CATCH RATES FOR SAILFISH (*Istiophorus albicans*) FROM THE SMALL SCALE DRIFT GILLNET FISHERY OFF LA GUAIRA, VENEZUELA: Period 1991-2007

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SUMMARY

Catch rates from 1991 to 2007 for sailfish (Istiophorus albicans) *from the small scale drift gillnet 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 sailfish caught and reported by port sampler in the fishing community of Playa Verde, off La Guaira-Venezuela. The analysis included the variables: year and season.*

KEYWORDS: *Sailfish, Catch rates, Caribbean Sea, Small Scale fishery*

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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 artisanal 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 drift 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 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, 2007).

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 sailfish 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 1991-2007, 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 (Fig. 1). The study area comprises the range of the small scale drift 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 (dressed weight in kg), morphometrics of landed fish (length measurements), and sex identification on all species caught. The small scale drift gillnet fishery has 35 registered boats operating from Playa Verde, these are artisanal 8 to 10 m wooden boats equipped with 2 outboard engines 48 - 75 HP, operated by a crew of 3 fishers (Fig. 1). This fleet performs daily trips with no refrigeration of the catch, and the net is set once. The nets are fished overnight (from 17:00 - 19:00 until 4:00 - 5:00) with the float line 12 to 15 m below the surface, total net lengths range between 1000 and 1500 m, and the average mesh size varies from 38 to 63 mm. The fishing operation is conducted year round only during the new moon phase (15-10 days of effective fishing under normal weather conditions).

Monthly landings and effort were aggregated for the whole fleet. For the standardization the only factor available other than year was season, defined here as winter (Dec-Jan-Feb) and summer (Mar-Nov). 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 sailfish were estimated by Generalized Linear Modeling approach assuming a lognormal model distribution. For sets that caught at least one sailfish, 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 $\chi 2$ (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

In the early period of the fishery (1991-1995) the mean number of sets remained stable at around 100 sets per year (Fig. 2, top left). Thereafter, the mean number of sets per year increased steadily reaching its maximum of 341 sets in 1998, although displaying the highest set variability during the year. A steady decline followed, until 2001 when it stopped at 178 sets. A steady continuous increase followed towards the end of the time series, where the mean number of sets rose from 196 to 365. The trend in the mean number of sets is a consequence of the mean number of boats operating from Playa Verde (Fig. 2, top right). Although, 35 boats with drift gillnets had been permitted to fish, 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. Beginning in 2000, the mean number of operating boats started to decline 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 a steady increase in the number of operating boats that have reached the maximum capacity of the permitted number of boats.

High annual landings of sailfish follow the same trend as the effort, the highest landings were observed in 1998 and 2007, with 181 and 185 tons, respectively (Table 1). There is a strong seasonality in the landings of sailfish but little seasonality in the fishing effort (Fig. 2, bottom). Cumulative landings for the period 1991-2007 show that the largest landings (25-28%) of sailfish occur during seven months, from April to October, whereas the lowest landings occur over a three month period (Dec-Feb) with a percentage of landings below 6%. 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 (main pattern follow a straight line), although small deviations appear at the lower end of the distribution (Figure 3).

The deviance analysis for the step-wise regression procedure for sailfish from the Venezuelan small scale drift gillnet fishery data is presented in table 2. For the mean catch rate given that it is a positive set, all the factors considered, *year* and *season*, and the interaction *year*×*season* were 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 sailfish 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 sailfish are shown in table 4 and figure 4. Coefficients of variation range from 26.7 to 31.9% for the model fit. The standardized CPUE series (in weight) show that the relative abundance of sailfish caught by the small scale fishery off La Guaira has been variable but show no clear tendency during the period 1991-2007.

The uniformity of gear and boats used by the fleet and the small size of the fishing area suggest that, neither area nor boat characteristics are likely to play a large part on CPUE variation; however, the effects of fishermen skills can not be discounted and may have to be investigated in the future. It is possible, that the decrease in active boats observed between 1999 and 2003, may have coincided with the departure of less efficient fishermen, therefore masking some possible biases in the data. However, 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, have not yet impacted the standardized catch rates.

