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UPDATED STANDARDIZED BLUEFIN CPUE FROM THE JAPANESE LONGLINE FISHERY IN THE ATLANTIC UP TO 2011 FISHING YEAR

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SUMMARY

Abundance indices of bluefin tuna from the Japanese longline fishery in the West and northeast Atlantic were provided as base case up to the 2011 fishing year. The indices were standardized with delta-lognormal model with random effect. The West Atlantic index fluctuated significantly since the 2007 fishing year, showing considerably high values for 2007, 2009, and 2011 fishing years. These high indices might be related to the abundance of relatively small-sized bluefin (135-150 cm, 50-60 kg) in the catch. The size data in the West Atlantic suggested a possibility of the mixing of fish from the east stock in the west catch. However, the possibility of appearance of the strong year-class of 2003 in the west stock as in the east stock cannot be rejected. The abundance index in the northeast Atlantic showed a steep increasing trend since the 2009 fishing year, and the size of the bluefin caught showed a continuous contribution from the 2003 year-class. The age structure of the catches in this area suggested that the full recruitment age into the northern fishing ground (north of 50°N) would be older matured fish, and the Japanese longline gradually exploited the 2003 year-class since the 2009 fishing year. In the CPUE series, several incomprehensible high points were observed in recent years, and these may partly reflect increase in abundance due to the strong year-class of 2003 and partly a consequence of the introduction of the IQ system to Japanese longliners. It was suggested that careful consideration is needed for the use of these CPUE series in the stock assessment of both the west and east stocks.

RÉSUMÉ

Les indices d'abondance de la pêcherie palangrière japonaise ciblant le thon rouge et opérant dans l'Atlantique Ouest et l'Atlantique Nord-Est ont été fournis comme le cas de base jusqu'à l'année de pêche 2011. Les indices ont été standardisés au moyen d'un modèle delta-normal avec effet aléatoire. L'indice de l'Atlantique Ouest présentait des fluctuations considérables depuis l'année de pêche 2007 et affichait des valeurs nettement élevées pour les années de pêche 2007, 2009 et 2011. Ces indices élevés pourraient avoir un rapport avec l'abondance du thon rouge de taille relativement réduite (135-150 cm, 50-60 kg) dans la capture. Les données de tailles de l'Atlantique Ouest suggéraient qu'il pourrait exister un mélange de poissons provenant du stock de l'Est dans la capture de l'Ouest. On ne peut toutefois pas rejeter la possibilité de la présence d'une forte classe d'âge de 2003 dans le stock occidental et dans le stock oriental. L'indice d'abondance de l'Atlantique Nord-Est présentait une tendance rapide à la hausse depuis l'année de pêche 2009 et la taille des thons rouges capturés indiquait la poursuite de la contribution de la classe d'âge de 2003. La structure démographique des prises dans cette zone suggérait que l'âge du recrutement total pour la zone de pêche septentrionale (Nord de 50ºN) concernerait des poissons plus âgés et que la flottille palangrière japonaise exploitait graduellement la classe d'âges de 2003 depuis l'année de pêche de 2009. Dans les séries de CPUE, plusieurs pics inattendus ont été observés au cours de ces dernières années, ce qui pourrait refléter en partie une augmentation de l'abondance due à la forte classe d'âges de 2003 et être également la conséquence de l'introduction du système de quota individuel auprès des palangriers japonais. Il a été suggéré qu'il conviendrait de faire preuve de prudence en utilisant ces séries de CPUE dans l'évaluation des stocks de l'Est et de l'Ouest.

RESUMEN

Se facilitan como caso base índices de abundancia de atún rojo de la pesquería palangrera japonesa en el Atlántico occidental y nororiental hasta el año pesquero 2011. Los índices se estandarizaron mediante un modelo delta-lognormal con efectos aleatorios. El índice del

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Atlántico occidental fluctuó significativamente desde el año pesquero 2007, mostrando valores considerablemente elevados para los años pesqueros 2007, 2009 y 2011. Estos índices elevados podrían estar relacionados con la abundancia de atún rojo de talla relativamente pequeña (135-150 cm, 50-60 kg) en la captura. Los datos de talla en el Atlántico occidental sugieren una posibilidad de mezcla de peces del stock del Este en la captura del Oeste. Sin embargo, no puede descartarse la presencia de la fuerte clase anual de 2003 en el stock occidental así como en el stock oriental. El índice de abundancia del Atlántico nordeste mostraba una marcada tendencia ascendente desde el año pesquero 2009, y la talla del atún rojo capturado mostraba la contribución continua de la clase anual de 2003. La estructura por edad de las capturas en la zona sugería que la edad de pleno reclutamiento para el caladero septentrional (Norte de 50ºN) afectaría a ejemplares más maduros, y que el palangre japonés ha estado explotando gradualmente la clase anual de 2003 desde el año pesquero 2009. En las series de CPUE se observaron varios valores elevados no explicables en años recientes, que podrían reflejar en parte un incremento en la abundancia debido a la fuerte clase anual de 2003, y también ser consecuencia, en parte, de la introducción del sistema de cuotas individuales para los palangreros japoneses. Se sugirió que se requiere una consideración minuciosa al utilizar estas series de CPUE en la evaluación de stock, tanto para los stocks del Este como del Oeste.

KEYWORDS

Bluefin tuna, stock abundance, catch and effort, CPUE standardization,
delta-lognormal model, Generalized Linear Mixed Model, long lining, size

Introduction

Japanese longline fishery data in the North Atlantic are valuable information for studying the bluefin tuna stock in the Atlantic. This fishery covered wide geographical areas in the North Atlantic and the Mediterranean Sea, where bluefin tuna were distributed, for more than five decades (**Figure 1**). This wide temporal/spacious coverage, together with a good accurate quality of the data is the most important advantages in providing reliable abundance trend for this species.

However, the patterns and areas of fishing by the Japanese longline fishery have changed through the history especially in the recent years, due to the introduction of IQ (individual vessels quota) and limited entry system to the Japanese longline vessels, since August 2007 voluntarily and August 2009 by law (Japan, 2011). Since the amount of catch and the number of vessels have been significantly reduced, the Japanese longline fishery has not been a major fishery for bluefin anymore. Although the abundance indices from this fishery are still very reliable and useful, it is strongly recommended to develop valid and reliable indices for other major fisheries (e.g. Mediterranean purse seine) while continued effort in improving Japanese longline index is also recommended.

This paper provides updated, to 2011 fishing season, abundance indices for the bluefin stocks in the Atlantic given in the previous studies (Oshima *et al*., 2008 and 2009, and Kimoto *et al*., 2010), i.e. the CPUE series standardized by application of Generalized Linear Modeling technique. It also provides with some candidates of alternative abundance indices for the Japanese longline fleet, observing very rapid changes in its fishing patterns, due to the introduction of a new regulatory measure for bluefin tuna.

Materials and methods

The catch and effort data (set by set data) of the Japanese longline fishery were obtained from the logbook by the National Research Institute of Far Seas Fisheries (NRIFSF), and used for the CPUE standardization for the period from 1975 to 2011 fishing years. The fishing years were used in this report; 2011FY refers to the period from August 1, 2010 to July 31, 2011. The data in 2012FY were incomplete and used only in the alternative abundance indices. Information on the number of hooks between floats (NHBF) is available since 1975 (indicative of the depth of the line). The catch history by the Japanese longline fishery dates back to much earlier period (back to 1958) but the catches before the mid-1970s mostly came from different areas (mostly tropical waters) from the current fishing grounds. Besides, there were no reliable and sufficient size data available for them. It should be noted that the fleets are very mobile and their operational practice and fishing techniques have been constantly modified during its history (Miyake *et al*, 2010).

The size data for bluefin tuna caught by the Japanese longline fishery have been collected through the research programs by the NRIFSF and observer program by the Fishery Agency of Japan (Kimoto *et al*., 2010). Since August 2008, Fishery Agency of Japan has started to tag (for identification) and collect the weight of all of the individual bluefin tuna caught by the Japanese longliners (Japan, 2011). Therefore converted size data, using weight-length relationship by ICCAT (Anon, 2011), are available practically for all fish caught since 2009FY; the number of available size data being 23,451, 17,899, 13,526, 2,890 in 209FY, 2010FY, 2011FY, and 2012FY, respectively. Applying slicing procedures to the size frequencies of bluefin caught by the Japanese longliners, catch at age was estimated for 2009 through 2012FYs from the converted size data. For slicing, the growth curve estimated by von Bertalanffy by ICCAT (Anon, 2011) was used.

The CPUE were standardized respectively for the traditional three areas by applying the same method as previously described by Oshima *et al*. (2008 and 2009) and Kimoto *et al.* (2010). These three areas are West Atlantic (off US and Canadian coast north of 30°N and west of 45°W), Northeast Atlantic (off Iceland north of 40°N and east of 45°W, and East Atlantic (30°N to 40°N, off Gibraltar to western Mediterranean Sea). The area definitions are seen in **Figure 4**. Total accumulative numbers of observations (set by set data) throughout the period to 2012FY for the standardized CPUEs are 56,998 in the West Atlantic, 87,676 in the Northeast Atlantic, and 64,294 in the East Atlantic (**Tables 1-3**), after eliminating some anomalies due to a technical error.

1. Base CPUE series (updated standardized CPUE to 2011FY)

In the east of 45°W, the Japanese longline vessels operated almost solely in the Northeast Atlantic and rarely in the East Atlantic, since 2010FY, due to the IQ system and their small quota (**Tables 2 and 3**). Therefore the CPUE series were updated to 2011FY for only in the West (1976-2011FY) and Northeast Atlantic (1990-2011FY) from the previous study (Kimoto *et al*., 2010), whereas the CPUE in the East Atlantic was not updated since 2010FY.

In the CPUE standardization, fishing year, month, area, main and branch line material and NHBF were considered as main effects in the model, and interactions between month and area were included as a random effect. The original area stratification of each index was shown in **Figure 2**. Information on material for main and branch lines is only available since 1994 and classified as either nylon or other materials. The lines used before 1994 were assumed as other materials. In order to keep the interaction in the model (avoiding lack of observations), some observations in neighboring strata (month and area) were aggregated (**Figure 3**). Categories in each main effect adopted in the model are shown below. Delta-lognormal model (Lo *et al*., 1992) was applied for standardizing CPUE, because the database used to include many zero-catch observations. Model formula of logistic regression model of the 1st step model is as follows,

$$\mathrm{Log}\frac{p}{1-p} = \mathrm{Intercept} + (\mathrm{Main\ effects}) + (\mathrm{Interaction\ term}) \qquad (1)$$

where $\mathrm{Log}(p/(1-p))$ is logit link function, p indicates ratio of positive catch and is assumed to binomially distributed. The model formula of lognormal model of the 2nd step is as follows,

$$\mathrm{LogCPUE} = \mathrm{Intercept} + (\mathrm{Main\ effects}) + (\mathrm{Interaction\ term}) + \mathrm{Error} \qquad (2)$$

where LogCPUE indicates natural logarithm of catch rate of positive set, that is the number of bluefin tuna per 1000 hooks, and error is also assumed to be distributed normally. The fitting was conducted by GLIMMIX macro and MIXED procedure of SAS/STAT package (Version 9.2) for the 1st and 2nd steps, respectively. Only significant variables among the considered main effects in the 1st step were used in the final model for each area, West, Northeast, and East Atlantic.

