SEXUAL MATURITY, SPAWNING SEASON AND ESTIMATION OF BATCH FECUNDITY OF SWORDFISH (*XIPHIAS GLADIUS*) CAUGHT BY THE REUNION-BASED PELAGIC LONGLINE FISHERY (SWOI)

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ABSTRACT

The Indian Ocean swordfish longline fishery based in Reunion Island started operating in 1991. From May 1998 to January 2001, Ifremer has compiled information on domestic longline fishery fishing in the French EEZ. Data are collected from logbooks, from regular at-sea and landing samples and from on-board scientists.

One of the aims of this programme (PPR), financed by the European Union and Reunion Local Councils, is to contribute to the management and conservation of the species taken in SWOI fisheries through a larger scale project monitored by IOTC.

During 52 campaigns onboard commercial longliners (327 days at sea) , scientists recorded length measurements of all swordfish caught. They also determined the sex, collected gonads and the anal fin.

Some aspects of the reproductive biology of swordfish around Reunion Island (between 19° and 25° South and 48° and 58° E) were studied from a sample of 1727 gonads (1107 ovaries and 620 testes) collected between May 1998-January 2001. They represent around 1.65% of the total number of swordfish unloaded by the domestic fleet.

Spawning was estimated to take place mainly from October to April. The vitellogenesis was characterised by Histological features and relations were made with macroscopic maturation index. Moreover, Characteristic dispersions of oocyte diameter were found for different sexual development stages. Median body size at sexual maturity (L_{50}) for female and male were 170.4 cm ± 2.4 cm and 119.8 cm ± 1.9 cm lower jaw fork length (LJFL) respectively.

First aspects of fecundity of swordfish from the southwest Indian Ocean were analyzed from gonads collected during campaigns onboard domestic longliners between may 1998-march 2001. Batch fecundity and spawning frequency were estimated respectively from 7 pairs of ovaries and 184 female in a reproductively active condition caught around Reunion Island (between 19° and 25° South and 48° and 58° East). The individual batch fecundity fluctuated from 900 000 hydrated oocytes for the smallest ripe female measured 124 cm lower jaw fork length (LJFL) to 4,19 millions for a large female sampled (225 cm LJFL). Two positive linear relationships were established between (1) batch fecundity (F_b, in number of hydrated oocytes) and ovaries weight (M_o in g) then (2) batch fecundity and LJFL (cm) : (1) $F_b = 0{,}0003*M_o + 0{,}3735$, (2) $F_b = 0{,}0232*L - 1{,}308$. The relative batch fecundity reaches from 23 to 66 hydrated oocytes/g body weight. Over October to April, the local reproductive season, females spawned 76 times that is less than every three days.

