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CATCH RATES FOR BLUE MARLIN (*MAKAIRA NIGRICANS*) FROM THE SMALL SCALE FISHERY OFF LA GUAIRA, VENEZUELA: Period 1991-2009

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SUMMARY

Catch rates from 1991 to 2009 for blue marlin (Makaira nigricans) *from the small scale fishery off La Guaira, Venezuela (a billfish hot-spot) were standardized by Generalized Liner Model techniques. The index of weight of fish per number of sets was estimated from gutted weight of blue marlin caught and reported by port sampler in the fishing community of Playa Verde. The analysis included the variables year and season.*

RÉSUMÉ

Les taux de capture de 1991 à 2009 du makaire bleu (Makaira nigricans) *en provenance de la pêcherie à petite échelle opérant au large de La Guaira (Venezuela) (lieu important pour les istiophoridés) ont été standardisés par des techniques de modèle linéaire généralisé. L'indice pondéral des poissons par nombre d'opérations a été estimé à partir du poids éviscéré du makaire bleu capturé et déclaré par les échantillonneurs au port opérant dans la communauté de pêche de Playa Verde. L'analyse incluait les variables année et saison.*

RESUMEN

Las tasas de captura desde 1991 hasta 2009 para la aguja azul (Makaira nigricans) *de la pesquería de pequeña escala de aguas de La Guaira, Venezuela (un punto de concentración de marlines) fueron estandarizadas mediante técnicas de modelación lineales generalizadas. El índice de peso de los peces por número de lances fue estimado a partir del peso eviscerado de las agujas azules capturadas y declaradas por el muestreador en puerto en la comunidad pesquera de Playa Verde. El análisis incluía las variables año y temporada.*

KEYWORDS

Blue marlin, Catch rates, Caribbean Sea, Small Scale fishery

1. Introduction

The area off La Guaira in Venezuela is considered one of the world's hot spots for billfish fishing where four Atlantic species (*Istiophorus albicans*, *Makaira nigricans*, *Tetrapturus albidus*, and *Tetrapturus pflugeri*) can be caught in one day (Machado and Jaen, 1982). Capture and landing of billfish off La Guaira area commenced in the early 1960's by sport fishermen (Gaertner et al., 1991), and was followed by artisanal fishermen in the early 1980's (Alio et al., 1994). It also started to concentrate commercial fishing for tunas and swordfish by purse seiners and longliners, respectively (Daniel Novoa, pers. comm.), increasing the risk of high bycatch mortality of billfish species in the area. In 1990 and in 2000, Venezuelan fishing authorities created and expanded a no-take zone for billfish by commercial purse seiners and longliners (Alio and Marcano, 2001), and allowing only 35 small scale fishing boats of the fishing community of Playa Verde that have traditionally fished in the area off La Guaira. A year after the creation (1991) of the no-take zone, an ICCAT sponsored port sampling program was started to monitor activities of the small scale gillnet fishery that has targeted billfish since it was initiated in an effort to monitor abundance variation in that important billfish 'hot spot' (Marcano et al., 2000). One of the goals of the port sampling program was to find alternative measurements of indices of abundance now that the sport

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fishing information from the area has declined to a minimum, and is only available from a couple of tournaments a year, all of which are tag and release (Marcano et al., 2005, 2008).

Standardized catch rates from commercial fishing fleets has become the norm for relative indices of abundance in ICCAT's stock assessment meetings. Generalized Linear Modeling (GLM) techniques have become a routine in the estimation of standardized catch rates using data from commercial fishing fleets (Maunder and Punt, 2004). In an effort to contribute with better abundance indices from the billfish fishery off La Guaira, catch rates for blue marlin were standardized using GLM techniques for the time series available.

2. Methods

The information used in this study came from the database of the ICCAT sponsored Venezuelan Enhanced Billfish Research Program for the period of 1991-2009, which consists of data collected by port sampling at the fishing community of Playa Verde in the La Guaira area located in the central coast (**Figure 1**). The study area comprises the range of the gillnet fleet fishing grounds that is concentrated in and around "el Placer de La Guaira" and " el Placer de Carayaca", a couple of sea plateau that rise up to 50-100 m from the surface.

