

STANDARDIZED CPUE FOR SWORDFISH CAUGHT BY SANTOS LONGLINERS OFF SOUTHERN BRAZIL (1986-1995)

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SUMMARY

Swordfish (*Xiphias gladius*) CPUE data (1988-1995) from longliners based in Santos City, São Paulo State, Brazil, fishing at 17°-35°S and 27°-51°W, were standardized by the General Linear Model (GLM). Available information on area, time, gear configurations and some interactions, were incorporated into the model.

The high increase in the swordfish CPUE in the last two years was mainly due to the change from traditional Japanese longline to surface longline.

The positive response of the swordfish stock to a directed fishing effort, even after seven years of high catches in the south Atlantic, may indicate that the level of exploitation of this species was below MSY. Therefore, as this analysis was based only on the Santos fleet, it should be carefully interpreted.

RÉSUMÉ

Les données relatives à la CPUE de l'espadon, *Xiphias gladius*, (1986-95) provenant de palangriers ayant leur port d'attache à Santos, dans l'Etat de São Paulo, au Brésil, et qui pêchent entre 17° et 35° Sud et 27° et 52° Ouest, ont été standardisées à partir du modèle linéaire généralisé (GLM).

Les informations disponibles sur l'espace/temps, sur la configuration des engins et sur certaines interactions ont été incorporées au modèle.

L'accroissement élevé de la CPUE de l'espadon au cours des deux dernières années est principalement due au passage de la palangre japonaise traditionnelle à la palangre de surface.

La réaction positive du stock d'espadon à un effort de pêche le ciblant, même après 7 ans de ponction élevée dans l'Atlantique Sud, peut indiquer que le niveau d'exploitation de ces espèces se trouvait en dessous de la PME ; cette analyse se fondant seulement sur la flotte de Santos, il faudra donc l'interpréter soigneusement.

RESUMEN

Por medio del Modelo Lineal Generalizado (GLM) se estandarizaron los datos de CPUE de pez espada (*Xiphias Gladius*) de 1986-1995, de los palangreros con base en Santos, Estado de Sao Paulo (Brasil) y que pescan en los 17°-35° S y 27°-52°W.

Se incorporó al modelo la información disponible sobre zona, tiempo, configuración del arte, así como algunas interacciones.

El gran incremento de CPUE de pez espada en los dos últimos años se debió sobre todo al cambio del palangre tradicional japonés por el palangre de superficie.

La respuesta positiva del stock de pez espada a un esfuerzo de pesca dirigido, incluso tras siete años de fuertes capturas en el Atlántico sur, podría indicar que el nivel de explotación de esta especie estaba por debajo del RMS, por lo tanto, dado que este análisis se basaba solo en la flota de Santos, debe interpretarse con prudencia.

INTRODUCTION

Swordfish (*Xiphias gladius*) is caught all year round by longliners settled in Santos City, São Paulo State, Brazil. Nevertheless the highest catches occur in the third quarter (AMORIM & ARFELLI, 1984). In Brazil it is also caught by drift gill nets in a small amount.

This species has a high economic importance for the Santos fleet, consisting of 16 boats in 1985 and fishing at 17° - 35° S and 27° - 52° W.

This fleet used to fish with traditional Japanese longline (LL), but since June of 1994 it has gradually changed to surface monofilament longline (SL) with stick light in order to catch swordfish (ARFELLI, 1996).

In the beginning (1958-79) the Santos fleet aimed the catch for tunas that represented more than 50% of total yield, gradually decreasing in the following years. From 1981

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to part of 1994 they directed the fishing effort to the sharks, which reached 59% of Santos longliners yield in 1993. The swordfish was almost always the second most caught species. Nevertheless, it was the most caught species in 1980, 82, 88, 94 and 95.

In this study, CPUE of Santos longliners were standardized using General Linear Model (GLM), accounting the effects of the area, time and gear configurations.

