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Trends in the recreational billfish fishery CPUE off Playa Grande (1961-1995), Central Venezuelan Coast

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Abstract

Trends in the catch per unit effort of billfishes in the Venezuelan sport fishery off Playa Grande Yachting Club were analyzed from 1961 to 1995. Nominal effort was standardized into effective fishing time. In spite of the great inter-annual variability, the CPUE of white marlin indicated a constant decrease along the time series. This trend is especially clear for the last 15 years, reaching the lowest index for the whole time series during 1993 (0.02 fish/ per man/ per trip). Abundance indices of blue marlin decreased strongly until 1976 (0.01 fish/ per man/ per trip). A period of increasing CPUE can be noted from 1976 to 1984 (0.14 fish), before it stabilized around 0.05 until 1993. This series reached a new level, close to 0.1 fish/ per man/ per trip, in the two most recent years, 1994-1995. The increase of apparent abundance of blue marlin since 1980 was also observed in other recreational fisheries located in the western North Atlantic. The change in target species (reflected by changes in fishing gears and in fishing grounds) for the longliner fleets, at the beginning of the 1980s, could be linked with the increase of apparent abundance of blue marlin. The analysis of CPUE data for sailfish showed an increase between 1963 to 1969, reaching 1.2 fish/ per man/ per trip, followed by a decreasing trend until 1982 (0.06 fish/ per man/ per trip). This series, after a small increase during 1983 - 1989 (0.15 to 0.20 fish/ per man/ per trip), stayed at a very low level during the recent years (less than 0.04 fish / trip). A non-parametric method is used to detect shifts in the mean of the CPUE time series. For white marlin, major change was found in 1983, with two other change-points in 1969 and 1977. For blue marlin, the strongest rupture in the CPUE series was detected during 1971, with two other major shifts in 1984 and recently in 1994. In the case of sailfish, 1976 can be considered the year of major change in the abundance index of this species.

Résumé

Les tendances des séries de capture par unité d'effort de poissons porte-épée de la pêche sportive vénézuélienne du Yachting Club de Playa Grande ont été analysées de 1961 à 1995. L'effort nominal a été standardisé en effort effectif. En dépit d'une grande variabilité inter-annuelle, la série temporelle de CPUE du marlin blanc se caractérise par une décroissance constante. Cette tendance est particulièrement nette au cours des 15 dernières années, avec un minimum de 0,02 poisson/ par pêcheur/ par bateau atteint en 1993. L'indice d'abondance du marlin bleu chute fortement jusqu'en 1976 (0,01 poisson/ par pêcheur/ par bateau). On peut noter ensuite une période de CPUE croissantes entre 1976 et 1984 (0,14 poisson), puis une stabilisation autour de 0,05 poisson jusqu'en 1993. Cette série atteint un nouveau niveau, proche de 0.1 poisson/ par pêcheur/ par bateau, au cours des années 1994-1995. L'augmentation de l'indice d'abondance apparente de marlin bleu depuis 1980 a été observée également dans d'autres pêcheries sportives de l'Atlantique nord-ouest. Cette hausse semble liée au changement d'espèces-cibles (qui se traduit par des modifications d'engins et de zones de pêche) des palangriers au début des années 80. L'analyse des CPUE du voilier a montré une hausse entre 1963 et 1969, jusqu'à 1,2 poisson/ par pêcheur/ par bateau, suivie par une chute régulière jusqu'en 1982 (0,06 poisson/ par pêcheur/ par bateau). Cette série, après une légère augmentation entre 1983 et 1989 (0,15 à 0,20 poisson), est restée à un niveau très faible au cours de la période la plus récente (moins de 0,04 poisson). Une méthode non-paramétrique a été utilisée pour détecter des points de rupture dans les séries temporelles de CPUE. En ce qui concerne le marlin blanc, des modifications majeures de la tendance ont été observées en 1983, ainsi qu'en 1969 et en 1977. Pour le marlin bleu, la plus forte rupture de la série apparait en 1971, avec deux autres points localisés en 1984 et récemment en 1994. Dans le cas du voilier, 1976 peut être considérée comme l'année de plus grande modification dans la tendance de la CPUE.

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INTRODUCTION

The most important recreational harbor in Venezuela for the billfish sport fishery is the Playa Grande Yachting Club. This marina is located in the central coast of Venezuela, relatively close (20 km) to the famous fishing grounds known as « Placer of La Guaira » (Jaen, 1960).

