B	6
	L-LL and S-LL	Northwest	Qt3-4	M*A, A*B	6
	L-LL and S-LL	Southwest	All season	Y*A, M*A, A*B, M*B	3

* Y: year, A: subarea, M: month, B: number of hooks per basket.

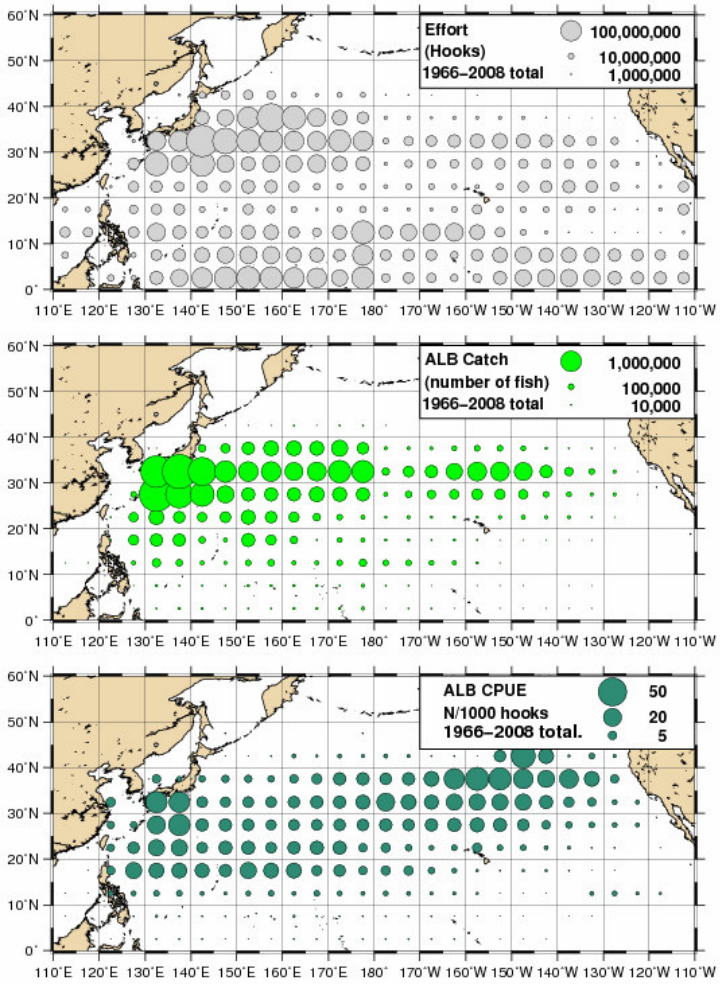


Fig. 1. Distribution of fishing effort, albacore catch and CPUE (nominal) in the north Pacific (1966-2008 total, large and small longline combined).

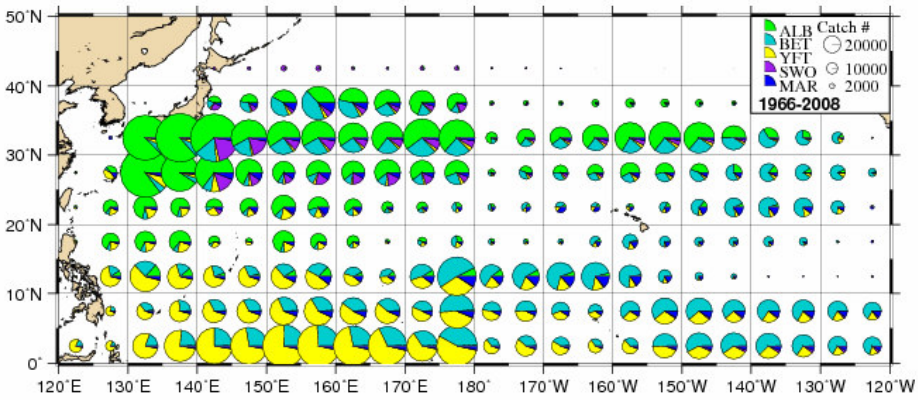


Fig. 2. Distribution of species composition of catch by Japanese longline fishery in the Pacific Ocean (ALB: albacore, BET: bigeye tuna, YFT: yellowfin tuna, SWO: swordfish, MAR: marlin species) (1966-2008 total, large and small longline combined).

