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A PROBABILITY MODEL FOR THE CATCH PER UNIT OF EFFORT (CPUE) OF THE SKIPJACK TUNA (*Katsuwonus pelamis*) POLE AND LINE FISHERY IN THE SOUTHWEST ATLANTIC

ANDRADE, H. A. & J. A. TEIXEIRA

UNIVALI – CTTMar, Rua Uruguai, 458. CEP 88302-202, Itajaí-SC, Brasil

ABSTRACT

The probability density function for the CPUE data is important to estimate possible outcomes of fishing events and as auxiliary information for the application of generalized linear models (GLM) in fisheries science. The negative binomial model fitted well CPUE frequency distributions of the pole and line skipjack tuna (*Katsuwonus pelamis*) fishery off southwest Atlantic, and is an alternative model to enable applications of GLM for this fishery. Since the normal distribution has not shown to be suitable for the CPUE distribution, expected fishery outcomes estimated from average calculations are biased and unreal.

Keywords: CPUE, skipjack tuna, pole and line, probability model

UM MODELO DE PROBABILIDADE PARA A CAPTURA POR UNIDADE DE ESFORÇO (CPUE) DA PESCARIA DE VARA E ISCA-VIVA DO BONITO LISTRADO (*KATSUWONUS PELAMIS*) NO SUDOESTE DO ATLÂNTICO

RESUMO

A função de densidade de probabilidade para a CPUE é importante para geração de estimativas de resultados possíveis de eventos de pesca e é também relevante como informação auxiliar na aplicação de modelos lineares generalizados (GLM) em ciência pesqueira. O modelo binomial negativo apresenta um bom ajuste às distribuições de freqüência das CPUEs das pescarias do bonito listrado (*Katsuwonus pelamis*) realizadas com o uso de vara e isca-viva no sudoeste do Atlântico, e é portanto, uma alternativa para aplicação do GLM na dessa pescaria. Uma vez que a distribuição normal não mostrou ser adequada para a distribuição da CPUE, estimativas de resultados esperados para eventos de pesca a partir do cálculo da média, são viciadas e irreais.

Palavras-Chaves: CPUE, bonito listrado, vara e isca-viva, modelo estatístico

INTRODUCTION

The variable CPUE (catch per unit of effort) is of major importance in fishery studies, because in several circumstances it holds as an index of the abundance of the exploited resource. Therefore, the CPUE is an indispensable component of some assessment models (*e.g.* dynamic biomass models). The CPUE is also used as an index of productivity of areas and oceanographic scenarios. In several studies the estimative of a statistic for central trend of the CPUE data is important and desirable to characterize a specific scenario (*e.g.* average CPUE of a given area in a specific season). The average is the statistic often used, because it is suitable for populations with a normal density probabilistic function. However, the use of the average is justified only when gaussian probability distribution fits well the CPUE data. Therefore, the determination of a suitable density function for CPUE is important. The knowledge about this probability distribution is also essential to the application of the linear generalized models (GLM). After Gavaris (1980) and Allen & Punsly (1984) provided examples of application of GLM in fisheries by using the CPUE as the response variable, the method has been widely used in fisheries science. The identification of the family of the probability model for response variable (*e.g.* CPUE) is requested for the application of GLM model (McCullagh & Nelder, 1989). Therefore, the objective of this work was to investigate the data from the skipjack tuna (*Katsuwonus pelamis*) pole and line fishery, in order to identify a suitable density function for the CPUE.

MATERIAL AND METHODS

Data from skipjack tuna fishery were collected from May, 1995 to December, 2000 in Itajaí (SC) harbor (Fig. 1). Most of catches upon West Atlantic skipjack stock (ICCAT, 1999) is carried out by Brazilian pole and line

