STANDARDIZATION OF CPUE OF SWORDFISH CAUGHT BY JAPANESE LONGLINERS IN THE NORTH ATLANTIC

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SUMMARY

This short document describes the results of update of CPUE standardization of swordfish caught by Japanese longliners in the north Atlantic. Most of the data and methods used in this study are followed by previous documents about Japanese swordfish catches. The general trend of standardized CPUEs (catch in number/ 1000 hooks) of ages 2-5+ were similar to each other. The flat trends obtained in the period between 1975 and 1991. After that, it decreased to almost zero in 2001 when Japanese longliners started to discard/release their swordfish catch. The CPUEs show rapid recovery trends in 2005-2012.

RÉSUMÉ

Ce bref document décrit les résultats de l'actualisation de la standardisation de la CPUE de l'espadon capturé par les palangriers japonais dans l'Atlantique Nord. La plupart des données et des méthodes utilisées dans cette étude s'appuient sur des documents antérieurs relatifs aux prises d'espadon japonaises. Les tendances générales des CPUE standardisées (prise en nombre/1.000 hameçons) des âges 2-5+ étaient similaires entre elles. Une tendance plane a été obtenue pendant la période courant de 1975 à 1991. Après cette période, celle-ci a été ramenée à presque zéro en 2001 lorsque les palangriers japonais ont commencé à rejeter/remettre à l'eau leur prise d'espadon. Les CPUE font apparaître des tendances de rétablissement rapide en 2005-2012.

RESUMEN

Este breve documento describe los resultados de la actualización de la estandarizacón de la CPUE del pez espada capturado por lo palangreros japoneses en el Atlántico norte. La mayoría de los datos y los métodos usados en este estudio se basan en documentos previos acerca de las capturas japonesas de pez espada. Las tendencias generales de las CPUE estandarizadas (captura en número/1000 anzuelos) de las edades 2-5+ eran similares entre sí. En el periodo entre 1975 y 1991 se obtuvieron tendencias planas. Después de eso, descendieron casi hasta cero en 2001, cuando los palangreros japoneses empezaron a descartar/liberar sus capturas de pez espada. Las CPUE presentan tendencias rápidas de recuperación en 2005-2012.

KEYWORDS

North Atlantic swordfish, Xiphias gladius, *Longline, CPUE*

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1. Introduction

Japanese longliners had started to discard and release all their swordfish catch in February 2001. Though the Japanese government requested all Japanese longliners to submit their dead discarded and live released swordfish in the same format as the log-book, availability of these data is quite low (Yokawa 2007a), data from the radio reporting system, which report the number of discarded and released swordfish every 10 days, was used in the estimation. Because the Japanese government requested Japanese longliners to continue releasing their live swordfish catch since the beginning of 2004, the data from the radio reporting system was also used for the estimation of the number and weight of these released swordfish. This request, however, had ceased in 2005, many vessels continued the live release until 2006 or 2007 as voluntary bases. In 2008, all Japanese longliners completely stopped this live release, but unfortunately, limited live release information is available in 2006 and 2007.

2. Materials and Methods

Most of the data and methods used in this study are followed by previous documents about Japanese swordfish catches (Yokawa 2000a, 2000b, and 2000c, Uosaki *et al.* 2003, Yokawa and Fukuda, 2004 and 2005, Yokawa *et al.* 2003, Yokawa 2007b).

The method to estimate the number and weight of dead discarded and live released swordfish in 2001-2005 was followed by the one in Yokawa and Fukuda (2004 and 2005). Age specific standardized CPUE of swordfish in the north Atlantic was estimated in the way as Yokawa (2000), Yokawa *et al.* (2003) and Yokawa (2007a). Because the number of swordfish reported by the radio reporting system was rather small in 2005 comparing to the previous years, in the strata which no swordfish catches were reported in 2005 and the logbook reported reasonably higher number of swordfish dead catch, catch numbers reported by the log-book were assumed to be the total catch in these strata with no live release. Because data by the radio reporting system were not available since 2006, only live release information in the log-book was used.

The set by set data of Japanese longliners were aggregated by year, vessel code, ten days of a month, hooks per basket and by subarea to estimate catch at size by sex using the sex ratio key estimated by Oritiz *et al.* (2000). For the conversion of catch at size to catch at age, the sex combined growth curve estimated by Arocha *et al.* (2003) was used. The same subarea stratification used by Oritiz *et al.* (2000) for the estimation of the sex ratio key is used in this analysis (**Figure 1**). For the CPUE analysis, these subareas were gathered into 5 areas as follows;

area 1; subareas 1, 2, 3
area 2; subareas 4, 5, 6
area 3; subareas 7,8,17,93
area 4; subareas 9, 10
area 5; subareas 91, 92

The data in the area 4 was not used in the CPUE analysis due to the rather small area size. In many years, no operation of Japanese longliners conducted in area 4. The data in the area 1 was also omitted from the CPUE analysis. The area 1 is one of the main fishing grounds of the Atlantic bluefin tuna for Japanese longliners, but the number of operations in this area decreased largely and the operational pattern also changed largely in recent years due to the introduction of new TAC regulation system to the eastern stock of the Atlantic bluefin tuna (Kimoto *et al.* 2012 and Kimoto 2012).

