Estimation of catch-per-unit-effort of striped marlin (*Tetrapturus audax*) caught by gillnet fleets in the Indian Ocean

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Abstract

Catches of striped marlin (*Tetrapturus audax*) of gillnet fleets increased fast in recent year. In 2015 close to 30% of all striped marlin reported were caught by fishermen which operates ordinary gillnets, offshore gillnets, or gillnets attached to longlines. In spite of the importance of the gillnet fisheries in the Indian Ocean, there are not catch and effort databases for striped marlin and other billfish. Therefore, estimations of catch-per-unit-effort (CPUE) in conventional ways are not feasible. However, the number of gillnet boats have been reported yearly to the Indian Ocean Tuna Commission (IOTC) which also have estimations of yearly catches. In this paper the numbers of boats are tentatively used as a proxy of the carrying capacity and of the effort of Iran, Pakistan and Taiwan gillnet fleets. Results indicate an outstanding increasing trend of the number of gillnet boats in Pakistan, which is an important issue for tuna fisheries management in the Indian Ocean. The low values of CPUE calculated for the beginning of Iran and Pakistan time series may be an indication that catches of that period were underestimated. CPUE time trends as calculated for the three countries were conflictive in some parts of time series. Although the results were encouraging, they might be carefully considered due to the assumptions underpinning the calculations, and because the CPUEs estimated are not standardized indices.

1. Introduction

In the Indian Ocean striped marlin (*Tetrapturus audax*) is a bycatch in longline, gillnet and handline fisheries. Catches of striped marlin were only 4% of the total catch of billfish in the recent year (Anon., 2016). However, the stock of striped marlin has been conituously overfished since 2013, which stress the need for data and reliable estimations of catch, effort and relative abundance indices to conduct stock assessment and other analyses useful for management. Available data concerning bycatch species are usually biased or incomplete. Typically only approximate catches and some life history information are available. In the case of striped marlin catch-per-unit-effort (CPUE) and relative abundance indices have been estimated based on commercial data. However, such estimations are available only for longline fleets of Japan and Taiwan (Ijima, 2017; Wang, 2017). In fact, longline have accounted for most of striped marlin caught in the Indian Ocean since 1950. However, the catches of gillnet have increased fast, while the catches of the traditional longlines have decreased in the recent years (Anon, 2016; Andrade, 2017). The lack of CPUE and estimations of relative abundance indices for striped marlin and other billfish species caught by gillnet fleets is critical in the Indian Ocean due to the increasing trend of gillnet catches. In the past fishing mortality of bycatch species were almost exclusively due to the longline fleet, but this is not true nowadays. Gillnet catches of striped marlin in recent years were similar to those of the traditional longline fleets (Andrade, 2017).

Estimation of relative abundance indices is a cornerstone of different stock assessment approaches. Often commercial catch and information concerning effort (e.g. number of hooks or of fishing sets) are used to calculate CPUE. If there are information about the fishing gear characteristics (e.g. number of hooks between floats, size of the net), and also data concerning when (month, daytime) and where (latitude and longitude) the fishing gear were operated, standardized CPUE can be calculated, which is assumed to be a relative abundance indices. However, there are not such data for striped marlin caught by gillnet fleets. When data is limited new attitude is required (MacCall, 2015). Quantities are not precisely knowable, even thought, one need to find out what are the policies to be used based on data available. In data limited scenarios it is important to explore all available data, even incomplete, and to explore "what-if" possibilities. In this paper I went over to look at available information on catch and on effort proxies for gillnet fleets, in an attempt to estimate an alternative catch rate using the limited data.

Most of striped marlin caught by gillnet boats were reported by Iran, Pakistan and Indonesia after 2000 (Anon, 2016). In the IOTC databases there are approximate estimations of the annual nominal catch but there are not data about catch and effort of gillnet. However, there is information concerning the historical time series of the number of gillnet boats of some countries. In this paper I assumed that the number of boats in the IOTC dataset is useful to estimate fishing effort proxies. CPUE time series were then estimated based on the number of boats. The CPUE calculated in this work is not a standardized CPUE, but it may worth the effort to consider it as a potential relative abundance indices at least for periods in which the fisherman strategy and the fishing power did not change much.

2. Data and Analysis

The approach used in this paper is similar to that of Andrade (2015). Some of the text below was extracted from the document mentioned above. Data concerning nominal catch of striped marlin were provided by the IOTC secretariat before the meeting (IOTC, 2017). Hereafter that data is denominated "catch database". In this database there are information of catch by year, country, and gear. Gillnet catches of striped marlin (MLS) are classified as: a) "Gillnet" (GILL); b) "Gillnet operated attached to a longline" (GL); or c) "Offshore gillnet" (GIOF). There are not catch-effort data for these categories, which imposes difficulties to calculate CPUE. The alternative is to use the number of boats reported in the IOTC databases as proxy of fleet carrying capacity and effort. Historic of the numbers of boats as it appears in the IOTC database was kindly prepared and made available by Ms. Lucia Pierre of IOTC Secretariat. This information is hereafter denominated "boat database".

In the boat database there is information concerning number and size of crafts (Length Overall –LOA or Gross Register Tonnage – GRT) by year and by gear as reported by the contracting parties. The gear categories in boat database are similar to those of the catch database. However, in some cases the number of boats of a main gear category (e.g. GIOF) was split into two or more size categories (e.g. 50-100 GRT and more than 100 GRT) in the boat database. Hence a CPUE calculation is not straightforward because there are two types of effort units (number of boats in 50-100 GRT category, and number of boats in > 100 GRT category), and only one aggregated catch. If one assumes that the efficiencies of the boats of different size are similar, total effort would be the sum of the numbers of boats, and the calculation of CPUE is a simple task. However, fishing powers of boat of different sizes may be different. Hence it is not sensible to sum the numbers of boats of the two categories of size.

If it is possible to convert the number of boats of a given category in the equivalent number of boats of another category, the two efforts (number of boats) may be summed up, and a CPUE can be calculated. In some cases the efficiencies of different boat categories can be calculated by solving a linear system $Y = X\beta$, in which Y is the vector (length n) of MLS catches, X is the matrix (dimension $n \times k$) with the number of boats in each of the k categories, and $\beta = \{\beta_1, \dots, \beta_k\}$ is the vector of parameter that represents the relative efficiency of each of the k different types of boats. The above model may have unique solution only if $n \geq k$. However, all useful roots or estimations of β components might be not negative. If available, the estimation of β can be used to convert the effort of one category to the effort of other category, then the two efforts (e.g. number of boats) are summed up to calculate the total effort and the CPUE. This approach, which resembles the "fishing power" concept in its simplest form, was applied in the analysis of Iran dataset (see below).