Indices of abundance for the billfish species caught by this sport fishery - blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*) and sailfish (*Istiophorus platypterus*)- were presented by Machado and Jaen (1982), Gaertner *et al.*, (1989, 1991) and by Gaertner and Alio (1994). Catches of longbill spearfish (*Tetrapturus pflugeri*) are not included because of its scarcity in this fishery. However, this species is relatively frequent in the artisanal catches in the eastern region of Venezuela, as reported by Marcano *et al.* (1994). The goal of the present study is to analyze the trends in catch per unit of effort (CPUE) for this recreational fishery.

METHODS AND DATA

The data base

Catch statistics (number of fish) and effort (number of trips), were collected monthly from January 1961 to December 1989. The months of June, July and August of 1964 and 1970, and August 1983 (partially sampled) were adjusted as explained in Gaertner et al. (1989). It is important to point out that this time series was interrupted at the end of the first quarter of 1990 by the prohibition made by the government to landings of billfish in the central part of Venezuela. Nevertheless, the catch and effort series were completed after 1990 until 1995 on a yearly basis.

Data analysis

Standardization of the effort

The abundance index is approximated by the concept of catch per unit of effort. An appropriate unit of effort is the effective fishing time, which corresponds to the number of hours fished minus the total fighting time lost by fishermen (Beardsley and Conser, 1981). Unfortunately the information about individual fighting time was not collected in the past, and is not always reported today. So we are obliged to use a "statistical estimate", obtained with a restricted number of observations, rather than the actual individual fighting time for each fish.

As explained in a former analysis (Gaertner and Alio, 1994), it was not possible to use:

(a) number of fish hooked per unit of effort (HPUE), which is considered as a better estimate than the CPUE index (Beardsley and Conser, 1981; Browder and Prince, 1990);

(b) information about the use of different categories of line-test.

Considering these limitations, we tried to standardize the nominal effort to a more effective effort unit in the following manner:

(a) Estimation of the daily effort (Day. eff.) by trip (for tournament and non-tournament days);

(b) Estimation of the fighting time for the 3 main species of istiophoridae (Species Fight.). It has been considered that between the strike and the time when the fish is brought on board, the other two fishermen (generally there are three on board) cannot fish. Hence, the estimate of the total time lost during the fighting time (Tot. Fight.) was multiplied by 3, as follows:

$$Tot.Fight. = 3 * \sum_{j=1}^{3} (Species\,Fight.j * C_j);$$

with Cj = No. of fishes captured for species j.

The effective effort (Eff) will be:

$$Eff = \frac{(3 * Day.eff. * No.Trip) - (Tot.Fight.)}{(3 * Day.eff.)}$$

The division by (3 * Day. eff.) is made in order to obtain a convenient unit in fishing hours per man per trip.

As mentioned above, fighting time was infrequently reported. Hence, fighting time and its confidence intervals were estimated by bootstrapping methods (see Gaertner and Alio, 1994).

Catches of other species, like tunas (generally yellowfin tuna: *Thunnus albacares*, YFT), wahoo (*Acanthocybium solandri*, WAH), dolphinfish (*Hippurus spp.*, DOR), and barracuda (*Sphyraena barracuda*, PIC), were not reported in the recent years, hence coresponding fighting times were not included in the present analysis.

Detecting changes in level within a CPUE time series.

Some useful statistical tests for the detection of shifts in the mean of the time series were reviewed by Lubès (1994). A non-parametric method for the change-point problem is the Mann-Whitney two-sample test, modified by Pettitt (1979). Consider a sequence of random variable X_1, X_2, .., X_i, .., X_N, with a change-point at t. We suppose than both distribution functions F_1 (X_i) for i = 1, ..., t and F_2 (X_i) for i = t+1, ..., N belong to the same population.

Let D_{ij} = sgn (X_i-X_j), where sgn (x) = 1 if x>0, 0 if x=0, -1 if x<0;
then consider:

$$U_{tN} = \sum_{i=1}^{t} \sum_{j=t+1}^{N} D_{ij}, and\, K_N = \max_{1<i<N} |U_{tN}|$$

For continuous data and when there are no ties in the series, U_{tN} can be calculated using the formula: $U_{tN} = U_{t-1\,N} + V_{tN}$, with V_{tN} = N+1 - $2R_i$, where R_i is the rank of X_i in the series of N observations, and $U_{1N} = V_{1N}$

If $k=K_N$, under H_0 (H_0 : no change against H_1 : change), we have approximatively:

$$\Pr (K_N > k) = 2 \exp (-6 k^2 / (N^3 + N^2))$$

For a risk level α, if $\Pr (K_N > k) < \alpha$, H_0 is rejected (see Pettitt, 1979, for more details).

