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UPDATED STANDARDIZED CATCH RATES IN NUMBER OF FISH BY AGE FOR THE NORTH ATLANTIC SWORDFISH (*XIPHIAS GLADIUS*) INFERRED FROM DATA OF THE SPANISH LONGLINE FLEET DURING THE PERIOD 1982-2023

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SUMMARY

Standardized catch rates in number of fish for ages specific 1-5+ during a period of 42-years were updated using log-normal General Linear Model (GLM) from 12,283 trips (148,481 fishing days) of the Spanish surface longline fishery targeting swordfish in the North Atlantic stock. The criteria used to define areas, times and models was similar to that used in recent analyses. The models also take into consideration the longline style and a target variable to consider for the two most important changes in fishing strategy. The models explained between 42%-47% of CPUE variability. The results for age-1 indicate a very positive phase of recruitment from 1997 onwards, with a global mean around twice as high as relative abundance compared to the level of the initial period 1982-1996. This level of recruitment will have a positive effect on the population dynamics of the remaining age classes.

RÉSUMÉ

Les taux de capture standardisés en nombre de poissons, pour les âges spécifiques de 1 à +5, pendant une période de 42 ans ont été actualisés en utilisant un modèle linéaire généralisé log-normal (GLM) à partir de 12.283 sorties de pêche (148.481 jours de pêche) de la pêcherie palangrière de surface espagnole ciblant l'espadon dans l'Atlantique Nord. Les critères utilisés pour définir les zones, périodes et modèles étaient similaires à ceux utilisés dans les récentes analyses. Les modèles tiennent également compte du style de palangre et d'une variable de ciblage pour étudier les deux changements les plus importants dans la stratégie de pêche. Les modèles expliquaient entre 42% et 47% de la variabilité de la CPUE. Les résultats pour l'âge 1 indiquent une phase de recrutement très positive à partir de 1997, avec une moyenne globale de deux fois plus élevée environ que l'abondance relative par rapport au niveau de la période initiale 1982-1996. Ce niveau de recrutement aura un effet positif sur la dynamique de la population des autres classes d'âge.

RESUMEN

Se actualizaron para un periodo de 42 años las tasas de captura estandarizadas, en número por edad 1-5+, mediante modelos lineales generalizados (GLM) con un enfoque lognormal a partir de 12.283 mareas (148.481 días de pesca) de la flota española de palangre de superficie dirigida al pez espada en el stock del Atlántico norte. El criterio para definir áreas, periodos y modelos fue similar al usado en recientes análisis. Los modelos también tomaron en consideración el estilo de palangre y una variable de especie objetivo para considerar los dos cambios más importantes en la estrategia de pesca. Los modelos explicaron entre el 42 %-47 % de la variabilidad de la CPUE. Los resultados de la edad-1 indican una fase de reclutamiento muy positiva a partir de 1997, con una media global en torno al doble de la abundancia relativa en comparación con el nivel del periodo inicial 1982-1996. Este nivel de reclutamiento tendrá un efecto positivo en la dinámica poblacional de las restantes clases de edad.

KEYWORDS

Swordfish; age specific CPUE; GLM; longline

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1. Introduction

Data collected since the eighties for scientific purposes from the commercial Spanish surface longline fishery targeting swordfish had been used to develop GLM standardized catch per unit effort for the North Atlantic swordfish stock using methods recommended by several authors and the ICCAT method working groups (Anon. 1989, 2001, 2010, 2014, Gavaris 1980, Kimura 1981, Robson 1966). Some of these indicators considered reliable have been selected and implemented as input parameters for the assessments of North Atlantic swordfish stock.

The surface longline gear of the Spanish fleet targeting swordfish remained relatively constant over last decades of the twentieth century in terms of structure and gear configuration (Rey *et al.* 1988, Hoey *et al.* 1988, 1989). The consistency of the fishing patterns, fishing areas and gear configurations during decades facilitated the interpretation and assumption of those catch rates as indices of relative abundance from regularly broad temperate areas of the Eastern and central North Atlantic taking advantage of the geographical expansion of this fleet during the eighties. These indices have been considered as complementary to those developed for other fleets fishing swordfish between warm and temperate waters of the North-western regions.

However, important changes in the fishing strategy and gear 'style' of the Spanish fleet have been introduced and scientifically reported in several documents since the end of the past century. The monofilament mainline so-called 'American style' longline (originally based on the 'Florida style longline') was widely introduced in the Spanish Atlantic fleet at the end of the past century and most vessels have been fishing with this gear style since then. The gear styles were already implemented in the most recent GLM runs (Mejuto and De la Serna 2000, Mejuto *et al*. 2003, García-Cortés *et al.* 2014, 2017, Ramos-Cartelle *et al.* 2021[a]).

On the other hand, the targeting criteria of the Spanish longline fleet fishing on the North Atlantic stock was historically based on targeting swordfish. But this strategy has later become more diffuse when swordfish quotas per vessel and frozen systems were introduced onboard instead of ice in most boats, focusing the trips on a combination of both swordfish and blue shark as the main abundant, full retained and valuable species; as it was also observed and reported to the SCRS for these or other groups of species in the case of several North and South Atlantic surface longline fleets (e.g. sharks, tuna vs. swordfish). The impact of these changes on the nominal and standardized CPUE of the Spanish fleet have been significant as described in literature and compared with results obtained using other approaches (Anon. 2001, Mejuto and De la Serna 1997, 2000, Mejuto *et al.* 1998, 1999, 2001, 2002). Most of these new factors had already been considered in the age-aggregated CPUE standardizations previously presented. However, the new events occurring in the most recent periods had not been taken into account in age-specific CPUE analyses of the Spanish longline fleet until recent contributions and the respective stock assessments (Mejuto *et al*. 2014, 2017, 2021).

Abundance indices in number of fish by age (or age proxies) had been featured by several authors in the past, presented and considered in some assessments of the northern swordfish stock. Those age-standardized indices had been available and useful until the 2009 assessment based on respective data from several longline fleets, such as the USA (Ortiz 2010), Canada (Paul and Neilson 2010), and Spain (Mejuto 1993). Certainly, the data available from some of these fleets perhaps did not achieved requirement for this type of analysis by age since in some cases the length-ages modelled came from low sampling coverage and/or from substitution of the length-age distributions among observations modelled. Additionally, in subsequent assessments of this stock, the priority given to Bayesian production models led most of those authors to stop updating their indices by age since - in addition to the possible existing qualitative limitations in some data - the working groups did not consider relevant those indices by age. It was generally decided to prioritize and recommend that authors develop standardized indices age-combined. As a consequence of all these events and other possible limitations, only the index in number of fish by 'age' of the Spanish fleet have remained updated and reported to the SWO species group after the 2009 assessment (Mejuto *et al.* 2014, 2017, 2021).