In some situations there are estimations of proportions of general catches of tuna and tuna like fish aggregated. If one assumes that these proportions applies also to striped marlin an overall indices of striped marlin catch rate for the j^{th} category of boat can be calculated as $U_j = \sum_y C_y \times p_j / \sum_y n_y$, in which U_j is the indices for the j^{th} boat category, p_j are the proportions mentioned above, and C_y and n_y are the catch and the number of boats in the y^{th} year. Thus the relative power of two boat categories, for example, may be calculated by dividing the indices U estimated for the two categories. Finally, the relative power can be used to convert the number of boats of one category into the number of boats of the other category in each year. This approach was used in the analysis of Taiwan dataset (see below).

Hereafter, the total effort calculated as explained above is called "effective" effort. Ordinary scatterplots and basic statistical analyses were used to explore catch, effort and CPUE time series. Differences among consecutive values of fishing effort, catch or CPUE values were assessed in an attempt to identify punctual discontinuities in the time series. To assess these differences in one or more dimension (e.g. the space of effort only, the two dimensional space defined by effort and catch) I have calculated the Euclidean distances. Split the CPUE time series in shorter parts was considered whenever a discontinuity was identified.

3. Results

3.1. Catch and Boat Databases

Gillnet catches of MLS were low before 1990, but there was a increasing trend since then (Figure 1). There was a peak in 2004-2005, followed by a plunge in 2008-2010, and by an increasing trend in the end of the time series. The proportion of total catch accounted for gillnet has increased along with the nominal catches. In recent years more than 27% of the striped marlin reported in the IOTC databases were caught by gillnet fleets.

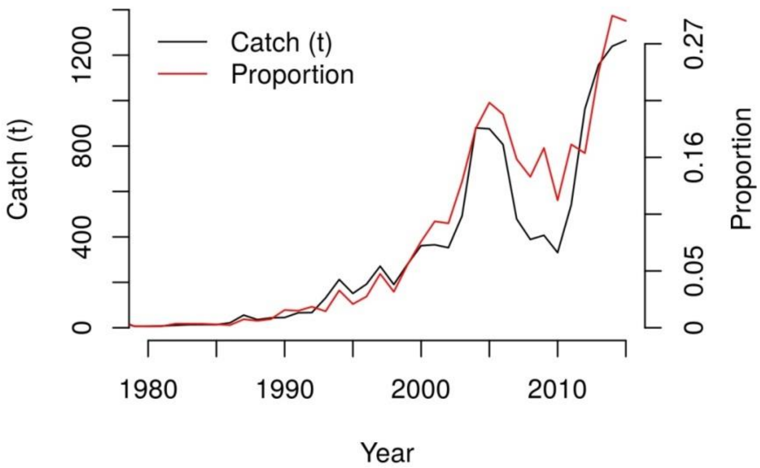

Figure 1 – Gillnet catch of striped marlin as estimated by IOTC.

Catches of major gillnet category can be split into three subgroups: ordinary gillnet (GILL), gillnet operated attached to a longline (GL) and offshore (GIOF) (Figure 2). There are data concerning GL category only for two years. The time series of GILL category is the longest one, while times series of GIOF catches starts in 1989. The peak and plunge showed before for total gillnet catches (Figure 1) were mainly due to the oscillation of GIOF catches (Figure 2). Catches of ordinary gillnet boats (GILL) were low until mid 1990, close to 200 t from 1984 to 2010, and then jumped to approximately 500 t in 2011 (Figure 2).

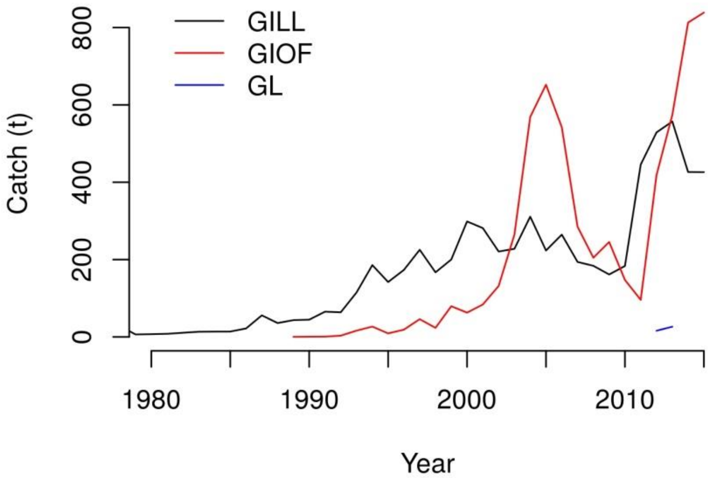

Figure 2 – Gillnet catches split into subgroups: "Gillnet" (GILL), "Gillnet operated attached to a longline" (GL), and "Offshore gillnet" (GIOF).

Gillnet catches by country accumulated from 1950 to 2015 are shown in Figure 3 A. Most of striped marlin unloaded in the Indian Ocean harbors was caught by Iran, Pakistan and Indonesia. Catches of Arabian Emirates, Taiwan and Sri Lanka were low. Gillnet catches of some other countries are very low and were not shown to not clutter. Catches accumulated in the last five years to show up in the time series are in Figure 3 B. In the recent years catches of Iran, Pakistan and Indonesia remain in the top of the rank. Taiwan was replaced by Jordan in the top six positions. In general most of gillnet catches are from countries located in the north margin of Indian Ocean.

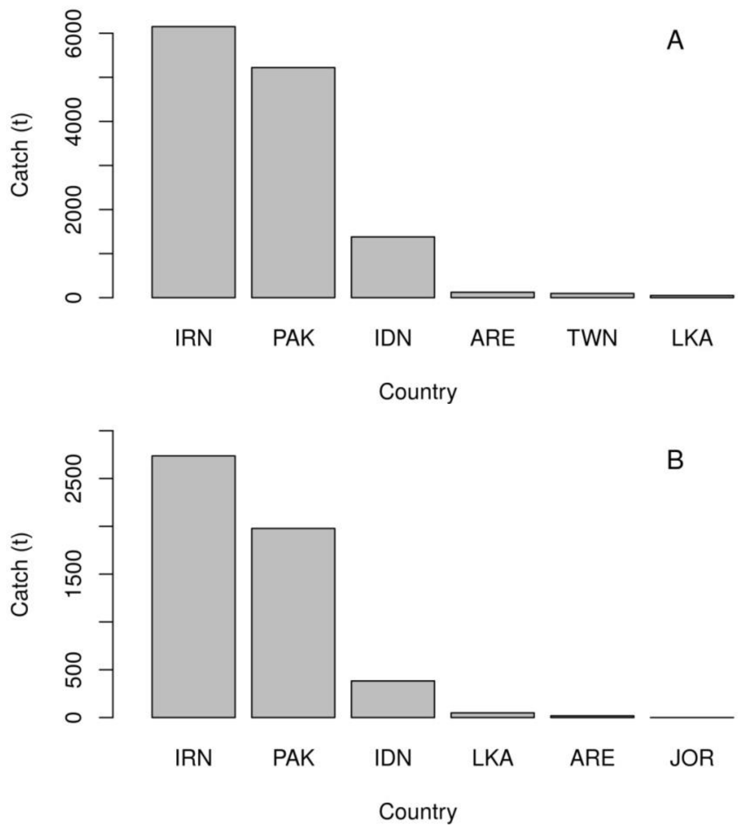

Figure 3 – Catches summed up from 1950 to 2015 (A), and catches summed up from 2011 to 2015 (B). Iran (IRN), Pakistan (PAK), Indonesia (IDN), Sri Lanka (LKA), Arabian Emirates (ARE), Taiwan (TWN), and Jordan (JOR).