Main effect / Area	West Atlantic	Northeast Atlantic
Stock	West	East
Fishing Year	1976-2011	1990-2011

Month	Nov, Dec, Jan, Feb	Aug-Oct, Nov, Dec, Jan-Mar
Area (Figure 3)	5 areas	4 areas
Material of main line	Nylon, others (since 1994)	Nylon, others (since 1994)
Material of branch line	Nylon, others (since 1994)	Nylon, others (since 1994)
Hooks between floats	5– 13 (individual)	4 - 7, 8 - 12 hooks

2. Alternative CPUE series

As explained earlier, the standardization of CPUE of the Japanese longline fishery became much more complicated, since the IQ system has been introduced. These complications are studied in the discussion Section later. In order to help some understanding of the changes and fluctuations of CPUE, five alternative CPUE series were developed and presented. They include updating to 2012FY instead of the base case to 2011FY, both in the West and Northeast Atlantic shown with their model diagnostics.

a) Updated standardized CPUE to 2012FY

Using exactly the same method as above with the final chosen categories, the CPUE series were updated to 2012FY in the West and the Northeast Atlantic. The data for 2012FY are, however, incomplete.

b) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N and 60-80W)

In this series, only the data in the areas 25-35N and 60-80W and in December and February (a window) were used. The series could be developed only for 2006 through 2011FYs. The area was stratified into 2 areas divided at 70W longitude. The CPUE series were analyzed using the same method as the base CPUE series.

c) Standardized CPUE in the areas BFT 53 and 54 (mainly north of 53: 50-60N and 15-35W)

In this series, only the data in the areas 50-60N and 15-35W, and in October and November (a window) were used for the period between 1995 and 2012FYs, during which Japanese longliners operated constantly in that time and space. The simple GLM analysis was done by SAS 9.3, because the positive catch ratio was constantly 80% on average in each fishing year (Figure 10). The followed equation is used as GLM,

$$\log(CPUE + Constant) \sim year + month + NHBF + \varepsilon \qquad (3)$$

where Gaussian errors (ε) and 10% of the minimum positive observed CPUE through the analyzed period were used.

d) Standardized CPUE using selected high nominal CPUEs in the Northeast Atlantic

In the Northeast Atlantic, the recent catch pattern has changed substantially and concentrated in time and space, due to the introduction of IQ system voluntarily since 2008FY (August 2007). The alternative CPUE series were analyzed with the assumptions that skippers would choose the best fishing season and areas when their operations were limited by IQ, but without the fear that the fishery would be closed. With these assumptions, 316 sets with the highest nominal CPUE were selected between September and December in each fishing year. The number of 316 sets was the smallest number of sets per year, recorded in the 2011FY. These data have only sets with positive catches, thus the simple GLM analysis were done by SAS 9.3. The categories which were fishing year, month, and area, as described above were used as main effects, and interactions between month and area were included.

Results and discussion

1. Base CPUE series (updated standardized CPUE to 2011FY)

Results of type 3 test for positive catch ratio (1st step) and CPUE of positive catch (2nd step) in the final model were showed in **Table 4**. The variables of main and branch line materials among the considered main effects were not significant for the West and Northeast Atlantic. These variables were excluded in the 1st and 2nd steps for the areas.

Residual patterns of positive CPUE in the 2nd step were slightly skewed to the left in these areas (**Figure 4**). Additionally, the residual distribution in the Northeast Atlantic had two modes.

There were large annual fluctuations in observed and predicted proportions of positive catch in the West Atlantic (**Figure 5**), while the proportions in the Northeast Atlantic showed less fluctuations compared to that in the West.

Observed CPUE of positive catch in the West Atlantic fluctuated without any trend during 1976-2011FY, and it jumped up sharply in 2007 and 2011FYs in the West (**Figure 6**). On the other hand, the CPUE in the Northeast Atlantic were stable until 2008FY except for 1996FY, and demonstrated an upward trend in the recent three years.

Standardized CPUE based on the Least Square Mean are shown in Figure 7 and Table 6. In the West Atlantic, the abundance indices showed gradual decline with large fluctuations from 1976FY to the mid-1980s, having reached the lowest in 1986FY. It recovered since then and showed relatively stable until the mid-2000s except for the sudden increase in 1996FY. It exhibited an increase after 2005FY with large fluctuations. In 2007, 2009, and 2011FYs, they showed very high levels. The confidence interval after 2007FY was wider than those in other years due to the less observations (**Table 1**). Relatively smaller-sized fish (135-150cm, 50-60kg) were abundant in 2009 and 2011FYs in the catches off Canadian coast (**Figures 1 and 2**, areas 18-19) in January, which were similar to 2007FY (Kimoto *et al*., 2010). This is well shown in the size data (**Figure 8**) of bluefin caught by Japanese longline, collected by Fishery Agency of Japan since 2009FY (more detail size information is available in Kimoto *et al*., 2012). In addition, the jump of the CPUEs in 2011FY was also due to the good catch of medium size fish (165-185cm, 95-120kg) from November to January, which was a similar size range appeared in the Northeast fishing ground between October and November. The sharp decline in the CPUEs in 2010FY was mainly because of many zero catch data (**Figure 5**). This may be related to a good catch rate of bigeye tuna, particularly in 2010FY, and that some vessels targeted bigeye rather than bluefin. The low CPUE in 2010FY were also caused by the shift of main fishing ground to south (25-35N and 65-75W) part of which was outside of the defined area to which CPUE was standardized, and hence large portion of data are not included in the analyses.

In the West Atlantic, the fishing ground changed substantially between years, and the area of the fishing ground shrank (**Figure 1**). There characteristics appeared since 2008FY when the fishermen's association introduced IQ system, and became more significant since 2010FY, where the IQ system has been officially applied by law while the total TAC has gradually reduced The CPUE series sometimes detected high abundance of relatively small-sized fish (135-150cm, 50-60kg). Moreover, the nominal CPUE values of some sets in 2011FY in the West area were as high as those observed in the Northeast, the size range of fish being very similar to the Northeast Atlantic (**Figures 8 and 9**). These suggested a possibility of mixing of fish from the east stock in the west catch. However, the possibility of appearance of a strong year class of 2003 in the west stock as in the east stock cannot be rejected. Therefore, careful considerations are needed for the use of the West CPUE in the stock assessment of the west stock with this complex information.

The Northeast Atlantic, north of 40°N (Areas 31-34 in Figure 3) was exploited by the Japanese longline fleet around 1990. This fishing ground has been constantly exploited since then, i.e. for more than 20 years. Especially in recent years, the Japanese activities were concentrated in this area, while there were hardly any operations in the south of 40°N including the Mediterranean Sea. It seems that this pattern would be maintained as far as a strict quota system continues. Therefore, the abundance index in the Northeast Atlantic would become more valuable for the stock assessment of the east stock.

In the Northeast Atlantic, overall abundance indices showed a slight increasing trend since 1990FY (**Figure 7**). The high value was observed in 1996FY and decreased thereafter and remained at the average level since 1999FY until 2005FY. It started increasing again in 2009FY and reached the highest value in the latest fishing year of analysis, 2011FY. In the recent years, the high CPUEs were observed in October and November, in the northern areas: 50-60N and 15-35W (**Figure 1**), where and when the most of the operations are concentrated, because the fish of high quality and value are available. Interestingly, the longline catch since 2010FY were consisted mainly of 2003 year class (**Figure 9**), while they were already detected in 2009FY catch. The similar result was observed in the analyses, which used only data in the major season (October and November) and area

(55-60N and 15-35W) (**Figure 12**: alternative CPUE). The fact that the 2003 year class shows up for the first time in the Japanese longline catches in 2009FY and thereafter dominated their catches (**Figure 9**), suggests that the full recruitment age into the northern fishing ground (north of 50N) would be older matured fish.

Probably, recruitment of this strong year class to this fishery contributed, at least partially, to the increase in the longline CPUE in that area. At the same time, the introduction of strict IQ system by law possibly has affected the skippers' behavior and efficiency, having resulted in this increase in the CPUEs.

In the recent years, the fishing grounds have changed or shrank (**Figure 1**) due to the introduction of IQ system for Japanese longline vessels, and the fishing season has extremely shortened because of the small quota and high CPUE. Also, the same strong year class probably appeared both in the West and Northeast Atlantic catches. In the 2012FY, these conditions became even more significant, showing the highest CPUE, as explained below. It is possible that the representativeness of the CPUE series of stock abundance might have changed by the introduction of the IQ system. Though only a few years were currently affected by the IQ system, it would be desirable to separate the CPUE series into different time blocks at the introduction of the IQ system. Additionally, if age-specific CPUE series could be developed, especially for the West Atlantic, they might help understanding the observed fluctuations in CPUE. As the size data of Japanese longline catches have been improved since 2009FY (100% coverage), and hence the age-based CPUE might be available for recent periods. Even with those reservations, the authors recommend to use the Japanese longline CPUE series up to 2011FY in the West Atlantic for the west bluefin stock, while that of the Northeast for the east bluefin stock assessments. Which of these two factors affected more in the CPUE has to be studied in future.

2. Alternative CPUE series

a) Updated standardized CPUE to 2012FY

In both the West and Northeast Atlantic, the standardized CPUE in the 2012FY became highest among all the past fishing years (**Figure 12-a**). The fishing ground and season in the 2012FY were basically the same as those in the 2011FY, but with less fishing days per vessel and less operating areas due to the high CPUEs. In the Northeast Atlantic, the 2003 year class again dominated catches (**Figure 8 and 9**). In the West Atlantic, the size composition of bluefin caught in the 2012FY were closely resemble to those caught in the Northeast Atlantic (**Figures 8 and 9**). Therefore, it is some doubt as to whether the CPUE in 2012FY in the Japanese West Atlantic fishery reflected the abundance of the west stock or not. Several bluefin fish were caught in the West Atlantic in September and October in 2012FY, which are usually out of bluefin season: thus those fish were not used for the standardization.

b) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N and 60-80W)

In these areas, the standardized CPUE showed a flat trend between 2006 and 2011FY (**Figure 12-b**). The confidence intervals were relatively wider than other CPUE series and all main effects were not significant (**Table 5**), because the number of hooks and analyzed years was not large. Japanese longline constantly caught bluefin of between 110 and 300kg (170-250cm) with the mode between 120 and 150kg (180-200cm) (**Figure 8**, particularly in 2010FY).

c) Standardized CPUE in the areas BFT 53 and 54 (mainly north of 53: 50-60N and 15-35W)

This index showed similar trends as the base case CPUE series up to 2012FY in the Northeast Atlantic described above (**Figure 12-c**).

d) Standardized CPUE using selected high nominal CPUEs in the Northeast Atlantic

The CPUE using only high nominal CPUEs in each year started in the 1993FY when all the vessels were adjusted to the new fishing ground. This CPUE series fluctuated at a relatively high level, between 1996 and 2001FYs (**Figure 12-d**). It declined low after 2002FY until 2008FY and showed increase again in the recent years.

This alternative CPUE assumes that fishermen know fish distribution and density very well. Under IQ system, longline vessels would be able to operate when and where high CPUEs of high-quality bluefin are expected. As there are yearly vaiations in fishing area and season, this may be too much to expect, (as to the fishermen's knowledge), but at least it shows some increase in abundance of fish favored by fishermen in recent years.

