

**UPDATED STANDARDIZED CATCH RATES BY AGE, COMBINED SEXES, FOR THE
SWORDFISH (*XIPHIAS GLADIUS*) FROM THE SPANISH LONGLINE FLEET
IN THE ATLANTIC, FOR THE PERIOD 1983-1997**

J. Mejuto, J.M. de la Serna and B. García¹

SUMMARY

Standardized age-specific catch rates were updated using General Linear Modeling (GLM) procedures from trips carried out by the Spanish surface longline fleet in the Atlantic during the 1983-1997 period for the North and South Atlantic swordfish stocks.

Indices were developed for ages ranging from 1 to 5+ using Gompertz growth models (sexes combined) and the slicing method for ageing the catch at size. The criteria used to define areas, time periods and models were very similar to those used in previous papers. Results indicate a decrease in ages 3, 4 and 5+. The highest CPUE value of age 1 obtained in 1997 coincides with the lowest value of the NAO index one year before.

RÉSUMÉ

Le taux de capture standardisé spécifique de l'âge a été actualisé au moyen du modèle linéaire généralisé (GLM), d'après des sorties effectuées par la flottille espagnole de palangre de surface pendant les années 1983-1997, pour les stocks de l'Atlantique Nord et Sud.

Des indices ont été élaborés pour les âges 1 à 5+ au moyen du modèle de croissance de Gompertz (tous sexes combinés) et de la méthode du découpage, afin de déterminer l'âge dans la prise par taille. Les critères de définition de la zone, de la durée et du modèle ressemblaient beaucoup à ceux qui avaient servi dans des travaux antérieurs. Les résultats montrent une baisse des âges 3, 4 et 5+. La valeur la plus élevée de CPUE pour l'âge 1 a été obtenue en 1997, et coïncide avec la valeur la plus faible de l'indice NAO de l'année précédente.

RESUMEN

Tasas de captura normalizadas fueron actualizadas mediante técnicas de Modelo Lineal Generalizado (MLG) a partir de mareas individualizadas realizadas por la flota española de palangre de superficie en el Atlántico Norte y Sur entre los años 1983-1997.

Los índices fueron desarrollados para las edades entre 1 y 5+ usando un modelo de crecimiento tipo Gompertz (sexos combinados) y el método de "slicing" en los procesos de transformación de las distribuciones de tallas en edades. Los criterios usados para la definición de áreas, períodos temporales y modelos fueron muy similares a los usados en documentos anteriores. Los resultados indican un descenso de la CPUE de las edades 3, 4 y 5+. El valor más alto de CPUE de la edad 1 para el período analizado fue obtenido en 1997, coincidiendo con el menor valor del índice N.A.O. un año antes.

¹ Instituto Español de Oceanografía, Spain.

1. INTRODUCTION.

Catch per unit of effort data from commercial fleets have been used as indices of abundance in a great number of fisheries. However, this interpretation may not necessarily be assumed 'a priori'. These indicators must be evaluated case by case, based on empirical knowledge of the fishery, the geographical range covered by the fleets in relation to the area distribution of the stock, etc., and taking into account the limits and risks that are implied by this assumption.

The Generalized Linear Modelling technique (GLM) (Robson, 1966; Gavaris, 1980; Kimura, 1981) seems to be a very useful instrument in the estimation of standardized catch rates, based on data from commercial fleets with unbalanced spatial and temporal activity.

The standardized catch rates of the Atlantic swordfish were used in recent years on a routine basis, obtained by means of GLM procedures based on data from commercial fleets, some of which targeted this species while others did not (Hoey et al., 1989; Anonymous, 1989; Anonymous, 1991; Hoey et al, 1993; Nakano, 1993; Mejuto, 1993; Scott et al., 1993; Mejuto, 1994; Mejuto and De la Serna, 1995, Mejuto and De la Serna, 1997; Mejuto et al., 1998).

These approaches have become a basic routine task in the assessment of stocks within the ICCAT dynamics.

The activity of the Spanish fleet has been carried out historically in the North East Atlantic. Its progressive geographical expansion towards new zones in the North Central-West and South Atlantic has resulted in an increase in the number of observations by spatial-temporal cell with the passing of time. In recent years an important change has been reported in the fishing strategy of the traditional fleet, targeting in some cases other species (Mejuto and De la Serna, 1997).

