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STANDARDIZED CPUE OF BLUE MARLIN (*Makaira nigricans*) CAUGHT BY RECREATIONAL FISHERY OFF SOUTHEAST BRAZIL (1996-2008)

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SUMMARY

The GLM, assuming a Poisson error distribution and log as link function, was used to generate a standardized blue marlin CPUE series by recreational fishing boats from Yacht Club de Ilhabela and Iate Clube do Rio de Janeiro, off southeast Brazil (1996-08). The response variable was the CPUE defined as number of fish caught per boats per fishing day. The following factors were tested: year (13); month (5); target (2), corresponding to tournaments target fish, and local (2) the two different fishing grounds. The deviance analysis showed that the "year" and "month" were the main factors explaining the observed CPUE variability (43% and 38%, respectively), while the "target" factor accounted for only 18%. The local factor was not significant and was not included in the final model. The overall deviance explained by the fitted model was 70%, indicating a reasonably good adherence. The distribution of residuals also provided a reasonably good fit. The present results show a strong oscillation of the standardized CPUE, around a mean value of 0.26, ranging roughly from 0.06 to 0.52. Such a marked fluctuation in the catch rate might result from the rather small area covered by the present work, with the CPUE index thus reflecting more the local availability of the stock, than its actual abundance.

KEYWORDS

Catch rate, Blue marlin, Catchability, Sport fishery

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1. Introduction

The billfishes are often caught as by-catch by the commercial longline fisheries in the Atlantic Ocean. More recently, however, there has been an increasing concern with the impact of sport fisheries on billfish stocks. In Brazil, although the offshore recreational fishing tournaments are carried out along the coast, they are conducted mainly off Rio de Janeiro and Cabo Frio, Cities, Rio de Janeiro State, by Iate Clube do Rio de Janeiro (ICRJ) but also off Ilhabela, Sao Paulo State, by Yacht Club de Ilhabela (ICY). Both Yacht Clubs hold game fishing tournaments mainly from October to February (spring/ summer). The ICY stopped their billfish tournaments since 2003/04 fishing season. Since 1999/00 almost all billfishes have been released.

The Marlim Project is conducted by researches from *Instituto de Pesca (IP)*, the *Grupo de Estudos da Pesca (GEPESCA), Coordenação de Programas de Pós-graduação em Engenharia (COPPE)* of the *Universidade Federal do Rio de Janeiro*, and by anglers *from the ICY and ICRJ*, who follow the championship of yacht clubs. They have been monitoring game fisheries since the 1992-1993 tournaments (Arfelli et al., 1994; Amorim and Arfelli, 2001; Amorim and Silva, 2005). As a result of this activity presently only blue and white marlins and sailfish heavier than 250 kg, 50 kg and 35 kg respectively are brought aboard in attempt to reach a record.

The main species caught in these tournaments are the blue marlin (*Makaira nigricans*), the white marlin (*Tetrapturus albidus*) and the sailfish (*Istiophorus platypterus*) (Amorim and Arfelli, 2001). Historically, most of the papers done on Brazilian game fishing tournaments have been only descriptive (Arfelli et al., 1994; Amorim and Arfelli, 2001; Amorim and Silva, 2005). In the SCRS/2008/048, a CPUE series of sailfish caught by the sports fishery based in Rio de Janeiro-RJ and Ilhabela-SP, from 1996 to 2007, was standardized by GLM.

The objective of the present study, therefore, was to evaluate the temporal changes in relative abundance of the blue marlin caught by the sport fishery based in Rio de Janeiro-RJ and Ilhabela-SP, from 1996 to 2008, based on a CPUE series, standardized by using the generalized linear model (GLM) approach. The white marlin series were too small to be standardized.

2. Material and Methods

Radio logbook records from recreational tournaments of Yacht Clubs from São Paulo and Rio de Janeiro have been collected since 1996, either by voluntary submission by tournament organizers or by onboard observers. The ICY series used was from 1998/99 to 2003/04 and ICRJ from 2002/03 to 2006/07 seasons. The data set included a total of 93 tournament days from 1996 to 2008. Records for each tournament day included boat names, total number of operating boats per tournament day, total number of fish hooked, and their fate (i.e. lost, released, tagged and released, or boarded), by species, as well as size and weight for all boarded fish.

The number of blue marlin caught per boats registered in the tournament per day (μ) was considered as a relative index of abundance. The logarithm was used as a link function, in the following GLM model:

$$\mu \sim year + month + target + local + interactions + \varepsilon$$

where the terms “year”, “month”, “target” and ” local” represent the main effects of the explanatory variables and “interactions” stands for the first order interaction between all main effects. ε is an independent identically distributed random variable, with a Poisson distribution. The factor “year” included data from 1996 to 2008, while “month” included only data from October to February, since there is no tournament out of this period. The factor “target” was based in the target fish set for each tournament, including blue marlin or sailfish. The factor “local” accounted for the tournaments carried out in “São Paulo” or in “Rio de Janeiro”, in two different fishing areas about 70 miles from coast, as follows: A: 23° to 24°S/41° to 42°W, for Rio de Janeiro; and B: 24º to 25°S/44º to 45°W, for São Paulo (**Figure 1**).