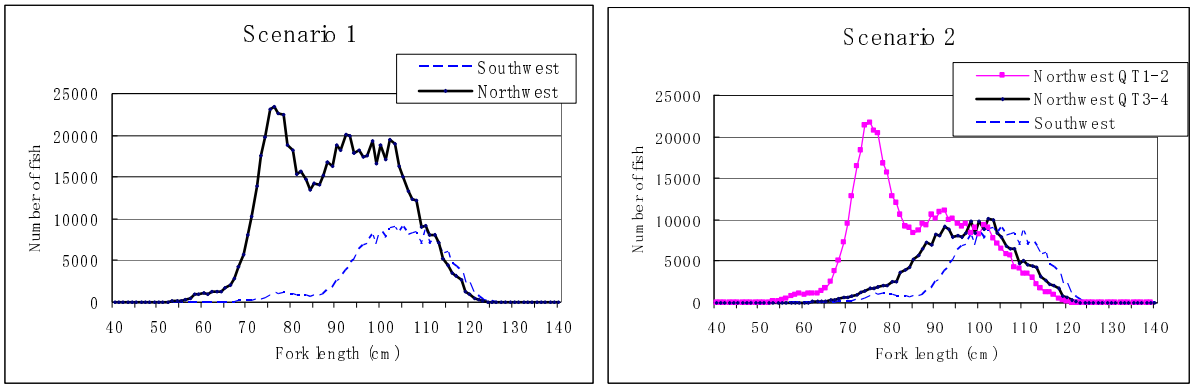


Fig. 3. Length frequency of the catch for each longline fishery defined.

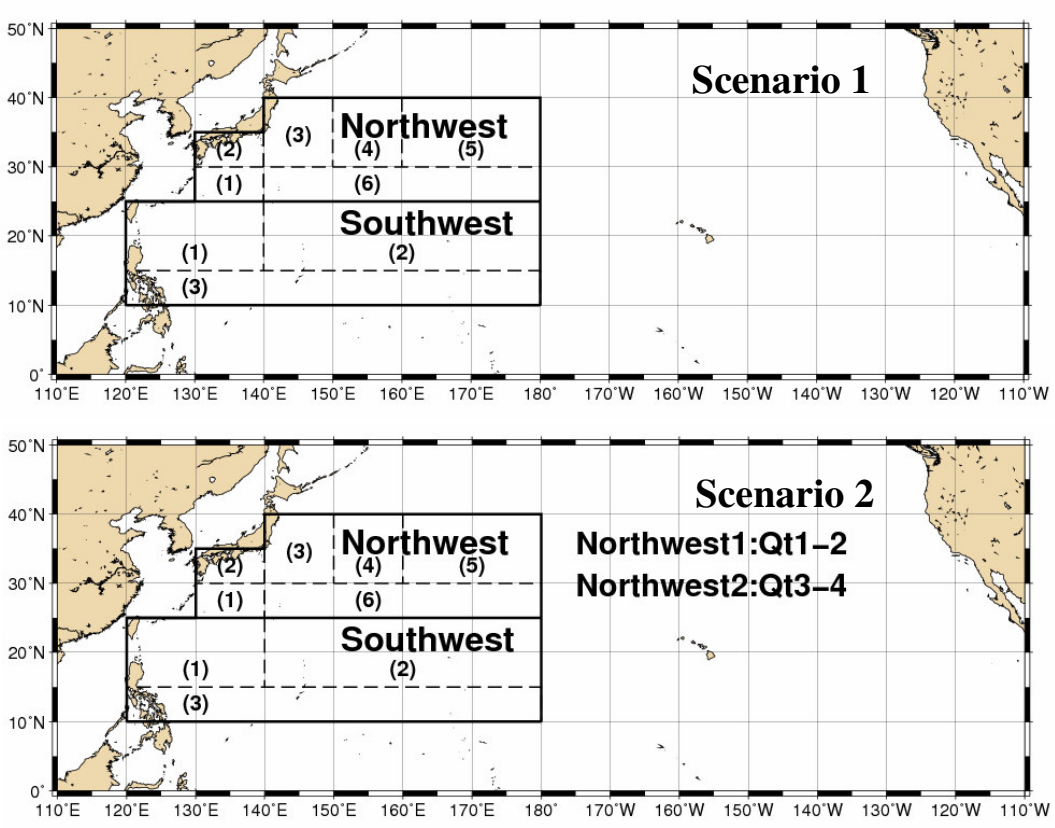


Fig. 4. Area and subarea definition and division by season for each scenario.