2. MATERIAL AND METHODS

2.1 BASIC DATA:

The records used in the analyses are from the Spanish longline activity in the Atlantic Ocean from 1983 to 1997. Data from the North Atlantic are usually provided by records per trip obtained by the Spanish Oceanography Institute (IEO) when fish are landed at the different base ports used by the Atlantic fleet.

Therefore, the data analyzed here cover practically all of the fishing areas targeted by the Spanish fleet in the Atlantic. The data base used combines the analyses of information per trip from the traditional fleet, log-book data from the long distance fleet and data recorded by on board observers.

The last decade marked the introduction of vessels having freezing systems on board and whose trips last over 60 days at sea. Log-books designed specifically for this fleet have been introduced progressively and voluntarily. In this case, the information obtained per set is compiled in "sub-trips" (group of sets carried out consecutively in the same 5x5 degree square/month) and is treated as an observation or trip of the traditional fleet.

Following the traditional criteria, nominal effort was defined by number of hooks (in thousands of hooks), calculated from the number of sets carried out and the mean number of hooks per set or computing the number of hooks by group of consecutive sets ('sub-trip') when available.

2.2. AGEING

The Gompertz's type equation (Anonymous, 1989) was used to obtain the catch at age (CAA) for ages 1 to 5+, for sexes combined. The 'slicing' methodology was done (Restrepo pers. comm.).

2.3. MODEL AND SPECIFICATIONS

The spatial definition was carried out using the same criteria as last paper (Mejuto and De la Serna, 1997) and very similar to previously reported papers (Mejuto, 1993; Mejuto, 1994; Mejuto and De la Serna, 1995). For the North-South Atlantic analyses the hypothetical boundary line was located at 5° N latitude, as assumed by the ICCAT. The year sequence from 1983 to 1997 was analyzed, when available, for combined sexes.

The standardized analyses were done using the GLM procedure. The main effects considered were year, time and area. The following basic model was defined:

$$\text{LOG (CPUE)} = u + Y_i + Q_j + A_k + A_j * Q_k + e_{ijk}$$

- u = overall mean.
- Y_i = logarithm of the effect year i.
- Q_j = logarithm of the effect time j.
- A_k = logarithm of the effect area k.
- e = logarithm of the normally distributed error term.

As in the previous papers :

a) Trips or "sub-trips" with values of CPUE = 0 from a particular age were omitted from the analyses. b) Trip records in which the number of fish sampled was less than 85% of the capture in number were not used. c) In order to improve the observation scheme, tentative areas 2 and 6 were combined and considered as area 2, areas 4 and 5 were combined as area 4 and areas 10 and 11 were combined as area 10 (Mejuto & de la Serna, 1995). Additional methodological information can be seen in other papers previously cited.

3. RESULTS AND DISCUSSION

In general the number of observations per cell (spatial-temporal) may be considered satisfactory in the North Atlantic. However, due to the progressive geographical expansion of the fleet in last decade, some cells were not properly represented, especially at the beginning of the time series. The number of available observations in the South Atlantic have been improved progressively through the time serie.

Standardized residual patterns by age obtained in each run show a normally distributed shape when there is a suitable number of observations (Mejuto, 1993).

Table 1 is a summary of the ANOVA results. The number of observations, R-square, mean square error (root) and F statistics for each age class and stock is provided.

Tables 2 and 3 provide information on estimated parameters, their standard error, relative CPUEs and upper and lower 95% confidence limits obtained for each age and stock. The standardized CPUEs for the different ages and stocks are plotted in figures 1 and 2.

The CPUE's from age classes 3,4 and 5 recorded in 1997 based on trips made in the North Atlantic confirm the pattern seen in previous years. The CPUE for age class 1 in 1997, however, was the highest in the time series, coinciding with characteristics environmental factors (NAO).

Additional information and data from long print-out results are available from the author upon request.

ACKNOWLEDGMENTS.