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Table 1. Number of longline sets by various strata for the West Atlantic CPUE standardization. Observations were aggregated by month, area (prefixed by A), materials of main line (M1=others, M2=nylon) and branch line (F1=others, F2=nylon), number of hooks between floats (prefixed by B). Area definition is shown in Figure 2. Year is fishing year (2011 means August 2010 to March 2011).

Year	Nov	Dec	Jan	Feb	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24
1976	347	322	266	208	9	1	0	0	0	0	0	0	163	196	2	0	0	0	14	268	19	7	442	19	0	0	3	0
1977	534	522	519	212	0	4	1	0	0	0	0	10	82	507	155	0	0	0	5	79	195	166	509	74	0	0	0	0
1978	516	559	377	45	0	4	0	1	0	0	0	3	202	238	94	0	2	0	5	24	184	54	677	8	0	0	1	0
1979	755	680	749	179	0	2	0	0	0	0	0	19	239	773	122	0	19	11	9	105	472	83	474	35	0	0	0	0
1980	824	777	683	170	0	7	0	0	0	0	0	0	90	254	113	54	0	3	3	56	898	563	397	16	0	0	0	0
1981	1513	1512	902	341	0	0	0	0	0	0	0	0	237	404	338	220	10	3	6	191	825	545	1250	210	0	0	0	29
1982	1753	846	206	116	0	2	1	3	1	0	0	0	337	213	144	52	0	0	1	46	68	201	1519	322	0	0	0	11
1983	891	694	623	504	0	0	1	0	0	0	0	0	151	173	235	10	0	0	0	50	1059	186	778	47	0	0	0	22
1984	629	624	572	212	0	0	0	0	0	0	0	0	45	188	71	9	1	2	0	56	969	267	337	86	0	0	0	6
1985	723	851	655	344	0	0	0	0	0	0	0	0	69	279	55	5	0	1	1	187	566	183	1060	164	0	0	1	2
1986	688	641	551	53	0	0	0	0	0	0	0	0	19	129	85	5	36	11	0	23	326	67	977	236	0	0	0	19
1987	897	944	710	42	0	30	11	0	21	7	0	0	6	297	287	1	0	0	0	170	669	251	662	161	0	0	2	18
1988	891	869	651	364	0	1	0	0	0	10	0	0	27	458	507	41	11	0	0	311	786	258	344	11	0	0	0	10
1989	804	1051	521	247	0	0	1	126	333	51	0	0	3	170	338	6	0	0	0	126	412	413	504	113	0	0	1	26
1990	663	782	766	296	0	0	5	57	294	81	0	0	0	63	171	37	15	0	0	59	462	515	575	128	0	0	0	45
1991	516	479	502	154	0	0	0	17	33	118	4	0	0	9	18	40	5	0	0	103	348	152	600	121	0	0	11	72
1992	310	667	392	2	0	0	0	0	41	21	3	0	0	6	9	1	10	0	0	16	172	215	583	150	0	1	1	142
1993	637	593	331	53	0	0	0	0	0	0	0	0	0	4	5	2	0	0	0	13	334	350	827	67	0	0	0	12
1994	336	574	533	92	0	0	0	0	0	0	0	0	0	17	9	9	26	0	0	6	308	245	629	282	0	0	0	4
1995	235	217	112	1	0	0	0	0	0	0	0	0	0	0	25	3	0	1	0	0	220	92	145	75	0	0	0	4
1996	38	371	70	0	0	11	0	0	0	0	2	0	0	0	11	0	0	0	0	24	52	15	138	177	0	0	0	49
1997	73	613	133	0	0	0	0	0	6	34	28	0	0	0	3	0	0	3	0	7	58	29	250	186	0	0	0	215
1998	31	746	375	33	0	0	17	0	26	5	0	0	0	8	79	1	3	30	0	0	154	38	224	354	0	0	0	246
1999	316	585	244	127	0	0	3	90	91	40	74	0	0	0	1	4	2	3	0	0	14	23	357	388	0	0	0	182
2000	347	565	201	153	0	0	0	23	93	31	112	0	0	2	5	0	0	1	0	1	166	48	493	235	0	0	0	56
2001	190	672	221	134	0	0	1	67	209	117	140	0	0	0	0	1	2	0	0	0	1	3	270	112	0	0	1	293
2002	638	837	320	395	0	22	7	96	245	390	140	0	0	27	29	0	7	10	0	0	14	14	314	230	0	0	0	645
2003	163	442	57	106	0	82	10	5	125	37	86	0	0	0	0	0	3	13	0	0	2	5	108	209	0	0	0	83
2004	41	156	461	167	0	72	2	52	137	72	27	0	0	30	42	5	1	0	0	0	18	10	64	273	0	0	0	20
2005	10	214	790	761	5	195	0	107	135	108	28	0	0	543	124	5	1	5	0	20	42	91	172	194	0	0	0	0
2006	0	136	561	368	18	121	4	73	180	136	32	0	0	38	165	2	0	0	0	1	119	17	73	72	0	0	0	14
2007	6	83	132	149	42	76	0	0	0	0	0	0	0	69	21	7	1	0	0	0	6	63	77	6	0	0	0	2
2008	0	59	143	40	81	121	0	0	0	0	0	0	0	1	1	0	0	0	0	0	13	3	14	7	0	0	0	1
2009	20	48	24	0	4	12	0	0	0	0	0	0	0	2	6	0	0	0	0	0	5	1	32	9	0	0	0	21
2010	89	51	6	0	1	34	10	0	0	0	0	0	0	2	3	0	0	0	0	0	0	30	66	0	0	0	0	0
2011	99	100	84	2	11	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	177	67	0	0	0	0
2012	57	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	23	0	0	0	0
Total	16580	19905	14443	6070	171	823	74	717	1970	1258	676	32	1670	5100	3273	520	155	97	44	1942	9957	5206	16175	4867	0	1	21	2249

Table 1. Continued.

Year	M1	M2	F1	F2	B5	B6	B7	B8	B9	B10	B11	B12	B13	Total
1976	1143	0	1143	0	971	172	0	0	0	0	0	0	0	1143
1977	1787	0	1787	0	1474	313	0	0	0	0	0	0	0	1787
1978	1497	0	1497	0	1399	95	0	0	0	3	0	0	0	1497
1979	2363	0	2363	0	1938	378	28	0	0	19	0	0	0	2363
1980	2454	0	2454	0	1989	384	50	28	0	3	0	0	0	2454
1981	4268	0	4268	0	2650	998	278	94	107	141	0	0	0	4268
1982	2921	0	2921	0	1223	811	180	116	135	317	99	40	0	2921
1983	2712	0	2712	0	906	1301	117	174	0	209	0	5	0	2712
1984	2037	0	2037	0	432	1345	144	20	6	65	19	6	0	2037
1985	2573	0	2573	0	43	1414	987	0	25	6	3	46	49	2573
1986	1933	0	1933	0	21	742	831	198	0	59	5	0	77	1933
1987	2593	0	2593	0	26	1083	1279	138	10	30	0	27	0	2593
1988	2775	0	2775	0	5	115	2326	275	0	14	0	10	30	2775
1989	2623	0	2623	0	0	383	1777	270	14	108	21	50	0	2623
1990	2507	0	2507	0	0	383	1961	132	0	17	0	14	0	2507
1991	1651	0	1651	0	15	147	1165	277	0	1	1	0	45	1651
1992	1371	0	1371	0	0	219	830	279	26	14	0	0	3	1371
1993	1614	0	1614	0	36	278	1049	174	25	46	0	6	0	1614
1994	921	614	982	553	25	175	1048	197	76	0	0	14	0	1535
1995	55	510	187	378	33	2	191	207	76	28	28	0	0	565
1996	328	151	287	192	0	15	127	237	91	9	0	0	0	479
1997	710	109	624	195	1	22	166	344	131	53	68	0	34	819
1998	1029	156	1022	163	0	0	322	645	85	101	32	0	0	1185
1999	1196	76	1079	193	0	59	129	855	47	108	0	53	21	1272
2000	1227	39	1183	83	0	3	120	639	256	116	51	33	48	1266
2001	1211	6	1198	19	0	6	133	808	61	162	20	20	7	1217
2002	2120	70	2022	168	0	0	60	1398	369	205	2	127	29	2190
2003	768	0	768	0	0	0	26	333	259	85	1	64	0	768
2004	746	79	793	32	0	0	105	442	231	47	0	0	0	825
2005	1709	66	1546	229	0	2	12	704	923	73	0	32	29	1775
2006	1047	18	948	117	0	0	2	471	431	96	0	48	17	1065
2007	370	0	324	46	0	0	0	141	203	26	0	0	0	370
2008	199	43	189	53	0	0	0	26	216	0	0	0	0	242
2009	82	10	82	10	0	0	0	63	22	7	0	0	0	92
2010	146	0	146	0	0	0	0	101	37	8	0	0	0	146
2011	285	0	285	0	0	0	0	78	207	0	0	0	0	285
2012	80	0	80	0	0	0	0	72	8	0	0	0	0	80
Total	55051	1947	54567	2431	13187	10845	15443	9936	4077	2176	350	595	389	56998

Table 2. Number of longline sets by various strata for the Northeast Atlantic CPUE standardization. Observations were aggregated by month, area (prefixed by A), materials of main line (M1=others, M2=nylon) and branch line (F1=others, F2=nylon), number of hooks between floats (prefixed by B). Area definition is shown in Figure 2. Year is fishing year.

Year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	A31	A32	A33	A34	A35	M1	M2	F1	F2	B4	B5	B6	B7	B8	B9	B10	B11	B12	Total
1990	0	0	61	206	308	195	143	23	930	0	6	0	0	936	0	936	0	0	6	326	458	77	45	24	0	0	936
1991	1	82	241	739	1106	343	158	28	2695	0	3	0	0	2698	0	2698	0	0	87	929	980	415	82	133	55	17	2698
1992	0	75	745	1738	1306	517	189	31	4489	97	15	0	0	4601	0	4601	0	79	170	2187	1534	448	34	113	0	36	4601
1993	16	344	1219	1372	869	341	59	15	1312	2592	77	254	0	4235	0	4235	0	29	93	3445	508	25	26	30	6	73	4235
1994	0	25	462	914	745	368	149	17	1522	1157	1	0	0	2167	513	2258	422	0	17	2125	400	5	0	0	0	133	2680
1995	0	119	293	646	459	134	27	0	314	259	232	873	0	378	1300	824	854	0	68	741	474	280	115	0	0	0	1678
1996	61	610	1228	930	255	0	0	0	288	454	3	2339	0	2139	945	2087	997	0	0	156	1639	1089	198	2	0	0	3084
1997	135	2044	1662	1558	115	11	0	0	941	1062	45	3477	0	4558	967	4301	1224	0	0	253	3039	1967	193	55	8	10	5525
1998	651	1469	2296	1846	68	3	0	0	313	928	8	5020	64	5650	683	5613	720	0	59	21	4352	1698	174	4	8	17	6333
1999	1163	1774	1878	654	128	10	0	0	262	692	4	4330	319	5224	383	4601	1006	0	1	184	2452	2815	60	47	0	48	5607
2000	877	1510	1836	1594	1168	49	24	0	1884	939	79	3974	182	6497	561	6569	489	0	1	76	2685	4005	254	13	0	24	7058
2001	637	1230	1685	1679	158	148	78	96	920	1282	15	3447	47	5414	297	5385	326	0	0	49	2056	3232	212	86	5	71	5711
2002	490	1070	1643	868	159	92	29	26	1202	678	22	2357	118	4189	188	3835	542	0	0	0	637	3463	201	61	15	0	4377
2003	270	941	1390	949	36	0	0	18	139	141	39	3255	30	3479	125	3410	194	0	1	1	333	2957	312	0	0	0	3604
2004	591	1233	1611	1513	1160	19	0	0	334	310	866	4615	2	5707	420	5767	360	0	0	1	706	4618	673	124	5	0	6127
2005	262	1113	1723	1947	1427	117	0	12	723	135	2569	3174	0	6239	362	5997	604	0	7	2	392	5231	910	59	0	0	6601
2006	256	826	1502	1514	1103	108	3	84	994	375	979	3048	0	5170	226	4801	595	0	0	0	366	3984	930	109	4	3	5396
2007	68	393	989	774	696	226	18	3	331	117	1396	1323	0	3044	123	2876	291	0	0	0	0	2944	223	0	0	0	3167
2008	51	482	790	665	539	205	5	0	314	48	848	1527	0	2660	77	2383	354	0	0	0	74	2639	24	0	0	0	2737
2009	186	731	864	846	384	33	0	0	444	534	229	1837	0	2966	78	2966	78	0	0	0	1	2712	325	6	0	0	3044
2010	0	217	789	429	46	1	0	0	23	87	5	1367	0	1356	126	1439	43	0	0	0	0	1373	109	0	0	0	1482
2011	0	16	488	175	0	0	0	0	3	95	0	581	0	627	52	647	32	0	0	0	0	633	44	2	0	0	679
2012	0	5	297	14	0	0	0	0	2	7	0	307	0	307	9	293	23	0	0	0	0	290	26	0	0	0	316
Total	5715	16309	25692	23570	12235	2920	882	353	20379	11989	7441	47105	762	80241	7435	78522	9154	108	510	10496	23086	46900	5170	868	106	432	87676