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Table 1. Landings of sailfish (SAI) dressed weight (kg) and total number of sets from the small scale drift gillnet fishery of Playa Verde during 1991-2007.

YEAR	SAI CATCH	TOTAL No. OF SETS
1991	32061	1417
1992	24953	1389
1993	60006	1495
1994	64701	1475
1995	41357	1301
1996	87941	2524
1997	113965	2472
1998	181749	4093
1999	140106	3100
2000	108914	2672
2001	63643	2137
2002	79067	2356
2003	93925	2392
2004	121588	2609
2005	121044	2609
2006	134982	3979
2007	185880	4383

Table 2. Deviance analysis table for explanatory variables in the GLM model for **sailfish** 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.

Model factors positive catch rates values	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	145,086371			
Year	16	125,725681	19,36	21,5%	0,250
Year Season	1	65,9641563	59,76	66,3%	< 0.001
Year Season Year*Season	16	54,882468	11,08	12,3%	0,804

Table 3. Analyses of GLM model formulations for **sailfish** catch rates (**in weight**) from the Venezuelan small scale fishery off La Guaira. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models. The star and 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
	Proportion Positives						
	Year Season	381,1	383,1	386,3			3,0491
*	**Year Season *Year*Season***	375,8	379,8	382,9	5,3	0,0213	2,8395

Table 4. Nominal and standardized (with GLM) CPUE (kg/set) for sailfish landed in Playa Verde.

Year	N Obs	Nominal CPUE	Standard CPUE	LowCI	UppCI	CV	std error
1991	12	21,73	12,74	6,83	23,75	31,9%	4,06
1992	12	18,10	16,44	9,09	29,75	30,3%	4,98
1993	12	39,21	27,53	15,85	47,79	28,1%	7,74
1994	12	38,42	31,28	18,15	53,91	27,7%	8,67
1995	12	33,82	34,45	20,09	59,08	27,5%	9,46
1996	12	32,97	31,47	18,27	54,22	27,7%	8,72
1997	12	53,74	37,53	21,97	64,08	27,2%	10,22
1998	12	46,86	41,32	24,29	70,26	27,0%	11,17
1999	12	43,73	48,72	28,83	82,34	26,7%	13,01
2000	12	34,87	31,27	18,15	53,89	27,7%	8,67
2001	12	25,56	25,44	14,58	44,39	28,4%	7,22
2002	12	31,48	20,32	11,45	36,05	29,3%	5,95
2003	12	36,83	31,12	18,05	53,65	27,7%	8,63
2004	12	44,16	44,24	26,08	75,03	26,9%	11,89
2005	12	40,29	41,82	24,60	71,08	27,0%	11,29
2006	12	31,44	30,43	17,63	52,52	27,8%	8,46
2007	12	42,35	40,82	23,99	69,46	27,1%	11,04