The authors would like to give their most heartfelt thanks to all the members of the indefatigable team who were involved in recording, preparing and processing the basic data of this fishery. Without the help of qualified and dedicated people such as M. Quintans, I. Gonzalez, E. Alot, M. Marin, E. Majuelos, J. A. Castro and J. Lorenzo, to name only a few, this paper would not have been possible. This research was carried out with funds from project 04.03 of the *Spanish Oceanography Institute*.

The temporal definition corresponded to "quarters" as follows:

- Q1 = January, February, March, Q2 = April, May, June
- Q3 = July, August, September, Q4 = October, November, December

The surface longline gear of the Spanish fleet has remained relatively constant over the years analyzed in terms of structure and configuration (Rey et al., 1988; Hoey et al., 1988). However in recent years small improvements and very important changes in the fishing strategy were detected. In recent years the fleet fishing in the North Atlantic has gradually changed its focus towards a multi-specific and multi-target activity. The long distance fleet, on the other hand, which targets primarily the South stock, appears to have maintained a fishing strategy directed towards the target species.

LITERATURE CITED.

- ANONYMOUS, 1988. Report of the ICCAT Swordfish Workshop. ICCAT. Col. Vol. Sci. Pap. Vol. XXVII: 1-146 pp.
- ANONYMOUS, 1989. Second ICCAT Swordfish Workshop. ICCAT. Col. Vol. Sci. Pap. Vol. XXIX: 71- 162 pp.
- ANONYMOUS, 1991. Informe del período bienal 1990-1991. I parte. ICCAT.
- ANONYMOUS, 1992. Reference Paper on 1991 Swordfish Stock Assessment. ICCAT. Col. Vol. Sci. Pap. Vol. XXXIX (2): 397-476 pp.
- GAVARIS, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37: 2272-2275.
- HOEY, J., J. MEJUTO, S. IGLESIAS, R. CONSER, 1988. A comparative study of the United States and Spanish longline fleet targeting swordfish in the Atlantic Ocean, north of 40° latitude. ICCAT. Col. Vol. Sci. Pap. Vol. XXVII: 230-239 pp.
- HOEY, J.; J. MEJUTO; R. CONSER, 1989. CPUE indices derived from combined Spanish and U.S. catch and effort data. ICCAT. Col. Vol. Sci. Pap. Vol. XXIX: 228-249.
- HOEY, J., J.; J. MEJUTO; J. PORTER; Y.UOZUMI, 1993. A standardized Biomass index of abundance for north Atlantic swordfish. ICCAT Col. Vol. Sci. Pap. Vol XL (1):344-352.
- KIMURA, D. K., 1981. Standardized measures of relative abundance based on modelling log (CPUE) and their application to Pacific Ocean Perch. J. Cons. Int. Explor. Mer. 39: 211-218.
- MEJUTO, J., A. GONZALEZ-GARCES, 1988. Gráficos de CPUE y peso medio por cuadrícula 5x5 grados, de la flota española de pez espada Xiphias gladius, años 1982-1985. ICCAT. Col. Vol. Sci. Pap. Vol. XXVII: 287-297.
- MEJUTO, J., 1993. Age specific standardized indices of abundance for Swordfish (Xiphias gladius) from the Spanish longline fleet in the Atlantic, 1983-1991. ICCAT Col. Vol. Sci. Pap. Vol. XL (1):371-392.
- MEJUTO, J., 1994. Standardized indices of abundance at age for Swordfish (Xiphias gladius) from the Spanish longline fleet in the Atlantic, 1983-1992. ICCAT Col. Vol. Sci. Pap. Vol. XLII(1):328-334.
- MEJUTO, J., J.M. de la SERNA, 1995. Standardized catch rates by age and length groups for swordfish (Xiphias gladius) from the Spanish longline fleet in the Atlantic, 1983-93. ICCAT Col. Vol. Sci. Pap. Vol. XVIV(3):114-125.
- MEJUTO, J., J. M. de la SERNA, 1997. Updated standardized catch rates by age for the swordfish (Xiphias gladius) from the Spanish lonline fleet in the Atlantic, using commercial trips from the period 1983-1995. ICCAT Col Vol. Sci. Pap. Vol. (SCRS 96/141).
- MEJUTO, J., J.M. de la SERNA, B. GARCIA, 1998. Updated standardized catch rates by ages, sexes combined, for the swordfish (Xiphias gladius) from the Spanish longline fleet in the Atlantic, for the period 1983-1996. ICCAT. Col. Vol. Sci. Pap. Vol. XLVIII(1):216-222.
- NAKANO, H., 1993. Estimation of standardized CPUE for the Atlantic swordfish using the data from the japanese longline fishery. ICCAT Col. Vol. Sci. Pap. Vol. XL (1):357-370.
- REY, J. C., J. MEJUTO, S. IGLESIAS, 1988. Evolución histórica y situación actual de la pesquería de pez espada (Xiphias gladius). ICCAT. Col. Vol. Sci. Pap. Vol. XXVII: 202-213 pp.
- ROBSON, D. S., 1966. Estimation of relative fishing power of individual ships. Res. Bull. Int. Comm. N.W. Atl. Fish, 3: 5-14.
- SCOTT, G.P.; V.R. RESTREPO; A. BERTOLINO, 1993. Standardized catch rates for swordfish (Xiphias gladius) from the U.S. longline fleet though 1991. ICCAT Col: Vol. Sci. Pap. Vol, XL (1):458-468.

