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Catch rates of sharks as bycatch by malagasy longliners

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ABSTRACT

Title : Catch per Unit of Effort of sharks caught by malagasy longliners

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In 2010 and 2011, 8 malagasy longliners evolved in the eastern part of Madagascar water and targeted tuna and swordfish. Except these target species, some billfish species and sharks were taken as Bycatch by this new fishery according to the data declared by ship-owners. Note that these results were obtained by the declarative system of fishing companies. The first analysis highlighted that the data series used are too inconsistent and incompletes because of misreporting and species misidentification. However, they are broken down by species and month. Estimates in terms of fishing effort were implemented in order to produce such an article while being aware of bias induced by the method adopted. Thus, this study revealed that the CPUE of sharks all species is [165; 92] Kg/1000 hooks in 2010 against [86; 48]/1000 hooks in 2011.

Keywords: CPUE, longliners, shark.

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INTRODUCTION

Fourth largest island in the world, Madagascar is located in the southern hemisphere to the east of Africa, 400 km from Mozambique and is crossed in its southern part by the Tropic of Capricorn. Fishing is one of the three main sectors (with mining and tourism) on which the Malagasy Government has sat on economic development (DGPRH, 2009).

Fishery resources in the maritime sector are scattered on a shelf for up to the 200 m isobath, an area of about 117,000 km^2 and a coastline extending for more than 5600 km, during their migration to significant cohorts of tuna occur within the exclusive economic zone (EEZ) of Madagascar around 1.14 million km^2 during the warmer seasons.

Following the implementation of the exploratory fishing fish from 2008 to 2009, three local fishing companies have begun to exploit tuna and tuna like species with 8 small vessels. However, fluctuation of functional vessels number applied due to the lack of experience of fishermen

The length of these vessels is about 12 to 16 m wich. Note that they evolve only in Madagascar waters about and the duration of one trip went 5 to 10 days. They used mainly a monofilament line. The length of main line is about 35 to 70 km and the float line is around 4 to 30 m. Night set is generally practiced (3 to 9 pm) with using circle hooks. They utilized that hook in order to reduce the catch rate of some bycatch species. 6 to 8 hooks per basket and 3 or 4 either yellow or red chemical lightsticks every 3 or 4 branch lines were deployed. Main of these companies utilized also bait squid (**Ommastrephidae**).

Since 2008, data collection has been remained difficult and based only on the companies' declarations. This is why the data available at the ministry of fisheries, from the beginning of the reporting process, are broken down by month and species. In addition, they are exempted of essential informations such as the number of set/trip, geographical positions of fishing operations, the number of hooks and bait used. Based on our observation throughout a visit to one of these companies fish are subject to systematic individual weighing.

METHODE

In summary, the available data are catch weight landings of eight vessels, and dispatched per month per boat. Some fishing characteristics belonging to two fishing boats are known such as the number of trip per boat, the number of sets and the number of hooks used. This is how the idea came to attempt to estimate the catch per unit effort (CPUE) of whole fleet by extrapolating these three parameters mentioned above. From these parameters index were generated in order to extrapolate catch rate of other companies for 2011. These indexes are subsequently kept for getting the similar effort in 2010, and, starting only from the number of operational vessels.

The tables below show a detail approach used to estimate the efforts corresponding to the year 2011:

Originally, there are number of vessels ($N_{i,j}$) operated during every month.

Month	Company A (Known)	Company B (Known)	Company C (Known)
January	$N_{A,ja}$	$N_{B,ja}$	$N_{C,ja}$
February	$N_{A,fe}$	$N_{B,fe}$	$N_{C,fe}$
March	$N_{A,mr}$	$N_{B,mr}$	$N_{C,mr}$
April	$N_{A,ap}$	$N_{B,ap}$	$N_{C,ap}$
May	$N_{A,ma}$	$N_{B,ma}$	$N_{C,ma}$
June	$N_{A,jn}$	$N_{B,jn}$	$N_{C,jn}$
Julay	$N_{A,jl}$	$N_{B,jl}$	$N_{C,jl}$
August	$N_{A,au}$	$N_{B,au}$	$N_{C,au}$
September	$N_{A,se}$	$N_{B,se}$	$N_{C,se}$
October	$N_{A,oc}$	$N_{B,oc}$	$N_{C,oc}$
November	$N_{A,no}$	$N_{B,no}$	$NC_{,no}$
December	$N_{A,de}$	$N_{B,de}$	$N_{C,de}$

