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Catch Per Unit of Effort of billfish caught by Malagasy longliners from 2010 to 2011

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RESUME

Titre : Captures par Unité d'Effort des poissons portes épées prélevés par des palangriers malagasy de 2010 à 2011

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C'est la première fois depuis son adhésion à la CTOI que Madagascar a pu produire un article scientifique qui penche sur les captures par unités d'efforts (CPUE) sur les activités de pêche de ses palangriers qui évoluent exclusivement dans la partie orientale de sa zone de pêche. Notons que la base de données permettant l'acquisition de ces résultats est obtenue par le système déclaratif des sociétés de pêche qui n'exige pas aux armateurs de déclarer systématiquement leurs activités de pêche. Des anomalies telles que l'incohérence des données ou encore l'absence des informations relatives aux efforts de pêche ont été constatées sur lesdites déclarations. On est alors obligé de solliciter des estimations pour pouvoir produire un tel article tout en ayant conscience des biais induit par la méthode adoptée. Des CPUE mensuelles (Kg/1000 hameçons) de l'ordre de [162;68]; [28 ;25]; [0 ;0] et [2 ;3] respectivement pour l'Espadon ; Makaire noire ; Marlin et Voilier ont été obtenues en 2010 contre [137 ;71]; [8 ;11]; [9 ;13] et [2 ;2] en 2011. De ces chiffres, on peut en déduire que : i) les poissons portes épées existent bien dans les eaux de Madagascar, il reste à prouver cette théorie par la mise en évidence des abondances ou biomasse et ii) le niveau d'incertitude des données reste encore élevé.

Mots clés : CPUE, palangriers, poissons porte épées, incertitude.

ABSTRACT

Title: Catch Per Unit of Effort of billfish caught by Malagasy longliners from 2010 to 2011

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This is the first time since joining the IOTC that Madagascar's scientist could produce a scientific paper that examines the catch per unit effort (CPUE) of its longliners' fishing activities wich evolve exclusively in the eastern part of its fishing area. Note that the database for the acquisition of these results is obtained by the declarative system of fishing companies that do not require ship owners to declare their fishing activities systematically. Anomalies such as the data inconsistency or lack of information on fishing efforts, were noted in such statements. Estimates have been done about efforts to be able to produce such article while being aware of error induced by the method adopted. Monthly CPUE (Kg/1000 hooks) of about [162;68]; [28 ;25]; [0 ;0] and [2 ;3] respectively for Swordfish, Black marlin, Striped marlin and Sailfish were obtained in 2010 against [137 ;71]; [8 ;11]; [9 ;13] and [2 ;2] in 2011. From these figures, we can infer that i) billfish do exist in the Madagascar water, it remains to prove this theory by assessing the abundance or biomass and ii) the primary sources of data that drive the expension of CPUE are uncertain and should be investigated further.

Keywords: CPUE, longliners, billfish, incertitude.

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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.

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

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.

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

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.

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

Month	No Set			Index	No Hooks		
	Company A (Known)	Company B ($NS_{,j}=I_{2,j}*NT_{B,j}$)	Company C ($NT_{,j}=I_{2,j}*NT_{C,j}$)	($I_{3,j}=NH_{A,j}/NS_{A,j}$)	Company A (Known)	Company B ($NH_{,j}=I_{3,j}*NS_{B,j}$)	Company C ($NH_{,j}=I_{3,j}*NS_{C,j}$)
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

