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UPDATED STANDARDIZED AGE SPECIFIC CATCH RATES FOR ALBACORE, *Thunnus alalunga,* FROM THE SPANISH TROLL FISHERY IN THE NORTHEAST ATLANTIC: 1981 to 2007.

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SUMMARY

Relative abundance indices by age group of albacore (Thunnus alalunga) caught by the Spanish troll fleet in the North Eastern Atlantic were estimated using catch in number of fish and effort data from 6932 individual trips collected for the period 1981-2007. Standardized CPUE´S for age groups 1 to 4 years old albacore were estimated separately through the General Linear Modelling approach by applying the log-normal error distribution model.

RESUMEN

Indices relativos por grupo de edad de atún blanco (Thunnus alalunga) capturado por la flota de superficie española de cacea se han estimado a partir de la captura en númerode peces y el esfuerzo de 6254 mareas recogidas para el período 1981-2005. Las tasas de captura (CPUE´s) de esta flota para los grupos de edad 1 a 4 años se estandarizaron aplicando el Modelo Lineal Generalizado a cada grupo de edad, asumiendo una distribución log-normal de errores.

KEYWORDS

Thunnus alalunga, Albacore, troll fleet, catch rates, GLM model, abundance indices, North Atlantic.

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1. Introduction

Data collected of nominal catch rates by age of individual trip from the Spanish surface commercial fleet have been used to develop relative abundance indices by age of immature albacore from the North Atlantic stock (Mejuto and Garcia, 1997; Ortiz de Zárate and Ortiz, 2004). In the absence of other independent sources of information from the population, the standardized catch rates derived by means of the General Linear Modeling approach are used as apparent abundance indices to tune the VPA analysis of the north Atlantic stock (Anon., 2008).

The SCRS has used standardized catch rates from the troll fishery as an index of relative abundance for juvenile albacore ages 2 and 3 of north Atlantic stock (Anonymous, 2008).

This paper presents an updated information on relative catch rates indices by age for albacore surface troll fishery from 1981 to 2007. The standardized age-specific catch rates (ages 1 through 4) were estimated by means of a general linear model GLM assuming the log-normal error distribution model in the analysis.

2. Material and methods

Information on trips from commercial troll vessels was recorded at landing ports through interviews of skippers. The following data was obtained for each trip: date of landing, number of fishing days, area of effort (5x5 degrees), catch in number, catch in weight (k), as well the catches landed by commercial categories were randomly sampled to the nearest centimeter (FL= 35–120 cm range) on each single trip recorded.

Age length keys were estimated by Santiago (2001) from length distribution analysis of north Atlantic albacore catch at size for the period 1975-1999 applying the Multifan length frequency analysis method.

The age length keys calculated on the third quarter of a given year for the period considered were used to age the catch length composition of albacore by sampled trip. The updated age length key estimated by Santiago and Arrizabalaga (2001) for 1999 was carried over up to 2007 catch at size distribution by trip.

In 2006 and 2007, the distribution of catches for the troll fleet has remained in the traditional fishing grounds for this fleet in the North eastern Atlantic and Gulf of Biscay waters (Ortiz de Zárate *et al*., 2009). Therefore the stratification of fishing area, which represents the spatial distribution covariate in the model fit in the GLM analyses is the same as in previous analyses (Ortiz de Zárate and Ortiz de Urbina, 2008) defined by four zones (NE, SE, NW, SW) that cover the Bay of Biscay area and the North eastern Atlantic waters as shown in **Figure 1**. The temporal covariate was defined by aggregation of month into strata in order to have enough observations in the same way as in previous analysis because no changes were detected in the last years added to the time series. Therefore the following strata were defined: May, June and July (quarter 1), August and September (quarter 3) and October and November (quarter 2).

The present analyses used the following factors: Year, Zone and Quarter to model age-specific logged CPUE from 1 to 4 age groups for troll fleet.

$LOG(CPUE) = \mu + Yi + Zk + Ql + \varepsilon_{ikl}$

where

μ = overall mean

Y = factor year; levels: 1981-2006

Z = factor zone: NW, NE, SW, SE in **Figure 1**.

Q = factor time, three artificially created quarters: 1, 2, 3.