The data collected included information on fishing operations, number of boats fishing, number of trips, landings, morphometrics, and sex identification on all species caught. The gillnet fishery continues to have 35 registered boats operating from Playa Verde, detailed information on vessel characteristics, fishing gear specification, and fishing operations are similar to the ones described by Arocha *et al.* (2009) for the same fishing community.

Monthly landings and effort were aggregated for the whole fleet. For the standardization the only factor available other than year was season, defined here, for the purpose of the present analysis, as trimesters (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec). Catch rates were transformed to log (cpue+10%mean) prior to the analysis.

For the Playa Verde small scale fishery data, relative indices of abundance for blue marlin were estimated by Generalized Linear Modeling approach assuming a lognormal model distribution. For sets that caught at least one blue marlin, estimated CPUE rates were assumed to follow a lognormal error distribution (lnCPUE) of a linear function of fixed factors and random effect for the interaction.

A step-wise regression procedure was used to determine the set of systematic factors and interaction that significantly explained the observed variability. The difference of deviance between two consecutive models follows a χ^2 (Chi-square) distribution; this statistic was used to test for the significance of an additional factor in the model. The number of additional parameters associated with the added factor minus one corresponds to the number of degrees of freedom in the χ^2 test (McCullagh and Nelder, 1989). Deviance analysis tables are presented for the data series. Final selection of explanatory factors was conditional to: a) the relative percent of deviance explained by adding the factor in evaluation (normally factors that explained more than 5% were selected), and b) The χ^2 significance.

Selection of the final model was based on the Akaike's Information Criterion (AIC), the Bayesian Information Criterion (BIC), and a χ^2 test of the difference between the [–2 loglikelihood] statistic of a successive model formulations (Littell et al., 1996). Relative indices for the model formulation were calculated as the year effect least square means (LSmeans) from the lognormal model components. The LSmeans estimates use a weighted factor of the proportional observed margins in the input data to account for the non-balance characteristics of the data. LSMeans of lognormal positive trips were bias corrected using Lo et al., (1992) algorithms. Analyses were done using the Glimmix and Mixed procedures from the SAS® statistical computer software (SAS Institute Inc. 1997).

3. Results and discussion

The trend in the mean number of sets over the time period analyzed show three distinct periods. A stable one, at the early period of the fishery (1991-1995) when the mean number of sets remained stable at around 100 sets per year (**Figure 2**, top left). A rise and fall period, when the mean number of sets per year increased steadily to reach its maximum in 1998, then followed by a steady decline until 2001 when it stopped around 170 sets. Lastly, a period of steady-increase appears to level off during the last 2 years of the time series.

Although, 35 boats with drift gillnets had been permitted to fish in the area, not all were operating during the early part of the fishery. It was until 1997 that most of the boats were operational as reflected by the increase in the mean number of sets when compared to the early period (**Figure 2**, top right). Beginning in 2000, the mean number of operating boats started to decline due to devastating land slides that occurred in the area and economics set backs that lasted until 2003. Between 2004 and 2005, several boats were replaced by newer ones due to government economic incentives to the artisanal fishers, which resulted in the steady increase in the number of operating boats that have almost reached the maximum capacity of the permitted number of boats for that fishery.

Annual landings of blue marlin follow the same trend as the effort, the highest landings were observed in 1999 and 2007, with 190 and 184 tons, respectively (**Table 1**). There is a strong seasonality in the landings of blue marlin but little seasonality in the fishing effort (**Figure 2**, bottom). Cumulative landings for blue marlin during the period 1991-2009 show a peak (~18%) in April, with important high landings in March and May. For the rest of the months, blue marling landings drops to about half, with the exception of September when blue marling landings are at its lowest level. Fishing effort on the other hand, is more or less uniformly distributed through the year, at least when the cumulative effort is considered.

The frequency distribution of log-transformed nominal CPUE+k is close to normality as observed in **Figure 3**. The distribution of residuals by year for the GLM observations show no apparent trends or bias (**Figure 3**), and the cumulative normalized residuals or qq-plot do not indicate strong deviations from the assumed error distribution of the model (**Figure 3**).