A voluntary and fruitful collaborative action between scientists from the USA and Spain began in 1988 (Hoey *et al.* 1989). A biomass index for both fleets combined was developed over the years considering those factors that contributed significantly to the variability of the CPUE observed in the respective fleets; including factors such as the longline styles and gear configurations, as well as respective changes in targeting described in literature. Other co-authors from the USA, Canada, Japan, Portugal and Morocco later joined this collaborative and voluntary action. This combined index has been used as a model input since the 1990s and was a collaborative effort between scientists from several countries. The last work under this methodological approach was presented in 2017 (Ortiz *et al.* 2017).

In the most recent assessment of this stock (Anon. 2022), a new combined fleet index was developed from the mandatory Task 2 provided to ICCAT by the contracting parties (Gillespie *et al.* 2022). The 2022 version of the combined index included catch and effort information from seven ICCAT longline fleets: EU-Spain, United States, Canada, Japan, EU-Portugal, Morocco and Chinese Taipei, which represented over 90% of annual swordfish catch reported to ICCAT of the northern stock. The 2022 version of this index was used as an indicator in recent surplus production models and there is interest in its potential use as an indicator for a model-based MP in the N-SWO management strategy evaluation. This index is currently considered a priority for the assessments of this stock and MSE processes.

In that sense, the objectives of the MSE 2024 meeting were established: i) for the SCRS to provide updates on development of the 2022 North Atlantic swordfish *combined index*; ii) for the SCRS to present early results from updates to the candidate management procedures (CMPs) and associated robustness tests; and iii) for Panel 4 and the SCRS to discuss development of an Exceptional Circumstances Protocol.

Despite the proposed work plan, the North Atlantic swordfish MSE Technical Subgroup determined at its last meeting in June 2024, that the standardized CPUEs used for the operating models (OM) need to be updated and it requested the authors of the papers to update their respective abundance indices presented in the last North Atlantic swordfish stock assessment with data up to 2023 and to anticipate those results. The present indices by 'age' were updated and already advanced to the MSE Technical Subgroup at mid-July 2024. In response to that request from the North Atlantic MSE Subgroup to update the age-specific index presented in the last North Atlantic swordfish stock assessment (Mejuto *et al.* 2021), the aim of the present paper is to report our age-specific standardized CPUE by adding information from the most recent years, including 2023 data. So, the present index by age is covering 42 years of scientific data.

2. Material and methods

The trip data used were obtained from the landings of the Spanish longline fleet fishing in the North Atlantic swordfish stock over a period of 42 years (1982-2023). The methods and specifications used in this paper have aimed to be consistent as far as possible with previous analyses in order to facilitate comparison with earlier results. The two most important events were also taken into account in these analyses: (a) the introduction of a monofilament gear style (American style) and (b) the changes over time in the targeting criteria of this fleet compared to the historical decades reported.

The analysis of standardized CPUE by age (number of fishes per thousand hooks) was developed using the methods traditionally applied in the ICCAT swordfish working groups and reported in previous papers (Mejuto 1993, 1994, Mejuto and De la Serna 1995, 1997, 2000, Mejuto *et al*. 1998, 1999, 2003, 2014, 2017, 2021). The sex-combined Gompertz's type growth model recommended and assumed by ICCAT based on tagging-recapture data (Anon. 1989) was used to obtain the number of fish by age (ages 1 to 5+) from catch size data sampled per trip. Conversion from size to 'age' was carried out using the ICCAT software 'aging' implemented in the North Atlantic swordfish stock, but also in other species-stock assessments. Trips with size-sampling coverage below 85% of the total catch in number of fish landed were excluded from the GLM analysis, as in previous papers.

The 'type of trip' or fishing strategy for the targeting, the gear style and the bait used were also considered in the modelling. The 'type of trip' was categorized as the percentage (ratio variable) in weight of swordfish landed per trip in relation to the amount of combined swordfish and blue shark landed, that indicates the prioritization followed by the skippers during the trips. After analyzing the behaviour of this fleet over time and assessing the impact of this variable within the nominal CPUE and the models, it was concluded that this ratio was the best proxy indicator for the skippers' targeting criteria belonging to this fleet over time (Mejuto and De la Serna 2000, Ortiz *et al.* 2010) and performed best among the different proxies simulated by the ICCAT methods working group-WGSAM (Anon. 2001). The 'ratio' was broken down into ten categories at 10% intervals for modelling the levels of type of trip.

The definition corresponding to 'quarter' was as follows: Q1 = January, February, March; Q2 = April, May, June; Q3 = July, August, September; Q4 = October, November and December. Three gear styles were defined: 1 = traditional multifilament mainline, 3 = new monofilament and 9 = unknown. Three bait types were also considered: 1 = mackerel, 6 = squid and 9 = other types or combinations. The spatial definition used for final runs considered five areas as in previous analyses by age (Mejuto *et al.* 2014, 2017, 2021) and was also considered in overall number of fish and biomass GLM analyses for this fleet (García-Cortés *et al.* 2014, 2017, Ramos-Cartelle *et al.* 2021[a], 2021[b]).

The standardized log-normal CPUE analyses were performed using GLM procedures (*SAS 9.4 ver*.). The models were defined as: Ln (CPUE) = u + Y + Q + A + G + B + R + Q*A + e. Where: u = overall mean, Y = year effect, Q = time effect (quarter), A = area effect, G = gear style effect, B = bait type, R = 'ratio' effect, e = logarithm of the normally distributed error term. More details about the methods can be found in the papers previously cited.

Taking into consideration the history of this fishery, available literature and knowledge, the traditional gear style and mackerel as bait were assumed for all trips during the initial period 1982-1985. A ratio equal to the average observed for trips in 1986 was retrospectively applied to all trips in the 1982-1985 period.

In the present and previous papers no substitution procedures of size information among trips were implemented and a very demanding criterion of minimum sampling coverage per trip was selected for the runs.