MATERIAL AND METHODS

The number of fish, fishing effort by area of 5 degrees square were obtained from the logbooks written by the captains of the tuna longliners, for January/1988 to October/1989 and January/1992 to December/95. The individual weight per trip was taken from the commercial sheets from the fishing companies "Irmãos Ono", "Kawal-Suisan Comércio e Indústria de Pescados Ltda.", "Imaipesca Indústria e Comércio de Pescados Ltda.", "Cooperativa Mista de Pesca Nipo-Brasileira" and "Terminal Pesqueiro de Santos (TPS)". The yield of swordfish in weight, by trip/area was obtained multiplying the number by the average weight of the trip.

Other information like type of gear and number of branch lines between floats were obtained in interviews with the fishermen during the landings at the TPS.

Standardized CPUE (kilograms per thousand hooks) were estimated through the General Linear Model (GLM), using the multiplicative model with log-normal error assumption (GAVARIS, 1980, 1988).

The main effect was:

yr: year from 1988 to 1995

qt: quarter:

- 1) January-March
- 2) April-June
- 3) July-September
- 4) October-December

area: four areas:

- 1) 20° - 30° S, 40° - 50° W
- 2) 20° - 30° S, 30° - 40° W
- 3) 20° - 30° S, 20° - 30° W
- 4) 30° - 40° S, 30° - 50° W

these area were determined by distribution of

CPUE and effort

gear: LL or SL

Bran: Number of branch lines ranged from 4-8.

Final model was as follows:

$$\log(\text{CPUE}+1) = \text{overall mean} + \text{yr} + \text{qt} + \text{area} + \text{gear} + \text{bran} + \text{interaction} + \text{error}$$

RESULTS AND DISCUSSION

As the result of the test run with three combinations of two way interaction, the model

$$\log(\text{CPUE}+1) = \text{overall mean} + \text{yr} + \text{qt} + \text{area} + \text{gear} + \text{bran} + \text{yr} * \text{qt} + \text{error}$$

was chosen.

The results of ANOVA test are showed in Table 1. The variability rate explained by the model (R-Square) was 37%. All effects, except branch effect were significant at 0.1% level. The interaction yr*qt was significant but other two-way interactions were insignificant or not available. The results showed that:

- For season, the best is the third quarter (July-September);
- For area, off shore area is the best;
- For gear, the catchability of SL is about 6 times higher than it of LL;
- For branch lines, there is not so drastic differences among the number of branch lines.

Table 2 shows the standardized CPUE of swordfish caught by Santos longliners off Southern Brazil (17° - 35° S and 27° - 52° W), and these CPUE with upper and lower 95% confidence limits and nominal CPUE (Table 3) were plotted in Figure 1. Analyzing the standardized CPUE, it was noticed that it has increased significantly in the last two years. The nominal CPUE showed the same trend. This fact was mainly influenced by the gear changes. The value in 1995 was two times of it in 1988 for both kind of CPUE.

The swordfish catch in the South Atlantic has increased significantly since 1988, specially due the expansion of Spanish fleet to South of 5° N, reaching 16,810 t in 1989, about 10,000 t more than the previous years. If this CPUE trend reflect correctly to the true abundance change, it means that the stock abundance increased twice, although the catch increased significantly. This phenomenon is unlikely compared with North Atlantic swordfish stock. Nevertheless it

must be considered that the Santos longliners fishing effort was directed to swordfish, including gear changes, during part of 1994 and 1995. Therefore these CPUE were generally higher than that obtained by Florida fleet (BERKELEY; IRBY JR.; JOLLEY JR., 1981) when this kind of gear was introduced.

The positive answer of the swordfish stock to a directed fishing effort, even after seven years of high catches in the South Atlantic, may indicate that the level of exploitation of this species was below the MSY. Similar result was obtained by ARFELLI (1996) analyzing the swordfish in the South Atlantic by the yield function for polycohortical populations (SANTOS, 1992).

As these results were based only in Santos fleet, it should be carefully interpreted.