The deviance analysis for the step-wise regression procedure for blue marlin from the Venezuelan small scale fishery data analyses are presented in **Table 2**. For the mean catch rate given that it is a positive set, the factors: *year* and *season*, and the interaction *year*×*season* were more significant. Once a set of fixed factors were selected, we evaluated the random interaction between the year and season effect.

The results from the random test analyses for blue marlin and the three-model selection criterion indicate, that for mean catch rate, the final model included the *year* and *season* as fixed factors and the random interaction of *year*×*season* (**Table 3**). Standardized CPUE series for blue marlin are shown in **Table 4** and **Figure 4**. Coefficients of variation range from 19.0 to 24.0% for the model fit. The blue marlin standardized CPUE series (in weight) show a sustained decline in the last 2 years of the series, after a period of slow recovery that started in 2003.

In past analyses, the uniformity of gear and boats used by the fleet and the small size of the fishing area suggested that area or vessel characteristics were likely to play a large part on CPUE variation (Arocha et al. 2006). It was also suggested that, the effects of fishermen skills could not be discounted. But the steady increase in the number of operating boats since 2004 to the maximum permitted capacity of the fishery, with the consequent increase in number of sets, may suggest an impact on the abundance of blue marlin off La Guaira by this fishery. However, in recent visits to the fishing community, fishers have indicated that the Official Fishery Administration has eased on current regulations by allowing fishers from neighboring communities to target istiophorids in the same area the community of Playa Verde fish, as well as not enforcing the restricted fishing zone to artisanal longline vessels that were banned from fishing the area since 1991. Therefore, it appears that there is a non-quantified effort that is not accounted for and from which there is no official data available. Venezuelan coordinators of the ICCAT's Enhanced Research Billfish Program have alerted officials on this matter, in an effort to monitor or estimate the unreported catch and effort so it can be incorporated in future analysis.

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Table 1. Landings in weight (kg) of gutted blue marlin (BUM) and total number of sets from the small scale fishery of Playa Verde during 1991-2009.

Year	*BUM Catch*	*Total No. of sets*
1991	16847	1417
1992	21005	1389
1993	23828	1495
1994	58045	1475
1995	48806	1301
1996	70671	2524
1997	86049	2472
1998	174628	4093
1999	190303	3100
2000	80090	2672
2001	55112	2137
2002	44757	2356
2003	54585	2392
2004	56727	2609
2005	68376	2609
2006	118190	3979
2007	184431	4383
2008	104824	3842
2009	68706	3970

Table 2. Deviance analysis table for explanatory variables in the GLM model for **blue marlin** catch rates (**in weight**) from the Venezuelan small scale fishery off La Guaira. Percent of total deviance refers to the deviance explained by the full model; *p* value refers to the probability Chi-square test between two nested models. The mean catch rate for positive observations assumed a lognormal error distribution.

Sailfish Vza Playa Verde Artisanal CPUE Index

Model factors positive catch rates values	**d.f.**	**Residual deviance**	**Change in deviance**	**% of total deviance**	***p***
1	1	108.970739			
Year	18	81.4306895	27.54	38.1%	0.069
Year Season	3	56.5786887	24.85	34.3%	< 0.001
Year Season Year*Season	54	36.5986399	19.98	27.6%	1.000

Table 3. Analyses of GLM model formulations for **blue marlin** catch rates (**in weight**) from the Venezuelan small scale fishery off La Guaira. Likelihood ratio tests the diference of –2 REM log likelihood between two nested models. The bold lettering model indicates the selected model.

GLM model with 10% positive constant	**-2 REM Log likelihood**	**Akaike's Information Criterion**	**Bayesian Information Criterion**	**Likelihood Ratio Test**	**Dispersion**
Year Season	373	375	378.3		
Year Season *Year*Season*	370.3	374.3	379	2.7	0.1003

Table 4. Nominal and standardized (with GLM) CPUE (gutted weight kg/set) for blue marlin landed in Playa Verde.

