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Standardized CPUE for blue sharks caught by Japanese tuna longline fishery in the Indian Ocean, 1971-1993 and 1994-2010

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Summary

The standardized CPUEs of blue shark caught by Japanese tuna longline fishery in the Indian Ocean was calculated using logbook data during 1971-1993 and 1994-2010, respectively. The standardized CPUEs obtained by selected catch and effort data (reporting rate of sharks washigher than 80 % per cruise) show the relatively stable trends up to the beginning of the 2000s when it start to decrease gradually. The CPUE trends estimated from the data sets filtered by the every 10% reporting categories were not markedly different expect ≥90% filter during 1994 to 2010. The general trends of CPUE of blue shark were rather robust for the change of the criteria of the selection of data (change of reporting ratio from 0 to 90 %), and thus it is considered that the results using ≥80% filter in this report, which is the criteria of data selection verified in the Atlantic, could be recognized to represent the trend of abundance of blue shark in the Indian Ocean.

Keywords

Blue shark, CPUE, Longline, Reporting rate

1.Introduction

For estimation of standardized CPUEs of pelagic shark species caught by Japanese longline fishery, the filtering method using reporting rate (percentage of sets with shark catch to one cruise) has been considered to be necessary because of several common problems with the shark catch data. Firstly the log-book reporting system of Japanese longline fishery only had possessed data of “species combined shark catch” before 1994, secondly the logbook data of the pelagic shark species does not include the information of dead discards and live release of sharks. In Atlantic Ocean, the CPUEs of pelagic sharks filtered by the reporting category were analyzed (Nakano and Honma, 1996; Shiode and Nakano, 2001), then Nakano and Clark (2006) found that the data of only blue shark catch was successfully extracted when the data was filtered by the criteria of higher than 80% of reporting ratio. Matsunaga (2007) assumed the same method can be applied on the data in the

Indian Ocean and reported the result of standardized CPUE during 1971 to 2005. In the present report, we estimated the standardized CPUEs of blue shark during 1971-1993 and 1994-2010, respectively. As the species specific data of sharks had become available since 1994, the standardized CPUEs using the only blue shark data with reporting rates greater than 80% were used during 1994 to 2010. Because the problem of releases and discards are still remain after introduction of new log book system in 1994, we set the assumption that the data with higher reporting ratio than 80% would record all the shark catches in order to extract only the data of the fishing vessel which report the shark catch accurately. To examine this assumption, the comparison of CPUE trends of different filtering criteria were conducted in each period.

2.Material and Methods

The standardized CPUEs during 1971-1993 and 1994-2010 were calculated respectively, as the Japanese log-book system had changed in 1993. In the period between 1971 and 1993 all shark species had been aggregated and categorized as "sharks", but in 1994 the logbook format was devised and the category of blue shark, mako sharks, porbeagle as well as other sharks was newly established instead of "sharks". Also the category of oceanic whitetip shark and thresher sharks had been separated from the category of other sharks after 1997. Therefore the data set categorized "sharks" were obtained for calculation between 1971 and 1993 and the data recorded as only blue shark were used between 1994 and 2010. The data for 2009 and 2010 are provisional.

The same filtering methods of Nakano and Honma (1996) was adapted. For standardized CPUE analysis for blue shark, the data set with reporting rates (percentage of operations with shark catch to total operations per cruise) greater than 80% were used, asthis reporting rate was recommended by Nakano and Clarke (2006). The generalized liner model same as Mtsunaga (2007) were used both during 1971-1993 and 1994-2010 for standardized CPUEs. The standardized CPUEs (number of sharks or blue shark caught per 1,000 hooks) were calculated using GLM procedure of SAS var. 9.2. The equations were as follows:

$$\ln(\text{CPUE}+\text{constant}) = YR + QT + AR + BR + QT*AR + QT*BR + \text{nominal error}$$

where ln: natural logarithm, CPUE: nominal CPUE (catch in number per 1,000 hooks), constant: 0.2, YR: effect of year, QT: effect of quarter, AR: effect of area, BR: branch line criteria (number of lines between floats; <9, 9-14, 13<). The GLM-tree methods (Ichinokawa and Brodziak, 2010) were used to describe the optimal area stratification for CPUE series in two periods, respectively.