The Pettitt's statistic is assumed to be more robust than the Cusum methods used sometimes to detect change in time series (Nicholson, 1984). This analysis has been made for the three recreational CPUE series off Playa Grande with the help of the Statisti package[3].

Relationships between series of CPUE

In order to see if local CPUEs in the western Atlantic Ocean follow similar trends, a correlation analysis was done. In a few cases, the time series were reconstituted directly from figures given in the bibliography. For this reason, and considering that correlation between CPUE series can be non-linear, this study has been made with the Spearman rank coefficient.

The Venezuelan sport fishery CPUEs, were compared with:

(a) blue marlin:
- the U.S. recreational fisheries in the northern Gulf of Mexico, 1971-1991 (fig. 3a; in Avrigian *et al.*, 1994), in the Mid Atlantic Bight, in Bahamas and in the northern Caribbean, 1973-1991 (fig. 5c, 6c, 7c; in Farber *et al.*, 1994);

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[3] Statisti : Logiciel statistique de détection de ruptures dans les séries chronologiques. Iccare-ur22-Dec-Orstom; Equipe Hydrologie/Géofluides-Bassin-Eau/CNRS-UMII ; Ecole des Mines de Paris. E-mail : boyer@orstom.rio.net.

- the Jamaican sport fishery, 1976-1992 (fig. 3; in Harvey and Graves, 1994);
- the Japanese longline fishery in the Northwest Atlantic, 1975-1989 (tab. 3; in Nakano *et al.*, 1994a).

(b) white marlin:

- the U.S. recreational fisheries in the northern Gulf of Mexico, 1971-1991 (fig. 3b; in Avrigian *et al.*, 1994), in the Mid Atlantic Bight, and in Bahamas, 1973-1991 (fig. 11c and 12c; in Farber *et al.*, 1994);
- the Japanese longline fishery in the Northwest Atlantic, 1975-1989 (tab. 3; in Nakano *et al.*, 1994b).

(c) for the sailfish:

- the U.S. recreational fisheries in the northern Gulf of Mexico, 1971-1991 (fig. 3c; in Avrigian *et al.*, 1994), and in the Florida East Coast and Keys, 1973-1992 (fig. 4; in Farber, 1994);
- the Mexican Caribbean sport-fishery in Cozumel island, 1971-1991 (tab. 1; in Martinez and Gonzalez, 1994);
- the Japanese longline fishery in the Northwest Atlantic, 1961-1992 (fig. 3; in Uozumi, 1995).

These individual time series of abundance did not cover the same time period. Hence, a "common" time series was developed from 1975 to 1989 for blue marlin and white marlin, and from 1973 to 1991 for sailfish. The correlation matrices are globally significant at the level α, since several individual values are significant at the Bonferroni corrected level α', where $\alpha' = \alpha / p$; with p = number of coefficients in the matrix.

RESULTS

Daily effort and fighting time

The mean daily effort is greater during tournament than non-tournament days (7h 03' vs. 6h 15'; Table 1). The lack of information about the number of tournaments per year, and the number of participants per event, before 1988, prevent us from correcting the data base with this result. Nevertheless, if we consider that in the past this proportion was roughly the same as the actual one (6 to 7 tournaments per year, with a general duration of two days for each of them), the bias does not seem to be very important. Thus, the estimate of the average non-tournament effort was used as the daily effort.

Category	Daily Effort	Variance	N. Observ.	C. I. upper	C. I. lower
Tournament	7.046 7h 02' 45"	1.076	105	7.244 7h 14' 38"	6.848 6h 50' 53"
Non-tourna.	6.249 6h 14' 46"	5.517	747	6.418 6h 25' 03"	6.080 6h 04' 50"

Table 1 - Daily effort (Daily eff.), in decimal values, and confidence-intervals (at 5% level) in relation with the categories of sportfishing-activities; from Gaertner and Alio (1994).