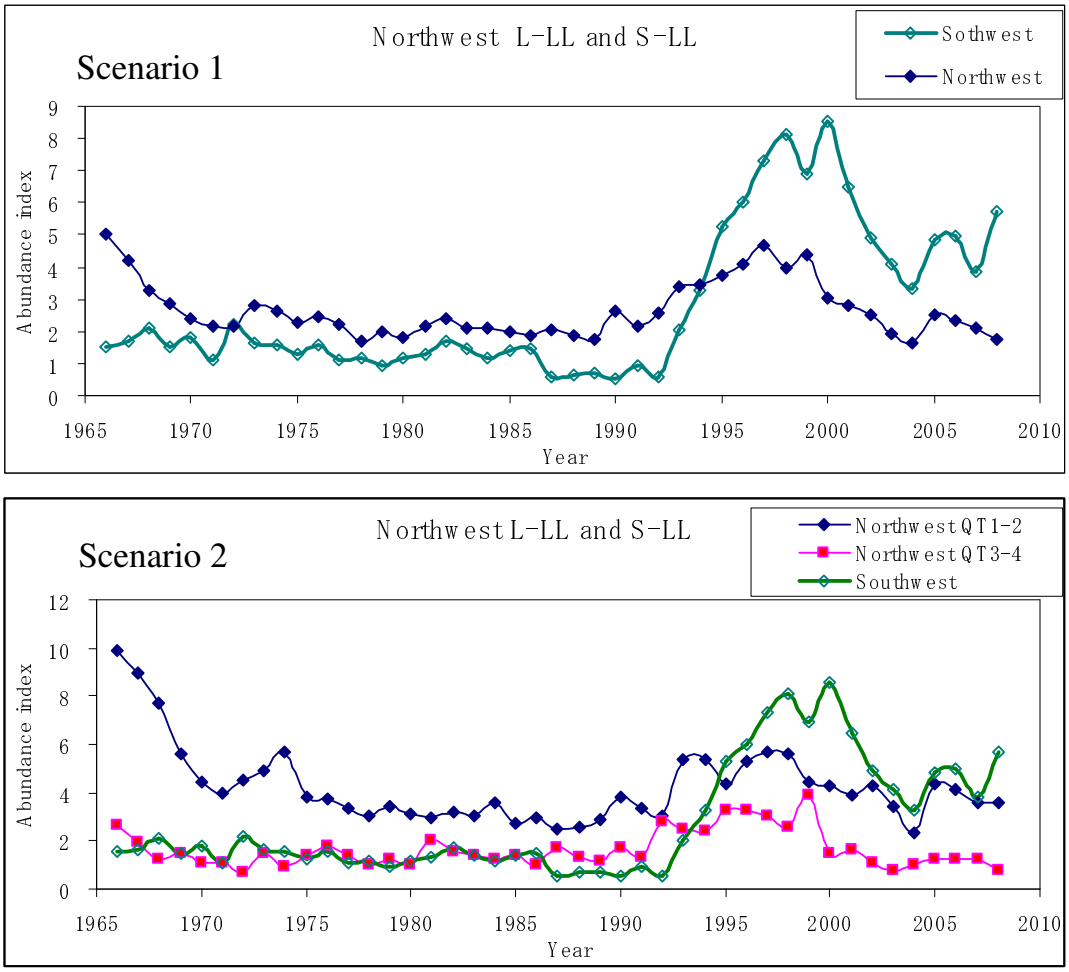
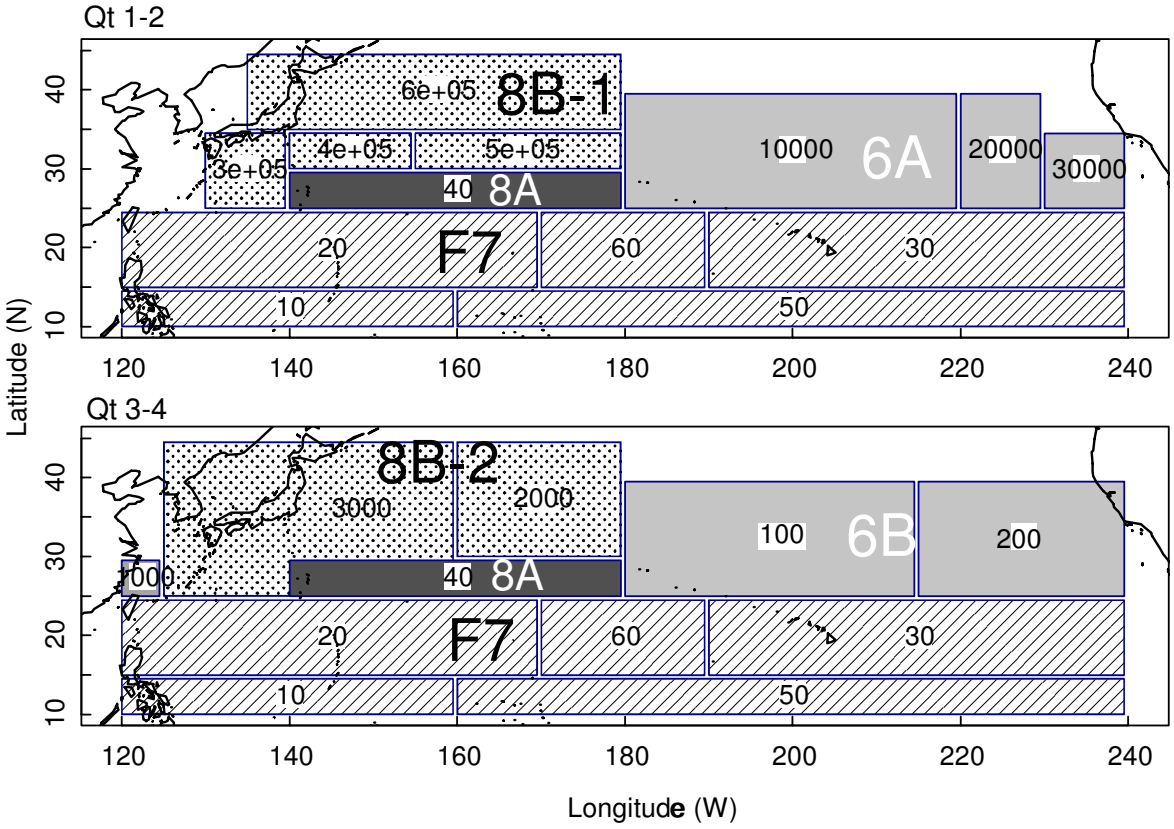