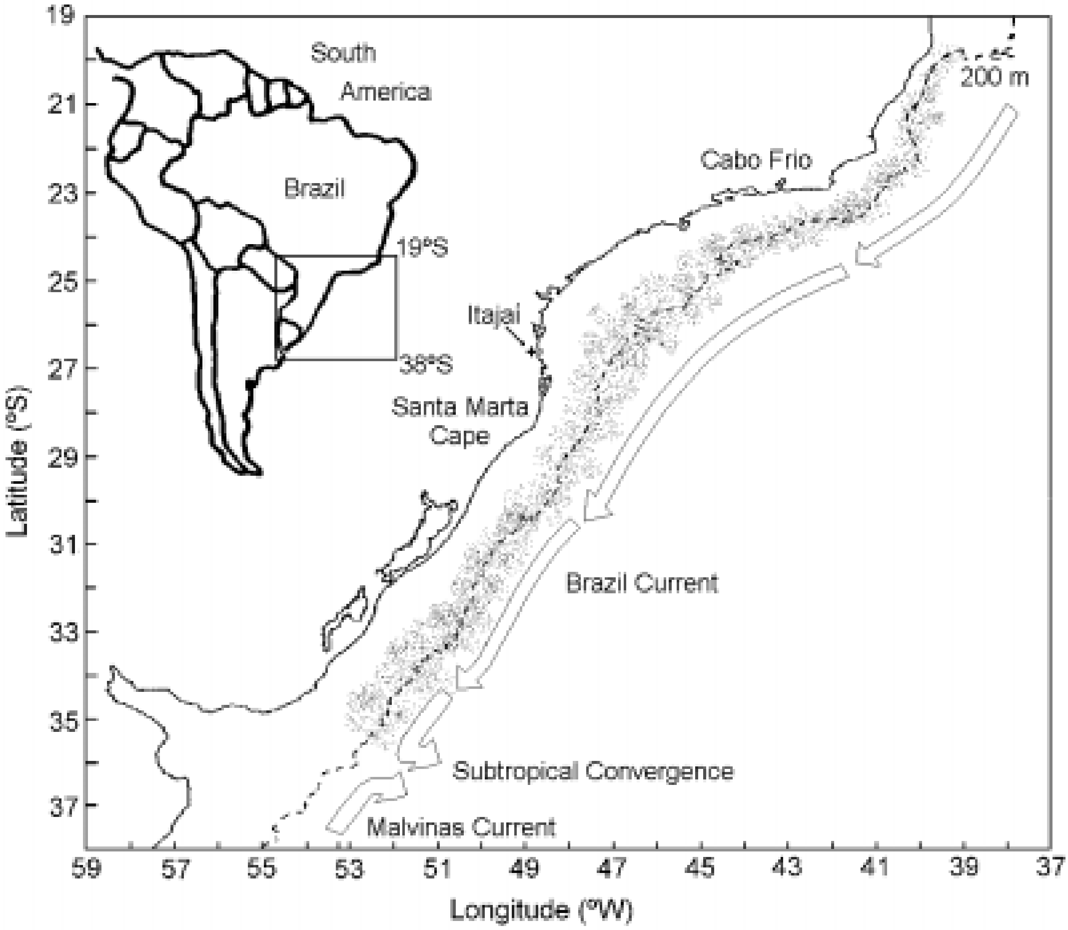

Fig. 1 – Skipjack tuna fishing area at Brazilian coast. The pole and line fleet fishing effort are concentrated around the shelf-break (200 m isobath) as indicated by the gray spots.

fleet (about 80 %), and most of this quantity is fished by the fleet based at Itajaí (SC) harbor which produces about 60% of national total catch. This fleet exploits all the skipjack fishing area, from 20º to 35º S (Fig. 1) (Vilela & Castello, 1993). Therefore, the data collected is representative of the fishing scenario in the Brazilian coast. The number of trips sampled was higher in summer than in the winter (Tab. 1), following the seasonal oscillation of the skipjack vulnerability to pole and line gear (Andrade & Garcia, 1999).

The unit of effort used was fishing days following ICCAT recommendations (ICCAT, 1999). The values of CPUE are expressed as weight caught in kilograms per fishing day. The properties of the CPUE frequency distribution were investigated using all data and the data grouped by month. The CPUE was classified in bins with range of 2,000 Kg. The negative binomial model was fitted to the data. The following version of the model was adapted to calculate so that the CPUE on the i^{th} fishing event (C_i) would be of class (c):

$$P\{C_i = c\} = \frac{\Gamma(k+c)}{\Gamma(k)c!}\left(\frac{k}{k+m}\right)^k\left(\frac{m}{m+k}\right)^c$$

(eq. 1)

The parameter *m* stands for the "mean" and is often denominated as "size" dispersion parameter. Moments methods were used to estimate the parameters and a standard chi-squared test was carried out to verify if the model is likely (goodness of fit). The frequency estimated for high CPUE classes would be zero and the chi-square calculation would be difficult. Therefore, the frequencies observed for very large CPUE values were pooled to avoid this problem.

Simulations were made using the fitted model to show differences between the expected CPUE provided by the model and the average CPUE. The aim was to illustrate how equivocated could be the use of the average to make predictions about the CPUE in fisheries where the probability for this variable is not normal.

RESULTS

The CPUE data frequency distribution in all months analyzed (months with sample size smaller than 25 were not used) showed a strong positive assimetry. The same shape was found for all data pooled (Fig. 2). The best fit of a negative binomial model was obtained with *m* equal to 9,191.147 and *k* equal to 1.186. The chi-square goodness of fit test showed that the null hypothesis can be accepted by far (P = 0.99).

