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UPDATED STANDARDIZED CATCH RATES FOR BLUEFIN TUNA (*Thunnus thynnus*) FROM THE TRAP FISHERY IN THE STRAITS OF GIBRALTAR

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SUMMARY

A General Linear Modeling (GLM) approach to analysis of variance was used to examine bluefin tuna catch rates from the Spanish trap fishery in the Straits of Gibraltar. Standardized catch rates for bluefin tuna were updated for the period 1981- 2000.

RESUMEN

Se utilizaron técnicas de análisis lineal generalizado (GLM) para analizar las tasas de captura de atún rojo procedente de la pesquería de almadrabas del Estrecho de Gibraltar. Se actualizaron las tasas de capturas estandarizadas para el período 1981- 2000.

KEYWORDS

Catch/effort, Least squares method, Abundance, Trap fishing.

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MATERIAL AND METHODS

Data were obtained from the Spanish trap fishery for bluefin tuna in the south of Spain. Information on catches in number of individuals, size composition, effort, and trap characteristics was collected from 1981 to 2000.

A General Linear Modeling (GLM) approach to analysis of variance was used to examine logged catch rates (catch in number of individuals per day of bunt set between consecutive net lifting operations or *matanzas*) for differences among the effects of year, month, and trap.

The general multiplicative model (Gavaris 1980, 1988) used was as follows:

$$\mathbf{Log\ (CPUE)} = \mu + \mathbf{Y_i} + \mathbf{M_j} + \mathbf{C_k} + \mathbf{M_i{*}T_k} + \mathbf{e_{ijk}}$$

where

	Log	: natural logarithm
	μ	: intercept
	CPUE	: catch rate
	$\mathbf{Y_i}$	: effect of factor year
	$\mathbf{M_j}$	: effect of factor month
	$\mathbf{T_k}$	: effect of factor trap
	$\mathbf{M_j{*}T_k}$ ...	: interaction term between month and trap
	$\mathbf{e_{ijk}}$	: error term $\mathbf{N}$ $(0, \sigma^2)$

Annual abundance indices were obtained from marginal means (least squares mean stimates), adjusted for the GLM statistically significant terms.

RESULTS

The final model, class level information and F-test are given in Table 1. Both factors, month and trap, and corresponding interaction were statistically significant at the 1 % level. R^2 was about 16 %. The distribution of the standardized residuals for the whole model is shown in Figure 1.

Standardized annual indices of abundance are shown in Table 2. Standardized CPUE with 95 % upper and lower confidence limits are shown in Figure 2.

LITERATURE CITED

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37; pp 2272- 2275.

Gavaris, S. 1988. Abundance indices from commercial fishing. Collected papers on stock assessment methods. CAFSAC Res. Doc. 88/61. 167 p.

Table 1.- GLM results for bluefin tuna catch rates in number of fish from the Spanish traps in the Straits of Gibraltar.

The GLM Procedure

Class Level Information

Class	Levels	Values
year	20	1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
month	3	4 5 6
trap	4	1 2 3 4

Number of observations 1755

Dependent Variable: lncpuen lncpuen

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	30	1146.835887	38.227863	10.84	<.0001
Error	1724	6081.799613	3.527726		
Corrected Total	1754	7228.635500			

R-Square	Coeff Var	Root MSE	lncpuen Mean
0.158652	68.11650	1.878224	2.757370

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	19	403.4926088	21.2364531	6.02	<.0001
month	2	436.3993362	218.1996681	61.85	<.0001
trap	3	224.1209100	74.7069700	21.18	<.0001
month*trap	6	82.8230323	13.8038387	3.91	0.0007

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	19	445.1000103	23.4263163	6.64	<.0001
month	2	400.4228360	200.2114180	56.75	<.0001
trap	3	100.2498957	33.4166319	9.47	

<.0001
month*trap 6 82.8230323 13.8038387 3.91
0.0007

Table 1.- (cont.)