The Bootstrap estimates of the individual fighting time by species indicate that fishermen need, on the average, a little more than thirty minutes to capture a blue marlin (once the strike occurs), twenty minutes for a white marlin, and ten minutes for a sailfish (Table 2). It must be emphasized that the size of the animals was not considered in this study (it is logical to think that the fighting time is longer for adult than for juvenile). These estimates must be limited to the central part of the Venezuelan coast where the size range of billfishes (LJFL in cm) captured in the recreational fishery off Playa Grande are:

- 180 cm and 210 cm for BUM;
- 150 cm and 175 cm for WHM;
- 165 cm and 180 cm for SAI, (Gaertner *et al.*, 1991).

On the other hand, it is known that blue marlin landed at marinas of Puerto La Cruz, in the eastern part of Venezuela, reach larger sizes than in the central part; hence fighting times would likely be greater.

Species	Species Fight. time	Variance	C.V.	N. Observ	C.I. upper	C.I. lower
BUM	.5437 32' 37"	.0070	15.376	19	.286 17' 10"	.678 40' 41"
WHM	.3431 20' 35"	.0070	24.438	19	.225 13' 30"	.534 32' 02"
SAI	.1759 10' 33"	.0010	18.375	66	.047 2' 49"	.236 14' 10"
DOR	.0729 4' 22"	.000+	9.441	120	.048 2' 53"	.086 5' 10"
WAH	.0538 3' 14"	.000+	7.269	133	.041 2' 28"	.063 3' 47"
YFT	.2122 12' 44"	.0047	32.330	46	.000 0' 00"	.304 18' 14"
PIC	.0414 2' 29"	.0001	25.711	7	.011 0' 40"	.071 4' 16"

Table 2 - Bootstrap estimations (1000 samples) of fighting time (Species Fight.) for the main species caught by sportfishermen in Venezuela. The "n" represent the size of the original sample; Approximate confidences Intervals (C.I.) were also obtained by bootstrapping (see Gaertner and Alio, 1994).

Trends in CPUE

Abundance indices of white marlin showed a decreasing trend along the time series but with a very high inter annual variability (at least during the first twenty years of this series). "Bad" years, such as 1963, 1969, 1974, and 1978, alternate with "good" years, such as 1964, 1971, 1975 or 1980 (Figure 1, upper part). On the other hand, since the beginning of the 1980s the variability has been low but with a steady decline of CPUE, reaching its lowest level during 1993 (0.015 fish per effective trip, per man). It is assumed than something happened at points where the Pettitt's statistic shows a clear change in slope. For white marlin, a strong evidence that a shift in the average CPUE occurred at t = 1983 is given by the approximate significance probability p ($p = 4.056 * 10^{-4}$). The plot of the U_{tN} (Figure 2, upper part) notes other change-points, at t = 1969 and t = 1977, which were masked by the high variability of CPUE during 1961-1981 in the Figure 1.

The CPUE of blue marlin decreased strongly from 1962 (0.25 fish per trip per man) to 1976 (year with the lowest index: 0.01). Progressively, the CPUE icreased to 0.14 in 1984, and then stabilized around 0.05 during 1985-1993. This serie reached a new level, close to 0.1 fish per trip, in the two most recent years (Figure 1, central part). The strongest indication for a change in the mean was found at t = 1971 ($p = 2.189*10^{-3}$). During 1984 and 1994, two other changes in mean level were noted (Figure 2, central part). As mentioned in the white marlin analysis, these shifts in mean did not appear so evident in the graph of the CPUE series (Figure 1, central part).

The CPUE of sailfish increased between 1963 and 1969 (the maximum value of the series was 1.2 in 1969) and decreased strongly until 1982 (0.06). This series, after some increase (0.15 to 0.20, from 1983 to 1989), has stayed at a very low level during the recent years (less than 0.04 fish / trip; see Figure 1, lower part). The Pettitt's statistic indicated a significant sudden change of the series at t = 1976 ($p = 1.692*10^{-4}$) and the plot of U_{tN} along the years showed than this decrease is relatively constant until 1995 (just a slow change can be detected during 1984-1985; Figure 2, lower part).