Gillnet catches time series by country and by gear subdivision are showed in Figure 4 A. Notice that Iran-GIOF and Pakistan-GILL were the major crossing country-gear categories concerning striped marlin caught with gillnet (Figure 4 A). Catches of Indonesia-GILL increased after 2005 but they remain lower than those of Iran and Pakistan. Catches of all other combinations gear-country were very low if compared to the catches of the three countries mentioned above. Therefore, a zoom of those low catches are shown in Figure 4 B. Notice that time spans of Sri Lanka, Jordan and Malaysia were very short. Hence, only time series GIOF.IRN, GILL.PAK, GILL.IDN, GILL.TWN and GILL.ARE were retained after this first step of the analysis.

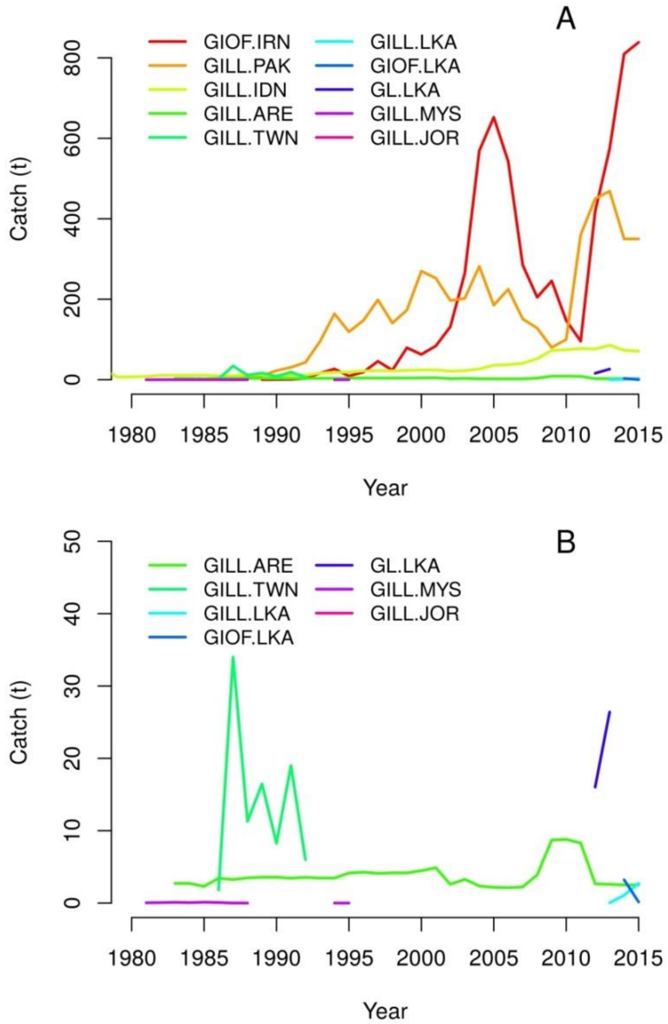

Figure 4 – Gillnet catches as reported in the IOTC dataset. Gillnet major gear group was split into ordinary gillnet (GILL), gillnet operated attached to a longline (GL), and offshore gillnet (GIOF). Countries: Iran (IRN), Pakistan (PAK), Indonesia (IDN) Arabian Emirates (ARE), Taiwan (TWN), Sri Lanka (LKA), Malaysia (MYS) and Jordan (JOR).

The five time series selected from the IOTC “catch database” are potentially useful to estimate catch rates. However, in the “boat database” there is information concerning only three of the combinations, namely GIOF. IRN, GILL.PAK and GILL.TWN. In addition, in the “boat database” GIOF boats of Iran were split into subgroups according to size, intermediate (50-100 GRT) and large (>100 GRT) boats. Gillnet (GILL) boats of Taiwan were split into small (100-200 LOA), intermediate (200-500 LOA) and large (500-1000 LOA). There is only one category for gillnet boats of Pakistan which are small (35-50 GRT). The unit of LOA measurements of Taiwan boats is reported as “m” (meters) in IOTC database. However, it is important to revise and clarify what the measurements mean. It is unlike that there is a boat of 1000 m of length in the water line for example.

Table 1 –Classification and characteristics of the gillnet boats reported in the IOTC database. Gear subgroups: ordinary gillnet (GILL) and offshore gillnet (GIOF). Size measurement types are: Gross Tonnage (GRT) and Length Overall (LOA), in tons (t) and meters ??? (m) respectively.

Country	Gear	Size	Type	Unit
IRAN I. R.	GIOF	50-100	GRT	T
IRAN I. R.	GIOF	>100	GRT	T
PAKISTAN	GILL	35-50	GRT	T
TAIWAN	GILL	100-200	LOA	m
TAIWAN	GILL	200-500	LOA	m
TAIWAN	GILL	500-1000	LOA	m

Times series of number of boats in the six categories showed in Table 1 are in Figure 5. Notice the outstanding increasing trend of the number of boats of Pakistan since 1980. In 2015 it was reported approximately 3,000 boats. This fleet of small boats is probably the largest gillnet fleet in the Indian Ocean. The fleet of Iranian GIOF boats of intermediate size was first reported in 1984 and it remained close to 500 until the end of 1990's. The number of boats increased from 1998 to 2004 reaching 996 units, but decreased until 2009. In the recent years the fleet of GIOF intermediate size boats of Iran was close to 500. The first record of large GIOF boats of Iran was in 2005. The number of boats increased 2000's, and in recent years close to 300 boats have been reported. The gillnet fleet of Taiwan were reported from 1985 to 1992. The number of boats in each of the three categories (small, intermediate and large) were always lower than 100.

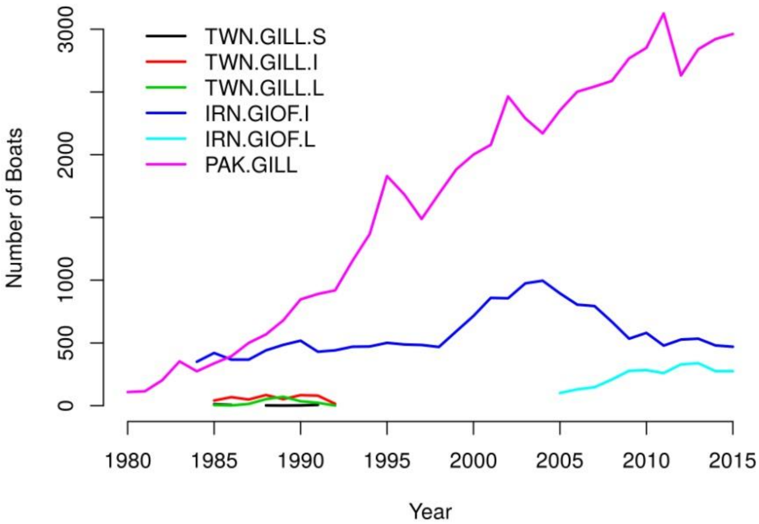

Figure 5 – Number of gillnet boats of Iran (IRN), Pakistan (PAK) and Taiwan (TWN) as reported in IOTC database. Gear categories are: ordinary gillnet (GILL) and offshore gillnet (GIOF). Size of boats are small (S), intermediate (I) and large (L). There is only one size category for gillnet boats of Pakistan.

