SCIENTIFIC COMMITTEE
SECOND REGULAR SESSION

7-18 August 2006
Manila, Philippines

MEASUREMENT-POINTS EXAMINATION OF CIRCLE HOOKS FOR PELAGIC LONGLINE FISHERY TO EVALUATE EFFECTS OF HOOK DESIGN

WCPFC-SC2-2006/EB WP-10

Paper prepared by

Matsunaga H, Hosono T, Shono H.

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

Analysis of longline CPUE of major pelagic shark species collected by Japanese research and training vessels in the Pacific Ocean

Matsunaga H, Hosono T, Shono H.
National Research Institute of Far Seas Fisheries, FRA, JAPAN

Abstract

The standardized CPUE for blue shark, bigeye thresher and silky shark, which are the main pelagic shark species caught by the tuna longline fishery, were calculated using research data collected by Japanese research and training vessels in the Pacific Ocean from 1992 to 2003. Though there were some fluctuations, the drastic changes of standardized CPUE were not observed for the three species during this period. And furthermore, three mathematical models for standardizing CPUE were compared using the data of bigeye thresher to assess the difference in CPUE trends due to the model selection.

Introduction

Blue shark *Prionace glauca* and other pelagic sharks are caught by tuna longline vessels in the oceans. Analyses based on Japanese fishery data revealed that the stock status of these pelagic shark species has been stable in the three Oceans (Nakano 1996, Matsunaga and Nakano 1996). In this document, we estimated the standardized CPUE for three major shark species (blue shark, bigeye thresher *Alopias supercilious* and silky shark *Carcharhinus falciformis*) using the research data obtained by the Japanese research and training vessels in the Pacific Ocean during 1992-2003. CPUE of some shark species has many zero values, which may cause some bias in estimation based on conventional methods. Therefore, we compared CPUE trends estimated from the analyses employing CPUE lognormal model, CATCH negative binominal model and Delta lognormal model using the data of bigeye thresher as a sample of zero-inflated data.

Material and Methods

Research data collected by the Japanese research and training vessels in the Pacific Ocean from 1992 to 2003 were used for the analysis. Considering the distribution of fishing effort (Fig.1), the area from 0 to 30N of the central region was divided into 5 sub-areas by the 10*20 degree of latitude and longitude.

In order to standardize CPUE of sharks, generalized linear models were used in this analysis. We used the CPUE model with lognormal error for blue shark, CATCH models with negative binominal error for bigeye thresher and silky shark because the CATCH negative binominal model were supposed to fit better to those data with many zero-caches than CPUE lognormal model.

Delta-lognormal model was recommended by Shono (2004) to solve the zero-catch problem. The calculation was performed through GLM and GEM procedure of SAS/STAT package (Version 9.1.3). The following forms were assumed as full models.

E (log (CPUE + constant)) = INTERCEPT + YR + QT + AREA + GEAR + INTERACTION

CPUE ~ N (μ , σ^2)

E (CATCH) = (Effort)*EXP(INTERCEPT + YR + QT + AREA + GEAR + INTERACTION)

CATCH ~ NB (α, β)

where log: natural logarithm, CPUE: nominal CPUE (catch of sharks in number per 1000 hooks), INTERCEPT: intercept, YR: effect of year (1992-2003), QT: effect of season (1-4 class 1: Jan-Mar, 2: Apr-Jun, 3: Jul-Sep, 4: Oct-Dec), AR: effect of area (1-5), GE: effect of gear type, INTERACTION: two way interactions, CATCH: nominal catch of sharks in number. EFFORT: number of hooks. YR, QT, AR and GE were incorporated as the main effect. Constant=1.Gear types were categorized into 3 (class 1: 5-8, 2: 9-13, 3: 14-16) for blue shark, 4 (class 1: 5-8, 2: 9-10, 3: 11-13, 4:14-16) for bigeye thresher and 3 (class 1: 5-9, 2: 10-14, 3: 15-16) for silky shark. In a CATCH model, Effort is set as an offset.

We made the variable selection using the stepwise F-test and Chi-square-test (Dobson 1990). Significant level was set at 5 %.

Comparison of CPUE trends obtained from the analysis employing CPUE model, CATCH model and Delta lognormal model were examined using the data of bigeye thresher. Variable selection was performed by the same methods as described above. Standardized CPUE in the Delta-lognormal model was calculated by multiplying the estimated ratio (1-R) and CPUE of positive catch. The following forms were assumed as full models.