Table 1- Summary of ANOVA: Number of observations, F statistic, R square and mean square error (root), for each age class and run considered

STOCK	AGE	# OBSERVA.	F value	R squared	RMSE
North	1	6718	133.0	0.3658	0.9612
	2	7250	86.10	0.2569	0.7709
	3	7260	69.76	0.2184	0.7100
	4	7117	76.53	0.2384	0.6986
	5+	7015	110.19	0.3139	0.7543
South	1	1593	25.75	0.2741	1.0516
	2	1912	43.09	0.3442	0.6308
	3	1941	27.39	0.2473	0.5151
	4	1939	54.27	0.3946	0.5340
	5+	1940	38.92	0.3184	0.6236

Total numbr observ.:North=7473, South= 1943.

Table 2. Estimated parameters, standard error, relative CPUEs and upper and lower 95% confidence limits. NORTH ATLANTIC, AGES 1-5+, period 1983-1997.

North Atlantic Spanish LL SWO, Age 1					
YR	LSMEAN	STDERR	UCPU1	CPU1	LCPU1
1997	-0.30431	0.040521	0.79926	0.73824	0.68187
1996	-1.02274	0.040020	0.38926	0.35990	0.33275
1995	-1.02139	0.038410	0.38853	0.36036	0.33423
1994	-1.03681	0.039958	0.38378	0.35487	0.32814
1993	-0.99928	0.043416	0.40122	0.36849	0.33843
1992	-1.13366	0.043083	0.35054	0.32215	0.29606
1991	-1.25319	0.046737	0.31333	0.28590	0.26088
1990	-1.12549	0.049963	0.35832	0.32490	0.29459
1989	-0.64918	0.047656	0.57428	0.52307	0.47642
1988	-0.50799	0.047690	0.66141	0.60239	0.54863
1987	-0.64971	0.058862	0.58707	0.52310	0.46611
1986	-0.90835	0.052385	0.44740	0.40374	0.36435
1985	-1.38110	0.075834	0.29241	0.25203	0.21722
1984	-1.37578	0.092968	0.30445	0.25374	0.21147
1983	-1.34160	0.093413	0.31533	0.26257	0.21864

North Atlantic Spanish LL SWO, Age 2					
YR	LSMEAN	STDERR	UCPU2	CPU2	LCPU2
1997	-0.25376	0.031576	0.82583	0.77627	0.72968
1996	-0.41552	0.030771	0.70136	0.66031	0.62166
1995	0.05571	0.029526	1.12077	1.05775	0.99828
1994	-0.13644	0.030928	0.92742	0.87287	0.82153
1993	-0.17676	0.033540	0.89543	0.83846	0.78511
1992	-0.10979	0.033421	0.95721	0.89652	0.83968
1991	-0.09414	0.035923	0.97717	0.91074	0.84882
1990	0.23051	0.037614	1.35654	1.26013	1.17057
1989	0.04593	0.036990	1.12649	1.04771	0.97444
1988	-0.11031	0.037603	0.96474	0.89619	0.83252
1987	-0.02891	0.045260	1.06271	0.97250	0.88995
1986	-0.30587	0.038567	0.79490	0.73703	0.68337
1985	-0.33030	0.053747	0.79970	0.71974	0.64778
1984	-0.63119	0.062688	0.60269	0.53300	0.47138
1983	-0.45095	0.066352	0.72709	0.63843	0.56057