Because the allocation of the Atlantic bluefin tuna to Japanese longliners became quite limited in the recent years, majority of operations concentrated into the center of fishing ground and high season for bluefin tuna fishery where the catch rate of swordfish was rather low in general. Such change of operational pattern in the area 1 in recent years should give unexpected influences on the catch rate of swordfish and development of quite complicated model should be necessary to standardize these influences. Thus it was judged to be premature to use the data in the area 1 for the estimation of abundance/biomass indices of the north Atlantic swordfish.

The number of hooks between float was used in the CPUE analysis as the proxy of target species. Standardization of CPUE of swordfish in the south Atlantic was estimated in the same way as one in Uosaki et al. (2003). Sets with number of hooks between floats with 3 and 4 were excluded from the analysis, as these operations almost disappeared in the end of the 1990s. Sets with number of hooks between floats being 5 to 30 were divided into two operational pattern; number of hooks between float = 5-11 were normal setting (gear type 2), number of hooks between float = 12-30 were deep setting (gear type 3). The standardization of CPUE was conducted using the GLM method and the following model;

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

where ln: natural logarithm, $CPUE_{ijkl:}$ nominal CPUE (catch in number per 10km of net, in year *i*, quarter *j*, area *k*, and gear configuration *l*), const: 1/20 of overall mean, μ: overall mean, YR*i*: effect of year *i*, QT_j: effect of quarter j, AR_k: effect of area *k*, GE_l: effect of mesh size category, INTER: interaction terms between YR*AR and AR*QT, and ε: normal error term. Analysis was conducted using the GLM procedure available in the SAS statistical computer software (Ver. 9.2). The area specific standardized CPUEs were weighted by the approximate size of the area to combine into the abundance index. For the estimation of biomass index, the same method described above was used.

3. Results and Discussions

The amount of effort (number of hooks) of Japanese longliners in the north Atlantic shows decreasing trend from 1994 to 2011 when it was stabilized up to 2012 (**Figure 2**, top panel). The unloaded catch number of swordfish reported by log-books also decreased in 1994-2001. During the period between 2001 and 2005, it was stayed in the low level, and this was due to the discards/release of swordfish by Japanese longliners. In 2006, it increased suddenly and stabilized up to 2012. The annual trends of the nominal CPUEs by number and by weight were almost same in 1994 -2012, and they were similar to the one of catch number (**Figure 2**, bottom panel).

The general trend of standardized CPUEs (catch in number/ 1000 hooks) of ages 2-5+ were similar to each other. The flat trends obtained in the period between 1975 and 1991 (**Figure 3**). After that, it decreased to almost zero in 2001 when Japanese longliners started to discard/release their swordfish catch. The CPUEs show rapid recovery trends in 2005-2012. The recent recovery trend was more obvious for the older ages, particularly the one of age 5+ in area 5 (**Figure 4**). This is supposed to be the fact that the swordfish catch by Japanese longliners occupied by older sized fishes. The level of CPUE of age 5+ is about 5 times higher than those of ages 3 and 4. The levels of CPUE of age 1 is about 10 times lower than that of age 5+. The CPUEs of age 1 does not show clear recovery trends in recent years (**Figure 3**), and this is supposed to be the following facts; 1) catch of age 1 is rather minor among swordfish catch by Japanese longliners, 2) operations with larger number of hooks between floats were introduced in recent years (number of hooks between floats is larger than 20), and the catchability of small swordfish of such "super deep sets" would be lower.

The estimated biomass index also shows similar trend as the abundance indices of older ages (**Figure 5**). The level of CPUE in most recent years is roughly same with the ones during the 1970s and the 1980s. Apparent recovery trend of CPUE was observed in area 5 in recent years (**Figure 6**). The inclusion of data in the area 1 produced slightly higher level of CPUEs in the early period (1975-1985) and slightly lower level in most recent years (**Figure 7**). The standardized CPUE in the area 1 shows largely upward trend in the earlier period and continuously downward trend in most recent years. The level of CPUE in the area 1 in most recent years is more than 10 times lower than those in the other areas, and almost close to zero. These things should indicate the fact that the model of CPUE standardization used in this study could not adequately adjust the effect of unique operational pattern of Japanese longliners targeting the Atlantic bluefin tuna in this area.

The sudden drops of CPUEs were observed in the period between 2000 and 2006 for all areas and age classes. Because this period corresponds to the period that Japanese longliners discards/release their catch of swordfish in the north Atlantic area. The information about discards and release were collected from variety of sources to include them in the CPUE analysis, but still unrealistic low levels of CPUEs were obtained. This should indicate the fact that the discards/release information used in this analysis is not sufficient for the estimation of abundance/biomass indices. The biomass indices estimated with/without data in the period between 2000 and 2006 showed almost identical trends.