Table n° 1 : Fluctuation of operating vessel number

From the number of trips done by company A can be generated index I_1 wich is the average number of travel that could make a small longliner for a month.

$$\mathbf{I_{1,j} = NT_{A,j} / N_{A,j}}$$

The total trips ($NT_{,j}$) of companies B and C may subsequently result by multiplying the number of operational vessels ($N_{i,j}$) by the index I_1.

$$\mathbf{NT_{i,j} = I_{1,j} \times N_{i,j}} \quad \textit{(i= B or C and j=january to december)}$$

Month	Company A (Known)	Company B (Known)	Company C (Known)	Index ($I_{1,j}=NT_{A,j}/N_{A,j}$)	No Trip		
					Company A (Known)	Company B ($NT_{,j}=I_{1,j}*N_{B,j}$)	Company C ($NT_{,j}=I_{,j}*N_{C,j}$)
January	$N_{A,ja}$	$N_{B,ja}$	$N_{C,ja}$	$I_{1,ja}$	$NT_{A,ja}$	$NT_{B,ja}$	$NT_{C,ja}$
February	$N_{A,fe}$	$N_{B,fe}$	$N_{C,fe}$	$I_{1,fe}$	$NT_{A,fe}$	$NT_{B,fe}$	$NT_{C,fe}$
March	$N_{A,mr}$	$N_{B,mr}$	$N_{C,mr}$	$I_{1,mr}$	$NT_{A,mr}$	$NT_{B,mr}$	$NT_{C,mr}$
April	$N_{A,ap}$	$N_{B,ap}$	$N_{C,ap}$	$I_{1,ap}$	$NT_{A,ap}$	$NT_{B,ap}$	$NT_{C,ap}$
May	$N_{A,ma}$	$N_{B,ma}$	$N_{C,ma}$	$I_{1,ma}$	$NT_{A,ma}$	$NT_{B,ma}$	$NT_{C,ma}$
June	$N_{A,jn}$	$N_{B,jn}$	$N_{C,jn}$	$I_{1,jn}$	$NT_{A,jn}$	$NT_{B,jn}$	$NT_{C,jn}$
Julay	$N_{A,jl}$	$N_{B,jl}$	$N_{C,jl}$	$I_{1,jl}$	$NT_{A,jl}$	$NT_{B,jl}$	$NT_{C,jl}$
August	$N_{A,au}$	$N_{B,au}$	$N_{C,au}$	$I_{1,au}$	$NT_{A,au}$	$NT_{B,au}$	$NT_{C,au}$
September	$N_{A,se}$	$N_{B,se}$	$N_{C,se}$	$I_{1,se}$	$NT_{A,se}$	$NT_{B,se}$	$NT_{C,se}$
October	$N_{A,oc}$	$N_{B,oc}$	$N_{C,oc}$	$I_{1,oc}$	$NT_{A,oc}$	$NT_{B,oc}$	$NT_{C,oc}$
November	$N_{A,no}$	$N_{B,no}$	NC,no	$I_{1,no}$	$NT_{A,no}$	$NT_{B,no}$	$NT_{C,no}$
December	$N_{A,de}$	$N_{B,de}$	$N_{C,de}$	$I_{1,de}$	$NT_{A,de}$	$NT_{B,de}$	$NT_{C,de}$

Table n° 2 : Fluctuation of trip number

Once the number of trips that could be done a vessel in a month are available, the same approach above can be reproduced. Indeed, the ratio between the number of set and the number of travel of A is an appreciable index that would highlight the number of set by other travel companies.

$$\mathbf{I_{2,j}= NS_{A,j} / (NT_{A,j})}$$

It remains, then, that doing the multiplication between the trips number of two remaining companies to estimate the number of set.

$$\mathbf{NS_{i,j}= I_{2,j} \times NT_{i,j}} \quad \textit{(i= B or C and j=january to december)}$$