Table 3. Number of longline sets by various strata for the East Atlantic CPUE. Observations were aggregated by month, area (prefixed by A), materials of main line (M1=others, M2=nylon) and branch line (F1=others, F2=nylon), number of hooks between floats (prefixed by B). Area definition is shown in Figure 2. Year is fishing year.

Year	Mar	Apr	May	Jun	July	A1	A2	A3	A4	A5	A6	A7	A8	A9	M1	M2	F1	F2	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	Total
1975	263	681	1433	218	235	789	1221	14	14	196	259	243	89	5	2830	0	2830	0	1620	958	252	0	0	0	0	0	0	0	2830
1976	148	717	727	118	268	116	882	1	3	79	366	267	259	5	1978	0	1978	0	1278	557	91	0	52	0	0	0	0	0	1978
1977	137	218	455	397	207	147	657	0	10	174	259	157	10	0	1414	0	1414	0	909	265	229	6	0	0	5	0	0	0	1414
1978	317	307	205	129	12	340	216	4	33	308	21	44	4	0	970	0	970	0	500	31	77	179	5	46	132	0	0	0	970
1979	118	167	177	116	25	47	297	0	39	163	27	26	4	0	603	0	603	0	438	115	22	15	13	0	0	0	0	0	603
1980	209	382	309	18	4	268	436	0	7	39	61	94	17	0	922	0	922	0	389	226	265	37	5	0	0	0	0	0	922
1981	300	335	190	34	15	269	238	0	1	209	112	42	3	0	874	0	874	0	447	93	189	96	46	0	3	0	0	0	874
1982	78	323	585	481	327	27	172	16	43	944	327	261	4	0	1794	0	1794	0	1033	454	136	0	0	46	63	6	56	0	1794
1983	180	552	664	614	195	126	284	0	75	1287	195	225	13	0	2205	0	2205	0	1622	157	141	43	15	21	180	25	1	0	2205
1984	349	903	956	517	271	225	558	3	17	1294	306	486	83	24	2996	0	2996	0	2318	155	285	58	63	22	41	48	6	0	2996
1985	44	677	686	71	38	36	190	58	4	380	70	705	73	0	1516	0	1516	0	1189	112	96	0	0	46	23	37	13	0	1516
1986	140	700	716	122	16	64	514	0	41	519	157	336	63	0	1694	0	1694	0	1360	98	78	51	8	20	8	16	55	0	1694
1987	241	590	429	93	12	112	587	9	6	197	179	229	35	11	1365	0	1365	0	960	128	114	31	66	3	19	10	34	0	1365
1988	387	894	684	125	56	16	780	56	8	756	227	212	63	28	2146	0	2146	0	1912	45	7	21	102	42	0	15	2	0	2146
1989	229	616	405	80	16	18	704	60	22	354	43	93	51	1	1346	0	1346	0	1003	161	60	53	12	21	0	11	12	13	1346
1990	311	735	591	260	14	192	770	44	79	659	70	93	2	2	1911	0	1911	0	947	651	81	63	55	0	4	0	28	82	1911
1991	172	739	779	528	58	348	328	44	338	958	157	102	0	1	2276	0	2276	0	1266	520	296	122	20	0	45	0	2	5	2276
1992	189	1029	1113	969	259	762	208	31	550	1555	256	161	22	14	3559	0	3559	0	1998	663	545	245	80	0	0	3	22	3	3559
1993	208	787	708	475	134	750	49	46	323	701	66	203	115	59	2312	0	2312	0	1248	413	457	54	102	0	6	15	14	3	2312
1994	182	1134	1093	29	4	666	107	50	352	510	155	280	136	186	473	1969	805	1637	1512	668	232	13	16	0	0	0	1	0	2442
1995	216	1273	1371	260	0	476	484	1	291	1062	360	68	184	194	1336	1784	1794	1326	551	782	1459	114	171	0	6	0	37	0	3120
1996	349	1232	1679	4	33	1112	398	21	252	461	71	552	148	282	2526	771	2642	655	78	512	1720	771	83	30	19	7	54	23	3297
1997	902	1468	1056	15	0	1241	1023	3	341	373	162	201	29	68	2938	503	2959	482	0	72	711	2053	373	88	13	49	23	59	3441
1998	882	1456	856	21	7	544	1424	33	148	470	183	20	100	300	2826	396	2738	484	0	0	257	2213	723	18	0	0	7	4	3222
1999	379	662	667	0	7	149	786	30	77	156	48	18	117	334	1626	89	1549	166	0	19	172	1317	197	10	0	0	0	0	1715
2000	400	520	405	0	0	139	446	22	92	253	12	123	121	117	1314	11	1249	76	0	27	182	887	213	8	7	0	1	0	1325
2001	248	578	431	0	0	85	287	86	131	214	8	107	131	208	1113	144	1176	81	0	32	173	669	349	27	7	0	0	0	1257
2002	389	405	771	0	0	441	17	151	53	192	1	217	97	396	1458	107	1435	130	0	0	336	750	407	72	0	0	0	0	1565
2003	155	427	799	6	0	119	132	53	17	172	6	278	141	469	1287	100	1287	100	0	0	316	662	303	32	74	0	0	0	1387
2004	27	328	608	2	0	22	67	131	8	130	0	271	171	165	914	51	893	72	0	0	128	440	219	79	99	0	0	0	965
2005	323	750	979	1	1	234	373	79	21	211	262	412	462	0	1889	165	1854	200	0	1	69	508	1260	204	12	0	0	0	2054
2006	464	384	331	18	0	234	344	194	6	49	29	313	28	0	1120	77	1069	128	0	0	0	241	641	227	44	0	44	0	1197
2007	111	535	560	0	0	66	252	6	3	89	269	459	62	0	1081	125	1013	193	0	0	0	242	884	57	13	3	2	5	1206
2008	139	452	482	0	0	65	430	0	2	67	138	367	4	0	1039	34	1061	12	0	0	0	103	928	35	7	0	0	0	1073
2009	0	44	161	0	0	12	28	3	0	4	17	141	0	0	126	79	126	79	0	0	0	0	137	67	1	0	0	0	205
2010	38	69	0	0	0	103	4	0	0	0	0	0	0	0	99	8	107	0	0	0	0	0	4	28	8	47	20	0	107
2011	5	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	5	0	0	0	0	5
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	9229	23069	24061	5721	2214	10365	15693	1249	3407	15185	4879	7806	2841	2869	57881	6413	58473	5821	24578	7915	9176	12057	7552	1254	839	292	434	197	64294

Table 4. Statistical results from GLMM analysis for positive catch ratio (1st step) and CPUE of positive catch (2nd step) in the final model for base CPUE series (updated standardized CPUE to 2011FY).

West Atlantic

Type 3 test of fixed effect for proportion of positive catch

Effect	DF	DF	Chi-square	F Value	Pr > ChiSq	Pr > F
year	35	499	135.41	3.87	<.0001	<.0001
month	3	499	133.6	44.53	<.0001	<.0001
area	4	499	128.21	32.05	<.0001	<.0001
nhbf	8	935	151.49	18.94	<.0001	<.0001

Type 3 test of fixed effect for LogCPUE with positive

Effect	DF	DF	F Value	Pr > F
year	35	412	2.95	<.0001
month	3	412	86.27	<.0001
area	4	412	6.94	<.0001
nhbf	8	30000	8.75	<.0001

Northeast Atlantic

Type 3 test of fixed effect for proportion of positive catch

Effect	DF	DF	Chi-square	F Value	Pr > ChiSq	Pr > F
year	21	215	215.79	10.28	<.0001	<.0001
month	3	215	152.8	50.93	<.0001	<.0001
area	3	215	30.03	10.01	<.0001	<.0001
nhbf	1	136	9.95	9.95	0.0016	0.002

Type 3 test of fixed effect for LogCPUE with positive

Effect	DF	DF	F Value	Pr > F
year	21	205	7.34	<.0001
month	3	205	34.72	<.0001
area	3	205	1.58	0.1945
nhbf	1	64000	17.56	<.0001

Table 5. Statistical results from GLMM analysis for positive catch ratio (1st step) and CPUE of positive catch (2nd step) in the final model for alternative CPUEs.

a) Updated standardized CPUE to 2012FY: West Atlantic

Type 3 test of fixed effect for proportion of positive catch

Effect	DF	DF	Chi-square	F Value	Pr > ChiSq	Pr > F
year	36	503	137.41	3.82	<.0001	<.0001
month	3	503	135.08	45.03	<.0001	<.0001
area	4	503	128.82	32.21	<.0001	<.0001
nhbf	8	935	151.9	18.99	<.0001	<.0001

Type 3 test of fixed effect for LogCPUE with positive

Effect	DF	DF	F Value	Pr > F
year	36	416	3.17	<.0001
month	3	416	86.32	<.0001
area	4	416	7.55	<.0001
nhbf	8	30000	8.76	<.0001

a) Updated standardized CPUE to 2012FY: Northeast Atlantic

Type 3 test of fixed effect for proportion of positive catch

Effect	DF	DF	Chi-square	F Value	Pr > ChiSq	Pr > F
year	22	219	218.8	9.95	<.0001	<.0001
month	3	219	152.79	50.93	<.0001	<.0001
area	3	219	29.99	10	<.0001	<.0001
nhbf	1	136	9.61	9.61	0.0019	0.0024

Type 3 test of fixed effect for LogCPUE with positive

Effect	DF	DF	F Value	Pr > F
year	22	209	10.37	<.0001
month	3	209	35.03	<.0001
area	3	209	1.63	0.1833
nhbf	1	65000	17.58	<.0001

b) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N

Type 3 test of fixed effect for proportion of positive catch

Effect	DF	DF	Chi-square	F Value	Pr > ChiSq	Pr > F
year	5	8	2.12	0.42	0.8319	0.8198
month	2	8	2.45	1.23	0.2931	0.3428
area	1	8	16.2	16.2	<.0001	0.0038
nhbf	2	11	0.92	0.46	0.6321	0.6437

Type 3 test of fixed effect for LogCPUE with positive

Effect	DF	DF	F Value	Pr > F
year	5	7	0.47	0.7876
month	2	7	0.09	0.9119
area	1	7	12.47	0.0096
nhbf	2	408	1.1	0.3323

b) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N and 60-80W)

Type 3 test of fixed effect

Effect	DF	Type III SS	Mean Square	F Value	Pr > F
year	17	10425.44	613.26	316.62	<.0001
month	1	1272.05	1272.05	656.76	<.0001

d) Standardized CPUE using selected high nominal CPUEs in the Northeast Atlantic

Type 3 test of fixed effect

Effect	DF	Type III SS	Mean Square	F Value	Pr > F
year	19	408.06	21.48	112.07	<.0001
month	2	22.71	11.36	59.26	<.0001
area	3	12.12	4.04	21.07	<.0001
npb	1	0.01	0.01	0.05	0.82
month*are	6	24.63	4.11	21.42	<.0001

Table 6. Nominal CPUE, number of sets, and abundance index statistics for base CPUE series (updated standardized CPUE to 2011FY) in the West and Northeast Atlantic.

