International Council for the Exploration of the Sea

C.M. 1998/O:23
Deepwater fish and fisheries

Reproduction of Black and White Anglerfish (*Lophius budegassa* Spinola, 1807; *Lophius piscatorius* Linnaeus, 1758) in the southern stock (ICES Divisions VIIIc and IXa)

by

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ABSTRACT

The reproduction of black anglerfish (*Lophius budegassa*) and white anglerfish (*L. piscatorius*) is studied from data collected between July 1996 and June 1997 in Portuguese and Spanish waters (ICES Divisions VIIIc and IXa). The sampling program was established by the EC Study Project 95/038 "Biological Studies of Demersal Species". A total of 1361 Black Anglerfish ranging from 5 to 89 cm and 1297 White Anglerfish ranging from 11 to 129 cm were sampled. The gonad maturity was visually classified into 5 stages. Black Anglerfish sex ratio analysed by length indicates that till 40 cm no sex is predominant, between 40 and 52 cm males represent more than 50% and over 52 cm females are predominant. Individuals over 70 cm are 100% females. Sex ratio by quarter for this species shows no variation along the year, being the female-male proportion very close to one. White Anglerfish shows a slightly higher percentage of males in lengths between 60 and 75 cm, after which females proportion increases until reaching the 100 % in the length class of 100 cm. For this species it is observed that during the 4th quarter 96 and the 1st quarter 97, both the proportion of males from 35cm to 60 cm and females greater than 60 cm is smaller than during the rest of the year. This variation can be related to a reproductive migration outside the studied area. The proportion of the maturity stages in each two months interval is analysed by sex, the results suggesting that for Black Anglerfish the spawning season takes place mainly between November and February. For White Anglerfish spawning males were observed along the year and spawning females were not observed. The spawning period based on mature females could be globally defined between January and June. Maturity ogives are analysed by length and age, for each sex and for combined sexes. The obtained lengths at first maturity (L50%) for Black Anglerfish were: 54.8 cm for females, 38.6 cm for males and 44.7 cm for combined sexes. For the same species, the obtained age at first maturity were 9 years for females, 7 years for males and 8 years for combined sexes. For White Anglerfish the male L50% was estimated as 50.5 cm and the obtained age of first maturity for males was around 6 years. For females the obtained values are respectively 93.9 cm and 14 years. These high female values are of poor reliability due to the low sampling of mature females. For this reason values for combined sexes were not estimated. A discussion of these results is made and a comparison with previous values for the same stocks and for the northern stocks is performed. A comparison with values used in the ICES W.G. assessment is also performed.

Key words: Reproduction, maturity ogives, sex ratio, Anglerfish, *Lophius budegassa, Lophius piscatorius.*

1. Introduction

Black Anglerfish (*Lophius budegassa* Spinola, 1807) and White Anglerfish (*Lophius piscatorius* Linnaeus, 1758) are two important species in the European fisheries. They are very similar, just distinguishable by the peritoneum colour (*L. budegassa* black and *L. piscatorius* white) or by the ray number of the second dorsal fin (*L. budegassa* 9-10 and *L. piscatorius* 11-12) (Caruso, 1986). Black and White Anglerfish are typical demersal species, living in the bottom, the former having a depth range between 70 m and 800 m and the later going deeper to 1000 m (Dardignac, 1988; Azevedo & Pereda, 1994). Their distribution area is very similar, Black Anglerfish has a more southern distribution (Mediterranean and eastern North Atlantic from British Isles to Senegal) compared to White Anglerfish (Mediterranean, Black Sea and eastern North Atlantic from Barents Sea to the Straits of Gibraltar). In the eastern North Atlantic this wide distribution area is divided for stock assessment purposes according to Figure 1.

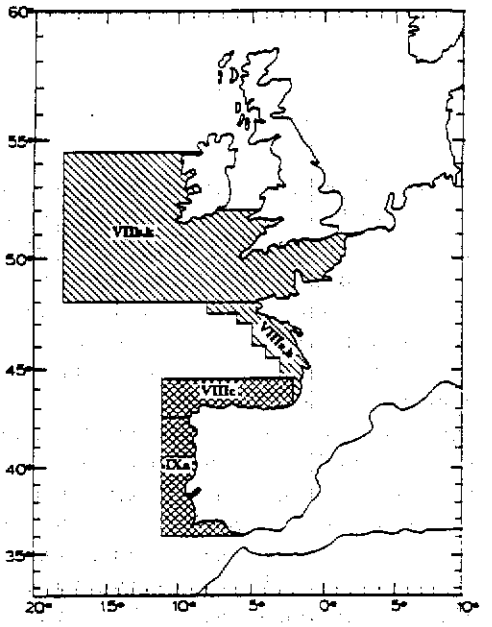

Figure 1: Anglerfish stocks geographical areas: nortern stocks (ICES Divisions VIIb, k and VIIIa, b) and southern stocks (ICES Divisions VIIIc and XIa)

Although a number of papers have been published describing various aspects of the biology of both Anglerfish species, the majority is for the northern distribution area and is based on a low sampling number of individuals. Also, there are still a lot of unknown aspects in the biology of both species that need to be investigated. In the southern distribution area, studies were developed concerning different aspects of the biology and ecology of both species: growth (Landa & Pereda, 1997; Duarte, *et.al.* 1997; Landa *et.al.*, 1998); reproduction (Azevedo, 1996a; Pires, 1996; both only for Black Anglerfish), feeding habits (Olaso et.al., 1982; Pereda & Olaso, 1990; Azevedo, 1996b) and area / depth distribution (Caruso, 1985; Vasconcelos et.al., 1986; Vasconcelos, 1990; Azevedo & Pereda, 1994; Azevedo, 1995; Pereda & Landa, 1998)