Month	No Trip			Index ($I_{2,j}=NS_{A,j}/NT_{A,j}$)	No Set		
	Company A (Known)	Company B ($NT_{,j}=I_{,j}*N_{B,j}$)	Company C ($NT_{,j}=I_{,j}*N_{C,j}$)		Company A (Known)	Company B ($NS_{,j}=I_{2,j}*NT_{B,j}$)	Company C ($NT,j=I_{2,j}*NT_{C,j}$)
January	$NT_{A,ja}$	$NT_{B,ja}$	$NT_{C,ja}$	$I_{2,ja}$	$NS_{A,ja}$	$NS_{B,ja}$	$NS_{C,ja}$
February	$NT_{A,fe}$	$NT_{B,fe}$	$NT_{C,fe}$	$I_{2,fe}$	$NS_{A,fe}$	$NS_{B,fe}$	$NS_{C,fe}$
March	$NT_{A,mr}$	$NT_{B,mr}$	$NT_{C,mr}$	$I_{2,mr}$	$NS_{A,mr}$	$NS_{B,mr}$	$NS_{C,mr}$
April	$NT_{A,ap}$	$NT_{B,ap}$	$NT_{C,ap}$	$I_{2,ap}$	$NS_{A,ap}$	$NS_{B,ap}$	$NS_{C,ap}$
May	$NT_{A,ma}$	$NT_{B,ma}$	$NT_{C,ma}$	$I_{2,ma}$	$NS_{A,ma}$	$NS_{B,ma}$	$NS_{C,ma}$
June	$NT_{A,jn}$	$NT_{B,jn}$	$NT_{C,jn}$	$I_{2,jn}$	$NS_{A,jn}$	$NS_{B,jn}$	$NS_{C,jn}$
Julay	$NT_{A,jl}$	$NT_{B,jl}$	$NT_{C,jl}$	$I_{2,jl}$	$NS_{A,jl}$	$NS_{B,jl}$	$NS_{C,jl}$
August	$NT_{A,au}$	$NT_{B,au}$	$NT_{C,au}$	$I_{2,au}$	$NS_{A,au}$	$NS_{B,au}$	$NS_{C,au}$
September	$NT_{A,se}$	$NT_{B,se}$	$NT_{C,se}$	$I_{2,se}$	$NS_{A,se}$	$NS_{B,se}$	$NS_{C,se}$
October	$NT_{A,oc}$	$NT_{B,oc}$	$NT_{C,oc}$	$I_{2,oc}$	$NS_{A,oc}$	$NS_{B,oc}$	$NS_{C,oc}$
November	$NT_{A,no}$	$NT_{B,no}$	$NT_{C,no}$	$I_{2,no}$	$NS_{A,no}$	$NS_{B,no}$	$NS_{C,no}$
December	$NT_{A,de}$	$NT_{B,de}$	$NT_{C,de}$	$I_{2,de}$	$NS_{A,de}$	$NS_{B,de}$	$NS_{C,de}$

Table n° 3 : Fluctuation of set carried out number

Finally, the estimated number of hooks follows the same logic by producing the index I_3. This is the ratio between the total number of hooks into the water and the total set made by the company A.

$$\mathbf{I_{3,j}= NH_{A,j} / NS_{A,j}}$$

The next step is to estimate the total number of hooks launched by the two societies B and C by using the index I_3 newly obtained.

$$\mathbf{NH_{i,j} = I_{3,j} \times NS_{i,j}} \quad \textit{(i= B or C and j=january to december)}$$

