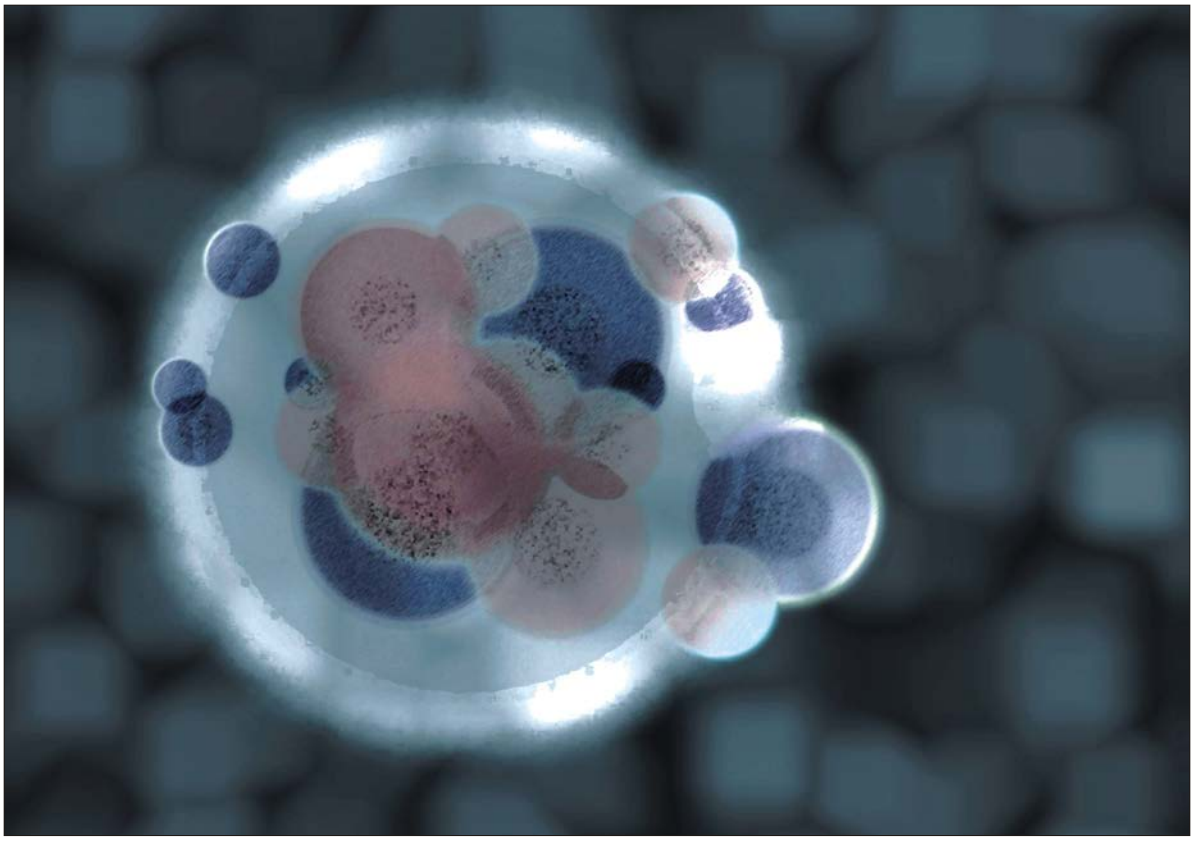

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El Niño Effects on Sport Fishing in the Mexican Pacific Ocean Between 1954 and 2001

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Abstract: The objective of this study was to carry out an analysis of the relationship between the Catch Per Unit Effort and the average size of the organisms and El Niño events from 1954 to 2001. Studies were done on the capture and effort rates from international sportfishing tournaments taking place in the six ports in the Mexican Pacific Ocean during different periods between 1981 and 2001. Results suggest a direct relationship between the abundance and the El Niño event, mainly from tournaments after 1976. More so, there is a positive, though less intense correlation between the El Niño index and the weights and lengths of caught organisms in sport fishing.