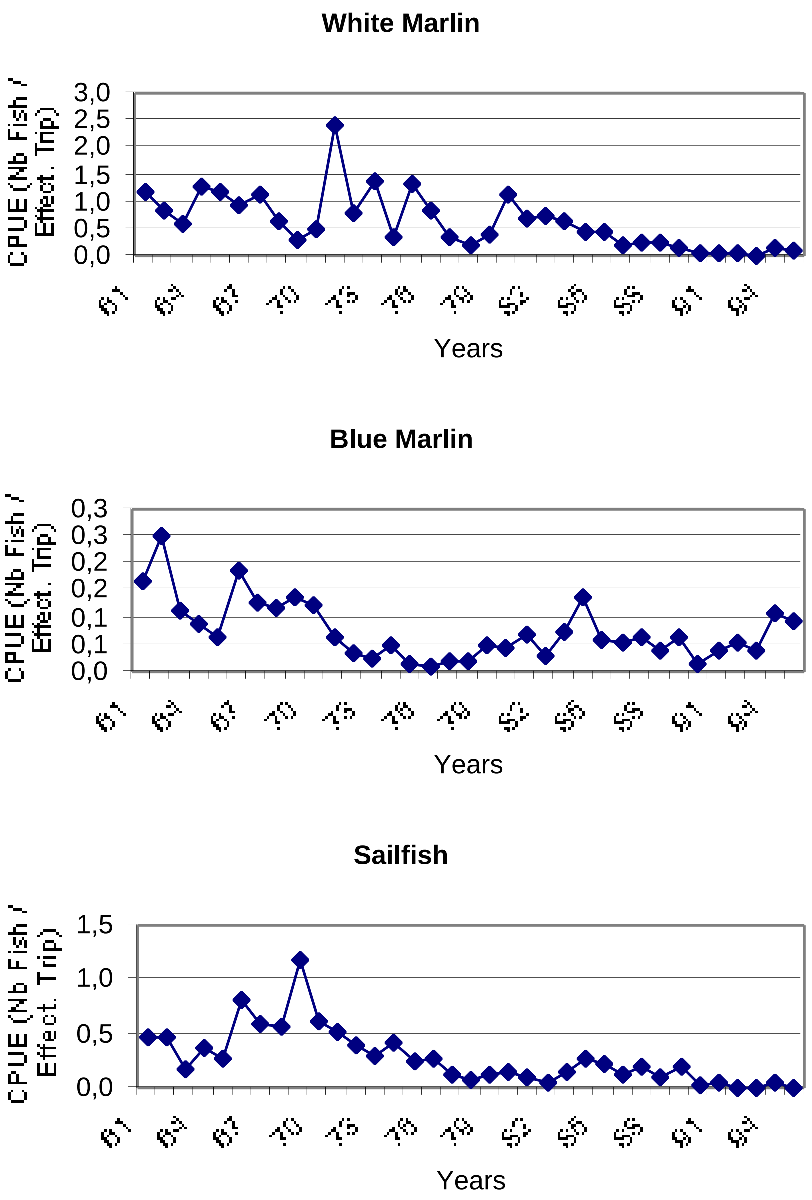

Fig. 1 - Yearly standardized CPUE (No fishes : effective effort) for billfishes at Playa Grande Yachting Club (Venezuela).

DISCUSSION

Since 1980, similar decreasing trends in white marlin CPUE were also reported in the U.S. sportfisheries in the western North Atlantic Ocean by Browder and Prince (1990), in the northern Gulf of Mexico by Avrigian et al. (1994), in the Mid Atlantic Bight and in the Bahamas (from 1975) by Farber et al. (1994). In the standardized CPUEs of white marlin caught by the Japanese longline fishery this trend began in 1962 and continued until 1980. Then the CPUE stayed stationary for the following ten years (Nakano et al., 1994a).

More interesting than to check the significance of correlations between CPUE series (in fact, with the Bonferroni correction, very few of these coefficients are significant), these values help us to classify local fisheries in terms of their proximity of their CPUE trends. For instance during the period selected for the analysis (1975-1989), the evolution of the Venezuelan CPUEs showed good similarity with CPUEs observed in the nor-