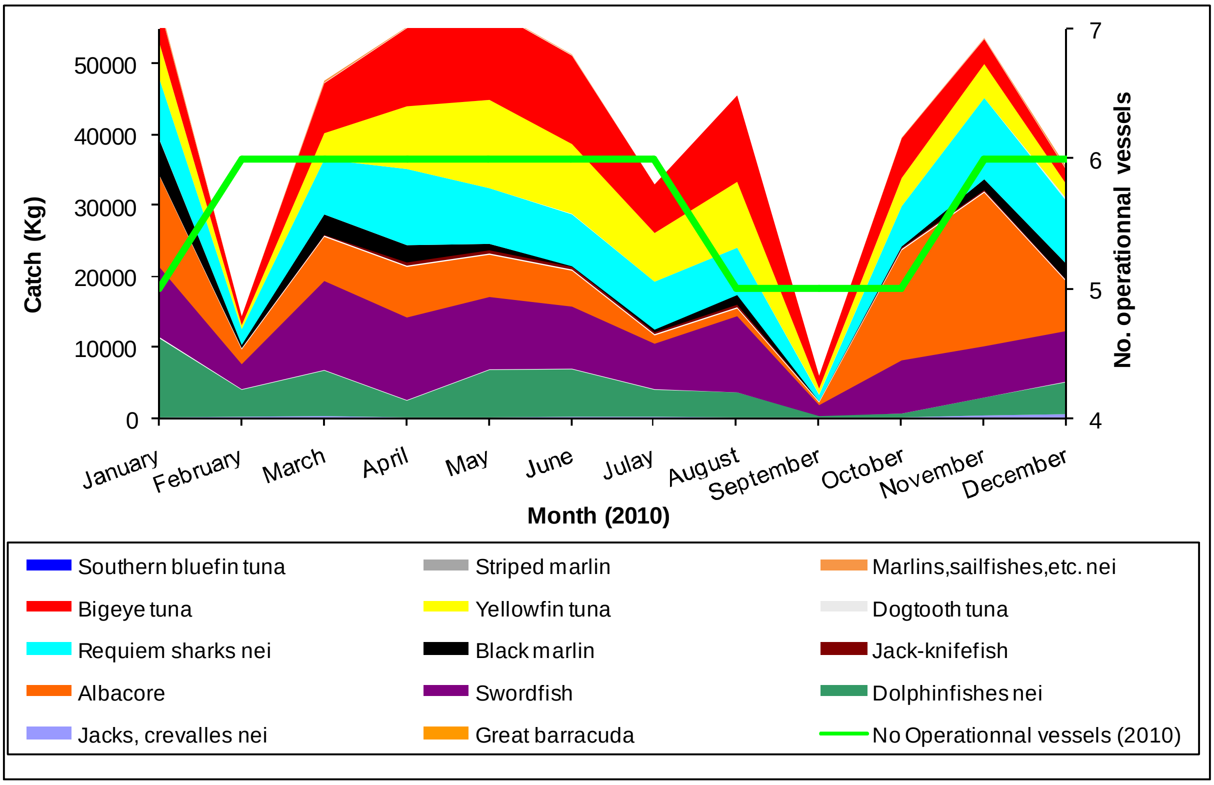

Chart n° 1 : Monthly catch and trend effort in 2010

Rose to 498 tons, the total catch for the year 2010 consists mainly of tuna and tuna like species (47%) of billfishes (23%) and 28% of bycatches. The average catch is around 41 tons but it reaches its minimum in september (5.9 tons) because of the number of operational vessels. 23.75% of these billfishes are largely predominated by swordfish (83.53%) which is followed by black marlin (15.16%) and others such as mixed billfishes and sailfishes nei, (1.3%). However, note that the lower catch in february and September might be due to the misreporting catch data.