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		2.850529574 B	0.31129071	9.16	<.0001
year	1981	-0.354768227 B	0.46278185	-0.77	0.4434
year	1982	0.202623727 B	0.27673087	0.73	0.4641
year	1983	-0.135383207 B	0.29449456	-0.46	0.6458
year	1984	0.291267732 B	0.32244432	0.90	0.3665
year	1985	-0.253976325 B	0.27831917	-0.91	0.3616
year	1986	-0.773441287 B	0.28419512	-2.72	0.0066
year	1987	-0.609886292 B	0.28429745	-2.15	0.0321
year	1988	-0.066878840 B	0.26761768	-0.25	0.8027
year	1989	-0.275535419 B	0.28268854	-0.97	0.3298
year	1990	-0.160579871 B	0.26608725	-0.60	0.5463
year	1991	-0.568520411 B	0.27458574	-2.07	0.0386
year	1992	-0.626945697 B	0.27565645	-2.27	0.0231
year	1993	-0.786187601 B	0.28357313	-2.77	0.0056
year	1994	-1.280062014 B	0.28834377	-4.44	<.0001
year	1995	-0.501441395 B	0.29790696	-1.68	0.0925
year	1996	-0.756355442 B	0.29586143	-2.56	0.0107
year	1997	0.419787085 B	0.25547216	1.64	0.1005
year	1998	0.261556933 B	0.28128855	0.93	0.3526
year	1999	0.807387678 B	0.26426031	3.06	0.0023

```
          year       2000      0.000000000 B       .               .         .
          month      4        -0.692269671 B      0.37865093      -1.83
0.0677
          month      5         0.688779781 B      0.26952616       2.56
0.0107
          month      6         0.000000000 B       .               .         .
          trap       1        -1.369065643 B      0.33513942      -4.09
<.0001
          trap       2        -0.123922888 B      0.30402898      -0.41
0.6836
          trap       3        -0.539862211 B      0.32498060      -1.66
0.0969
          trap       4         0.000000000 B       .               .         .
          month*trap 4 1       1.517951872 B      0.49239321       3.08
0.0021
          month*trap 4 2       0.067162946 B      0.46692438       0.14
0.8856
          month*trap 4 3       0.568487013 B      0.47797806       1.19
0.2345
          month*trap 4 4       0.000000000 B       .               .         .
          month*trap 5 1       0.470918748 B      0.37678297       1.25