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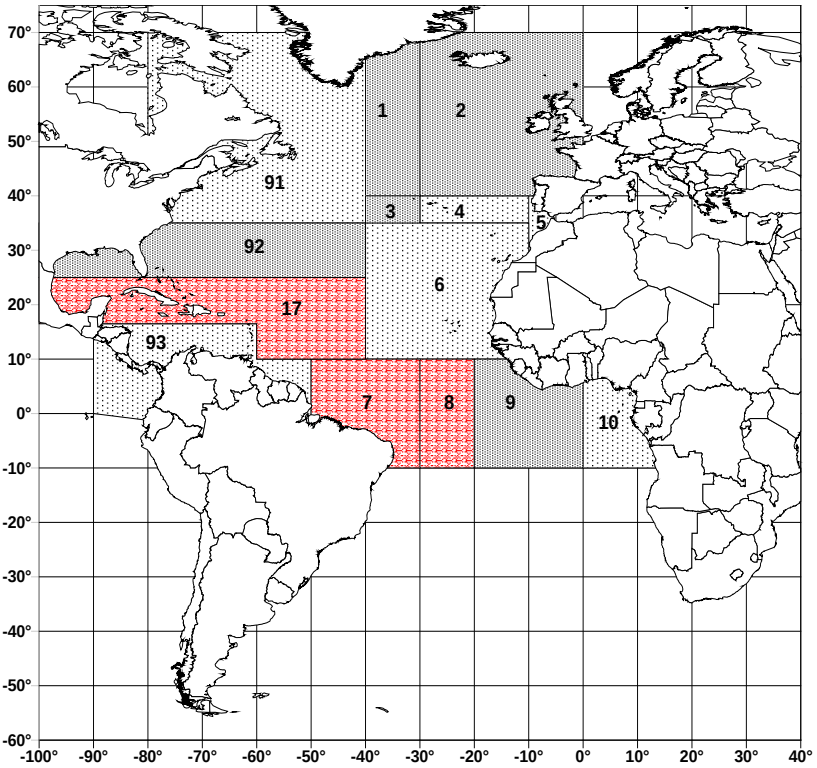


Figure 1. The area stratification used in the CPUE analysis. The data only in the north of 5N are used in the study (copied from Figure 7 in Ortiz *et al.* (2000)).

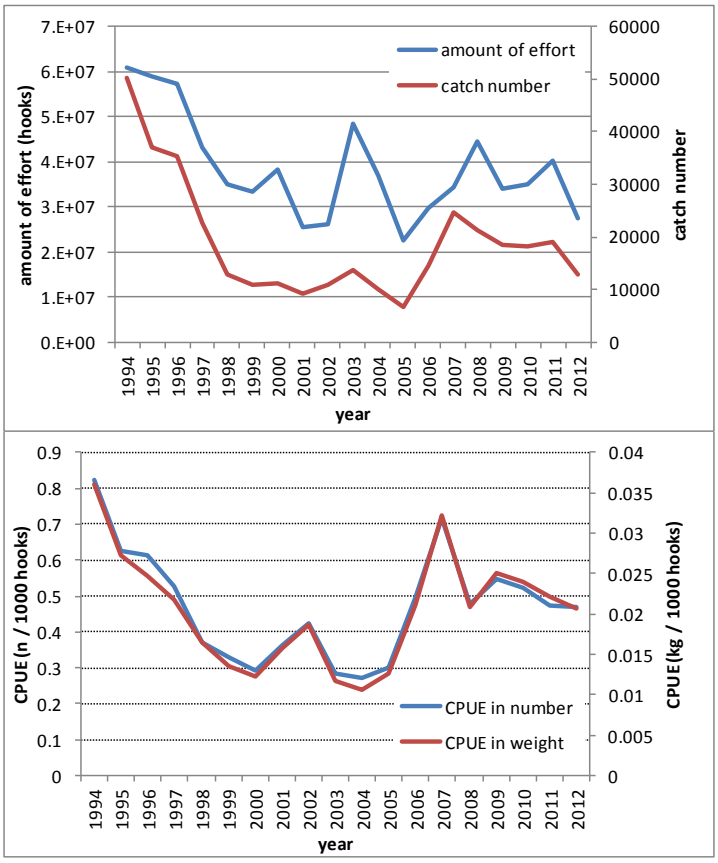


Figure 2. The annual trend of the amount of effort (number of hooks) and catch number of swordfish (top panel), and the trend of nominal CPUE in number and weight (kg) (bottom panel) in 1994 -2012.