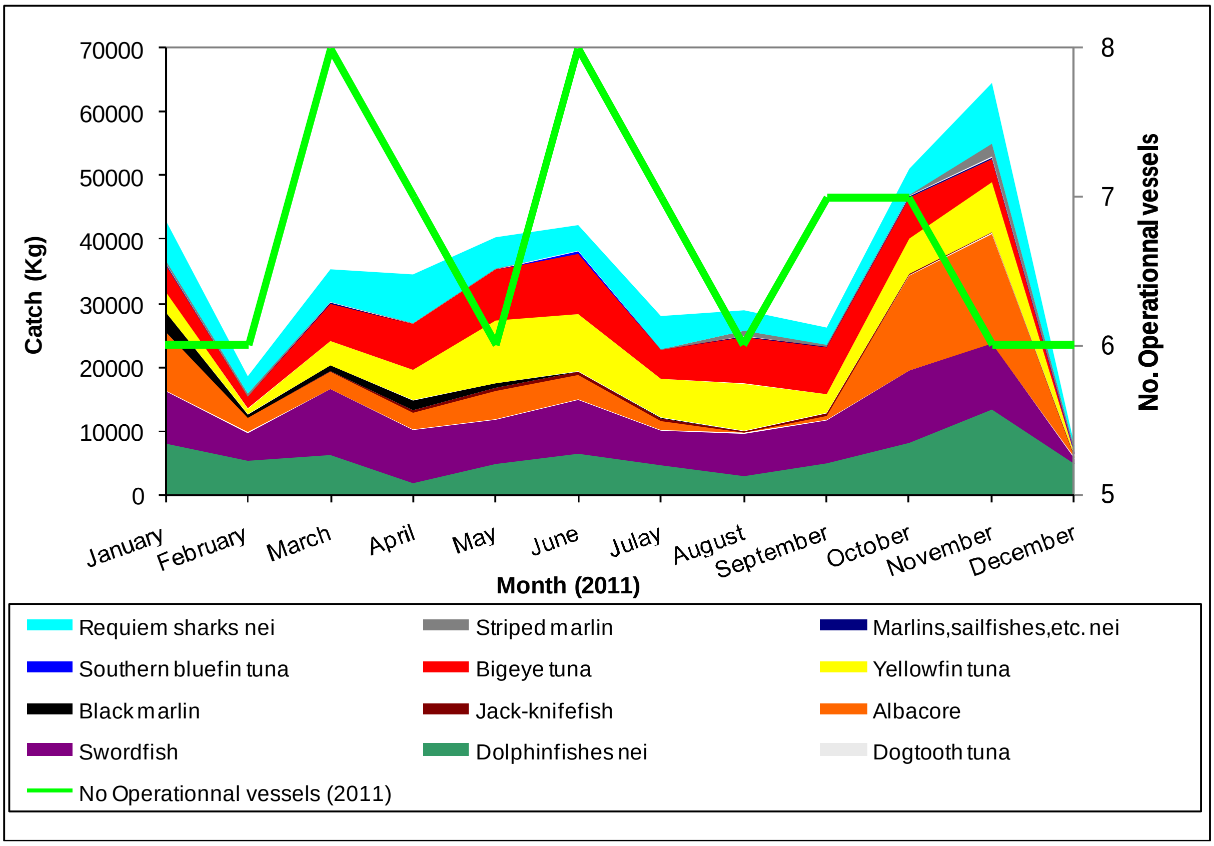

Chart n° 2 : Monthly catch and trend effort in 2011

These trends in terms of capture, which amounted to some 421 tonnes, were found also for the year 2011. In other words, tuna and similar species reached 45% of the total catch, while the billfishes were 24% and the total of bycatch was 31%. The peak is reached in november in spite of the minimum number of boats operating, a substantial yield was recorded. November catch is also characterized by the abundance of yellowfin tuna (26%). As for billfishes, their catch is still dominated by the swordfish as in 2010 with a percentage up to 86%. It is followed by the black marlin (6%), striped marlin by (5%) and by mixed billfishes and sailfish nei, (1%).