3. Results and discussion

A total number of 12,283 trip-observations (266.249 million hooks, 148,481 fishing days) from the whole period 1982-2023 fulfilled the demanding size-coverage and other criteria established for the analyses. **Table 1** is a summary of the ANOVA results for each age-specific analysis. The models by age explained between 42% and 47% of the variability in CPUE.

Table 2 shows the estimated parameters obtained from the CPUE analyses in number of fish by age. Quarter, area and gear are the most important factors in explaining the variability of the age 1 CPUE. The year variable also seems to be relatively important for age 1 suggesting that inter-annual variability plays a relatively important or moderate role. Area, gear and ratio are the main factors for age 2. But gear and ratio are regularly the most important factors for main target ages along with the area or quarter factors. Type III SS suggests a different ranking of factors for the different ages, as would be expected in a species segregated in some extend according to the size-age. The bait factor regularly explained a minor or negligible part of the CPUE variability or was not significant for any age.

Figures 1 and **2** represent the normal fit, the frequency distribution of the standardized residuals and the normal probability *qq-plot* diagnosis of the GLM runs for standardized CPUE in number of swordfish by age. **Figure 3** presents the variability box-plot of the standardized residuals by year for each age.

Table 3(a-e) provides information on estimated parameters, their standard error, standardized CPUE by age and upper and lower 95% confidence limits obtained for the runs. The mean standardized CPUE figures by age and their 95% confidence intervals are plotted (**Figure 4)**.

Given the huge difficulty in obtaining highly representative CAS data by trip over almost four decades and obtaining the CAA using the sex-combined growth model from tagging-recapture data, as recommended and assumed by ICCAT for North Atlantic swordfish (Anon. 1989), these CPUE indicators by 'age' obtained through slicing methods or other alternative methods also tested, could also help to better understand stock dynamics and interpret those trends observed in the age-combined CPUE of each fleet, and between fleets. The present 'age' analyses, despite their limitations and difficulties, may be useful in some cases at least as complementary information to be considered as long as the CAS data are qualitatively adequate and are not affected by size-substitution among the observations used in the analyses or affected by lack of size data or bias (Mejuto *et al.* 2021).

The updated CPUEs in this study could be considered as indicators of the abundance of the most prevalent age groups in this fishery during the period analysed. Some of the national measures adopted since the first ICCAT minimum size recommendations came into force have had different effects on the fleets, and therefore different effects on the data by fleet should be expected.

However, the strict coverage requirements established for the present analysis have considerably reduced the number of observations available after 2011 because of changes in landing procedures and other limitations. Accordingly, the authors place more reliance on age-specific abundance indicators prior to 2012. Age 1 CPUE values for the most recent periods should be treated with caution as they are likely to be underestimated. A more detailed discussion about the size-sampling coverage, targeting criteria, and other aspects of the analysis, is described in previous papers (Mejuto *et al.* 2017, 2021). Environmental considerations related to these indices can be found in previous contributions (Mejuto *et al.* 2017).

Although age 1 CPUE values should be treated with caution for the most recent periods as they are likely to be underestimated, the whole results are suggesting that the overall mean level of annual recruitments would have been proximately around double o more since year 1996 in relation to the values during the 1981-1995 period. This positive phase had positive effects on other ages and the subsequent demographic change since mid-1990s onwards, which could be one of the main causes for explaining the different availabilities by size-age, average weights and the overall CPUEs of the different areas-fleets analyzed.

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Table 1. Summary of ANOVA analysis in number of fish by age: Number of trip-observations finally used, R-square fit, mean square error (root), F-statistics and Pr > F, for each age group considered in the ATLN.

Age	*# Observa.*	*R-Square*	*RMSE*	*F-Stat*	*Pr > F*
1	10936	0.4371	0.9755	115.52	<0.0001
2	11932	0.4670	0.7259	142.31	<0.0001
3	11902	0.4428	0.6685	128.75	<0.0001
4	11563	0.4194	0.6903	113.68	<0.0001
5+	11317	0.4534	0.7284	127.76	<0.0001

Table 2. Summary of ANOVA by factor for CPUE analysis, in number of fish by age-group in the North Atlantic stock for the 1982-2023 period.

Age	*Factor*	*DF*	*Type III SS*	*Mean-Square*	*F-value*	*Pr > F*
1	Year	41	1292.177440	31.516523	33.12	<.0001
1	Quarter	3	1084.045300	361.348432	379.71	<.0001
1	Area	4	633.410875	158.352719	166.40	<.0001
1	Gear	2	110.968824	55.484412	58.30	<.0001
1	Bait	2	21.859851	10.929925	11.49	<.0001
1	Ratio	9	371.449666	41.272185	43.37	<.0001
1	Quarter*Area	12	224.128249	18.677354	19.63	<.0001
2	Year	41	700.330270	17.081226	32.42	<.0001
2	Quarter	3	157.718336	52.572779	99.78	<.0001
2	Area	4	504.355466	126.088866	239.32	<.0001
2	Gear	2	216.641159	108.320580	205.59	<.0001
2	Bait	2	12.079571	6.039785	11.46	<.0001
2	Ratio	9	1162.859560	129.206617	245.23	<.0001
2	Quarter*Area	12	152.752650	12.729387	24.16	<.0001
3	Year	41	423.589141	10.331442	23.12	<.0001
3	Quarter	3	14.069563	4.689854	10.49	<.0001
3	Area	4	191.758022	47.939506	107.28	<.0001
3	Gear	2	263.672863	131.836431	295.01	<.0001
3	Bait	2	10.796782	5.398391	12.08	<.0001
3	Ratio	9	1349.240010	149.915557	335.47	<.0001
3	Quarter*Area	12	74.446778	6.203898	13.88	<.0001
4	Year	41	484.504157	11.817175	24.8	<.0001
4	Quarter	3	110.724617	36.908206	77.45	<.0001
4	Area	4	94.545634	23.636408	49.60	<.0001
4	Gear	2	249.393575	124.696787	261.69	<.0001
4	Bait	2	6.930161	3.465081	7.27	0.0007
4	Ratio	9	1386.959840	154.106649	323.40	<.0001
4	Quarter*Area	12	39.088022	3.257335	6.84	<.0001
5+	Year	41	702.245725	17.127945	32.29	<.0001
5+	Quarter	3	308.638216	102.879405	193.93	<.0001
5+	Area	4	331.275090	82.818772	156.11	<.0001
5+	Gear	2	154.467438	77.233719	145.59	<.0001
5+	Bait	2	4.771566	2.385783	4.50	0.0112
5+	Ratio	9	1182.005240	131.333916	247.56	<.0001
5+	Quarter*Area	12	93.217302	7.768109	14.64	<.0001

Table 3(a). Estimated parameters (Lsmean), standard error (Stderr), standardized CPUE in number by age 1 (Cpue1) and upper and lower 95% confidence limits (Ucpue1, Lcpue1) for the case base analysis of the North Atlantic for the years 1982-2023.