ε_{ikl} = log-normal error distribution

Analyses were done using GLM procedure of S-PLUS 2000 statistical software (Professional release 2) which includes the contrast treatment option to estimate the coefficients relative to the first level of each factor in the model.

Relative indices of abundance were estimated for each age catch rate albacore mode. The least squares means (LSmeans) were bias corrected using the algorithm of Lo et al., (1992) and back-transformed estimates of cpue´s expressed in number of fish by fishing day were calculated.

3. Results and discussion

Total number of observations included in the analyses were 6932 trips, however the number of observations decreased according to each age group recorded by trip. As a result, the total number of observations for age 1 cpue´s was 6658, for age 2 the number of observations was 6559, being 6722 the observations for age 3 cpue´s and finally 5015 observations for age 4 cpue´s.

As observed the percentage of null observations is small, 5 % for ages 2, less than 5% fro ages 1 and 3 and over for age group 4 (27%) in the data set, therefore the log CPUE was used to predict standardized least squares means by age only on the positive observations.

The summary statistics of the analysis of deviance (ANOVA) for each of the four models fit and the significance tests are shown in consecutive **Table 1a, 1b, 1c** and **1.d** As it is presented, the GLM model fit for age 1 CPUE albacore accounted for 32.7 % of the variability of the observed log-cpue while model fit for age 2 albacore catch rates explained the 44 % of the variability and model fit to age 3 albacore 24.2 %. Finally the 26.3 % of variability is explained by the model fit for age 4 albacore catch rates.

The change in deviance from the null model (Type I) estimated on each model fit, shows that all predictor variables, year, zone and quarter have a significant effect ($p<.0001$) to explain the log-catch rate in number of fish per day fishing for ages 1, 2 ,3 and 4. The year effect contribute most to explained the variance in the dependent variable log-cpue followed by the quarter and zone predictors variables.

Diagnostics of the GLM fitted models for catch rates of age 1, age 2, age 3 and age 4 are shown in **Figure 2.** Plots of standardized residuals of model fit and the normalized cumulative residuals (or QQ-residual plots) from log -CPUE modeled show a reasonable overall fit of residuals.

Estimated standardized catch rates (CPUE) of age group 1, 2, 3 and 4 their standard error and estimated coefficients of variation for the four models are presented in the consecutive **Table 2a, 2b, 2c, 2d** respectively.

Time series trends of the standardized CPUE indices and their estimated 95 % confidence intervals obtained for ages 1, 2, 3, and 4 for the troll fleet are shown in **Figure 3**.

The age group 1 albacore is not a group size targeted by this fleet during all fishing season according to the annual spatial distribution of juvenile albacore recruited to the fishery. Nevertheless it could be interpreted as a "proxy" index of recruitment cohort strength. Then the increase trend reflected on the time series after 2003 with a peak catch rate in 2005 and 2006 might indicate two strong cohorts in the 2004 and 2005 years followed by a decrease in 2006.

The albacore ages 2 and 3 are presently targeted by the troll fleet therefore could be considered as apparent abundance indicators of the immature albacore population in the North stock.

The age 2 relative abundance index shown an increasing trend since the low level observed from 2000 to 2003 period, reaching the highest value on record in 2005 for the time series analyzed, then followed by a decrease trend up to 2007.

In the case of the age 3 relative abundance index, the time series shown a steady increasing trend since the lower level registered in 2002 and 2003 fishing seasons, levering off with previous years values in the time series analyzed.

Finally the age 4 is very scarce in troll catches, being mainly caught at the end of the fishing season in the autumn months in the Bay of Biscay fishing ground and fluctuates on annually bases.

AKNOWLEDGEMENTS

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Table 1.a. Deviance table analysis. Logged catch rates. ALB. Age 1. (% of total deviance refers to that for the null model; *P(>|Chi|)* refers to consecutive models).

	Resid. Df	*Resid. Deviance*	*Change in Deviance*	*% of total deviance*	*model % deviance*	*P(>|Chi|)*
NULL	6658	11931.400				
YEAR	6632	8854.000	3077.400	25.7924468	25.7924468	0.0000E+00
YEAR QUARTER	6630	8401.000	453.000	3.7967045	29.5891513	5.3800E-82
YEAR QUARTER ZONE	6627	8021.400	379.600	3.1815210	32.7706723	1.1450E-67

Table 1.b. Deviance table analysis. Logged catch rates. ALB. Age 2. (% of total deviance refers to that for the null model; *P(>|Chi|)* refers to consecutive models).