West Atlantic

Year	Sets	Nominal CPUE	Lower 95% CI	Upper 95% CI	Std. CPUE	CV
1976	1143	3.162	0.099	0.494	0.657	0.418
1977	1787	6.412	0.541	1.234	2.424	0.208
1978	1497	4.091	0.234	0.698	1.200	0.278
1979	2368	1.308	0.171	0.448	0.822	0.244
1980	2455	2.334	0.340	0.759	1.508	0.202
1981	4282	2.997	0.477	0.871	1.912	0.151
1982	2927	0.693	0.150	0.387	0.715	0.241
1983	2320	0.520	0.055	0.202	0.313	0.334
1984	1963	1.738	0.211	0.494	0.958	0.215
1985	2573	2.924	0.243	0.554	1.089	0.209
1986	1933	0.399	0.009	0.081	0.081	0.586
1987	2583	1.841	0.144	0.406	0.717	0.264
1988	2775	2.109	0.245	0.550	1.089	0.204
1989	2623	1.145	0.201	0.468	0.910	0.214
1990	2506	1.072	0.157	0.409	0.752	0.242
1991	1651	0.988	0.152	0.422	0.752	0.259
1992	1371	1.854	0.254	0.589	1.148	0.212
1993	1682	1.241	0.245	0.600	1.138	0.226
1994	1535	2.114	0.229	0.546	1.050	0.219
1995	565	1.046	0.151	0.466	0.788	0.286
1996	479	4.150	0.524	1.164	2.317	0.202
1997	819	2.325	0.299	0.801	1.453	0.250
1998	1185	1.413	0.132	0.402	0.684	0.284
1999	1272	1.178	0.139	0.453	0.744	0.302
2000	1266	1.495	0.186	0.531	0.934	0.266
2001	1217	0.704	0.095	0.428	0.597	0.391
2002	2190	0.560	0.131	0.422	0.697	0.299
2003	768	0.869	0.108	0.484	0.679	0.387
2004	825	2.051	0.099	0.424	0.608	0.376
2005	1775	1.209	0.159	0.382	0.732	0.222
2006	1065	1.596	0.274	0.666	1.268	0.225
2007	370	5.224	0.421	1.025	1.950	0.225
2008	242	1.454	0.130	0.516	0.768	0.356
2009	54	2.200	0.329	1.199	1.864	0.332
2010	146	0.343	0.117	0.470	0.696	0.358
2011	285	5.211	0.625	1.599	2.967	0.238

Northeast Atlantic

Year	Sets	Nominal CPUE	Lower 95% CI	Upper 95% CI	Std. CPUE	CV
1990	619	0.840	0.046	0.162	0.364	0.325
1991	2522	0.901	0.063	0.186	0.459	0.276
1992	4358	1.065	0.133	0.257	0.783	0.166
1993	4173	0.951	0.138	0.238	0.767	0.138
1994	2596	1.496	0.157	0.298	0.914	0.161
1995	1618	1.724	0.174	0.298	0.963	0.136
1996	3041	2.520	0.466	0.785	2.560	0.131
1997	5384	1.332	0.297	0.497	1.626	0.129
1998	6268	0.960	0.147	0.278	0.854	0.161
1999	5522	1.031	0.213	0.384	1.210	0.148
2000	6976	1.025	0.230	0.367	1.230	0.117
2001	5532	1.359	0.270	0.440	1.458	0.122
2002	4083	0.859	0.205	0.339	1.116	0.126
2003	3564	1.141	0.204	0.360	1.146	0.143
2004	6124	0.976	0.193	0.309	1.034	0.118
2005	6591	0.763	0.140	0.222	0.745	0.116
2006	5091	0.952	0.164	0.260	0.874	0.116
2007	3163	0.976	0.169	0.269	0.902	0.116
2008	2736	1.320	0.198	0.314	1.055	0.116
2009	3044	2.025	0.292	0.462	1.553	0.115
2010	1482	3.516	0.461	0.774	2.527	0.130
2011	679	4.614	0.714	1.400	4.232	0.169

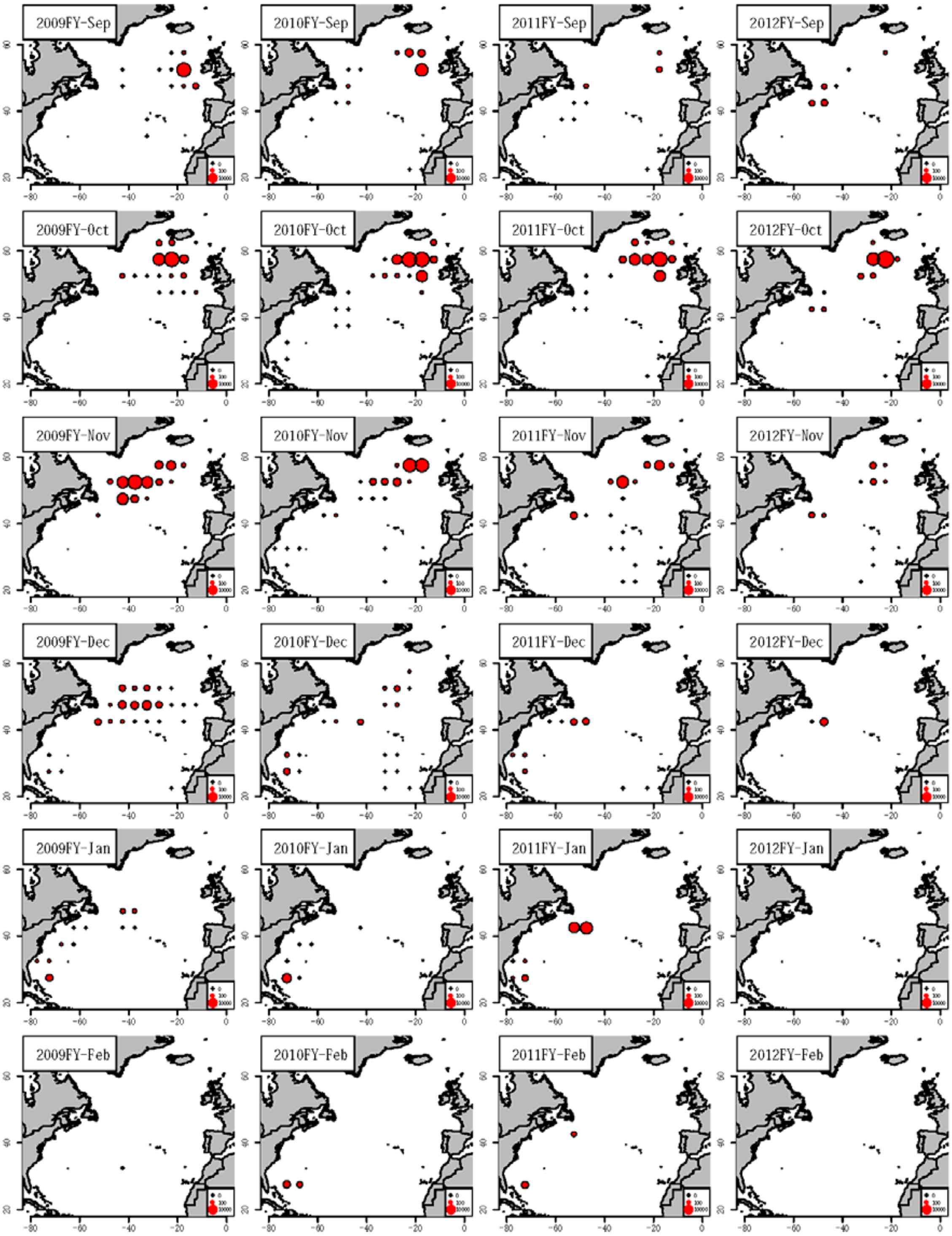


Figure 1. Monthly distributions of accumulative bluefin catch by Japanese longliners by 5x5 degree area in the main season (September-February: top to bottom) in the period between 2009 and 2012 FYs (left to right).

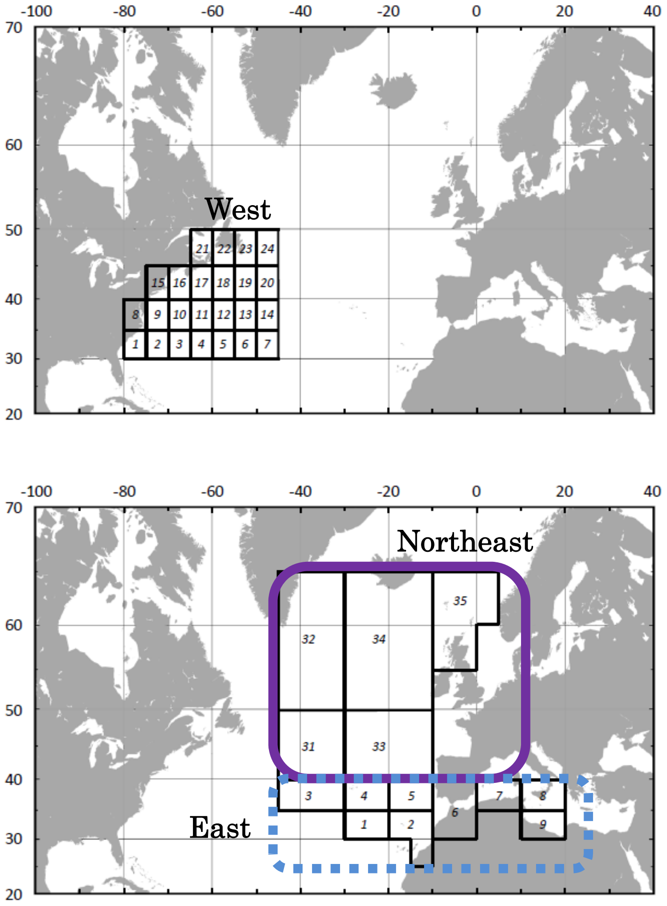


Figure 2. Areas considered in the CPUE standardization. Upper panel indicates area stratification used for the West Atlantic. Lower panel shows the same information for the Northeast and East Atlantic for the east stock. Numbers from 31 through 35 and from 1 through 9 denote for these area, respectively. Numbers indicate original area stratification used in Tables 1-3.