2) Variability of efforts

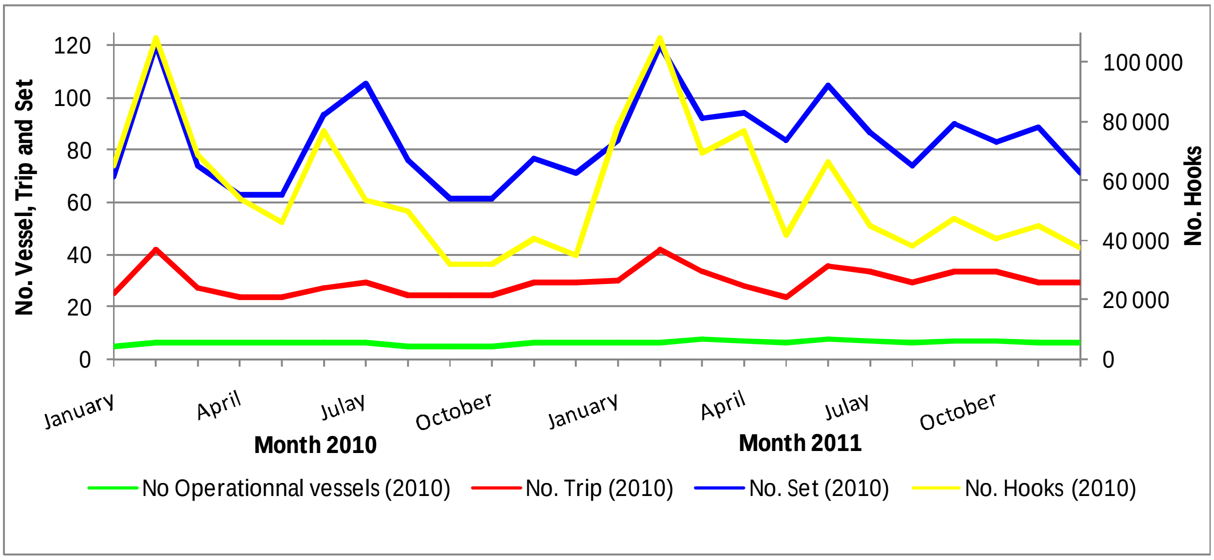

Chart n° 3 : Trend of average nominal efforts

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 homogeneities 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 $p = 0.085$; set the number of $p = 0.198$ 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. There are no significant differences in terms of catches of billfish (For swordfish $p = 0.44$, $p = 0.08$ black marlin and the mixed of billfish $p = 0.84$) except for striped marlin catch that recorded significantly different between the two years ($p = 0.009$).

