

**STANDARDIZED CATCH RATES IN NUMBER AND WEIGHT FOR THE SWORDFISH  
(*XIPHIAS GLADIUS*) FROM THE SPANISH LONGLINE FLEET IN THE MEDITERRANEAN SEA,  
1988-1993**

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**SUMMARY**

Standardized catch rates in number and weight were developed using General Linear Modelling (GLM) procedures from 5,931 trips carried out by the Spanish surface longline fleet targeting swordfish in the western Mediterranean from 1988-1993.

The variability rate explained by the model was 14% and 19% for analyses in number and weight, respectively.

**RESUME**

Des taux de capture standardisés en nombre et en poids ont été élaborés par la méthode du modèle linéaire généralisé (GLM) à partir de 5.931 sorties effectuées par la flottille palangrière espagnole qui a visé l'espadon dans l'ouest de la Méditerranée de 1988 à 1993.

Le taux de variabilité expliqué par le modèle était de 14 % et 19 % respectivement pour les analyses en nombre et en poids.

**RESUMEN**

Tasas de captura normalizadas, en número de peces y en peso (kg peso vivo), han sido obtenidas mediante técnicas de Modelo Lineal Generalizado (MLG) a partir de 5.931 mareas realizadas por la flota española de palangre de superficie dirigida al pez espada en el Mediterráneo occidental, durante el período 1988-1993.

La tasa de variabilidad explicada por el modelo fue del 14% y 19% para los análisis en número y peso, respectivamente.

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LONGLINE FLEET IN THE MEDITERRANEAN SEA, 1988-1993.**

by (\*): **J. Mejuto and J. M. de la Serna**

**ABSTRACT.**

Standardized catch rates in number and weight were developed using General Linear Modelling (GLM) procedures from 5931 trips carried out by the Spanish surface longline fleet targeting swordfish in the West Mediterranean from 1988-1993.

The variability rate explained by the model was 14 % and 19 % for analyses in number and weight, respectively.

**RESUMEN.**

Tasas de captura normalizadas, en número de peces y en peso (kg peso vivo), han sido obtenidas mediante técnicas de Modelo Lineal Generalizado (MLG) a partir de 5931 mareas realizadas por la flota española de palangre de superficie dirigida al pez espada en el Mediterráneo Occidental, durante el período 1988-1993.

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Key words: swordfish, CPUE, GLM, longline, Mediterranean.

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## 1. INTRODUCTION.

The surface longline fishery targeting swordfish has become a traditional activity in the Mediterranean Sea. A great number of countries have been carrying out this fishery with the number of catches for this species and gear exceeding 7000 Tons in recent years.

However, information on this fishery has often been affected by a number of limiting factors that may be termed "endemic" in the enormous amount of fisheries in the Mediterranean.

- The great number of countries involved in the fishery.
- The dispersion of the fleets and landing ports.
- The abundance of non-industrial fleets that engage in opportunistic activities in relation to the target species, gear, etc.

These factors, among others, complicate the global tracking of this fishery and only partial or local studies have been successfully carried out. They are, however, of great interest.

The above problem has been especially patent on reviewing the data available on catch rates (ANONYMOUS, 1993), which may on occasion be assumed as abundance indices for stock assessment.

The information available is often from relatively small areas and/or in formats difficult to standardize (GARCES & REY, 1984; CAMIÑAS et al., 1986; POTOSCHI et al., 1993, DI NATALE et al., 1993)

Both the national offices and the scientific community involved in the study of this species must make an effort to coordinate the criteria in order to gather information and carry out analyses. Along these lines, the framework of an International Commission would seem to be the most appropriate means of tackling this problem.

The standard catch rates of the Atlantic swordfish were recently obtained on a routine basis by means of GLM 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). This has become a basic, routine task in the assessment of the Atlantic stocks within the ICCAT dynamics.

As in the case of the Atlantic, the Generalized Linear Modelling technique (GLM) (ROBSON, 1966; GAVARIS, 1980; KIMURA, 1981) could be a useful instrument in the estimation of 'relative abundance indices' for the Mediterranean Sea, based on data from commercial fleets with unbalanced spatial and temporal fishing patterns.

The activity of the Spanish fleet has been carried out traditionally in the West Mediterranean Sea. However, data bases with the formats and necessary resolution to make a more thorough analysis have only been created in recent years.

Nevertheless, the activity of this fleet may be considered relatively variable as regards the fishing pattern over time. Changes in the structure of the gear, hook size, target sizes, etc. (REY & ALOT, 1984) are possible in a highly opportunistic fishery. It is difficult to consider all these factors in a retrospective study of these characteristics.

