

## STANDARDIZED CPUE FOR SHARKS AND BLUE SHARKS CAUGHT BY THE CHINESE TAIPEI LONGLINE FISHERY IN THE SOUTH ATLANTIC OCEAN

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### SUMMARY

*The shark catch data reported by observers in the period 2002-2003 were used to adjust the historical shark catch in Task I and to estimate blue shark catch for Taiwanese longline fishery in the South Atlantic Ocean. The standardized CPUE for sharks and blue shark caught by Taiwanese longline fishery in the South Atlantic Ocean was estimated based on adjusted logbook data. Standardized CPUE and relative CPUE series of all sharks combined caught by Taiwanese longline fishery showed a stable trend although slightly high values were found in 1995 and 1996. Similar trend was also found for the blue shark. The stable trend suggested that the blue shark stock in the South Atlantic Ocean seems at the level of optimum utilization.*

### RÉSUMÉ

*Les données de capture des requins déclarées par les observateurs au cours de la période 2002-2003 ont été utilisées pour ajuster les prises historiques des requins dans la Tâche I et estimer les prises de requins peaux bleues de la pêcherie palangrière du Taïpei chinois opérant dans l'Atlantique Sud. La CPUE standardisée pour les requins et les requins peaux bleues capturés par la pêcherie palangrière du Taïpei chinois dans l'Atlantique Sud a été estimée d'après les données ajustées des carnets de pêche. Les séries de la CPUE standardisée et de la CPUE relative de tous les requins combinés capturés par la pêcherie palangrière du Taïpei chinois ont dégagé une tendance stable, bien que des valeurs légèrement élevées soient apparues en 1995 et 1996. Une tendance similaire s'est également dégagée pour le requin peau bleue. La stabilité de la tendance laisse à penser que le stock de requin peau bleue dans l'Atlantique Sud semble être au niveau d'utilisation optimale.*

### RESUMEN

*Se utilizaron los datos de captura de tiburones comunicados por los observadores durante el periodo 2002-2003 para ajustar la captura histórica de tiburones en la Tarea I y para estimar la captura de tintorera de la pesquería de palangre de Taipei Chino en el océano Atlántico meridional. Se estimó la CPUE estandarizada para los tiburones y tintoreras capturados por la pesquería de palangre de Taipei Chino en el océano Atlántico meridional partiendo de los datos de los cuadernos de pesca ajustados. Las series de CPUE estandarizada y de CPUE relativa de todos los tiburones combinados capturados por la pesquería de palangre de Taipei Chino exhibían una tendencia estable aunque con niveles ligeramente elevados en 1995 y 1996. También se observó una tendencia similar para la tintorera. La tendencia estable sugiere que el stock de tintorera del océano Atlántico meridional parece hallarse en un nivel de utilización óptima.*

### KEYWORDS

*By-catch, Catch composition, Length-weight relationships, Size distribution, Prionace glauca*

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## 1. Introduction

Taiwanese longline fishery has operated in the Atlantic Ocean since late 1960s. However, the shark by-catch of Taiwanese tuna longline vessels has never been reported until 1981 because of its low value compared with tunas. According to the Task I data, shark by-catch of Taiwanese tuna longline fishery in the Atlantic Ocean fluctuated from 538 tons in 1992 to 2,244 tons in 1999 (**Table 1**). Unfortunately, no species-specific data were available until 2003 because shark catch was recorded as “sharks” before then. The category “sharks” on the logbook has been separated into four species namely blue shark, mako shark, silky shark, and others since 2003. As Taiwanese longline fishery has widely covered the Atlantic Ocean especially the South Atlantic, our fishery statistics must be one of the most valuable resources, which describe stock status of pelagic shark. Since FAO and international environmental groups paid much attention to the conservation of elasmobranchs in recent years, it is useful to examine recent trend of sharks and blue shark stocks by logbook of tuna fisheries. However, standardization on Taiwanese catch rate on sharks is not straightforward because the data has confounded with many factors, such as under-reporting and target-shifting effects. Thus, the first step in this study is to adjust the catch data of sharks in Task I and estimate the catch of blue shark based on observers’ records. Then the CPUEs of sharks and blue shark in the South Atlantic Ocean are standardized using the adjusted logbook data of Taiwanese longline fishery from 1991-2002.