E(Log (R/(1-R))) = INTERCEPT + YR + QT + AR + GE + INTERACTION + (Log (Effort))

R ~ NB (α, β)   R: zero-catch ratio in the total operations

E(Log (CPUE)) = INTERCEPT + YR + QT + AR + GE + INTERACTION

CPUE ~ N (μ , σ^2)   CPUE: nominal CPUE except zero-catch

Results and Discussion

As a result, the following models with many explanatory variables were finally selected.

Blue shark:

Log (CPUE + 1) = INTERCEPT + YR + QT + AR + GE + (YR*QT) + (YR*AR) + (QT*AR) + ERROR

Bigeye thresher:

CATCH = (Effort)*EXP (INTERCEPT + YR + QT + AR + GE + (YR*QT) + ERROR)

Silky shark:

CATCH = (Effort)*EXP (INTERCEPT + YR + QT + AR + (AR*QT) + ERROR)

The results of ANOVA are shown in Table 1, 2 and 3 for the three species. Figure 2 shows the year trend of standardized CPUEs. The standardized CPUE of blue shark ranged between 3 and 4 until 2001 except 1997. Those in the latter period (2002-03) were in a little low level. This result is somewhat different from the increasing trend of standardized CPUE for blue shark in the North Pacific Ocean since 1990 estimated from the logbook data (Matsunaga & Nakano 2006). Therefore, the phenomenon observed in this analysis may not occur in the whole Pacific Ocean and be temporary. Further study is necessary for this matter. The CPUE of bigeye thresher was stable (0.2-0.3) during this period. The CPUE of silky shark ranged around 0.1 to 0.2. Though some fluctuations were observed during the 12 years, the stock status of silky shark was not supposed to have changed greatly during this period.

The final models of each analysis using CPUE lognormal and Delta lognormal models for bigeye thresher are as follows.

CPUE-lognormal model:

Log (CPUE + 1) = INTERCEPT + YR + QT + AR + GE + (YR*QT) + ERROR

Delta-lognormal model:

Log (R/(1-R)) = INTERCEPT + YR + QT + AR + GE + (YR*QT) + ERROR + (Log (Effort))

Log (CPUE) = INTERCEPT + YR + QT + AR + GE + (YR*QT) + ERROR

The same variables were selected in three models. R, average and SD of CPUE in the Delta lognormal model were estimated to be 0.68, 0.89 and 0.19 respectively. Standardized CPUE of bigeye thresher calculated by three methods are compared in Fig.3 (upper: estimated CPUE, lower: scaled value dividing by the mean of CPUE). Though the levels of CPUE are a little different, the year trends were similar in the three methods. This result indicates that CPUE trends of bigeye thresher obtained by the analyses using CPUE lognormal model so far was not misleading. However, more detailed study especially for model selection for CPUE standardization is necessary because the zero-catch rate and other characteristics of data may be different depending on the species or areas. Difficulty in estimating confidence intervals by Delta lognormal model analysis is another problem to solve.

Conclusion

No drastic changes of standardized CPUE were observed for blue shark, bigeye thresher and silky shark, which were the main pelagic shark species in the tuna longline fishery from 1992 to 2003 in the north Pacific Ocean.

Reference

Nakano, H. (1996): Historical CPUE of pelagic shark caught by Japanese longline fishery in the world. Information Paper submitted to the 13th CITES Animals Committee, Doc. AC. 13.6.1 Annex, 7pp.

Matsunaga, H and H. Nakano (1996): CPUE trend and species composition of pelagic sharks caught by Japanese research and training vessels in the Pacific Ocean. Information Paper submitted to the 13th CITES Animals Committee, Doc. AC. 13.6.1 Annex, 8pp.

Matsunaga, H and H. Nakano (2006): Blue shark, Prionace glauca. The Current Status of International Fishery Stocks. 256-262.

Shono, H. (2004): A review of some statistical approaches used for CPUE standardization. Bull. Jpn. Soc. Fish. Oceanogr., 68(2), 106-120.

Table 1 Results of ANOVA for the finally selected model in the analysis of blue shark

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	109	3332.5	30.6	99.0	<.0001
Error	15690	4847.4	0.3		
Corrected Total	15799	8179.9			

R-Square	Coeff Var	Root MSE	logCPUE Mean
0.407	34.868	0.556	1.594

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	11	44.9	4.1	13.2	<.0001
QT	3	25.7	8.6	27.7	<.0001
AR	4	313.3	78.3	253.5	<.0001
GE	2	23.3	11.6	37.6	<.0001
YR*QT	33	261.5	7.9	25.7	<.0001
YR*AR	44	329.9	7.5	24.3	<.0001
QT*AR	12	350.8	29.2	94.6	<.0001