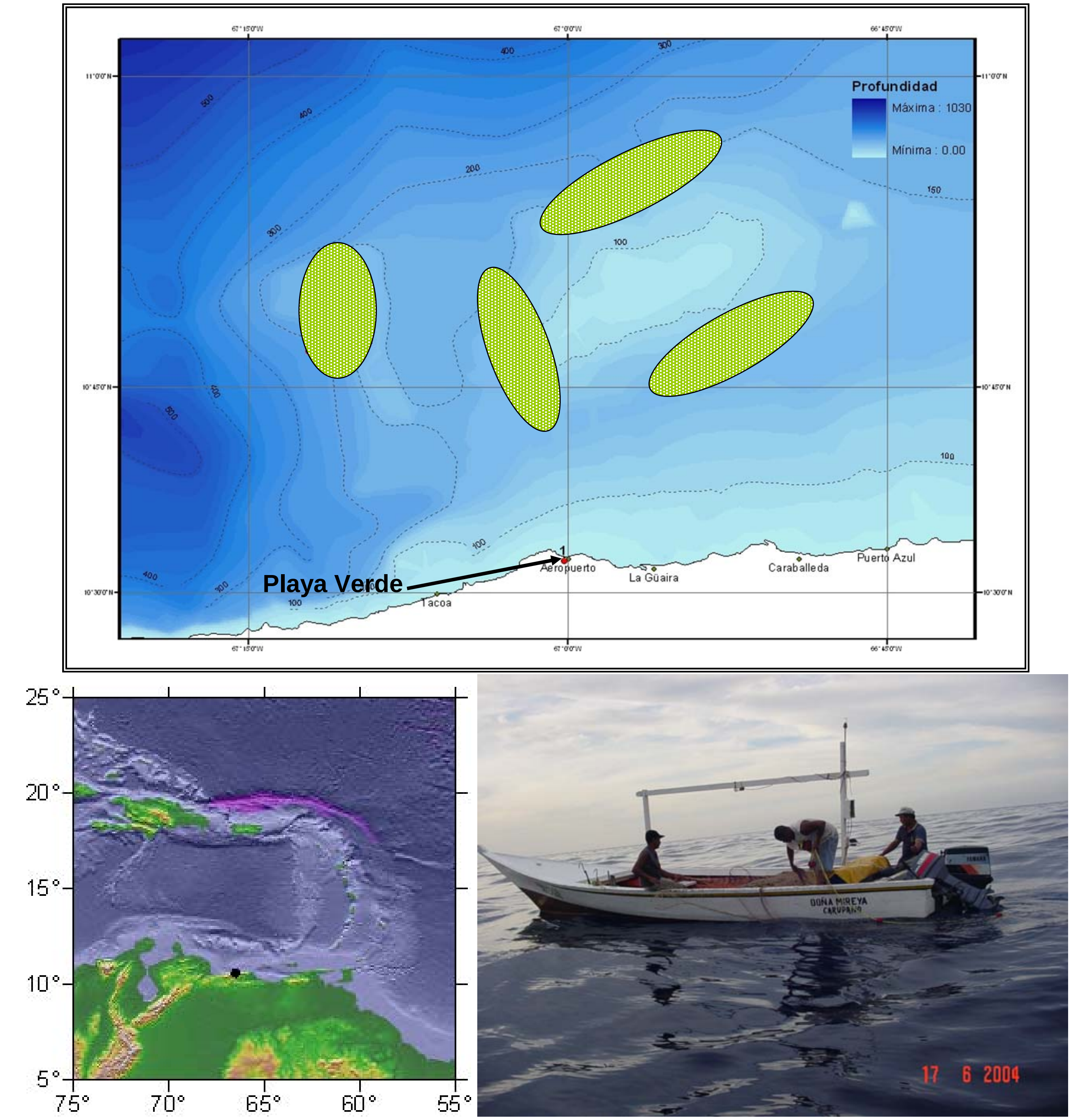


FIGURE 1. Map of fishing area of the small scale drift gillnet fishery off La Guaira showing relative location in reference to the Venezuelan coast (bottom left) and detailed fishing grounds (top) showing both plateau (Placer de Carayaca and Placer de La Guaira) (bottom right). Type of boat permitted to fish off La Guaira, and operated from Playa Verde fishing community, image show initial set of the fishing gear before sunset.