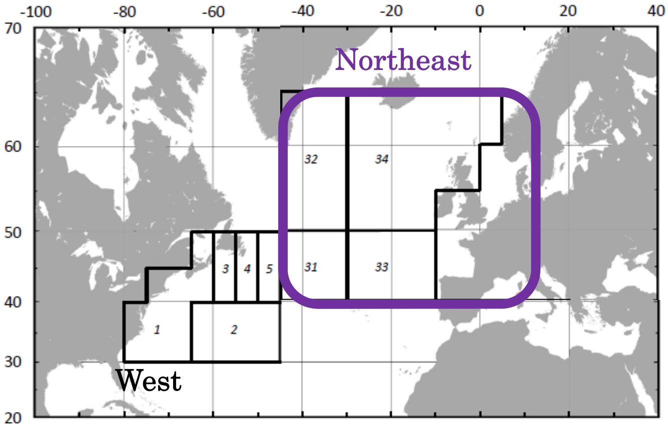
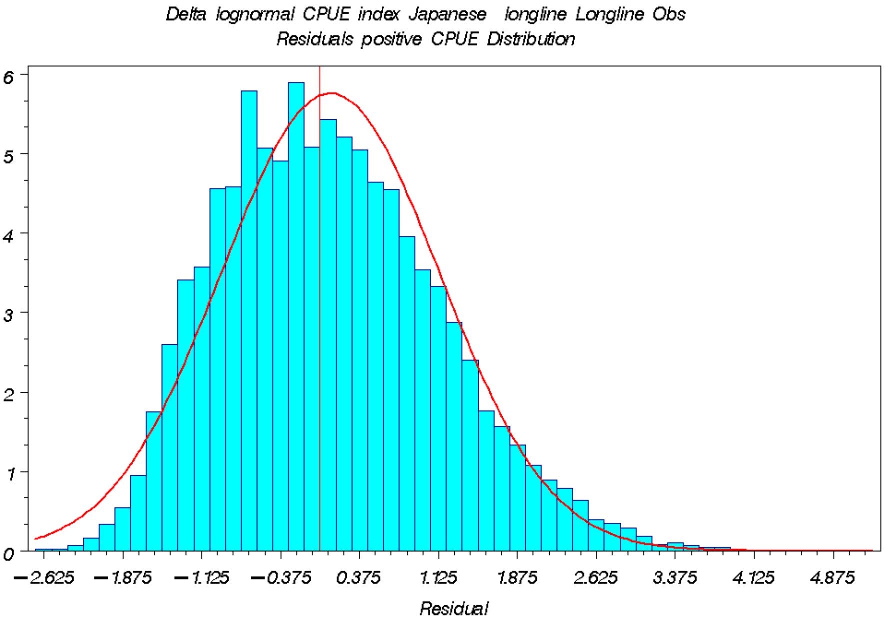


Figure 3. Combined areas used in the CPUE standardization for the West and the Northeast Atlantic. Numbers from 1 through 5 and from 31 through 34 denote for the West and the Northeast Atlantic, respectively.

1. Base CPUE series (updated standardized CPUE to 2011FY)

West Atlantic



Northeast Atlantic

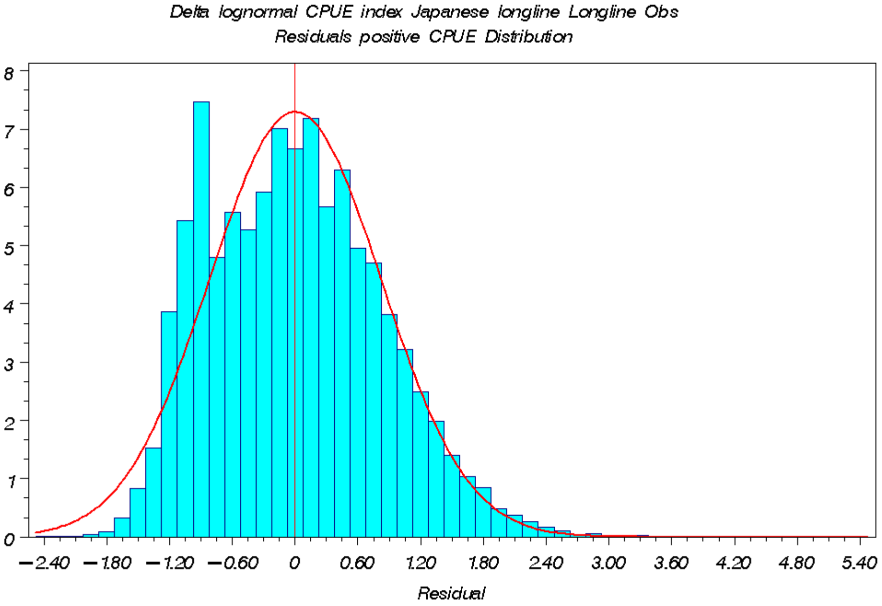
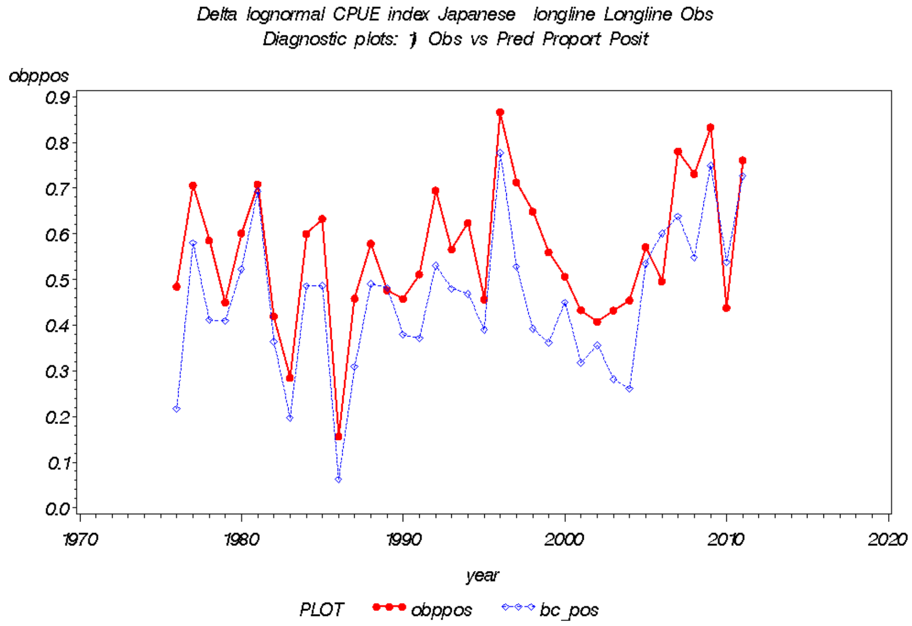


Figure 4. Residual distributions in the 2nd steps of CPUE standardization with positive catch for the CPUE series up to 2011FY (1. Base CPUE series). Upper panel, West Atlantic; lower panel, Northeast Atlantic.

1. Base CPUE series (updated standardized CPUE to 2011FY)

West Atlantic



Northeast Atlantic

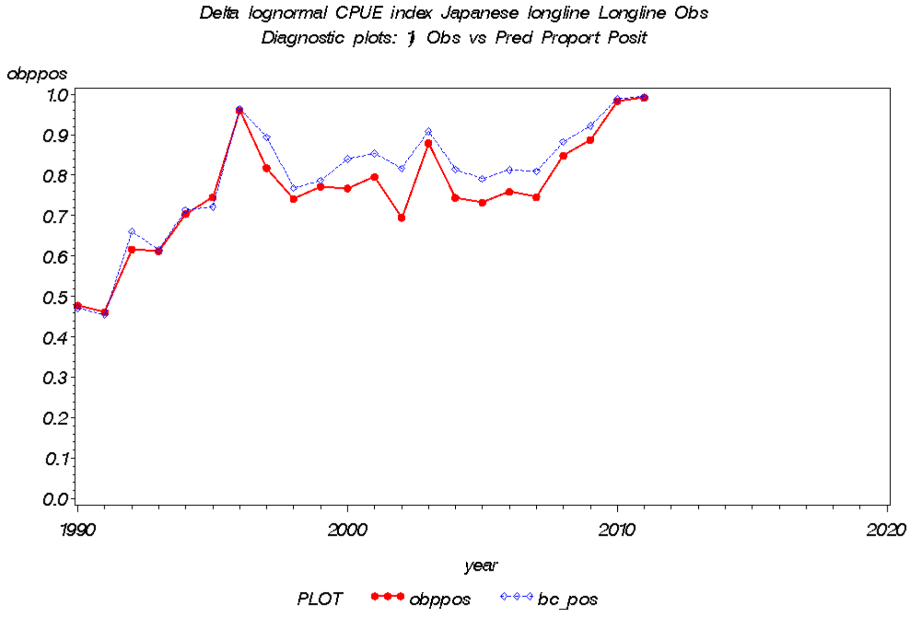
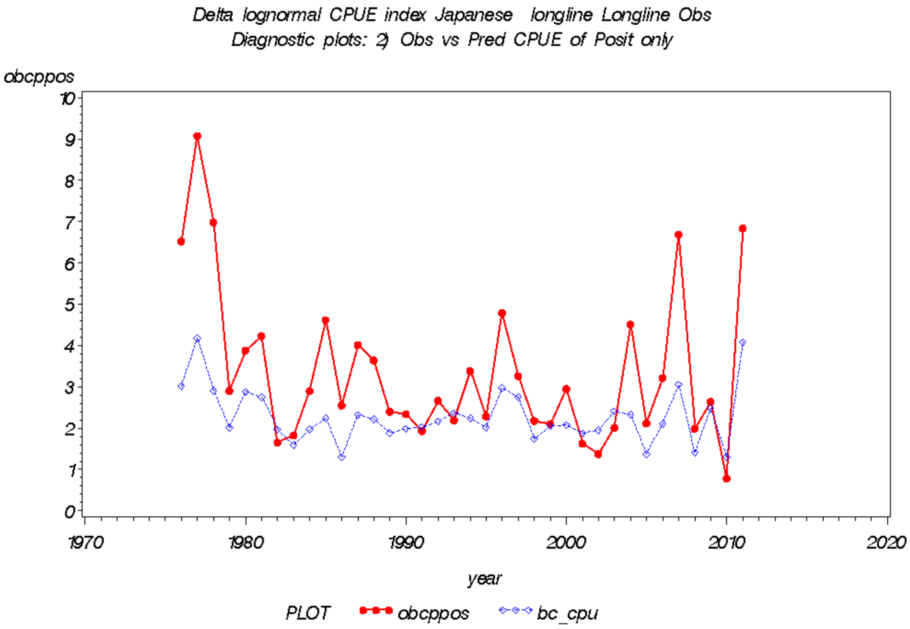


Figure 5. Observed and predicted proportion of positive catch observation for the CPUE series up to 2011FY (1. Base CPUE series). Upper panel, West Atlantic; lower panel, Northeast Atlantic.