YR	*LSMEAN*	*STDERR*	*Ucpue1*	*Cpue1*	*Lcpue1*
1982	-1.48253	0.23054	0.366	0.233	0.148
1983	-1.02152	0.12474	0.463	0.363	0.284
1984	-1.03918	0.12464	0.455	0.357	0.279
1985	-1.05554	0.11169	0.436	0.350	0.281
1986	-0.69659	0.09566	0.604	0.501	0.415
1987	-0.25715	0.10780	0.961	0.778	0.630
1988	-0.05135	0.08924	1.136	0.954	0.801
1989	-0.22698	0.09078	0.956	0.800	0.670
1990	-0.80028	0.09169	0.540	0.451	0.377
1991	-0.90981	0.08983	0.482	0.404	0.339
1992	-0.82215	0.08825	0.525	0.441	0.371
1993	-0.62054	0.08829	0.642	0.540	0.454
1994	-0.61992	0.08636	0.640	0.540	0.456
1995	-0.57802	0.08524	0.665	0.563	0.476
1996	-0.56201	0.08557	0.677	0.572	0.484
1997	0.17329	0.08592	1.413	1.194	1.009
1998	0.04340	0.08616	1.241	1.048	0.885
1999	0.21031	0.09193	1.484	1.239	1.035
2000	0.23122	0.09142	1.514	1.265	1.058
2001	0.30378	0.08669	1.612	1.360	1.148
2002	-0.01623	0.08598	1.169	0.988	0.834
2003	-0.02106	0.09063	1.174	0.983	0.823
2004	-0.05421	0.09267	1.141	0.951	0.793
2005	-0.05849	0.09609	1.144	0.948	0.785
2006	0.35748	0.10018	1.749	1.437	1.181
2007	0.55271	0.11463	2.190	1.749	1.397
2008	0.45279	0.11660	1.990	1.583	1.260
2009	-0.34348	0.12264	0.909	0.715	0.562
2010	-0.15589	0.10720	1.062	0.861	0.697
2011	0.32447	0.10903	1.723	1.392	1.124
2012	-0.02122	0.11947	1.246	0.986	0.780
2013	-0.26673	0.12828	0.993	0.772	0.601
2014	-0.31783	0.13006	0.947	0.734	0.569
2015	0.00596	0.12192	1.287	1.013	0.798
2016	-0.31558	0.12692	0.943	0.735	0.573
2017	-0.36539	0.13656	0.915	0.700	0.536
2018	-0.35637	0.15451	0.959	0.709	0.523
2019	-0.59273	0.17055	0.784	0.561	0.402
2020	-0.43572	0.17846	0.932	0.657	0.463
2021	0.09910	0.11036	1.379	1.111	0.895
2022	-0.01354	0.13379	1.294	0.995	0.766
2023	-0.11173	0.11771	1.134	0.901	0.715

Table 3(b). Estimated parameters (Lsmean), standard error (Stderr), standardized CPUE in number by age 2 (Cpue2) and upper and lower 95% confidence limits (Ucpue2, Lcpue2) for the case base analysis of the North Atlantic for the years 1982-2023.

YR	*LSMEAN*	*STDERR*	*Ucpue2*	*Cpue2*	*Lcpue2*
1982	-0.04081	0.16395	1.342	0.973	0.706
1983	-0.18529	0.08529	0.986	0.834	0.706
1984	-0.38569	0.08283	0.803	0.682	0.580
1985	-0.03089	0.07701	1.131	0.972	0.836
1986	0.20495	0.06739	1.404	1.230	1.078
1987	0.59767	0.07755	2.123	1.823	1.566
1988	0.42489	0.06440	1.739	1.533	1.351
1989	0.56952	0.06520	2.013	1.771	1.559
1990	0.67567	0.06536	2.239	1.970	1.733
1991	0.36892	0.06421	1.644	1.449	1.278
1992	0.34419	0.06321	1.600	1.414	1.249
1993	0.35150	0.06320	1.612	1.424	1.258
1994	0.43145	0.06187	1.741	1.542	1.366
1995	0.67650	0.06090	2.220	1.971	1.749
1996	0.23665	0.06131	1.431	1.269	1.126
1997	0.40086	0.06173	1.688	1.496	1.325
1998	0.73425	0.06181	2.357	2.088	1.850
1999	0.89186	0.06592	2.782	2.445	2.149
2000	1.06564	0.06474	3.302	2.909	2.562
2001	1.02294	0.06224	3.148	2.787	2.467
2002	0.76751	0.06160	2.435	2.158	1.913
2003	0.85154	0.06581	2.672	2.348	2.064
2004	0.51004	0.06586	1.899	1.669	1.467
2005	0.54999	0.06870	1.988	1.737	1.518
2006	0.59842	0.07262	2.103	1.824	1.582
2007	0.89635	0.08292	2.893	2.459	2.090
2008	1.26888	0.08428	4.211	3.570	3.026
2009	0.98922	0.08788	3.207	2.700	2.272
2010	1.00152	0.07644	3.172	2.730	2.350
2011	0.63524	0.07678	2.200	1.893	1.629
2012	1.01820	0.08262	3.266	2.778	2.362
2013	0.68722	0.09077	2.385	1.996	1.671
2014	0.79298	0.08688	2.630	2.218	1.871
2015	1.09750	0.08450	3.549	3.007	2.548
2016	0.39503	0.08766	1.769	1.490	1.255
2017	0.43620	0.09350	1.866	1.554	1.293
2018	0.70394	0.10448	2.495	2.033	1.656
2019	1.18464	0.10921	4.074	3.289	2.655
2020	0.58026	0.11363	2.247	1.798	1.439
2021	0.66023	0.07785	2.261	1.941	1.666
2022	1.00025	0.09503	3.290	2.731	2.267
2023	0.94362	0.08630	3.054	2.579	2.178

Table 3(c). Estimated parameters (Lsmean), standard error (Stderr), standardized CPUE in number by age 3 (Cpue3) and upper and lower 95% confidence limits (Ucpue3, Lcpue3) for the case base analysis of the North Atlantic for the years 1982-2023.

