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BIOLOGICAL ASPECTS OF WHITE ANGLERFISH (*Lophius piscatorius*) IN THE BAY OF BISCAY (ICES Division VIIIa,b,d), IN 1996-1997

by

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ABSTRACT

A total of 1129 White Anglerfish were analysed from monthly samples taken in the Bay of Biscay on board of commercial vessels and at the main fishing ports of the Basque Country during 1996-1997. The specimina length range was between 12.5-136.5 cm of total length.

The total length (cm)-total weight (g) relationship was described by the multiplicative function: $Wt = 0.2636\ L^{2.841}$, $r = 0.9883$. Other relationships (total length–commercial gutted, –scientific gutted, –tail weight) have been also obtained.The conversion factor calculated for the commercial gutted (i.e. with liver) to total weight relationship was 1.14, and for the tail to total weight relationship was 2.79.

The reproductive period in the Bay of Biscay, observed by macroscopic and histological studies, extends from May to August with a peak in May-June. The L_{50} was calculated at 52.7 cm in length for males, at 73.2 cm for females and at 68.2 cm for sexes combined. The A_{50} was calculated at 5.0 years for males, at 7.0 years for females and at 6.0 years for sexes combined. Sex ratio in fish below 80 cm in length did not appear to depart from 1:1; above this length females clearly predominated.

For growth studies 1385 exemplars were aged by illicia reading. Fish between 1 and 25 years old were found. Annual age-length keys were established. Annual parameters of the von Bertalanffy growth equation were calculated for both sexes: $L_\infty = 150$, $t_o = -0.0236$, $K = 0.0882$, for Males: $L_\infty = 100$, $t_o = -0.1051$, $K = 0.1517$ and for Females: $L_\infty = 150$, $t_o = -0.2961$, $K = 0.0882$.

Key-words: *Lophius piscatorius*, biology, growth, reproduction, illicia, age, Bay of Biscay.

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INTRODUCTION

White Anglerfish or monfish *(Lophius piscatorius* (L 1758) is a lophiiform fish distributed from Barents Sea to Gulf of Guinea and Mediterranean Sea at depths ranging from 50 to more than 1000 meters. Multispecific fisheries catch this species in ICES Sub-areas VI to IX. France, Spain, United Kingdom and Ireland take the major proportion of these catches.

Two ICES Working Groups on the Assessment (Southern Shelf Demersal Stocks, SSDSWG and Northern Shelf Demersal Stocks, NSDSWG) are involved in the monitoring and assessment of this species. Three stocks have been recognised for assessment and management purposes: Anglerfish in Sub-area VI, Anglerfish in Divisions VIIb-k and VIIIa,b,d and Anglerfish in Divisions VIIIc and IXa. The catches (landings and discards) from the three anglerfish stocks amounted in 1996 for *ca.* 19.506 t, 19,660 t and 2,955 t respectively (ICES CM, 1998a,b).

In the Bay of Biscay (Div. VIIIa,b,d) anglerfish catches are usually comprised by two species: White Anglerfish (*L. piscatorius*) and black anglerfish (*L. budegassa,* Spinola, 1807). In this sea area 2,898 t of White Anglerfish were caught in 1996. Mean annual landings in the Basque Country ports from the Bay of Biscay in the last three years period [1994-1995-1996] were around 410 t and most of them were obtained by "baka"- and "bou"-trawlers.

There is a rather scarce number of studies about the biology, ecology, and growth of anglerfish in the Northeast Atlantic in spite of its economical importance. The existent information is referred mainly to its morphologic description, systematic, taxonomy and geographical distribution (Lozano, 1960; Whitehead et al., 1986; Smith et al., 1986; Moyle et al., 1988; Sánchez et al., 1991). There are also some studies about reproduction of White Anglerfish in the NW coast of Scotland (Afonso-Dias et al., 1996), age and growth (Dupouy, 1986; Crozier, 1989; Peronnet et al., 1991), feeding (Crozier, 1985; Pereda et al., 1990), genetic relations betwen both anglerfish species (Crozier, 1988). However no studies have been found about reproductive and other biological aspects of this species in the Bay of Biscay.

