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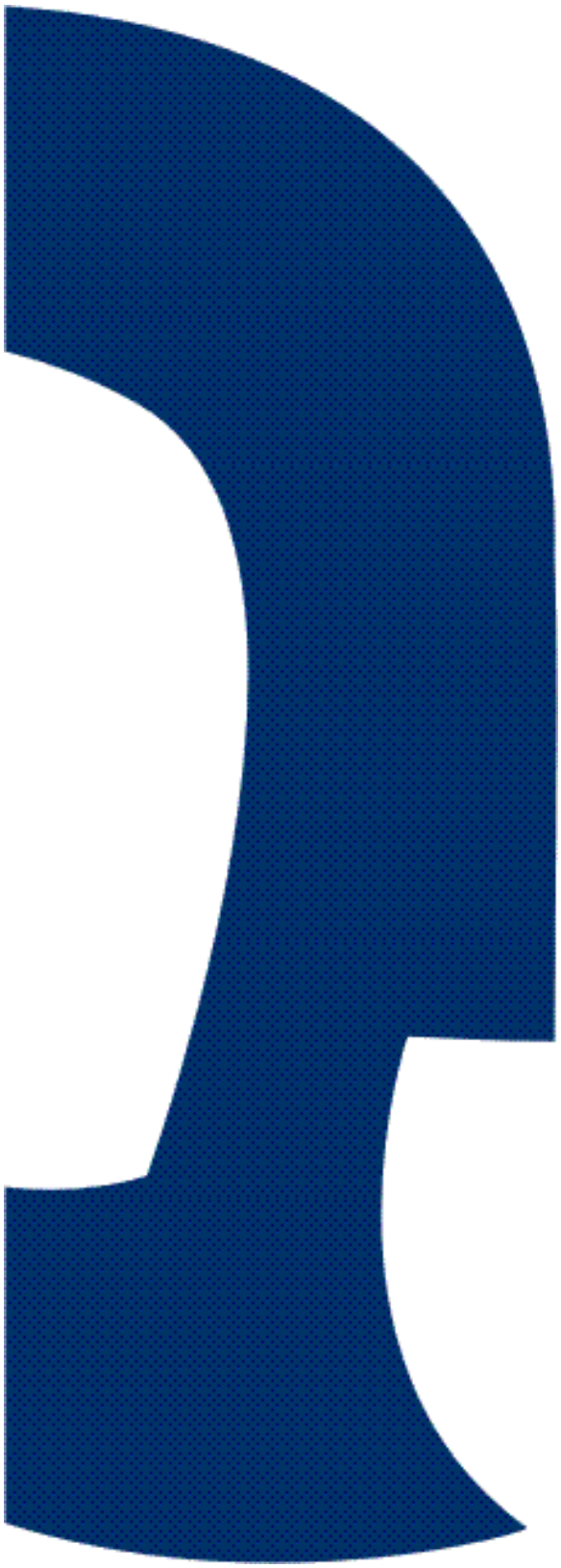

Notes on the biology of *Notoscopelus resplendens* (Richardson, 1845) off the Canary Islands

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Curso 2015/2016

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Trabajo de Fin de Grado para la obtención del título de Graduado en Ciencias del Mar por la Universidad de Las Palmas de Gran Canaria.

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Abstract

The reproductive biology of *Notoscopelus resplendens* (Richardson, 1845) is described on the base of 659 specimens caught during B/E "La Bocaina" cruisers, carried out between 1999 and 2002, off the Canary Islands. The total length (TL) of fish varied between 20.95 and 95.29 mm, while the total weight (W) ranged between 0.05 and 5.66 g. The reproductive activity was observed in January and March, while in May and November the majority of fish caught were in the process of maturation.

Off the Canary Islands *Notoscopelus resplendens* is a batch spawner with asynchronous ovarian development and indeterminate fecundity. The average size at first maturity (L_{50}) in males was 68.74 mm LT (n=115), but in females it was 73.40 mm LT (n=145). The macroscopic scale of maturation was validated through the histological analysis of the ovarian development. The sex ratio was not different of the 1:1.

KEY WORDS: *Notoscopelus resplendens*, Total length/Total weight relationship, reproduction, sex ratio, fecundity, spawning season, relative condition factor, Canary Islands, central-eastern Atlantic.

INTRODUCTION

Mesopelagic fishes are the dominant fish species in the ocean and between the vertebrates with the largest biomass in the planet (Van Noord, 2013). The total biomass of these species has been estimated in about 1000 million tons (Gjøsaeter & Kawaguchi, 1980, Lam & Pauly, 2005), but according Irigoien et al. (2014), these values may be underestimated by an order of magnitude. Moreover, these last authors estimated that the contribution of these species to the respiration in deep water would be about 10%, so their role in the ocean ecosystems and their contribution to ocean biogeochemical cycles are of vital importance.

Myctophidae is the main family within mesopelagic fish, and it is present in all the world´s oceans (Hulley, 1990a). Mycthophidae are distributed throughout the water column, from the most superficial levels during the night, to water exceeding 2000 m deep during the day, but are more frequent between 200 and 1000 m deep (the mesopelagic zone) as part of Deep Scattering Layers (DSL) (Hulley, 1990a). In addition, myctophids play an important role in energy transfer in pelagic ecosystems, linking to the planktonic organisms such as copepods, ostracods and larvaceans (Cherel et al., 2010; Pérez-Rodríguez, 2012), with pelagic fish (Greer-Walker and Nichols, 1993; Battaglia et al., 2013), cephalopods (Parry, 2006; Rosas- Luis et al., 2014), seabirds (Hedd et al., 2009) and marine mammals (Ohizumi et al., 2003). And despite the intense predation they support, the myctophids are highly abundant (Lisovenko & Prut´ko, 1987) and it is important to understand their populations dynamics, and particularly their reproductive biology (Lowerre-Barbieri et al., 2011; Irigoien et al., 2014). Furthermore, some authors suggest that the DSL itself would be a fishery resource (Shotton et al., 1997). In this context, the interest on the biology, ecology and population dynamic of mesopelagic fishes is increasing progressively (Olivar et al., 2012; Bernal et al., 2014; Cavallaro et al., 2015; Bernal et al., 2013; Battaglia et al., 2014).

Notoscopelus resplendens (Fig. 1) is a cosmopolitan species that form part of the DSL community. In the Atlantic, it is distributed from southern Britain to South Africa, including the Mediterranean, and from Newfoundland to Rio de la Plata (Hulley, 1990b). In the eastern Atlantic, the area of major abundance is reported along the African coast, including the Canary Islands (Nafpaktitis, 1975). Like many other mesopelagic species (Clarke, 1978; Giske et al., 1990; Robison, 2003; Collins et al., 2012), *N. resplendens*

migraters from the depths to the surface areas at night, crossing water with very different features (Albikovskaya, 1988).