## MATERIAL AND METHODS

### 2.1 BASIC DATA:

The records used in the analyses are from Spanish longline activity in the Mediterranean Sea from 1988 to 1993. Data are records per trip obtained by the Spanish Oceanography Institute (IEO) when trips were landed at the most important landing ports used by the Spanish Mediterranean fleet.

Records by trip for GLMs analyses were structured as follows:

Vessel Code, Date of landing, Landing in number, Landing in Kg round weight, Number of fish sampled, Catch by LJFL (5 cm intervals), Quadrant, Area (5x5 degrees), Type of fleet, Number of sets, Hooks by set, Type of bait.

Following the traditional criteria, nominal effort by trip was defined as number of hooks (in thousands of hooks), calculated from the number of sets carried out and the mean number of hooks per set.

### 2.2. MODEL AND SPECIFICATIONS

The areas used in the tentative analysis are shown in Figures 1. After completing the preliminary runs, 3 areas were defined in order to obtain a more accurate plan of the different spatial-temporal cells.

Tentative areas 1 and 2 were combined and considered as area 2. Areas 4 and 6 were not used because no observations were available from these unusual fishing zones (Figure 1).

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

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

$\bar{u}$  = 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.  
 CPUE was defined as Catch (in number or weight) divided by the nominal effort

### 3. RESULTS AND DISCUSSION

Table 1 shows the number of observations per year/area/quarter used in the GLM analyses. A total of 5931 trips were used. In general the number of observations per cell (spatial-temporal) may be considered satisfactory.

Table 2 and 3 is a summary of the ANOVA results. The number of observations, R-square, mean square error (root), F statistics, etc., is provided. The variability rate explained by the model (R-square) was 14% and 19% for the analyses in number and weight, respectively.

Standardized residual patterns for CPUE<sub>n</sub> and CPUE<sub>w</sub> analyses in general show a normal type when number of observations is suitable (Figure 2).

Table 4 provides information on estimated parameters, with the standard error, relative CPUEs and upper and lower 95% confidence limits obtained. The standardized CPUE, in number and weight, and the confidence limits are plotted in Figure 3.

### ACKNOWLEDGEMENTS.

The authors would like to give their deepest thanks to all the members of the 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 E. Alot, J. A. Romero, to name only a few, this paper would not have been possible.

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### LITERATURE CITED.

- ANONYMOUS, 1988. Report of the ICCAT Swordfish Workshop. ICCAT Col. Vol. Sci. Pap. Vol. XXXVII. 1-146 pp.
- ANONYMOUS, 1989. Second ICCAT Swordfish Workshop. ICCAT Col. Vol. Sci. Pap. Vol. XXXIX. 71-162 pp.
- ANONYMOUS, 1991. Informe del periodo bienal 1990-1991. 1 parte. ICCAT.
- ANONYMOUS, 1992. Reference Paper on 1991 Swordfish Stock Assessment. ICCAT Col. Vol. Sci. Pap. Vol. XXXIX (2). 397-476 pp.
- ANONYMOUS, 1993. Second GFCM/ICCAT Consultation on Stocks of Large Pelagic Fishes in the Mediterranean Sea. ICCAT Col. Vol. Sci. Pap. Vol. XL(1).
- CAMIÑAS, J. A., E. ALOT, A. RAMOS. 1986. Analisis de las CPUE del Pez Espada, (*Xiphus gladius*) del area BIL-95 en el año 1984. ICCAT Col. Vol. Sci. Pap. Vol. XXV. 175-184.
- DI NATALE, A.; A. MANGANO, A. MAURIZI, L. MONTALDO, E. NAVARRA, S. PINCA, G. SCHIMMENTI, M. VALASTRO, 1993. Swordfish (*Xiphus gladius* L.) longline fishery in the western Italian Seas and in Sicily Channel. 1991 Report. ICCAT Col. Vol. Sci. Pap. Vol. XL(1):468-473.
- GARCÉS, A.G.; J.C. REY, 1984. La pesquería española de Pez Espada (*Xiphus gladius*). 1973-1982. ICCAT Col. Vol. Sci. Pap. Vol. XX(2):419-427.
- 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.
- 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. XXX: 228-249.
- HOEY, 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-GARCÉS, 1988. Gráficos de CPUE y peso medio por cuadrícula 5x5 grados, de la flota española de pez espada *Xiphus gladius*, años 1982-1985. ICCAT Col. Vol. Sci. Pap. Vol. XXXVII. 287-297 pp.
- MEJUTO, J. (1993). Age specific standardized indices of abundance for Swordfish (*Xiphus 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 (*Xiphus gladius*) from the Spanish longline fleet in the Atlantic, 1983-1992. ICCAT Col. Vol. Sci. Pap. Vol. XLII(1):328-334.
- 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.
- POTOSCHI, A., G. CAVALLARO, P. STURIALE, G. PISCIOTTA, A. GRANATA, B. MELLINI, 1993. The Swordfish (*Xiphus gladius* L., 1758) surface longline fishing practised in the fisheries of eastern Sicily. ICCAT Col. Vol. Sci. Pap. Vol. XL (1):327-330.
- REY, J.C.; E. ALOT, 1984. Contribucion al estudio de la Pesquería de pelangre del pez espada (*Xiphus gladius*) en el Mediterraneo Occidental. ICCAT Col. Vol. Sci. Pap. Vol. XX(2):428-434.
- 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 (*Xiphus gladius*) from the U.S. longline fleet though 1991. ICCAT Col. Vol. Sci. Pap. Vol. XL (1):458-468.