Month	No Set			Index	No Hooks		
	Company A (Known)	Company B ($NS_{i,j}=I_{2,i}*NT_{B,j}$)	Company C ($NT_{i,j}=I_{2,j}*NT_{C,j}$)	($I_{3,j}=NH_{A,j}/NS_{A,j}$)	Company A (Known)	Company B ($NH_{i,j}=I_{3,j}*NS_{B,j}$)	Company C ($NH_{i,j}=I_{3,j}*NS_{C,j}$)
January	$NS_{A,ja}$	$NS_{B,ja}$	$NS_{C,ja}$	$I_{3,ja}$	$NH_{A,ja}$	$NH_{B,ja}$	$NH_{C,ja}$
February	$NS_{A,fe}$	$NS_{B,fe}$	$NS_{C,fe}$	$I_{3,fe}$	$NH_{A,fe}$	$NH_{B,fe}$	$NH_{C,fe}$
March	$NS_{A,mr}$	$NS_{B,mr}$	$NS_{C,mr}$	$I_{3,mr}$	$NH_{A,mr}$	$NH_{B,mr}$	$NH_{C,mr}$
April	$NS_{A,ap}$	$NS_{B,ap}$	$NS_{C,ap}$	$I_{3,ap}$	$NH_{A,ap}$	$NH_{B,ap}$	$NH_{C,ap}$
May	$NS_{A,ma}$	$NS_{B,ma}$	$NS_{C,ma}$	$I_{3,ma}$	$NH_{A,ma}$	$NH_{B,ma}$	$NH_{C,ma}$
June	$NS_{A,jn}$	$NS_{B,jn}$	$NS_{C,jn}$	$I_{3,jn}$	$NH_{A,jn}$	$NH_{B,jn}$	$NH_{C,jn}$
Julay	$NS_{A,jl}$	$NS_{B,jl}$	$NS_{C,jl}$	$I_{3,jl}$	$NH_{A,jl}$	$NH_{B,jl}$	$NH_{C,jl}$
August	$NS_{A,au}$	$NS_{B,au}$	$NS_{C,au}$	$I_{3,au}$	$NH_{A,au}$	$NH_{B,au}$	$NH_{C,au}$
September	$NS_{A,se}$	$NS_{B,se}$	$NS_{C,se}$	$I_{3,se}$	$NH_{A,se}$	$NH_{B,se}$	$NH_{C,se}$
October	$NS_{A,oc}$	$NS_{B,oc}$	$NS_{C,oc}$	$I_{3,oc}$	$NH_{A,oc}$	$NH_{B,oc}$	$NH_{C,oc}$
November	$NS_{A,no}$	$NS_{B,no}$	$NS_{C,no}$	$I_{3,no}$	$NH_{A,no}$	$NH_{B,no}$	$NH_{C,no}$
December	$NS_{A,de}$	$NS_{B,de}$	$NS_{C,de}$	$I_{3,de}$	$NH_{A,de}$	$NH_{B,de}$	$NH_{C,de}$

Table n° 4 : Fluctuation of hooks deployed number

Following these estimates above, all units of effort are now available in this case: the number of operational vessels, trips, sets and hooks deployed. Note that these parameters are broken down by month and company. They will allow to highlight the different catch rate of the Malagasy national fleet.