	Resid. Df	*Resid. Deviance*	*Change in Deviance*	*% of total deviance*	*model % deviance*	*P(>|Chi|)*
NULL	6559	12820.100				
YEAR	6533	11604.200	1215.900	9.4843254	9.4843254	7.6260E-217
YEAR QUARTER	6531	9540.700	2063.500	16.0958183	25.5801437	0.0000E+00
YEAR QUARTER ZONE	6528	7170.600	2370.100	18.4873753	44.0675190	0.0000E+00

Table 1.c. Deviance table analysis. Logged catch rates. ALB. Age 3. (% of total deviance refers to that for the null model; *P(>|Chi|)* refers to consecutive models).

	Resid. Df	*Resid. Deviance*	*Change in Deviance*	*% of total deviance*	*model % deviance*	*P(>|Chi|)*
NULL	6722	7937.700				
YEAR	6696	7050.900	886.800	11.1720020	11.1720020	2.6950E-191
YEAR QUARTER	6694	6739.700	311.200	3.9205311	15.0925331	6.7460E-76
YEAR QUARTER ZONE	6691	6014.600	725.100	9.1348879	24.2274210	1.5600E-174

Table 1.d. Deviance table analysis. Logged catch rates. ALB. Age 4. (% of total deviance refers to that for the null model; *P(>|Chi|)* refers to consecutive models).

	Resid. Df	*Resid. Deviance*	*Change in Deviance*	*% of total deviance*	*model % deviance*	*P(>|Chi|)*
NULL	5015	9814.200				
YEAR	4989	8578.300	1235.800	12.5919586	12.5919586	1.0890E-162
YEAR QUARTER	4987	7420.800	1157.500	11.7941350	24.3860936	7.4100E-174
YEAR QUARTER ZONE	4984	7235.900	184.900	1.8840048	26.2700984	1.9790E-27

Table 2a. Standardized CPUE (number x fishing days^{-1}), standard error, coefficient of variation and 95% confidence limits (based on a Normal approximation) for albacore age 1 troll fishery.

YEAR	*lsmeans*	*std. Err*	*std. CPUE*	*95% upp*	*95% low*	*CV (%)*
1981	3.183946	0.195535	24.607797	36.100666	16.773754	6.141268
1982	0.722034	0.130299	2.076165	2.680246	1.608234	18.046088
1983	-0.122175	0.167192	0.897449	1.245450	0.646686	136.845853
1984	2.230539	0.122895	9.375409	11.928915	7.368508	5.509675
1985	2.329278	0.120885	10.345843	13.111886	8.163315	5.189801
1986	2.505744	0.101495	12.315941	15.026641	10.094232	4.050495
1987	0.356952	0.229831	1.467211	2.302122	0.935098	64.386888
1988	2.807526	0.083570	16.626827	19.585987	14.114753	2.976637
1989	2.182056	0.073326	8.888378	10.262172	7.698494	3.360429
1990	2.419469	0.061625	11.261251	12.707005	9.979989	2.547061
1991	3.353723	0.059655	28.659997	32.214806	25.497450	1.778770
1992	2.967559	0.065113	19.485659	22.138100	17.151016	2.194158
1993	2.975821	0.066381	19.648947	22.379168	17.251808	2.230679
1994	2.456960	0.077288	11.704184	13.618523	10.058942	3.145676
1995	3.365648	0.063533	29.010728	32.857817	25.614069	1.887679
1996	3.188309	0.068977	24.305133	27.823542	21.231641	2.163436
1997	3.695766	0.067465	40.368180	46.075151	35.368087	1.825475
1998	3.108778	0.066913	22.443859	25.589096	19.685213	2.152386
1999	3.038670	0.060072	20.915163	23.528588	18.592022	1.976929
2000	1.993687	0.061979	7.356675	8.306900	6.515146	3.108753
2001	2.102419	0.063521	8.202482	9.289992	7.242279	3.021322
2002	3.042996	0.063719	21.010578	23.805464	18.543827	2.093954
2003	3.484177	0.063748	32.661894	37.008779	28.825575	1.829643
2004	3.623436	0.057928	37.529002	42.041299	33.501010	1.598697
2005	3.970726	0.061302	53.122735	59.904800	47.108495	1.543845
2006	3.994695	0.063929	54.420354	61.684944	48.011310	1.600358
2007	2.953223	0.059810	19.201954	21.590213	17.077878	2.025253

Table2.b. Standardized CPUE (number x fishing days^{-1}), standard error, coefficient of variation and 95% confidence limits (based on a Normal approximation). for albacore age 2 troll fishery.