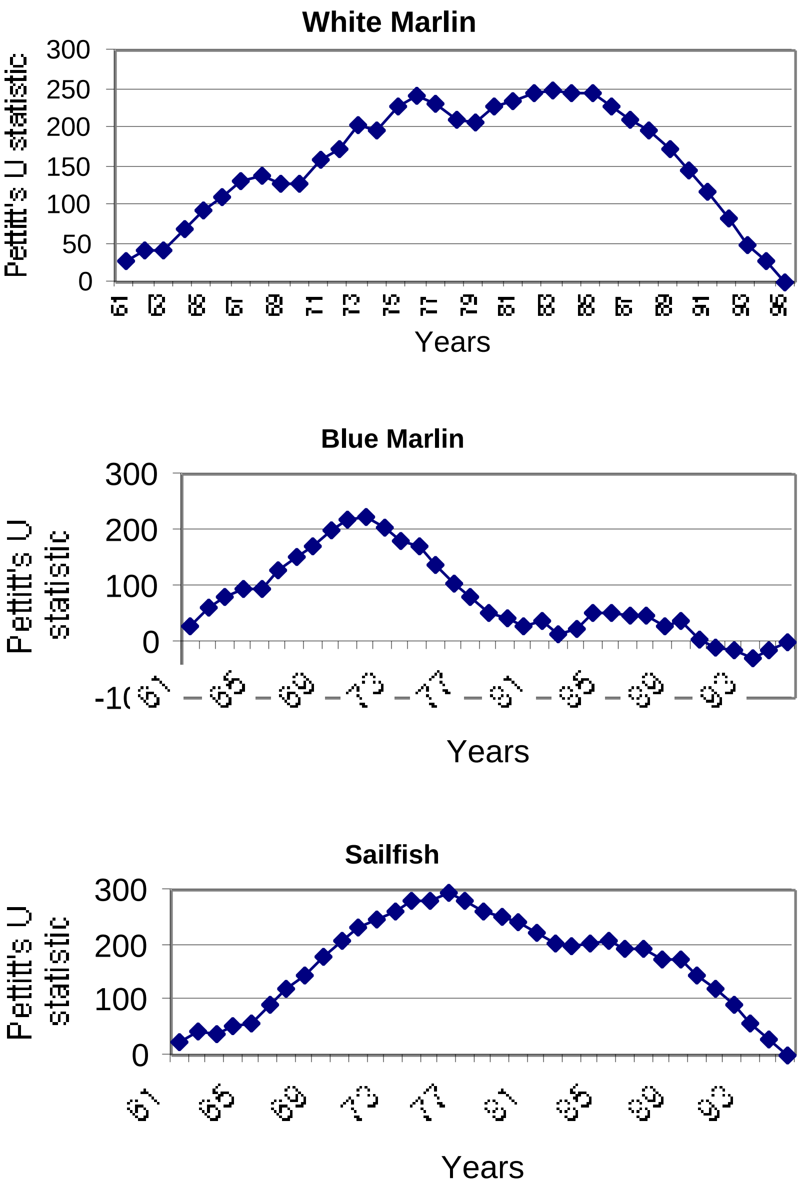

Fig. 2 - Changes in the yearly Pettitt's statistic for billfishes at Playa Grande Yachting Club.

thern Gulf of Mexico (r = 0.63) and in the Bahamas (r = 0.55; Table 4). There is good correlation between CPUE series for the Bahamas and the Gulf of Mexico (0.819) and with the Mid Atlantic Bight (0.722). In contrast, the Japanese longline index partially exhibited a different pattern than abundances estimated with sportfisheries data. The size structures of the catches may not be the same. It seems that a major portion of the white marlin captured by the Japanese longliners in the North Atlantic Ocean are animals less than 150 cm (Uozumi and Nakano, 1994); whereas the size range in the recreational fishery off Playa Grande is 150 cm to 175 cm (Gaertner et al., 1991). It was noted by Alio et al. (1994) that white marlin caught in the sport fishery were larger than fish landed by the longliners and by the artisanal fishery off the central coast of Venezuela. Nevertheless, comparison between shore-based and at-sea sampling size frequencies with U.S. tournament data, during the Second ICCAT Billfish Workshop, did not confirm to these observations (ICCAT, 1994; p. 83).