YR	*LSMEAN*	*STDERR*	*Ucpue3*	*Cpue3*	*Lcpue3*
1982	0.03021	0.14574	1.386	1.042	0.783
1983	0.09182	0.07797	1.281	1.100	0.944
1984	0.08352	0.07484	1.262	1.090	0.941
1985	0.17532	0.07010	1.371	1.195	1.041
1986	0.27160	0.06183	1.484	1.315	1.165
1987	0.50346	0.07138	1.908	1.659	1.442
1988	0.34819	0.05922	1.594	1.419	1.263
1989	0.23627	0.06009	1.427	1.269	1.128
1990	0.51903	0.06009	1.894	1.683	1.496
1991	0.56389	0.05887	1.976	1.761	1.569
1992	0.47414	0.05810	1.803	1.609	1.436
1993	0.33572	0.05823	1.571	1.401	1.250
1994	0.18265	0.05687	1.344	1.202	1.076
1995	0.50086	0.05596	1.844	1.653	1.481
1996	0.19650	0.05638	1.362	1.219	1.092
1997	-0.00374	0.05691	1.116	0.998	0.893
1998	0.03836	0.05710	1.164	1.041	0.931
1999	0.40692	0.06067	1.695	1.505	1.336
2000	0.64290	0.05958	2.141	1.905	1.695
2001	0.56678	0.05733	1.975	1.765	1.578
2002	0.45784	0.05666	1.769	1.583	1.417
2003	0.57895	0.06054	2.013	1.787	1.587
2004	0.14341	0.06070	1.302	1.156	1.027
2005	0.12779	0.06319	1.289	1.139	1.006
2006	0.01544	0.06746	1.162	1.018	0.892
2007	0.10495	0.07652	1.294	1.114	0.959
2008	0.44399	0.07823	1.823	1.564	1.341
2009	0.52458	0.08093	1.987	1.695	1.447
2010	0.40809	0.07056	1.731	1.508	1.313
2011	0.26319	0.07102	1.499	1.304	1.135
2012	0.33223	0.07717	1.627	1.398	1.202
2013	0.20063	0.08421	1.447	1.227	1.040
2014	0.43611	0.07944	1.813	1.552	1.328
2015	0.65405	0.07840	2.250	1.929	1.654
2016	0.19594	0.08070	1.430	1.220	1.042
2017	0.02151	0.08646	1.215	1.026	0.866
2018	0.13551	0.09736	1.392	1.151	0.951
2019	0.54360	0.10199	2.114	1.731	1.417
2020	0.41412	0.09780	1.842	1.520	1.255
2021	0.33709	0.07187	1.617	1.404	1.220
2022	0.43528	0.08745	1.841	1.551	1.307
2023	0.70639	0.07939	2.375	2.033	1.740

Table 3(d). Estimated parameters (Lsmean), standard error (Stderr), standardized CPUE in number by age 4 (Cpue4) and upper and lower 95% confidence limits (Ucpue4, Lcpue4) for the case base analysis of the North Atlantic for the years 1982-2023.

YR	*LSMEAN*	*STDERR*	*Ucpue4*	*Cpue4*	*Lcpue4*
1982	0.22608	0.15113	1.705	1.268	0.943
1983	-0.00385	0.08152	1.173	0.999	0.852
1984	0.02387	0.07825	1.198	1.027	0.881
1985	0.05097	0.07346	1.219	1.055	0.914
1986	-0.00844	0.06506	1.129	0.994	0.875
1987	0.09595	0.07480	1.278	1.104	0.953
1988	-0.06582	0.06259	1.061	0.938	0.830
1989	-0.16289	0.06347	0.964	0.851	0.752
1990	-0.13980	0.06356	0.987	0.871	0.769
1991	0.02551	0.06231	1.161	1.028	0.910
1992	0.06395	0.06146	1.205	1.068	0.947
1993	-0.14598	0.06169	0.977	0.866	0.767
1994	-0.29676	0.06028	0.838	0.745	0.662
1995	-0.15443	0.05935	0.964	0.858	0.764
1996	-0.38263	0.05998	0.769	0.683	0.608
1997	-0.54386	0.06066	0.655	0.582	0.516
1998	-0.64098	0.06098	0.595	0.528	0.468
1999	-0.49718	0.06449	0.692	0.610	0.537
2000	-0.16468	0.06292	0.961	0.850	0.751
2001	-0.37586	0.06100	0.775	0.688	0.610
2002	-0.35476	0.06027	0.791	0.703	0.624
2003	-0.16929	0.06401	0.959	0.846	0.746
2004	-0.41681	0.06413	0.749	0.661	0.582
2005	-0.65358	0.06721	0.595	0.521	0.457
2006	-0.68699	0.07108	0.580	0.504	0.439
2007	-0.90260	0.08038	0.476	0.407	0.348
2008	-0.58160	0.08322	0.660	0.561	0.477
2009	-0.44640	0.08481	0.758	0.642	0.544
2010	-0.62835	0.07473	0.619	0.535	0.462
2011	-0.41666	0.07512	0.766	0.661	0.571
2012	-0.42205	0.08244	0.773	0.658	0.560
2013	-0.51508	0.08918	0.714	0.600	0.504
2014	-0.17480	0.08429	0.994	0.843	0.714
2015	0.02859	0.08202	1.213	1.032	0.879
2016	-0.32797	0.08456	0.853	0.723	0.613
2017	-0.42882	0.09243	0.784	0.654	0.546
2018	-0.49758	0.10325	0.748	0.611	0.499
2019	-0.21623	0.10846	1.002	0.810	0.655
2020	-0.36060	0.11047	0.871	0.702	0.565
2021	-0.20743	0.07627	0.946	0.815	0.702
2022	-0.17565	0.09271	1.010	0.843	0.703
2023	0.17365	0.08599	1.413	1.194	1.009

Table 3(e). Estimated parameters (Lsmean), standard error (Stderr), standardized CPUE in number by age 5+ (Cpue5+) and upper and lower 95% confidence limits (Ucpue5+, Lcpue5+) for the case base analysis of the North Atlantic for the years 1982-2023.