For comparison of filtering effects, the normalized CPUEs with greater than every 10% of reporting rate were calculated using the same area stratifications and equations as standardizing CPUEs with >80% reporting rate.

3. Result and Discussion

The analysis of the GLM-tree model indicated continuous decrease of the AIC value up to the 15 splits of area in 1971-1993 and 20 splits in 1994-2010 (Fig. 1), which indicating statistically the larger number of areas gives better fits of data to the GLM model. Ichinokawa and Brodziak (2010) mentioned that the GLM-tree algorithm tends to subdivide area with a substantial amount of fishery data, which would lead to a prevalence of strata with low sample size and make it impossible to calculate the least square means in some cases. Thus the 10 and 8 area strata were arbitrarily chosen for the CPUE analysis for blue shark as further subdivisions of area only gain smaller amount of decrease of AIC and produced the luck of data coverage (Figs. 2 and 3).

Through 1971 to 2010, the standardized CPUEs of blue shark whose reporting rate were more than 80 % show relatively stable levels (Table 1 and Fig. 4). The CPUE trends estimated from the data sets filtered by the every 10% reporting categories were not markedly different expect ≥90% filter during 1994 to 2010 (Fig. 6). It suggests that the results using ≥80% filter in this report would successfully represent the abundance trends in Indian Ocean in the period analyzed and the effects of the annual and/or regional reporting level difference could be adjusted through the standardizing process. Consequently, the results in this report indicate that the stock status of blue sharks has not changed remarkably over the past four decades in the Indian Ocean. The gradual decreasing trends is observed in the estimated abundance index and thus, the stock assessment of Indian blue shark stock should be conducted as soon as possible to attain sustainable management of this stock.

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Table 1. Annual, standardized CPUEs and 95% confidence.

1971-1993				1994-2010			
Year	CPUE	Lower	Upper	Year	CPUE	Lower	Upper
1971	1.53554	1.4225	1.65644	1994	1.70933	1.60397	1.82085
1972	2.00031	1.85158	2.15982	1995	1.6934	1.59162	1.80097
1973	1.45894	1.34551	1.5807	1996	1.7037	1.58027	1.8357
1974	1.61945	1.50097	1.74618	1997	1.42874	1.34648	1.51538
1975	1.70771	1.58102	1.84342	1998	1.70773	1.59808	1.82406
1976	1.47368	1.3565	1.59968	1999	2.16384	2.00083	2.33892
1977	1.62483	1.48927	1.77126	2000	1.59368	1.47549	1.7202
1978	1.85586	1.71409	2.00813	2001	1.85356	1.73115	1.98372
1979	1.91597	1.76959	2.07324	2002	1.68967	1.57865	1.80763
1980	2.08023	1.93003	2.24103	2003	2.2649	2.08995	2.45321
1981	1.61775	1.49797	1.74596	2004	1.51191	1.40131	1.63014
1982	1.63489	1.51161	1.76705	2005	1.35534	1.26603	1.45009
1983	1.95785	1.81329	2.1128	2006	1.09679	1.02185	1.17632
1984	1.68704	1.56202	1.82094	2007	1.50923	1.40423	1.6211
1985	1.65009	1.53132	1.77701	2008	1.49465	1.43282	1.55881
1986	1.54276	1.43035	1.66292	2009	1.40105	1.34395	1.46025
1987	1.85208	1.71654	1.9972	2010	1.10629	1.0562	1.15838
1988	1.81489	1.68099	1.95832				
1989	1.58049	1.45953	1.71027				
1990	1.51941	1.39991	1.64784				
1991	1.63745	1.50669	1.77823				
1992	1.39976	1.28837	1.51948				
1993	1.99523	1.83856	2.16395				

Table 2. Output of Type III analysis.