1. Base CPUE series (updated standardized CPUE to 2011FY)

West Atlantic



Northeast Atlantic

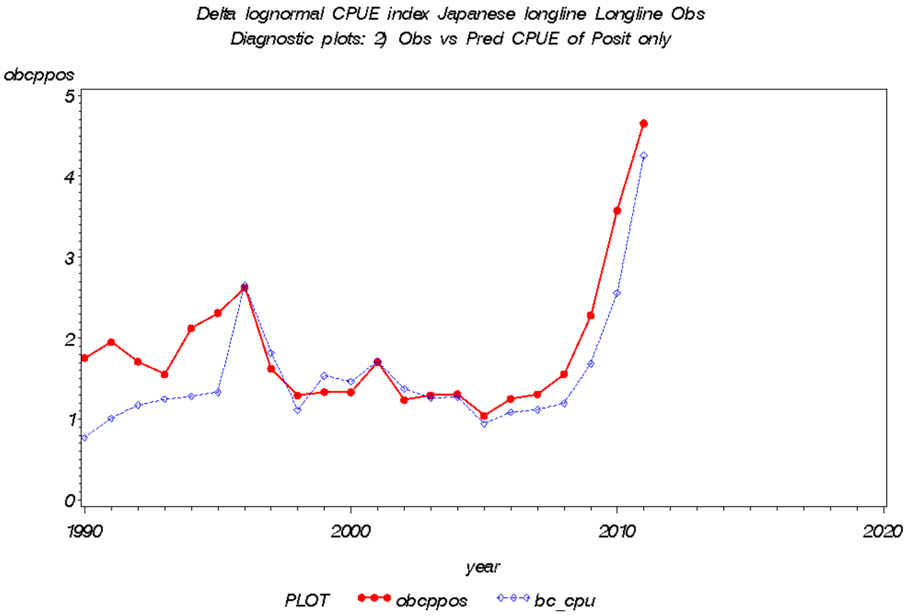
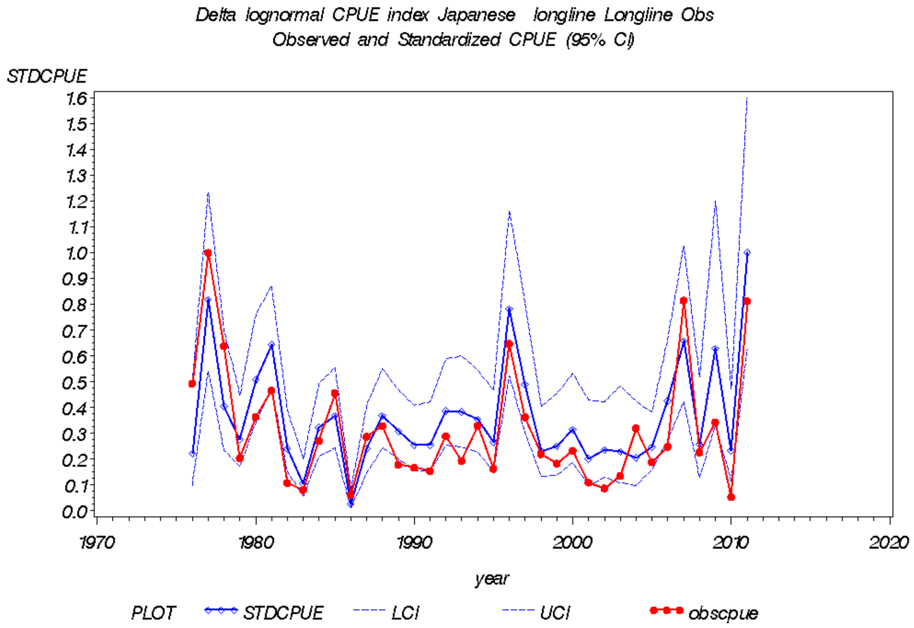


Figure 6. Observed and predicted CPUE of positive catch set for the CPUE series up to 2011FY (1. Base CPUE series). Upper panel, West Atlantic; lower panel, Northeast Atlantic.

1. Base CPUE series (updated standardized CPUE to 2011FY)

West Atlantic



Northeast Atlantic

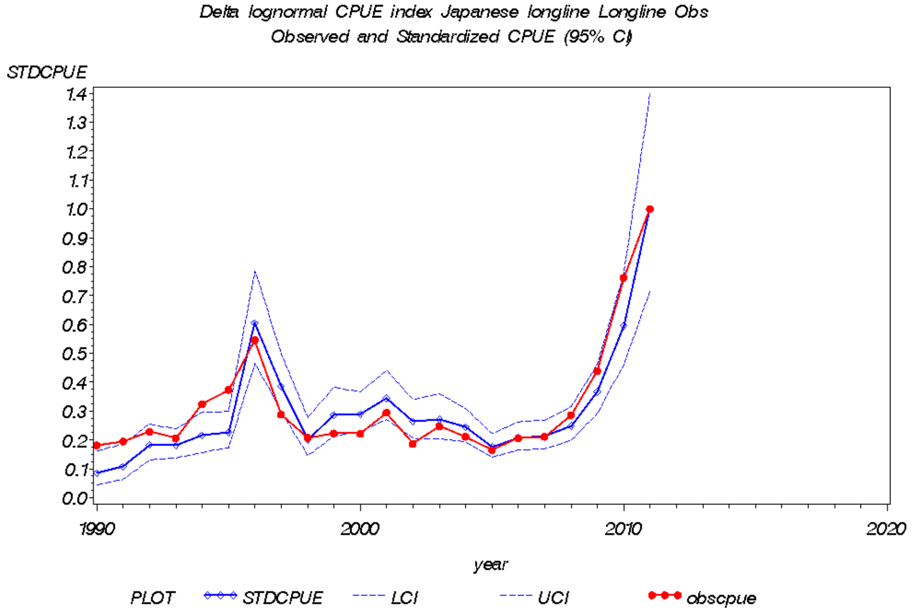


Figure 7. Standardized CPUE with 95% confidence intervals and nominal CPUE for the CPUE series up to 2011FY (1. Base CPUE series). Upper panel, West Atlantic; lower panel, Northeast Atlantic.

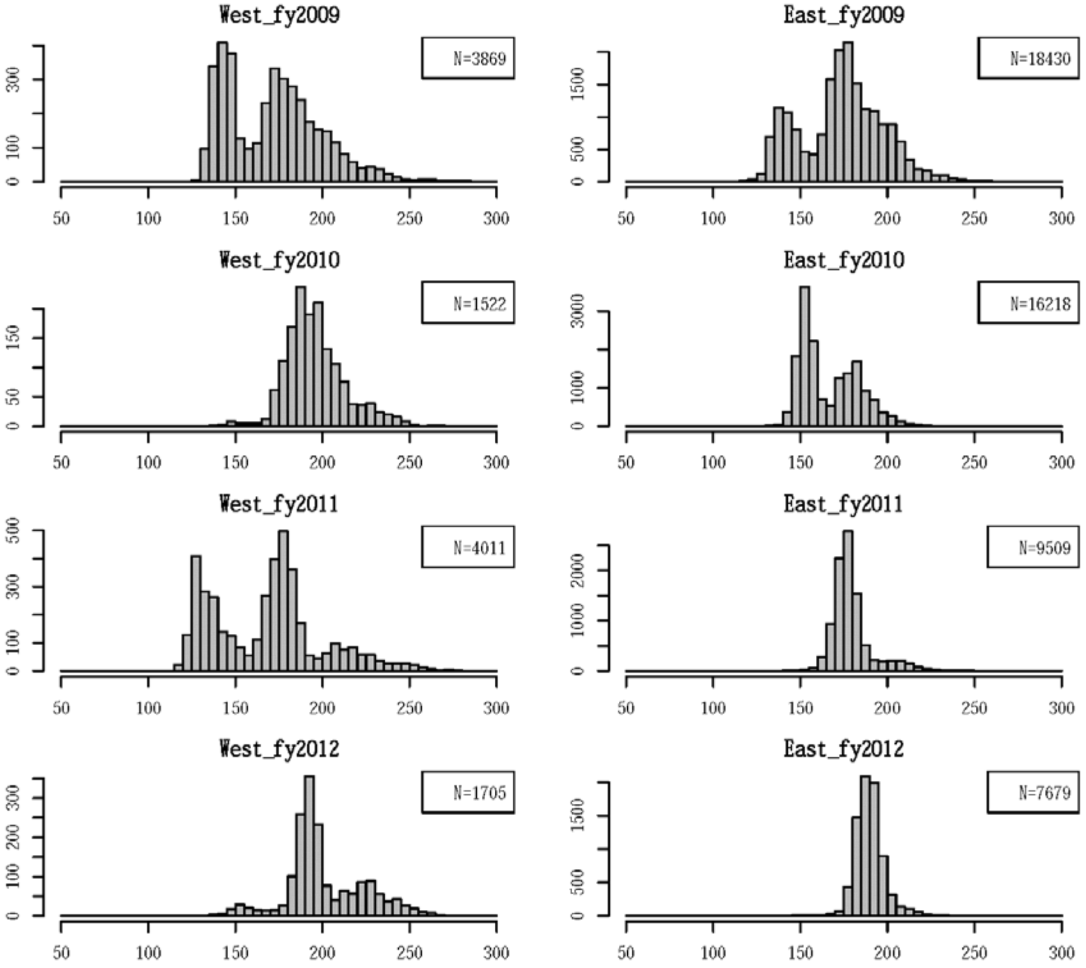


Figure 8. Converted fork length frequencies using the length-weight conversion factors (Anon, 2011) from 2009 to 2012FY measured by on board size measurement program in the west Atlantic (left panel) and the Northeast Atlantic (right panel).

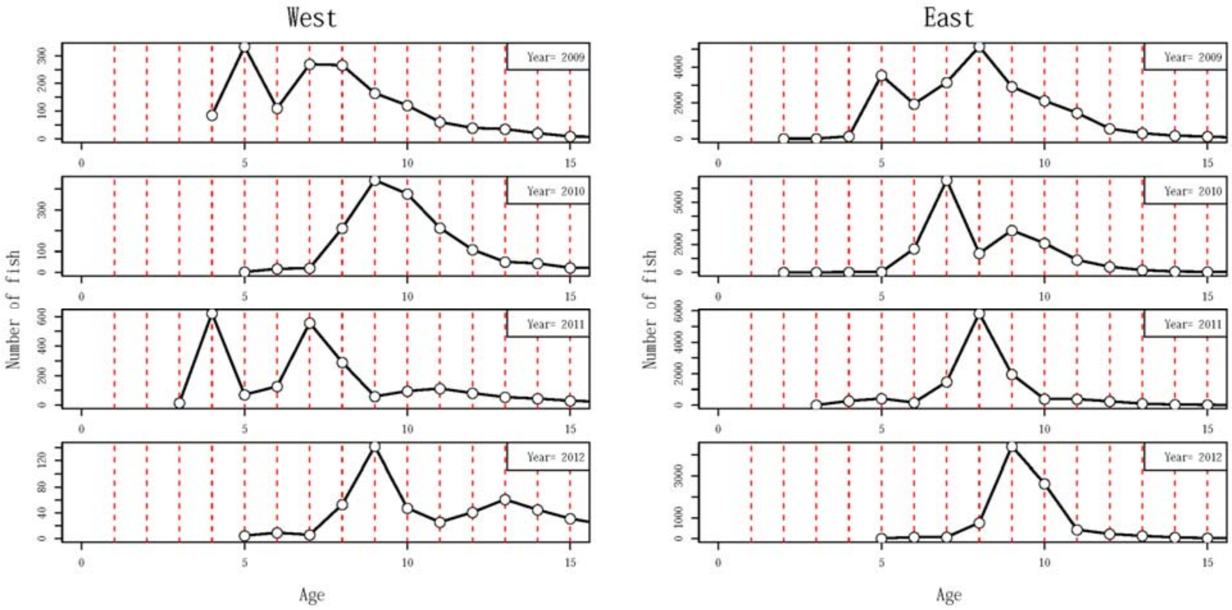


Figure 9. Catch at age was estimated for 2009 through 2012FYs from the converted size data in the West (right panel) and Northeast Atlantic (left panel), applying slicing procedures to the size frequencies of bluefin caught by the Japanese longliners.