In this work the results of a biological study on growth and reproduction of White Anglerfish, *L. piscatorius,* carried out during 1996-1997 in the Bay of Biscay (Div. VIIIa,b,d) are presented.

MATERIALS AND METHODS

During 1996-1997, an intensive sampling program was carried out on a monthly basis to obtain representative number of *Lophius piscatorius* in order to advance in the biology knowledge of the species. The sampling and the posterior analysis of the biological data were founded by E.U. under the Study Contract DGXIV: Biological Studies of Demersal Fish (BIOSDEF) and by Basque Country Government (Department of Industry, Agriculture and Fisheries). Biological samples were collected from Spanish landings at the main fishing ports of the Basque Country and on board of commercial vessels which operate in Div. VIIIa,b,d. For the purpose of this study, all the analysis are based on the compiled analysis of samples of the two years as only one synthetic "biological year".

To study the relationship between length (in cm) and weight (in g), the aim of the sampling was to weigh –at least for the commercial gutted weight- 10 fish by length classes of 2 cm, by quarter. The length considered was the total length. Weighting was carried out on board using a precision balance specially designed for measuring on unstable conditions. "Total weight (Wt)", "commercial gutted weight (Wg)" (i.e. with liver), "scientific gutted weight (Ws)" (i.e. full gutted and without liver) and "tail weight (Wb)" (i.e. full gutted and without head) and total length relationships were described by multiplicative functions using Statgraphics Plus 3.0 program. Different conversion factors –i.e. for commercial gutted weight (Wg) to total weight (Wt), scientific gutted weight (Ws) to total weight, and tail weight (Wb) to total weight relationships- were also calculated by forcing the linear relationships through the co-ordinates origin. At the end of the study, a total number of 1129 White Anglerfish were measured and weighted ("commercial gutted weight (Wg)").

A total of 1493 sectioned illicia of *L. piscatorius* were prepared and read for determining the fish age. Once the illicium was removed from the fish at sea or in the fishing port, it was stored in a little paper envelope with the basic data relating to the exemplar examined. Before mounting and cut in the laboratory, illicia were peeled to make reading easier. They were embedded in black plastic plates and sectioned at *ca.* 500 µm to a distance of 5 mm of the illicia basis. After this, they were mounted in slices covered with a layer of non-plastic resin (Eukit), without a coverslip on surface. Readings were made with a binocular microscope under transmitted light at usually 100 x magnifications.

The criteria used for ring interpretation were the same as the one used in the "International Ageing Workshop on European Monkfish" hold at Lorient (France) in June of 1997 (Anon, 1997). Those illicia whose age reading was uncertain were dismissed for the final analysis.

Mean length and weight at age were calculated. Growth parameters were estimated from the mean length at age for the study period [1996-1997]. FISHPARM program (Prager *et al.*, 1987) was used for those purposes. The model chosen to estimate growth was the von Bertalanffy (1938) growth equation: $L_t = L_\infty (1 - e^{-K(t-t_0)})$. For each sex, the largest lengths found during the three years period were assigned to L_∞.

Monthly evolution of the condition factor (CF) was calculated as the relationship between the total or gutted weight and length. The monthly evolution of the gonosomatic index (GSI) was calculated as the relationship between gonad weight and total or gutted weight.

Spawning season was estimated by means of the study of the percentages of maturity stages assigned *de visu* and histologically to the specimina. Maturity ogives (*de visu* and by histology or microscopy) by length and age were calculated by means of the percentage of mature males, females and both sexes combined during the spawning period of the study [1996-1997].

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RESULTS

1. Sampling level

The *L. piscatorius* biological data were obtained by a routinely sampling on the main ports of the Basque Country (Ondarroa and Pasajes) or mainly on board of commercial vessels. The sampling period started in April 1996 and finished in May 1997. The sampling level for the different biological purposes, grouped by quarters and for the total sampling period, is shown in Table 1.1. The length ranges of the specimina obtained are presented in Table 1.2.

Table 1.1. Sampling level of *L. piscatorius* carried out during the period [1996-1997] in Div. VIII a,b,d.