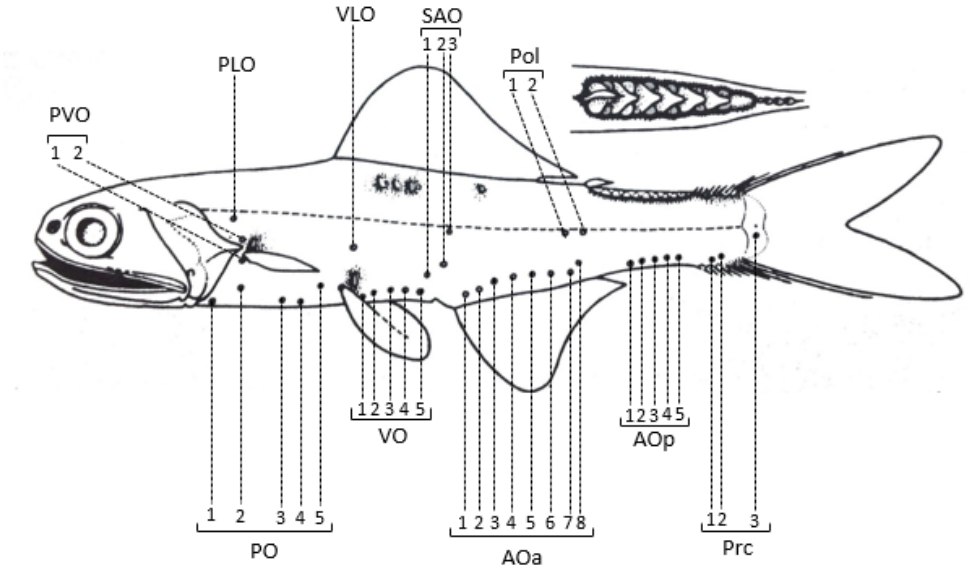

Figure 1. Terminology of photophores in *Notoscopelus resplendens* (Richardson, 1845). AOa (7-9), anterior anal organs; AOp (5-7), posterior anal organs; PLO (1-2), suprapectoral organ; PO (5), thoracic organs or pectoral organs; Pol (2-3), posterior-lateral organs; Prc (3), precaudal organs; PVO (2), subpectoral organs; SAO (3), supraanal organs; VLO (1), supraventral organ; VO (5), ventral organs. Males with supra-caudal gland only, consisting of 8-9 scale-like luminous segments. (Hulley, P.A., 1986).

In spite of abundance and importance of *Notoscopelus resplendens* in the mesopelagic ecosystem, the biology and ecology of is poor known, and most of the information is related with growth, reproduction and life cycle in the Pacific Ocean (Moser & Ahlstrom, 1996). Therefore, the aim of this study is to provide information on the reproductive biology of this species in the waters of the Canary Islands.

MATERIAL AND METHODS

The study was based on the analysis of 659 specimens caught during the 4 cruises (MESOPELAGIC 05/99, PELAGIC 01/00, PELAGIC 11/00, BOCAINA 03/02) carried out by the B/E "La Bocaina", between 1997 and 2002, off the Canary Islands in a depth range between 13 and 1035 m (Fig. 2). The specimens were caught with a commercial semi-pelagic trawl net, that was amended adding a covered cod-end of 5 mm mesh size (Bordes et al., 1998). In the last cruise (BOCAINA 03/02) this was replaced by pelagic trawl with a cod-end mesh size of 10.4 mm (Bordes et al., 2002). Fishing operations were monitored using acoustic telemetry, with a net-sounder SCANMAR which provided information on depth, vertical and horizontal opening of trawl mouth, etc.

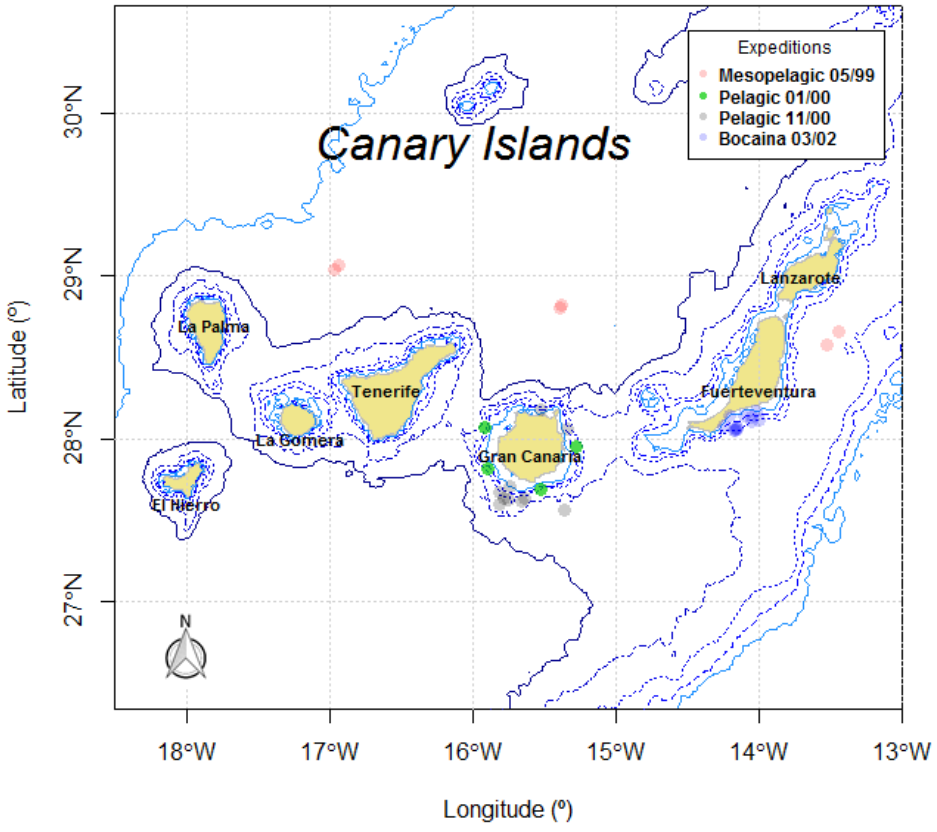

Figure 2. Sampling area conducted by the B/E La Bocaina between 1999 and 2002.

Captured specimens were labelled and stored in 70% ethanol, for later analysis. Once in the laboratory, from each fish was recorded the total length (*TL*) and fork length (*FL*), in mm, and also was taken the total weight (*TW,0.00 g*), eviscerated weight (*EW, 0.00 g*), and the gonad weight (*GW, 0.0000 g*).

The specimens were grouped into length classes of 10 mm, and the length frequency distribution was analysed, in percentage, by cruises. The relationship between the total length and the total weight, described by the potential Ricker (1973) function was calculated: $TW = a\,TL^b$, where *a* and *b* are the coefficients of relationship between both variables. To determinate the variation of the values of '*b*' covariance analysis was performed according to the method of Snedecor & Cochran (1967), where the statistical significance of isometric exponent (b) was analyzed by the function: *ts =(b-3)/Sb* (Sokal & Rohlf, 1987), where *ts* is the value of the test statistic '*t*', '*b*' is the slope and *Sb* is the standard error of '*b*'. Values obtained from the t-test and statistically tabulated values of 'b' (p-value = 0.05), were classified as isometric (b=3) or allometrics (allometric negative b < 3; allometric positive b >3).

Relative condition factor (*Kn*), as is indicative of the physiological changes that occur in the organisms, was calculated for each individuals as follows (Anderson & Gutreuter, 1983):

$$Kn = TW/W_s$$

where *Ws* its theoretical weight estimated for each individual on the basis of the length/weight relationship above.

Sex was estimated to 598 samples, due to external body dimorphism, although the state of maturity were determined for only 539 individuals through gonad macroscopic observation. The macroscopic scale of maturity was base in Arriaga et al. (1983), adapted to the specific characteristics of this species, and validate with histological analysis of gonads (Table I).

Table I. Scale sexual maturity and female histological features of N. resplendens.

Stage	Anatomical characteristics	Histological characteristics (Females)
I. Inmature/regenerating	Small gonads and filamentous adhered between the swimming bladder and the vertebral axis, in the middle area of the visceral cavity. Are protected by a wrapping adipose, are translucent and the blood supply is not visible	Small ovaries, often clear, blood vessels indistinct. Only oogonia and PG oocytes present.
II. Developing	Gonads definable to the naked eye, they occupy approximately half of the visceral cavity. In the females translucent, opaque in the males.	Enlarging ovaries, blood vessels becoming more distinct. PG, CA, and Vtg1 oocytes present.
III. Spawning capable	Gonads bulky, which can take up 2/3 or more of the visceral cavity. Visible blood irrigation, abundant and highly branched.	Large ovaries, blood vessels prominent. Individual oocytes visible macroscopically. Vtg3 oocytes present or POFs present in batch spawners.
IV. Regressing	Gonads bulky that occupy the entire visceral cavity or more than two-thirds, covering many times the intestine by their ventral part.	Flaccid ovaries, blood vessels prominent. Atresia (any stage) and POFs present. Some CA and/or vitellogenic (Vtg1, Vtg2) oocytes present.