## 2. Materials and methods

The logbook data of Taiwanese longline fishery from 1991 to 2002 provided by the Overseas Fisheries Development Council of the Republic of China was used in this study. These logbook data contain basic information on fishing time, area, hooks and catches of 14 species including major tunas, billfishes and sharks. Species-specific catch data including tunas, billfishes, and sharks from observers’ records in 2001-2003 were used to estimate the catch ratio of sharks to tunas and the proportion of blue shark in sharks catch for Taiwanese longline fishery in the South Atlantic Ocean.

The South Atlantic Ocean (south of 5°N) was stratified as 3 areas namely A (5°N-15°S), B(15°S-50°S, west to 20°W), C(15°S-50°S, 20°W-20°E) based on the distribution of shark CPUE recorded by observers during the period of 2002-2003 (**Figure 1**). Because area A is the tropical waters, bigeye tuna (BYT) and yellow fin tuna (YFT) are the major target species and swordfish (SWO) is the major bycatch species. The ratio of shark catch (both in number and weight) to the total catch of BYT, YFT, and SWO was used to adjust the historical shark catch data on set basis. For each set, the shark catch was not adjusted if no bigeye tuna was recorded. In area B and C, the ratio between sharks and albacore was used to adjust historical shark catch data on set basis. For each set, the shark catch was not adjusted if no albacore was recorded. The proportion of blue shark in sharks catch was estimated for each area.

The GLM including main effects of year (Y), quarter (Q), area (A) and interactions under the assumption of lognormal error structure was used for standardization of nominal CPUE:

$$\ln(\text{CPUE}_{ijk} + \text{const}) = \mu + Y_i + Q_j + A_k + (\text{interactions}) + \varepsilon_{ijk}$$

where CPUE is nominal cpue (catch in number per 1000 hooks, in year i, quarter j, area k), const is 0.05,  $\mu$  is overall mean,  $Y_i$  is effect of year i,  $Q_j$  is effect of quarter j,  $A_k$  is effect of area k, interactions are any combination of two way interaction, and  $\varepsilon_{ijk}$  is the error term.

## 3. Results and discussion

According to the observers’ records, the ratios of sharks to the total catch of BYT, YFT, and SWO in area A are 20.3% and 19.6% in number and weight, respectively. Blue shark occupied 55.7% and 89.1% of sharks catch in number and weight, respectively. In area B, the ratios of sharks to the total catch of ALB in area B are 3.4% and 9.5% in number and weight, respectively. Blue shark occupied 96.4% and 96.3% of sharks catch in number and weight, respectively. While in area C, sharks are only 0.7% and 2.5% of ALB catch in number and weight. And, blue shark owned 82.4% and 75.8% of sharks catch in number and weight, respectively.

Nominal CPUE series of sharks increased from 1993, peaked in 1996 and decreased thereafter. Standardized CPUE and relative CPUE series of all sharks combined caught by Taiwanese longline fishery showed a stable trend although slightly high values were found in 1995 and 1996 (**Tables 2,3; Figures 2,3**). Similar trend was also found for blue shark (**Tables 4,5; Figures 4,5**). The stable trend suggested that the blue shark stock in the

South Atlantic Ocean seems at the level of optimum utilization. Nakano (2001) documented that the blue shark in the South Atlantic Ocean has an increasing trend in the period of 1993-2000. He standardized the blue shark CPUE based on three reporting levels and no significant difference was found among levels (Nakano 2001). According to Nakano's (2001) report, although no comparison on standardized CPUE between different reporting levels was made in this study, we believe the results obtained in this study can represent the stock status of blue shark in the South Atlantic Ocean.

Target-shifting is one of the factors that may affect the standardization of CPUE trend. Taiwanese longline fishery in the Atlantic Ocean mainly targeted on albacore in the 1970's and 1980's and shifted to bigeye tuna since 1990's. In this study, the CPUE series before 1991 is not used, and the model for standardization has taken into account the effect of target species as mentioned in Materials and Methods section. Therefore the target-shifting effect is negligible if exists.