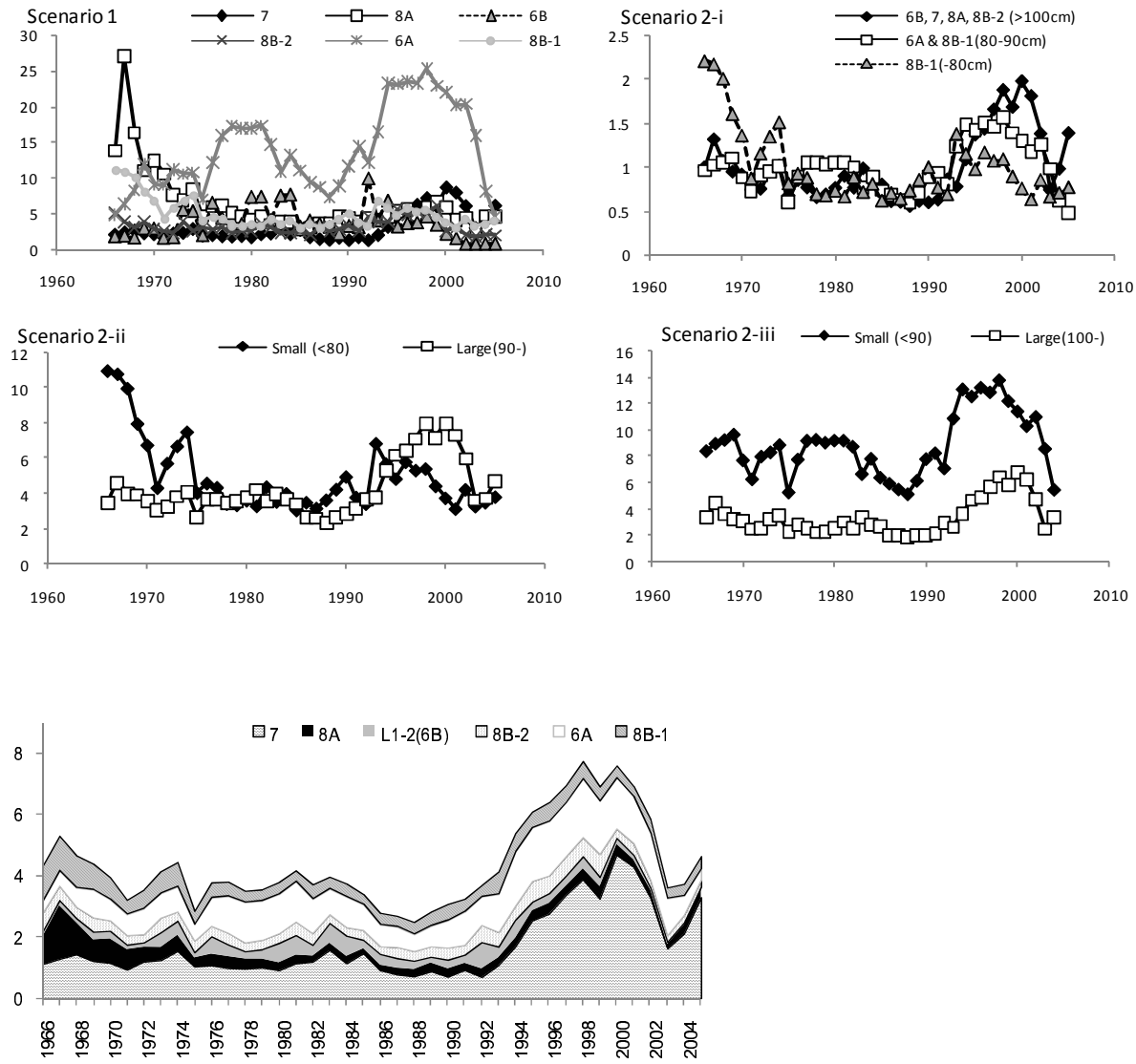