Key words: Sailfish, CPUE, abundance, environmental index

INTRODUCTION

The El Niño phenomenon, also known as El Niño Southern Oscillation (ENSO), has become a studied climatic anomaly. Often considered synonym for disaster, for example, in Brazil and Australia intense droughts have occurred impacting agriculture. In California preventive plans against disasters were carried out before the strong winter rains and floods would appear caused by this phenomenon. Originally, El Niño was the name given to the warm seasonal currents that occasionally flowed southward along the costs of Peru and Ecuador during the Christmas season in contrast to the very cold currents that usually flowed northward at that time[1-4].

The sport fishing began its development in Mexico in 1936, but not until the end of the 40's and throughout the 50's, when the areas of Acapulco, La Paz, Mazatlán, Cabo San Lucas, Puerto Vallarta, Manzanillo and Zihuatanejo began to be developed, was the fishing of billfish considered an attraction[5]. Manzanillo, Colima, in particular, host an annual sportfishing tournament in November. The objective of this tournament continues being the capture of the heaviest sailfish. Although, there are diverse factors which could mask possible correlations between capture index and the El Niño phenomenon. For example, previously a special prize was granted for the largest number of organisms regardless of their size , an award also existed for the smallest billfish in the tournament, no limit existed in the number of organisms a fisherman could present to the jury and a minimum size limit was not stipulated for the registration. Moreover it was custom to give the judges the total of organisms captured during the journey even without opportunity to win a prize. Recently, it has been observed that some fishermen do not report all of their captures, leaving a certain quantity of fish (generally the smallest) on board the crafts. At the same time, the organizers of sportfishing tournaments and clubs, have begun to advocate the release of smaller catch. These changes have contributed to, at the present time, the CPUE index underestimates abundance and slants weight and size averages towards larger values.

Commercial fishing is another activity that interacts with sport fishing. This activity began after the Second World War in the region today is the Mexican Economic Exclusive Zone in the Pacific ocean (MEEZ), when the Japanese fleet expanded its fishing operations toward the Oriental Pacific, East of the 130°W. This fleet began its expansion in 1956 and by 1963 they were fishing in most tropical and subtropical areas of that zone[6]. In 1976, México declared 200 mile for MEEZ, this date coincides approximately with the technological transformation of long line deep sea fishing developed by the Japanese fleet. These actions caused a marked decrease in the level of effort applied on the billfishes in this area[7]. In the sportfishing tournaments carried out in Manzanillo

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has been reported significant differences among the slopes of the CPUE tendency during the periods 1954-76 and 1976-89 and associated to the changes in commercial fishing effort throughout the region[8]. This suggests that the history of sailfish fishing, in this region, can be divided into two periods. The first one (1954-1976) is characterized by the beginning of commercial fishing by the international long liner fleet with a growing effort and the development of sport fishing in the main ports in the country. The second period (1976 to 2001) began with the declaration of the 200 miles of MEEZ, characterized by a decrease of fishing effort exerted by the international long liner fleet and the operation, in discontinuous fashion, of a small Mexican long liner fleet.

Another aspect that suggests the separation of both periods is mentioned by some authors who carried out an analysis of the period 1950-1998 and reported that one of the most interesting aspects in the ENSO is the lack of La Niña events since 1976 and this opens the possibility to link changes in the ENSO as being partially caused by the increment observed in greenhouse gases[9,10]. They argue moreover that noticeable changes in the general circulation of the Pacific basin have taken place with tropical Pacific sea surface temperature shifts in the mid to late 1970´s and they wonder if there is a systematic difference between El Niño events prior to 1976 and since then. They present evidence for this, illustrating the typical evolution of El Niño events before and after 1976 using different indicators of the phenomenon and their intensity. The MEI shows that the average behavior of El Niño, before 1976, can be characterized by a rapid onset phase from March/April to June/July, mature conditions until May/June of year one. The maturity phase often features two separate peaks around July and December of the year zero. More recent events have taken much longer time to mature resulting in a delayed peak around March/April of year one, with a shorter duration of the mature stage and a slow decline towards the end of year one. In addition, they have been developed several statistical tests to assess the likelihood of the recent behavior of the ENSO as part of a natural decadal time scale variation[10]. Using an auto-regressive model (ARIMA) to measure the ENSO, going back to 1882, they found that the El Niño events since 1976 and the 1990-95 event have been unexpected events considering the previous record, with a probability of occurrence about once in 2,000 years.