In addition to the temporal and spatial effects, environmental factors are important which may affect the representation of standardized CPUE of pelagic fish i.e., swordfish and blue shark in North Pacific (Bigelow et al. 1999), and bigeye tuna in Indian Ocean (Okamoto et al. 2001). In this study, environmental effects were not included in the model for standardization. It will be preferable to develop a model incorporated with environmental effects in the future.

## References

- BIGELOW, K.A., C. H. Boggs, and X. He. 1999. Environmental effects on swordfish and blue shark catch rates in the US North Pacific longline fishery. *Fish. Oceanogr.*, 8(3): 178-198.
- MATSUSHITA, Y. and H. Matsunaga. 2001. Species composition and CPUE of pelagic sharks observed by Japanese observer for tuna longline fisheries in the Atlantic Ocean. ICCAT Shark data preparation meeting, Halifax, Canada.
- NAKANO, H. 2001. Standardized CPUE for the blue sharks caught by Japanese longline fishery in the Atlantic Ocean. ICCAT Shark data preparation meeting, Halifax, Canada.
- OKAMOTO, H., N. Miyabe, and T. Matsumoto. 2001. GLM analyses for standardization of Japanese longline CPUE for bigeye tuna in the Indian Ocean applying environmental factors. *IOTC Proceedings 4*: 491-522.
- SHIODE, D. and H. Nakano. 2001. Verification of shark catch data of the logbook records in Japanese longline fishery in comparison with the observer reports. ICCAT Shark data preparation meeting, Halifax, Canada.

**Table 1.** Annual shark catch (t) for the Taiwanese tuna longline fishery in the Atlantic Ocean (1991-2002).

<i>Year</i>	<i>1991</i>	<i>1992</i>	<i>1993</i>	<i>1994</i>	<i>1995</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>
Catch	654	538	1,011	1,896	2,121	2,283	2,228	2,056	2,244	1,809	1,047*	826*

**Table 2.** Standardized CPUE of sharks caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).

<i>Year</i>	<i>ucpue</i>	<i>acpue</i>	<i>lcpue</i>	<i>nominal</i>
1991	1.1814234	1.1715527	1.1622293	0.73685
1992	1.1772839	1.1649987	1.1535798	0.95261
1993	1.2898166	1.2749921	1.2609936	0.52272
1994	1.3900504	1.3764394	1.3633569	0.79616
1995	1.6792546	1.6555115	1.6327244	1.19246
1996	1.5737165	1.5586031	1.5439592	1.41654
1997	1.306367	1.2992537	1.2923212	1.12338
1998	1.192605	1.1880698	1.1836584	1.14213
1999	1.3291372	1.3224949	1.3160042	0.71928
2000	1.3071511	1.3003455	1.2937177	0.71417
2001	1.2777107	1.2706391	1.2637582	0.54704
2002	1.293265	1.2830884	1.2732975	0.67882