Due to the long tail of the CPUE distribution the median of the observed CPUE

Tab.1 – Number of fishing trips sampled by month and year in the Itajaí(SC) harbor.

Year	Month												
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1995	0	0	0	0	1	2	6	5	1	0	14	9	38
1996	10	8	13	11	15	6	0	1	1	0	6	1	72
1997	13	16	10	8	1	5	2	8	4	5	0	1	73
1998	20	9	20	11	5	9	2	7	3	1	2	3	92
1999	30	12	5	14	5	2	8	3	3	0	6	0	88
2000	20	8	3	9	7	4	8	1	0	0	4	3	67
Sum	93	53	51	53	34	28	26	25	12	6	32	17	430

(6,800 kg) is much lower than the average (9,337 kg). According to the fitted model, 68.2% of the CPUE are expected to be smaller than the mean (9,337) in a time series of fishing events. The results of 500 possible CPUE outcomes based on the fitted model are showed in the figure 3 in comparison with expected CPUE averages.

DISCUSSION

The binomial model shape fitted well to CPUE data (Fig. 2) which implies that, the average is a poor index to express the central tendency of the CPUE frequency distribution. Therefore the use of the average index to represents the CPUE in a given situation in the skipjack tuna fishery (*e.g.* fishing areas/season), or to forecast future outcomes at the fishery or even to make interpolations to fulfill lacks in time CPUE series data can be equivocated (Fig. 3). The traditional gaussian model is not suitable to CPUE data and should not be used in the construction of errors in assessment models (*e.g.* process error in a dynamic biomass model), or used as the family of the probability distribution in applications of GLM models for the skipjack tuna fisheries. Indeed we suspect there are rare fishery examples in which the CPUE shows a normal distribution, because in measurements of continuous positive data, the distribution is usually skewed (McCullagh & Nelder, 1989).

Fishermen should not expect that the outcome of trials would be around the average CPUE. They should be prepared to deal often with low CPUE values in most occasions. Few outcomes will be higher than 9.000 kg, but when they occur the probability to get a very high CPUE, larger than 18.000 kg for instance, is not negligible. The pattern described (*i.e.* plenty of low and few large CPUE outcomes) should be: a) taken into account in optimizing costs with the fishery production processing in the industries plants; b) used as auxiliary information to support management decisions based on the CPUE indexes of individual boats.

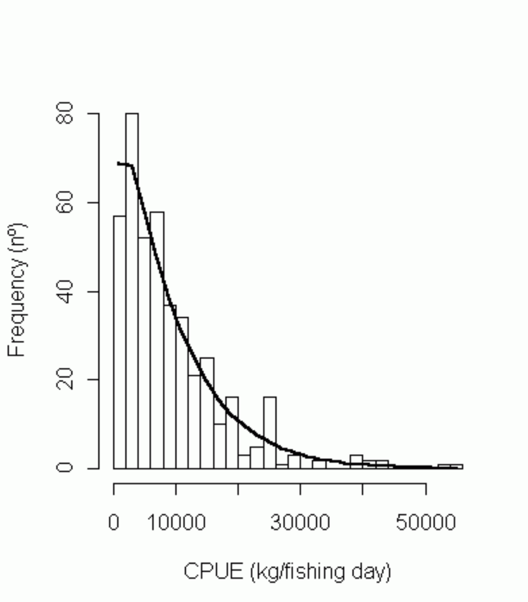

Fig. 2 – Frequency distribution of CPUE data from skipjack pole and line fishing fleet. The data were collected from May, 1995 to December, 2000. The line stands for the fitted negative binomial model.

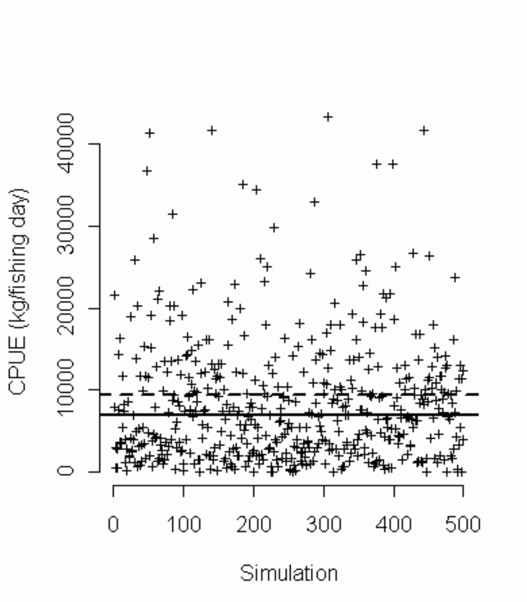

Fig. 3 – Simulation of 500 values of CPUE expected under the fitted model. The solid line stands for the observed median of CPUE of skipjack tuna, while the dashed stands for the average CPUE.

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