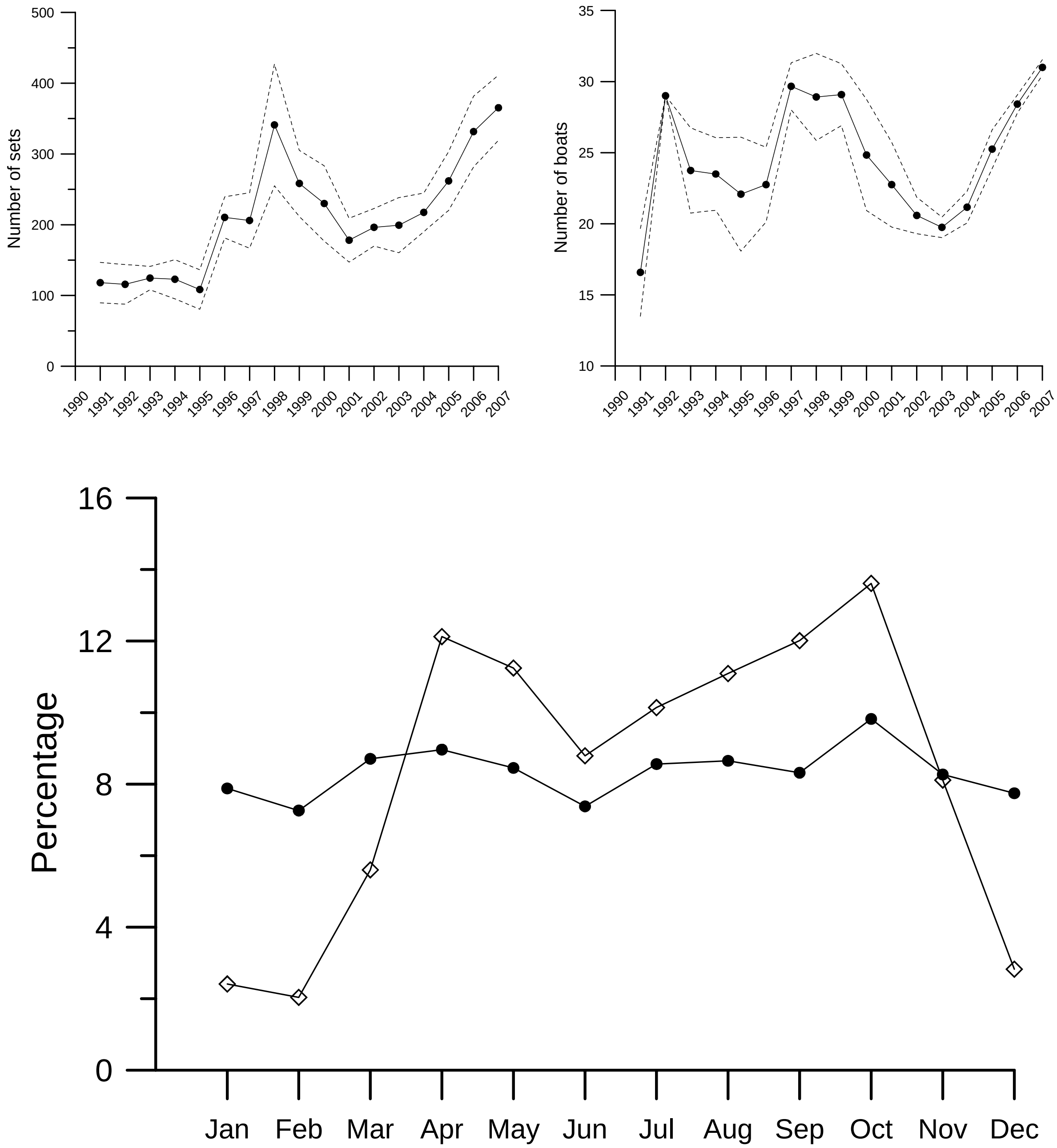
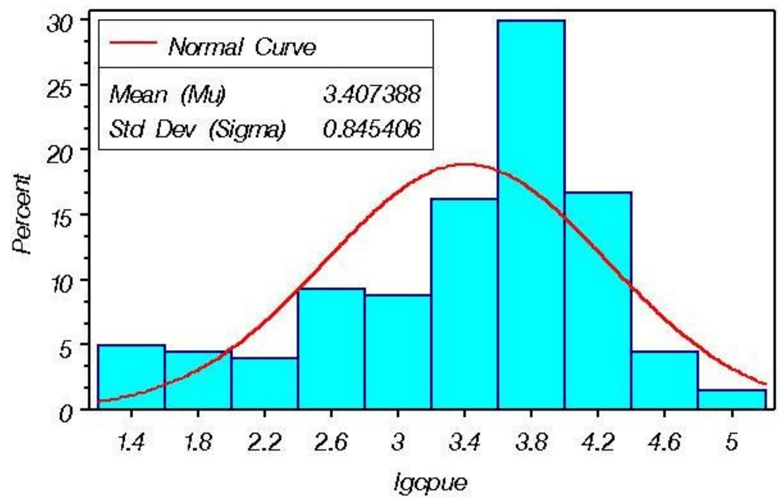