TABLE 1 OF AREA BY QTR  
CONTROLLING FOR YR=1988

AREA	QTR				Total
Frequency	1	2	3	4	
2	1	29	73	34	137
3	33	60	69	49	211
5	4	28	177	18	227
Total	38	117	319	101	575

TABLE 2 OF AREA BY QTR  
CONTROLLING FOR YR=1989

AREA	QTR				Total
Frequency	1	2	3	4	
2	34	140	213	75	462
3	40	76	93	43	252
5	5	2	162	25	194
Total	79	218	468	143	908

TABLE 3 OF AREA BY QTR  
CONTROLLING FOR YR=1990

AREA	QTR				Total
Frequency	1	2	3	4	
2	26	108	217	79	430
3	21	54	150	71	296
5	0	12	285	69	366
Total	47	174	652	219	1092

TABLE 4 OF AREA BY QTR  
CONTROLLING FOR YR=1991

AREA	QTR				Total
Frequency	1	2	3	4	
2	19	104	157	90	370
3	45	76	101	74	296
5	2	0	146	0	148
Total	66	180	404	164	814

TABLE 5 OF AREA BY QTR  
CONTROLLING FOR YR=1992

AREA	QTR				Total
Frequency	1	2	3	4	
2	18	80	356	116	570
3	55	54	187	147	443
5	0	10	95	17	122
Total	73	144	638	280	1135

TABLE 6 OF AREA BY QTR  
CONTROLLING FOR YR=1993

AREA	QTR				Total
Frequency	1	2	3	4	
2	144	190	494	204	1032
3	51	38	85	85	259
5	5	19	74	18	116
Total	200	247	653	307	1407

Table 1 - Number of observations by year/area/quarter used in the GLM analyses.

Dependent Variable: CPUI (CPUE in number)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	488.64700144	30.54043759	62.00	0.0001
Error	5914	2912.96079421	0.49255340		
Corrected Total	5930	3401.60779566			

	R-Square	C.V.	Root MSE	CPUI Mean
	0.143652	33.53952	0.7018215	2.09252085

Source	DF	Type I SS	Mean Square	F Value	Pr > F
CYR	5	173.45136178	34.69027236	70.43	0.0001
QTR	3	261.42130516	87.14043505	176.92	0.0001
AREA	2	11.09184593	5.54592296	11.26	0.0001
QTR*AREA	6	42.68248858	7.11374810	14.44	0.0001
Source	DF	Type III SS	Mean Square	F Value	Pr > F
CYR	5	142.80446926	28.56089385	57.99	0.0001
QTR	3	88.59941460	29.53313820	59.96	0.0001
AREA	2	15.79050317	7.89525158	16.03	0.0001
QTR*AREA	6	42.68248858	7.11374810	14.44	0.0001