YEAR	Quarter	ICES Division	Illicia	Length/ Commercial Gutted Weight (Wg)	Length/ Total Weight (Wt)	Length/ Scientific Gutted Weight (Ws)	Gonads
1996-97	1	VIIIa,b,d	413	393	298	103	371
	2	VIIIa,b,d	452	446	298	40	175
	3	VIIIa,b,d	277	138	134		175
	4	VIIIa,b,d	351	152	14	14	367
TOTAL	ALL	VIIIa,b,d	1493	1129	744	157	1088

Table 1.2. Length range (cm) of *L. piscatorius* collected during the study period in Div. VIII a,b,d.

YEAR	Quarter	ICES Division	Illicia	L/W (Wg)	L/W (Wt)	L/W (Ws)	Gonads
1996-97	ALL	VIIIa,b,d	15.5-137.5	12.5-136.5	12.5-111.5	12.5-111.5	12.5-111.5

2. Length and Weight relationships

2.1. Annual Length and Weight relationships

The total length and weights relationships for the total year and by sexes are shown in Tables 2.1.1, 2.1.2, 2.1.3 and 2.1.4. Total number of specimina, length (cm) and weight (g) ranges and the values of the correlation coefficients are also presented.

Length-weight relationships were compared between quarters and sexes. Statistical differences were checked at 95% confident level. Length ranges used for comparison were the same for each sex.

Table 2.1.1. Total Length-Total Weight (Wt) relationship.

	Function	N	R	Length range (cm)	Weight-range (g)
Males	$Wt=0.02724\ L^{2.829}$	280	0.9801	24.5-86.5	175.5-7060.5
Females	$Wt=0.02828\ L^{2.826}$	218	0.9896	12.5-111.5	33.5-20789.5
Sexes combined	$Wt=0.02636\ L^{2.841}$	563	0.98834	12.5-111.5	33.5-20789.5

When males and females Length-Total Weight relationships were compared for the same length ranges on annual basis no significant differences at 95 % confidence level were found.

Table 2.1.2. Total Length-Commercial Gutted Weight (Wg) relationship.

	Function	N	R	Length range (cm)	Weight-range (g)
Males	$Wg=0.01924\ L^{2.879}$	425	0.9853	22.5-86.5	144.5-6240.5
Females	$Wg=0.02090\ L^{2.862}$	355	0.9920	12.5-111.5	27.5-17311.5
Sexes combined	$Wg=0.01883\ L^{2.885}$	1129	0.9931	12.5-111.5	27.5-26000.5

When males and females Length-Commercial Gutted Weight relationships were compared for the same length ranges on annual basis no significant differences at 95 % confidence level were found.

Table 2.1.3. Total Length-Scientific Gutted Weight (Ws) relationship.

	Function	N	R	Length range (cm)	Weight-range (g)
Males	$Ws=0.01857\ L^{2868.}$	79	0.9904	24.5-86.5	150.5-5971.2
Females	$Ws=0.01506\ L^{2.935}$	61	0.9904	12.5-111.5	26.9-15985.5
Sexes combined	$Ws=0.01665\ L^{2.903}$	157	0.9928	12.5-111.5	26.9-15985.5

When males and females Length-Scientific Gutted Weight relationships were compared for the same length ranges on annual basis there were found significant differences at 95 % confidence level.

Table 2.1.4. Total Length-Tail Weight (Wb) relationship.

	Function	N	R	Length range (cm)	Weight-range (g)
Males	$Wb=0.0021\ L^{3.214}$	41	0.9862	24.5-44.5	50.9-419.9
Females	$Wb=0.0072\ L^{2.886}$	28	0.9846	12.5-111.5	27.0-7210.0
Sexes combined	$Wb=0.0052\ L^{2.963}$	71	0.9846	12.5-111.5	27.0-7210.0

When males and females Length-Tail Weight (Wb) relationships were compared for the same length ranges on annual basis no significant differences at 95 % confidence level were found.