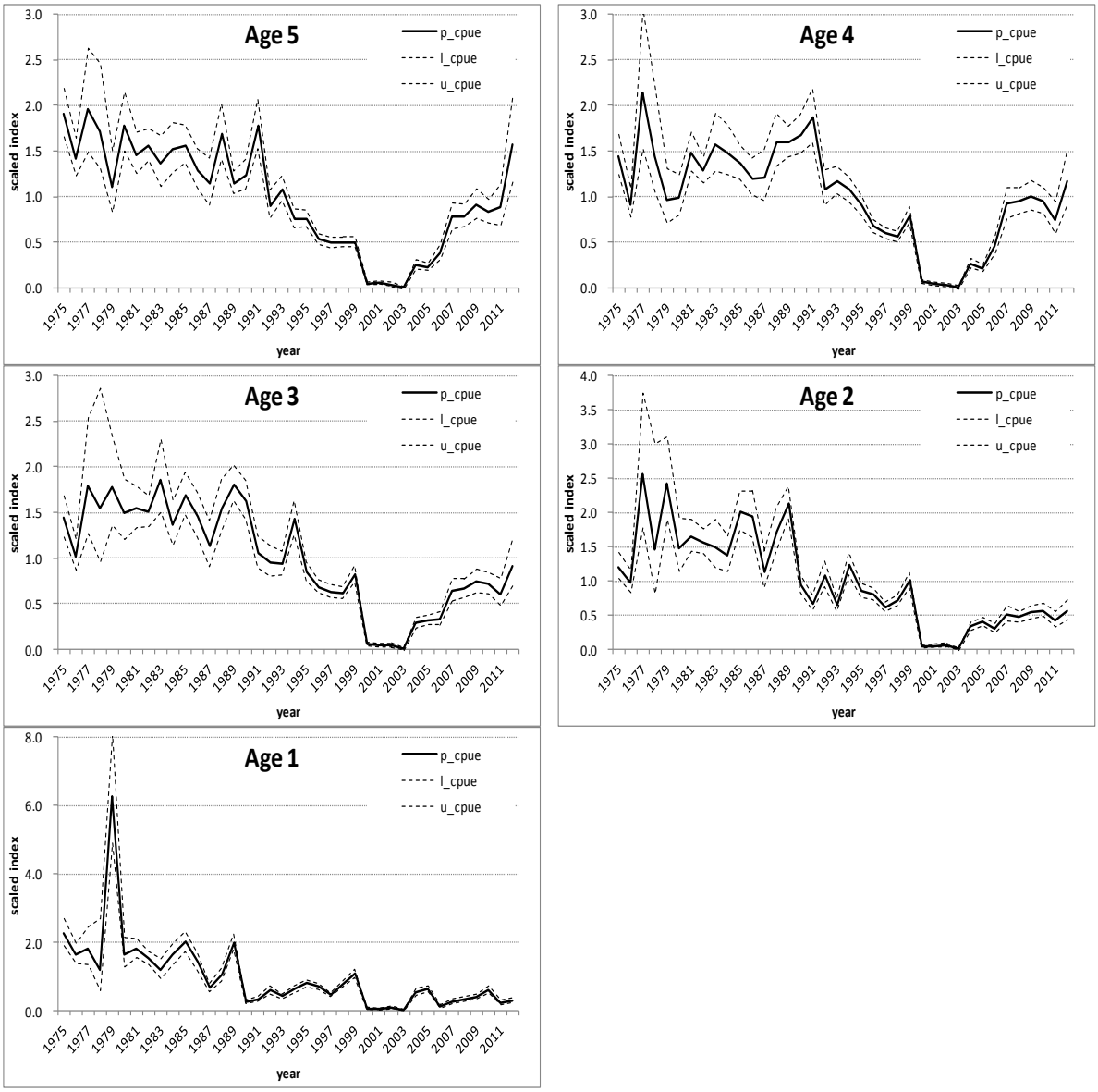


Figure 3. Standardized CPUE of ages 1-5 years old swordfish caught by Japanese longliner in 1975-2012 in the north Atlantic (north of 5N). All values scales to their means which set at 1.0.