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	2.342315349 B	36.29	0.0001	0.06454007
CYR 1	-0.384323515 B	-10.56	0.0001	0.03639890
2	-0.493579492 B	-13.40	0.0001	0.03684745
3	-0.528819554 B	-13.64	0.0001	0.03876827
4	-0.197104226 B	-5.39	0.0001	0.03656618
5	-0.423815301 B	-11.15	0.0001	0.03800001
6	0.000000000 B	.	.	.
QTR 1	-0.139243727 B	-0.75	0.4521	0.18518143
2	0.042215314 B	0.41	0.6791	0.10204418
3	0.259313094 B	4.15	0.0001	0.06251023
4	0.000000000 B	.	.	.
AREA 2	0.085274711 B	1.30	0.1920	0.06535002
3	0.422274291 B	6.30	0.0001	0.06698912
5	0.000000000 B	.	.	.
QTR*AREA 1 2	-0.424676595 B	-2.20	0.0276	0.19273902
1 3	-0.475118508 B	-2.46	0.0139	0.19313059
1 5	0.000000000 B	.	.	.
2 2	-0.303037089 B	-2.76	0.0058	0.10971702
2 3	-0.744831462 B	-6.57	0.0001	0.11343635
2 5	0.000000000 B	.	.	.
3 2	-0.109109932 B	-1.53	0.1255	0.07121451
3 3	-0.420848128 B	-5.58	0.0001	0.07544770
3 5	0.000000000 B	.	.	.
4 2	0.000000000 B	.	.	.
4 3	0.000000000 B	.	.	.
4 5	0.000000000 B	.	.	.

Table 2- Results of ANOVA for GLM analyses applied to the Mediterranean swordfish caught by the Spanish longline fleet, from 1988 to 1993. CPUE in number of fishes.

MEDITERRANEAN Spanish LL SWO, CPUE IN WEIGHT  
General Linear Models Procedure

Dependent Variable: CPU2 (CPUE in weight)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	694.85683316	43.42855207	86.93	0.0001
Error	5914	2954.35068466	0.49955203		
Corrected Total	5930	3649.20751783			

R-Square	C.V.	Root MSE	CPU2 Mean
0.190413	15.23820	0.7067899	4.63827847

Source	DF	Type I SS	Mean Square	F Value	Pr > F
CYR	5	170.81079275	34.16215855	68.39	0.0001
QTR	3	346.94658429	115.64886143	231.51	0.0001
AREA	2	151.98262516	75.99131258	152.12	0.0001
QTR*AREA	6	25.11683096	4.18613849	8.38	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
CYR	5	197.07250514	39.41450103	78.90	0.0001
QTR	3	165.39302325	55.13100775	110.36	0.0001
AREA	2	156.84291672	78.42145836	156.98	0.0001
QTR*AREA	6	25.11683096	4.18613849	8.38	0.0001

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	4.891599193 B	75.26	0.0	0.06499698
CYR 1	-0.247516670 B	-6.75	0.0001	0.03665658
2	-0.625206613 B	-16.85	0.0001	0.03710830
3	-0.478098097 B	-12.25	0.0001	0.03904272
4	-0.209712702 B	-5.69	0.0001	0.03682505
5	-0.311308327 B	-8.13	0.0001	0.03826903
6	0.000000000 B	.	.	.
QTR 1	-0.164651855 B	-0.88	0.3773	0.18649240
2	-0.504105282 B	-4.91	0.0001	0.10276659
3	0.178971001 B	2.84	0.0045	0.06295276
4	0.000000000 B	.	.	.
AREA 2	0.101057698 B	1.54	0.1247	0.06581266
3	0.519903455 B	7.71	0.0001	0.06746336
5	0.000000000 B	.	.	.
QTR*AREA 1 2	-0.683127587 B	-3.52	0.0004	0.19410349
1 3	-0.404595630 B	-2.08	0.0375	0.19449784
1 5	0.000000000 B	.	.	.
2 2	-0.010742581 B	-0.10	0.9226	0.11049374
2 3	-0.073615897 B	-0.64	0.5193	0.11423940
2 5	0.000000000 B	.	.	.
3 2	-0.134313164 B	-1.87	0.0611	0.07171866
3 3	-0.282505303 B	-3.72	0.0002	0.07598182
3 5	0.000000000 B	.	.	.
4 2	0.000000000 B	.	.	.
4 3	0.000000000 B	.	.	.
4 5	0.000000000 B	.	.	.

Table 3- Results of ANOVA for GLM analyses applied to the Mediterranean swordfish caught by the Spanish longline fleet, from 1988 to 1993. CPUE in kg round weight.

MEDITERRANEAN Spanish LL SWO, CPUE IN NUMBER

YR	LSMEAN	STDERR	UCPU1	LCPU1
1993	1.96128	0.025334	7.4727	6.76623
1992	1.85202	0.027270	6.7251	6.04326
1991	1.81678	0.030019	6.5278	6.1548
1990	2.14850	0.027303	9.0465	8.5752
1989	1.92179	0.028491	7.2285	6.8359
1988	2.34560	0.033189	11.1474	10.4453

MEDITERRANEAN Spanish LL SWO, CPUE IN WEIGHT

YR	LSMEAN	STDERR	UCPU2	LCPU2
1993	4.59621	0.025513	104.224	99.141
1992	4.21852	0.027463	71.717	67.959
1991	4.36563	0.030232	83.542	78.735
1990	4.63402	0.027496	108.667	102.966
1989	4.53242	0.028693	98.403	93.022
1988	4.84373	0.033424	135.612	127.013

Table 4. - Estimated parameters, standard error, relative CPUEs, and upper and lower 95% confidence limits, for the standardized CPUE in number and weight, respectively.