The aim of this study is to present the results of the reproductive biology of both Anglerfish species, after a one year sampling program in the Iberian coast (southern distribution area). Data were collected by the sampling program established for the EC Study Project 95/038 "Biological Studies of Demersal Species" (Azevedo & Duarte, 1998; Landa & Pereda, 1998)

2. Materials and Methods

Sample source

The sampling period had it's beginning in July 96 and finished in June 97, completing one year. Samples were taken on board of IPIMAR and IEO research surveys, on board of commercial vessels, on landings of commercial vessels and by buying ungutted individuals. The sampled area covered ICES Divisions VIIIc and IXa, the depth strata ranging between 50 m and 800 m, approximately.

For the reproduction study of both species, the total length (cm) was collected, the sex was identified (male, female and undetermined) and the gonad maturity was analysed for each specimen. A total of 1361 Black Anglerfish ranging from 5 to 89 cm and 1297 White Anglerfish ranging from 11 to 129 cm were sampled. Part of the growth study results obtained by Landa *et.al.* (1998) was used in this study to obtain age maturity ogives.

Sex identification

Anglerfish does not present a sexual dimorphism and therefore sex identification is just possible by analysing the gonads. The characteristics used to identify each sex are described in Table I.

Table I: Sex identification for both Anglerfish species

Males	Females
Tube-shaped gonad being white the dominant colour	Band-shaped gonad linked to the abdomen by a transparent membrane. Colour usually orange but dependent on maturity stage.

The sex ratio is analysed considering two important components:

- The variation of the sex ratio by length, because males and females have different growth rates.
- The variation of the sex ratio along the year, to see if the female – male proportion is the same.

Gonad maturity

The gonad maturity was analysed macroscopically and a five-stage maturity scale (Table II) was used to classify each gonad. The external aspects used to categorise each gonad was for males: size, colour and presence of sperm and for females: size, colour and presence / quantity of oocytes.

Table II: Gonad maturity stages by sex for both Anglerfish species

Maturity stage	Males	Females
I Immature or virgin	Tube-shaped very small testicles, pink or transparent. Sperm not visible	Band-shaped ovaries, very transparent and without visible oocytes.
II Maturing	Testicles taking up a greater proportion of the visceral cavity. White coloured. Sperm not visible or just a little appearing in the lumen.	Ovaries taking up a little part of the visceral cavity, with a brown-orange colour. No vascularisation and no oocytes visible.
III Mature or pre-spawning	White coloured testicles with the lumen full of sperm.	Orange-coloured ovaries with accentuated vascularisation. Presence of some hyaline oocytes.
IV Spawning	Sperm is easily freed by applying pressure to the abdomen.	An enormous gelatinous mass wraps the hyaline oocytes.
V Post-spawning	Testicles appear red and stained. There is no sperm, or a little residual.	Soft or retracted ovaries, very vascularised. Residual oocytes present.

Spawning period

The spawning period was determined for each species by analysing the evolution of the maturity stages by sex. A two-month group is used for this purpose. A first analysis calculates the percentages of mature individuals by sex (percentages of stages III, IV and V together, relative to the total) and a more closer analysis is given by a graphical representation of each spawning stage by a two month group. Only individuals susceptible to reproduction were used, that is, individuals whose length was over the minimum maturity length (L_{25}) (Azevedo, 1996a; Afonso-Dias & Hislop, 1997).

Maturity ogives by length and age

The period considered for this analysis is the period of highest maturity percentages for each species. For Black Anglerfish only data from January and February entered in this analysis and for White Anglerfish different analysis were performed considering different periods. Maturity ogives were estimated by length and age and in each case by sex and for combined sexes, using the logistic model. For the maturity ogive by length, a length interval of 2 cm was used for Black Anglerfish and a length interval of 5 cm for White Anglerfish. The maturity ogive by age was obtained based on the ages given by Landa *et.al.* (1998). The maturity percentages were calculated taking together the maturity stages that are close to spawning (stages III, IV and V), relative to the total.

3. Results and Discussion

3.1. Sex-ratio

In Figure 2 is represented the sex-ratio for each length group for Black Anglerfish and Figure 3 shows the same data for white Anglerfish.