Year	N Obs	Nominal C	Standard	Low	Upp	coeff var	std error
1991	10	14.43	10.92	6.86	17.37	23.6%	2.57
1992	9	17.97	12.59	7.84	20.22	24.0%	3.03
1993	12	16.19	15.70	10.43	23.61	20.6%	3.24
1994	12	40.30	32.34	22.21	47.11	19.0%	6.13
1995	12	35.50	31.48	21.60	45.89	19.0%	5.98
1996	12	28.16	25.07	17.06	36.84	19.4%	4.87
1997	12	35.93	30.47	20.88	44.47	19.1%	5.81
1998	12	42.65	40.84	28.22	59.10	18.6%	7.61
1999	12	66.59	68.12	47.52	97.64	18.1%	12.36
2000	12	26.23	24.92	16.96	36.63	19.4%	4.84
2001	12	24.58	18.24	12.24	27.20	20.2%	3.68
2002	12	17.70	16.81	11.22	25.18	20.4%	3.43
2003	12	21.70	20.13	13.57	29.87	19.9%	4.01
2004	12	22.14	23.38	15.87	34.45	19.6%	4.57
2005	12	26.31	25.50	17.37	37.45	19.4%	4.94
2006	12	28.94	28.57	19.54	41.78	19.2%	5.48
2007	12	39.37	33.00	22.67	48.03	18.9%	6.25
2008	12	25.26	25.51	17.37	37.45	19.4%	4.94
2009	12	16.84	17.96	12.04	26.80	20.2%	3.63