RESULTS

1) Compositions species and Number of operationnal vessels

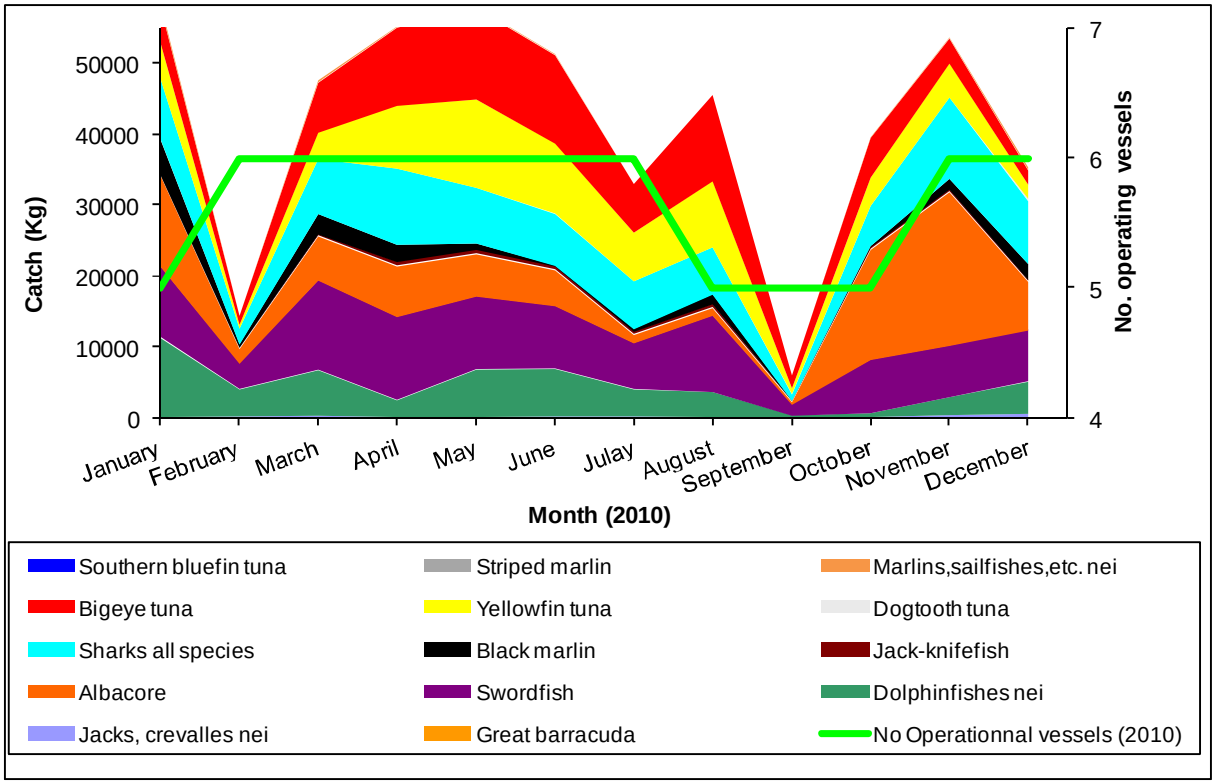

Chart n° 1 : Monthly catch and trend effort in 2010

The average catch is around 41 tons but it reaches its minimum in september (5.9 tons) because of etheir the decreasing of operating vessels or some mireporting data. Rose to 498 tons, the total catch for the year 2010 consists mainly of tuna and tuna like species (47%), of swordfishes (20%) and 32% of bycatch. The main species on the total bycatch are sharks (52%), dolphinfishes (33%) and black marlin (11%). Note that the lower catch in february and September might be due to the misreporting catch data.