3.2. Catch, Effort and Cath-per-Unit-Effort

3.2.1. Iran

Most of billfish unloaded in Iran were caught by fleets home based in Hormozgan, or Sistan and Balochestan provinces (Rajaei, 2016), which are located in the south (Figure 6). Striped marlin has been caught by boats of different sizes which operates offshore gillnets (GIOF). In order to calculate CPUE the aggregated catch of GIOF category need to be split into categories of boats according to its size.

Figure 6 – South part of Iran with indication of the provinces. Map was adapted from www.geographicguide.com/asia/maps/iran.htm.

Dr. Fariborz Rajaei has kindly provided data concerning the catches and the number of boats by size category in each province in 2013 and 2014 (Table 1). In addition Drs. Fariborz Rajaei and Reza Shahifar provided the information that almost all billfish unloaded was caught by intermediate (50-100 GRT) and large (> 100 GRT) boats. Hence I have considered that almost all striped marlin unloaded in Iran was caught by intermediate and large size boats based on Hormozgan or Sistan and Bluchestan provinces only.

Table 1 – Catches of striped marlin and number of boats of each Iranian province in 2013 and 2014. Gear categories are gillnet (GILL) and offshore gillnet (GIOF). Sizes of boats are in Gross Register Tonnage (GRT). Source: Dr. Fariborz Rajaei – Senior Expert – Iran Fisheries Organization.

		Number of Boats			
Year	Province	GILL (0-50 GRT)	GIOF (50-100 GRT)	GIOF (>100 GRT)	Catch (t)
	Khozestan	139	3	0	0
2013	Busher	1,498	55	0	3
	Hormozgan	2,932	175	55	1,444
	Sistan and Bluchestan	502	301	283	5,954
	Total	5,071	534	338	7,401
	Khozestan	103	2	0	0
2014	Busher	1,415	65	0	1
	Hormozgan	2,711	168	55	2,231
	Sistan and Bluchestan	633	250	220	9,375
	Total	4,862	485	275	11,607

In order to calculate the relative efficiencies of the two GIOF boats categories (50-100 GRT and > 100 GRT) I have used a linear model. In the first attempt the first attempt the response variable was the catch in Hormozgan and Sistan/Bluchestan provinces, while the explanatory variables were the number of boats of intermediate and large size based on those two provinces. However, the solutions were not useful because one of the estimation was negative. Then I did 1000 simulations by adding random values to the explanatory variables and fitting again the model. Most of the useful solutions resulted in estimations which indicate that the power of the large boats were 3 times the power of intermediate boats. Those relative efficiencies estimations were used to convert the number of boats GIOF > 100 GRT in number of boats GIOF 50-100 GRT, and finally to estimate CPUE in each year of the time series.

Catch, effort (number of boats) and estimations of CPUE are shown in Figure 7. Notice that discontinuities (“jumps”) appear in the series. For example, the catches experienced a three fold increase from 2002 to 2004, but the number of boats did no change much. The catches decreased fast from 2006 to 2007, but the number did not change much. Catches peaked in 2014 and 2015 but the numbers of boats in those years were lower than in 2013. Notice also that the catches were very low (close to zero) before 1997. The relationships between the number of boats and catch, and between the number of boats and catch rate were similar.

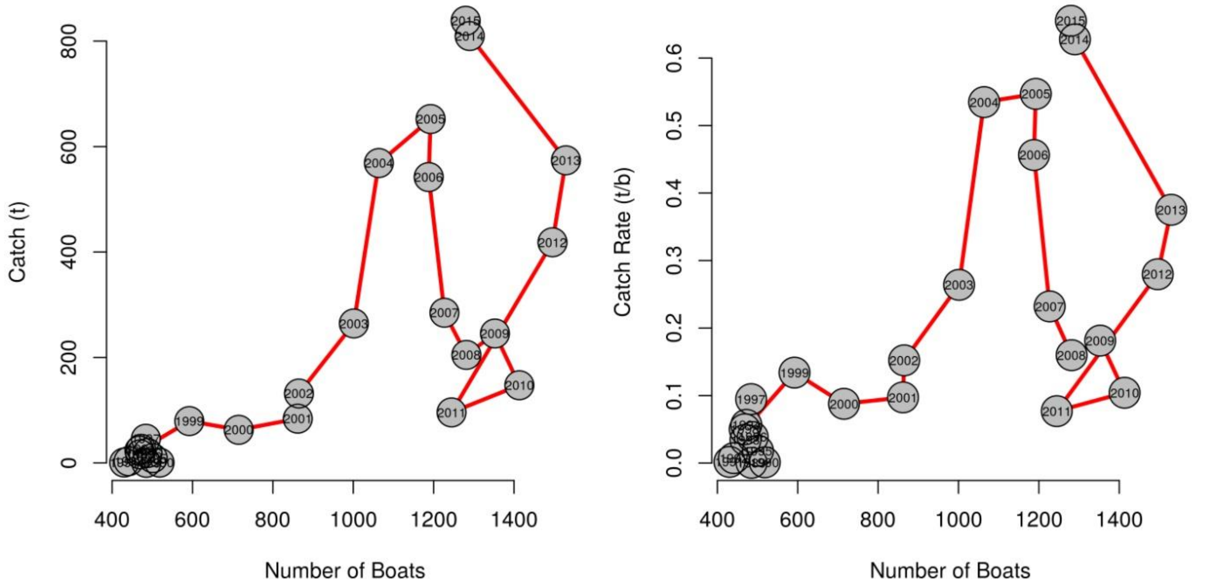

Figure 7 – Catch, number of boats and catch rate as calculated for Iranian boats which operates with ordinary gillnets. Years are indicated by the numbers inside filled gray circles.

Euclidian distance in one dimensional (e.g. catch), two dimensional (e.g. catch and number of boats), and three dimensional spaces (catch,number of boats and CPUE) are in Figure 8. The calculations for the two dimension space of “number of boats and CPUE” did not convey additional information, hence they were not showed to not clutter. Red lines in the figure stand for the mean plus 2 times the standard deviation. High values above the red line indicate potential discontinuities in the time series. Solutions of years around 2003 were high in most of the calculations (one, two and three dimensional spaces). The discontinuity in the mid 2000’s maybe be due to changes in the fishery system or in the statistical monitoring program. Remind that the fleet large size GIOF boats were first reported in mid 2000’s. These issues might be discussed by the group. Hopefully national researchers of Iran can clarify the question. Here in this preliminary analysis I have decided to consider the entire time series, but also the possibility of splitting it into two parts.