North Atlantic Spanish LL SWO, Age 3					
YR	LSMEAN	STDERR	UCPU3	CPU3	LCPU3
1997	-0.57205	0.029477	0.59819	0.56461	0.53292
1996	-0.37179	0.028409	0.72928	0.68978	0.65242
1995	-0.01797	0.027156	1.03626	0.98255	0.93162
1994	-0.29612	0.028467	0.78669	0.74400	0.70362
1993	-0.10632	0.031122	0.95615	0.89957	0.84634
1992	0.10267	0.030749	1.17752	1.10865	1.04381
1991	0.19329	0.032710	1.29426	1.21389	1.13851
1990	0.15842	0.034615	1.25466	1.17236	1.09546
1989	-0.17994	0.034337	0.89400	0.83581	0.78141
1988	-0.06453	0.034601	1.00389	0.93807	0.87656
1987	0.03329	0.041684	1.12284	1.03475	0.95357
1986	-0.06958	0.035206	1.00004	0.93336	0.87113
1985	0.05248	0.048235	1.15973	1.05511	0.95993
1984	0.03535	0.055712	1.15731	1.03759	0.93026
1983	0.01749	0.060148	1.14705	1.01949	0.90612

Table 2 (cont.) Estimated parameters, standard error, relative CPUEs and upper and lower 95% confidence limits. NORTH ATLANTIC, AGES 1-5+, period 1983-1997.

North Atlantic Spanish LL SWO, Age 4

YR	LSMEAN	STDERR	UCPU4	CPU4	LCPU4
1997	-1.02587	0.029930	0.38031	0.35864	0.33821
1996	-0.85959	0.028694	0.44801	0.42351	0.40035
1995	-0.56778	0.026875	0.59765	0.56699	0.53789
1994	-0.67388	0.028212	0.53892	0.50993	0.48250
1993	-0.46730	0.030968	0.66623	0.62700	0.59007
1992	-0.22435	0.030357	0.84841	0.79941	0.75323
1991	-0.23474	0.032343	0.84297	0.79119	0.74259
1990	-0.40041	0.034427	0.71724	0.67044	0.62669
1989	-0.47002	0.033915	0.66833	0.62535	0.58513
1988	-0.36416	0.034141	0.74330	0.69519	0.65019
1987	-0.24698	0.041036	0.84729	0.78181	0.72139
1986	-0.22600	0.034454	0.85395	0.79819	0.74607
1985	0.03152	0.047181	1.13327	1.03317	0.94191
1984	0.06343	0.054363	1.18703	1.06706	0.95921
1983	0.02707	0.058983	1.15537	1.02923	0.91687

North Atlantic Spanish LL SWO, Age 5+

YR	LSMEAN	STDERR	UCPU5+	CPU5+	LCPU5+
1997	-1.22277	0.033062	0.31430	0.29458	0.27609
1996	-1.01602	0.031622	0.38537	0.36221	0.34045
1995	-0.73734	0.029365	0.50694	0.47859	0.45182
1994	-0.77749	0.030411	0.48801	0.45977	0.43316
1993	-0.56186	0.033375	0.60903	0.57047	0.53434
1992	-0.35630	0.032917	0.74734	0.70064	0.65687
1991	-0.45758	0.035061	0.67825	0.63320	0.59115
1990	-0.58653	0.037339	0.59891	0.55664	0.51736
1989	-0.58675	0.036832	0.59817	0.55651	0.51775
1988	-0.44779	0.037017	0.68760	0.63948	0.59472
1987	-0.31860	0.044252	0.79383	0.72788	0.66740
1986	-0.19131	0.037252	0.88905	0.82645	0.76826
1985	0.01081	0.050953	1.11848	1.01218	0.91598
1984	0.12335	0.058536	1.27098	1.13322	1.01038
1983	0.06920	0.063451	1.21601	1.07381	0.94824

Table 3. Estimated parameters, standard error, relative CPUEs and upper and lower 95% confidence limits. SOUTH ATLANTIC, AGES 1-5+, period 1989-1997.

