RESEARCH ARTICLE

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PRELIMINARY STUDY OF BLUE SHARK *PRIONACE GLAUCA* DIET IN MOROCCAN WATERS

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SUMMARY_____

The blue shark *Prionace glauca* (Linnaeus, 1758) is a pelagic fish, belonging to the Carcharhinidae family. It is one of the top predators placed at the top of the food chain and for this reason it must be followed to preserve it against any illegal fishing. Its presence in the landings of the Moroccan fleet by both longliners and boaters shows that this species has become highly exploited and needs to be followed. The main objective of this work is to know its place in the ecological niche determining the ecological role of this predator in the ecosystem. The study of *Prionace glauca* diet is intended to highlight, in the short term, feeding periods and prey preferences according to the state of maturity of the animal and will allow in the medium term to understand the behavior of this species in the marine ecosystem. Since February 2015, biological sampling has been collected at the wholesale fish market of Casablanca where the catches of *Prionace glauca* transit from several Moroccan ports. Investigations included size measurements, sex determination and stomach recovery for macroscopic analysis. The frequency of occurrence showed that European pilchard *Sardina pilchardus* is the main prey in *Prionace glauca*. The immature individuals eating preference is the European pilchard *Sardina pilchardus* although for mature are rays and sharks. The cephalopods and rays are more consumed by females whereas Birdbeak dogfish *Deania calceus* and the swordfish *Xiphias gladius by* males. The emptiness rate show that 56% of the dissected stomachs were empty indicating that there are periods of low *Prionace glauca* feeding during the "autumn-winter" seasons.

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Key words: Prionace glauca, emptiness coefficient, frequency of occurrence, prey.

1. INTRODUCTION

In Morocco, pelagic sharks, including *Prionace glauca*, are mainly caught by drifting longlines used by two types of fleet; longliners and canoes. Pelagic sharks are usually caught in Morocco with other species that have always been considered to have a high economic value such as swordfish and tuna (Inrh, 2015). Pelagic sharks were not entirely popular among Moroccan people, until recent decades when their flesh has become appreciated. Rather, their fins were still estimated. Since, they were exported to other foreign markets such as Asia and Europe (Dent and Clarke, 2015).

Currently, Sharks are also exploited as other fishes for their antioxidants, which are useful in human feeding and for their skeletal muscle defenses (López-Cruz et al., 2010). Their content variations are related not only to the species but to the oxidative events according to the vital cycle phase, sexual maturity, water characteristics, capture method as well as favorite diet (Guerriero et al., 2002 ; 2003 ; 2004 ; (Barrera-García et al., 2012) .

This species is fished mainly by two types of segments; small boats and longliners using the same gear that is drifting longlines. Among longliners, this machine measure 70 miles in length with a large number of hooks ranging from 1200 to 1400 units. In small boaters this machine is shorter with an average length of 2 miles and an average number of 400 units hook.

Longliners, mainly located at the port of Dakhla put about 22 -24 hours to get to the fishing area, often near “cap blanc”. They perform tides of 15 days and operate in areas of 600 fathoms and 12 nautical miles from the coast. They mainly target swordfish and sharks incidentally. The catch is usually composed of 25% of swordfish, *Xiphias gladius* (Linnaeus, 1758), 70% of blue shark, *Prionace glauca* and 5% of shortfin mako, *Isurus oxyrinchus* (Rafinesque 1810).

The tides of small boats last only two days. They take about 8 hours to get to the fishing area. Contrary to the longliners fishing in ocean waters, small boats operating waters closer to the coast no more than 5 miles.

The scientific monitoring has been initiated in Morocco with the aim of carrying out biological and ecological studies serving as necessary elements for the best management of stocks of this species classified. The study of the *Prionace glauca*diet will, in the short term, define feeding periods and prey preferences and will, in the medium term, understand the behavior of this species in the marine ecosystem.