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

3) CPUEs

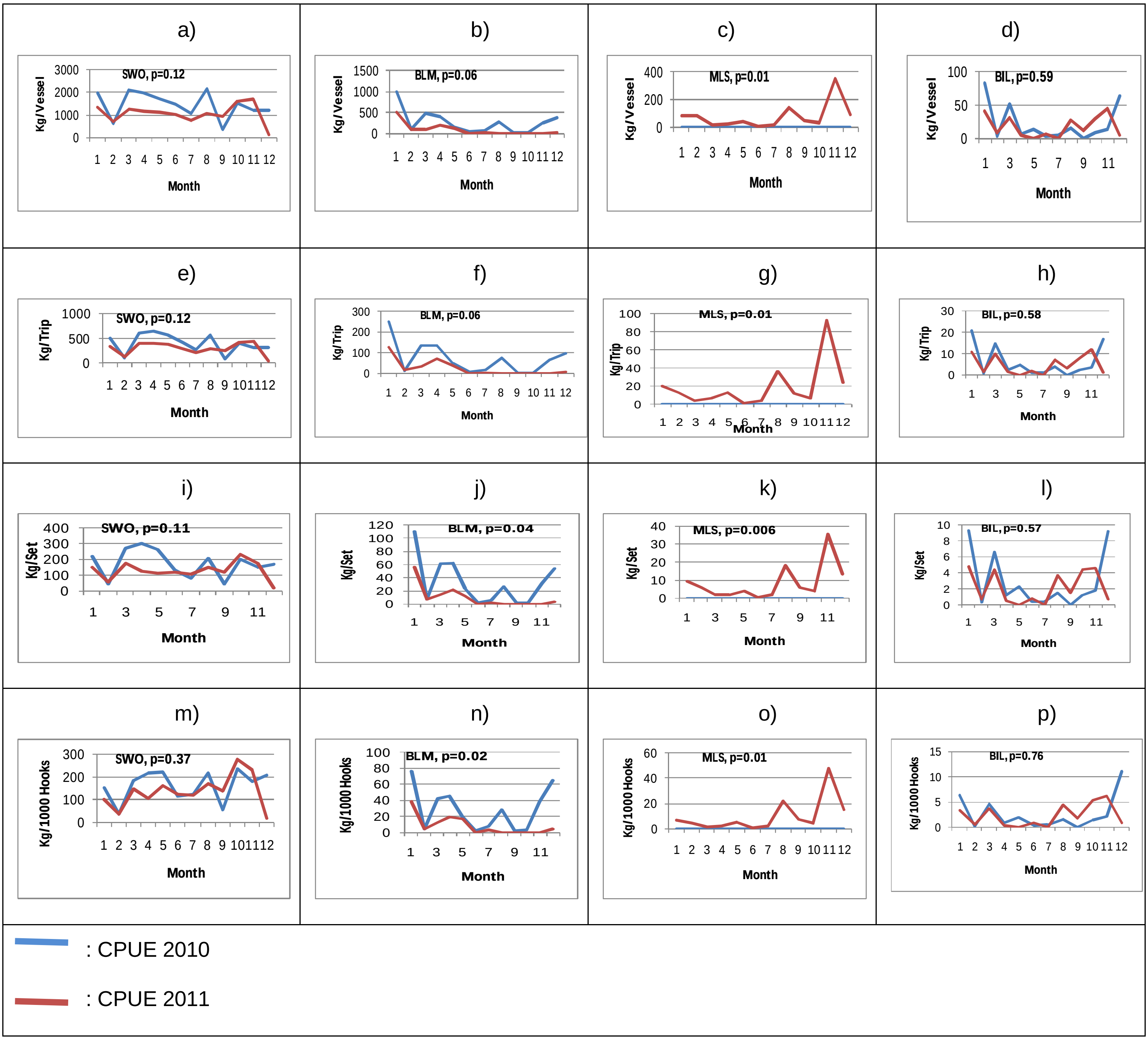

Chart n° 4 : Trend of nominal CPUEs by month of swordfish, black marlin, striped marlin and mixed of billfish with consideration to these different units: a-d No. operational vessel, e-h) No. trips, i-l) No. sets and m-p) No. hooks

For the swordfish, no significant difference was noted on the CPUEs (a-e-i-m) whatever unity of effort considered. Catches and yields swordfish are also stable throughout the two years. As for black marlin (b-f-j-n), yields are clearly less important than the swordfish. The CPUEs of the year 2010 are larger than those of 2011. Catch per set (j) and by 1000 hooks (n) obtained are significantly different for those years. We note, moreover, significant efficiencies at the beginning and at the end of the year. Regarding the striped marlin (c-g-k-o), no catch was recorded in 2010. Their catch rates during the year 2011 are quite similar to those of black marlin. They are marked mainly by the peak in november whose purpose remains to be elucidated. Finally, for the mixed of billfish (d-h-l-p), it should be noted that these are billfish species that have not been properly identified and predominated by sailfishes nei. Thus, these species are caught by Malagasy small longliners with tiny yields shown. Note also that the CPUEs those recorded in 2010 and 2011 are stochastically identical.

DISCUSSION

Given the peculiarity of this type of fishery that used small fishing vessels and inexperienced in terms of targeting swordfish, the elements of comparison are few. However, Reunion longline fleet, which is deemed as being the best in the region, has already developed similar research in this study. Note that these are based on a data set obtained from the strict protocols since 1994. Reunionese scientists found since this year nominal CPUEs of some species among others, swordfish, and tropical tuna species. At the beginning of the exploitation, the La Reunion fishery has recorded around 16 individuals per 1000 hooks, but recent results indicate approximately 0.23 kg / Hook or about 230 Kg/1000 (in 2008) with a downward trend. We estimate that this trend could reach for the years 2010 and 2011 around 200 Kg/1000 hooks. Thus, the CPUEs obtained respectively in 2010 and 2011 of around [162, 68] Kg/1000 Hooks and [137, 71] Kg/1000 Hooks are not considered very bad. Acquiring experiences malagasy fishermen and getting improved data collection according to a strict protocol, performance comparison of these two fleets will be more interesting given that they evolved almost in the same fishing area.

CONCLUSION

In conclusion, certainly Malagasy owners lack experience associated with this fishery, but the relatively encouraging results suggest a booming industry. Subject to uncertainties and significant deficiencies reported data could still afford to produce some efficiency indicators of fishing and abundance of billfish in the Madagascar waters. Thus, the present work has revealed that the billfish actually exist in its waters, or more precisely in its eastern part. They are predominated by swordfish that are caught almost the same way as yellowfin tuna or bigeye tuna.

Efforts will still be done by the Ministry of fisheries in order to achieve the objectives which consist in i) strengthening the statistical system tuna to medium term, ii) the development of national management plans of resources and tuna like species based on scientific studies. To do this, we must begin to implement the two units of data collection for this fishery in Toamasina and Sainte Marie.

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