The increase of apparent abundance of blue marlin was also observed since the end of the1970s; in the U.S. recreational indices in the western North Atlantic (Browder and Prince ,1990), in the Mid Atlantic Bight, Bahamas and Caribbean (Farber et al., 1994), and in the Gulf of Mexico (with the exception of the years 1988-1991, Avrigian et al., 1994). Similar conclusions can be drawn from the Jamaican sport fishing activities (Harvey and Graves, 1994), and more recently (1986-1989) in the U.S. Virgin Islands (Friedlander, 1991). The evolu-

Year	Effort	BUM	WHM	SAI
61	604,5	0.169	1.194	0.475
62	407,3	0.253	0.826	0.462
63	439,0	0.112	0.610	0.162
64	493,7	0.087	1.272	0.369
65	478,9	0.065	1.180	0.259
66	584,7	0.187	0.925	0.803
67	725,3	0.128	1.148	0.583
68	796,0	0.119	0.646	0.560
69	774,5	0.136	0.296	1.183
70	822,7	0.123	0.496	0,609
71	917,9	0.065	2.433	0.518
72	1056,2	0.032	0.797	0.390
73	715,9	0.024	1.399	0.284
74	704,0	0.047	0.357	0.419
75	683,1	0.016	1.340	0.243
76	696,4	0.011	0.853	0.270
77	764,9	0.021	0.355	0.130
78	973,8	0.020	0.175	0.082
79	643,4	0.047	0.387	0.128
80	882,3	0.043	1.152	0.147
81	916,3	0.068	0.692	0.096
82	913,9	0.031	0.744	0.055
83	1195,2	0.072	0.644	0.151
84	1170,8	0.140	0.442	0.259
85	1300,5	0.061	0.445	0.214
86	1184,7	0.054	0.208	0.127
87	1280,3	0.064	0.230	0.206
88	1253,3	0.038	0.246	0.101
89	1136,5	0.066	0.158	0.193
90	929,3	0.017	0.051	0.028
91	1109,5	0.040	0.056	0.040
92	1162,8	0.052	0.028	0.006
93	1033,7	0.039	0.015	0.000
94	741,1	0.108	0.127	0.039
95	553,0	0.094	0.108	0.011

Table 3 - Yearly effort (No trips standardized in effective fishing time) and yearly CPUE (No fishes / effective effort) for blue marlin, white marlin and sailfish at Playa Grande Yachting Club from 1961 to 1995.

	Venez.	G. Mex.	M At. B.	Bahamas	LL Japan
Venez.	+ 1				
G. Mex.	+ 0.626	+ 1			
M At. B.	+ 0.356	+ 0.587	+ 1		
Bahamas	+ 0.549	+ 0.819	+ 0.722	+ 1	
LL Japan	- 0.118	+ 0.189	+ 0.369	+ 0.256	+ 1

Table 4 - Spearman rank correlation coefficients for white marlin CPUEs between different fisheries (1975-1989): Venezuela, Northern Gulf of Mexico, U. S. Mid Atlantic Bight, Bahamas, and Japanese longline.

tion of the CPUE index derived from the Japanese longliners could also indicate a recuperation of the stock over the most recent decade (Nakano et al., 1994b).

The fluctuations of apparent abundance of blue marlin in theVenezuelan sport fishery appear to be correlated with CPUEs collected in the Bahamas, the Gulf of Mexico and Jamaica (r ≥ 0.5; Table 5). In contrast, the Venezuelan CPUE series is not well correlated with the Caribbean CPUE series (r = 0.28). It can be noted than some CPUEs appear to be independent, or exhibit negative correlation, with the others ones (e. g. Mid Atlantic Bight and longline Japanese series). The size frequencies of blue marlins captured by the Japanese longline fishery in the North Atlantic cover a large range (approximately 150 cm to 220 cm; Uozumi and Nakano, 1994) compared to 180 cm to 210 cm in the Venezuelan sportfishery (Gaertner et al., 1991). The proportion of large animals caught by sportfishermen would be more important than in the longliner catches; at least near the Venezuelan coasts (Alio et al., 1994).

	Venez.	G. Mex.	Jamaica	M At. B.	Bahamas	Caribbe.	LL Japan
Venez.	+ 1						
G. Mex.	+ 0.555	+ 1					
Jamaica	+ 0.495	+ 0.029	+ 1				
M At. B.	- 0.077	- 0.097	- 0.007	+ 1			
Bahamas	+ 0.568	- 0.006	+ 0.464	+ 0.094	+ 1		
Caribbe.	+ 0.284	+ 0.248	+ 0.139	+ 0.398	+ 0.493	+ 1	
LL Japan	- 0.064	- 0.004	+ 0.159	- 0.243	- 0.258	+ 0.132	+ 1

Table 5 - Spearman rank correlation coefficients for blue marlin CPUEs between different fisheries (1975-1989). Venezuela, Northern Gulf of Mexico, Jamaica, U. S. Mid Atlantic Bight, Bahamas, Northern Caribbean, and Japanese longline.