2. MATERIALS AND METHODS

The study area is located in the east of North

Atlantique Ocean especially in the Moroccan waters. Biological sampling collection have been carried out from February 2015 to 2017 at level of the Casablanca wholesale fish market where the catches of *Prionace glauca* transit from several Moroccan ports (Figure 1). It is necessary to note that in most cases *Prionace glauca* is gutted on board so that the flesh is damaged. But in some cases, it was possible to attend eviscerations of some individuals of *Prionace glauca*. It was therefore possible to collect the stomachs and to reveal elements useful for knowing its preferential prey, the period of low feeding.

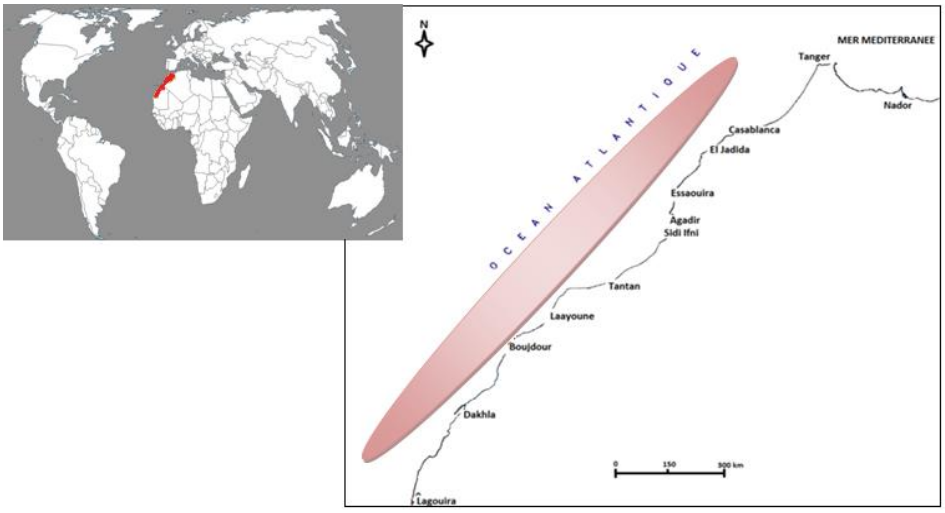

Fig. 1: map of Moroccan sea showing the shark fishing area (in pink)

The total length (LT) of the individuals was measured with a tape measure to the centimeter. The gender was determined by observing the cloacal part of the individual; the males are easily identified by the presence of the pterigopods, the females are identified by the absence of these organs.

The stomachs were dissected to record their digestive status, full or empty stomachs. The empty stomachs will be used to calculate the emptiness rate (*Cv*) in order to determine periods during which *Prionace glauca* abstains from food (Jean-Claude Hureau, 1970).

$$Cv = \frac{\text{Number of empty stomachs x } 100}{\text{total number of stomachs examined}}$$

The full stomachs can be classified, in this study, according to their digestion status in three phases:

- Phase I: Start of digestion, usually the prey no longer has head, but the item is always identifiable.
- Phase II: Advanced digestion; the item begins to lose its appearance and shape, usually is not identifiable yet it can be classified by family.
- Phase III: Digestion very advanced: the item is well digested; the stomach contents are in the form of a viscous liquid.

Dietary contents were analyzed in the macroscopic scale and the preys were identified to the lowest possible taxon or category using species catalogs. The number of items was also noted for relative measurement of prey quantity which is frequency of occurrence of food (*F%*) (Preti et al., 2001).

$$F\% = \frac{\text{Number of stomachs containing item i x 100}}{\text{Number of full stomachs examined}}$$

3. RESULTS

The number of stomachs analyzed for this diet study counted 84 individuals with 44 females, 31 males and 9 unidentified. The sample taken for diet study covered almost all size classes caught and landed in Morocco. If it is compared to the results of the biological sampling carried out by Hamdi et al. (2017), where the sizes of the individuals caught were between 100 and 310 cm (LT), diet sample covers almost all size classes landed (figure 2).