**Table 3.** Standardized relative CPUE of sharks caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).

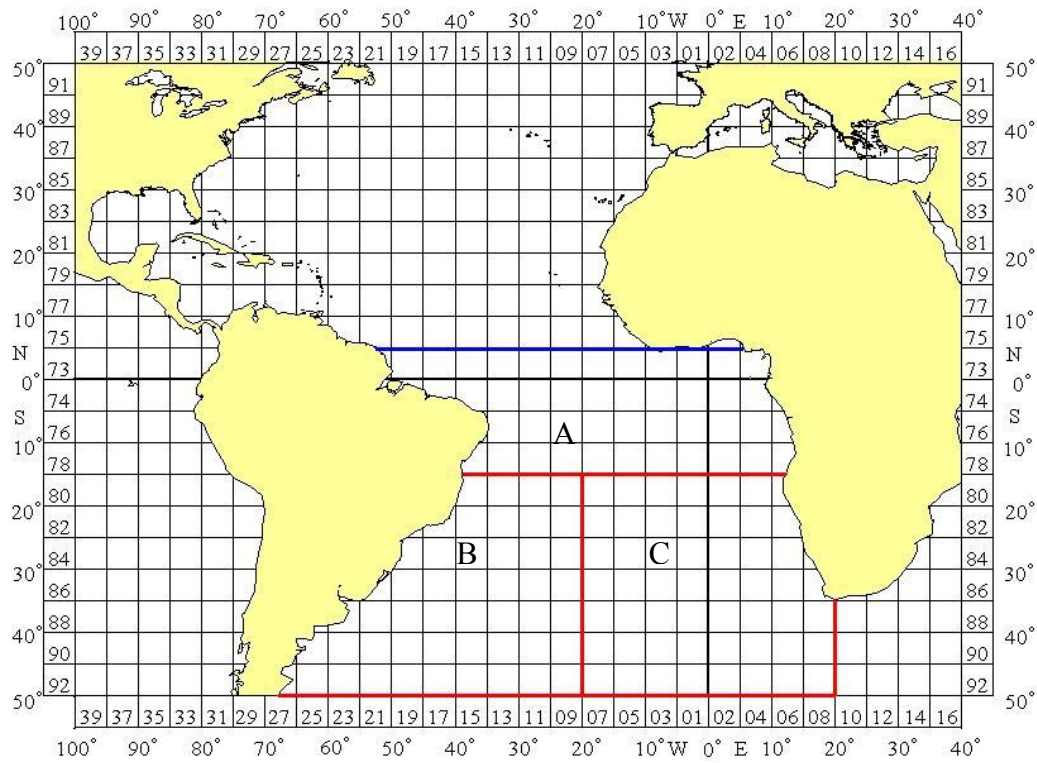
<i>Year</i>	<i>ucpue</i>	<i>acpue</i>	<i>lcpue</i>	<i>nominal</i>
1991	1	1	1	1
1992	0.9964962	0.9944057	0.9925578	1.292814
1993	1.0917479	1.0882925	1.0849783	0.7093981
1994	1.1765895	1.1748847	1.1730533	1.0804913
1995	1.4213825	1.4130917	1.4048212	1.6183212
1996	1.3320512	1.3303739	1.3284462	1.9224265
1997	1.1057568	1.1090014	1.1119331	1.5245708
1998	1.0094645	1.0140985	1.0184379	1.550017
1999	1.1250303	1.1288394	1.1323102	0.9761553
2000	1.1064205	1.1099334	1.1131346	0.9692203
2001	1.0815011	1.0845769	1.087357	0.7424035
2002	1.0946668	1.0952033	1.0955648	0.9212458

**Table 4.** Standardized CPUE of the blue shark caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).

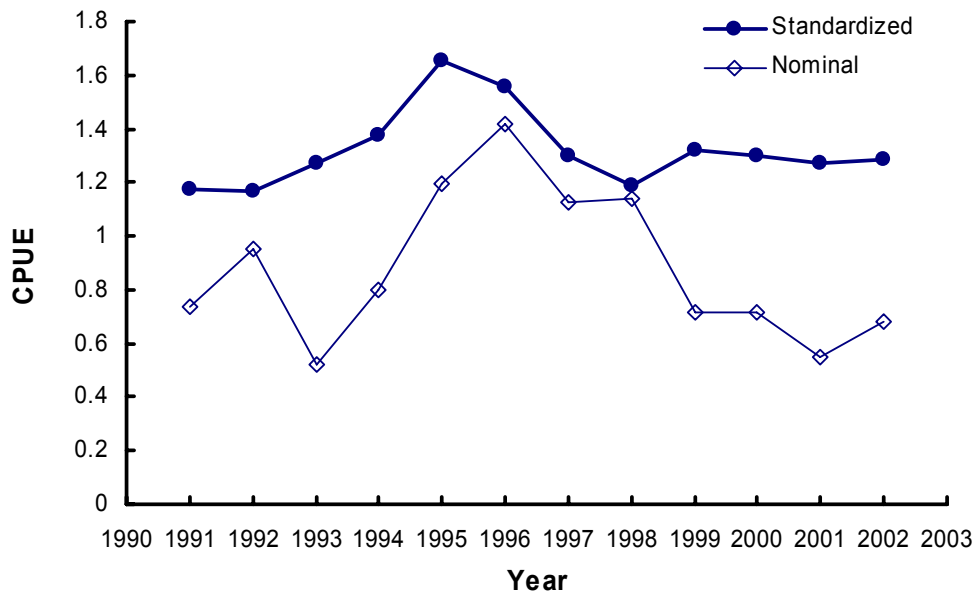
<i>Year</i>	<i>ucpue</i>	<i>acpue</i>	<i>lcpue</i>	<i>nominal</i>
1991	1.1424785	1.1349629	1.1278464	0.48254
1992	1.1372579	1.1280382	1.1194192	0.66309
1993	1.2012828	1.1914845	1.182168	0.3318
1994	1.2968652	1.2870593	1.2775958	0.5365
1995	1.4778672	1.4624747	1.4476333	0.6857
1996	1.3990872	1.3893555	1.3798848	0.85209
1997	1.2393661	1.2340729	1.2288884	0.65977
1998	1.1638343	1.160116	1.1564789	0.68363
1999	1.2070266	1.2030861	1.1992304	0.39398
2000	1.2047595	1.2004662	1.19626	0.40573
2001	1.1900794	1.1854708	1.1809628	0.29313
2002	1.2042296	1.1974808	1.1909723	0.39081