SAMPLING PROGRAM

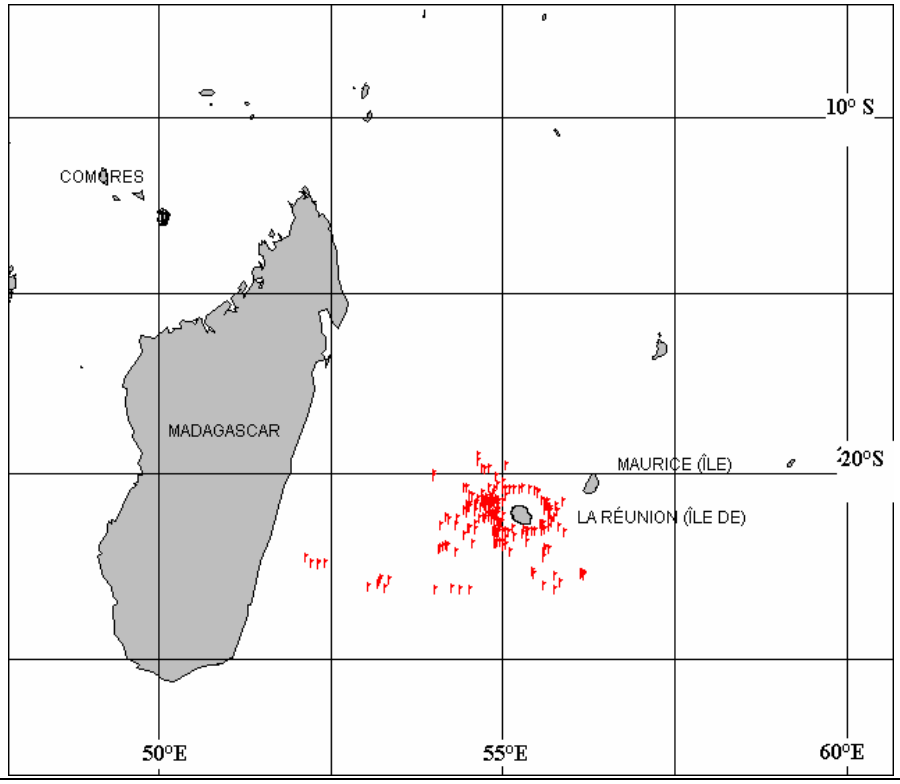


Figure 1 : Capture locations from which samples of swordfish were obtained during May 1998 to January 2001

MEDIAN BODY SIZE AT SEXUAL MATURITY

FEMALE

To determine the median body size at sexual maturity and the spawning season , the validated method for classification of the reproductive activity of female swordfish proposed by Hinton *et al* (1997) has been used .

Female swordfish are considered in a reproductively active condition when :

$$GI = \frac{\ln(Pg)}{\ln(efl)} >= 1.375$$

Pg : gonad weight (g)
EFL : Eye fork length (cm)

MALE

Males were presumed" sexually active" if sperm was observed after a visual inspection of the testes.

Nonlinear regression fit the logistic model for the percentage of sexually mature versus LJFL (LJFL-5 cm class), for female and male Swordfish (*Xiphias gladius*) caught by the Reunion-based pelagic longline fishery during May 1998-January 2001. Best fit lines are predicted relationships. Symbols represent mean percentages mature per 5-cm LJFL class.

FEMALE

Median body size at sexual maturity (L_{50}) was 170.4 cm ± 2.4 cm lower jaw fork length (LJFL).

for female:

% mature =1/ (1+exp(16.2506-0.0953421*LJFL)

(r^2 = 0.998; n=553)

MALE

Median body size at sexual maturity (L_{50}) was 119.8 cm ± 1.9 cm lower jaw fork length (LJFL).

for male:

% mature =1/ (1+exp(10.17580-0.0848839*LJFL)

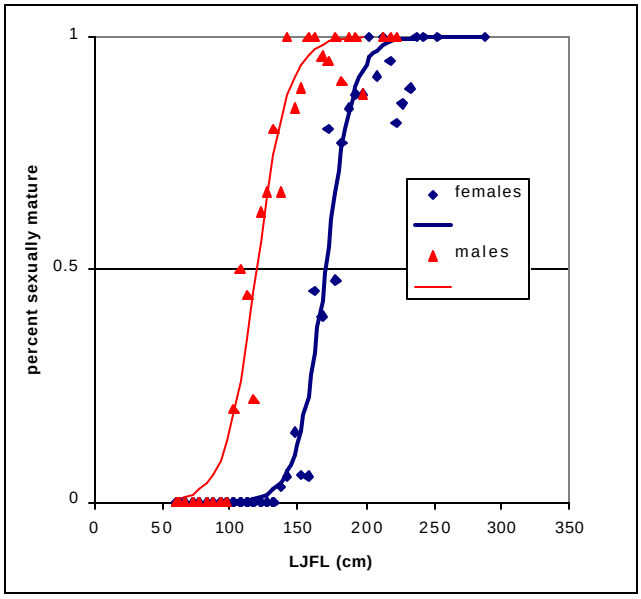


Figure 2 : Nonlinear regression fits of the logistic model for percentage sexually mature versus LJFL (LJFL-5 cm class), for female and male Swordfish (Xiphias gladius) caught by the Reunion-based pelagic longline during may 1998-january 2001. Best fit lines are predicted relationships. Symbols represent mean percentages mature per 5-cm LJFL class.

SPAWNING SEASON

Spawning was estimated to take place mainly from October to April.