FIGURE 2. Effort expressed in total number of sets (top left) and mean number of boats (top right) per year of the drift gillnet fishery operating from the fishing community of Playa Verde in the area off La Guaira-Venezuela. Dashed lines indicate 95% confidence intervals. Seasonal pattern of landings of sailfish (open rhombs) and fishing effort (filled circles) in the Playa Verde fishery (bottom). Percentages were calculated from the cumulative landings over the period 1991-2007.


Normal Curve
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Std Dev (Sigma) 0.845406
Percent
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5
10
15
20
25
30
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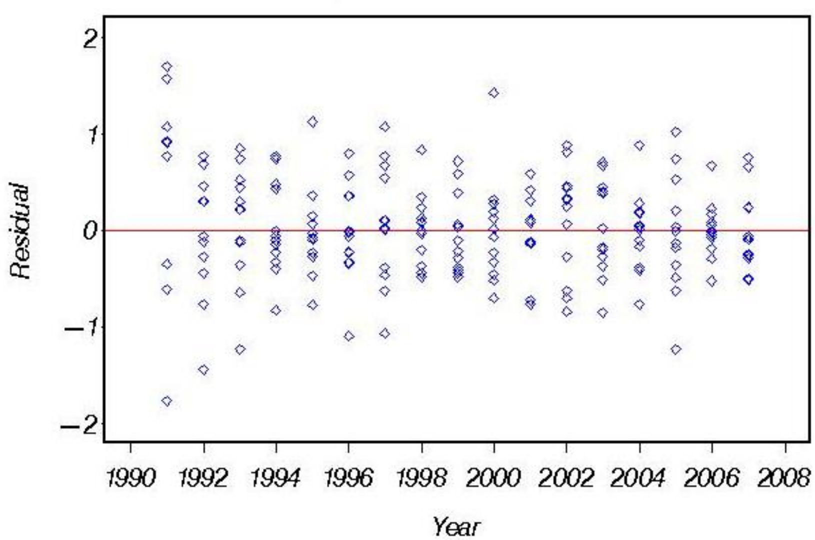
4.6
5
lgcpue


Residual
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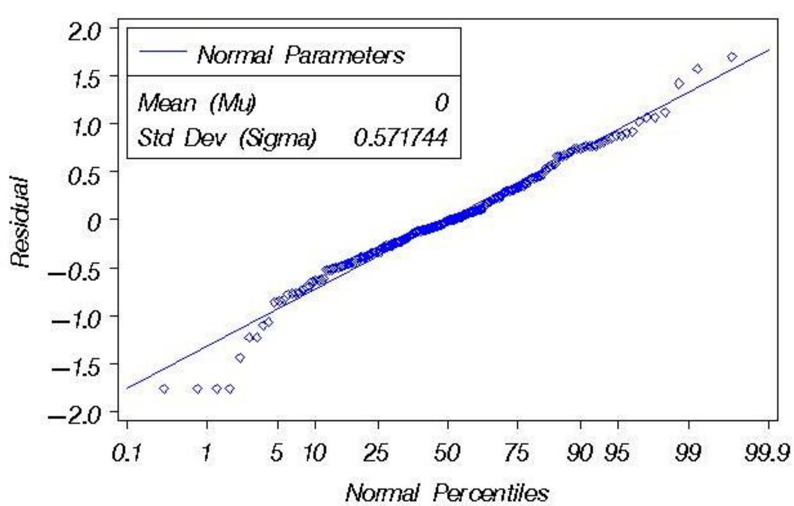
1
0
−1
−2
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year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Std Dev (Sigma) 0.571744
Residual
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1.0
0.5
0
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−1.0
−1.5
−2.0
0.1
1
5
10
25
50
75
90
95
99
99.9
Normal Percentiles

