SCRS/2001/083 Col.Vol.Sci.Pap. ICCAT, 54 (4): 1349-1360. (2002)

STANDARDIZED CPUE FOR BLUE SHARKS CAUGHT BY JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN

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SUMMARY

The standardized CPUE for blue shark caught by Japanese longline fishery in the Atlantic Ocean was given using the logbook data filtered by 70% of reporting category during 1971-2000. Those logbook data includes shark catch classified as sharks. Another blue shark standardized CPUE were obtained for the period of 1993-2000 using species specific catch record and filtered 70, 80 and 90% of reporting category for the comparison. The sensitivity was checked using 70, 80 and 90% filtered data for both data sets. Blue shark CPUEs indicate relatively stable trends during past three decades for North, South and whole Atlantic stock hypothesis.

RÉSUMÉ

La CPUE standardisée du requin peau bleue capturé par les palangriers japonais dans l=Atlantique est obtenue au moyen d=extraits de livre de bord filtrés par 70% de la catégorie de déclaration en 1971-2000. Ces extraits de livres de bord comprennent des captures de requins enregistrées en tant que requins. Une autre CPUE standardisée du requin peau bleue a été obtenue pour la période 1993-2000 d=après des registres de capture spécifiques de l=espèce filtrés par 70%, 80% et 90% de la catégorie de déclaration aux fins de la comparaison. La sensibilité a été testée au moyen de 70%, 80% et 90% des données filtrées pour les deux jeux de données. Les CPUE du requin peau bleue montrent une tendance relativement stable depuis trois décennies selon les hypothèses Atlantique nord, Atlantique sud et Atlantique entier.

RESUMEN

La CPUE estandarizada del tiburón azul capturado por la pesquería de palangre japonesa en el océano Atlántico se estimó utilizando los datos de los cuadernos de pesca, filtrando el 70% de los datos comunicados en los cuadernos para 1971-2000. Estos datos de los cuadernos de pesca comprenden capturas de tiburones clasificadas como tiburones. Otra CPUE estandarizada se obtuvo para el período 1993-2000 utilizando registros de captura especificados por especies y filtrando un 70, 80 y 90% de los datos con fines comparativos Se comprobó la sensibilidad de ambos grupos de datos utilizando un 70, 80 y 90% de los datos filtrados. Las CPUE de los tiburones azules indican la existencia de unas tendencias relativamente estables en las últimas tres décadas para las hipótesis de un solo stock atlántico y de stocks separados del Atlántico norte y sur.

KEYWORDS

Catchability, Time series analysis, Population dynamics, High seas fisheries, Long lining, Pelagic fisheries, Tuna fisheries, Logbooks, Blue shark

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1. INTRODUCTION

Nakano and Honma (1996) reviewed CPUE of pelagic shark in the Atlantic Ocean using Japanese longline logbook data with filtering of shark reporting category, e.g. the ratio of operations shark caught to total number of operations in a cruise. Shiode and Nakano (2001) examined shark species composition and level of CPUE by reporting category comparing with records of shark catch by Japanese observer data and concluded the CPUE using filtered logbook data could be used as an abundance index of the species. Because, the filtered logbook data more than 70% reporting category includes more than 86% of blue shark catch in number and the level of CPUE were in the range of variation of observed CPUE recorded by observer on boards.

The standardized CPUE of pelagic sharks caught by Japanese longline fishery in the Atlantic Ocean was introduced previous reports submitted to ICCAT sub-committee on by-catches (Nakano and Honma 1996, Nakano 1998, Nakano 1999). Since Japanese longline fishery has widely covered high sea area of the Atlantic Oceans, its fishery statistics must be one of the most valuable resources, which describe stock status of pelagic shark. International concern over the conservation of elasmobranch species has been continued. Therefore, it is useful to examine recent trend of stock status of blue shark by updating logbook of tuna fisheries. This paper estimated the standardized CPUEs of blue shark in the Atlantic Ocean using the logbook data of Japanese longline fishery from 1971 to 2000.

2. MATERIALS AND METHODS

The same filtering was adapted and the data more and equal 70% of shark reporting category was used for analysis. The data which reporting category more and equal 80% and 90% were used for sensitivity test. Time series of the data were 30 years from 1971 to 2000, although data for 2000 is provisional. The Japanese logbook system was modified from 1993 and sharks catch record were separated by species (blue, porbeagle, shortfin mako and other sharks from 1993 and blue, porbeagle, shortfin mako, oceanic whitetip, thresher sharks and other sharks from 1997). Then standardized CPUE using species specific logbook data for blue shark was examined for the comparison. Species specific catch data was also filtered, since reporting behavior was variety by vessel or fishermen. The data reporting category 70, 80 and 90 were used for analysis.

Standardized CPUE (number of sharks caught per 1,000 hooks) were calculated using Mixed procedure of SAS to eliminate some biases by change of fishing ground and fishing seasons. A Mixed procedure is a generalization of the standard linear model that provides with flexibility of modeling not only the means of the data but their variances and covariances (SAS Institute 1996). Although Mixed procedure can handle random-effect parameters, only fixed-effects parameter was used in this time. Therefore MLM model is same as GLM model for this analysis. It is useful for the model selection which the mixed procedure of SAS produces several information criteria values.