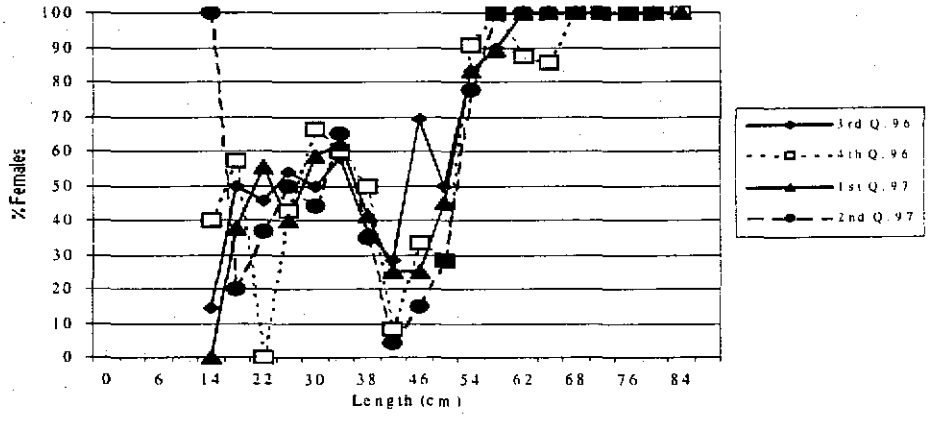

Figure 2: Sex ratio by length and quarter for Black Anglerfish

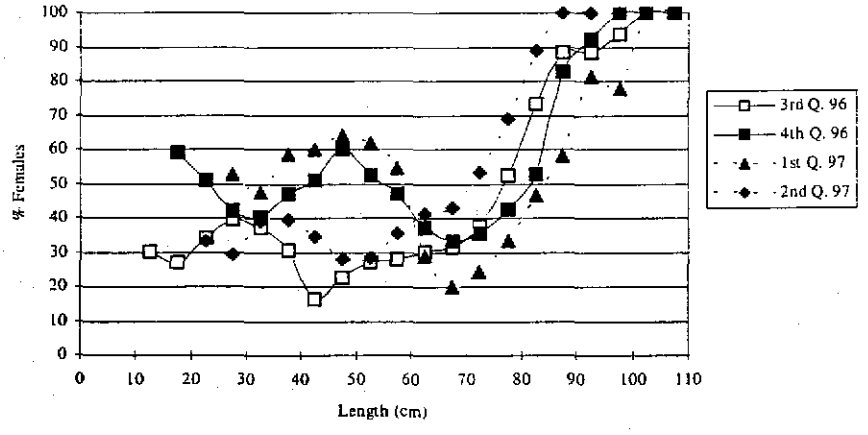

Figure 3: Sex ratio by length and quarter for White Anglerfish

Sex ratio by length

Both figures show that there is an important variation of the sex ratio by length. Also, females of both species attain higher lengths than do males: Black Anglerfish males over 60 cm just appeared in the 4th quarter 96 and measuring more than 70 cm didn't appear at all. On the other hand, females measuring more than 80 cm appeared in all quarters. White Anglerfish measuring more than 85 cm were over than 50% females in all quarters and measuring more than 100 cm were all females.

The same figures show that in both species exists a length interval where males occurred more than expected (around 70 % males). This length interval is for Black Anglerfish between 40 and 52 cm and for White Anglerfish between 60 and 75 cm. A probable reason for this is the different growth rate between sexes that exists in both species (Duarte *et.al.*, 1997). Males have a much slower growth rate, which as it slows at older ages produces a relative male accumulation.

Sex ratio by quarter

In Figures 2 and 3 the sex ratio is also shown by quarter. For Black Anglerfish it is seen that in all quarters the female percentage is approximately the same in each length interval (Figure 2). In Table III this observation is confirmed because the female-male proportion is very close to one in every quarter, suggesting that there is no variation in the sex ratio along the year. The range of sampled depth strata were approximately the same along the year.

Table III: Sex ratio by quarter and total sex ratio for Black Anglerfish

		3rd Quart. 96	4th Quart. 96	1st Quart. 97	2nd Quart. 97	Total
No.	F	163	110	211	135	695
	M	154	100	196	180	699
Prop.	F:M	1 : 0.94	1 : 0.91	1 : 0.93	1 : 1.33	1 : 1.01

For White Anglerfish the female percentage shows an important variation between quarters in length groups over 35 cm (Figure 3). As it is observed, during the 4th quarter 96 and the 1st quarter 97 higher female percentages are observed between lengths 35 cm and 60 cm while during the same period lengths greater than 60 cm present lower female percentages, compared to the rest of the year. This variation could be a consequence of a reproductive migration to an area or depth outside the one sampled. This way, males over 35 cm and females over 60 cm would leave the sampled area during the spawning season and the female percentage would increase between 35 cm and 60 cm and decrease in lengths greater than 60 cm (compared to the rest of the year).

Table IV: Sex ratio by quarter and total sex ratio for White Anglerfish

		3rd Quart. 96	4th Quart. 96	1st Quart. 97	2nd Quart. 97	Total
No.	F	198	141	132	130	601
	M	242	125	162	138	667
Prop.	F:M	1 : 1.22	1 : 0.89	1 : 1.23	1 : 1.06	1 : 1.11

From Table IV it is seen that for White Anglerfish more males were observed except for the 4th quarter 96, while for Black Anglerfish (Table III) only in the 2nd quarter 97 the males appeared more than the females.

3.2. Spawning period

A first approach to infer about the spawning season is given by the percentages of mature individuals in each two-month group. Results are in Tables V and VI for each species.

Table V: Percentage of mature individuals by sex and by groups of two months for Black Anglerfish

	Jul-Ago	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun
Males (%)	53.1	32.1	60.0	62.0	48.3	68.5
Females (%)	3.0	5.4	10.5	33.3	8.8	18.4

Table VI: Percentage of mature individuals by sex and by groups of two months for White Anglerfish

	Jul-Ago	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun
Males (%)	100.0	56.0	87.0	84.0	84.0	78.0
Females (%)	2.0	4.0	13.0	12.0	8.0	8.0

From Tables V and VI it is seen that in both species mature males appear in higher percentages all around the year and it's difficult to establish for each species a limited spawning season by just analysing these male data. Mature females appear in much lower percentages than males, but on the other hand, for Black Anglerfish a defined maximum of mature females appears in January-February.

In Figures 4 and 5 the evolution of each maturity stage is represented by sex. This allows a closer analysis to the spawning stage evolution.