Souh Atlantic Spanish LL SWO, Age 1					
YR	LSMEAN	STDERR	UCPU1	CPU1	LCPU1
1997	-0.69487	0.07761	0.58291	0.50065	0.43000
1996	-0.68043	0.08654	0.60226	0.50830	0.42900
1995	-0.79046	0.08668	0.53966	0.45534	0.38420
1994	-0.79435	0.08990	0.54113	0.45371	0.38041
1993	-0.79840	0.09026	0.53934	0.45189	0.37861
1992	-1.46507	0.12111	0.29512	0.23276	0.18358
1991	-1.12910	0.13231	0.42273	0.32617	0.25166
1990	-0.95151	0.22104	0.61027	0.39571	0.25658
1989	-1.97850	0.24319	0.22940	0.14243	0.08843

South Atlantic Spanish LL SWO, Age 2					
YR	LSMEAN	STDERR	UCPU2	CPU2	LCPU2
1997	0.03473	0.03946	1.11947	1.03615	0.95903
1996	0.13522	0.04533	1.25244	1.14596	1.04854
1995	0.13014	0.04472	1.24456	1.14013	1.04446
1994	0.12173	0.04644	1.23842	1.13066	1.03228
1993	-0.37824	0.04610	0.75065	0.68580	0.62654
1992	-0.23393	0.05957	0.89101	0.79282	0.70545
1991	-0.01480	0.07138	1.13616	0.98782	0.85885
1990	-0.29085	0.12350	0.95968	0.75335	0.59139
1989	0.25202	0.13056	1.67607	1.29764	1.00465

South Atlantic Spanish LL SWO, Age 3					
YR	LSMEAN	STDERR	UCPU3	CPU3	LCPU3
1997	0.31744	0.03205	1.46341	1.37431	1.29064
1996	0.70755	0.03679	2.18221	2.03038	1.88912
1995	0.85529	0.03642	2.52777	2.35361	2.19145
1994	0.62021	0.03782	2.00382	1.86065	1.72771
1993	0.37780	0.03710	1.57021	1.46008	1.35767
1992	0.47648	0.04848	1.77299	1.61229	1.46615
1991	0.69703	0.05801	2.25334	2.01117	1.79502
1990	0.73906	0.10084	2.56458	2.10464	1.72720
1989	1.02340	0.10658	3.44861	2.79848	2.27090

South Atlantic Spanish LL SWO, Age 4					
YR	LSMEAN	STDERR	UCPU4	CPU4	LCPU4
1997	-0.07782	0.03325	0.98799	0.92565	0.86724
1996	0.43484	0.03814	1.66584	1.54584	1.43449
1995	0.53170	0.03776	1.83383	1.70303	1.58155
1994	0.38412	0.03921	1.58682	1.46945	1.36077
1993	0.28396	0.03852	1.43362	1.32937	1.23269
1992	0.39470	0.05025	1.63960	1.48581	1.34644
1991	0.46545	0.06014	1.79521	1.59561	1.41820
1990	0.64049	0.10454	2.34163	1.90780	1.55435
1989	0.64411	0.11048	2.37920	1.91595	1.54291

South Atlantic Spanish LL SWO, Age 5+					
YR	LSMEAN	STDERR	UCPU5	CPU5	LCPU5
1997	0.18797	0.03883	1.30322	1.20771	1.11920
1996	0.48586	0.04454	1.77563	1.62719	1.49116
1995	0.68448	0.04409	2.16380	1.98467	1.82036
1994	0.69329	0.04578	2.19035	2.00238	1.83054
1993	0.62759	0.04491	2.04753	1.87498	1.71698
1992	0.68315	0.05868	2.22528	1.98351	1.76802
1991	0.67810	0.07022	2.26642	1.97499	1.72104
1990	0.79961	0.12208	2.84720	2.24131	1.76435
1989	0.58729	0.12902	2.33613	1.81415	1.40879