For standardization, CPUE was calculated shot by shot of operations. The area strata used for the analysis were shown in Figure 1. Numbers of branch line between floats were classified into three categories. CPUE of pelagic sharks were obtained for same three geographical units used in the previous report, *i.e.* the north, south and overall Atlantic Ocean. The north unit includes area 1 to 5; the south includes area 6 to 8. The equation for standardizing CPUE was as follows:

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

where ln: natural logarithm, $CPUE_{ijkl}$: nominal CPUE (catch in number per 1,000 hooks, in year i, quarter j, area k, branch line criteria l), 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, br_l : branch line criteria l, INTER : any combination of two way interaction, and ε : normal error term. The same effects selected for previous report including interaction terms were used for analysis. The interactions included for the models were QT*AREA, QT*br for the North, South and overall Atlantic stock hypothesis. Analysis was made through the mixed procedure of computer software, 'SAS System for windows Ver. 6.12'.

3. RESULTS AND DISCUSSIONS

Table 1 shows number of observations in each year by geographical unit and reporting category 70, 80 and 90%, respectively. Type III analysis revealed that all main effects and interaction of selected models were significant (Table 2).

Figure 2 show the standardized CPUEs for the North, South and overall units. The values of CPUE ranged around 1.0 to 8.0 and were in the range of reported CPUE by observer on board for pelagic sharks caught by longline fishery. The reported CPUE of pelagic sharks (number of caught per 1,000 hooks) were 1.31 -38.8 (Strasburg 1958, Lopez et al. 1979, Witzell 1985, Hazin et al. 1990, Taniuchi 1990, Bonfil 1994). The sensitivity of data set were checked using the data of reporting category of 70, 80 and 90% (Fig.3). The standardized CPUEs for each reporting category indicate same trends in the same stock unit hypothesis, although high reporting rate reveals high CPUE revel. The results indicate relatively stable level with small fluctuation in the North unit and some high level of CPUE were observed between 1976 to 1980 in the South and overall units. The CPUE for North unit indicates decreasing trend in the recent years, but it for the South increasing recently. Although such CPUE revealed different trends between North and South, fluctuations of CPUE were relatively small comparing with some tunas and billfishes caught by Atlantic fisheries. Therefore results of the analysis suggests that stock status of pelagic sharks have not changed drastically during more than two decades in high sea area of the Atlantic Ocean.

Standardized CPUEs using species specific data with reporting category of 70, 80 and 90% were shown in Figure 4. The CPUEs of each reporting category indicate similar trends among Stock units. The CPUE for the North indicates decreasing trend and the South reveals increasing trend. Species specific CPUEs and CPUEs used species combined data set were compared (Fig. 5). Both CPUEs indicated similar trends and same level of CPUE among stock units.

The sharks caught in high seas are mainly consisted of blue shark (Strasburg 1958, Hazin et al. 1990, Bonfil 1994, Matsunaga and Nakano 1996, Nakano and Honma1996). Therefore, the stock status of blue shark in the Atlantic Oceans might not change during the periods. However, there is few information of long-term stock status for the other shark species, which inhabits in the high sea area. It is necessary to conduct further research activities on board, such as observer program, to examine the population dynamics for each species.

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Table 1. Number of observations by geographical unit in each year.

	70%			80%			90%		
	North	**South**	**overall**	**North**	**South**	**overall**	**North**	**South**	**overall**
1971	**1609**	**1333**	**2942**	**812**	**782**	**1594**	**235**	**384**	**619**
1972	**637**	**516**	**1153**	**422**	**274**	**696**	**265**	**99**	**364**
1973	**688**	**782**	**1470**	**452**	**448**	**900**	**127**	**267**	**394**
1974	**1194**	**398**	**1592**	**889**	**286**	**1175**	**666**	**98**	**764**
1975	**1126**	**498**	**1624**	**636**	**151**	**787**	**476**	**44**	**520**
1976	**951**	**29**	**980**	**529**	**6**	**535**	**241**	**0**	**241**
1977	**577**	**321**	**898**	**287**	**292**	**579**	**130**	**268**	**398**
1978	**517**	**267**	**784**	**403**	**165**	**568**	**241**	**110**	**351**
1979	**83**	**322**	**405**	**0**	**322**	**322**	**0**	**322**	**322**
1980	**307**	**389**	**696**	**99**	**388**	**487**	**99**	**388**	**487**
1981	**422**	**429**	**851**	**401**	**143**	**544**	**317**	**34**	**351**
1982	**353**	**1155**	**1508**	**283**	**770**	**1053**	**221**	**559**	**780**
1983	**476**	**232**	**708**	**363**	**146**	**509**	**162**	**74**	**236**
1984	**657**	**1126**	**1783**	**455**	**839**	**1294**	**297**	**609**	**906**
1985	**757**	**1296**	**2053**	**385**	**1099**	**1484**	**354**	**1024**	**1378**
1986	**290**	**1065**	**1355**	**237**	**882**	**1119**	**183**	**871**	**1054**
1987	**697**	**828**	**1525**	**481**	**815**	**1296**	**363**	**750**	**1113**
1988	**689**	**893**	**1582**	**363**	**631**	**994**	**295**	**532**	**827**
1989	**734**	**1694**	**2428**	**521**	**1305**	**1826**	**326**	**1200**	**1526**
1990	**522**	**1623**	**2145**	**343**	**1470**	**1813**	**155**	**1412**	**1567**
1991	**573**	**1947**	**2520**	**260**	**1723**	**1983**	**117**	**1505**	**1622**
1992	**881**	**849**	**1730**	**779**	**601**	**1380**	**602**	**512**	**1114**
1993	**1094**	**1747**	**2841**	**909**	**1661**	**2570**	**709**	**1116**	**1825**
1994	**1657**	**3206**	**4863**	**1480**	**3144**	**4624**	**1253**	**2642**	**3895**
1995	**1994**	**2220**	**4214**	**1865**	**1826**	**3691**	**1534**	**1292**	**2826**
1996	**1385**	**1884**	**3269**	**1220**	**1645**	**2865**	**1118**	**808**	**1926**
1997	**930**	**1310**	**2240**	**798**	**1213**	**2011**	**623**	**925**	**1548**
1998	**2380**	**1030**	**3410**	**1600**	**773**	**2373**	**875**	**629**	**1504**
1999	**1018**	**1070**	**2088**	**928**	**1013**	**1941**	**760**	**773**	**1533**
2000	**787**	**355**	**1142**	**613**	**355**	**968**	**311**	**355**	**666**
Total	**25985**	**30814**	**56799**	**18813**	**25168**	**43981**	**13055**	**19602**	**32657**