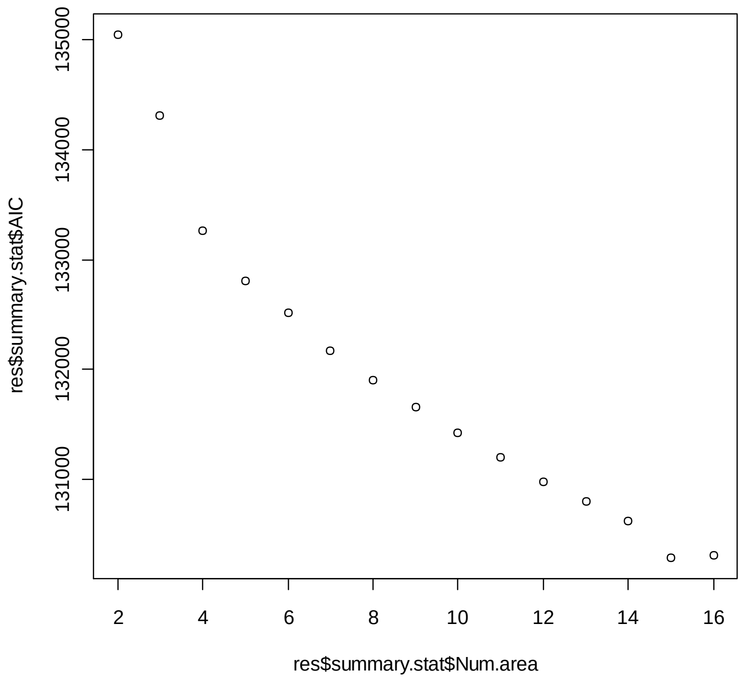
1971-1993

Effect	DF	Type III SS	Mean square	F Value	Pr>F
year	22	464.606	21.118	31.95	<.0001
se	3	9.163	3.054	4.62	0.0031
area	9	2357.454	261.939	396.32	<.0001
br	2	166.747	83.374	126.15	<.0001
se*area	27	746.184	27.636	41.82	<.0001
se*br	6	39.578	6.596	9.98	<.0001

1994-2010

Effect	DF	Type III SS	Mean square	F Value	Pr>F
year	16	470.343	29.3964	48.77	<.0001
se	3	103.869	34.6231	57.44	<.0001
area	7	826.997	118.1424	196.02	<.0001
br	2	8.680	4.3402	7.2	0.0007
se*area	21	352.061	16.7648	27.82	<.0001
se*br	6	99.996	16.6661	27.65	<.0001

(a) 1971-1993



(b) 1994-2010

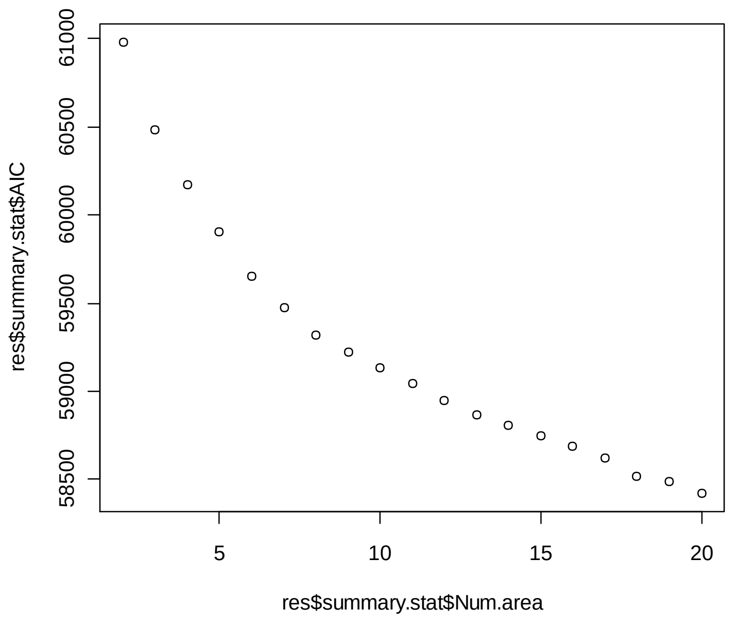


Figure 1. AIC values of the GLM models adapted by the data categorized as "sharks" between 1971 and 1993 ((a) upper) and the data of "blue shark" between 1994 and 2010 ((b) lower) according to the number of the area stratification by the GLM-tree.