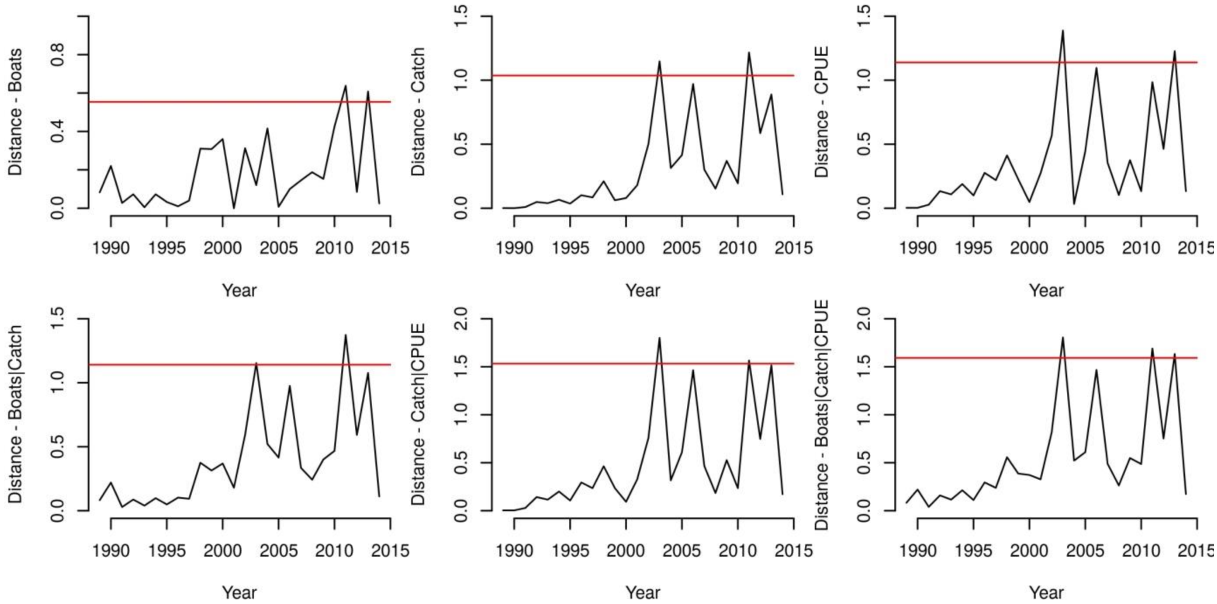

Figure 8 – Euclidian distances in one (number of boats, or catch, or CPUE), two (boats|catch or catch|CPUE) or three (boats|catch|CPUE) dimensions. Red lines stand for the mean plus 2 times the standard deviation.

The CPUE series for Iran are in Figure 9. The values were divided by their mean to make ease comparisons. Notice that in the CPUE increased from 1989 until the beginning of 2000's, but there is a peak in 2005, followed by a plunge and another peak (Figure 9 A). The alternative is to split the series into 1989-2002 and 2003-2015 time spans (Figure 9 B). The CPUE series of Iran might be carefully considered, particularly the first part. It is unlike that the low values (close to zero) in the beginning of the time series, and that the outstanding increase of scaled CPUE reflects changes of biomass.

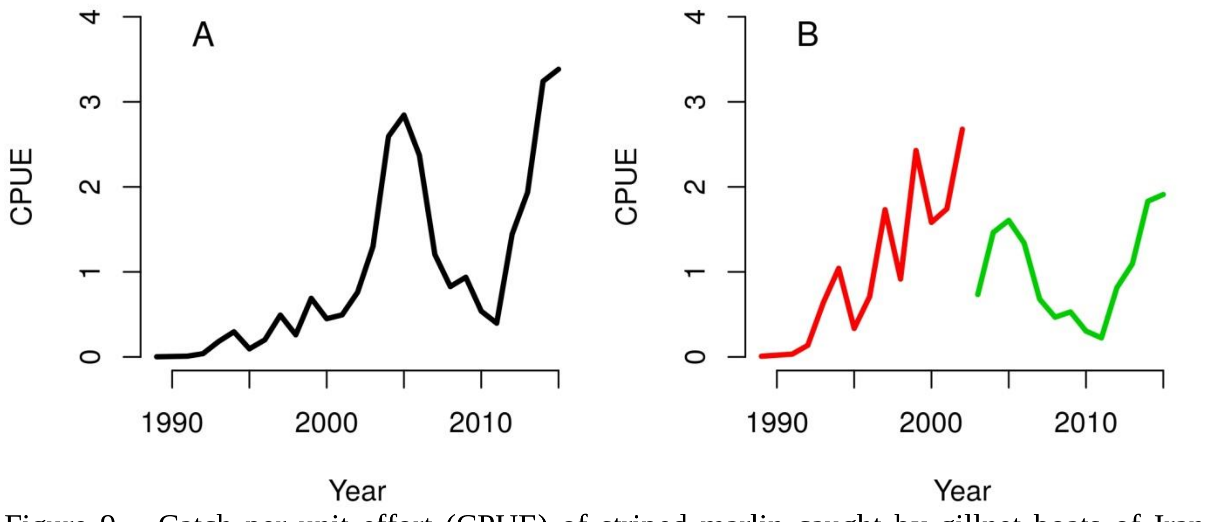

Figure 9 – Catch per unit effort (CPUE) of striped marlin caught by gillnet boats of Iran. Entire times series (A) and time series split into two parts (B). Values were divided by the mean.

3.2.2. Pakistan

There are just one gillnet catch time series (GILL) and only one gillnet boats category (35-50 t GRT) in the IOTC databases. Therefore main alternative to calculate catch rates is simple divide the GILL catches by the number of boats as they appear in the databases. Results are showed in Figure 10. In general the number of boats had increased fast but in a stead pace all across the years. Catches also increased across the years, but there was a plunge in 2000's and a jump from 2010 to 2011. Overall catch rates increased in the beginning of 1990's, and since then the oscillation was large with some peaks and plunges.