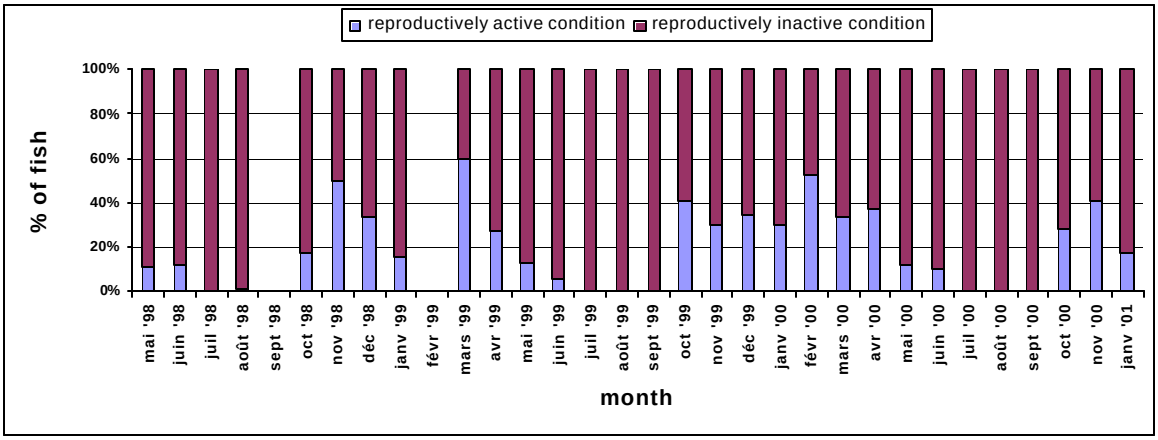


Figure 3 : Monthly evolution of the percentage female swordfish in reproductive condition around Reunion: Between 17°S and 23°S and 49 E and 57 E) during May 98-January 2001.

SEX RATIO

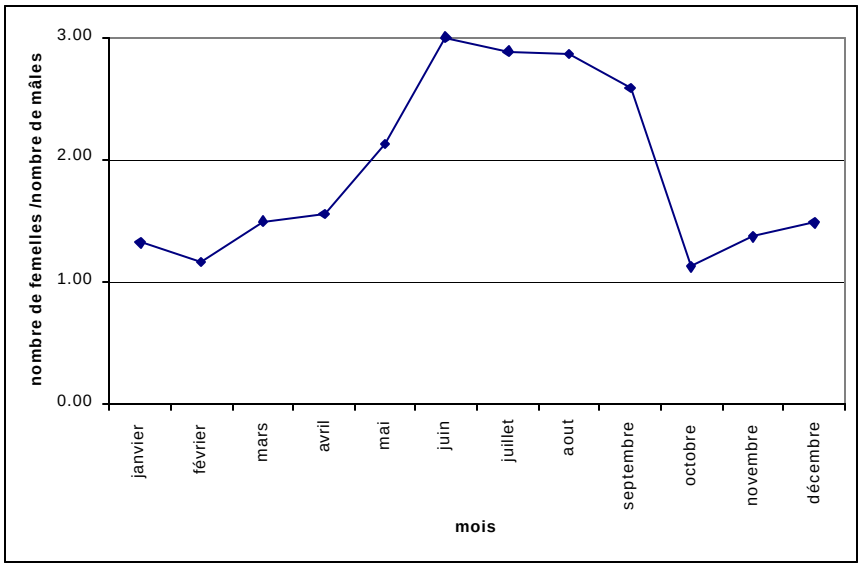


Figure 4 : showed the monthly sex ratio and suggested that individual of both sexe were caught throughout the year. Female were predominant from june to October.

Relationship between sex ratios (females/males) and Lower Jaw Fork Length(LJFL, 5 cm classes) for Swordfish (*Xiphias gladius*) caught by the Reunion-based pelagic longline during may 1998-january 2001 has been related.

The proportion of female beetween 100 and 230 cm were estimated with the following polynomial fonction :

$y = 1E\text{-}11x6 - 1E\text{-}08x5 + 5E\text{-}06x4 - 0.0011x3 + 0.1355x2 - 8.3638x + 209.38$