YR	*LSMEAN*	*STDERR*	*Ucpue5+*	*Cpue5+*	*Lcpue5+*
1982	0.20978	0.15935	1.707	1.249	0.914
1983	-0.05661	0.08579	1.122	0.948	0.802
1984	-0.00858	0.08239	1.169	0.995	0.846
1985	-0.08916	0.07746	1.068	0.917	0.788
1986	-0.18626	0.06854	0.952	0.832	0.727
1987	-0.18044	0.07887	0.978	0.838	0.718
1988	-0.32088	0.06602	0.828	0.727	0.639
1989	-0.42754	0.06697	0.745	0.654	0.573
1990	-0.48178	0.06702	0.706	0.619	0.543
1991	-0.35335	0.06574	0.801	0.704	0.619
1992	-0.22779	0.06479	0.906	0.798	0.703
1993	-0.38376	0.06500	0.776	0.683	0.601
1994	-0.54886	0.06347	0.655	0.579	0.511
1995	-0.49303	0.06275	0.692	0.612	0.541
1996	-0.72673	0.06356	0.549	0.484	0.428
1997	-0.92728	0.06430	0.450	0.396	0.350
1998	-0.90922	0.06486	0.458	0.404	0.356
1999	-1.08484	0.06874	0.388	0.339	0.296
2000	-0.55645	0.06645	0.654	0.575	0.504
2001	-0.79969	0.06436	0.511	0.450	0.397
2002	-0.73118	0.06404	0.547	0.482	0.425
2003	-0.58573	0.06793	0.637	0.558	0.488
2004	-0.77381	0.06774	0.528	0.462	0.405
2005	-0.81165	0.07092	0.512	0.445	0.387
2006	-0.78918	0.07600	0.529	0.456	0.392
2007	-0.74084	0.08566	0.566	0.478	0.405
2008	-0.64989	0.08775	0.622	0.524	0.441
2009	-0.63570	0.09066	0.635	0.532	0.445
2010	-0.82089	0.08039	0.517	0.441	0.377
2011	-0.53439	0.07976	0.687	0.588	0.503
2012	-0.18941	0.08800	0.987	0.831	0.699
2013	-0.49913	0.09336	0.732	0.610	0.508
2014	-0.13898	0.08968	1.042	0.874	0.733
2015	0.01500	0.08695	1.208	1.019	0.859
2016	-0.10345	0.08758	1.075	0.905	0.762
2017	-0.10980	0.09933	1.094	0.900	0.741
2018	-0.40391	0.10625	0.827	0.671	0.545
2019	-0.02873	0.11529	1.226	0.978	0.780
2020	-0.62302	0.12836	0.695	0.541	0.420
2021	-0.31310	0.08132	0.860	0.734	0.626
2022	-0.29258	0.09736	0.908	0.750	0.620
2023	0.05931	0.09163	1.275	1.066	0.890

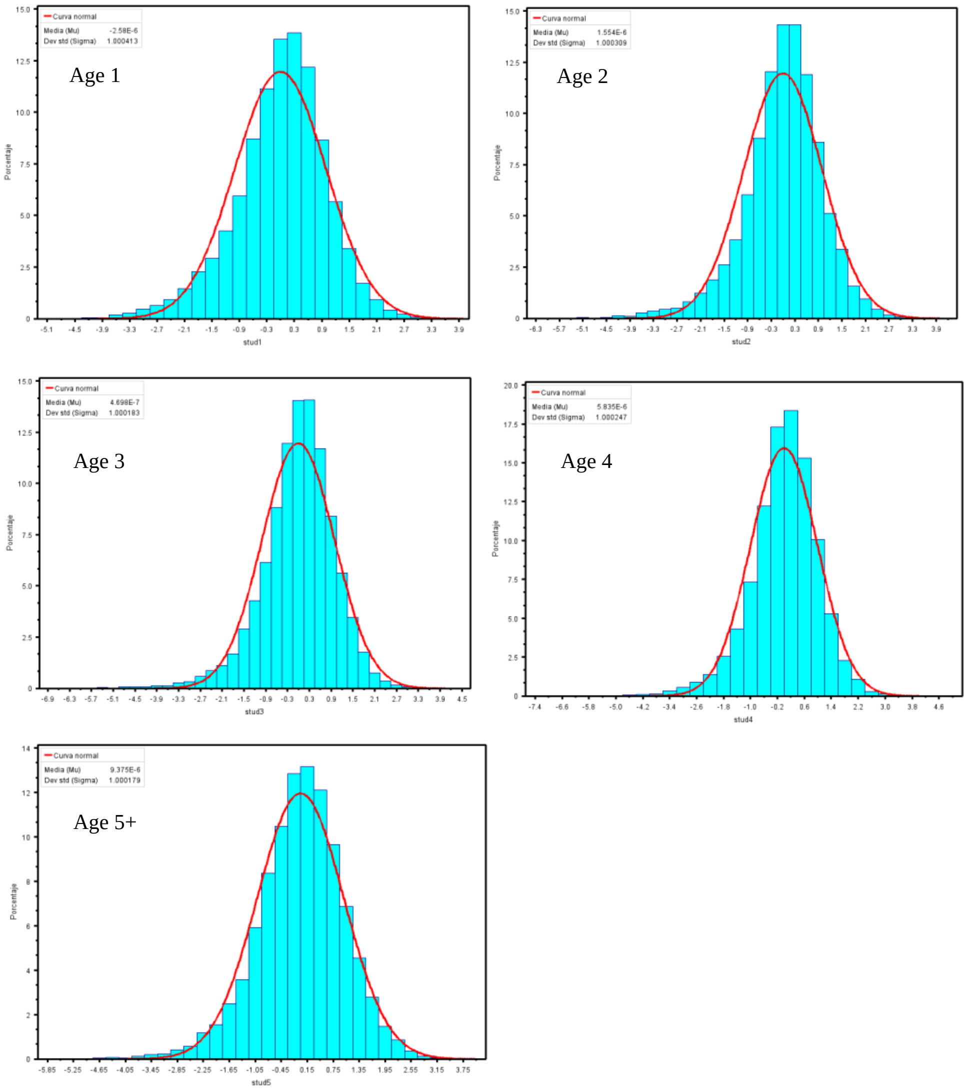

Figure 1. Normal fit and frequency distribution of the standardized residuals by age, years combined, obtained as diagnosis of the standardized CPUE in number of swordfish from the analyses of the North Atlantic stock for the period 1982-2023.