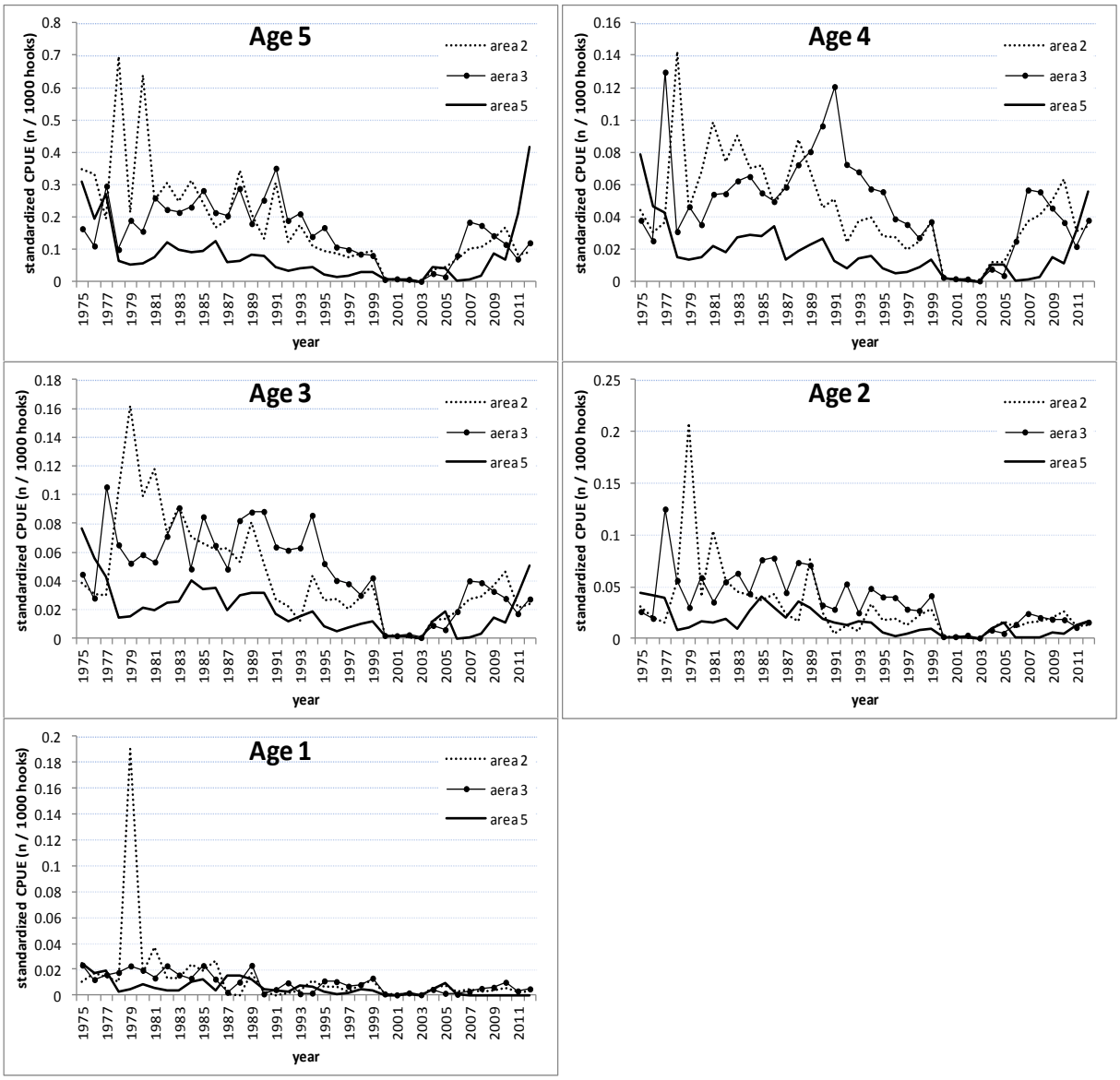


Figure 4. Standardized CPUE (n / 1000 hooks) of ages 1 – 5 years old swordfish by the area caught by Japanese longliner in 1975 – 2012 in the north Atlantic (north of 5N).

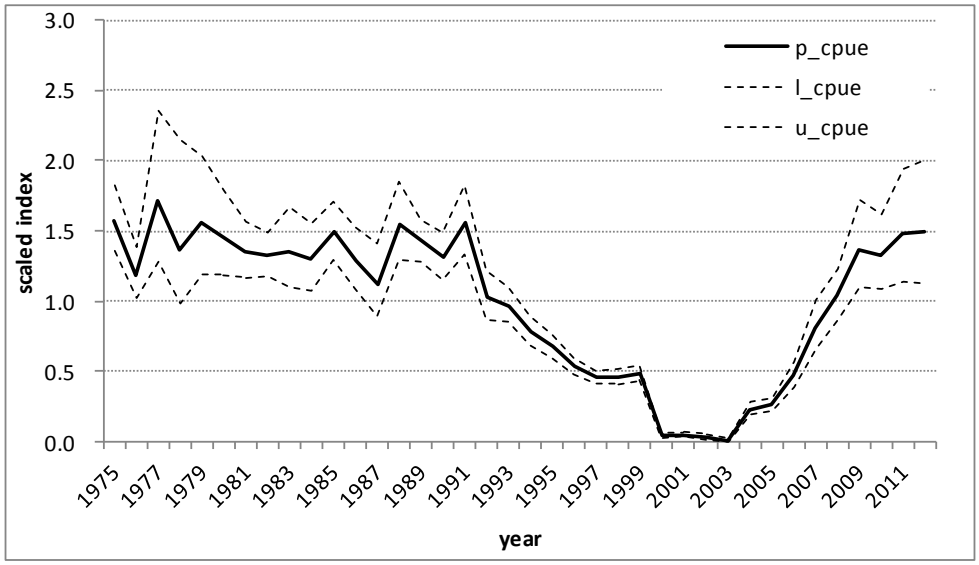


Figure 5. Standardized CPUE (kg / 1000 hooks) of swordfish caught by Japanese longliner in 1975 – 2012 in the north Atlantic (north of 5N). All values scales to their means which set at 1.0.