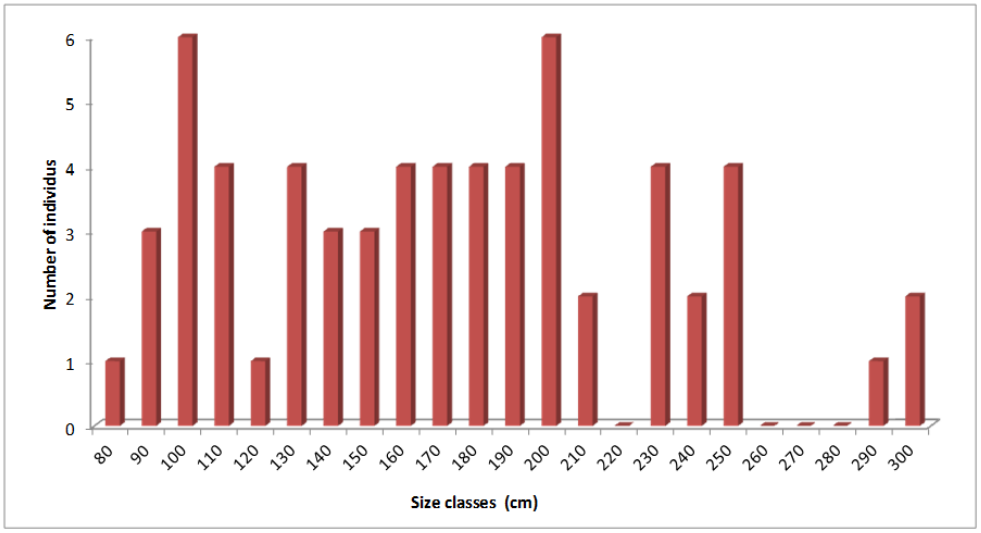

Fig.2: Structure of sampled individuals

During the macroscopic analysis of the stomach contents of the individuals sampled, the stomachs were in two main states: full or empty.

41 stomachs were empty representing almost 49% of the stomachs analyzed. The rest of the stomachs is full. The monthly evolution of the emptiness index revealed two periods (figure 3):

- One during the autumn-winter season where the stomachs are usually empty and show no trace of feeding. In this case *Prionace glauca* slows down its feeding activity.
- The second period is located during the spring-summer seasons. The stomachs are filled with prey; the animal is in high feeding activity.

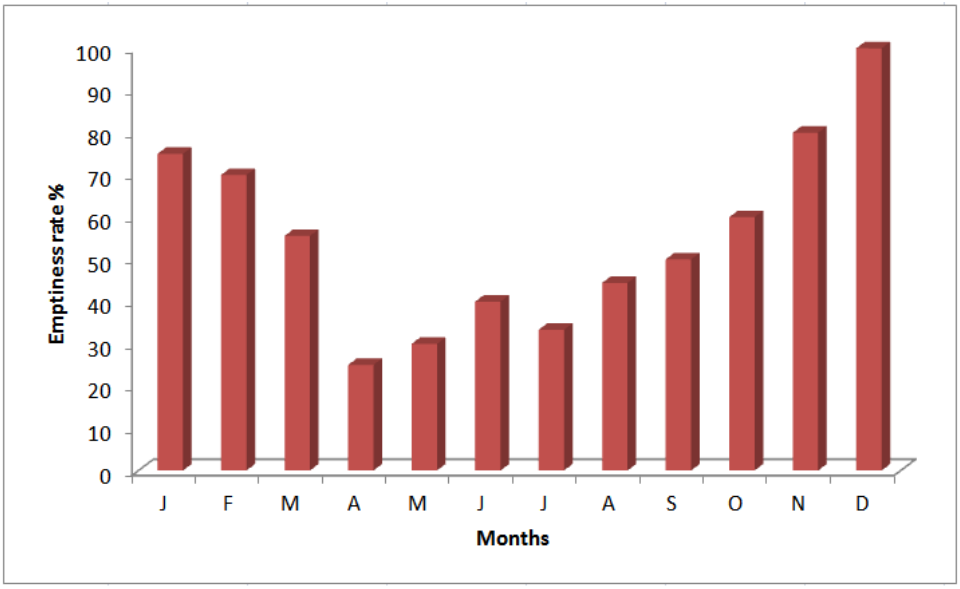

Fig. 3 : Monthly evolution of the emptiness rate (2015-2017)