Vtg1 primary vitellogenic oocyte, CA cortical alveolar oocytes, Vtg2 secondary vitellogenic oocyte, Vtg3 tertiary vitellogenic oocyte, PG primary growth oocyte, POF postovulatory follicle complex, OW ovarian wall.

The sex rate was calculated for the whole sampling period and by cruise, and estimated if these rates were significantly different from the theoretical ratio 1:1 through the chi-square test. Moreover, the maturity curve, and the lengths at first (L50) and massive maturity (L95) (sensus Vazzoler, 1996), for both sexes were calculated. We calculated the percentage accumulated by size class of mature individuals. The data obtained were adjusted to a normal cumulative curve by analysis of iterative nonlinear regression. Furthermore, in order to detect possible differences between the lengths of first maturity of males and females, a test comparison of means was performed. The data were fixed to a logistic model as follows:

$$P_r = \frac{100}{1 + e^{-r\,(L-L50)}}$$

where *Pr* is the percentage of sexually mature individuals, *r* is a constant that indicates the slope of the curve, L_{50} is the length at which 50% of individuals were mature, and *L* is the fish length (at the x-axis) for which is calculated the *Pr*.

To determine the spawning season, the gonads of individuals were monitored over time, and the average monthly values of Gonadosomatic Index (*GSI*) was calculated. This was calculated for each specimen, as the relationship between *GW* and *TW* (see Anderson & Gutreuter, 1983). That is to say:

$$GSI = \left(\frac{GW}{TW}\right) 100$$

Another method used to determine the spawning season is based on the analysis of variations of the frequency of individuals in each stage of maturity, which was determined by macroscopic observation. To do this, the number of fish in each stage of maturity and their frequencies, expressed in percentages, per season was calculated.

A total of 50 ovaries were fixed and preserved in 4% buffered formaldehyde for their histological analysis in order to verify the previously assigned macroscopic maturity stages. For this, the fixed tissues were dehydrated in a series of ethanol solutions, cleared in xylene, and then embedded in paraffin in a vacuum chamber. Slices of tissue were sectioned at 4 µm, and stained with Harris hematoxylin followed by eosin counterstaining (Luna, 1968). To describe the scale of gonadal maturity, it was used the standardizes nomenclature given by Brown-Peterson et al. (2011) with the pertinent modifications for this species.

Finally, 142 samples of female gonads were collected in order to estimate the total fecundity (Hunter et al., 1992), and 84 samples for batch fecundity (De Vlaming, 1983) through the gravimetric method. According to Murua et al. (2003), the fecundity (F) was determined as the product of gonadal weight and the number of eggs per gram of ovarian tissue (ovarian density). The ovarian density is determined by counting the number of oocytes (O_i) present in a sample of ovarian tissue.

To evaluated the proportion of the subsample in which the oocytes are extracted, as a rule, it is sufficient when the coefficient of oocytes per unit weight is less than 5% (Hunter et al., 1985; Kjesbu, 1989). The oocytes were manually released from the ovarian stroma, and then counted using an stereoscopic microscope. To estimate the total fecundity, total oocytes were counted in vitellogenic (Hunter et al., 1992), while for batch fecundity counted only hydrated oocytes (*H*) (De Vlaming, 1983).

The statistical analysis was performed using the statistical package IBM SPSS Statistics for Macintosh, Version 22.0.

RESULTS

Length Frequency Distributions

The length frequency distribution shows the presence of two predominant groups of lengths along the sampling period. In most of the samples (May 1999 and November 2000) predominated individuals of relative small size (smaller than 60 mm TL), but in March 2002 larger fish were more abundant (larger than 65 mm TL) (Fig. 3). The sex ratio in each length group was 1:1.

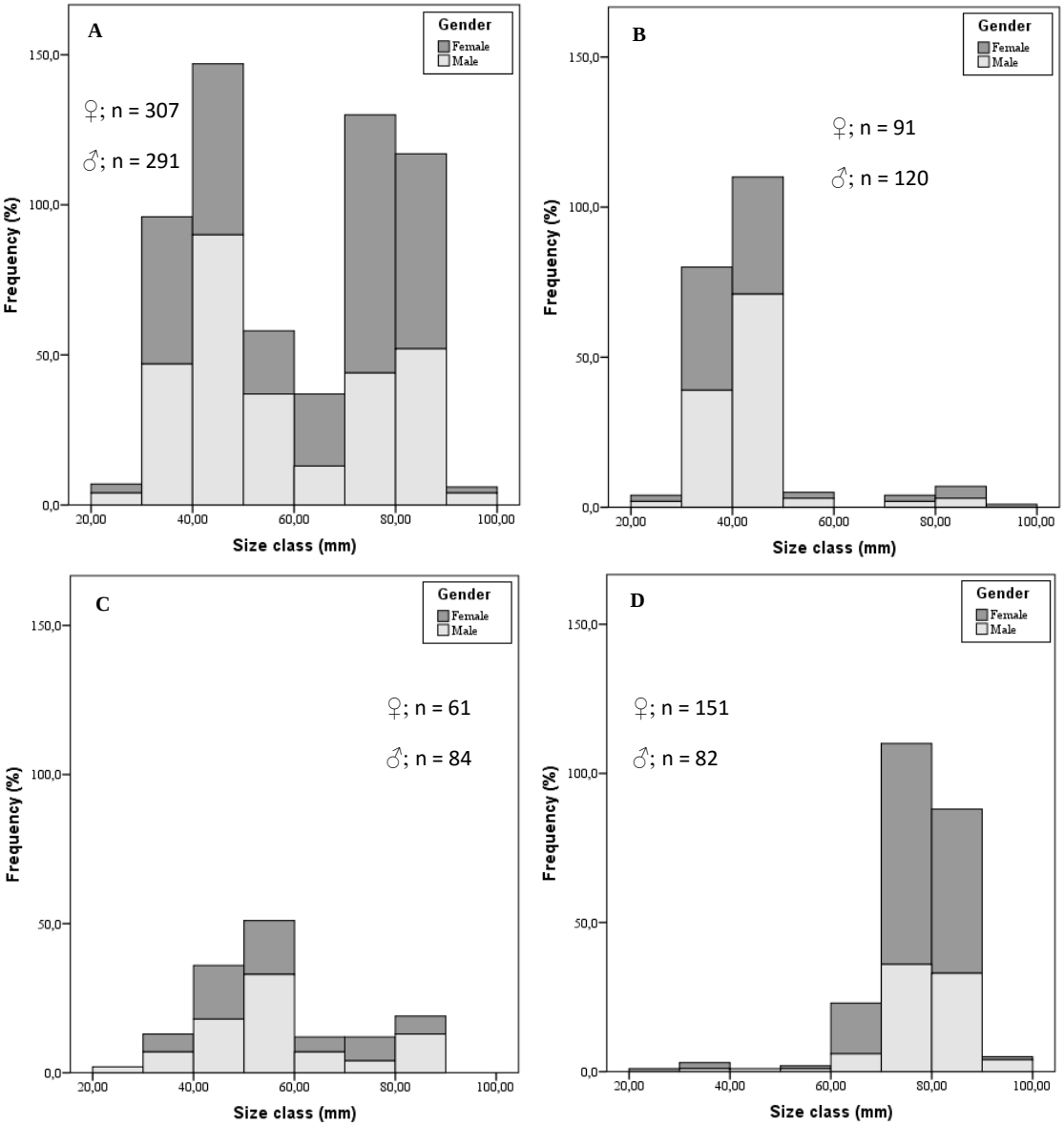

Figure 3. Distribution of size frequencies per cruises: (A) All sampling period, (B) May 1999, (C) November 2000, (D) March 2002.