Another factor that has influenced the fishery of the region is the Mexican legislation, which at the moment exclusively reserves the swordfish, marlin, sailfish and dolphin fish (as well as other species) for sport fishing, in a fringe of 50 miles measured from the coast and in two areas of exclusion that include the mouth of the Gulf of California and the Gulf of Tehuantepec. Permits have not been granted for commercial fishing of these species since 1990, with the exception of the swordfish and only some permits have been authorized for the fishing of shark with long lines, because this practice has a considerable incidental capture of species reserved to sport fishing.

The sailfish (*Isthiophorus platypterus)* is the main objective specie in the sportfishing tournaments in Manzanillo. It is distributed in all tropical and sub-tropical seas of the world, however in the Mexican Pacific, especially abundant concentrations of this species exist[6].

The Mexican Pacific region is generally characterized by a mass of warm subtropical surface water from the South Pacific eddy and a mass of Equatorial surface water (Cold waters with lower salinities from the current of California and the current of Peru can also be distinguished but as separate masses of water). In this region El Niño is characterized by abnormally warm superficial water. In relation to this, it has been reported that the seasonal north-south migrations of sailfish seemed to coincide with the seasonal movements of the 28°C isotherm[11]. Also, it has been described a positive and significant correlation among the CPUE for sailfish and superficial temperature of the sea during sportfishing tournaments in Manzanillo[8].

The better CPUE for sailfish, in the area today is the MEEZ, it was obtained at the beginning of fishing activities during the late 50's, in both commercial and sport fishing. However this diminished in continuous fashion, shown a tendency associated to the increment in the commercial fishing effort[6,8]. This situation continued until the end of 70's; after this date there are no reports about fishing operations in this region; except for the reports of a long liner fleet that operated under the Mexican flag[12].

Analysis had become of the effect of the commercial fishing on the sportfishing as well as an analysis of the relationship of superficial sea temperature and sea level associated to the fluctuations in CPUE in the sportfishing tournaments in Manzanillo between 1954 and 1990. They report the cross correlation reaches its maximum when the series are compared and delays are closest to zero[8].

The sport fishermen in Mexico frequently assure that the fishing success and the organism captured at the moment are inferior to that previously obtained[13,14]. These comments could be interpreted, if they were true, as an over exploitation of the resource due to a relative high catch effort. If the effects of the El Niño phenomenon and the effect of the changes in tournament regulations are excluded, the analysis of tendencies in average length and weight as well as that of CPUE in sportfishing could

serve as element to corroborate this asseveration. Considering the aforementioned, the objective of this study was to carry out an analysis of the relationship that exists between the values and the tendencies of the El Niño index and the CPUE abundance index regarding average size of the organisms captured in the sportfishing tournaments carried out between 1954 and 2001.

MATERIALS AND METHODS

A monthly index reported in internet was used as an indicator of the occurrence and intensity of the phenomenon El Niño[15]. This index, known as MEI, is a multivariate measure of El Niño, expressed as the principal component of the six variables observed in the tropical Pacific. This index is calculated every month for the 2 preceding months and defines El Niño conditions to any positive value of the index[9]. Average values for the October-November and November-December periods were used to compare this index with the CPUE series of the sportfishing tournaments carried out in Manzanillo.

Information published annually in brochures from the Fishing Club of Manzanillo about the November´s tournament, from 1954 until 2001 were analyzed. This information, consist of a listing where the total number of fish caught and the number of participating fishermen for each tournament. After 1981, biological samplings of the captures obtained in these events were done. The information reported by the club was tested using χ^2 for the past 21 years of the series. The CPUE was defined as the total number of organisms caught during the event, divided by the total number of participant fishermen. The analysis was done dividing the period into two stages, between 1954-1976 and 1976-2001[9,10,16].

An analysis of the size and weight of the sailfish caught in sportfishing tournaments throughout 6 ports of the Mexican Pacific Ocean during different time periods between 1981 and 2001 has also done. Table 1 shows the name of these ports, the period where the information is available and the number of organisms caught in that period. Sport fishing information collected from the southern Baja Californian area is also included. To eliminate the possible bias caused by the fact that in some tournaments the relative minimum size of the organisms that could be registered was limited, the heaviest 30 organisms were selected and the average eye-fork length and total weight was calculated.