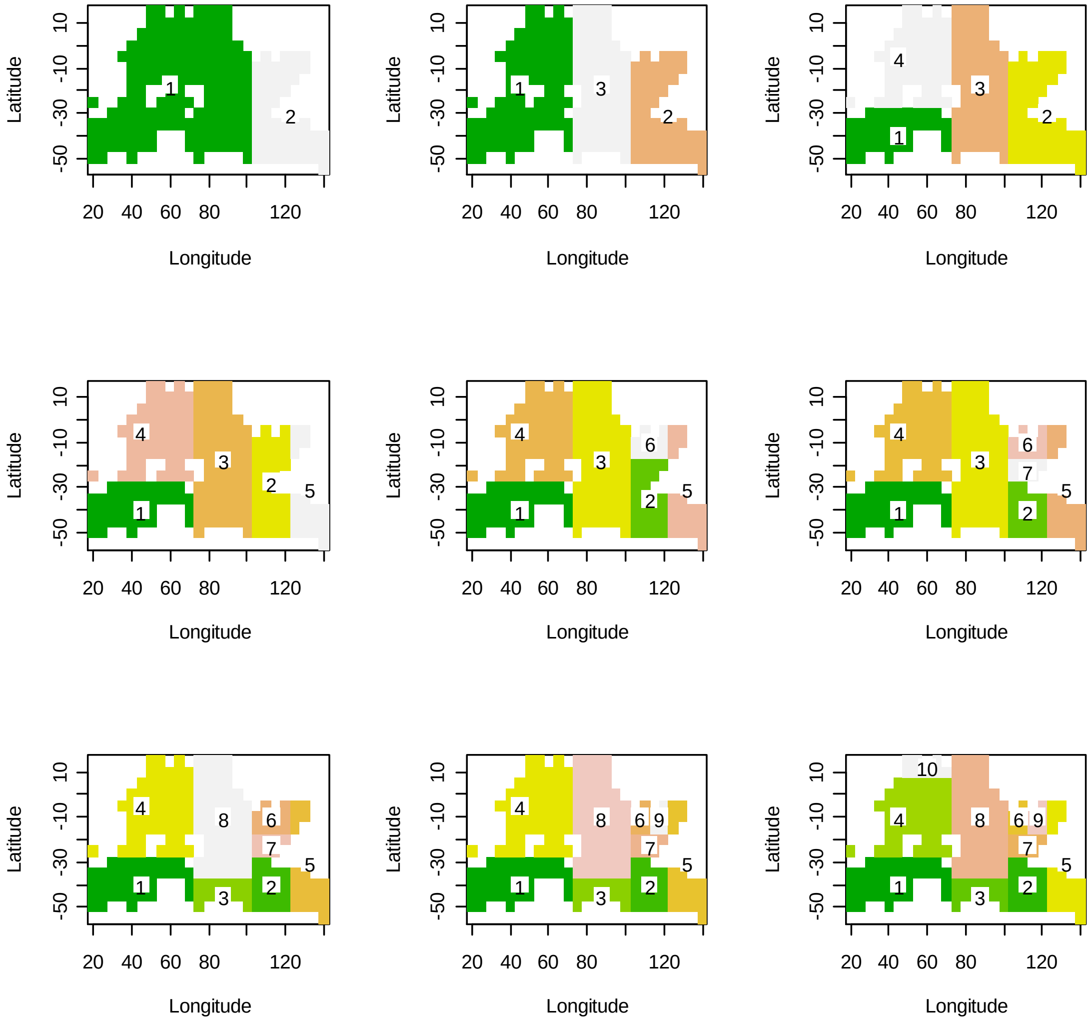


Figure 2. The steps of area stratification limited up to 10 areas by the GLM-tree using the same data as Figure 1 ((a) upper). Stratification with the 10 areas was used in the CPUE analysis during 1971-1993 .