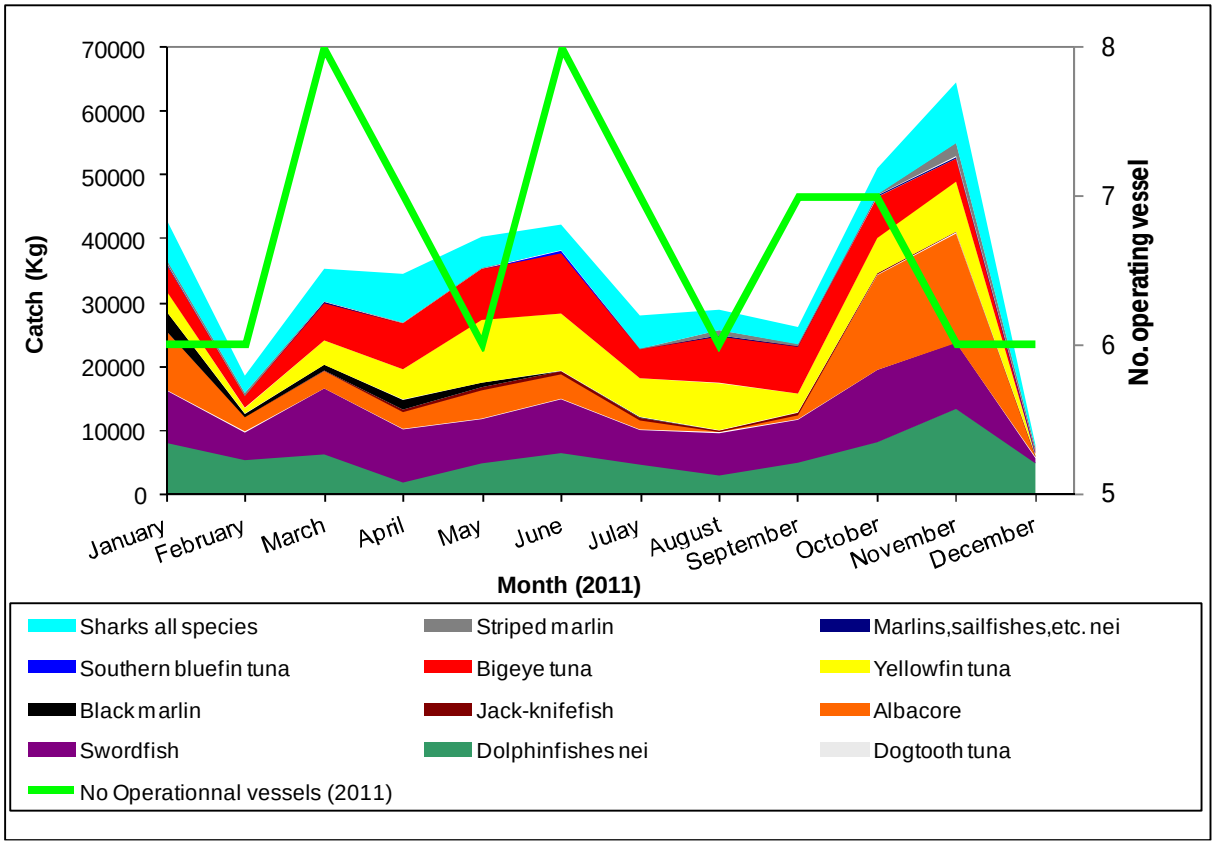

Chart n° 2 : Monthly catch and trend effort in 2011

The total catch in 2011 was 421 tons whose 45% were tuna, 21% were swordfish and 24% composed by bycatch. The peak is reached in november in spite of the minimum number of operating vessels. November catch is also characterized by the abundance of yellowfin tuna (26%). The main species on the total bycatch are dolphinfish (49%), sharks (43%), black marlin (7%) and striped marlin (6%).

2) Variability of efforts

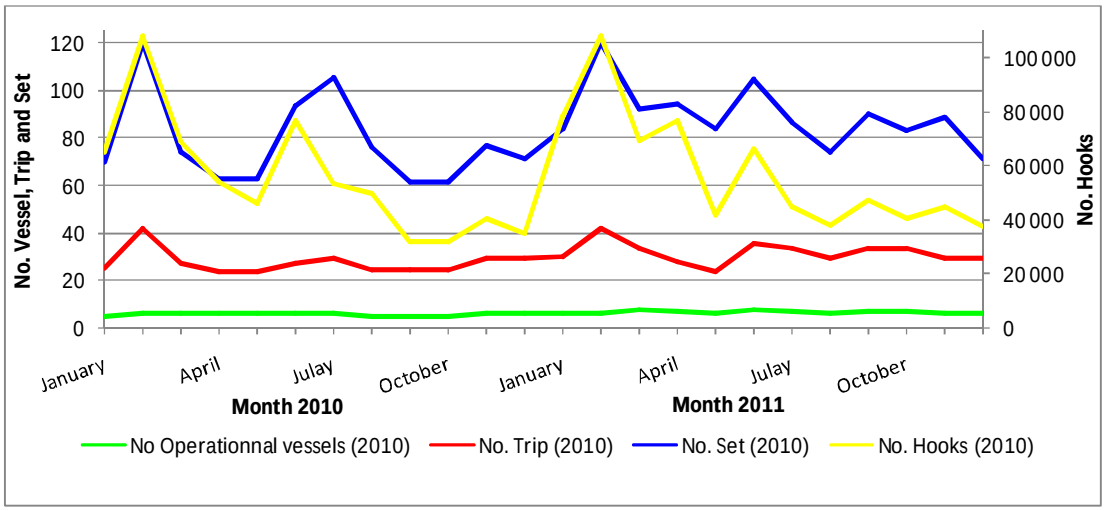

Chart n° 3 : Trend of average nominal efforts

The chart above shows the fluctuation of the various units of effort that can be considered in light of available data. These include numbers of vessels really fished, trips made, executed sets and hooks dropped by them. There has been a relatively strong correlation amongst of them because the last three have been generated from the number of functional vessels. Tests were done to analyze the homogeneity of these units between 2010 and 2011. Only the fluctuation in the number of ship carried out got a significant difference (p = 0.001). In contrast, the other three units are all homogeneous parameters between the two years (for the number of trip *p = 0.085*; the number of set *p = 0.198* and the number of hooks *p= 0.763*). In other words, the number of trips, sets made and hooks deployed are likely similar in both 2010 and 2011.The catch of sharks in 2010 (84.75 tons) is significantly higher than that in 2011 (56.14 tons) (with *p=0.04*).

This leads to highlight the catch per unit effort (CPUE) in order to highlight the impacts of national longline fleet to the sharks throughout the previous two years.