YEAR	*lsmeans*	*std. Err*	*std. CPUE*	*95% upp*	*95% low*	*CV (%)*
1981	3.120883	0.189327	23.076288	33.444450	15.922375	6.066444
1982	3.372756	0.117674	29.361351	36.977877	23.313640	3.488951
1983	3.056025	0.113723	21.380751	26.719359	17.108813	3.721277
1984	2.871013	0.117304	17.776786	22.371974	14.125447	4.085799
1985	2.608281	0.112189	13.661399	17.021278	10.964737	4.301251
1986	3.074928	0.096929	21.750258	26.300995	17.986914	3.152242
1987	3.162911	0.183153	24.039144	34.420868	16.788666	5.790641
1988	3.160092	0.079723	23.647800	27.647268	20.226898	2.522802
1989	2.553561	0.067592	12.882191	14.707024	11.283781	2.646951
1990	3.098569	0.059012	22.204833	24.927550	19.779506	1.904494
1991	3.489417	0.057140	32.820373	36.709823	29.343015	1.637531
1992	3.319525	0.062807	27.701797	31.330694	24.493220	1.892036
1993	3.204180	0.063502	24.685006	27.956811	21.796103	1.981863
1994	3.670715	0.072092	39.382182	45.359251	34.192722	1.963982
1995	3.386997	0.061165	29.632367	33.406531	26.284597	1.805889
1996	3.542044	0.066693	34.614354	39.448133	30.372883	1.882895
1997	3.062241	0.065352	21.421108	24.348413	18.845740	2.134123
1998	2.963277	0.065666	19.403111	22.068225	17.059855	2.215992
1999	2.745154	0.058979	15.594104	17.505084	13.891740	2.148471
2000	2.066398	0.060758	7.910917	8.911389	7.022768	2.940301
2001	2.483053	0.061250	12.000260	13.530938	10.642740	2.466730
2002	2.385300	0.064050	10.884619	12.340526	9.600477	2.685196
2003	2.507696	0.064071	12.301836	13.947870	10.850056	2.554957
2004	3.309048	0.056529	27.402823	30.613542	24.528841	1.708310
2005	3.612287	0.061632	37.121135	41.887437	32.897182	1.706187
2006	3.502150	0.061212	33.248953	37.487161	29.489906	1.747837
2007	3.271990	0.058897	26.409524	29.641129	23.530242	1.800037

Table 2.c. Standardized CPUE (number x fishing days^{-1}), standard error, coefficient of variation and 95% confidence limits (based on a Normal approximation).for age 3 albacore troll frishery.