Table 2. Outputs of Type III analysis for the models selected in each unit.

NDF is the numerator degrees of freedom, and DDF is the denominator degrees of freedom.

North Atlantic: **Tests of Fixed Effects**

Source	NDF	DDF	Type III ChiSq	Type III F	Pr > ChiSq	Ord ChiSq	Pr > F	Ord F
YR	29	6.00E+04	3461.62	119.37	0.0001	0	0.0001	0
QT	3	6.00E+04	87.34	29.11	0.0001	0	0.0001	0
AREA	8	6.00E+04	541.07	67.63	0.0001	0	0.0001	0
BR	2	6.00E+04	239.31	119.65	0.0001	0	0.0001	0
QT*AREA	24	6.00E+04	340.02	14.17	0.0001	0	0.0001	0
QT*BR	6	6.00E+04	374.43	62.4	0.0001	0	0.0001	0

South Atlantic: **Tests of Fixed Effects**

Source	NDF	DDF	Type III ChiSq	Type III F	Pr > ChiSq	Ord ChiSq	Pr > F	Ord F
YR	29	3.10E+04	3593.74	123.92	0.0001	0	0.0001	0
QT	3	3.10E+04	10.73	3.58	0.0133	0.0135	0.0133	0.0183
AREA	2	3.10E+04	168.68	84.34	0.0001	0	0.0001	0
BR	2	3.10E+04	64.89	32.45	0.0001	0	0.0001	0
QT*AREA	6	3.10E+04	28.9	4.82	0.0001	0	0.0001	0.0002
QT*BR	6	3.10E+04	164.77	27.46	0.0001	0	0.0001	0

overall Atlantic: **Tests of Fixed Effects**

Source	NDF	DDF	Type III ChiSq	Type III F	Pr > ChiSq	Ord ChiSq	Pr > F	Ord F
YR	29	5.70E+04	3361.31	115.91	0.0001	0	0.0001	0
QT	3	5.70E+04	56.33	18.78	0.0001	0	0.0001	0
AREA	7	5.70E+04	527.03	75.29	0.0001	0	0.0001	0
BR	2	5.70E+04	258.52	129.26	0.0001	0	0.0001	0
QT*AREA	21	5.70E+04	362.59	17.27	0.0001	0	0.0001	0
QT*BR	6	5.70E+04	359.3	59.88	0.0001	0	0.0001	0

Table 3. Annual, standardized CPUE from the models selected in each unit.