3) Catch rates of sharks

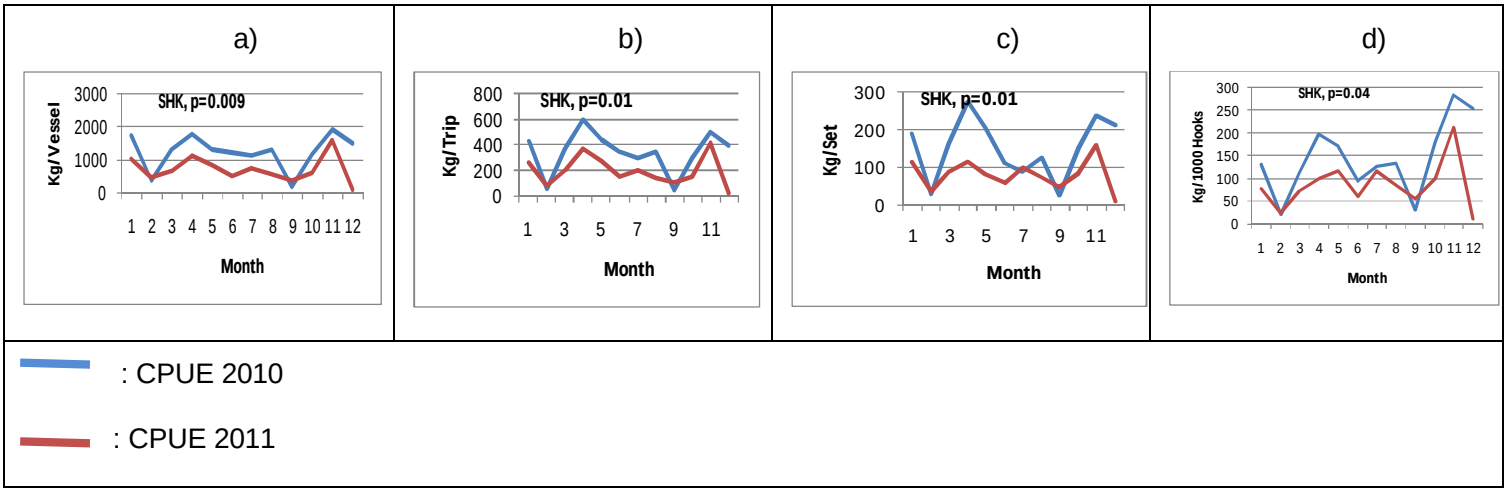

Chart n° 4 : Trend of nominal CPUEs of sharks (all species) whose effort units taken are as follows, for a) the number of operational vessels b) the number of trip, c) the number of set, and d) the number of hooks launched.

The charts above show significant differences in catch rate recorded from 2010 to 2011. In other words, significant decreases in yields in terms of sharks' catch were recorded among 2010 to 2011, in spite of the increasing number of Malagasy longliners available for this fishery. (a), CPUE (catch per number of operational vessels) reached [1273, 514] Kg/Vessel in 2010 against [708, 394] Kg/Vessel in 2011. (b) Total catch of sharks around [342, 158] Kg/Trip was sought in 2010 against [195, 116] Kg/Trip 2011. (c) In this case, each set was able to land [151, 78] Kg shark in 2010 if in 2011 it was [80, 40] kg. (d) In 2010, total sharks caught by longliners Malagasy was [144, 79] Kg/1000 Hooks while in 2011 it reached [87, 51] Kg/1000 Hooks in 2011. It is also difficult to ignore the peaks recorded by the curves on November in both years whose the reason remains unclear.

CONCLUSION

In conclusion, the sharks are caught accidentally in large quantities by Malagasy longliners in eastern Madagascar's fishing zone. This study is one of published paper which would reveal the interrelationships between the fishery and sharks through the highlighting of CPUEs. Note that despite the lack of knowledge of the biology of sharks and the lack of information on the said interrelation, this paper contributes to restart the challenge on the conceptualization of a shark conservation plan in Madagascar. Despite the variability due to the number of operational vessels and the lack of operational experience of malagasy shipowners related to the longline fishery, the trend of average sharks' catch decreased from 2010 to 2011. However, on behalf of the precautionary principle, it is necessary to generate specific measures of sharks bycatch mitigation especially on april and november. According to the statistics gotten from the companies targeting tuna and swordfish by longliners, these sharks are mainly composed by Mako sharks (*Isurus spp.*) Madagascar is in this case urged to redouble its efforts to collect the information conceptualizing future national action plans of sharks.

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