The deviance analysis was used in a stepwise approach to select the set of exploratory variables and interactions. The relative percent of explained total deviance by the model was used to select the final model. Factors and interactions that accounted for 5% or more of the explained total deviance by the model were included in the final model (Ortiz and Arocha, 2004). A *p*-value based on χ^2 test statistic (α= 0.05) was also used to evaluate the significance of each additional factor included in the model.

Finally the residual distribution was checked in order to evaluate the goodness of the fitted model, following Ortiz and Arocha (2004). The estimates of standardized CPUE were based on the predictions obtained for each year, fixing the level of remaining factors at the level with the highest number of observations. The confidence intervals of estimates were also presented.

3. Results and Discussion

The mean value of blue marlin nominal CPUE was greater in the early phase of the studied period, particularly in 1996 and 1998, with the lowest values being observed in 2004 and 2006. The monthly CPUE, in turn, was higher for October and November than in the remaining months (**Figure 2**). Expectedly, the blue marlin CPUE was usually higher when it was the main target of the tournament. In general, when the blue marlin is the target species, the yacht speed is higher than when the boats are targeting sailfish. The bait type also changes, depending on the species targeted, with a preference for dead, artificial bait when the blue marlin is targeted and natural baits when the target species is the sailfish. The CPUE in São Paulo was always higher than in Rio de Janeiro (**Figure 2**).

Based on the stepwise approach, the factors “year”, “month” and “target” were included in the model, with no interactions. The deviance analysis (**Table 1**) shows that the “year” and “month” were the main factors explaining the observed CPUE variability (43% and 38%, respectively), while the “target” factor surprisingly accounted for only 18%. The overall deviance explained by the fitted model was 70%, indicating a reasonably good adherence. The distribution of residuals (**Figure 3**) also provided a reasonably good fit.

The standard errors of the standardized CPUE were rather large for 1996, 1998, 2001 and 2008 (**Figure 4**), but the great majority of their values were smaller than the year coefficient estimations. The overall pattern of the standardized CPUE show a strong oscillation around a mean value of 0.26 ranging roughly from 0.06 to 0.52. The maximum value of 0.52 was obtained in the last year, while the lowest value was found in the immediately previous one. Such a marked fluctuation in the catch rate might result from the rather small area covered by the present work, with the CPUE index thus reflecting more the local availability of the stock, than its actual abundance.

More recently, Amorim *et al*. (2006) presented the standardization of blue marlin catch rates based on data from the Yacht Club of Ilhabela and the sport fishery of Canavieiras, in the State of Bahia, using generalized linear models (GLM) and found a similar trend of standardized CPUE**.** Likewise stable trends of standardized catch rates of blue marlin were also found in the Caribbean and the Gulf of Mexico (Ortiz and Arocha, 2004). However, due to the temporal and spatial limitations of the present data, the results should be viewed with caution.

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Table 1- Deviance analysis of the fitted model for the standardization of blue marlin CPUE caught by the recreational fishery in Southeast Brazil (1996-2008).

Terms	Df	Deviance	Resid. Df	Resid. Dev.	F.Value	Pr(F)	Explained deviance	Pseudo R2
			93	25,62				
Year	12	7,83	81	17,79	4,96	5,28E-06	43%	31%
Month	4	6,94	77	10,85	13,20	3,255E-08	38%	58%
Target	1	3,27	76	7,58	24,87	3,774E-06	18%	70%

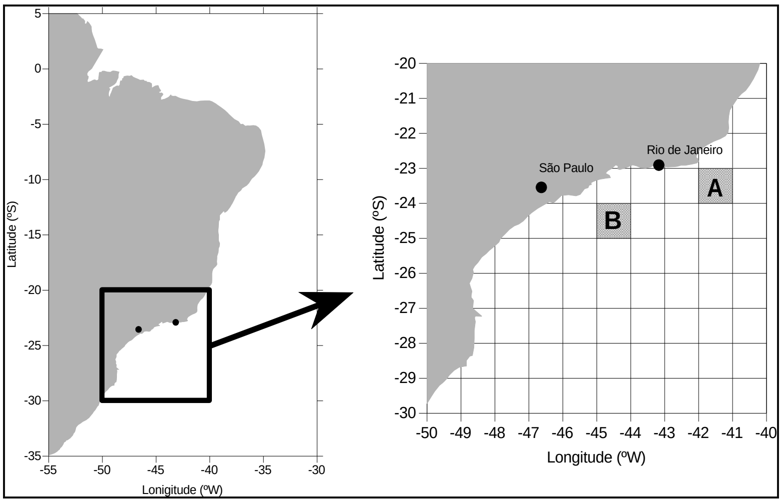

Figure 1- Fishing grounds of recreational fishery off Southeast Brazil, representing two different fishing areas about approximately 70 miles from the coast. A: 23° to 24°S/41° to 42°W, for Rio de Janeiro and B: 24º to 25°S/44º to 45°W, for São Paulo