**Table 5.** Standardized relative CPUE of the blue shark caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).

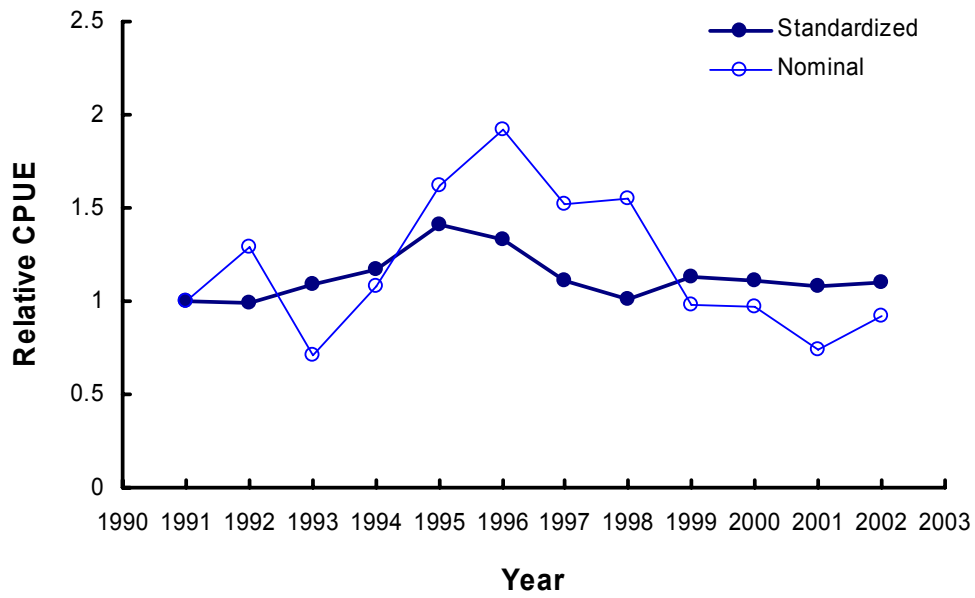
<i>Year</i>	<i>ucpue</i>	<i>acpue</i>	<i>lcpue</i>	<i>nominal</i>
1991	1	1	1	1
1992	0.9954305	0.9938987	0.9925281	1.3741659
1993	1.0514709	1.0498003	1.0481639	0.6876114
1994	1.1351332	1.13401	1.1327746	1.1118249
1995	1.2935624	1.288566	1.2835376	1.4210221
1996	1.224607	1.2241418	1.2234687	1.7658432
1997	1.0848047	1.0873244	1.0895884	1.3672856
1998	1.0186926	1.022162	1.0253869	1.4167323
1999	1.0564984	1.0600224	1.0632923	0.8164712
2000	1.054514	1.057714	1.0606586	0.8408215
2001	1.0416646	1.0445018	1.0470954	0.607473
2002	1.0540501	1.0550836	1.0559702	0.8099018