Length-Weight relationship

For the observed length range (20.95-95.29 mm TL), weight ranged between 0.05 and 5.66 g. Thus, the relationship between the total length and the total weight, for the all sampled specimens (n= 659) is expressed by the equation:

$$P = 1.08\ E-05\ L^{2.869} \qquad (R^2 = 0.965)$$

On the other hand, this relationship by sex is described by the equations $P=1.97\ E-06\ L^{2.725}$ for females (n=307; R^2=0.964), and $P=6.44\ E-06\ L^{2.996}$ for males (n=291; R^2=). However, while males showed isometric growth (t-test, b t=1.972, p>0.05), females followed a negative allometric development (t-test, b t=1.972, p<0.05) as well as the whole population (t-test, *b* t=1.972, p<0.05) (Fig. 4).

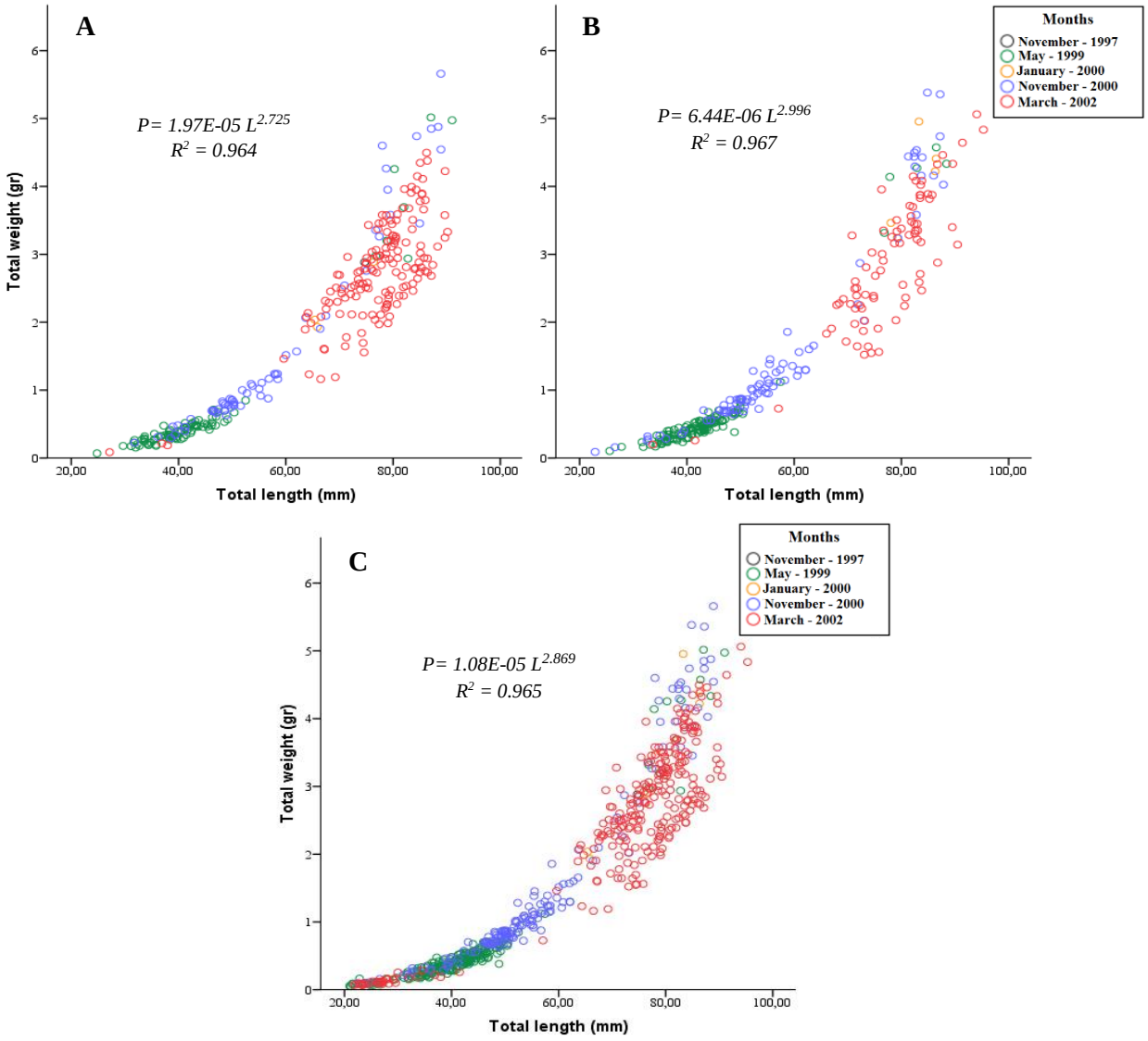

Figure 4. Total length/Total weight relationship: (A) Females, (B) Males, (C) All individuals, for each cruises in Canary Islands between 1997 and 2002.

Relative conditions factor (Kn)

Kn values ranged between 2.5 and 0.5 (Fig. 5). The 44% of females (n=22) and 56% of males (n=28) captured in May 1999 showed relatively high values of Kn, particularly in the length group larger than 60 mm TL. This larger group also showed values of Kn higher than 1 in January 2000. However, in November 2000 the 43.48% of females (n= 40) and 56.5% of males (n= 52) have a Kn higher than 1, but in the whole range of lengths. Finally, in March 2002 the 61.47% females (n= 75) and 38.53% of the males (n= 47) show Kn values higher than 1, but in the length range between 60 and 90 mm TL.

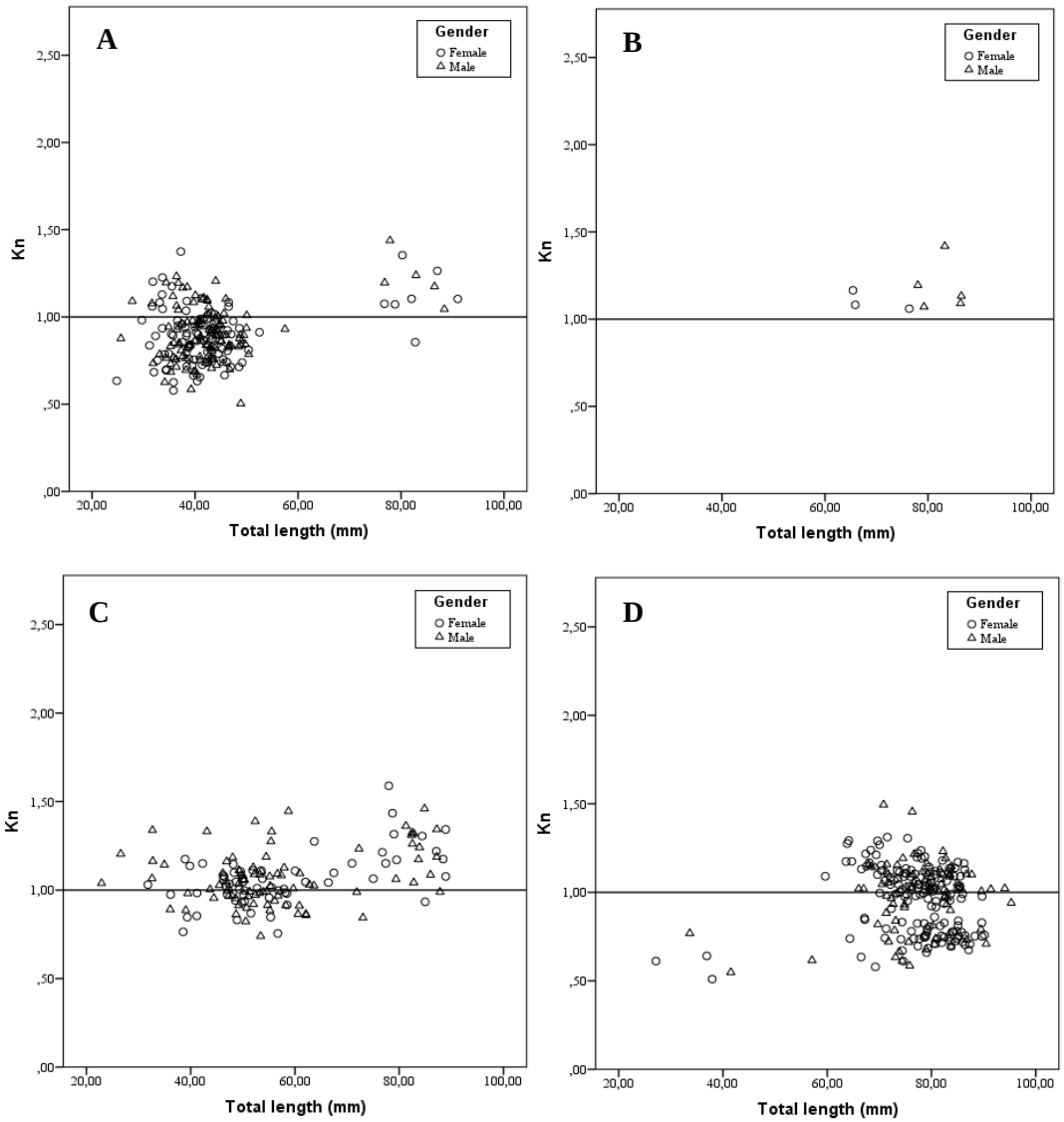

Figure 5. Variation of relative condition factor (Kn): (A) May 1999, (B) January 2000, (C) November 2000, (D) March 2002, throughout the range of sizes available for *N. resplendens.*