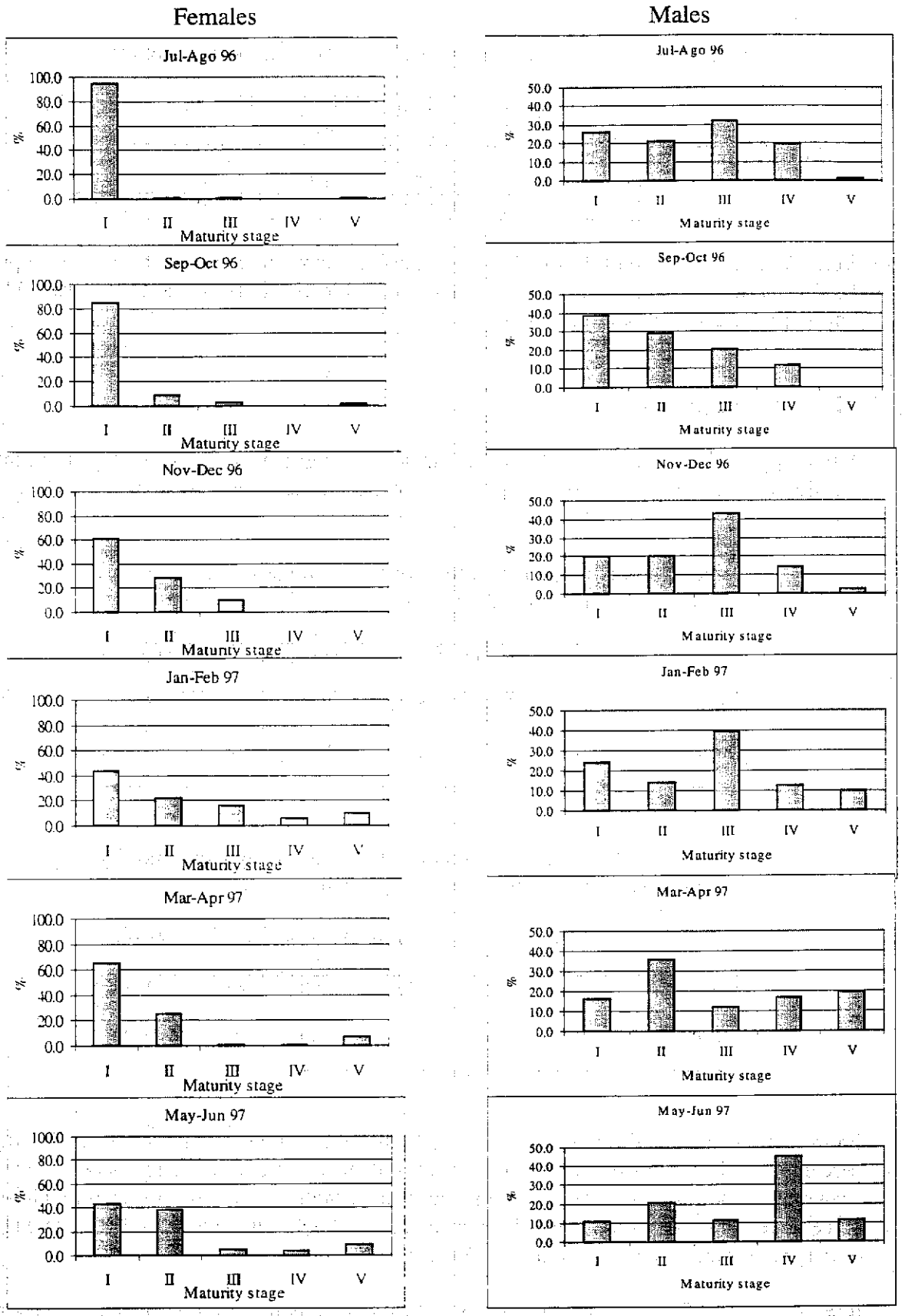

Figure 4: Percentage evolution of each maturity stage by sex for Black Anglerfish