2.2. Total Weight, Gutted Weight and Tail Weight relationship for the year

The annual relationship between Total Weight (Wt) and Commercial Gutted Weight (Wg), Scientific Gutted Weight (Wg) and Tail Weight (Wb) for males, females and both sexes combined are presented in Table 2.2.1, 2.2.2, 2.2.3 and 2.2.4. The Length and Weight ranges, number of fish and correlation coefficient used are also included. The slopes and intercepts of these linear regressions were statistically compared at a 95 % confident level to determine whether there were differences between males and females in weight growth.

Table 2.2.1. Total Weight (Wt)-Commercial Gutted Weight (Wg) relationship.

	Function	N	R	Wt range (g)	Wg-range (g)
Males	Wt=-19.133 + 0.887 Wg	277	0.9976	175.5-7060.5	152.5-6240.5
Females	Wt=5.349 + 0.869 Wg	218	0.9946	33.5-20789.5	27.5-17311.5
Sexes combined	Wt=1.053 + 0.873 Wg	559	0.9976	33.5-20789.5	27.5-17311.5

Table 2.2.2. Total Weight (Wt)-Scientific Gutted Weight (Ws) relationship.

	Function	N	R	Wt range (g)	Ws-range (g)
Males	Wt=-2.706 + 0.833 Ws	79	0.9952	175.5-7060.5	150.5-5971.5
Females	Wt=50.007 + 0.788 Ws	61	0.9943	33.5-20789.5	26.9-15985.5
Sexes combined	Wt=38.094 + 0.794 Ws	157	0.9972	33.5-20789.5	26.9-15985.5

Table 2.2.3. Commercial Gutted Weight (Wg)-Scientific Gutted Weight (Ws) relationship.

	Function	N	R	(Wg) range (g)	(Ws) range (g)
Males	Wg=-0.573 + 0.962 Ws	79	0.9996	152.5-6175.2	150.5-5971.5
Females	Wg=32.887 + 0.930 Ws	61	0.9995	27.5-17311.3	26.9-15985.5
Sexes combined	Wg=24.247 + 0.935 Ws	157	0.9995	27.5-17311.3	26.9-15985.5

Table 2.2.4. Total Weight-Tail Weight relationship.

	Function	N	R	(Wt) range (g)	(Wb) range (g)
Males	Wt=-6.776 + 0.348 Wb	40	0.9711	175.5-1303.5	27.5-7210.5
Females	Wt=12.0.2 + 0.358 Wb	28	0.9966	33.5-20789.5	27.0-7210.0
Sexes combined	Wt=-6.360 + 0.359 Wb	71	0.9964	33.5-20789.5	27.0-7210.0

When each relationship was statistically compared by sexes for the same length range, in all cases significant differences were found. As before, males appeared to growth in a different way than females on an annual basis.

3. Conversion Factor

Conversion factors between weights were calculated for all the year by sexes (Table 3.1, 3.2, 3.3 and 3.4). In all the tables the function and the standard errors obtained for the conversion factor are included.

Table 3.1. Conversion Factor for Commercial gutted weight (Wg) to Total weight (Wt) by sex.

	Conversion Factor Function	S.E.	N	R	Length-range (cm)
Males	Wt=1.1358Wg	0.0023	277	0.9952	24.5-86.5
Females	Wt=1.1496Wg	0.0033	218	0.9946	12.5-111.5
Sexes combined	Wt=1.1453Wg	0.0019	559	0.9976	12.5-111.5

Table 3.2. Conversion Factor for Scientific Gutted Weight (Ws) to Total Weight (Wt) by sex.

	Conversion Factor Function	S.E.	N	R	Length-range (cm)
Males	Wt=1.2029Ws	0.0044	79	0.9952	24.5-86.5
Females	Wt=1.2580Ws	0.0069	61	0.9943	12.5-111.5
Sexes combined	Wt=1.2477Ws	0.0042	157	0.9972	12.5-111.5

Table 3.3. Conversion Factor for Commercial Gutted Weight (Wg) to Scientific Gutted Weight (Ws) by sex.

	Conversion Factor Function	S.E.	N	R	Length-range (cm)
Males	Ws=0.9996Wg	0.00139	79	0.9996	24.5-86.5
Females	Ws=0.9359Wg	0.00251	61	0.9995	12.5-111.5
Sexes combined	Ws=0.9408Wg	0.00167	157	0.9995	12.5-111.5

Table 3.4. Conversion Factor for Tail Weight (Wb) to Total Weight (Wt) by sex.