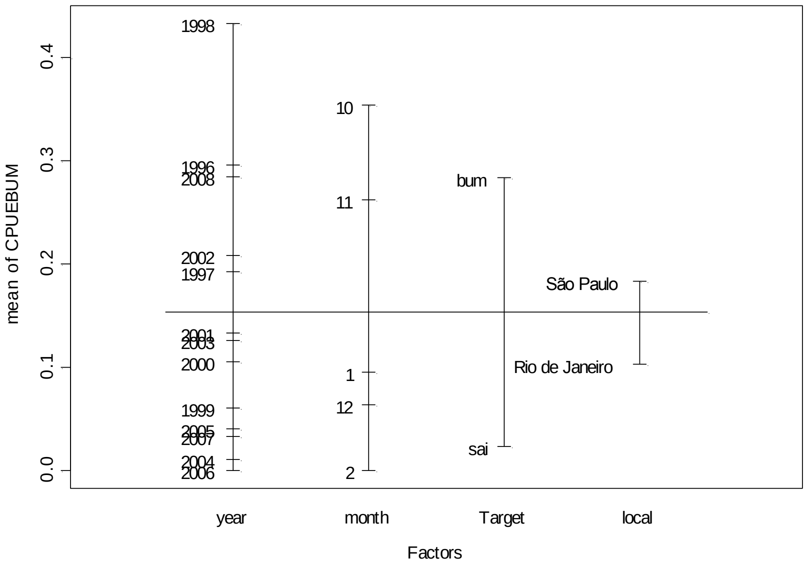

Figure 2- Mean of blue marlin nominal CPUE (n° of fish/ n° of boats/ day) for each factor and level from recreational fishery off Southeast Brazil, from 1996 to 2008.

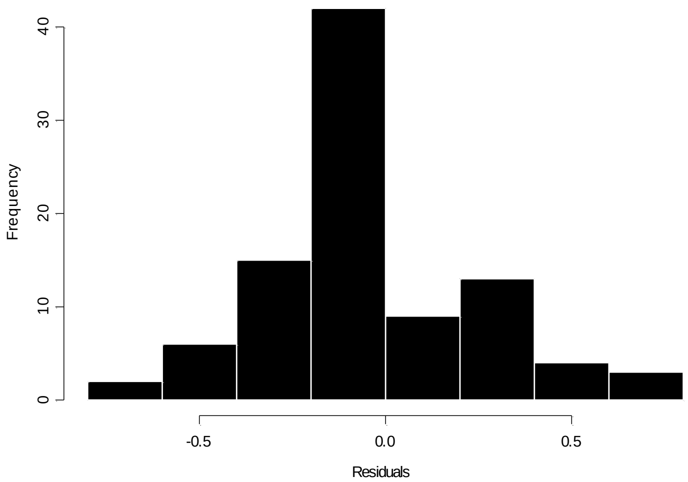

Figure 3- Histogram of residuals of the fitted model for the CPUE standardization of blue marlin caught by the recreational fishery off Southeast Brazil, from 1996 to 2008.

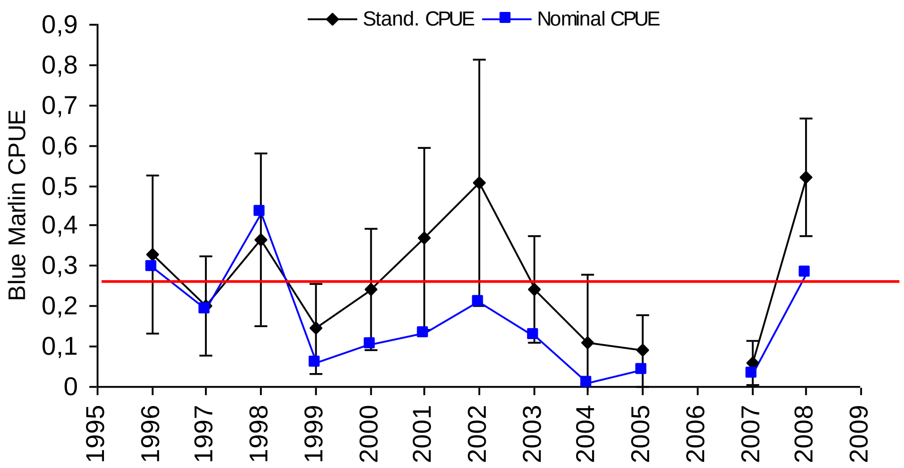

Figure 4- Nominal and standardized CPUE of blue marlin caught by the recreational fishery off Southeast Brazil, from 1996 to 2008 (the red arrow shows the overall mean value).