YEAR	*lsmeans*	*std. Err*	*std. CPUE*	*95% upp*	*95% low*	*CV (%)*
1981	2.192652	0.168526	9.087069	12.643758	6.530876	7.685952
1982	2.860758	0.106279	17.573734	21.643663	14.269125	3.715073
1983	2.896365	0.102172	18.202973	22.238868	14.899510	3.527585
1984	2.556465	0.106564	12.963573	15.974747	10.519992	4.168420
1985	2.254253	0.099828	9.575767	11.645260	7.874046	4.428447
1986	2.612042	0.087179	13.678731	16.227578	11.530229	3.337563
1987	2.448461	0.165640	11.730348	16.229544	8.478431	6.765056
1988	2.657192	0.071463	14.292654	16.441559	12.424610	2.689399
1989	2.303671	0.060305	10.029089	11.287415	8.911042	2.617796
1990	2.050376	0.053080	7.781776	8.634980	7.012875	2.588794
1991	2.136456	0.053229	8.481378	9.414031	7.641124	2.491449
1992	2.381551	0.057102	10.839333	12.122971	9.691612	2.397697
1993	2.457186	0.057458	11.691203	13.084843	10.445997	2.338369
1994	2.072631	0.065394	7.962706	9.051593	7.004809	3.155114
1995	2.196029	0.055416	9.003056	10.036015	8.076414	2.523482
1996	1.245353	0.060595	3.480545	3.919467	3.090776	4.865712
1997	1.819641	0.059112	6.180433	6.939630	5.504292	3.248572
1998	2.079971	0.058336	8.017865	8.989075	7.151588	2.804636
1999	2.048581	0.054197	7.768286	8.638909	6.985404	2.645603
2000	2.145914	0.053102	8.561916	9.501068	7.715597	2.474569
2001	2.249421	0.055173	9.496684	10.581237	8.523295	2.452777
2002	1.370993	0.054374	3.945087	4.388746	3.546278	3.966009
2003	1.561349	0.055233	4.772520	5.318186	4.282842	3.537549
2004	2.089759	0.048720	8.092568	8.903440	7.355546	2.331378
2005	2.094757	0.051267	8.134149	8.993970	7.356526	2.447396
2006	2.219146	0.055266	9.213530	10.267604	8.267668	2.490399
2007	2.300686	0.050938	9.993980	11.043272	9.044388	2.214036

Table 2.d. Standardized CPUE (number x fishing days^{-1}), standard error, coefficient of variation and 95% confidence limits (based on a Normal approximation).for age 4 albacore troll fishery.

YEAR	*lsmeans*	*std. Err*	*std. CPUE*	*95% upp*	*95% low*	*CV (%)*
1981	-0.479387	0.242560	0.637647	1.025775	0.396378	50.597936
1982	-0.580032	0.145644	0.565850	0.752794	0.425330	25.109694
1983	0.002532	0.144432	1.013047	1.344536	0.763284	5704.132209
1984	-0.101083	0.150026	0.914088	1.226569	0.681214	148.418588
1985	-0.550367	0.145943	0.582913	0.775949	0.437899	26.517443
1986	-0.546565	0.114294	0.582729	0.729048	0.465776	20.911422
1987	-1.030012	0.257676	0.369054	0.611544	0.222716	25.016814
1988	-0.233147	0.098467	0.795886	0.965313	0.656196	42.234099
1989	-0.563045	0.094292	0.572009	0.688123	0.475489	16.746731
1990	0.155339	0.071510	1.171044	1.347236	1.017895	46.034656
1991	-1.219641	0.084790	0.296400	0.349988	0.251017	6.952070
1992	-0.355741	0.079708	0.702883	0.821735	0.601222	22.406122
1993	-0.717623	0.083985	0.489634	0.577246	0.415320	11.703157
1994	-0.750303	0.088874	0.474092	0.564305	0.398302	11.845048
1995	-1.135782	0.085194	0.322339	0.380918	0.272768	7.500953
1996	-1.343828	0.119163	0.262704	0.331818	0.207985	8.867416
1997	-1.053516	0.096824	0.350348	0.423562	0.289789	9.190528
1998	-0.536805	0.094644	0.587237	0.706930	0.487810	17.630993
1999	0.401771	0.077905	1.499010	1.746298	1.286740	19.390329
2000	0.500951	0.075189	1.654962	1.917741	1.428189	15.009232
2001	0.245281	0.077896	1.281864	1.493306	1.100361	31.758042
2002	-0.100573	0.073852	0.906789	1.048021	0.784590	73.431127
2003	-0.179099	0.079423	0.838664	0.979929	0.717764	44.346037
2004	0.106394	0.069081	1.114917	1.276572	0.973733	64.929221
2005	-0.267103	0.076423	0.767833	0.891906	0.661020	28.611639
2006	-0.846124	0.083346	0.430568	0.506976	0.365675	9.850342
2007	-0.533498	0.078300	0.588350	0.685940	0.504645	14.676712

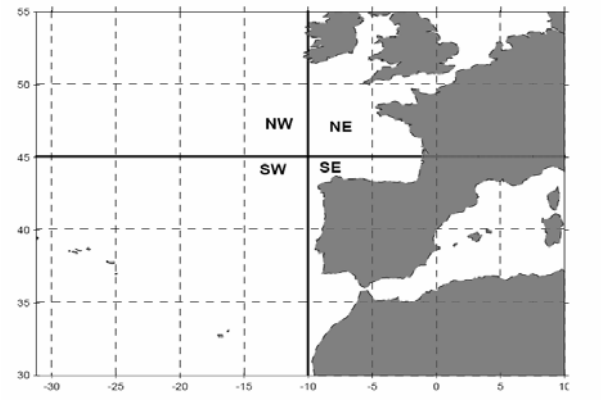

Figure 1. Area stratification used in the analysis for Atlantic albacore troll fishery.