For quantitative comparison of the series of CPUE, length and weight with El Niño index, a standardization of the data was made. Additionally, an analysis of cross correlation evaluating the correlation between the CPUE and the environmental index was done. The series tendencies were presumed lineal and were calculated by a square minimum method and their significance was assess by a t-test[17]. The variation in the series was quantified by the total sum of squares.

A totally randomized ANOVA was carried out to identifying if the changes in average size and weight of the 30 heaviest organisms within the 1981-2001 period were statistically significant.

Table 1: Name of the ports and information of the organisms caught

Port	Period	Sailfish captured	Average No. of sailfish	Average longitude (cm) eye-fork
Baja California Sur	1987-2000	1,340	---	
San Blas, Nayarit	1983-2000	389	36	167.74
Puerto Vallarta, Jalisco	1988-2000	880	80	174.38
Barra de Navidad,Jalisco	1989-2001	872	67	163.70
Manzanillo, Colima	1981-2001	2,401	126	169.29
Lázaro Cárdenas, Michoacán	1992-2001	233	26	166.07
Zihuatanejo, Guerrero	1992-2001	839	93	166.9
	Total	6,954		

RESULTS

Most values of the El Niño index during the sportfishing tournaments in Manzanillo were negative for the first period. During the second period, most of them were higher than cero (Fig. 1). The slope value for the tendency line of the CPUE series for the first period is -0.0314, while the value for the second period is -0.00885 (Fig. 2). The analysis of χ^2 indicates there are no significant differences among the data reported by the fishing club (published in magazine promotions) and those documented in biological samplings for the registration of the number of captured organisms (χ^2=11.07) and for the number of participants in the tournaments (χ^2=12.57).

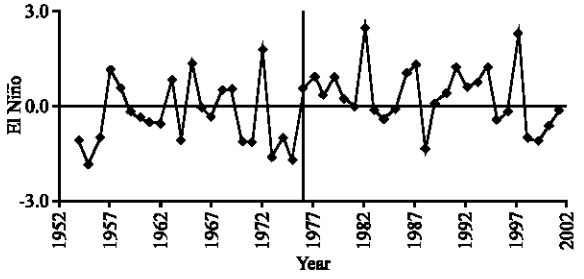

Fig. 1: Average values of the Multivariate El Niño index for October-November and November-December from 1954 to 2001. The vertical line in 1976, indicates the division of the series in the considered periods

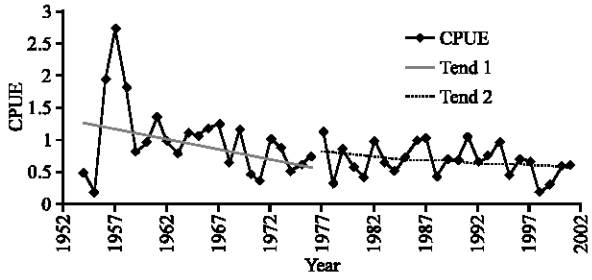

Fig. 2: Catch Per Unit Effort and tendency in the annual sportfishing tournaments in Manzanillo, México from 1954 up to 2001. The tendency lines correspond to the periods in which the series were divided according to the level of fishing effort and characteristics of El Niño in those periods. (CPUE=Catch Per Unit Effort, Tend 1=Tendency for the first period, Tend 2=Tendency for the second period)

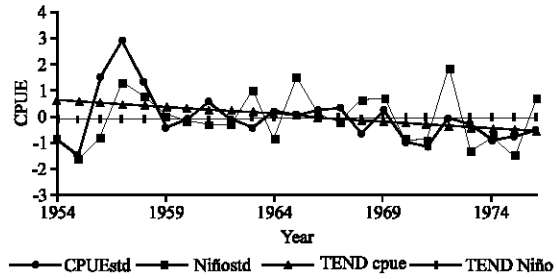

Fig. 3: Standardized values of Catch Per Unit Effort, Multivariate index of El Niño and tendency lines in the sportfishing tournaments in Manzanillo, Mexico for the period 1954-1976 (CPUEstd= Standardized CPUE, Niñostd=Standardized index of El Niño, TENDcpue=Slope of the CPUE tendency, TENDNiño=Slope of the MEI tendency)