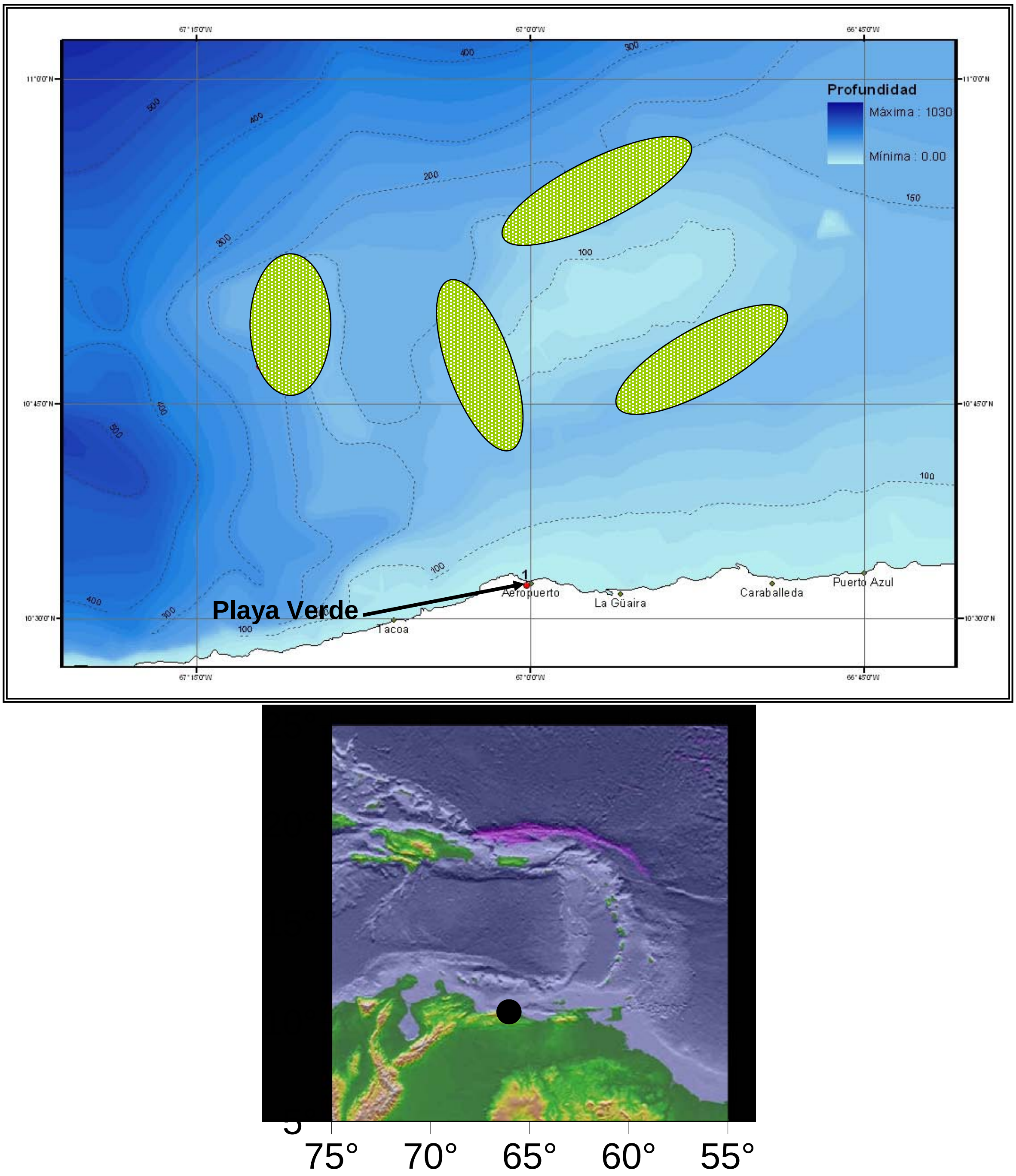

Figure 1. Map of fishing area of the small scale gillnet fishery off La Guaira showing relative location in reference to the Venezuelan coast (bottom) and detailed fishing grounds (top) showing both plateau (Placer de Carayaca and Placer de La Guaira).