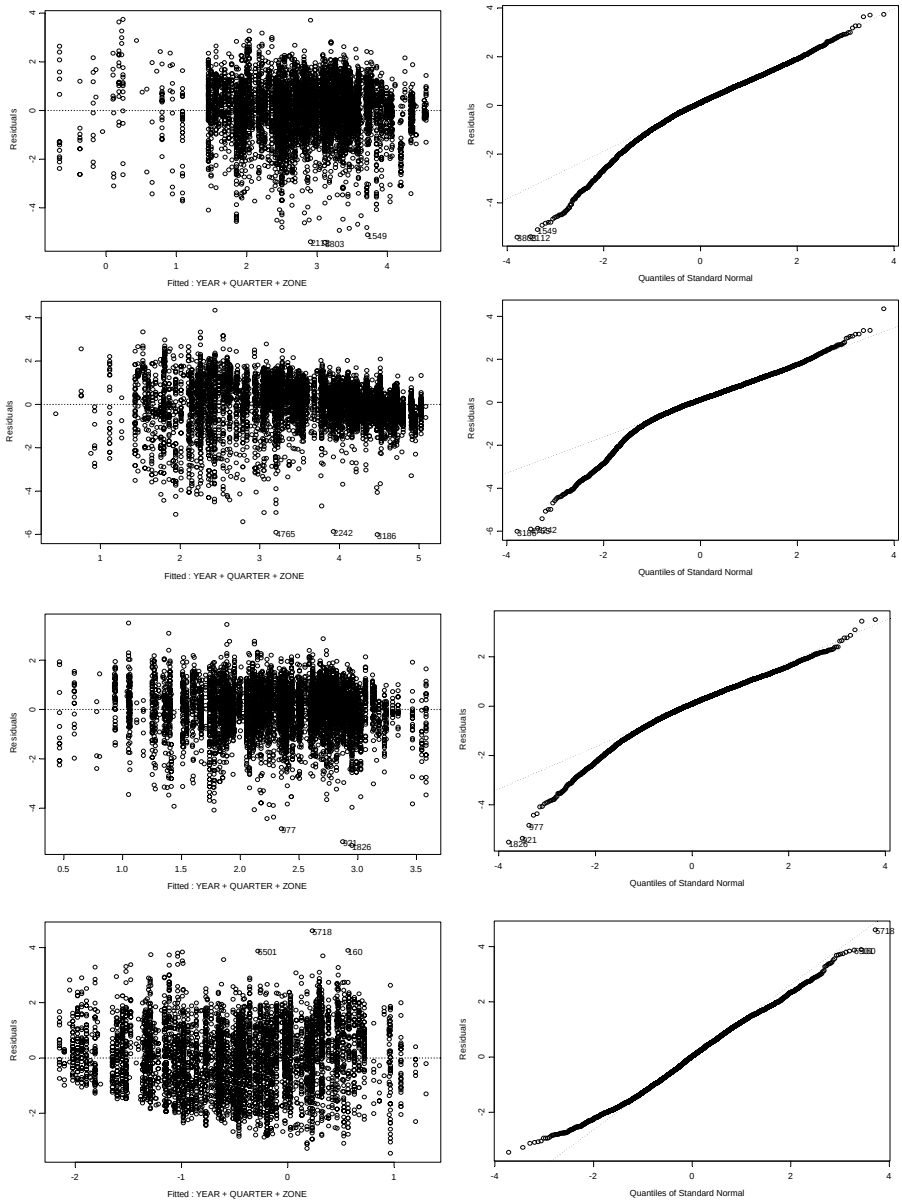

Figure 2. Diagnostics of models fit (from top to bottom: residual v fitted model, quantiles of standard normal or QQ plot) to age 1 to 4 albacore log-normal CPUE´s.1981-2007.