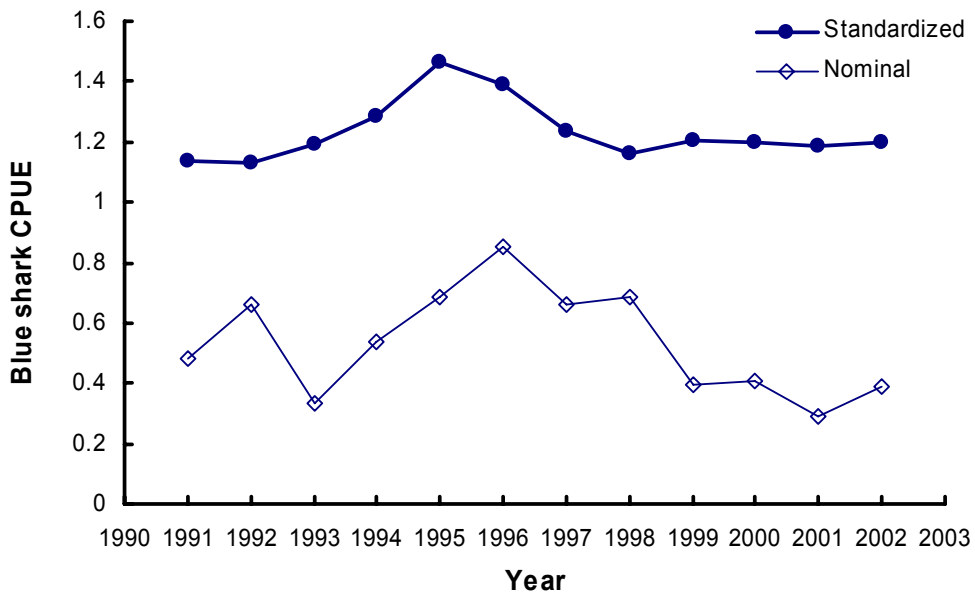
**Figure 1.** Area stratification used for the analysis of South Atlantic sharks.



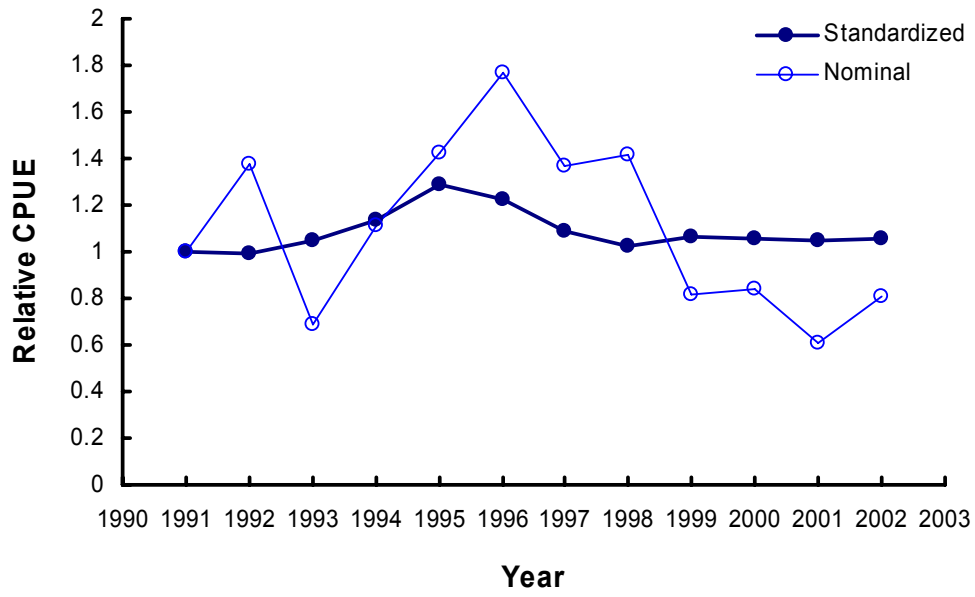
**Figure 2.** Standardized CPUE of sharks caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).



**Figure 3.** Standardized relative CPUE of sharks caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).



**Figure 4.** Standardized CPUE of the blue shark caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).



**Figure 5.** Standardized relative CPUE of the blue shark caught by the Taiwanese longline fishery in the South Atlantic Ocean (1991-2002).