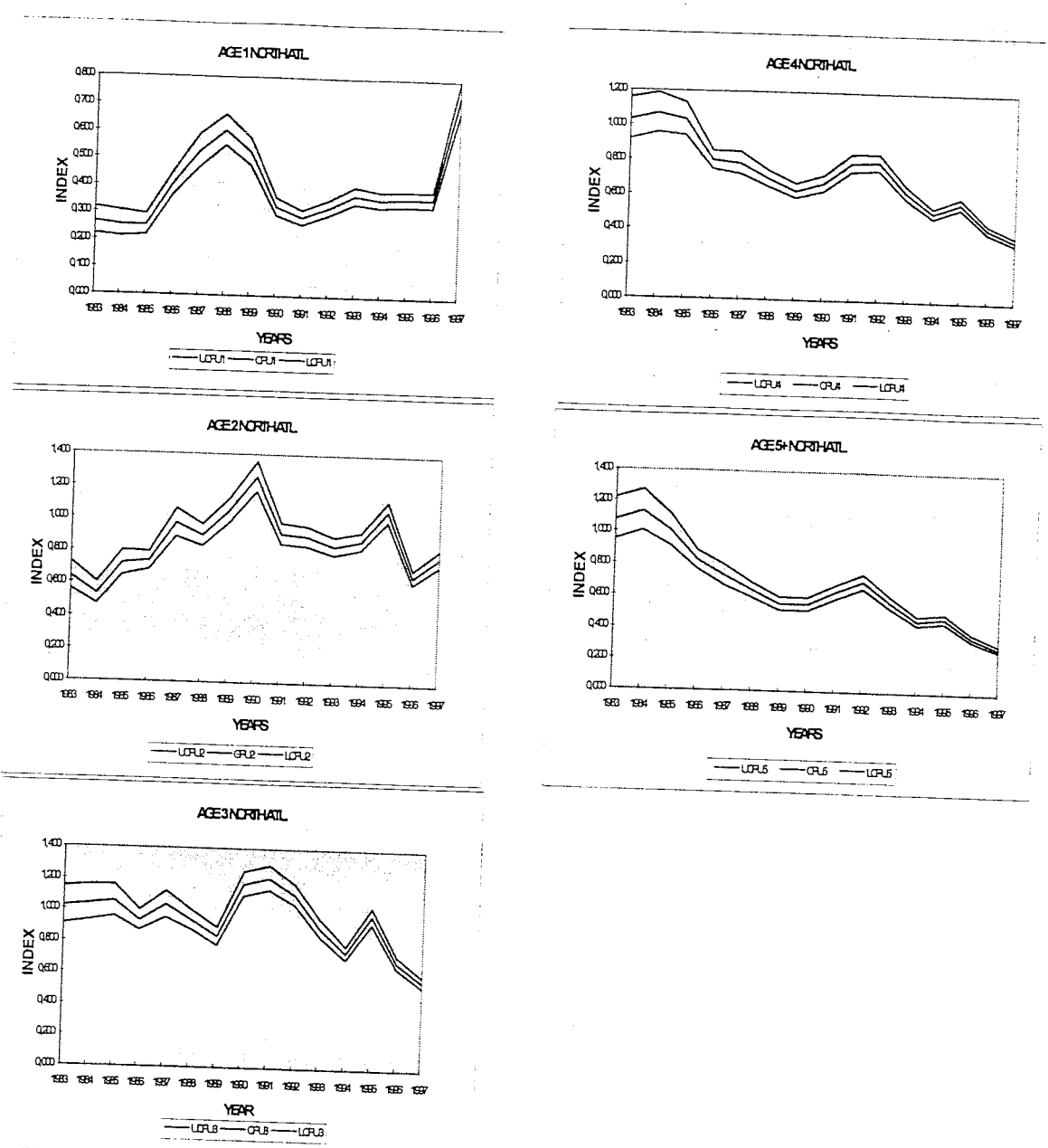


Figure 1.- Annual change of standardized catch rates index by age class (and 95% confidence interval). **NORTH ATLANTIC**. Ages: 1-5+. Sex: MALES+FEMALES. Gompertz growth model (Anonymous, 1989), years 1983-1997.