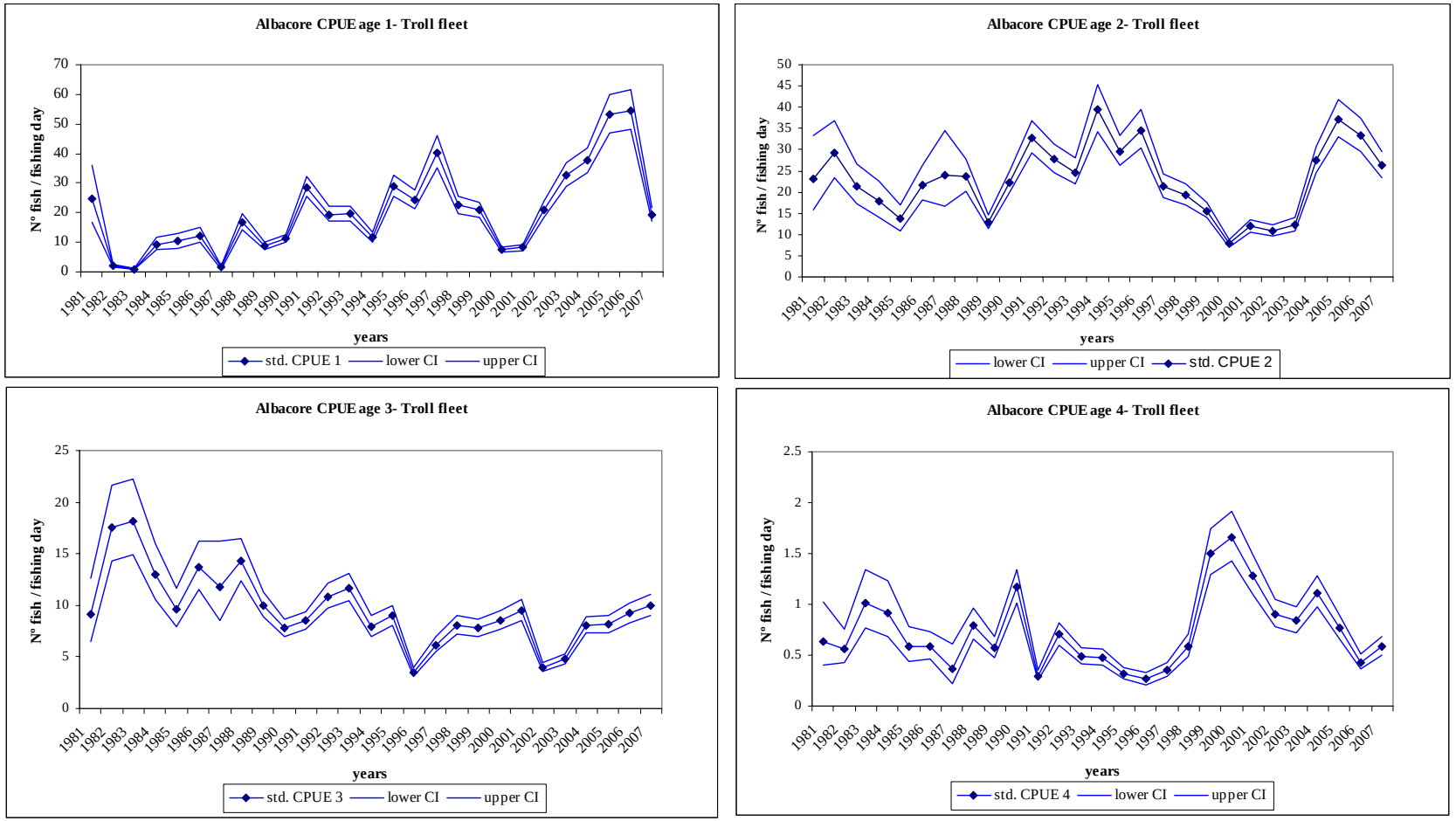

Figure 3. Estimated standardized indices of relative abundance in number of fish per fishing day and 96% confidence intervals. Albacore ages 1 to 4 groups respectively shown (left to right and top to bottom) from 1981 to 2007.