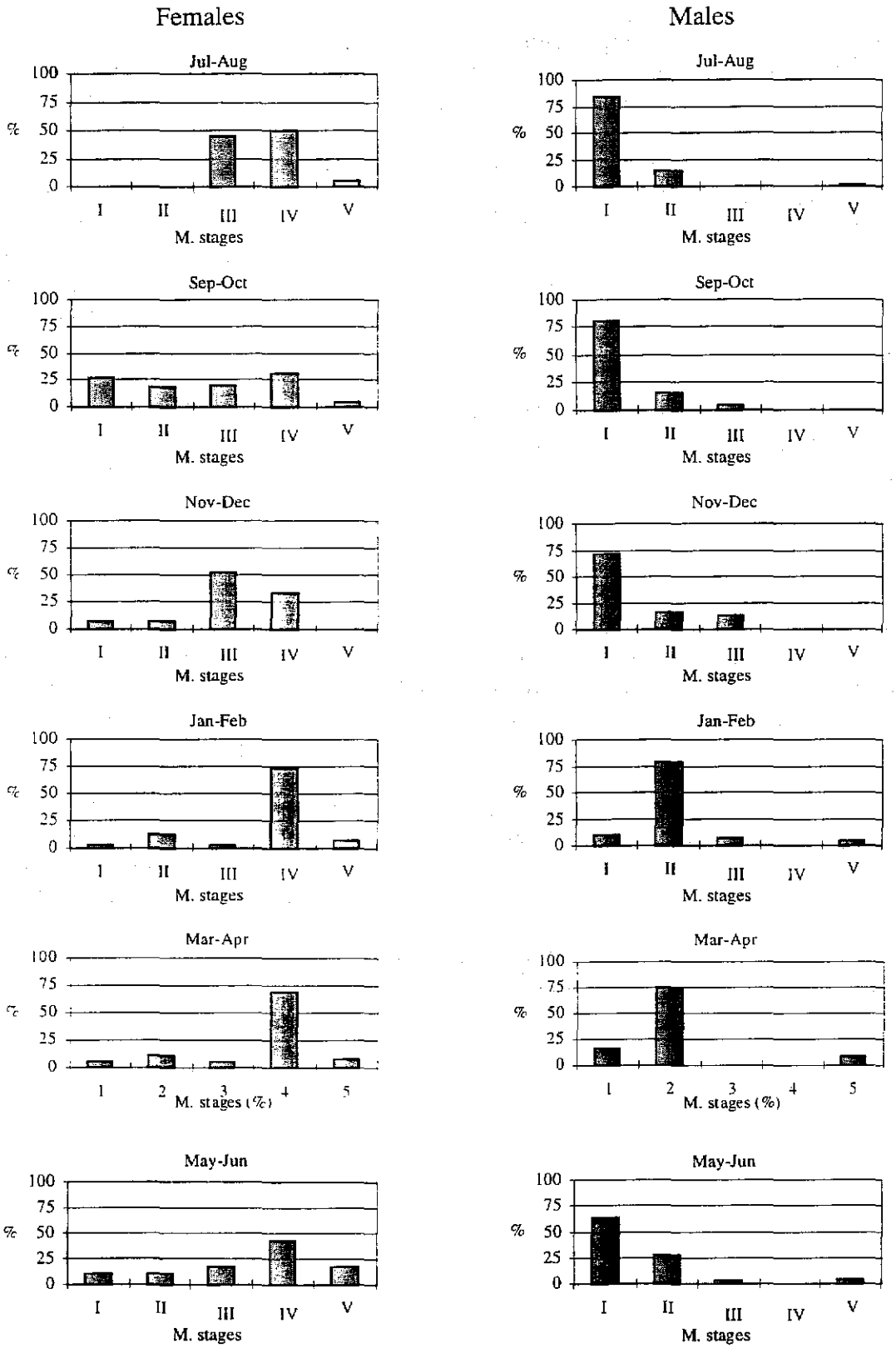

Figure 5: Percentage evolution of each maturity stage by sex for White Anglerfish

Black Anglerfish spawning period

From Figure 4 it is seen that Black Anglerfish spawning males (stage IV) appear high in all months and post-spawning males (stage V) appear in higher percentages between March and June, indicating that the spawning peak could fall before. Analysing the spawning stage evolution for females, it is seen that spawning females (stage IV) attain higher percentage in January–February and that after these months stage V is the most important (excluding stage I and II). These results suggest that the period after February is a post-spawning period, being in agreement with the male data. Also, the period before January seems to be a pre-spawning period and may be overlapping the beginning of the spawning season (because a high percentage of post-spawning females appear in January-February).

According to Azevedo (1996a) and Pires (1996) Black Anglerfish spawning season takes place mainly between October and March. The results from this study suggest a narrower spawning season, which could be defined for the studied area from November to February.

White Anglerfish spawning period

White Anglerfish spawning data from Figure 5 are more difficult to interpret. First of all, spawning females (stage IV) were not found along the studied area, although it is observed that most maturing females appear mainly between November and January, having their post-spawning period between March and June. Therefore it could be guessed that the spawning season would be within these period.

Afonso-Dias and Hislop (1997) find mature females between November and May which is in agreement with our results. The male data suggest approximately the same, because the period where most spawning males (stage IV) can be found goes from January to June (Figure 12). Afonso-Dias and Hislop (1997) also find in Scottish waters males either in maturity process or already mature all along the year but individuals in the post-spawning (stage V) appear in a higher proportion between April and August. The results would corroborate the spawning period from January to June excepting the possibility of some differences in the spawning period due to the latitude.

3.4. Maturity ogive by length

Black Anglerfish

With the total female data from January and February a maturity ogive by length was estimated. Figure 6 shows the obtained ogive and in Tables VII and VIII are the regression data and the lengths of 25%, 50% and 75% maturity for this estimation.

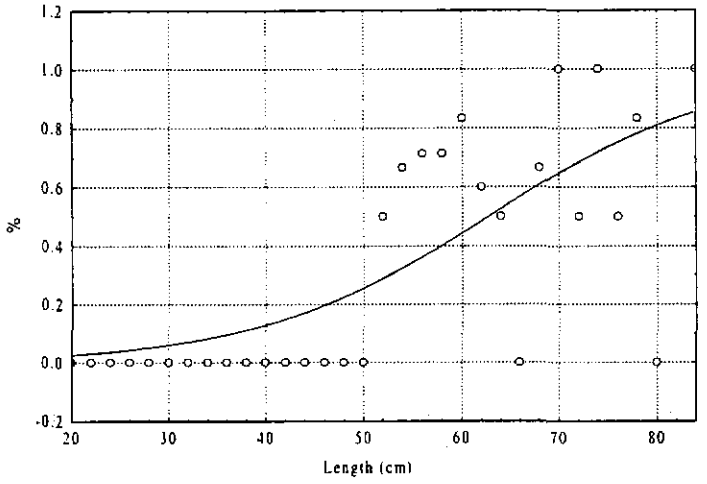

Figure 6: Black Anglerfish maturity ogive for females using all data

As it is evident from the graphic analysis (Figure 6), the percentage of mature females only reaches 100 % in three length intervals. This is not an expected situation, considering that this analysis is based on data from the spawning season previously determined. Two main reasons for the unexpected results are pointed out:

i) Errors in the maturity stage classification. In fact, a study on the reproduction of the southern Anglerfish showed that errors may occur on the macroscopic discrimination between stage V and stage II in females (Pires, 1996) since some females where macroscopically classified as II but a more closer microscopic analysis revealed that they were stage V.
ii) Delay in the maturation process of the larger individuals. In fact, based on previous studies, it is expected that females larger than 60 cm are mature and have already spawn at least once, since females L50% was estimated to be 56 cm (Azevedo, 1996a).