	North Atlantic:			South Atlantic:			overall Atlantic:		
Year	**CPUE**	**Lower**	**Upper**	**CPUE**	**Lower**	**Upper**	**CPUE**	**Lower**	**Upper**
1971	**0.7819**	**0.6938**	**0.8776**	**1.1990**	**1.1027**	**1.3021**	**0.9837**	**0.9300**	**1.0397**
1972	**1.1925**	**1.0412**	**1.3604**	**0.9579**	**0.8489**	**1.0774**	**1.0835**	**0.9993**	**1.1731**
1973	**1.0384**	**0.9072**	**1.1833**	**1.4434**	**1.3120**	**1.5856**	**1.2029**	**1.1209**	**1.2897**
1974	**2.1992**	**1.9865**	**2.4314**	**1.2339**	**1.0901**	**1.3928**	**1.9328**	**1.8164**	**2.0556**
1975	**1.3323**	**1.1867**	**1.4919**	**0.8372**	**0.7400**	**0.9436**	**1.1607**	**1.0823**	**1.2437**
1976	**0.8599**	**0.7547**	**0.9752**	**0.6274**	**0.3695**	**0.9874**	**0.8946**	**0.8186**	**0.9757**
1977	**1.8199**	**1.6042**	**2.0596**	**6.8546**	**6.1145**	**7.6804**	**2.9867**	**2.7693**	**3.2195**
1978	**1.9201**	**1.6848**	**2.1829**	**2.6668**	**2.3357**	**3.0399**	**2.1851**	**2.0102**	**2.3732**
1979	**1.6581**	**1.2432**	**2.1819**	**9.3954**	**8.3960**	**10.5099**	**6.4575**	**5.8128**	**7.1701**
1980	**3.2596**	**2.8186**	**3.7622**	**6.6293**	**6.0043**	**7.3165**	**4.8394**	**4.4683**	**5.2393**
1981	**2.8504**	**2.4997**	**3.2444**	**1.0462**	**0.9290**	**1.1746**	**1.7880**	**1.6495**	**1.9364**
1982	**1.7770**	**1.5297**	**2.0571**	**2.8060**	**2.6212**	**3.0026**	**2.4455**	**2.3032**	**2.5956**
1983	**1.5619**	**1.3623**	**1.7850**	**2.3509**	**2.0505**	**2.6900**	**1.8589**	**1.7050**	**2.0247**
1984	**0.9235**	**0.8028**	**1.0571**	**2.6505**	**2.4716**	**2.8410**	**1.8502**	**1.7473**	**1.9582**
1985	**0.9179**	**0.7982**	**1.0501**	**2.1635**	**2.0253**	**2.3099**	**1.6211**	**1.5344**	**1.7119**
1986	**2.2557**	**1.9331**	**2.6241**	**2.1580**	**2.0061**	**2.3199**	**2.0612**	**1.9321**	**2.1978**
1987	**1.6906**	**1.5002**	**1.9008**	**3.2880**	**3.0488**	**3.5444**	**2.4365**	**2.2978**	**2.5825**
1988	**1.0604**	**0.9288**	**1.2057**	**2.0880**	**1.9304**	**2.2569**	**1.5515**	**1.4588**	**1.6491**
1989	**1.2965**	**1.1453**	**1.4630**	**2.0965**	**1.9740**	**2.2257**	**1.8160**	**1.7294**	**1.9063**
1990	**1.3078**	**1.1383**	**1.4968**	**2.3038**	**2.1674**	**2.4478**	**2.0479**	**1.9463**	**2.1540**
1991	**1.0403**	**0.9037**	**1.1919**	**2.0215**	**1.9077**	**2.1412**	**1.8101**	**1.7245**	**1.8993**
1992	**1.9086**	**1.7188**	**2.1159**	**2.0461**	**1.8923**	**2.2108**	**2.0927**	**1.9794**	**2.2116**
1993	**2.5907**	**2.3416**	**2.8629**	**2.1588**	**2.0309**	**2.2937**	**2.4169**	**2.3113**	**2.5268**
1994	**2.8503**	**2.6029**	**3.1186**	**2.1453**	**2.0399**	**2.2555**	**2.4544**	**2.3697**	**2.5418**
1995	**2.4324**	**2.2267**	**2.6547**	**1.6185**	**1.5255**	**1.7163**	**2.0871**	**2.0101**	**2.1667**
1996	**2.6619**	**2.4199**	**2.9251**	**1.4272**	**1.3396**	**1.5195**	**1.9672**	**1.8857**	**2.0517**
1997	**2.1360**	**1.9192**	**2.3736**	**1.5561**	**1.4494**	**1.6693**	**1.8715**	**1.7783**	**1.9688**
1998	**1.8181**	**1.6624**	**1.9859**	**1.4581**	**1.3503**	**1.5730**	**1.8038**	**1.7298**	**1.8804**
1999	**1.4182**	**1.2693**	**1.5809**	**1.6911**	**1.5708**	**1.8192**	**1.6618**	**1.5772**	**1.7502**
2000	**1.3488**	**1.1888**	**1.5255**	**2.0451**	**1.8215**	**2.2925**	**1.5328**	**1.4252**	**1.6470**