x=LJFL in cm

$r^2 = 0.9444$

n= 26

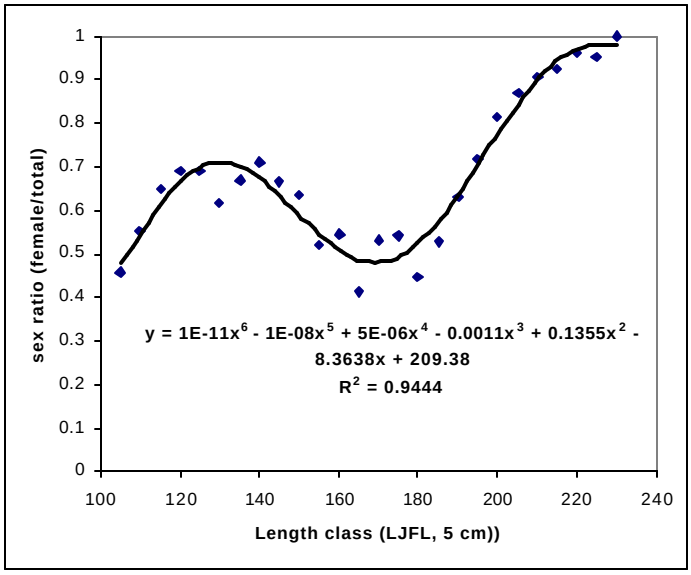


Figure 5 : Relationship between sex ratios (females/males) and Lower Jaw Fork Length (LJFL, 5 cm classes) for Swordfish Swordfish (Xiphias gladius) caught by the Reunion-based pelagic longline during may 1998-january 2001

BATCH FECUNDITY

In order to estimate the batch fecundity, the gravimetric method described by Hunter *et al.* (1985) has been adapted. Collected onboard commercial fishing vessels in the southwest Indian Ocean between 19° and 25° S and 48° and 58° E, 7 pairs of swordfish ovaries were weighted. Then 30 "core samples" of gonad (0,15 to 0,25 g) for each

individual were taken and precisely weighed. Core samples were filtered twice over to separate hydrated and non-hydrated oocytes (sieves of 1 mm and 0.5 mm). Using the Images Analyzer (,both sets were counted to estimate first a mean number of oocytes by gram of ovaries and afterwards the batch fecundity.

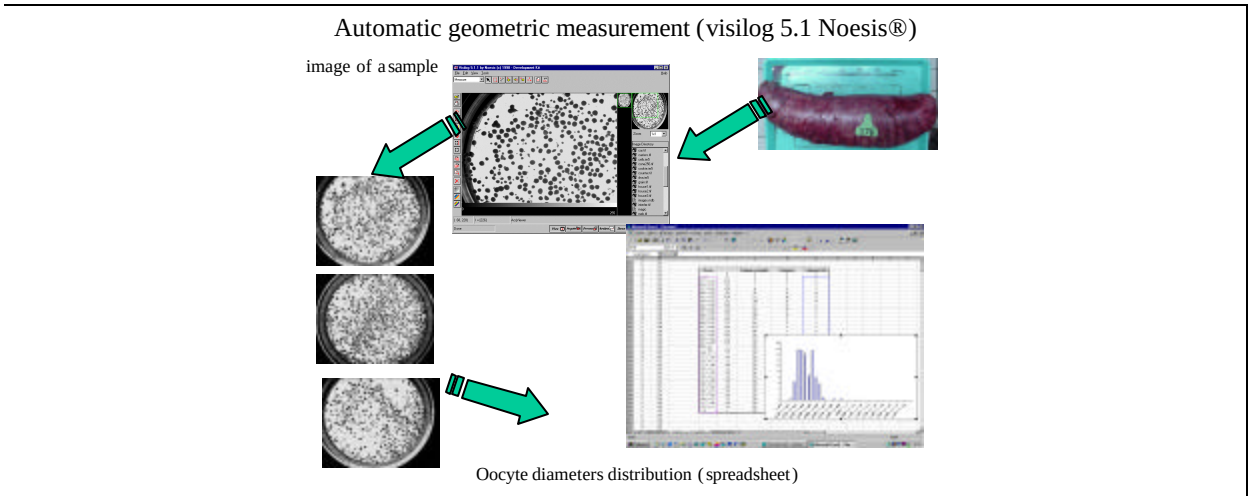


Figure 6 : Automatic geometric measurement

Whereas mean quantities of hydrated and non-hydrated oocytes randomly vary from individual to individual, the number of hydrated oocytes represents roughly from a quarter to half the total quantity of ooctytes in ripe gonads

Batch fecundity estimates were 0.9 millions for 2 kg of ovaries and more than 4 millions hydrated oocytes for 12 kg of gonads.