Reason i) may explain some of the unexpected values but it is not believable that explain all of them. Therefore, reason ii) seems more reliable. In order to inspect this hypothesis a

maturity ogive was estimated including all females over 65 cm as mature. The resulting ogive is seen in Figure 7 and the regression data in Table VII.

The same estimation was performed for males (using all data) and for combined sexes (using the modified female and all male data). The male maturity ogive is represented in Figure 8. Male and combined sexes regression data and expected L25%, L50% and L75% are in Tables VII and VIII.

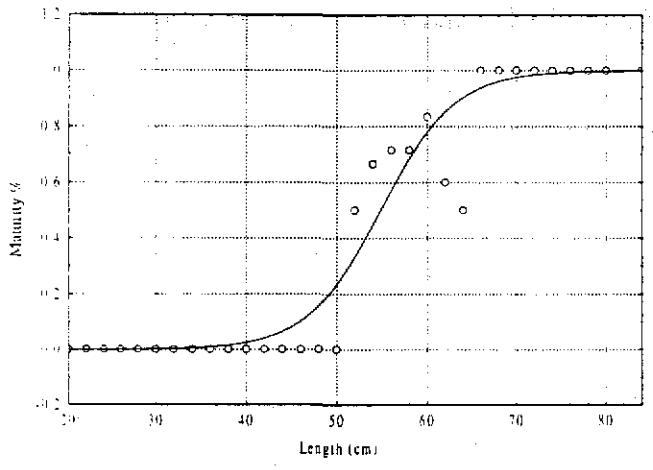

Figure 7: Black Anglerfish maturity ogive for females considering females over 65 cm as mature

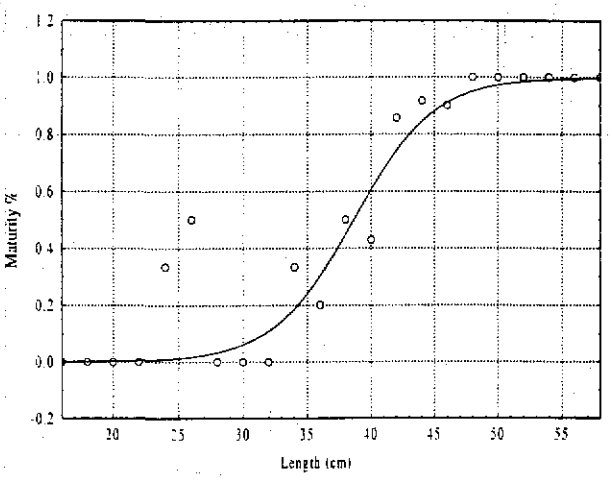

Figure 8: Black Anglerfish maturity ogive for males

From the male maturity ogive (Figure 8) it is seen that after 46 cm all observed males were mature, like expected during the main spawning period.

Table VII: Black Anglerfish regression data for the maturity ogive by length

	Number	Coefficients		R	Length (cm)	
		a	b		Min.	Max.
Females (Total data)	138	-5.260	0.084	0.728	20.0	84.0
Females (> 65 cm as mature)	138	-13.404	0.245	0.965	20.0	84.0
Males (Total data)	121	-12.185	0.315	.941	16.0	58.0
Combined sexes (females over 65 cm as mature)	259	-5.671	0.127	0.942	10.0	84.0

The correlation (R) obtained for the female data is higher for the second analysis because part of the point dispersion (in higher lengths) was minimised.

Table VIII: Lengths of 25%, 50% and 75% of maturity for Black Anglerfish

		Length (cm)
Females (total data)	L25%	49.6
	L50%	62.7
	L75%	75.8
Females (considering females over 65 cm as mature)	L25%	50.3
	L50%	54.8
	L75%	59.3
Males (total data)	L25%	35.1
	L50%	38.6
	L75%	42.1
Combined sexes (females over 65 cm as mature)	L25%	36.1
	L50%	44.7
	L75%	53.4

It is seen from Table VII that using all the female data in the analysis, between L25% and L75% there is a length interval of about 26 cm corresponding to an age range of 7 years, considered not to be biologically believable. Therefore the maturity ogive obtained from Figure 7, with a length interval of about 9 cm (age range of 2 years) between L25% and L75% is more reliable.

In 1996(a) Azevedo estimated a maturity ogive by length for combined sexes for the southern Black Anglerfish, giving a L25%, 50% and L75% of respectively 40cm, 45cm and 51cm. Comparing the data obtained by Azevedo with these from Table VIII, it is seen that the value of L50% is about the same (45cm) and that the length interval between L25% and L75% is higher in this work (18cm) than in Azevedo (11cm).

White Anglerfish

This species-spawning period does not seem to be defined in any short period and it can cover a wide range of months. The maturity ogive estimation has to take this into account.

Although no spawning females were found along the studied period, it was tried to estimate the maturity ogive with the few females (N=21) in maturity process or in post-spawning stage. In consequence of the reduced number of females, the maturity ogive by length was estimated based on the period going from November to June. Figure 9 shows the obtained ogive and in Tables IX and X are the regression data and the lengths of 25%, 50% and 75% maturity for this estimation.