Sex ratio

In general, the sex ratio of *Notoscopelus resplendens* off the Canary Islands was not different than 1:1 (Chi-square =0.40; N= 598; p>0.05). Only in May 1999, males significantly predominated in the fish sample (Chi-square= 3.98; N= 211; p<0.05), but in March 2002 predominated the females (Chi-square= 20.43; N= 233; p<0.05).

Size at first maturity

From the total of sexed individuals (n=598), the 43.47% of them were mature. Although the caudal gland in males was observed from the 33.63 mm TL, the average lengths at first maturity (L50) were estimated at 68.74 and 73.40 mm TL for males (n=115) and females (n=145), respectively. That is to said, females mature at a larger size than males (t-test, p<0.05). Moreover, the length of massive maturity (L95) was reached at 76.94 mm TL in males, and at 84.95 mm TL in females (Fig. 6).

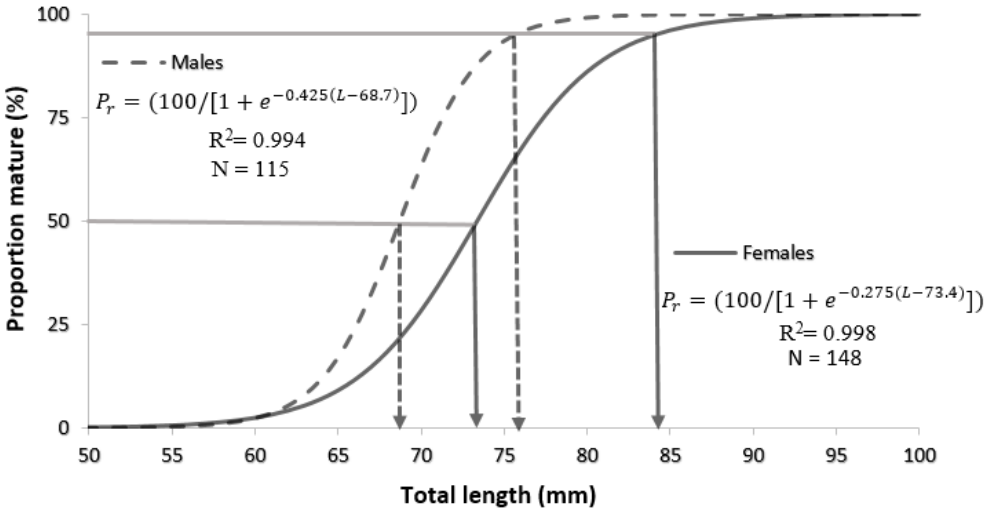

Figure 6. Curve sexual maturity for females and males.

Spawning season

In all samples were observed fish at stage III (Spawning) and IV (Regressing) (Fig. 7). Moreover, in May 1999 and November 2000, a relatively high proportion of spawning individuals were recorded. However, in January 2000 and in March 2002 fish were observed in spawning and regressing stages.

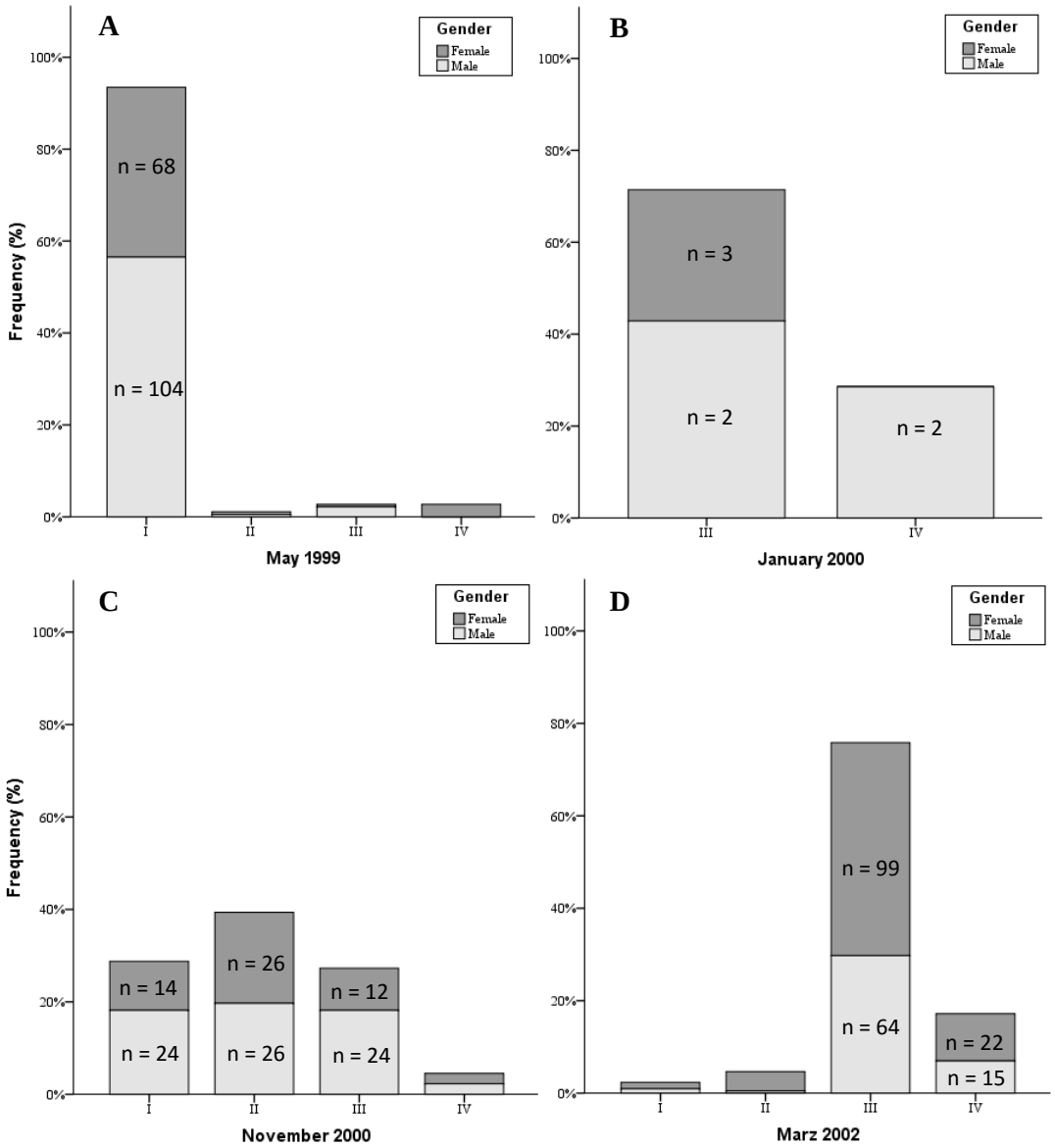

Figure 7. Variation state of maturity for females and males (A) May 1999, (B) January 2000, (C) November 2000, (D) March 2002.