The analysis of full stomachs determined 11 families of prey with varying frequencies of occurrence (table 1). Indeed, the Clupeidae, represented by the European pilchard *Sardina pilchardus* (Walbaum, 1792) showed a high frequency of occurrence of about 40%, which means that *Prionace glauca*has a preference for *Sardina pilchardus*, which is the most abundant pelagic species in the Moroccan waters. Cephalopods are preys which come second; their occurrence frequency is 16, 27% (table 1).

Table 1: Results of macroscopic analysis of stomach contents

Prey category	family	Species	F0 %
Pelagic teleosts	Clupeidae	European pilchard (*Sardina pilchardus*)	39,53
	Scombridae	Mackerel (*Scomber sp*)	2,32
	Belonidae	Species not detectable	2,32
	Carangidae	Horse mackerel (*Trachurus sp*)	4,65
	Scombridae (Small tuna)	Species not detectable	2,32
	Xiphidae	Species not detectable	2,32
Demersal teleosts	Lophiidae	Lophius sp	2,32
	Sparidae	Species not detectable	2,32
Unidentified teleosts	"not detectable"	Species not detectable	9,30
Elasmobranchs	Centrophoridae	Birdbeak dogfish	4,65
	Rajidae	Species not detectable	9,30
Cephalopods	"not detectable"	Species not detectable	16,27
Crustaceans	"not detectable"	Shrimps not detectable	2,32
Viscos liquids	"not detectable"		20,93
Anthropogenic material (Plastic)	-	-	2,32

The Frequency of occurrence by sex showed that the *Sardina pilchardus* is the main prey preferred in both sexes of *Prionace glauca* with a slightly higher preference in females. The cephalopods and rays are more consumed by females. On the other side, males tend to feed on large species such as Birdbeak dogfish *Deania calceus* (Lowe, 1839) and the Xiphidae (Figure 4). It is clear that the number of stomachs containing the viscous liquid is greater in females than in males. Perhaps it means that the females wait until their prey is completely digested, to feed again.