0.2115
          month*trap 5 2       0.445840402 B      0.34368448       1.30
0.1947
          month*trap 5 3       0.174916546 B      0.36281232       0.48
0.6298
          month*trap 5 4       0.000000000 B       .               .         .
          month*trap 6 1       0.000000000 B       .               .         .
          month*trap 6 2       0.000000000 B       .               .         .
          month*trap 6 3       0.000000000 B       .               .         .
          month*trap 6 4       0.000000000 B       .               .         .

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was
used to solve
      the normal equations.  Terms whose estimates are followed by the letter 'B'
are not
      uniquely estimable.
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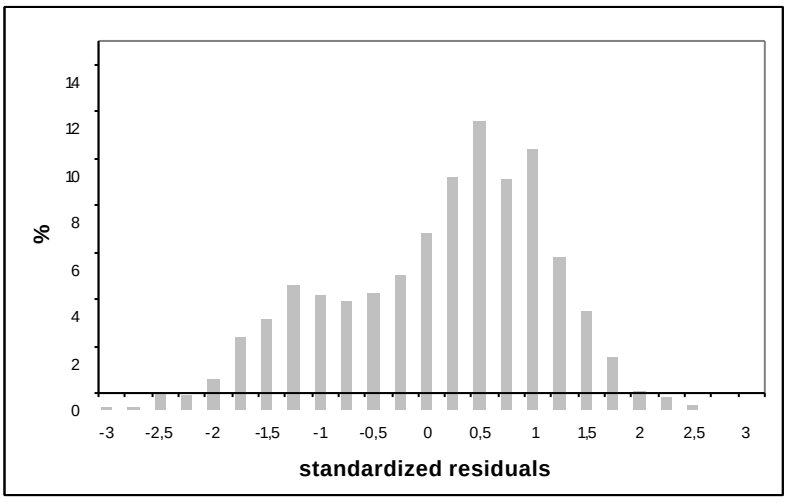

Figure 1 .- Standardized residuals for GLM fit (catch rates in number of fish).

Table 2.- Standardized CPUE series in number of fish for the Spanish Trap fishery in the Straits of Gibraltar.

Year	Least Sqr. Mean	Std. Error	LN CPUE (number)	Lower CI 95%	Upper CI 95%
1981	2,2568	0,4197	2,3449	1,52	3,17
1982	2,8142	0,1972	2,8337	2,45	3,22
1983	2,4762	0,2233	2,5011	2,06	2,94
1984	2,9029	0,2596	2,9366	2,43	3,45
1985	2,3576	0,2004	2,3777	1,98	2,77
1986	1,8382	0,2052	1,8592	1,46	2,26
1987	2,0017	0,2057	2,0229	1,62	2,43
1988	2,5447	0,1834	2,5615	2,20	2,92
1989	2,3361	0,2054	2,3571	1,95	2,76
1990	2,4510	0,1794	2,4671	2,12	2,82
1991	2,0431	0,1915	2,0614	1,69	2,44
1992	1,9846	0,1950	2,0037	1,62	2,39
1993	1,8254	0,2078	1,8470	1,44	2,25
1994	1,3315	0,2152	1,3547	0,93	1,78
1995	2,1102	0,2260	2,1357	1,69	2,58
1996	1,8552	0,2238	1,8803	1,44	2,32
1997	3,0314	0,1647	3,0449	2,72	3,37
1998	2,8732	0,2036	2,8939	2,49	3,29
1999	3,4190	0,1779	3,4348	3,09	3,78
2000	2,6116	0,2008	2,6318	2,24	3,03

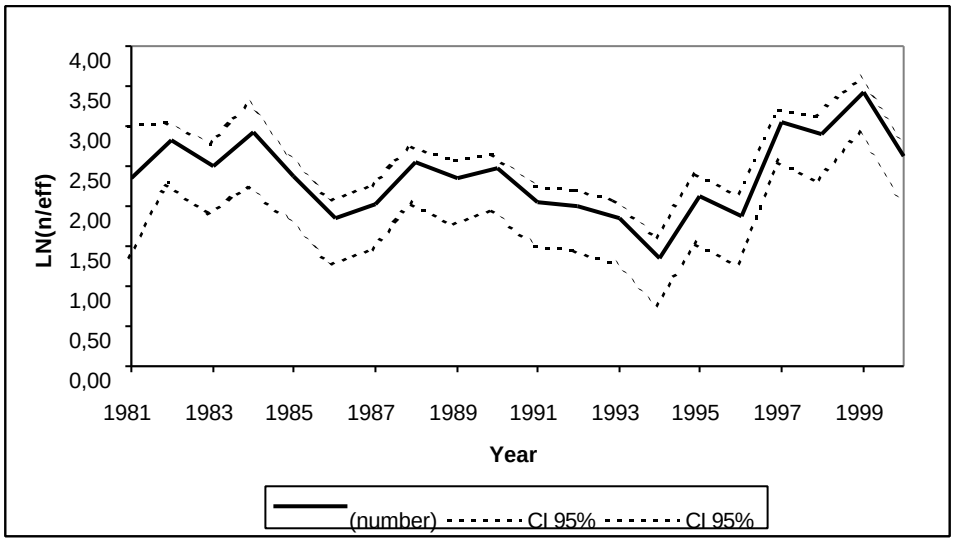

Figure 2 .- Standardized CPUE series in number of fish for the Spanish BFT Trap fishery in the Straits of Gibraltar. Dashed lines indicate 95% confidence bands.