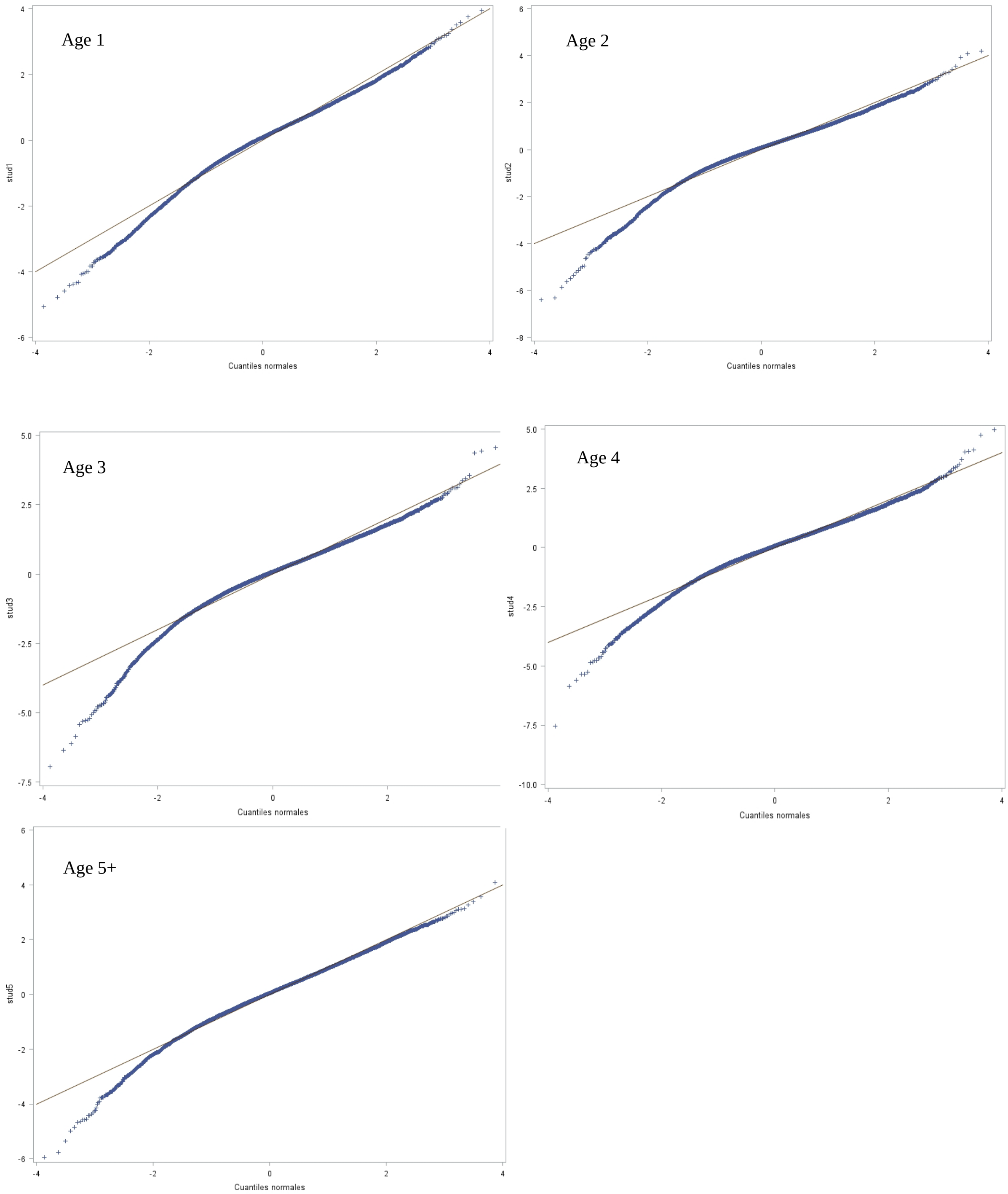

Figure 2. Normal probability qq-plot obtained for the GLM analyses for standardized CPUE in number of swordfish by age in the North Atlantic stock for the period 1982-2023.