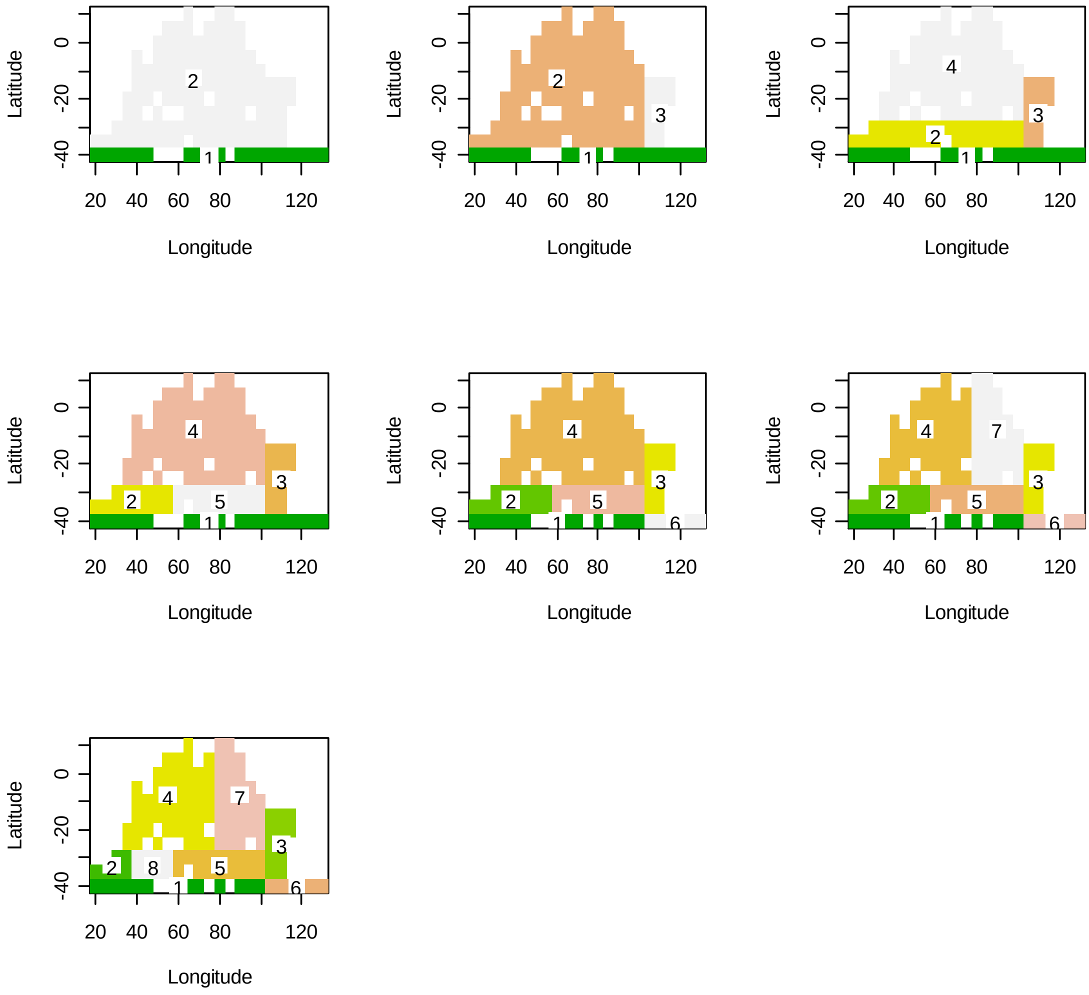


Figure 3. The steps of area stratification limited up to 8 areas by the GLM-tree using the same data as Figure 1 ((b) lower). Stratification with the 8 areas was used in the CPUE analysis during 1994-2010 .