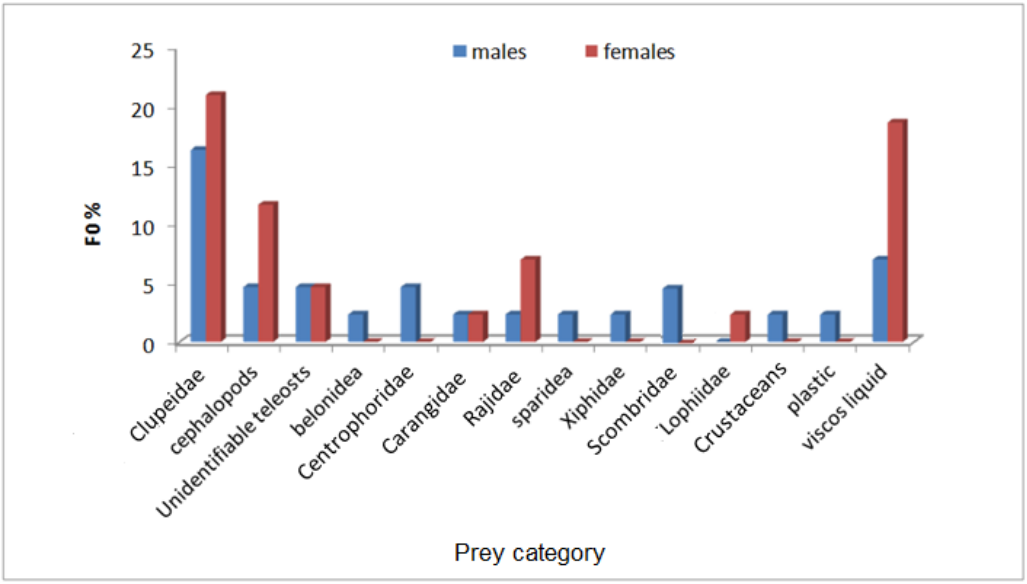

Fig. 4: Frequency of occurrence by sex

Assuming that the first maturity size is about 1,90m (calculated for males in Moroccan waters by Hamdi et al. (2017) and in the Chile region by Bustamante and Bennett (2013), we found that 63% of the full stomachs Belong to juvenile sharks who predominantly eat small prey such as *S. pilchardus* followed by cephalopods (Figure 5). While mature feed large species such as rays, centrophoridae and xiphidae. Indeed, the shark's stomach is large and occupies almost 1/3 of the body. Therefore, the mature sharks whose the length exceed 2 meters are able to ingest whole animals of large size or large quantity of small animals.

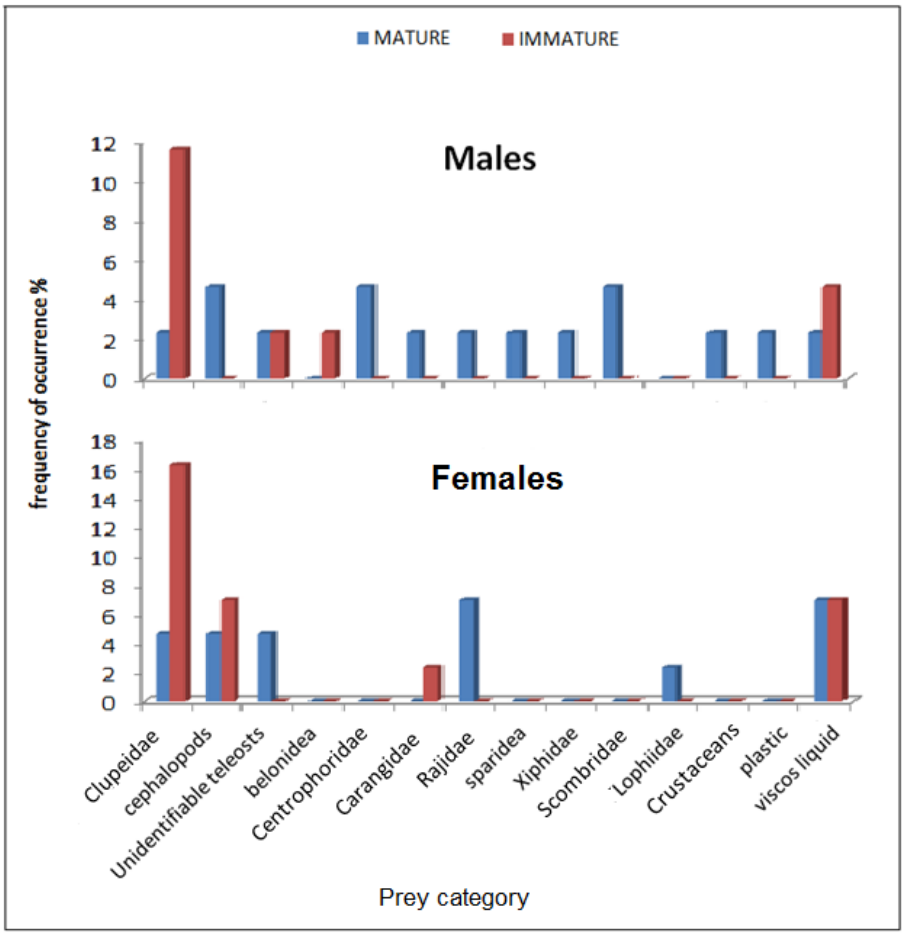

Fig. 5 : Frequency of occurence by maturity state

4. DISCUSSION

In this study, the empty stomachs could be explained by stopping feeding related to the phenomenon of stomach eversion, a probable means of purging oneself of indigestible objects (Brunnschweiler et al., 2005) or other reason such us the reproduction. Springer (1960) concluded that the pregnant sharks cease feeding when they enter nursery area, as a protection measure for the young (Wetherbee et al., 1990). So, it is useful to analyze the emptiness index by sex to see the effect of animal behaviors on diet such as mating, litter and parturition in females.