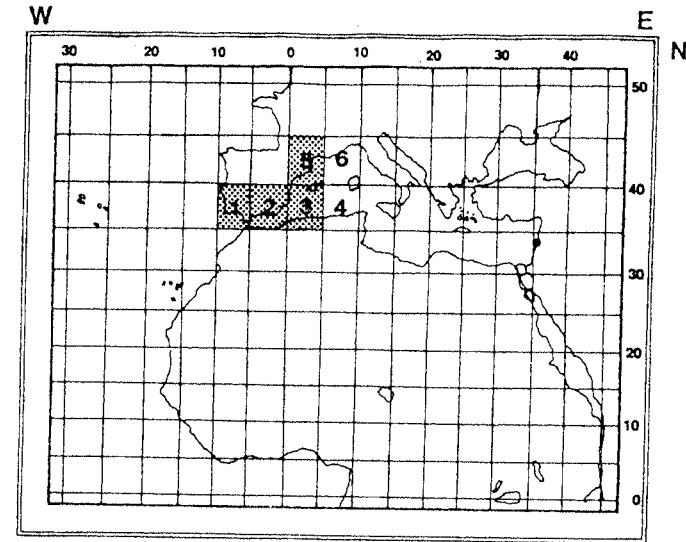


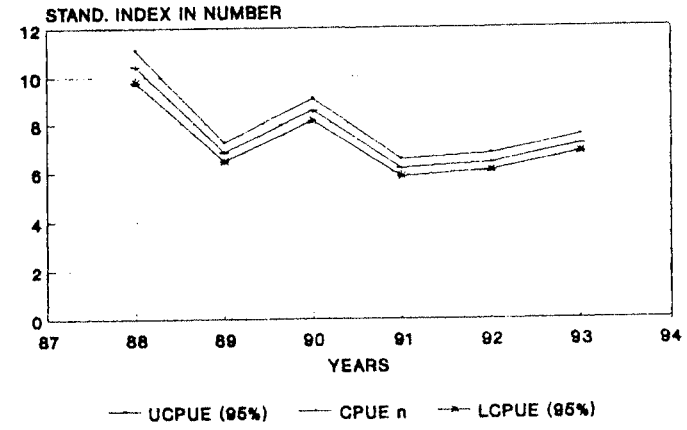
Figure 1.- Geographical area division used for preliminary GLM analyses for Spanish longline catch and effort data 1988-1993, in the Mediterranean Sea. Shaded areas indicate squares where observations were available.

Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

SWO, MED., LL SPANISH CPUE NUMBER OF FISH



Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

Year	CPUE	CPUE	CPUE
1988	1.00	1.00	1.00
1989	0.75	0.75	0.75
1990	0.85	0.85	0.85
1991	0.65	0.65	0.65
1992	0.70	0.70	0.70
1993	0.80	0.80	0.80
1994	0.75	0.75	0.75

SWO, MED., LL SPANISH CPUE KG ROUND WEIGHT

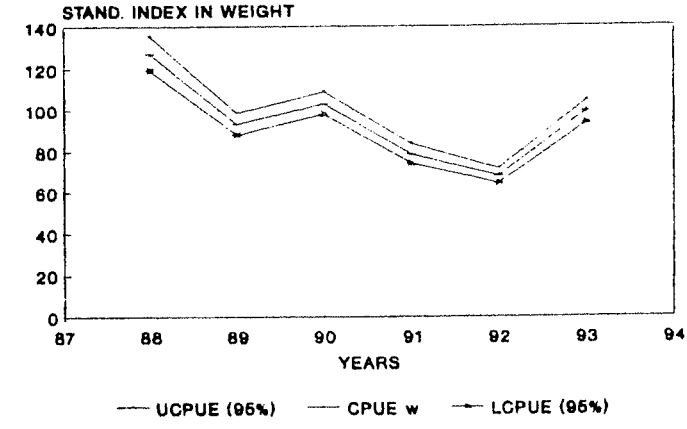


Figure 3.- Annual change of standardized CPUE index, in number of fish and kg round weight, for the Mediterranean swordfish caught by the Spanish longline fleet.

Figure 2 Histograms (%) standardized residuals by year from the general linical model analyses, in number and weight, respectively.