	Conversion Factor Function	S.E.	N	R	Length-range (cm)
Males	Wt=2.9394Wb	0.00421	40	0.9711	24.5-44.5
Females	Wt=2.7863Wb	0.00354	28	0.9966	12.5-111.5
Sexes combined	Wt=2.7925Wb	0.00234	71	0.9964	12.5-111.5

4. Growth at Age

The age determination of *L. piscatorius* was made by means of illicia readings. As explained before, illicia were obtained in routine sampling carried out at sea on board of commercial ships and at the main fishing ports of the Basque Country. The way of preparing and reading the illicia was similar to the recommended at the "Workshop on Anglerfish Growth" hold at Lorient (France) in 1997 (Anon, 1997).

4.1. Age-Length keys

From the age reading results, Semestral Age-Length Keys for sexes combined and Annual Age-Length Keys for males and females were built. In this paper, a synoptical Annual Age Length Key (ALK) for *L. piscatorius* in Div. VIIIa,b,d for both sexes combined during the period [1996-1997] is presented (Table 4.1.1). In this Table all the ages read for all the size classes are presented.

Table 4.1.1. Annual Age Length Key for White Anglerfish (Div. VIIIa,b,d) in the study period [1996-1997].

Length	Age (years)																									Total	Length
(cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	(n)	(cm)
15		1																									1	15
16		1																									1	16
17		4	1																								5	17
18		5	1																								6	18
19		8	2																								10	19
20		6																									6	20
21		5	5																								10	21
22		5	8																								13	22
23		1	13																								14	23
24			18	2																							20	24
25			16	1																							17	25
26			13																								13	26
27			2	4																							6	27
28			16	1																							17	28
29			11	11																							22	29
30			11	11																							22	30
31			7	15	1																						21	31
32			9	18	1																						28	32
33			7	31	1																						39	33
34				22	2	1																					25	34
35			1	18	7																						26	35
36				19	2																						21	36
37				15	18																						33	37
38				8	33																						41	38
39			1	9	26																						36	39
40				6	36	1																					43	40
41				4	34	1																					39	41
42				2	26	2																					30	42
43				1	3	1																					5	43
44					35	6																					41	44
45					2	6																					8	45
46					18	23																					41	46
47					16	12																					28	47
48					8	29	1																				38	48
49					8	24																					32	49
50					1	25	3																				29	50
51					4	26	5																				35	51
52						24	8																				32	52
53					1	19	13	1																			33	53
54						18	8	1																			27	54
55						11	18	4																			33	55
56						7	16	1																			24	56
57						4	17																				21	57
58						6	18	2																			26	58
59						4	22	2	1																		29	59
60						1	17	1																			19	60
61						1	11	3																			15	61
62							13	14																			27	62
63							9	7	1																		17	63
64						1	12	6	3																		22	64
65							4	11	1																		16	65
66							2	6																			8	66
67							1	1	2	1																	5	67
68							1	13																			14	68
69							1	8	5																		14	69
70								9	1	1																	11	70
71							2	4	7																		13	71
72								2	9	3																	14	72
73								1	4	1																	6	73
74								3	1																		4	74
75									6	3																	9	75
76								1	7	5																	13	76
77								1	8	3																	12	77
78								1	3	4																	8	78
79								1		3																	4	79
80									1	8	1																10	80
81										4																	4	81
82									1	4	2																7	82
83									1	5																	6	83
84									1	3	1																5	84
85									2		2																4	85
86											3	1															4	86
87										1	3																4	87
88										1																	1	88
89									1																		1	89
90										1	1	1															3	90
91											1	2															3	91
92												3	1														4	92
93											1	1															2	93
94											1	2															3	94
95																													95
96											1	1	1														3	96
97												4															4	97
98											1	1		1													3	98
99																													99
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111																1											1	111
112																1											1	112
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116																													116
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118														1			1			1							3	118
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123																		1									1	123
124																													124
125																													125
126																													126
127																													127
128																							1			1	2	128
129																													129
130																													130
Total (n)		36	##	##	##	##	##	##	66	51	18	16	4	3	2	2	2	2		1	1		1			1	1385	Total (n)
Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total (n)	Age

4.2. Mean Length at Age and Mean Weight at Age

For the study period [1996-1997], Mean Length and Mean Weight at Age were calculated using the Age Length Keys and the new Total Length-Total Weight relationships obtained (Table 4.2.1.).