Table 2 Results of ANOVA for the finally selected model in the analysis of bigeye thresher

Source	DF	Chi-Square	Pr > ChiSq
YR	11	81.7	<.0001
QT	3	156.4	<.0001
AR	4	1059.3	<.0001
GE	3	133.9	<.0001
YR*QT	33	278.7	<.0001

Table 3 Results of ANOVA for the finally selected model in the analysis of silky shark

Source	DF	Chi-Square	Pr > ChiSq
YR	11	196.8	<.0001
QT	3	9.9	0.0192
AR	4	1254.1	<.0001
QT*AR	12	195.2	<.0001

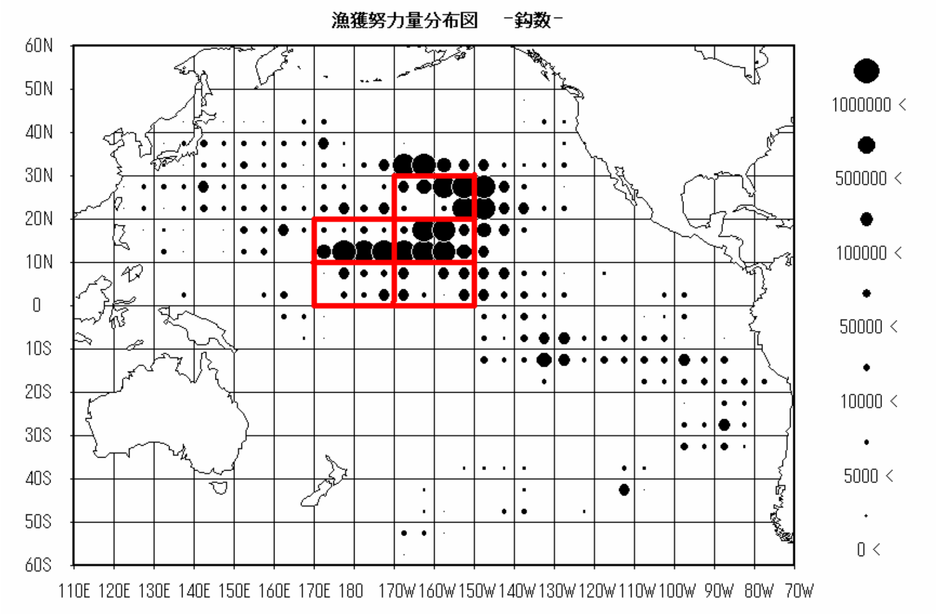


Fig.1 Distribution of fishing effort indicated in number of hooks and area classification used for the analysis.