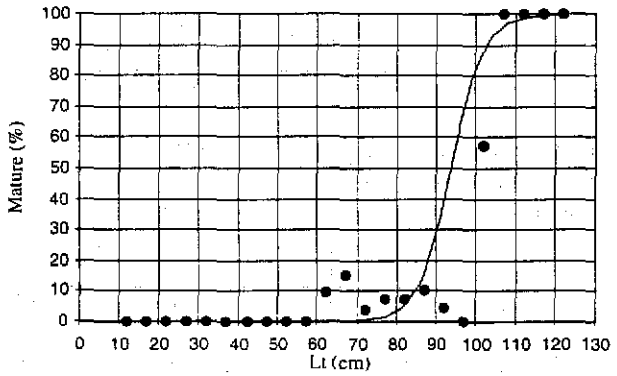

Figure 9: White Anglerfish maturity ogive for females

Since mature males appeared all around the year, the male maturity ogive was considered for two possible spawning seasons: a wide one, which would go from November to August (Figure 10), and a shorter one, which would go from January to June (Figure 11). In tables IX and X are the regression data and the lengths of 25%, 50% and 75% maturity.

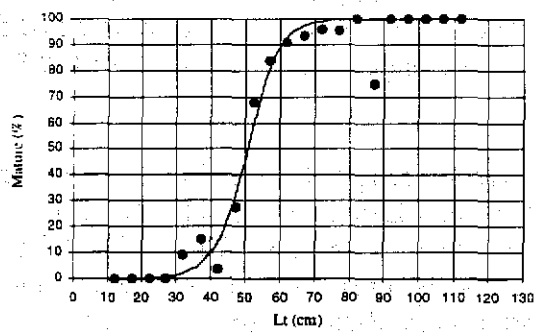

Figure 10: White Anglerfish maturity ogive for males (November - August)

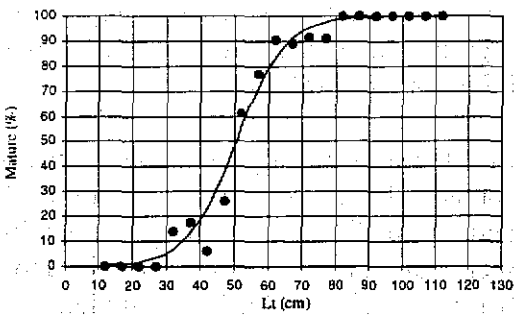

Figure 11: White Anglerfish maturity ogive for males (January - June)

Table IX: White Anglerfish regression data for the maturity ogive by length

	Number	Coefficients		Length (cm)	
		a	b	Min.	Max.
Females (Spawning Nov.-Jun.)	21	-22.696	0.242	62.0	122.0
Males (Spawning Nov.-Aug.)	338	-10.812	0.215	32.0	110.0
Males (Spawning Jan.-Jun.)	197	-7.157	0.142	32.0	110.0

Table X: Lengths of 25%, 50% and 75% of maturity for White Anglerfish

		Length (cm)
Females (Spawning Nov.-Jun.)	L25%	89.3
	L50%	93.9
	L75%	98.4
Males (Spawning Nov.-Aug.)	L25%	45.2
	L50%	50.3
	L75%	55.5
Males (Spawning Jan.-Jun.)	L25%	42.8
	L50%	50.5
	L75%	58.3

In the female maturity ogive (Figure 9) it can be seen that 60 cm is the smallest length from which some females are mature, which agrees with the length values observed by Afonso-Dias and Hislop (1997). Nevertheless from that length on only a few individuals maturing or in post-spawning stage determine the adjusted curve. This maturity ogive with a L_{50} of 93.9 cm is not similar to the one estimated by Afonso-Dias and Hislop (1997), (L_{50} = 73,5 cm). Such an ample difference in L_{50} value is not expected. Taking into account that in the mentioned work the authors do find spawning females and that the values of our estimations for males are similar to theirs (as we will see further), it

would be very likely that the actual maturity ogive for females were similar to the one estimated in their zone. Nevertheless, this possibility can not be corroborated until enough samples are available.

Two hypothesis are posed to explain this shortage of spawning females:
i) Mature females could have left the studied area during the spawning season, which would explain that no mature females were found .
ii) The reproduction does not take place annually, but less frequently.

The first hypothesis seems to be more likely given the information obtained from the fishermen about the few spawning females found in 1998. Nevertheless, all the females found in the first quarter of 1998 (outside the sampling program of the project) have very big lengths, which prevent us from rejecting the estimated maturity ogive.

However, it should be noted that spawning males appear, contrary to females, in the studied area and for a long period.

In the male maturity ogive it may be seen that the results obtained from the two spawning seasons are very alike. These results agree with those of Afonso-Dias and Hislop (1997) in Scottish waters, which determine a L_{50} of 49 cm, that is a length very similar to the one obtained in this study (50 cm).

3.5. Maturity ogive by age

Black Anglerfish

For this analysis, Black Anglerfish females older than 11 years were considered as mature because of the sampling errors or the delay in the maturation process referred previously in the length maturity ogive estimation. On the other hand, all males entered for this estimation and for combined sexes male and female data used previously were joined. In Table XI are the obtained maturity percentages at age.

Table XI: Black Anglerfish maturity percentages at age

	Maturity Ogive												
Age	2	3	4	5	6	7	8	9	10	11	12	13	14
Females maturity %	0	0	0	0	0	1	6	28	68	92	98	100	100
Males maturity %	0	3	7	17	35	58	78	90	96	99	100	100	100
Combined sexes Maturity %	0	2	5	10	20	35	53	71	84	92	96	98	100

Black Anglerfish maturity ogives in Table XI indicate a long maturing process. Only between ages 9-10, 50% females are mature and 100% maturity is only achieved at age 13. For males, 50% maturity occurs between age 6 and 7 and 100% maturity only at age 12.