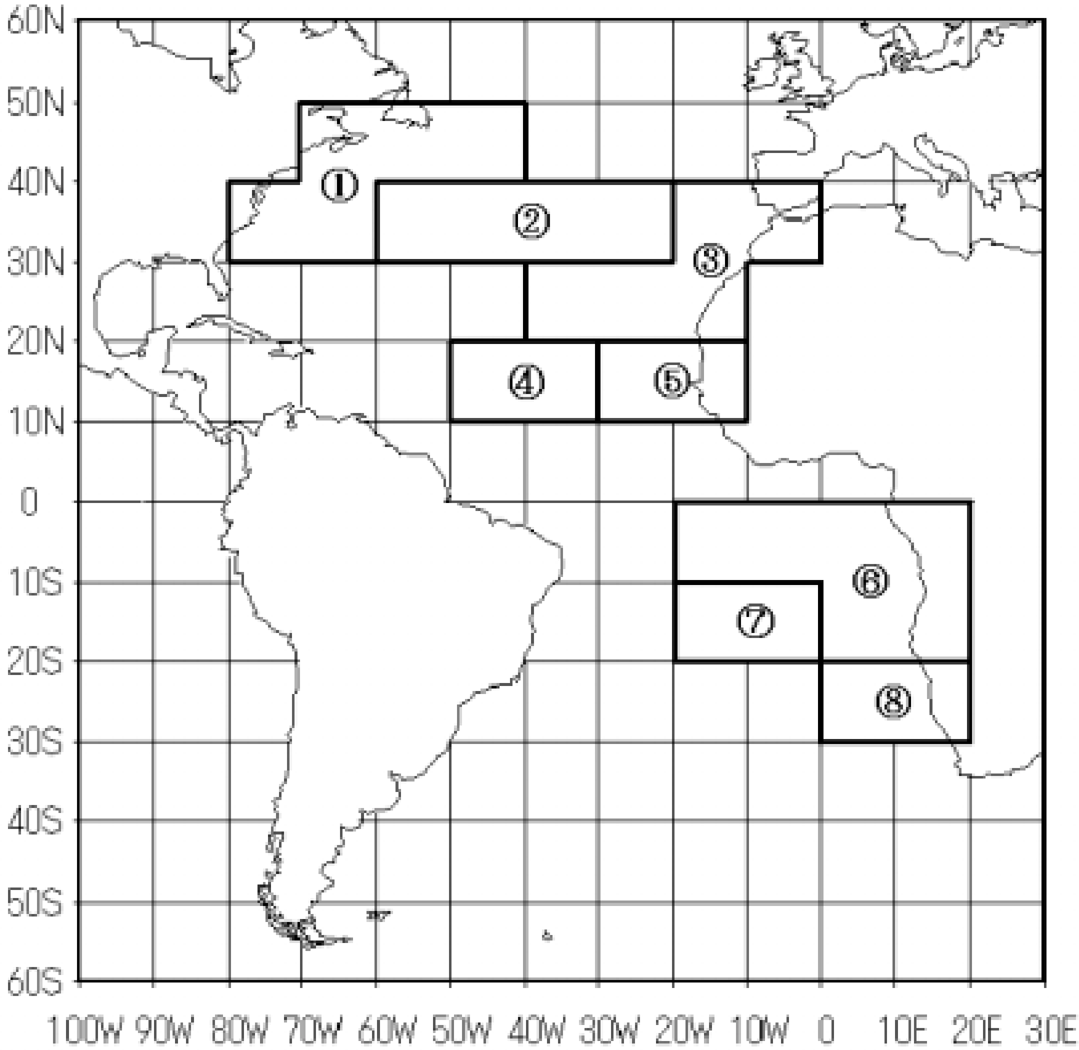


Figure 1. Area classification used for the analysis.