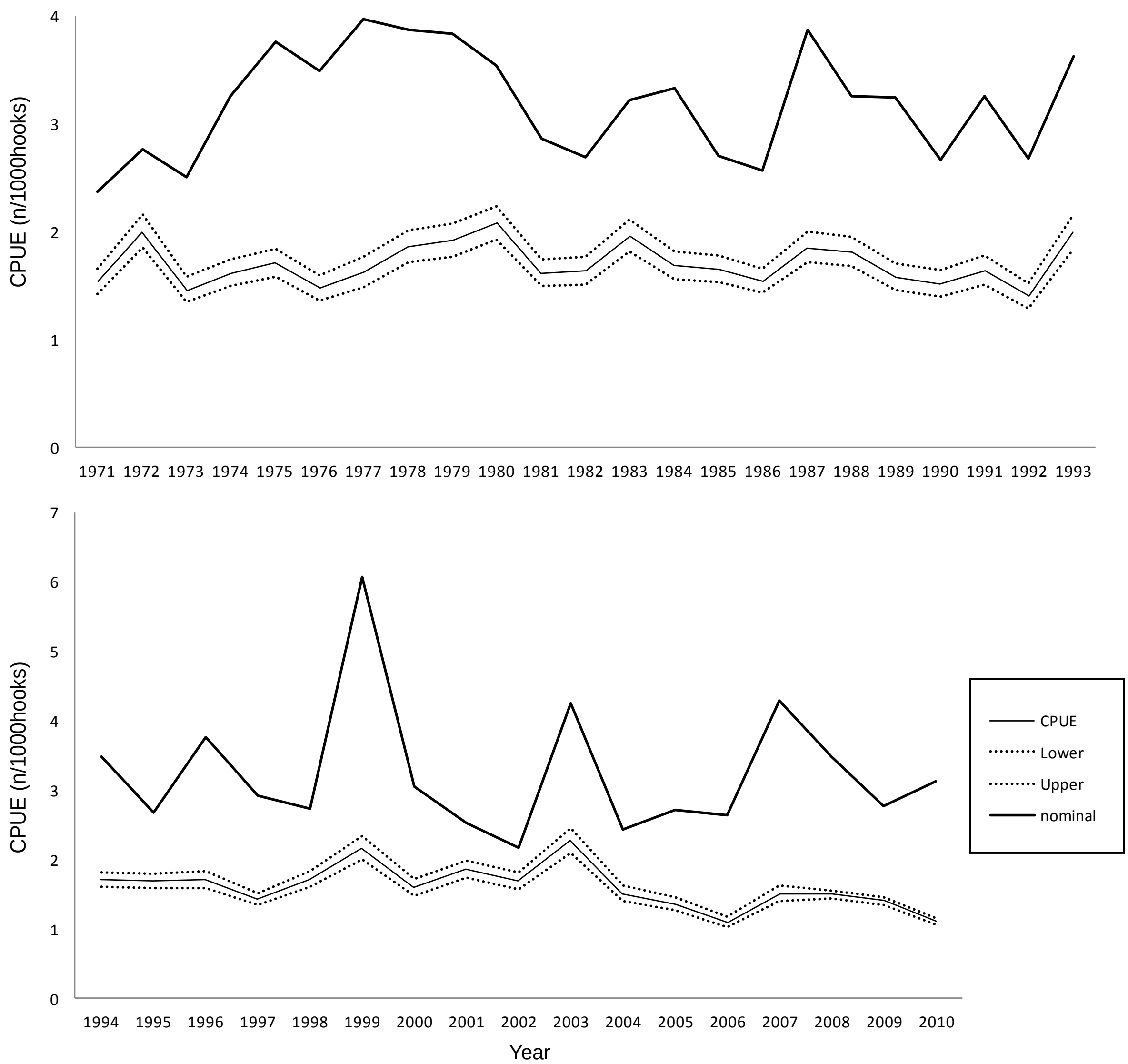


Figure 4. Standardized CPUE, 95% confidence intervals and nominal CPUE for blue shark in Indian Ocean (upper: 1971-1993, lower: 1994-2010).