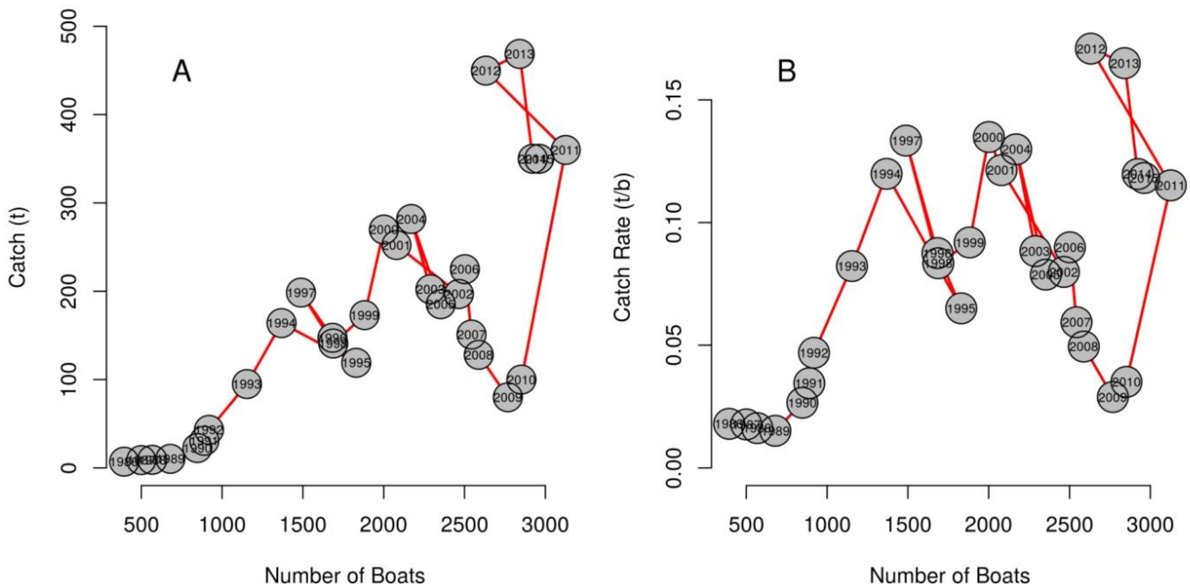

Figure 10 – Catch, catch rates and number of gillnet boats of Pakistan as calculated using IOTC database. Years are indicated by the numbers inside filled gray circles.

Euclidian distances in the space of coordinates of catch, number of boats and CPUE are in Figure 11. Again the calculations concerning the two dimensional space of "number of boats and CPUE" are not shown to not clutter. Values above the red line indicate potential discontinuities in the time series. Solutions of years from 1992 to 1994, and from 2009 to 2011 were high in two or more calculations. The whole CPUE time series may be considered, but I also assumed that the discontinuities reflect changes of the quality of data or of fishery system (e.g. fishermen strategy). The later may result in change of catchabilities. These assumptions might discussed by the group if the intention is to use the estimations of CPUE as relative abundance indices. Hopefully national researchers of Pakistan can clarify the question.

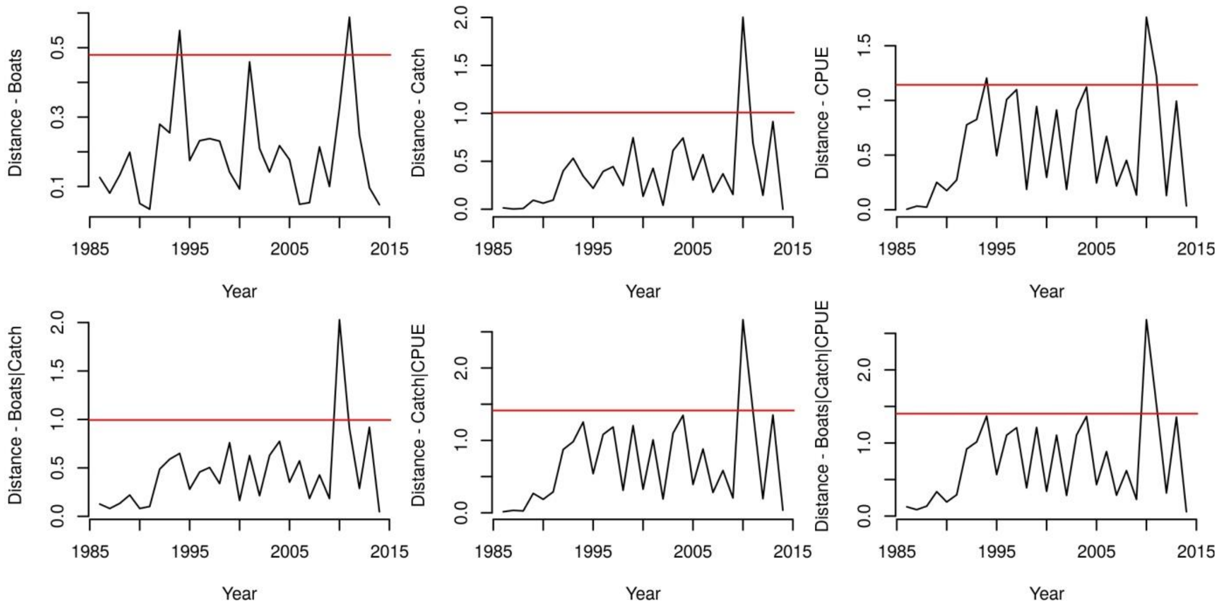

Figure 11 – Euclidian distances in one (number of boats, or catch, or CPUE), two (boats|catch or catch|CPUE) or three (boats|catch|CPUE) dimensions. Red lines stand for the mean plus 2 times the standard deviation.

Here in this preliminary analysis I have decided to consider the entire time series, but also the possibility of splitting it into three parts 1986-1992, 1993-2010, 2011-2015 (Figure 12). The CPUE showed a sharp increasing trend in the first part. In the second part the CPUE oscillated across the years but decreased in the end of the time span (1993-2010). Third part is short, and there was not a clear time trend.

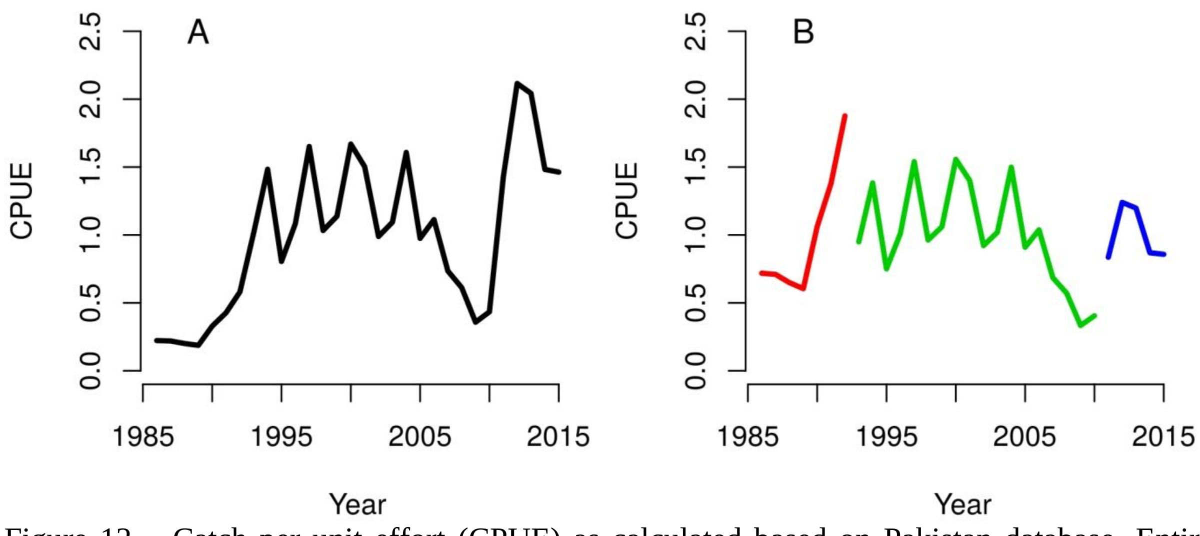

Figure 12 – Catch per unit effort (CPUE) as calculated based on Pakistan database. Entire times series (A) and time series split into three parts (B). Values were divided by the mean.