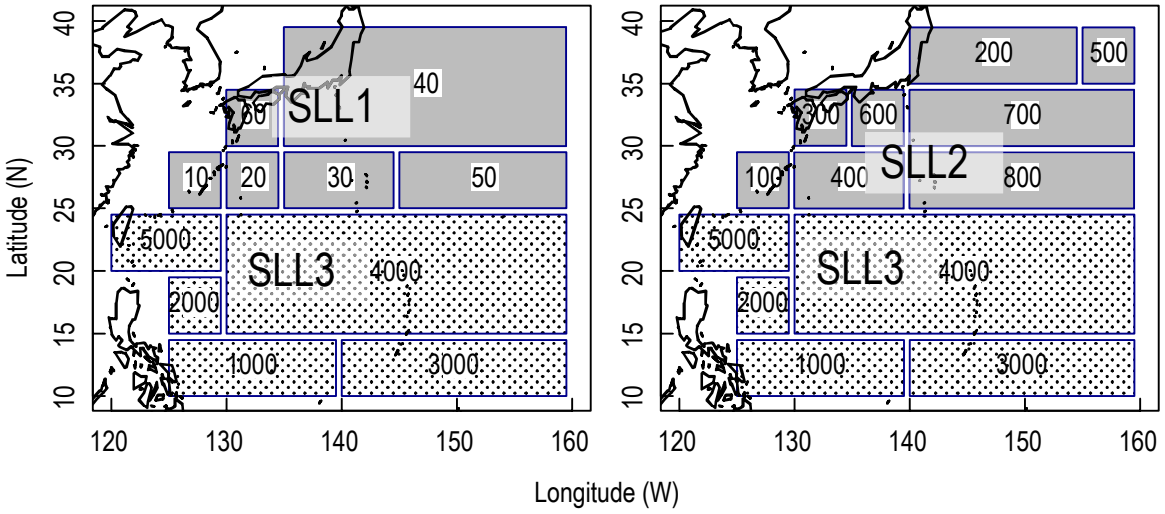
Fig. 5. Abundance indices for longline fishery defined in this study.