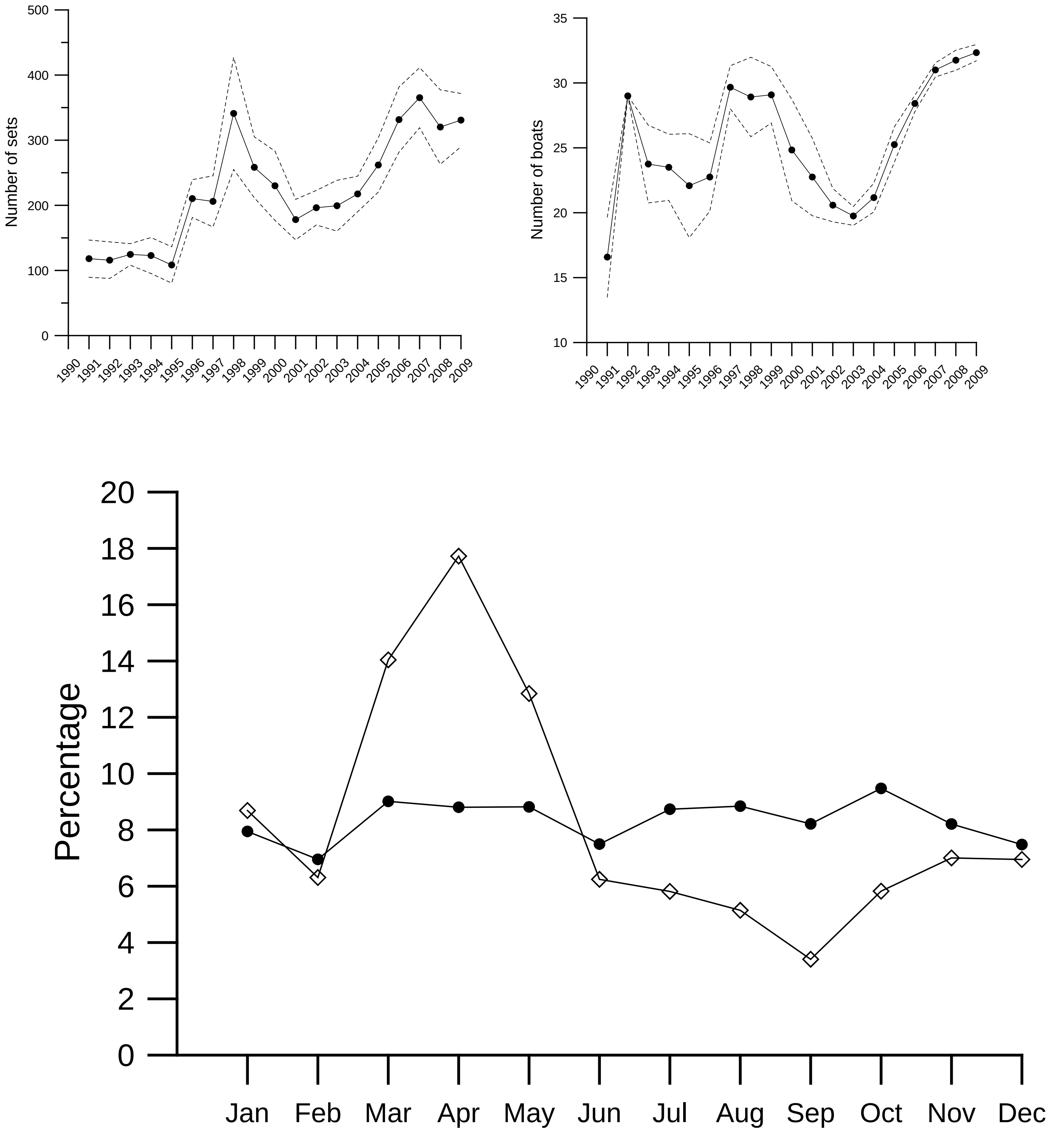

Figure 2. Effort expressed in total number of sets (top left) and mean number of boats (top right) per year of the gillnet fishery operating from the fishing community of Playa Verde in the area off La Guaira. Dashed lines indicate 95% confidence intervals. Seasonal pattern of landings of blue marlin (open rhombs) and fishing effort (filled circles) in the Playa Verde fishery (bottom). Percentages were calculated from the cumulative landings over the period 1991-2009.