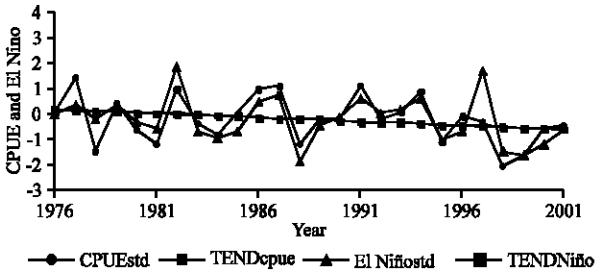

Fig. 4: Standardized value of Catch Per Unit Effort, Multivariate index of El Niño and tendency lines in the sportfishing tournaments in Manzanillo, Mexico for the period 1976-2001 (CPUEstd=Standardized CPUE, NIÑOstd=Standardized index of El Niño, TENDcpue=Slope of the CPUE tendency, TENDNiño=Slope of the MEI tendency)

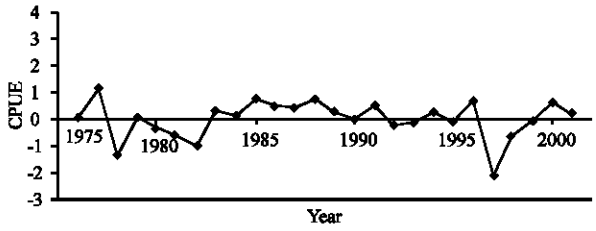

Fig. 5: Series of CPUE in sportfishing tournaments in Manzanillo, Mexico and tendency after extracting the attributable variation to environmental changes for the period 1976-2001

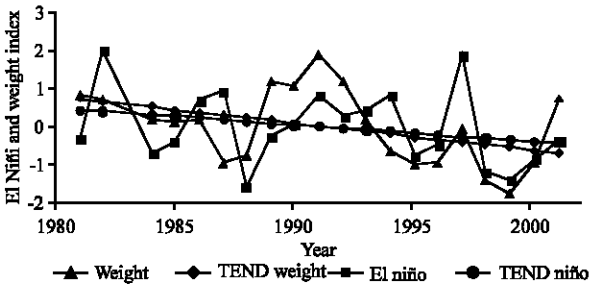

Fig. 6a: Average Weight, Multivariate index of El Niño and tendency for sailfish caught in sportfishing tournaments in several ports of the Mexican Pacific Ocean (WEIGHT= Standardized average weight, TENDweight= Weight tendency, EL NIÑO= Standardized El Niño index, TENDniño= El Niño index tendency)

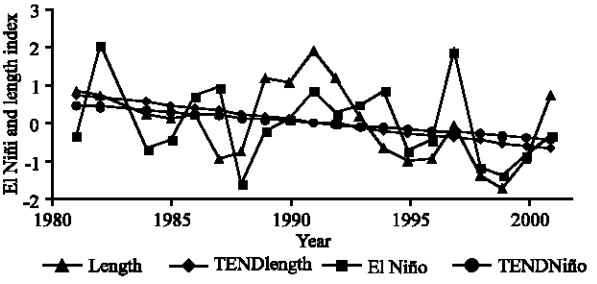

Fig. 6b: Average Length, Multivariate index of El Niño and tendency for sailfish caught in sportfishing tournaments in several ports of the Mexican Pacific Ocean (LENGTH= Standardized average length, TENDlength= Length tendency, EL NIÑO= Standardized El Niño index, TENDniño= El Niño index tendency)

After being standardized, the CPUE shows a negative slope of -0.0553 for the first period; while the environmental index presents a positive slope of 0.0018 that is not significantly different from zero (Fig. 3). For this period, the cross correlation coefficient presents

a maximum value of 0.45 when the series were compared with zero delays.