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

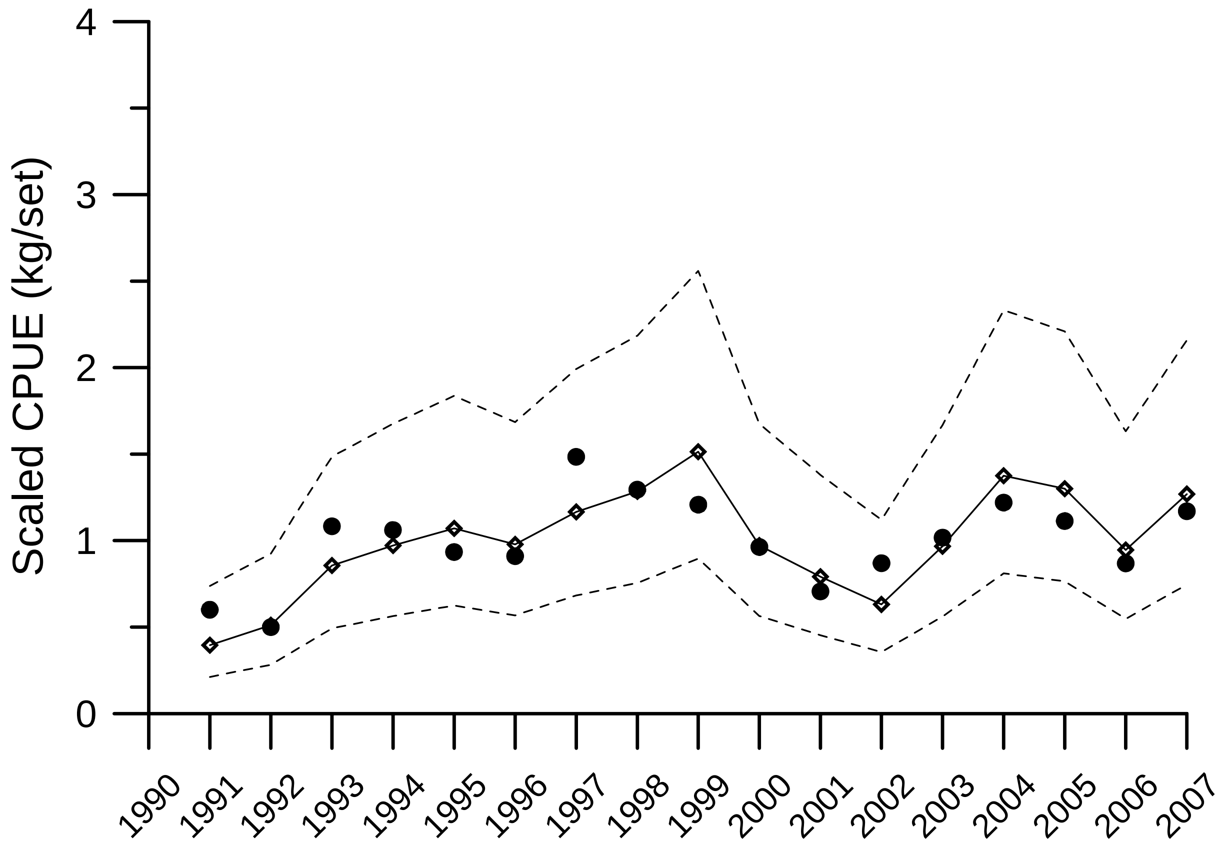

FIGURE 4: Scaled estimated nominal (filled circles) and standardized (with GLM) CPUE for sailfish landed in Playa Verde community (off La Guaira-Venezuela). Dashed lines represent 95% Confidence limits of standardized values.