CONCLUSIONS

The high increase of the swordfish CPUE in the last two years was mainly due the changes of traditional Japanese longline to surface longline.

The positive answer of the swordfish stock to a directed fishing effort, even after seven years of high catches in the South Atlantic, may indicate that the level of exploitation of this species was below the MSY, therefore as this analysis was based only in Santos fleet, it should be carefully interpreted.

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Table 1. Summary of ANOVA test.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	39	1659.78	42.56	31.74	0.0001
Error	2137	2865.06	1.34		
Total	2176	4524.85			

R-Square = 0.367 C.V. = 23.898

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	7	149.31	21.33	15.91	0.0001
QT	3	434.32	144.77	107.98	0.0001
AREA	3	48.26	16.09	12.00	0.0001
GEAR	1	109.24	109.24	81.48	0.0001
BRAN	4	22.53	5.63	4.20	0.0022
YR*QT	21	198.37	9.35	6.97	0.0001

Table 2. Standardized CPUE (kg) for Santos longliners swordfish with 95 % confidence limits.

Year	mean	lower	upper
86	187.90	113.36	311.08
87	191.79	116.60	315.08
88	313.45	194.05	505.95
89	423.90	257.47	697.40
92	318.73	198.41	505.28
93	318.31	200.03	506.17
94	493.60	309.00	788.11
95	396.78	250.22	628.85

Quarter	mean	lower	upper
1	164.37	103.24	261.36
2	275.90	173.81	438.10
3	657.47	412.92	1048.50
4	325.86	204.30	519.40

Area	mean	lower	upper	
1	321.99	236.40	438.44	(20-30 S, 40-50 W)
2	221.67	151.04	325.12	(20-30 S, 30-40 W)
3	598.04	150.85	2362.21	(20-30 S, 20-30 W)
4	227.75	164.84	314.52	(30-40 S, 30-50 W)

Gear	mean	lower	upper
LI	129.73	82.68	203.22
SI	758.30	444.11	1294.57

Branch	mean	lower	upper
4	378.89	252.98	567.23
5	229.86	155.26	340.06
6	271.63	180.70	408.05
7	376.48	227.93	621.43
8	343.05	85.12	1373.52

Table 3. Nominal CPUE (kg) of swordfish from Santos longliners (1971-95).

Year	CPUE	Year	CPUE
1971	198.4	1984	125.4
72	234.5	85	182.0
73	164.8	86	216.0
74	536.5	87	280.1
75	567.1	88	352.9
76	281.7	89	317.1
77	312.4	90	332.3
78	147.8	91	209.2
79	240.9	92	174.0
80	958.1	93	165.9
81	349.8	94*	284.4
82	382.2	95*	437.5
83	194.5		

Source: ARFELLI (1996)

(*) include surface longliners

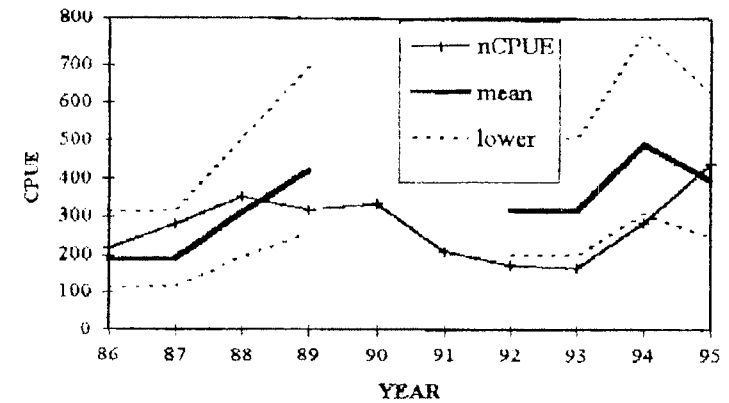


Figure 1. Standardized and nominal CPUE (kg/thousand hooks) of swordfish from Santos longliners