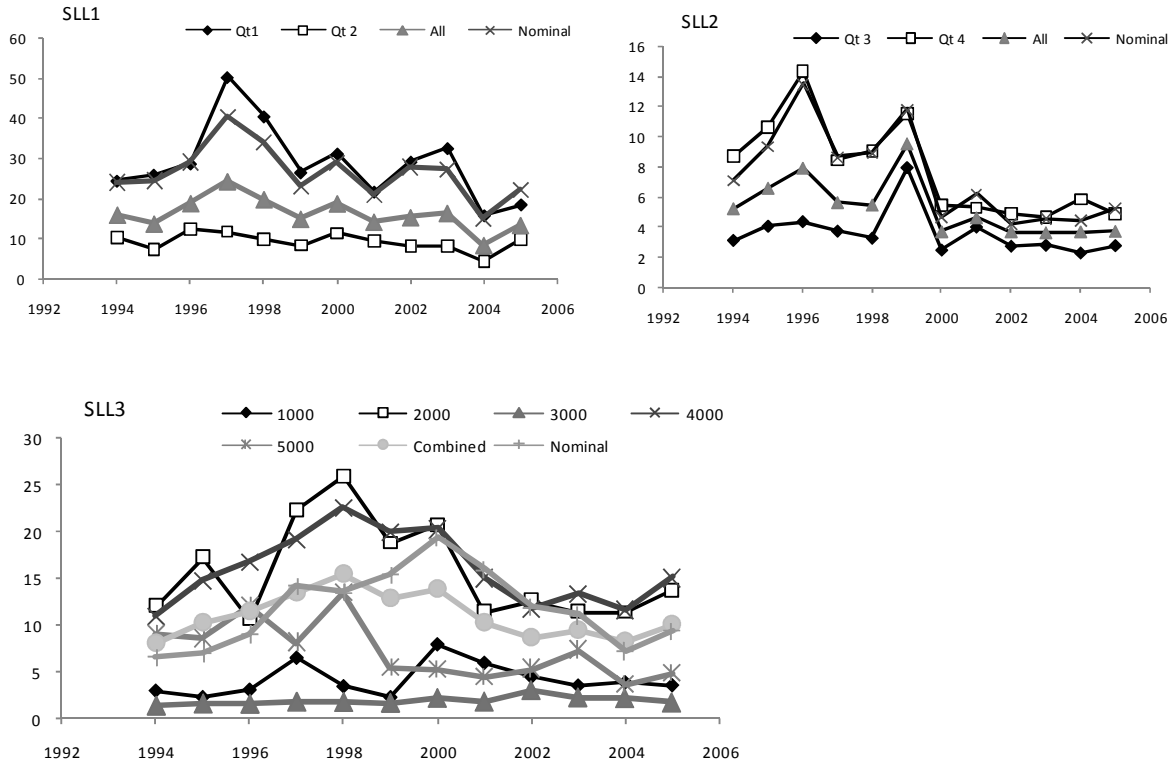
Appendix Fig. 1. Subarea definition used in standardizing CPUE in each fishery for offshore (large) longliners for the previous study (Ichinokawa, 2009a).



Appendix Fig. 2. CPUE series for each scenario for arrangement of offshore longliners of the previous study (Ichinokawa, 2009a).



Appendix Fig. 3. Subarea definition used in standardizing CPUE in each fishery for coastal (small) longliners by the previous study (Ichinokawa, 2009b).



Appendix Fig. 4. CPUE series for each scenario for arrangement of coastal longliners by the previous study (Ichinokawa, 2009b).