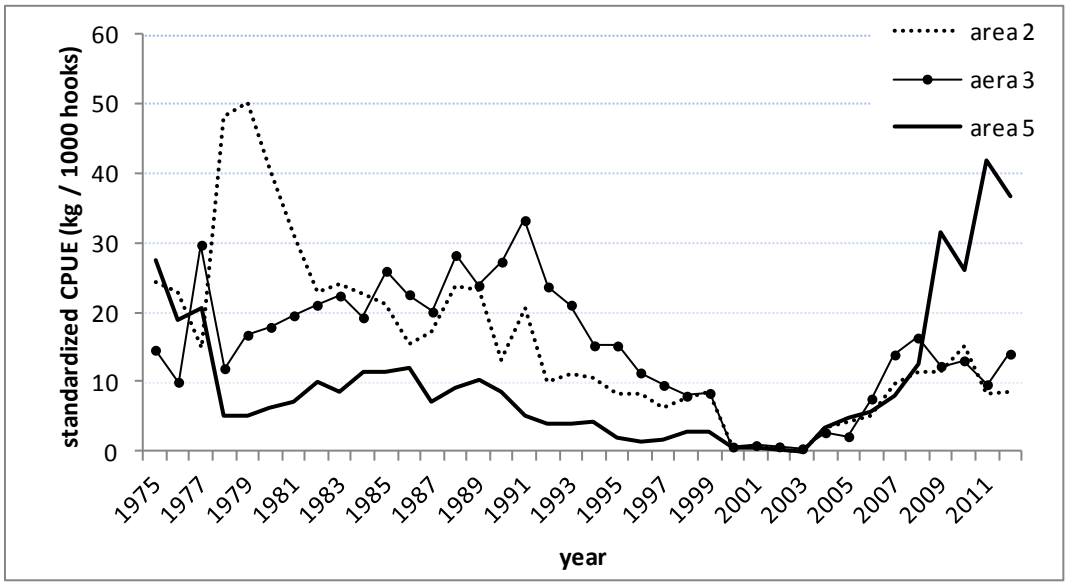


Figure 6. Standardized CPUE (kg / 1000 hooks) of swordfish by the area caught by Japanese longliner in 1975 – 2012 in the north Atlantic (north of 5N).

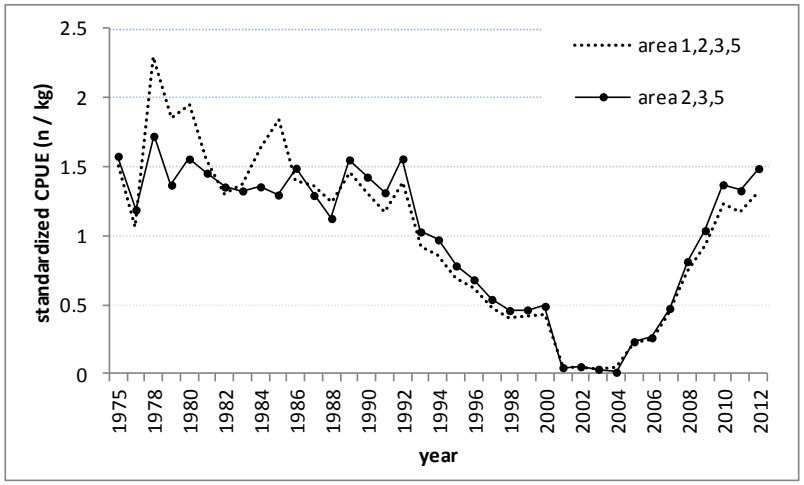


Figure 7. Biomass indices calculated by two different data sets.

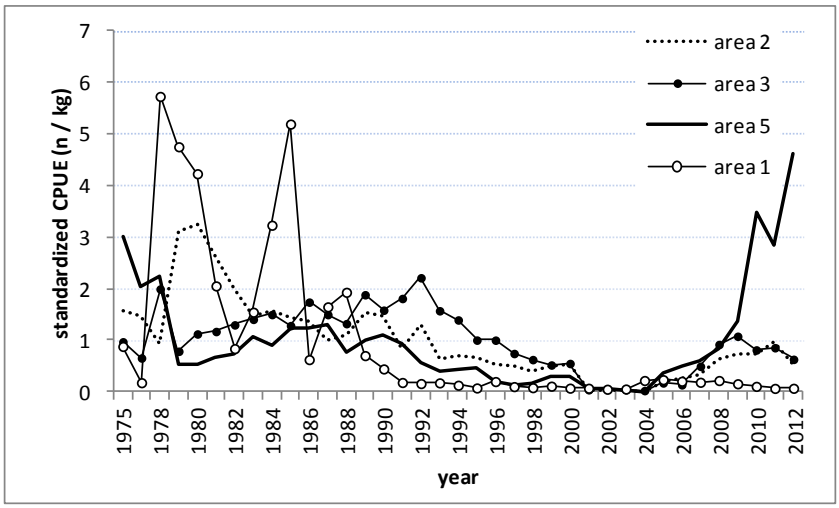


Figure 8. Standardized CPUE (kg / 1000 hooks) of swordfish by the areas 1, 2, 3, and 5 caught by Japanese longliner in 1975 – 2012 in the north Atlantic (north of 5N) .

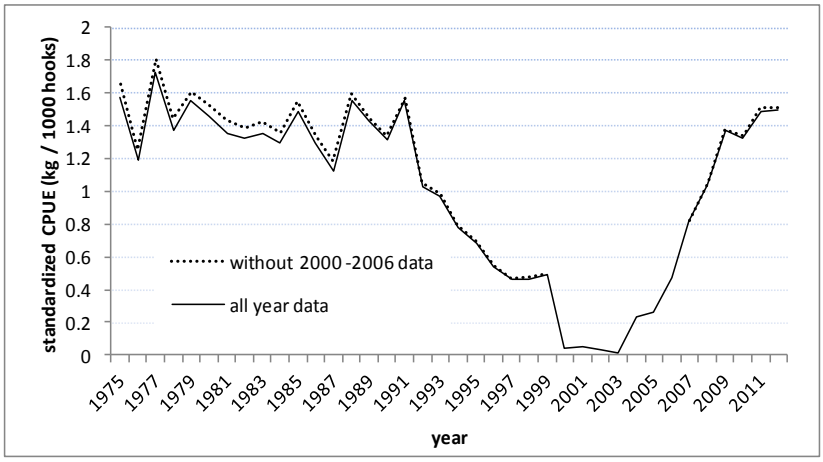


Figure 9. Comparison of biomass indices estimated with/without data in the period between 2000 and 2006 when Japanese longliners actively discards/release their catch of swordfish in the north Atlantic.