Although the maturing process does not seem to occur continuously in the length range larger than 65 mm TL, it was observed that the temporal evolution of GSI was simultaneous in males and females (Fig. 8), with the exception of larger length classes in November 2000.

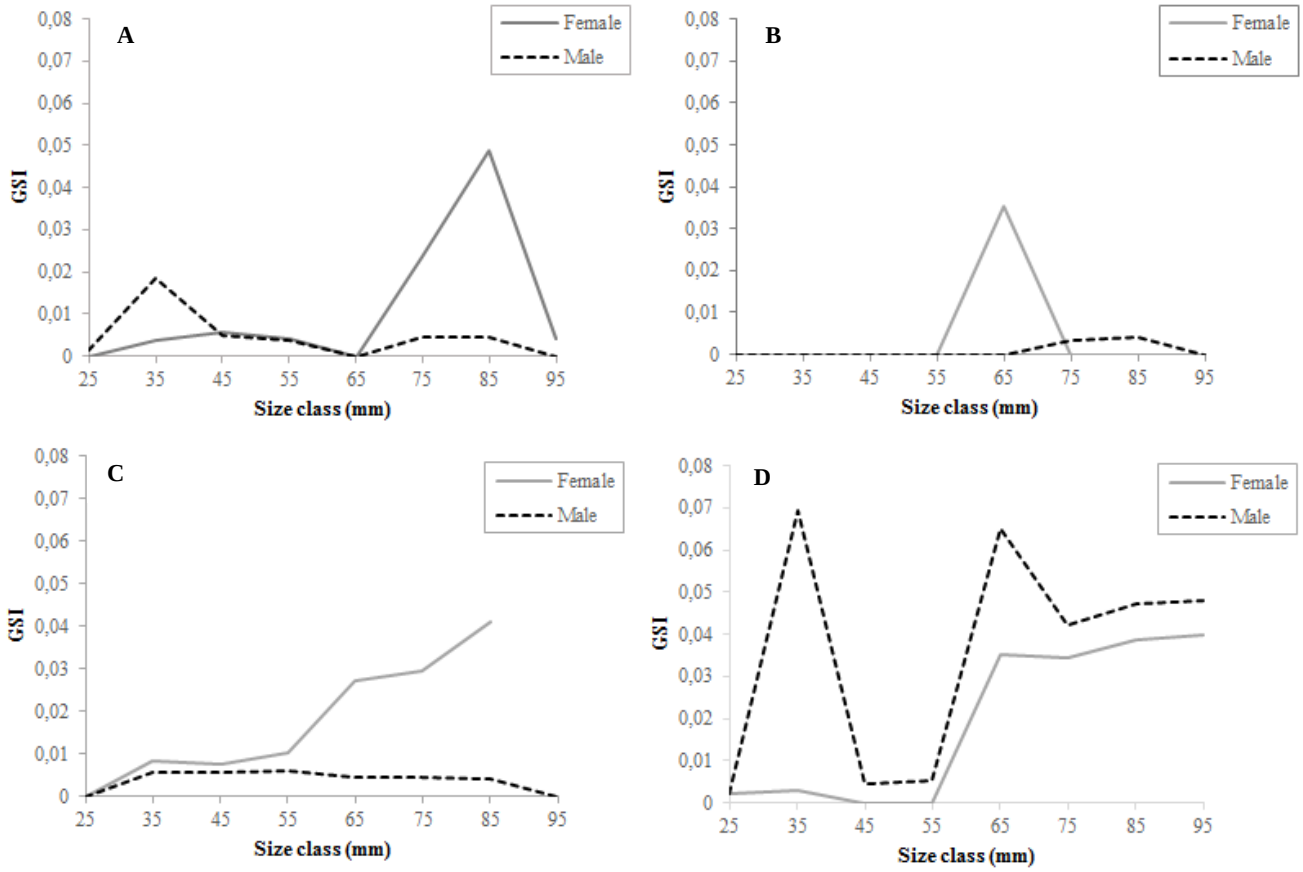

Figure 8. Variation of Gonadosomatic index: (A) May 1999, (B) January 2000, (C) November 2000, (D) March 2002, throughout the range of sizes available for *Notoscopelus resplendens*.

Histological analysis

The description of five different stages of development in female gonads was performed, and the macroscopic observations were validated with gonad tissue histology. In table 1 are described the main macroscopic and histological features of each maturity stage. *Notoscopelus resplendens* is a batch spawner with asynchronous ovarian development.

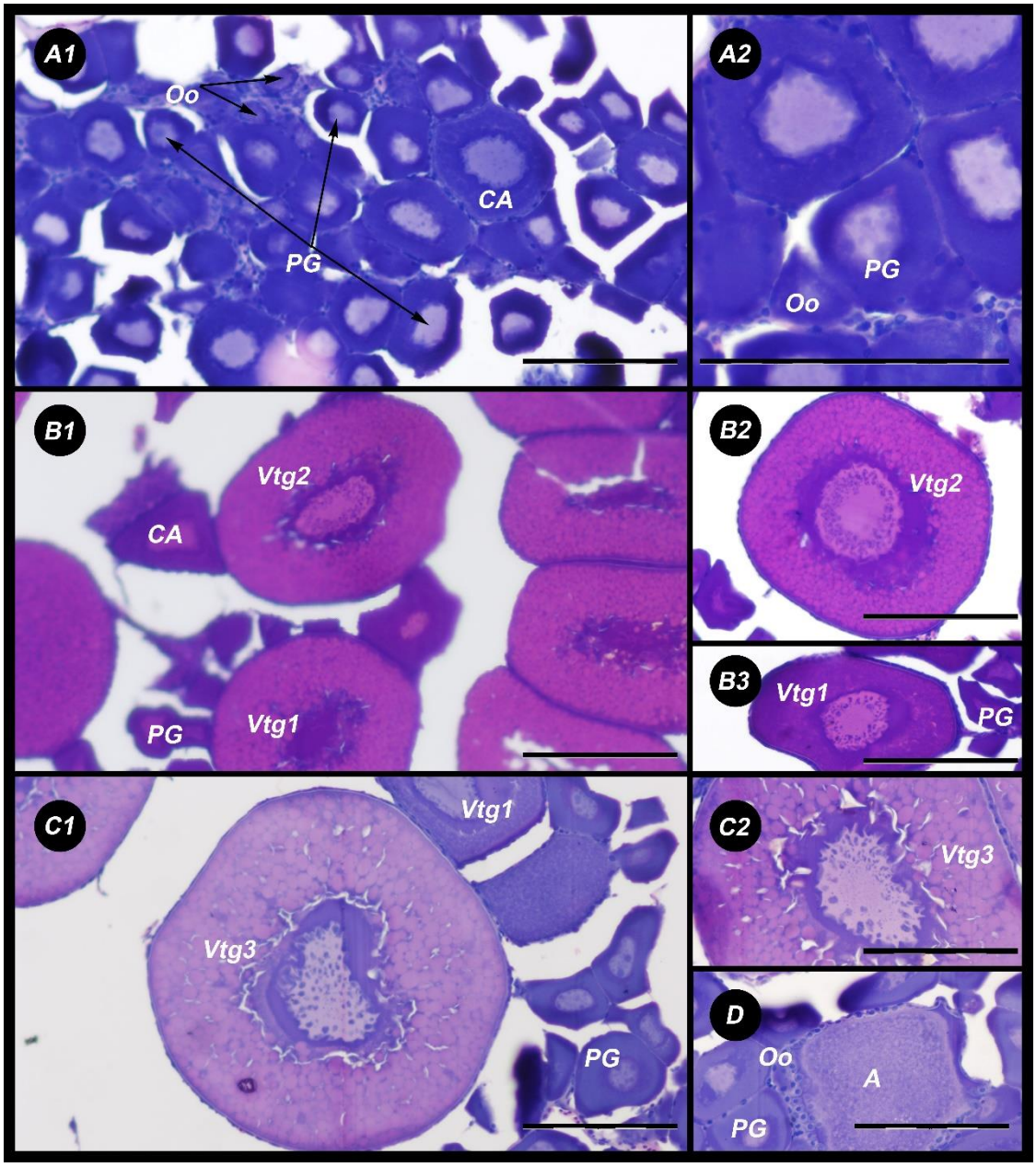

Figure 9. Histological sections of female gonads: (A) Immature, A1, A2=Oo: Oogonia, CA: cortical alveolar oocytes, PG: Primary growth oocyte (B) Development, B1,B2,B3= CA, PG, Vtg1= primary vitellogenic, Vtg2= secondary vitellogenic (C) Spawning, C1, C2, C3= Vtg1, PG, Vtg3: tertiary vitellogenic. (D) Regression: Oo, PG, A: Atresia (Scale bar = 50 micron (**µm)**).