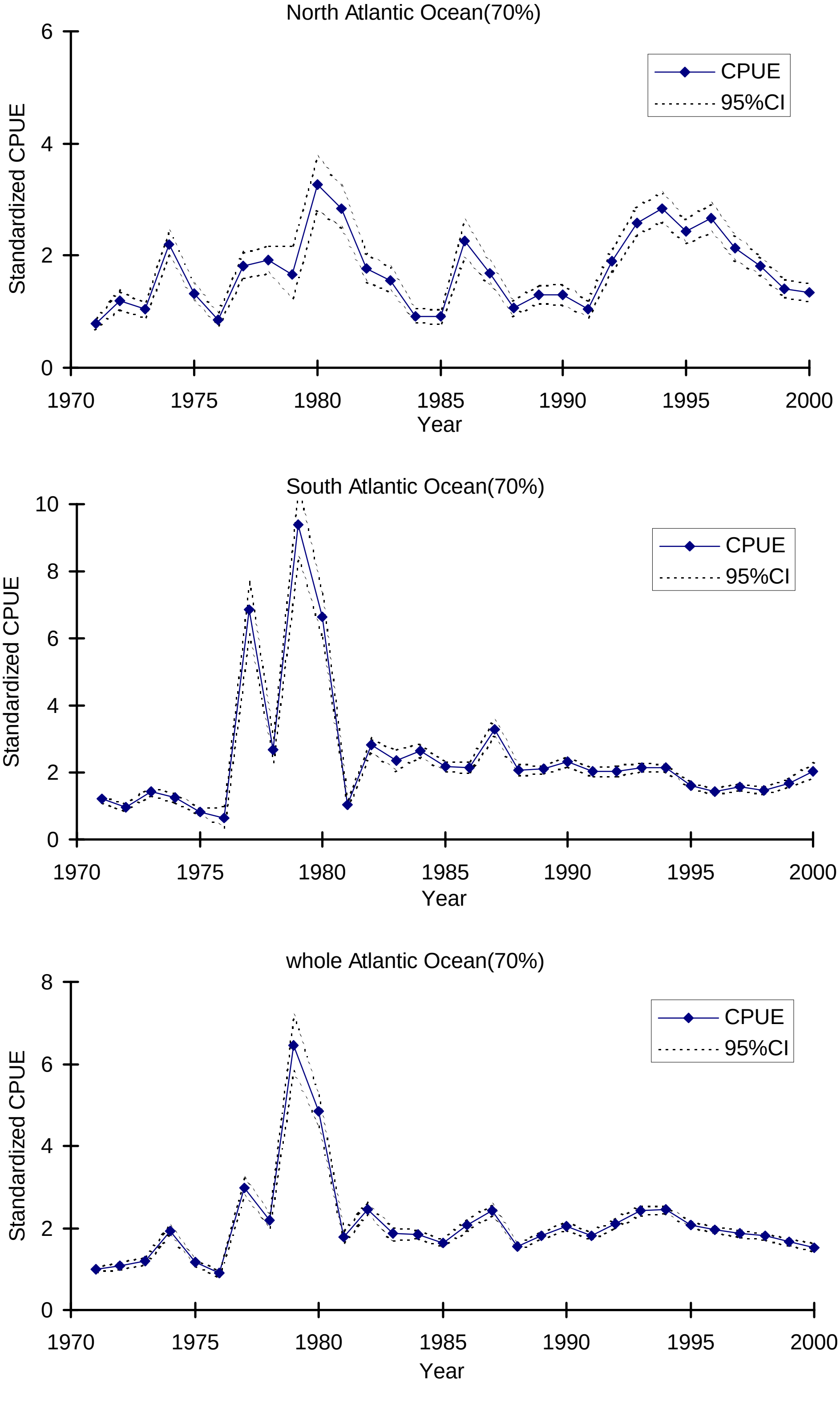
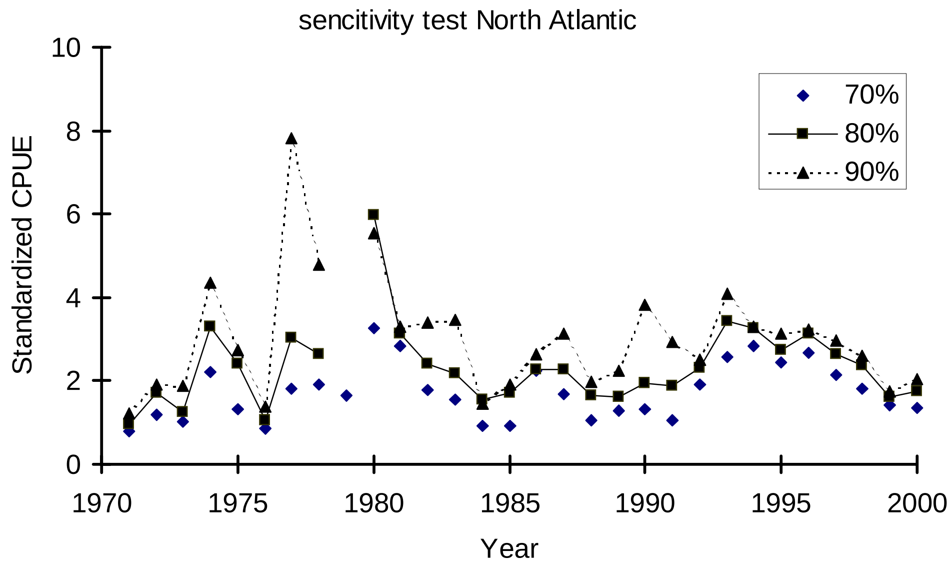
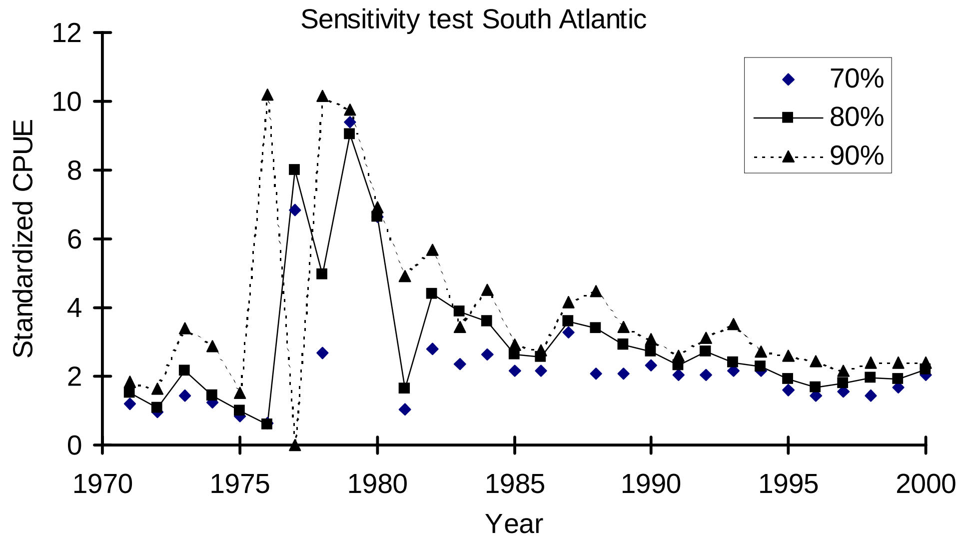


Figure 2. Standardized shark CPUE and 95% confidence intervals based on the logbook data of Japanese longline fishery in the Atlantic Ocean.