3.2.3. Taiwan

There is one gillnet catch time series (GILL) and three categories of gillnet boats of Taiwan (100-200 LOA; 200-500 LOA; and 500-1000 LOA) in the IOTC databases. However, the time series of small boats is shorter than the catch time series, furthermore, the number of small boats are very low. Hence, I have assumed that almost all striped marlin unloaded was caught by intermediate (200-500 LOA) and large (500-1000 LOA) boats. The proportion of total tuna and tuna like species caught by gillnet fleet in general was estimated as 32% and 39% for intermediate and large size boats (Dr. Wang – pers. comm.). I have used these proportions to estimate the relative power of intermediate and large boats as explained in the “Data and Analysis” section. Large size boats are estimated to be 2.66 times more efficient than boats of intermediate size. This estimation was then used to convert the number of large boats in the relative number of boats of intermediate size. The final estimations of catch, effort, and CPUE values are shown in Figure 13. Catches peaked in 1987 but were in general lower than 20 t in the other years of the time series. The number of the boat increased from 1986 to 1989, but decreased in the beginning of 1990’s right before the end of the fishery. Catch rates were higher in 1987 and 1992, but remained lower than 0.15 t/boat in the other years of the time series.

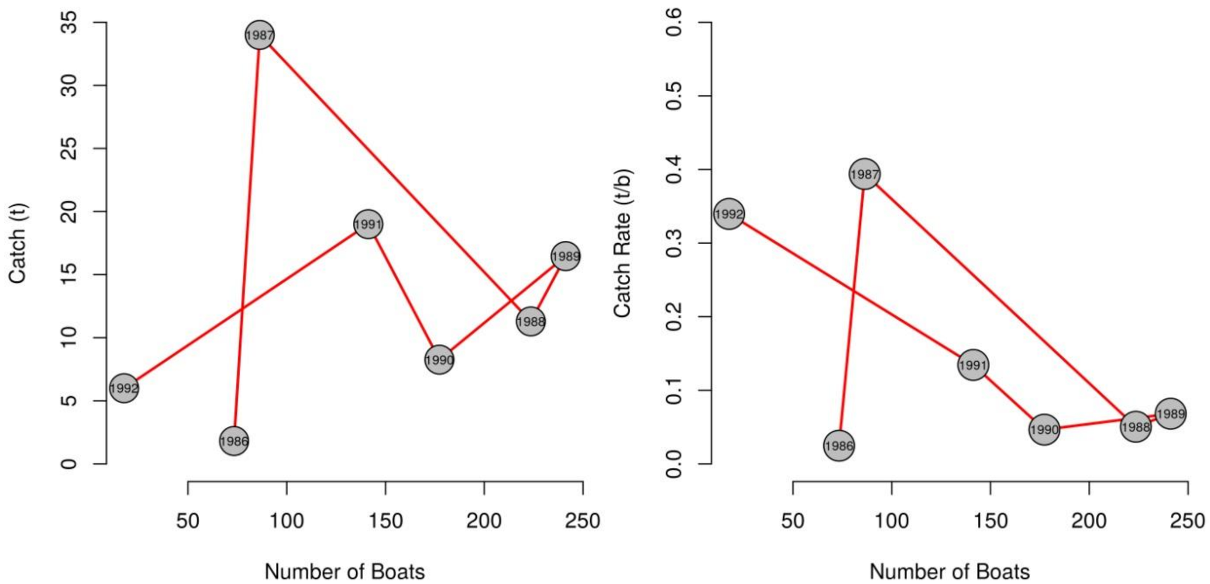

Figure 13 – Catch, catch rates and number of gillnet boats of Taiwan as calculated using IOTC database. Years are indicated by the numbers inside filled gray circles.

Euclidian distances in the space of coordinates of catch, number of boats and CPUE are in Figure 14. Values above the red line indicate potential discontinuities in the time series. Notice that the distances between 1986 and 1987 were higher the mean plus two times the standard deviation, though the distance between 1987 and 1988 was also high. The whole CPUE time series may be considered. An alternative would be to discard the CPUE of 1986. Times series of CPUE of Taiwan (gillnet fleet) are in Figure 15. Overall the oscillation was large in the beginning of the series. The CPUE peaked in 1987, did not change much from 1988 to 1990, but increased in 1991 and 1992.

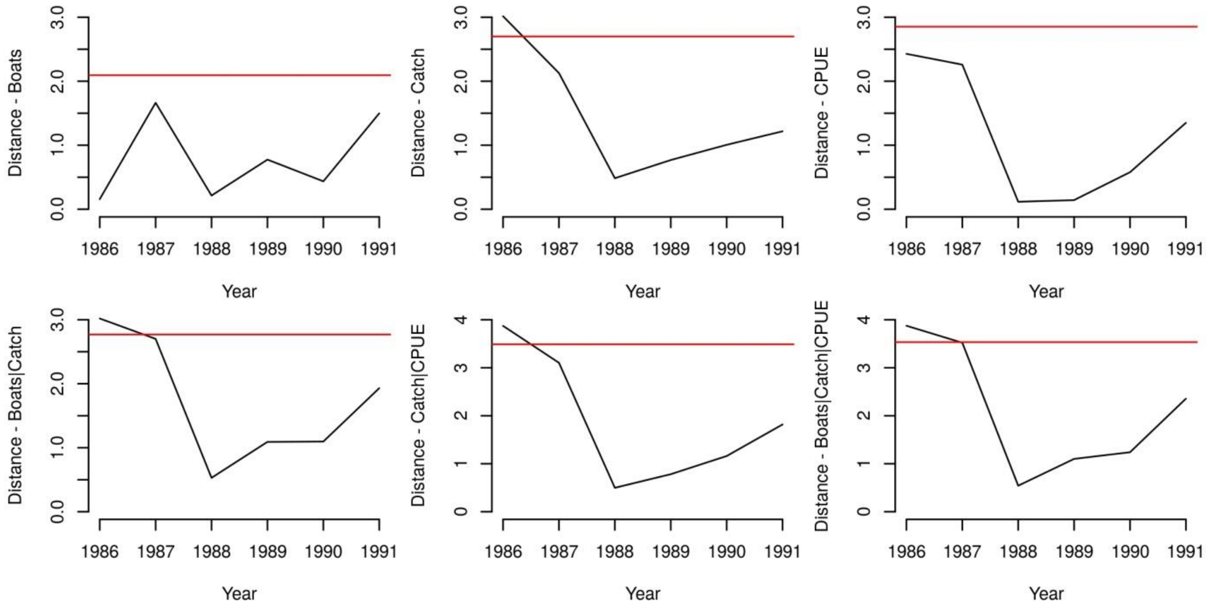

Figure 14 - Euclidian distances in one (number of boats, or catch, or CPUE), two (boats|catch or catch|CPUE) or three (boats|catch|CPUE) dimensions. Red lines stand for the mean plus 2 times the standard deviation.