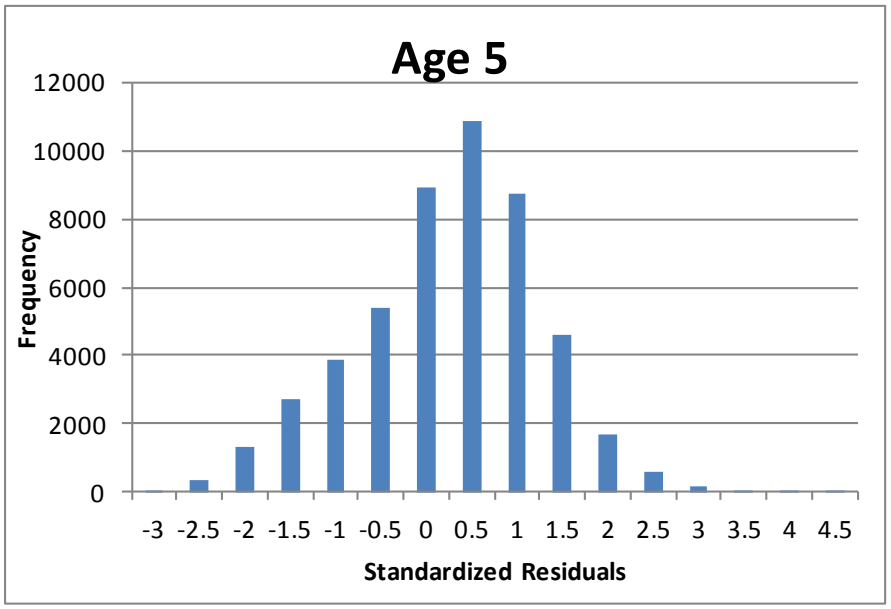
Combined sex age 5

(a) The model with combined sex at age5

	DF	Sum of squa	Mean squar	F value	Pr > F
Model	123	39098	318	215	<.0001
Error	49257	72810	1		
Corrected Total	49380	111908			

R-Square=0.243, Coeff=-53.525,Var=1.215, Root= -2.271

Effects	DF	Type III SS	Mean squar	F value	Pr > F
year	37	17116	463	313	<.0001
area	2	2038	1019	689	<.0001
gear	1	1206	1206	816	<.0001
qt	3	730	243	165	<.0001
area*qt	6	1874	312	211	<.0001
year*area	74	4672	63	43	<.0001

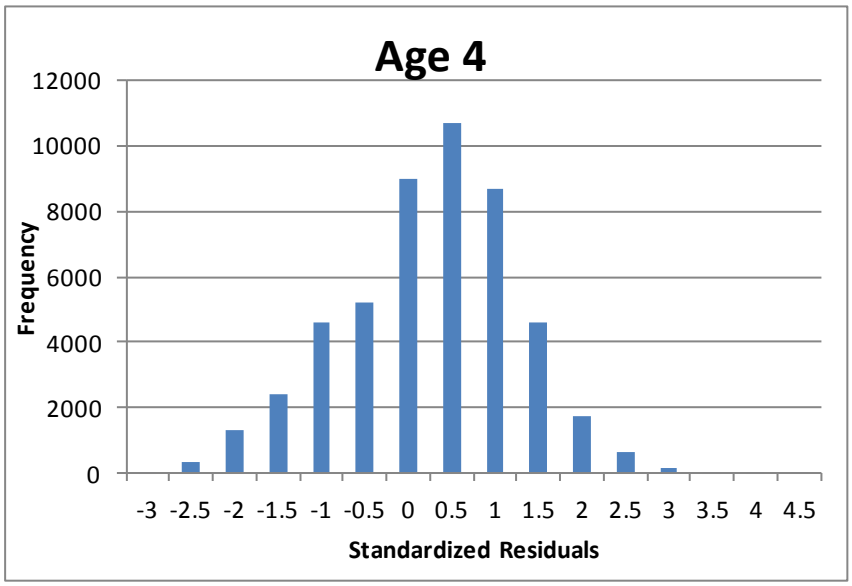


Combined sex age 4

(b) The model with combined sex at age4					
	DF	Sum of squa	Mean squar	F value	Pr > F
Model	123	39469	321	216	<.0001
Error	49257	73169	1		
Corrected	49380	112638			
Total					

R-Square=0.350, Coeff=-34.187,Var=1.218, Root= -3.565

Effects	DF	Type III SS	Mean squar	F value	Pr > F
year	37	16353	442	298	<.0001
area	2	2356	1178	793	<.0001
gear	1	1177	1177	793	<.0001
qt	3	631	210	142	<.0001
area*qt	6	1593	266	179	<.0001
year*area	74	4715	64	43	<.0001