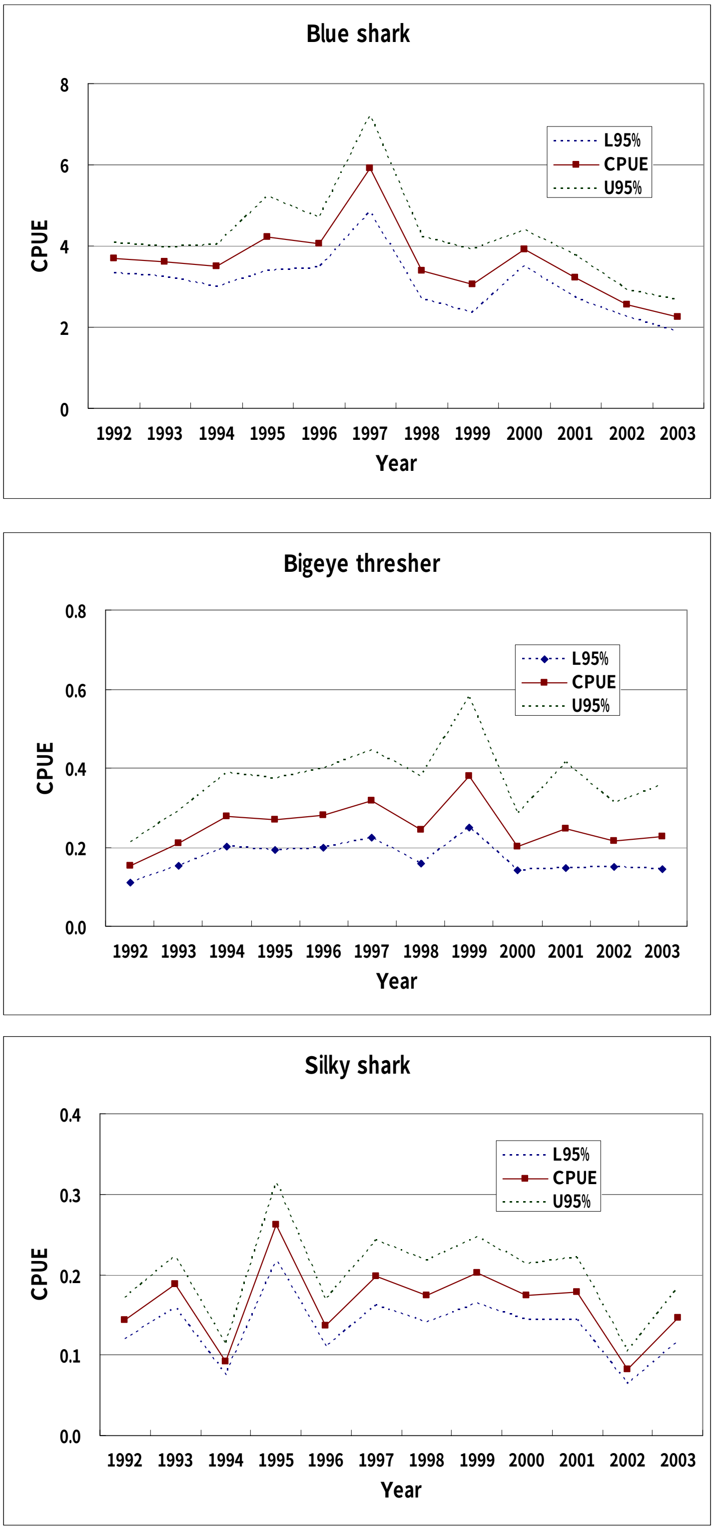
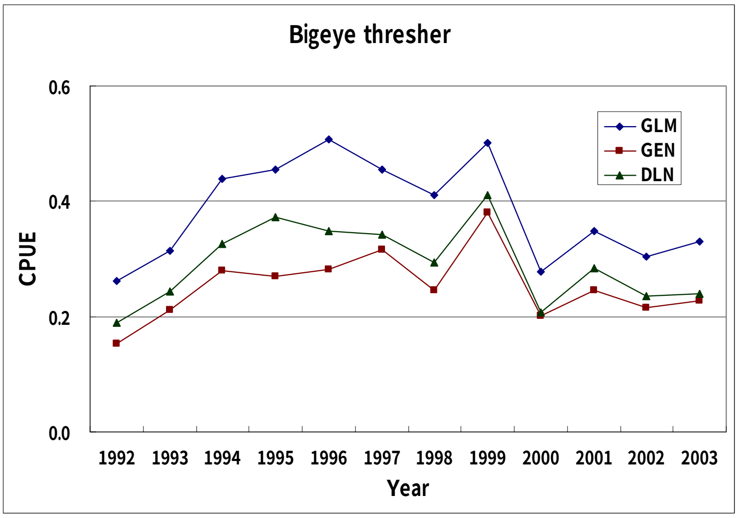


Fig.2 Standardized CPUE and 95% confidence intervals for three shark species (upper: blue shark, middle: bigeye thresher, lower: silky shark) obtained using Japanese observer data.



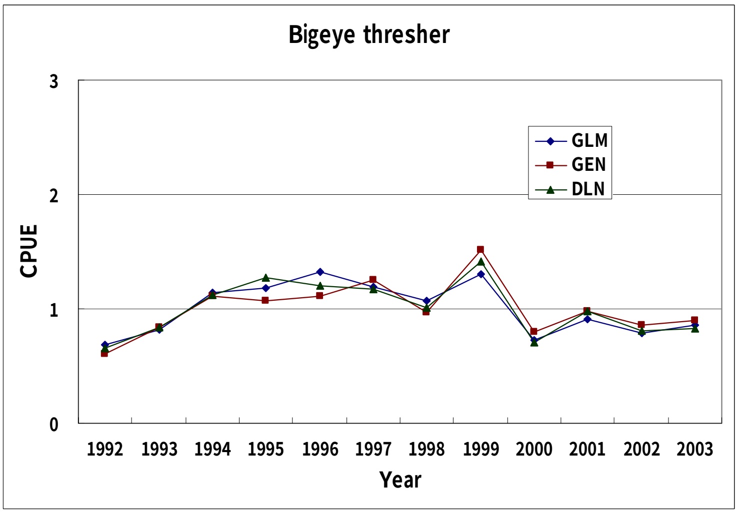


Fig.3 Comparison of standardized CPUE trends calculated by three methods (upper), and scaled value dividing by the mean of CPUE (lower). GLM: CPUE lognormal model, GEN: CATCH delta binominal, DLN: Delta lognormal.