During the last twenty years, time series observed in others sailfish fisheries showed the same global decreasing trends that we described in theVenezuelan recreational fishery, but not exactly with the same pattern. For instance, the decrease of CPUE began more recently (approximately 1977-1979) for both U. S. Gulf of Mexico fishery (Avrigian et. al, 1994) and Mexican Cozumel fishery (Martinez and Gonzalez, 1994) than in theVenezuelan waters. The situation is very different for the combined Florida East Coast and Keys CPUE, where apparent abundance increased regularly since 1985 (Farber, 1994). All of the relationships between abundance indices are summarized in Table 6. The trends observed in the Japanese longline index since 1961 (Uozumi, 1995) are very similar to the changes of CPUE off Playa Grande. The size structures from the sailfish sportfishery (165 cm to 180 cm; Gaertner et al., 1991) are the same for landings made by the artisanal fishery (gillnet) and by the longline fishery in the same zone (Alio et al., 1994), making sailfish different than the others istiophoridae.

	Venez.	G. Mex.	Florida	Cozumel	LL Japan
Venez.	+ 1				
G. Mex.	+ 0.515	+ 1			
Florida	- 0.276	+ 0.455	+ 1		
Cozumel	+ 0.124	+ 0.658	+ 0.327	+ 1	
LL Japan	+ 0.530	+ 0.885	+ 0.322	+ 0.583	+ 1

Table 6 - Spearman rank correlation coefficients for sailfish CPUEs between different fisheries (1973-1991): Venezuela, Northern Gulf of Mexico, Florida East Coast and Keys, Cozumel, and Japanese longline.

CONCLUSION

To conclude this comparative analysis, it must be noted that CPUE series are correlated (considering that local environmental conditions probably affect local catchabilities). In particular it is interesting to note the good correlation between the Venezuelan fishery and the U.S. Gulf of Mexico fishery for the three species of billfishes.

Analysis of causality of change-points in the CPUE series is useful to detect the impact of a specific fishery on the dynamics of the resource. Unfortunately, it is sometimes difficult to directly evaluate the individual effect of each gear, or to discriminate gear effect and area effect (generally changes in the use of a gear are combined with changes in fishing location). For instance, it is logical to think that the general decrease of apparent abundance of the billfishes in the 1970s was linked to the development of sportfishery activities and to the high pressure exerted by longliners.

A major change occured for longliners when Japanese and Korean fleets decided to replace the regular longline gear by the deep longline to target bigeye tuna (Thunnus obesus). This operation began in the late 1970s by the Japanese boats (but was significant only after 1980; Table 2 in Uozumi and Nakano, 1994) and during 1980 for the Korean longliners (Yang and Gong, 1987). Considering: (a) the date of this change and (b) the fact that the deep longline shows considerably lower hook rates for billfishes than the regular one (Suzuki et al., 1977; Yang and Gong, 1987), the increase of blue marlin CPUE could be related to these modifications. As mentioned above, it is difficult to discriminate the gear effect and the combined area effect (see Figure 1, in Uozumi and Nakano, 1994). The same hypothesis, which could be suggested for sailfish (compare with Florida CPUE from Farber et al., 1994) can not be drawn for white marlin where CPUE is decreasing.

For white marlin the impact of the other effects, like the increase of fishing effort in the recreational fisheries, especially in the 1960s and in 1970s, should be analyzed. The increase of fishing effort in the major recreational locations can be noted in Venezuela (Table 3, present analysis), in the Gulf of Mexico (Figure 2a, Avrigian et al., 1994) or in several locations in the U.S.A. (Figure 3, Farber et al., 1994).

In the same way, the impact of the longline swordfish fishery (well developed in this region during the past 20 years) and of traditional, or new, artisanals fisheries, are not known. For instance, in Venezuela, before 1987, no commercial fishery targeting istiophoridae was developed (Alio et al., 1994). Nevertheless, the increase in the price of billfish meat encouraged the orientation of the effort in some artisanal fisheries towards these species. The very low CPUE recorded since 1990 in the sportfishery off Playa Grande for white marlin and for sailfish could indicate local competition between gears (especially, if we consider that occurence of billfishes is seasonal in Venezuelan waters).

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