A positive linear relationship was established between (1) batch fecundity (F_b, in number of hydrated oocytes) and ovaries weight (M_o in g) :

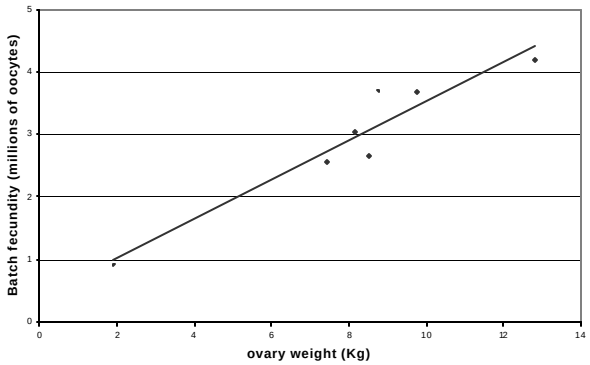
$F_b = 0{,}0003*M_o + 0{,}3735$

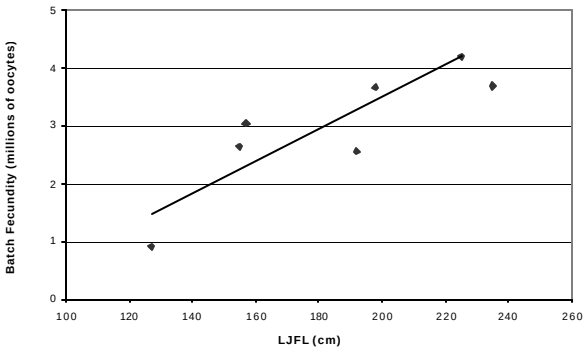
The individual batch fecundity fluctuated from 900 000 hydrated oocytes for the smallest ripe female measured 124 cm lower jaw fork length (LJFL) to 4,19 millions for a large female 225 cm. The representing relationship between batch fecundity and LJFL (cm) was also linear and positive :

$F_b = 0{,}0232*L - 1{,}308$

The relative batch fecundity (F_{rb}) decreased from 66 to 23 hydrated oocytes/g body weight with the theoretical body weigh (W_b kg from LJFL values). A linear relationship was defined

$F_{rb} = -0.2275* W_b + 60.124$





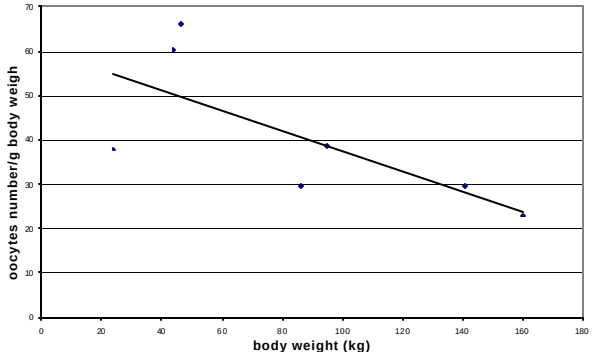


Figure 7 : Relation between batch fecundity and ovary weight (a), relation between batch fecundity and fish lengh (b) and relation between oocytes number per gram of body weight and body weight (c) of swordfish in the Southwest Indian Ocean We aim to confirm the different relationship presented in this study to point out if any annual variations of fecundity for this species could occurred.

For the determination of spawning frequency, number of female in a reproductively active condition and the number of females with hydrated oocytes were counted from samples collected between may 1998-january 2001 (Tab. I). Thus, the average percentage of spawning females during the seven months of the spawning season was 36,04 %. According to drastic statistic conditions, the swordfish spawning frequency estimates indicate an average of one spawning every 2,77 days. If our sample represented the entire mature population and no variability occurred within years, a ripe female would have spawned about 76 times during the 212 days of the main reproductive season.

Table I. Percentage of spawning swordfish females during the main spawning season (October-April) between May 1998 and January 2001

Mois	Es : Nombre d	Ep : Nombre d	% d'individus au stade 5
octobre	31	12	38.71
novembre	46	21	45.65
décembre	32	16	50
janvier	14	4	28.57
février	10	4	40
mars	20	6	30
avril	31	6	19.35
moyenne			36.04
total	184	69	

References

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HUNTER J.R., 1985: Preservation of northern anchovy in formaldehyde solution. *In* : R. Lasker (editor), An egg production method for estimating spawning biomass of pelagic fish : Application to the northern anchovy. *Engraulis mordax*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 36, 63- 65.