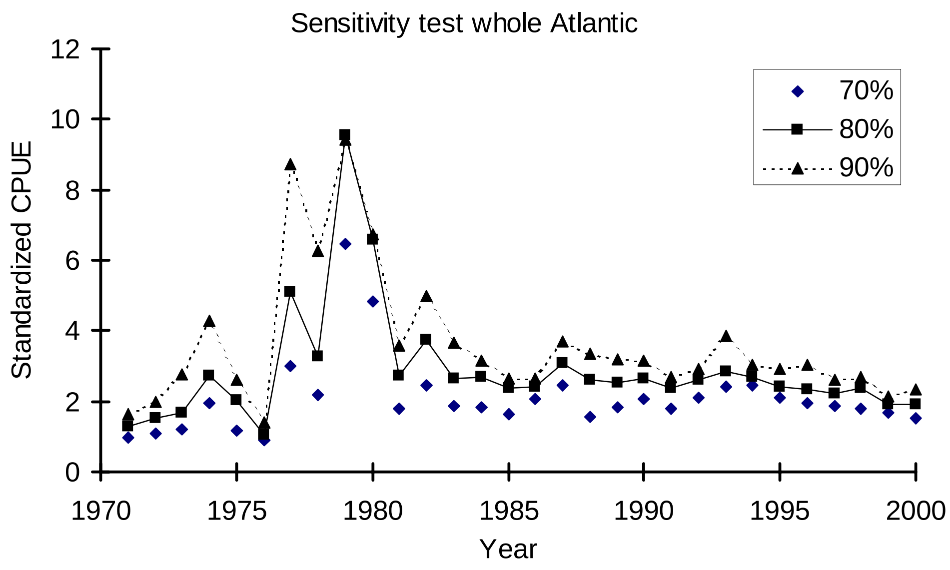


Fig. 3. Sensitivity test of Standardized CPUE for blue shark using filtered data by 70, 80 and 90% reporting category.