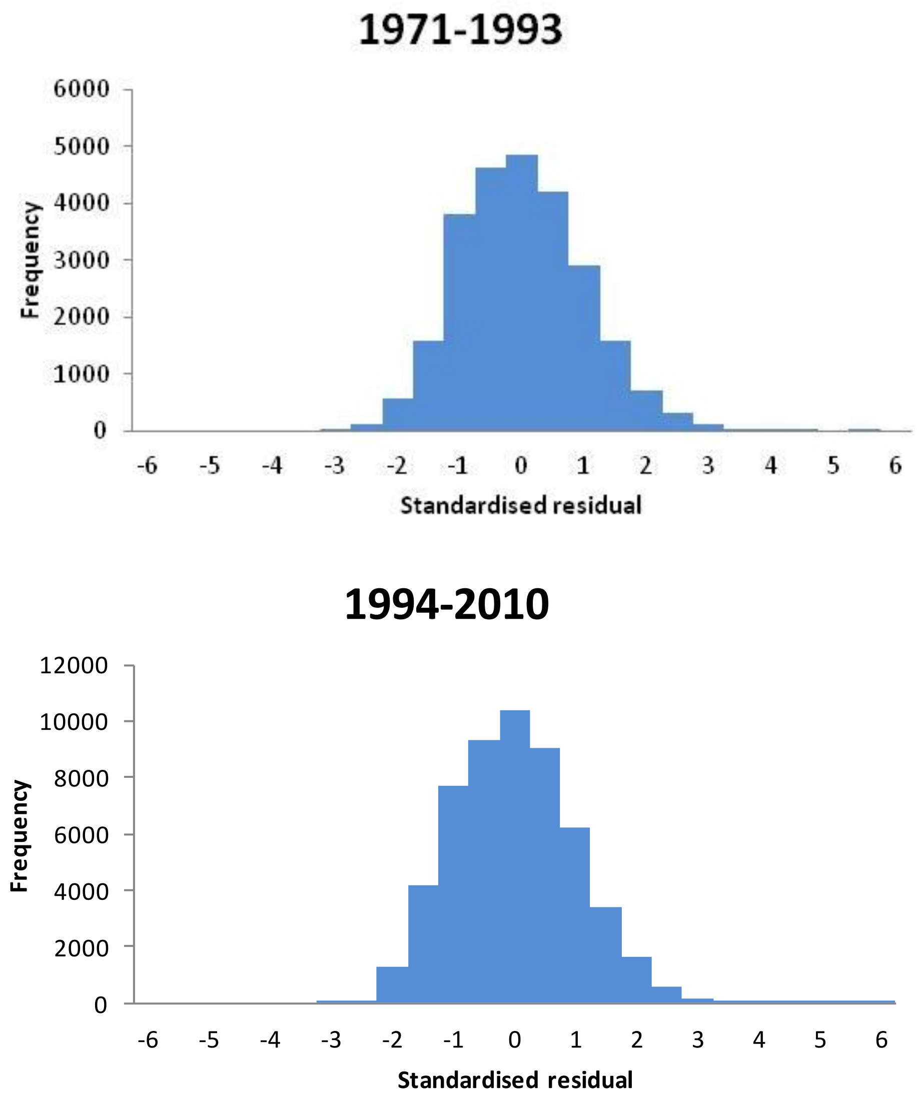
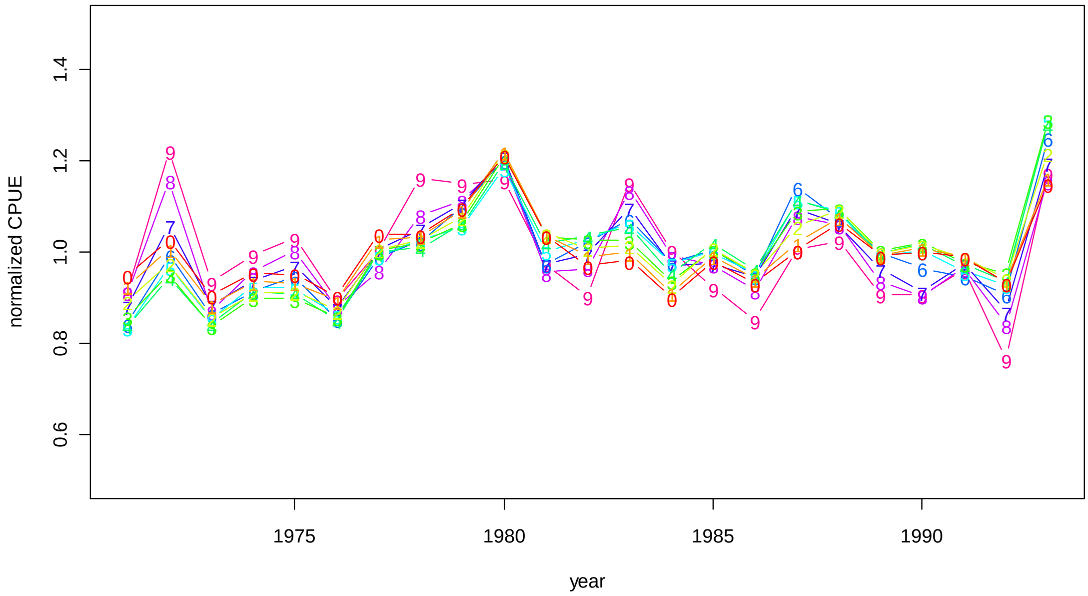