Fecundity

The total fecundity (TF) and batch fecundity (BF) was related to TL. The total fecundity of mature females (stages III and IV, between 60.03 mm and 90.17 mm TL), was described by the equation $TF= 0.1196\ TL^{2.2779}$ (n= 142; R^2=0,7379), with an average of 2529.14 ± 512.84 eggs (range= 2444.49 – 2613.79). However, for females between 74.71 mm and 90.17 mm TL, batch fecundity was described by $BF= 6E\text{-}07\ LT^{4.8478}$

(n=84; R^2=0,7187), with an average of 1068.69 ± 369.84 eggs/spawn pulse (range= 1089.24 – 1248.05) (Fig. 10).

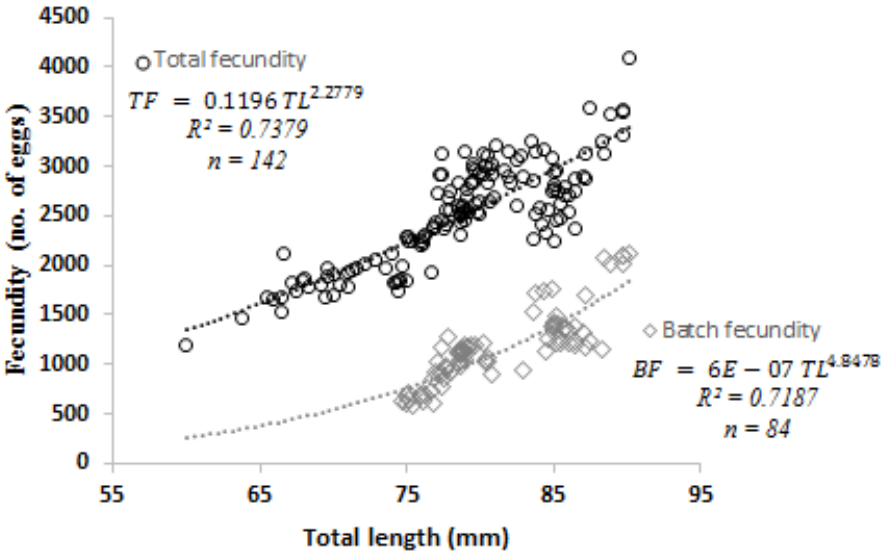

Figure 10. Relationship between the total and batch fecundity with the total length of *Notoscopelus resplendens*.

DISCUSSION

The specimens of *Notoscopelus resplendens* caught in waters of the Canary Islands between, 1999 and 2002, ranged from 20.95 and 95.29 mm TL, while the total weight (TW) varied between 0.050 and 5.660 g.

The bathymetric distribution observed (from 13 to 1035 m depth) during cruises by B/E La Bocaina were similar than reported by Fischer et al. (1987) for *Notoscopelus elongatus* (from 375 to 1000 m depth during the day, and from 45 to 150 m depth during the night). In this regard, it should be noted that *N. resplendens* off Canary Islands were caught between 700 and 2000 m deep during the day (juveniles were found in shallower water), while in the night the depth range decreased from 10 to 100 m deep (Hulley, 1986).

While females showed a negative allometric growth, this was isometric in males. However, the value obtained from allometric coefficient for all specimens (b=2.87) is quite similar than estimated by Gjøsaeter (1981) in *Notoscopelus elongates kroeyeri* in the Northeast Atlantic. This similarity in the way of growing of both species may be due to characteristics of the genus *Notoscopelus*, as determined by the environmental characteristics where both species inhabit (deep and cold waters), and the pattern of daily migration along the water column (Hulley 1986; Fischer et al., 1987).

The proportion of males and females in the sample obtained was similar, but we are not able to exclude any differences in their proportionality according to season or depth range. In this regards, in May 1999 a greater number of males were captured, while in March 2002 the sex ratio was favorable to females. These differences in the sex ratio over the months, and even with the seasons and depth intevals, has been observed in several species of myctophids, such as *Benthosema pterotum* (Dalpadado, 1983).

Hulley (1986) found that in male *Notoscopelus resplendens* the large supra-caudal gland begins to develop at 41 mm, reaching sexual maturity at 66 mm TL, but we determined that this gland begins to develop at a smaller length (33.63 mm TL). However, the average length of first maturity of males estimated for this species off the Canary Islands, from the macroscopic observation of gonadal development, was quite similar to that given by Hulley (1986). Thus, the estimated length at first maturity in the Canaries for males was 68.79 mm TL, and 73.40 mm TL for females. Although information about sex differences in growth is not available for *N. resplendens*, females of several species

of myctophids grow faster than males and reach a larger length (Linkowski et al., 1993; Linkowski, 1997; Greely et al., 1999).

Notoscopelus resplendens shown reproductive activity during winter (January to March), and the histological analysis of the females gonads indicates that this species has an asynchronous ovarian development and is a successive batch spawner. The GSI was higher in fish larger than 60 mm TL. Moreover, the specimens caught showed relatively high values of Kn in late autumn and winter, while in early spring the proportion of individuals with Kn lower than 1 was significantly important, particularly in fish of large sizes. In this regards, Gjøsaeter, (1981), reported that Kn variations in *N. elongatus kroeyeri* were related with the spawning season. Also, Sabatés & Masò (1990) found that for this species in the Mediterranean, the Kn declined in the spawning season, and it occurs from Winter to Spring, with a pick in April. Therefore, the weight loss observed in specimens of *N. resplendens*, during the cruises in late Winter and early Spring, is related with the end of the reproductive season of this species in waters of the Canary Islands, due to decreased reproductive tissue (Maldonado-Ocampo et al. 2005). Moreover, it agree with Hulley (1986), who indicated that the reproductive season of this species off Bermuda take place between late Autumn and Winter.

On the other hand, *Notoscopelus resplendens* presents batch fecundities similar to than other myctophids (Nakamura, 1970; Dalpadado, 1988; Gartner, 1993; García-Seoane et al., 2014; Sassa et al., 2014). Batch fecundities vary from 578 to 2122 eggs in fish between 74.71 and 90.17 mm TL, a length range larger than reported for other species of the same family of similar size. However, though *N. resplendens* shows sizes higher than other myctophids, it produces a similar eggs production, and consequently may have a higher energy cost for reproduction (Sassa et al., 2014). Regarding the total fecundity, Chiyuki Sassa et al. (2014) found that, in the Pacific, *Benthosema pterotum* shows similar values (2854 ± 87 eggs) to those found in for *N. resplendens* off the Canary Islands.

CONCLUSION

1. *Fish of Notoscopelus resplendens caught* off the Canary Islands showed a length range between 20.95 and 95.29 mm TL, a total weight (TW) that varied between 0.05 and 5.66 g, and were present between 13 and 1035 m depth.
2. The males showed isometric growth (b=2.996), while females showed a negative allometric growth (b=2.725) as the all specimens (b=2,87).
3. The sex ratio was 1:1, but cannot be exclude any seasonal differences from this ratio.
4. The caudal gland began to develop at 33.63 mm TL. The L50 was estimated to be 68.79 mm and 73.40 mm TL for males and females, respectively.
5. *Notoscopelus resplendens* shows reproductive activity during Winter-Spring (January to March). The species is an asynchronous spawner with successive pulses of spawning.
6. The GSI was higher in fish ranged between 60 and 80 mm TL. Moreover, the Kn values were high during ending autumn and winter, while in early spring the proportion of individuals with values less than 1 was significantly important, particularly in large sizes fish.
7. Partial fecundities ranged from 578 to 2122 eggs in fish between 74.71 and 90.17 mm TL.