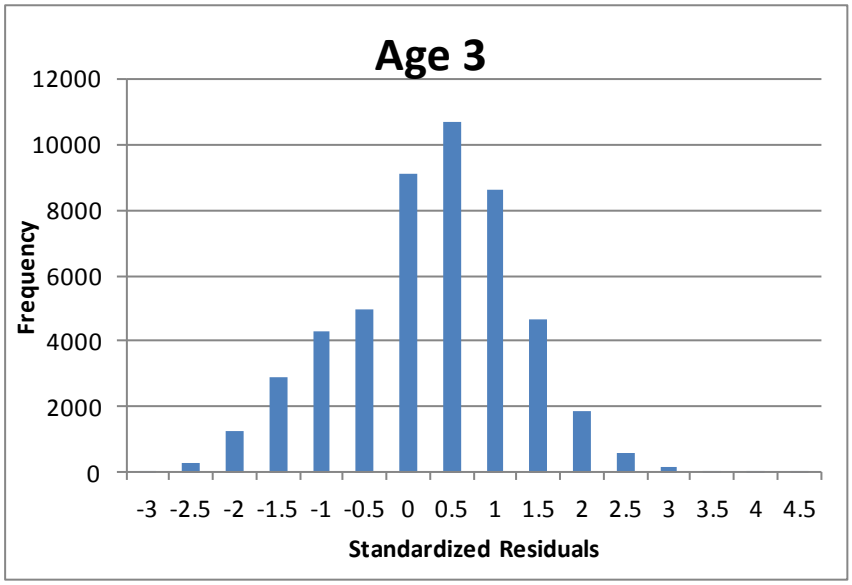


Combined sex age 3

(c) The model with combuned sex at age3					
	DF	Sum of squa	Mean squar	F value	Pr > F
Model	123	36742	299	194	<.0001
Error	49257	75718	2		
Corrected Total	49380	112460			

R-Square=0.326, Coeff=-35.025,Var=1.239, Root= -3.539

Effects	DF	Type III SS	Mean squar	F value	Pr > F
year	37	16875	456	297	<.0001
area	2	1649	824	536	<.0001
gear	1	1087	1087	707	<.0001
qt	3	825	275	179	<.0001
area*qt	6	1221	204	132	<.0001
year*area	74	5004	68	44	<.0001

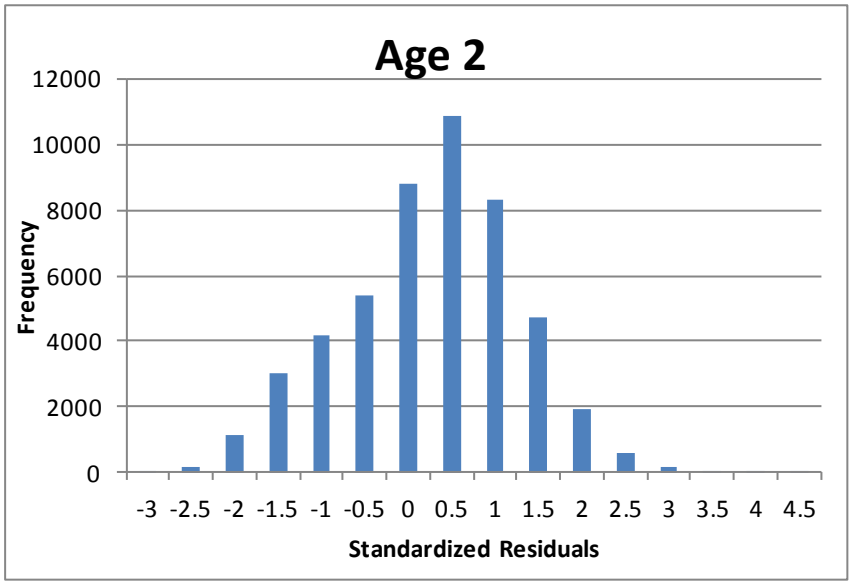


(d) The model with combuned sex at age2

	DF	Sum of squa	Mean squar	F value	Pr > F
Model	123	36000	293	183	<.0001
Error	49257	78964	2		
Corrected Total	49380	114964			

R-Square=0.313, Coeff=-32.677,Var=1.266, Root= -3.874

Effects	DF	Type III SS	Mean squar	F value	Pr > F
year	37	16919	457	285	<.0001
area	2	1345	672	419	<.0001
gear	1	797	797	497	<.0001
qt	3	1252	417	260	<.0001
area*qt	6	1222	204	127	<.0001
year*area	74	6164	83	52	<.0001



Biomass index (kg / 1000 hooks)

(e) The model with biomass index (kg / 1000 hooks)					
	DF	Sum of squa	Mean squar	F value	Pr > F
Model	123	34684	282	187	<.0001
Error	49257	74177	2		
Corrected Total	49380	108860			

R-Square=0.318, Coeff=53.544,Var=1.227, Root= 2.291

Effects	DF	Type III SS	Mean squar	F value	Pr > F
year	37	18187	492	326	<.0001
area	2	820	410	272	<.0001
gear	1	787	787	522	<.0001
qt	3	577	192	128	<.0001
area*qt	6	1506	251	167	<.0001
year*area	74	4113	56	37	<.0001