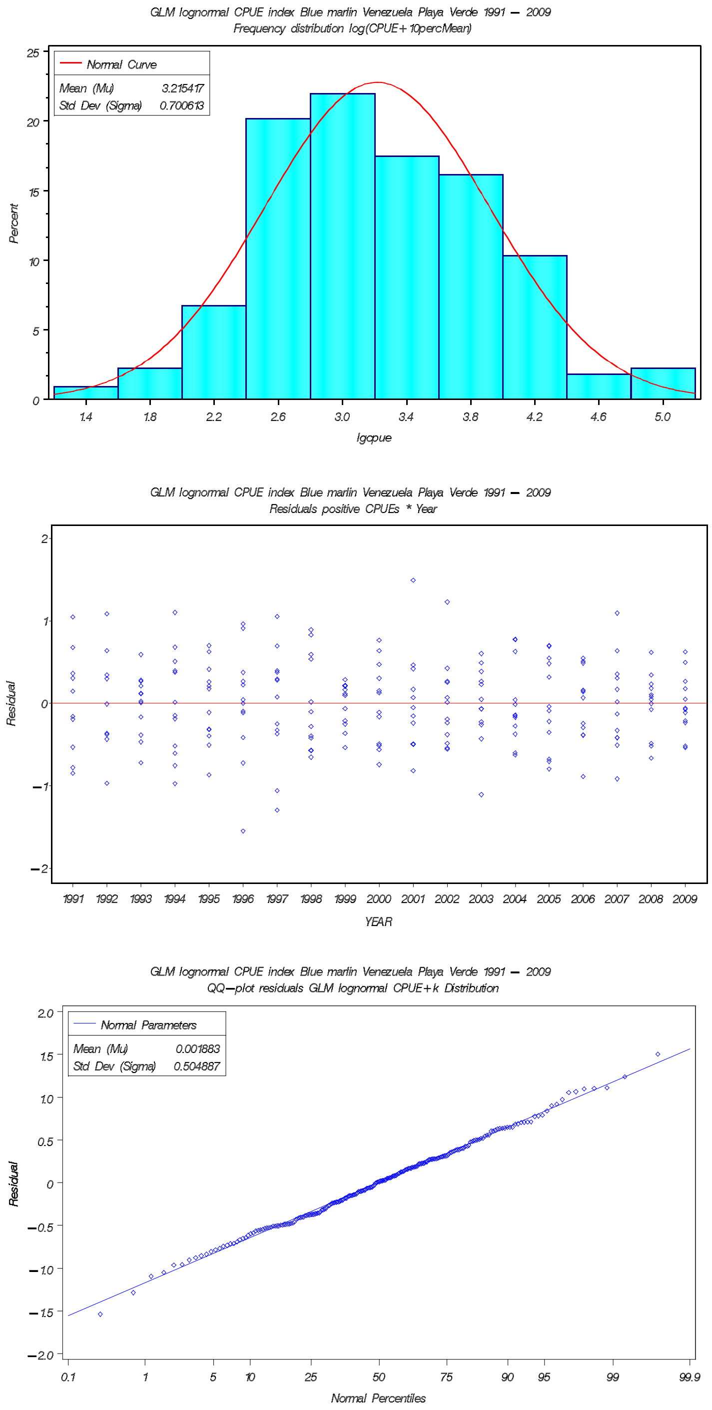

Figure 3. Frequency distribution of log-transformed nominal CPUE+10%mean (top). Diagnostics plots of residuals from GLM of log CPUE+k by year (middle) and cumulative normalized residuals or QQ-plot (bottom).

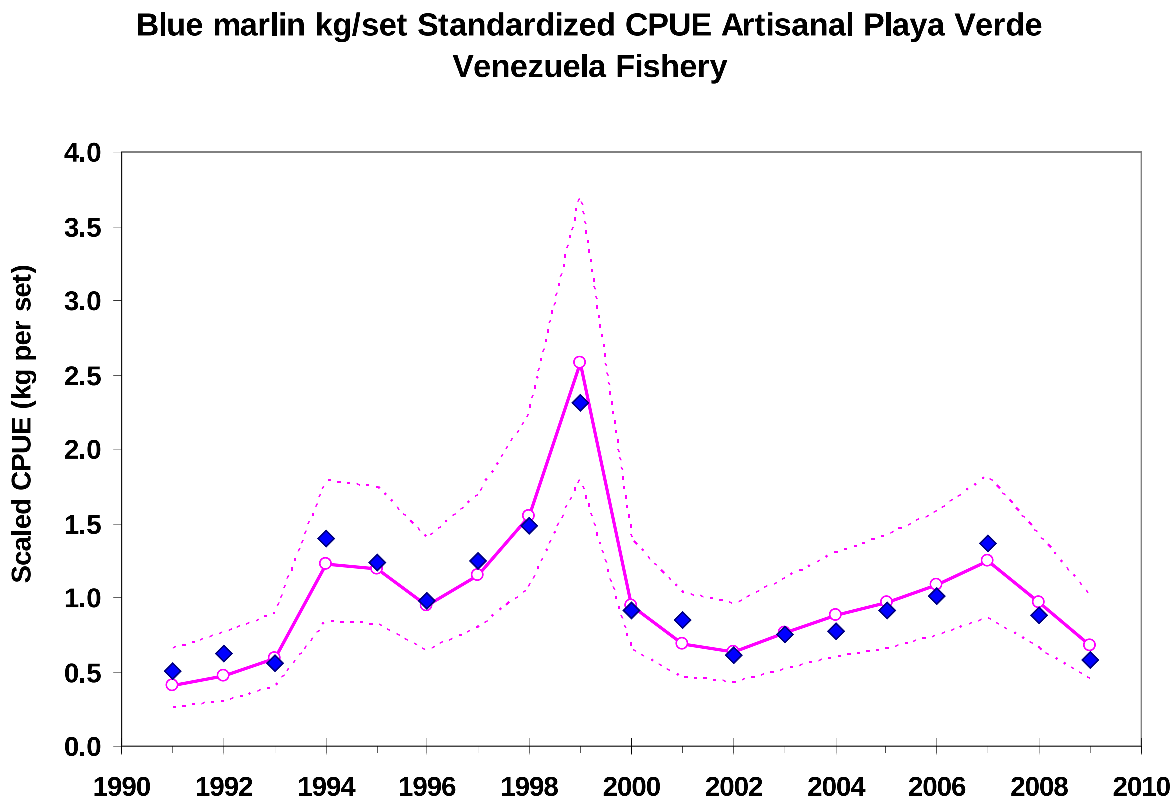

Figure 4. Nominal (filled rhombs) and standardized (with GLM) CPUE for Blue marlin landed in Playa Verde. Dashed lines represent 95% Confidence limits of standardized values.