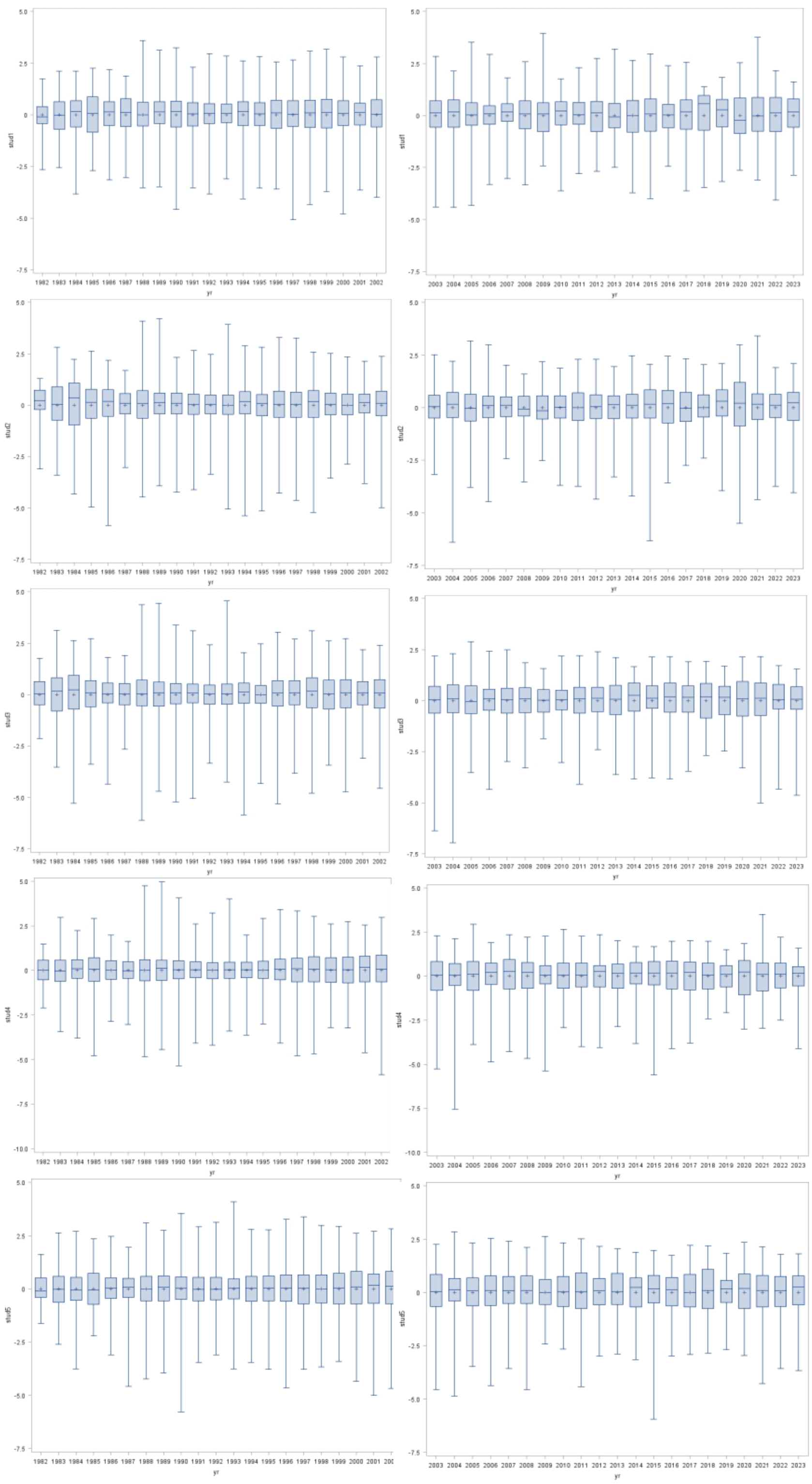

Figure 3. Variability box-plot of the standardized residuals by year obtained from GLM analyses of the standardized CPUE in number of swordfish by age for the North Atlantic stock during the periods 1982-2000 (left panels) and 2001-2023 (right panels). Respective ages from Age 1 (top panels) to Age 5+ (bottom panels).

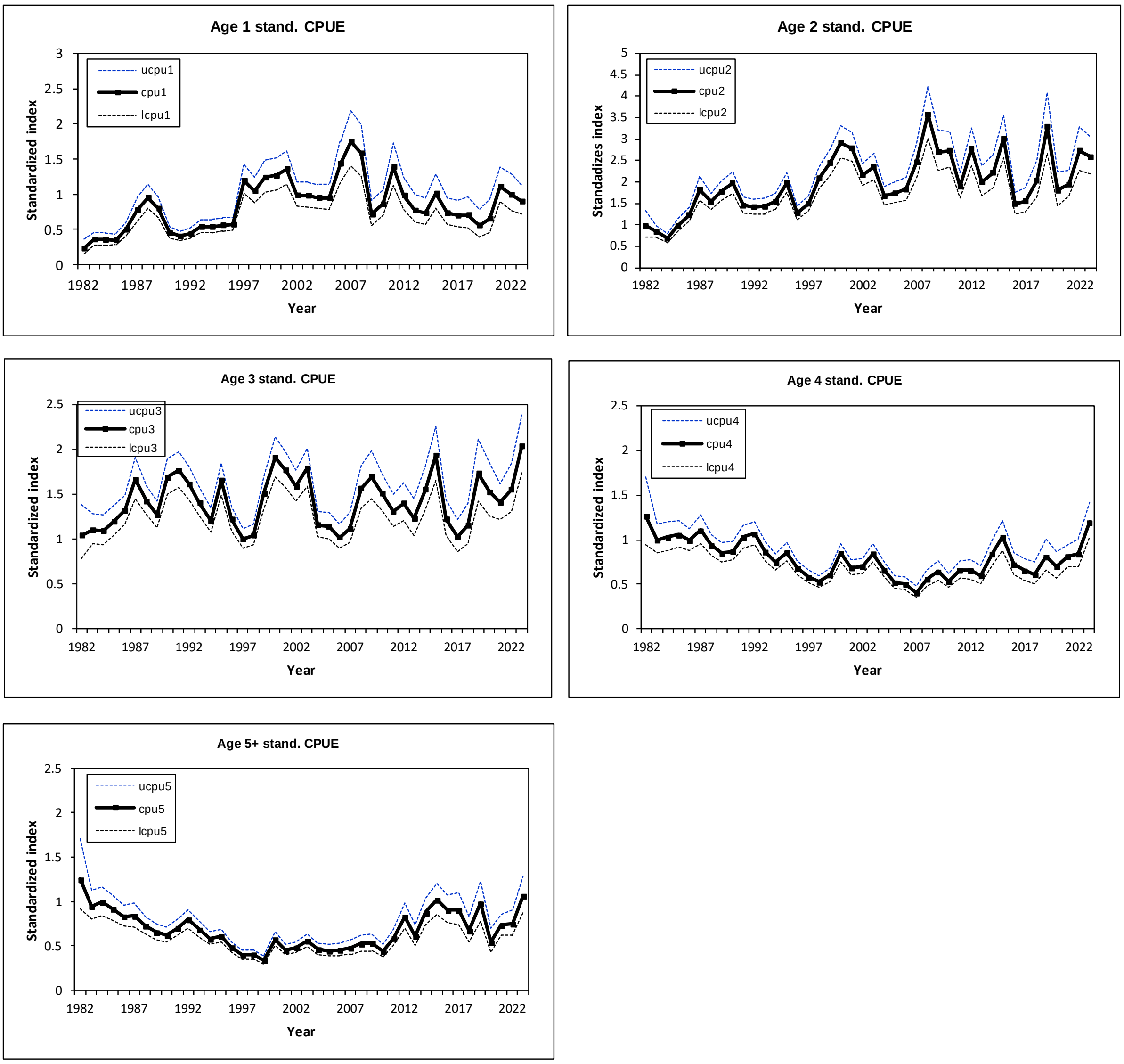

Figure 4. Annual change of the standardized catch rates in number of fish per thousand hooks for ages (1-5+) and 95% confidence intervals obtained in the North Atlantic, for the period 1982-2023.