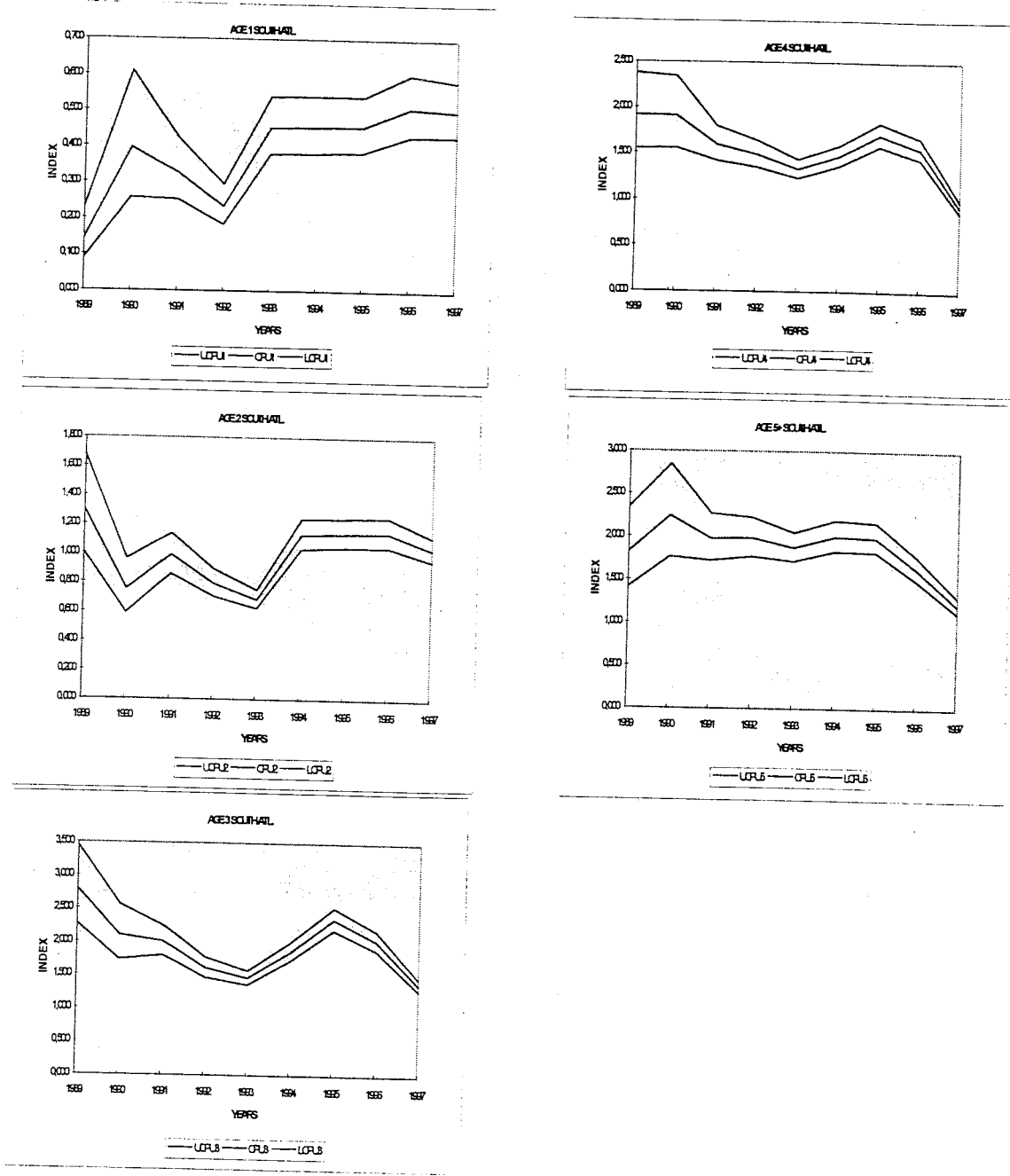


Figure 2.- Annual change of standardized catch rates index by age class (and 95% confidence interval). **SOUTH ATLANTIC**. Ages: 1-5+. Sex: MALES+FEMALES. Gompertz growth model (Anonymous, 1989), years 1989-1997.