Figure 5. Standardized residuals for CPUE analysis of blue shark (upper: 1971-1993, lower: 1994-2010).



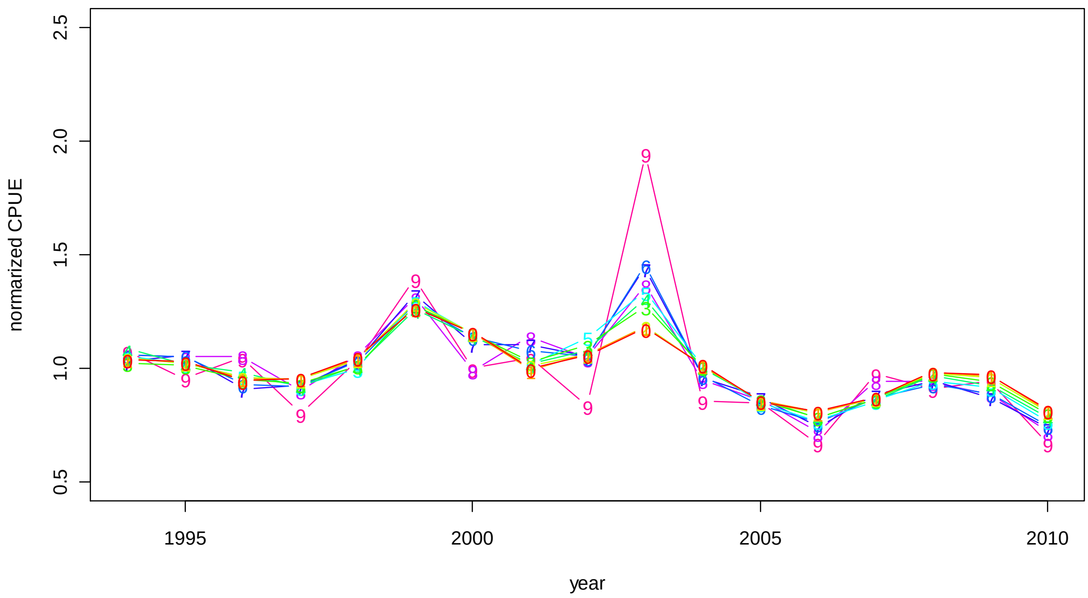


Figure 6. Normalized CPUEs of every 10% reporting rate (upper: 1971-1993, lower: 1994-2010). Figures show the reporting categories (9: ≥90%, 8: ≥80%, 7: ≥70%, 6: ≥60%, 5: ≥50%, 4: ≥40%, 3: ≥30%, 2: ≥20%, 1: ≥10%, 0: no filtering).