It is noted that the prey that have just been ingested are intact in the stomachs of shark individuals and easily identifiable. But generally, the last two phases of digestion are the most noted in this study, this is most likely due to the long duration between the capture of the animal and the time of the analysis of the stomachs which exceeds 74 hours. Comparing these results with those of the other regions, it find that the prey are well identified as is the case (Kubodera and Watanabe, 2007; Cord and Campana, 2003; Clarke et al., 1996; Biton Porsmoguer, 2015). In fact,

almost all studies of *Prionace glauca* diet are carried out aboard vessels and therefore the time between caches and stomach analysis is significantly reduced (4-5 hours).

Prionace glauca off the Equador have more preference for cephalopods than for Clupeidae (Rosas-Luis et al, 2015). In Canada Off Nova scotia, Atlantic mackerel *Scomber scombrus* was most frequently consumed (Cord and Campana, 2003). In California, near Catalina Island, the northern anchovy, *Engraulis mordax*, was the predominant prey item for *Prionace glauca* (Tricas, 1976). Another result published by (Nakano and Seki, 2003), in north Pacific shows that shark stomachs also contain small pelagics and cephalopods.

Prionace glauca feeds other species such as the pigeon that its presence in stomach has been confirmed by a fisherman who eviscerates sharks. This finding was confirmed by the study that was conducted off Brazil (Vaske Junior et al., 2009). Also the anthropogenic material as plastic bags was found in the stomachs; it reflects the level of pollution that knows the oceans due to human. This suggests to carry out further analyzes with the aim of highlighting the rate of toxin accumulated in the liver of shark. Indeed, during this study, some livers were found in abnormal aspects representing brownish spots.

Overall, *Prionace glauca* feed on a wide range of prey and are able to change prey to take advantage of those that are most abundant depending on the place and the season. According to them, *Prionace glauca* are able to prosecute and capture prey from multiple sources, and are generally considered to be feeding opportunistically.

It is clear that although this animal is pelagic, it reaches deep areas by feeding benthic species such as the sharks of funds that it found in the stomach of two individuals. This prey colonizes depths between 75-1500 m. This could explain the vertical movements that this animal performs, observed by Carey and Scharold (1990).

A feeding study conducted in Canadian waters on *Prionace glauca* caught during a fishing tournament of Nova Scotia in August and September (1999-2001) showed that pelagic and demersal teleost fish were the main prey (Cord and Campana, 2003). Scientists observed prey differences in size and sex of sharks, which probably reflects segregation of depth and/or prey selectivity depending on the size of the prey and shark.

However, the studies continuity is essential in order to compare, in every country, the variability of prey over time

5. CONCLUSION

The study of *Prionace glauca* diet is carried out for the first time in Morocco. Although the number of samples is small we had results that are

comparable to those of other countries. *Prionace glauca* generally feeds on small teleosts and cephalopods when it is immature and large pelagic when it is mature. The results showed that *Prionace glauca in* Moroccan waters feeds mainly on the *Sardina pilchardus*, which is the most dominant species in the Moroccan region. The F_0% index of *Sardina pilchardus* which it is 39.53 results higher than that of cephalopods.

The monthly evolution of the emptiness index showed a period of low intensity of feeding located in autumn-winter which could be related to the phenomenon of gastric reversion or to something else . The results of the diet will be used to understand the behavior of *Prionace glauca*in each area of its distribution. In fact, the shark changes prey according to the biotope where it lives. These results will also serve to complete the data needed to run ecosystem models such as the eco path model.

In perspective, the number of individuals sampled was not sufficient to show the food preferences per season. However, seasonal biological sampling is in progress in order to be able to determine this index. In the other side, the state of the preys in the analyzed stomachs is generally digested, it was impossible to discriminate the species of these preys. So, in further studies of the diet, it would be interesting to use the prey determination guides to identify the prey by species not only by family, and this from the beaks of cephalopods, pieces of crustaceans, scales, eyes of fish...

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