ACKNOWLEDGEMENTS

Firstly, I would like to thank my tutor, Jose Juan Castro Hernández, for his advice and recommendations, which I have served as a guide to carry out this document. Thanks so much for giving me your valuable time.

On the other hand, I also want to thank all those who, during my cycles of practices and development of my final degree project, have been offered and have provided me with their support to resolve any of my concerns. In this sense, to thank, D. Fernando Bordes Caballero and D. Antonio Barrera-Lujar for putting at my disposal samples of fish from research surveys, which have been indispensable to develop this project.

Also, I am grateful to the Marine Sciences Faculty for these four years of intense training, to all my teachers, both of theoretical classes and practices, who have helped make me someone else who is prepared and responsible.

Last but not least, to thank my family and friends, love and support at all times, and particularly in this last course, when I needed them more than ever. I feel very proud of being surrounded by so many valuable people.

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Anexe

Anexe I: Memoria Final del Trabajo Fin de Grado (TFG)

Descripción de las actividades desarrolladas durante la realización del TFG

El trabajo se realizó en la Facultad de Ciencias del Mar, en la Universidad de las Palmas de Gran Canaria. En el laboratorio (B-203) donde comencé con el Dr. José Juan Castro Hernández en el año 2013/2014, una intensa labor de formación científica que culminé con la elaboración de varios trabajos sobre la biología y distribución de peces de la Capa de Reflexión Profunda en aguas del Archipiélago Canario. Estos trabajos que fueron presentados en el IV Simposio Internacional en Ciencias Marinas (Las Palmas de Gran Canaria entre el 11 y 13 de junio de 2014) como posters, motivaron mi interés para seguir investigando sobre estos peces y así elaborar este trabajo. Para ello me encargué:

- Búsqueda de artículos de uno de los mictófidos más abundantes de las aguas del Archipiélago canario.
- Recolectar de todas las muestras que estaba a mi disposición la especie de interés.
- Toma de datos de los caracteres biométricos:

    a) Los ejemplares fueron medidos con ayuda de un calibrador hasta el milímetro más próximo, determinando así la longitud total y longitud furcal.
    b) Igualmente, cada pez fue pesado para obtener el peso total.
    c) Se extrajeron las gónadas, distinguiendo el sexo en aquellos que era posible. Las gónadas también fueron pesadas.
    d) En caso de las hembras, se separaron los ovocitos del tejido y luego fueron contados.
    e) Extracción del contenido estomacal e identificación del contenido.
    f) Realización de los cortes histológicos.

- Procesamiento de los datos:

Para procesar los datos se hizo uso del paquete estadístico IBM SPSS Statistics versión 22.0, donde adquirí ciertos conocimientos en la optativa de PESQUERÍAS. Los datos se procesaron a fin de obtener información sobre la biología reproductiva de la especie a partir de:

a) Distribución por campañas de las frecuencias de talla.
b) Relación Longitud Total/Peso Total.
c) Factor de condición relativo.
d) Proporción de sexo.
e) Talla de primera madurez.
f) Época de desove.
g) Cortes Histológicos
h) Fecundidad.

También se utilizó el programa R (V.3.1.2; R Core Team, 2014) para elaborar los distintos mapas que representan las campañas que se llevaron a cabo, donde se hizo constar los distintos lances donde se capturaron ejemplares de la especie de interés, así como la dirección y longitud de los lances.

Formación recibida

Durante la realización de mi trabajo de fin de grado, adquirí conocimientos sobre distintos aspectos. En primer lugar, se me explicó la mejor manera de cómo manejarme en el laboratorio, ya que, en el mismo laboratorio trabajaban otros alumnos de diferentes proyectos y que compartíamos material.

Conocer el funcionamiento de los distintos aparatos que eran importante para las medidas de los caracteres merísticos, como calibres manuales y digitales, la balanza digital y las distintas lupas con sus respectivos focos integrados. Se me aportó el conocimiento oportuno de la estadística necesaria para realizar los apartados que figuran en este trabajo, donde para ello los conocimientos que tenía sobre el paquete IBM SPSS Statistics eran insuficientes, lo cual también obtuve prácticas de dicho programa.

Por otro lado, adquirí formación básica de como bucear en diferentes revistas científicas y libros, que fueron necesarios para aportar una correcta información al trabajo.

En ocasiones, cuando algunos resultados no salían como esperaban, largas explicaciones de cómo deberían salir también aportaban formación y conocimiento.

Nivel de integración e implicación dentro del departamento y relaciones con el personal.

El nivel de integración e implicación dentro del departamento y relaciones con el personal fue bastante satisfactorio. Desde el principio, tanto mi tutor, como aquellos investigadores que componen el departamento, que en los inicios no tenía relación alguna, se mostraron bastante receptivos e interesados en los que estaba haciendo en el laboratorio. El tutor, bastante cercano y siempre con una actitud positiva y atenta para dirigir mis dudas en los momentos en los que surgían, tanto en su despacho, como en el laboratorio, en los pasillos de la facultad y mediante el correo institucional, han hecho que la relación y el trabajo que se realizaba, siempre fuese grato.

Cabe destacar que, en todo momento se me trató como uno más en el departamento. Se puede reflejar, ya que, sin conocerme se me puso a mi disposición las muestras de los ejemplares que necesitaba y en muchas ocasiones algunos investigadores, doctorandos y alumnos tanto de grado como de licenciatura se acercaban, en bastantes ocasiones a ayudarme y en otras para aconsejarme. Este trato en el departamento hizo que nunca me sintiera desplazado y por lo tanto fue una motivación extra para el trabajo diario.

Aspectos positivos y negativos más significativos relacionados con el desarrollo del trabajo de fin de grado.

Aspectos positivos: aprender a trabajar en equipo ha sido lo más importante en esta experiencia. Aunque durante en el transcurso de la carrera se hacen trabajos en grupos, con este trabajo, me he dado cuenta del trabajo que existe detrás de la investigación, donde en la enseñanza no es posible de apreciar.

El trabajar en equipo me ha servido para adquirir una mayor disciplina de trabajo, aprendes a ser más responsable, ya que, si fallas puedes poner en riesgo el trabajo que se hace conjuntamente. También, conocer bastantes investigadores de tu mismo ámbito de trabajo, proyectos de investigación asociados al ámbito que me interesa, e incluso, conocer investigadores que hacen trabajos parecidos y poner nuestros propios puntos de vista y compartir ideas que surgen con los estudios elaborados, me han servido para

valorar mi trabajo, como motivación para seguir adelante con mi formación y para sentirme en ocasiones como un investigador más.

Aspectos negativos: el poco tiempo que tenemos para realizar estos proyectos. Creo que para realizar una buena investigación se necesita más de un trimestre.

Valoración personal del aprendizaje conseguido a lo largo del trabajo de fin de grado.

Ha sido una experiencia enriquecedora y necesaria en nuestro grado. Enriquecedora porque aprendes todo aquello que no ves y está detrás de esos resultados que trabajamos día a día en las clases teóricas o prácticas. Elaborar tus propios resultados, procesarlos y sacar conclusiones que pueden ser válidos o no, es lo que te hace reconocer tu trabajo y el trabajo de los demás científicos que a veces por cuestiones de gustos o porque simplemente no se comprenden, no los tratamos con cariño. Y necesario porque estos tipos de trabajo son primordiales en ciencia.

Sentir que puedo ser capaz de elaborar un trabajo de estas características aplicando todo lo aprendido durante el curso y compaginarlo, además, con prácticas de laboratorio en la que también aprendes a trabajar en equipo, ha sido increíble.