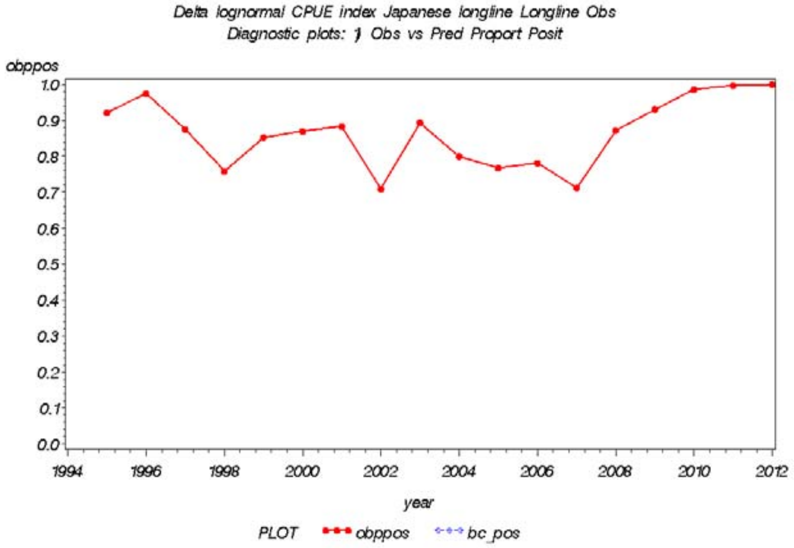
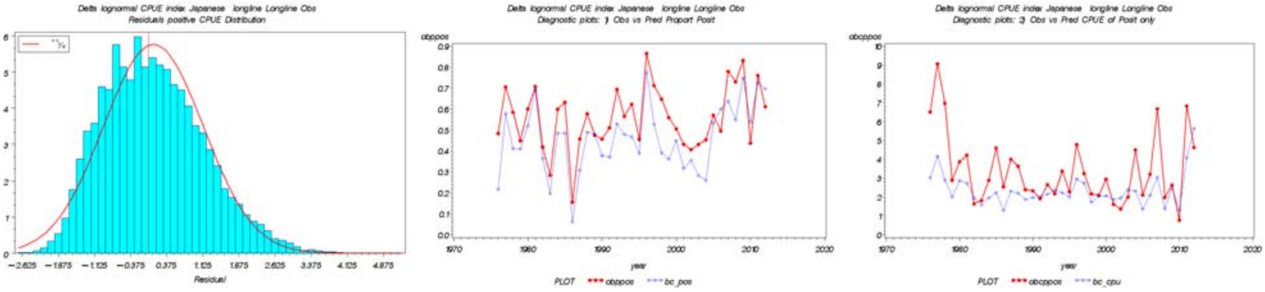


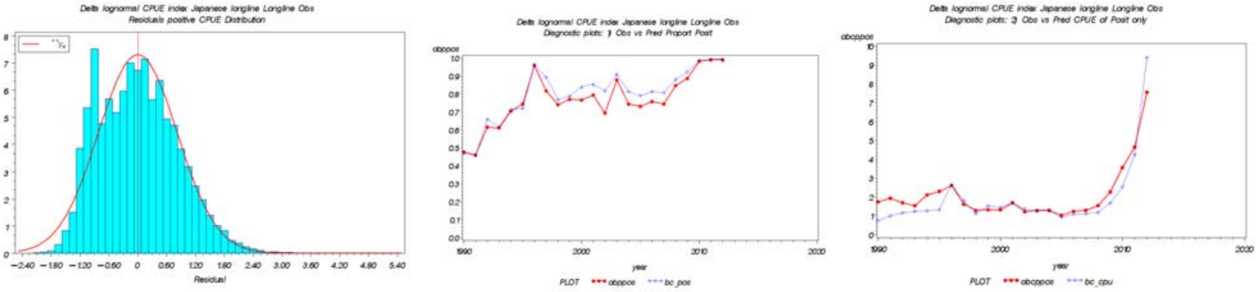
Figure 10. Observed proportion of positive catch observation for the CPUE series in the areas BFT 53 and 54 (mainly north of 53: 50-60N and 15-35W) (2-c. Alternative CPUE series).

2. Alternative CPUE series

a) Updated standardized CPUE to 2012FY: West Atlantic



b) Updated standardized CPUE to 2012FY: Northeast Atlantic



c) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N and 60-80W)

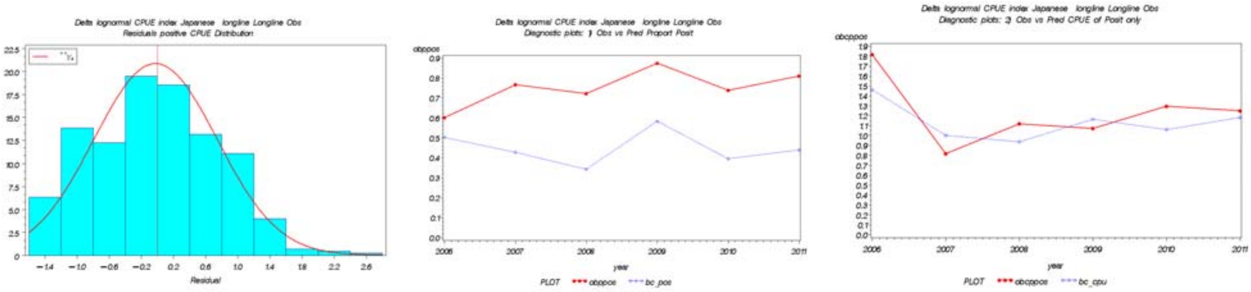
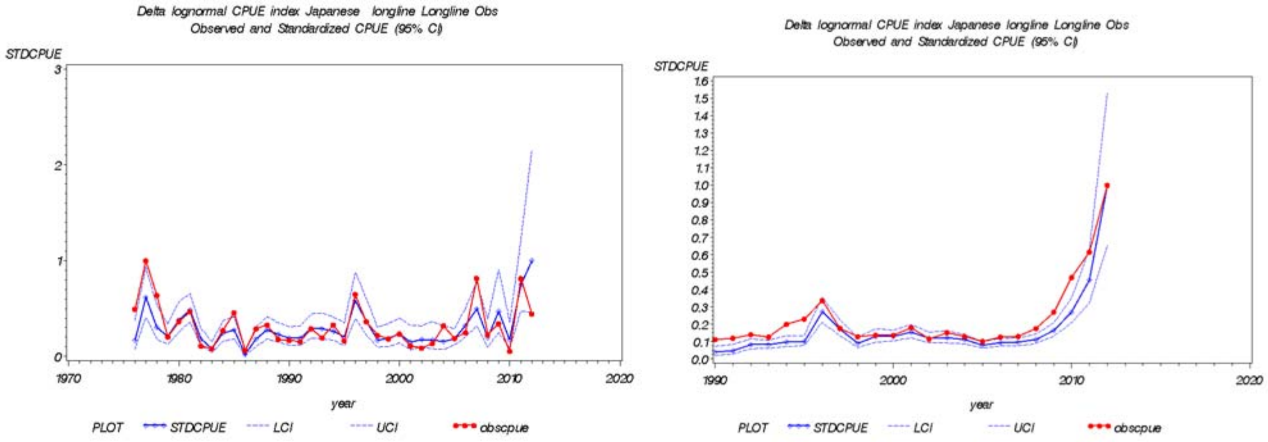


Figure 11. Residual distributions in the 2nd steps of CPUE standardization with positive catch (left), observed and predicted proportion of positive catch observation (middle), and observed and predicted CPUE of positive catch set (right) for the alternative CPUE series using delta-lognormal model. Upper panel: 2-a) up to 2012FY in the West Atlantic; middle panel: 2-a) up to 2012FY in the Northeast Atlantic; and lower panel: 2-b) in the areas BFT55 and 61(mainly 61: 25-35N and 60-80W).

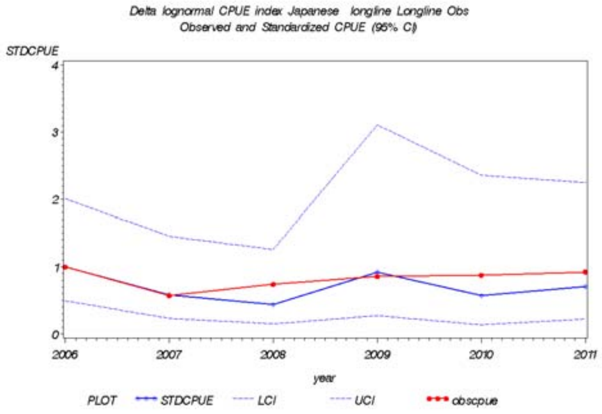
3. Alternative CPUE series

a) Updated standardized CPUE to 2012FY: West (right) and Northeast Atlantic (left)

West Atlantic ***Northeast Atlantic***



b) Standardized CPUE in the areas BFT 55 and 61 (mainly 61: 25-35N and 60-80W)



c) Standardized CPUE in the areas BFT 53 and 54 (mainly north of 53: 50-60N and 15-35W) (left)

d) Standardized CPUE using selected high nominal CPUEs in the Northeast Atlantic (right)

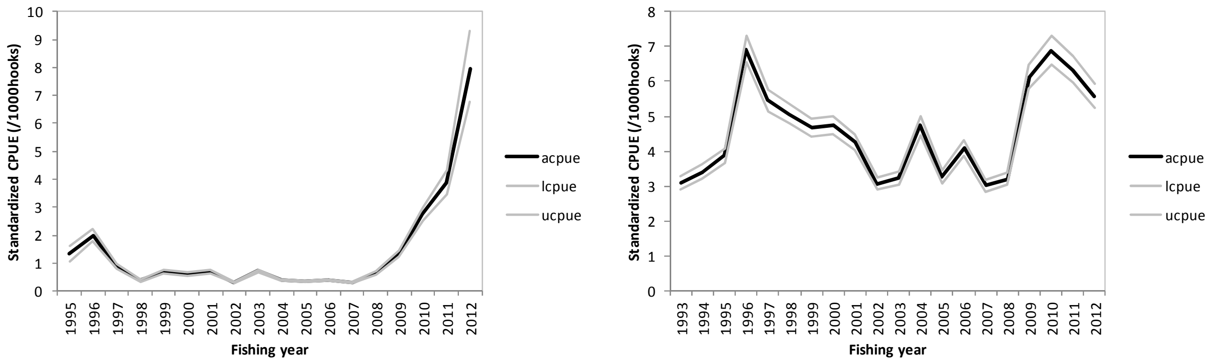


Figure 12. Standardized CPUE with 95% confidence intervals and nominal CPUE for the alternative CPUE series.