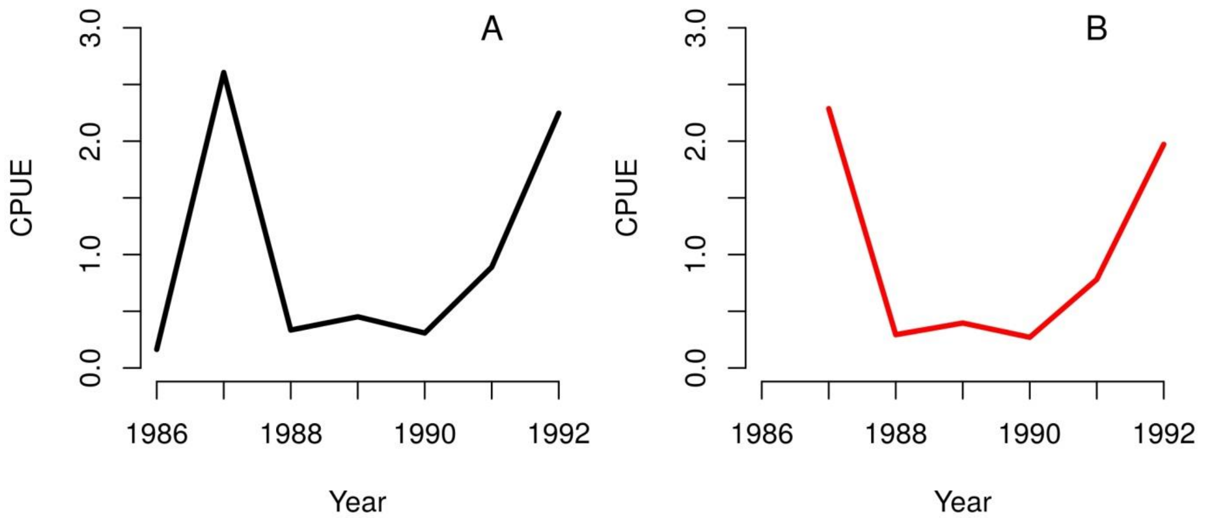

Figure 15 – Catch per unit effort (CPUE) as calculated based on Pakistan database. Entire times series (A) and time series split into three parts (B). Values were divided by the mean.

4. Discussion

The available dataset concerning striped marlin caught by gillnet boats is limited. Most of striped marlin have been caught by fishermen which operates ordinary, or offshore gillnets, or even mixed gear combinations of gillnet and longline. There are not catch-effort datasets. Only approximate estimations of catches and historical reports of the number of boats are available. In addition, there are some complications because the gear categories appearing in the catch dataset does not include information on boat sizes, which are in the historical reports of the number of boats. Hence several assumptions were necessary in order to advance. In this sense all the calculations showed here might be considered as tentative results.

Simple descriptive analyses of catches and of the number of boats are usually overlooked. Such analyses can reveal issues which are important for stock assessment and management. For example, the outstanding increase of number of gillnet boats of Pakistan in the recent decades probably has no parallel in the worldwide tuna fisheries. The lack of detailed information about catch and effort of that huge gillnet fleet is certainly a critical issues for the stock assessment and management of stocks of tunas and of many other species in the Indian Ocean.

The outstanding low values of catch rates in the beginning of Iran and Pakistan time series may be an indication that the catches were underreported. Consequently, to drop the early part of the CPUE time series is an alternative. In addition huge increase (or decrease) in one or more dimensions (number of boats, catch and CPUE) from one year to another it is not reliable. To split the time series into shorter time spans is also an alternative.

Estimations of catch rates of striped marlin for Iran, Pakistan, and Taiwan are showed together in Figure 16. Iran and Pakistan time series were split into shorter time spans. Time series were in agreement in some periods, but conflictive in other periods. For example, Iran and Pakistan CPUE time series were similar from 2003 to 2010, but they are conflictive from 1993 to 2002, and after 2011. Comparisons might be carefully considered because the are uncertainties about fishermen strategy, characteristics of the nets (e.g. size of mesh) and other factors which may result in differences concerning catchabilities or even the fraction of the stocks (e.g. ages) exploited by the two fleets. Nevertheless, because Iran and Pakistan are close to each other, and their gillnet fleets operate mainly in Gulf of Oman and Arabian Sea, some similarity of the CPUE series was expected, though Pakistan boats are small (35-50 GRT), and maybe operate in more coastal waters.

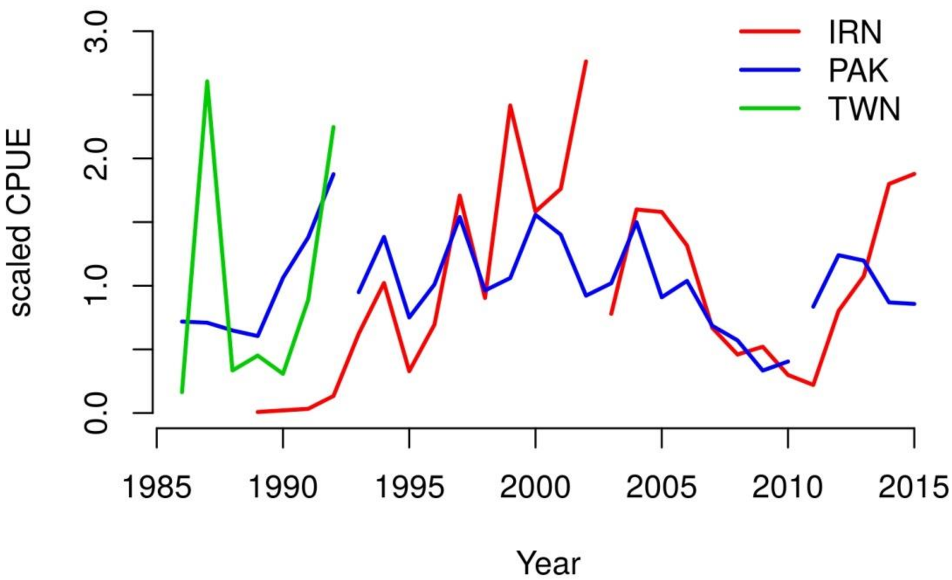

Figure 16 – Scaled Catch per unit effort (CPUE) as calculated based on Iran, Pakistan and Taiwan databases. Values were divided by the mean.

Final Remarks

Results showed here might be carefully considered given this was the very first attempt to estimate catch rate for striped marlin .

Usefulness of the number of boats as proxy of effort and the assumptions underpinning the calculations deserve attention and should be further investigated in the future.

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