For combined sexes, age at first maturity is around 8 years. Until 1996 assessment, the maturity at age ogive for combined sexes was derived from the northern stocks maturity at length distribution, by applying the southern stocks growth parameters. As was referred before, in 1996(a) Azevedo estimated for this stock a maturity ogive by length, giving a L50% of 45cm. By converting this L50% using the growth parameters, an age of 7 years is obtained for combined sexes. These values are very different from what is considered for the northern stock, a L50% of 30cm (Dardignac, 1988) corresponding this to an age of 4 years.

In Table XII the maturity ogive for combined sexes obtained in this study is presented with the ogive used in the ICES W.G. stock assessment. Important differences are observed indicating that Black Anglerfish matures at older ages (and higher lengths) than has been considered until now. A discrepancy of 3-4 years is obtained between the age of first maturity used in the stock assessment and the value obtained in this study.

Table XII: Black Anglerfish combined sexes maturity ogive used in the ICES W.G. and obtained in this study

	Maturity Ogive for combined sexes												
Age	2	3	4	5	6	7	8	9	10	11	12	13	14
ICES W.G. maturity ogive (ICES, 1995)	0	25	50	75	100	100	100	100	100	100	100	100	100
This study maturity ogive	0	2	5	10	20	35	53	71	84	92	96	98	100

This high discrepancy and the importance of this parameter for an improved stock assessment justifies a revision of the maturity ogive used in the ICES W.G.

For the same species in the northern stock, high discrepancies are also observed between the age of first maturity obtained in the EC Study Project (Lucio, *et.al.*, 1998) and the one used in the northern stock assessment WG. A difference of about 3-4 years is observed and a revision of the maturity ogive is also suggested.

White Anglerfish

White Anglerfish maturity ogives were estimated for the same periods considered previously. For females this period is between November and June and for males two periods are considered, from November to August and from January to June.

Table XIII: White Anglerfish maturity percentages at age

	Maturity Ogive												
Age	4	5	6	7	8	9	10	11	12	13	14	15	16
Females maturity % (Nov.-Jun.)	0	0	0	0	0	0	0	0	0	25	50	75	100
Males maturity % (Nov.-Aug.)	0	25	50	75	100	100	100	100	100	100	100	100	100
Males maturity % (Jan.-Jun.)	0	25	50	75	100	100	100	100	100	100	100	100	100

Afonso-Dias and Hislop (1997) obtained a length of first maturity for females from the northern stock that, converted into age using the growth parameters from that stock, gives an age of first maturity of around 7.5 years. The female age at first maturity obtained in this study is rather late, around age 14 (Table XIII). The geographical influence can not explain the high difference obtained for this parameter between stocks of the same species. The low number of sampled mature females introduces probably a certain error in the maturity ogive estimation and in consequence these results are of low reliability. Hypotheses concerning the low capture of mature females were previously referred.

For males, both periods indicate an age of first maturity of 6 years (Table XIII). By converting the L50% for males obtained by Afonso-Dias and Hislop (1997) an age of around 5 is obtained for the northern stock. The difference of one year in this parameter between the northern and the southern stocks suggests that White Anglerfish from the southern stock needs probably more time to achieve sexual maturity. This conclusion is just based on the male data because female data are not reliable. For the same reason, combined sexes estimation was not performed.

4. Conclusions

- The variation of the sex ratio by length is important in both Anglerfish species of the southern stock. Females from both species attain greater body lengths compared to males. The different growth rate between sexes is probably the reason for this variation.

- Sex-ratio variation by quarter is not observed for Black Anglerfish. On the other hand, for White Anglerfish an important variation in the sex ratio of length groups over 35 cm was observed between quarters. A probable reason for this variation is a reproductive migration outside the sampled area or depths.

- The main spawning periods could be defined for Black Anglerfish from November to February and for White Anglerfish from January to June. Spawning period estimation was difficult for White Anglerfish due to the low number of observed mature females.

- Black Anglerfish length of first maturity for females, males and combined sexes were respectively estimated as 54.8 cm, 38.6 cm and 44.7 cm. The obtained value for combined sexes is very close to the one determined by Azevedo (1996a) (45 cm) for the same stock, but is much higher than the value considered for stock assessment purposes in the ICES W.G. (30 cm).

- White Anglerfish length of first maturity was determined for females as 93.9 cm, which is very high, compared to values from the northern stock. But due to the low mature females sampled, this result is of low reliability. For males a value of around 50.5 cm was obtained for this parameter, which is very close to the value obtained for the northern stock. Combined sexes length of first maturity was not determined for this species due to the low sampling of mature females.

- Black Anglerfish ages of first maturity were estimated for females, males and combined sexes, and the obtained values were respectively 9.5 years, 7 years and 8 years. The value for combined sexes is much higher than the value for the same parameter used in the stock assessment ICES W.G. (4 years). A revision of the maturity ogive used for stock assessment purposes is suggested.

- White Anglerfish ages of first maturity were estimated for both sexes. The value obtained for females is around 14 years. It is higher than expected, probably due to the low sampling number of mature females, therefore this result is of low reliability. Male's age of first maturity is around 6 years. It is 1 year higher relative to the value obtained for the northern stock of this species by converting the L50%. This difference for the male value is an indication that White Anglerfish from the southern stock needs probably more time to achieve sexual maturity. Again, because of low sampling of mature females, estimation for combined sexes was not performed.

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