For the second period, after standardization, both series present negative slopes, about with the same magnitude: -0.0359 for the CPUE and -0.0343 for El Niño (Fig. 4). The total variation present in the CPUE standardized series (SCTcpue=25), is explained at 52.2% because the changes in the environmental index; while the slope is explained at 95.64% because of these same changes. The cross correlation coefficient for these series was 0.74, this maximum value was obtained when the series were compared without displacements among them.

When the variation and slope of the CPUE attributable to the environmental variable is extracted, a series with a slope of -0.0016, a value not significantly different to zero, is obtained. This series could describes better the tendency of the CPUE in the last 26 years (Fig. 5).

In the Fig. 6a and 6b the standardized series corresponding to the weight, length and El Niño index for the 1981-2001 period are shown. All of them present a negative tendency. The values of the slopes are -0.0708 for length, -0.1082 for weight. and -0.0439 for the El Niño index. According the results for average length and weight of the 30 heaviest organisms, in both cases the null hypothesis is rejected ($p = 1.002$ E-46; $p = 3.145$ E-81).

DISCUSSION

For the first period (1954-1976), there are coincidences among the variations of the series, mainly for the first 7 years. Later, there are inconsistencies, which could be due to differences in the occurrence of the El Niño happening before 1976 as compared with those manifested after that year[9]. This is reflected in a lesser association among the indicator of abundance of the sailfish and the MEI. However it is interesting to observe that the environmental variable (slope with near positive value to zero) in this period, does not explain the decrease of the CPUE (negative slope). This is consistent with the theory of a decrease in abundance associated to the increment of the fishing effort during this first period. The biggest component of that fishing effort was applied by the international long liner fleet, because in this lapse sport fishing was incipient and the Mexican commercial fishing did not exist.

For the second period (1976-2001) which began with the declaration of the 200 miles of MEEZ, the CPUE showed a tendency, with a slope sensibly smaller than the first period. Also, there is a narrow and direct correspond among the CPUE in the sportfishing tournaments in Manzanillo and the MEI index. Coincidence reflected in a greater percentage of explained variation and a greater coefficient of cross correlation. In this period, the environmental variable as well as the CPUE present negative slopes of approximately the same magnitude. This behavior is consistent with the theory that a negative effect existed in the abundance during the first period and it was mitigated when Mexico declared the 200 miles of MEEZ, allowing the stabilization of the abundance index. It can see only a decrease in its value correlated with the decrease of the environmental indicator for this period. Due to the changes in tournament regulations, a slope of CPUE with a value near to zero for the last period could be indicative of recovery of the resource, not only an equilibrium stage.

In the analysis of lengths and weights, the average values observed for these organisms, in general, presenting periods of increment and decrement coincide with the multivariate index MEI. It is observed that the series corresponding to size and weight present a negative tendency that seems to coincide with the tendency of El Niño index for the analyzed period. Suppose the existence of an association among these indexes, it could be calculated that a part of the negative tendency in the size of the captured orgamisms is explained by the decrease in the environmental El Niño index, that means that about 51% of the decrease observed in length and weight in this period can be attributed to the tendency El Niño index during the period of 1980-2001. From statistical analysis of results it can be seen in the variation between years, random variation, reaches 82% for the case of length and 75% for the analysis of the weight, which is consistent with the highly risky nature of the fishing process. It is quite possible that this is the cause of the relatively low variation percentage explained by the environmental variable.

Based on the aforementioned, it can be conclude that information points toward a direct relationship between the occurrence and intensity of the phenomenon El Niño and the CPUE in the sportfishing tournaments in Manzanillo. The analysis of crossed correlation suggests that, since a maximum value is presented when the series are compared without displacement, the effects of the oceanographic changes associated to the ENSO produce a geographical redistribution of the population of the sailfish toward upper latitudes, causing its availability increased along the costs of Colima during the dates in which the tournament are realized and thus the organisms are larger in size, an unusual situation that does not happen in normal years when the fishing area is dispersed southward to regions where warmer temperatures prevail.

Seemingly the negative slope of the series analyzed during the last period correspond to the events of El Niño, since the late 70´s, have been associated to climatic changes in the scale of decades although in context the natural variability revealed by the registrations, could be

evidence of global climatic change rather than an unusual long period fluctuation[10].

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