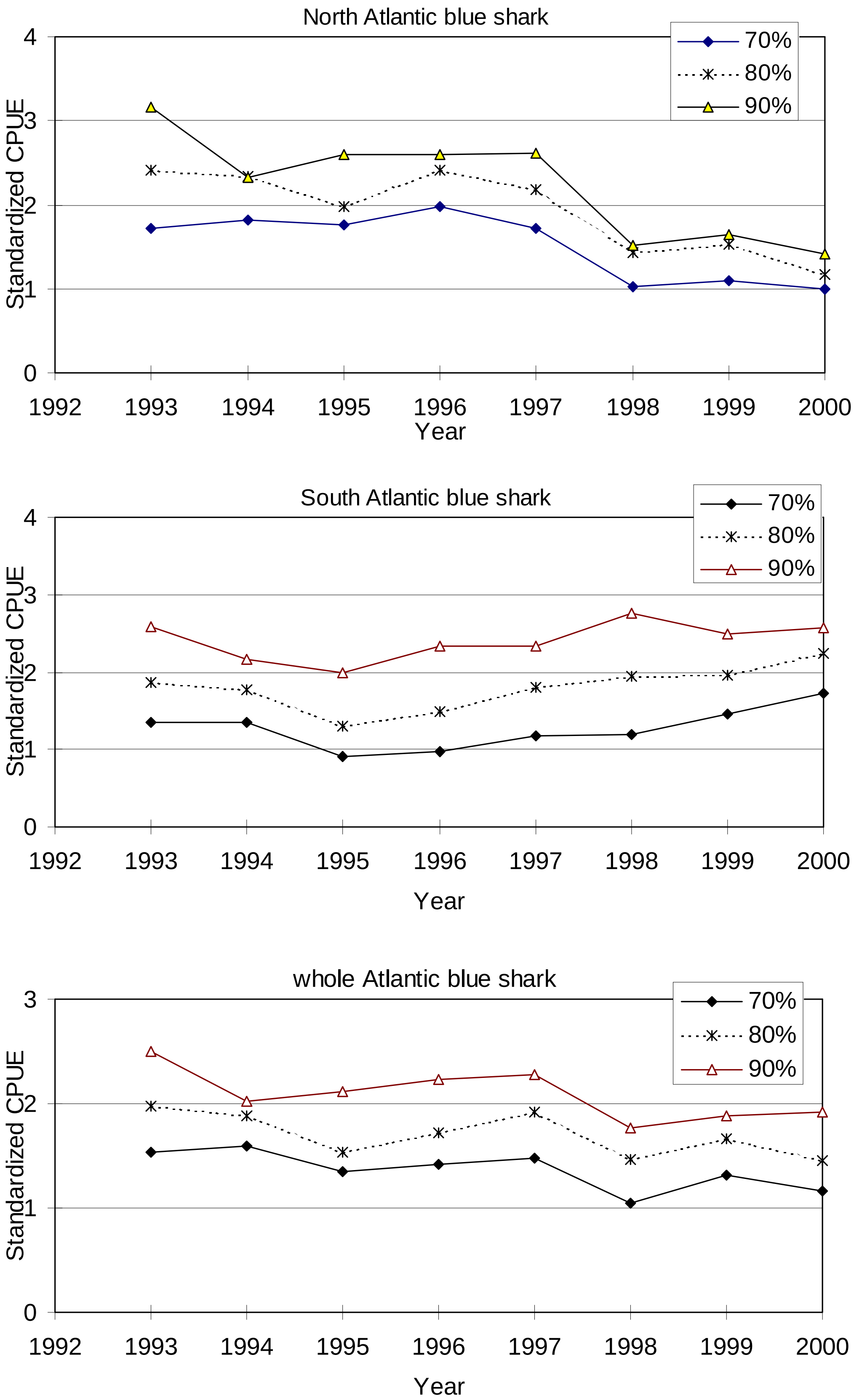


Fig. 4. Standardized CPUE for blue shark using filtered species specific logbook data. The data of reporting category 70, 80 and 90% are used for analysis.

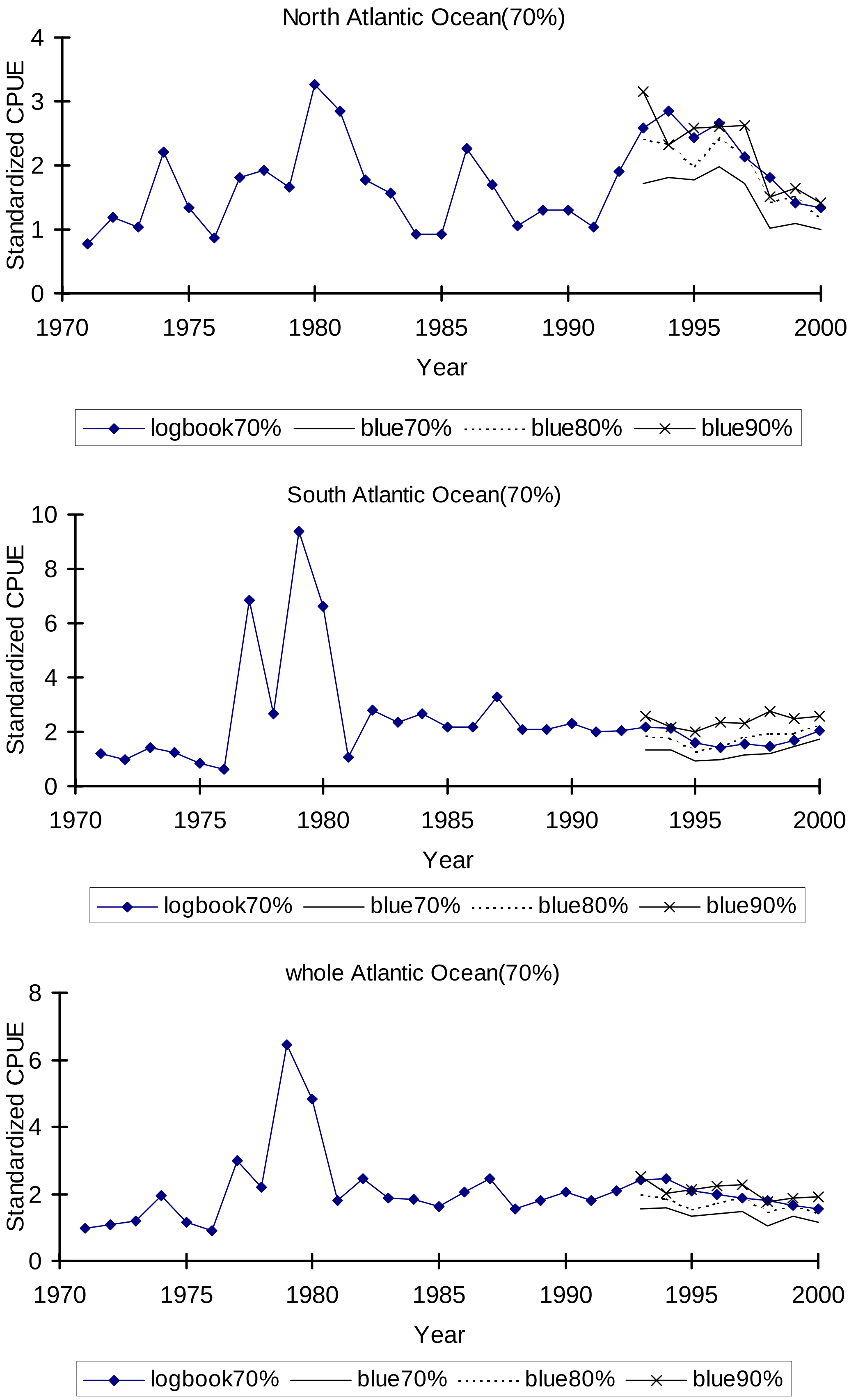


Fig. 5. Comparison of standardized CPUEs using filtered logbook data as classified sharks and blue shark. CPUEs using species specific logbook data includes reporting category 70, 80 and 90%.