Table 4.2.1. Mean Length at Age and Mean Weight at Age for the period [1996-1997].

Males				Females				Sexes combined			
Age	N	Mean W (g)	Mean L (cm)	Age	N	Mean W (g)	Mean L (cm)	Age	N	Mean W (g)	Mean L (cm)
0				**0**				**0**			
1	5	129.35	19.80	**1**	1	194.64	23.00	**1**	36	123.23	19.42
2	30	372.17	28.63	**2**	32	346.46	27.78	**2**	160	311.19	26.69
3	87	628.00	34.34	**3**	67	590.39	33.70	**3**	205	595.11	33.73
4	176	1064.08	41.48	**4**	118	1096.89	41.97	**4**	346	1068.72	41.57
5	161	1837.76	50.37	**5**	79	1882.84	50.91	**5**	253	1841.50	50.45
6	95	2693.40	57.74	**6**	71	2972.77	59.82	**6**	201	2760.81	58.23
7	40	4036.11	66.43	**7**	42	4091.52	67.05	**7**	113	3908.38	65.78
8	16	5009.26	72.00	**8**	39	5911.28	76.26	**8**	75	5380.08	73.67
9	15	5879.37	76.20	**9**	23	7215.58	81.96	**9**	51	6560.37	79.12
10	3	8583.81	87.00	**10**	10	8894.96	88.00	**10**	18	8795.24	87.72
11				**11**	10	10703.72	94.20	**11**	16	10510.28	93.56
12				**12**	3	11933.97	97.67	**12**	4	12684.81	99.75
13				**13**	2	13444.94	102.00	**13**	3	15715.73	107.33
14				**14**	2	14595.63	105.00	**14**	2	14595.63	105.00
15+				**15+**	8	25507.99	118.25	**15+**	10	21801.36	120.50

On an annual basis, Mean Length at Age obtained for males was similar to that for females until age 5. Females older than 5 years appear consistently larger than males. Females reach older ages. Thus, in general younger fish were similar in length but from age 5 to older ages, females appeared bigger than males in all cases.

It has to be pointed out that only the synthetic table is showed. However, when ages were not grouped in a 15+ age class, the illicia readings resulted in highest ages of 22 years old for females and 10 years old for males. One individual of 136 cm in length was aged 25 years old but its sex was indeterminate because fish was examined gutted. However, based on the observations carried out in the biology of this species, it is very probable that it was a female because males have not been observed to reach such large sizes.

4.3. Growth parameters

The von Bertalanffy Growth equation has been applied to estimate the growth pattern of White Anglerfish. The growth equation parameters were estimated by means the FISHPARM program (Prager et al., 1987) applying the Mean Length values at Age calculated from the annual ALK for the study period. As explained before the L_∞ assigned values were the length of the largest fish found during the two time periods (Table 4.3.1). The observed Mean Length at Age for males, females and sexes combined and the expected values obtained by the von Bertalanffy growth function are presented in Figure 4.3.1.

Table 4.3.1. Growth parameters of White Anglerfish in the Bay of Biscay for the period [1996-97] with restricted L_∞.

	Males	Females	Sexes combined	Period
L_∞	100	150	150	Annual
K	0.1517	0.0854	0.0882	Annual
t_0	-0.1051	-0.2961	-0.0236	Annual
r^2	0.9834	0.9931	0.9914	

5. Condition Factor

The condition Factor (CF) was calculated as follows: $CF_t = W_t / L^3 * 100$ and $CF_g = W_g / L^3 * 100$

Where W_t = Total weight (g), W_g = Commercial Gutted weight (g), L = Total Length (cm)

In this section, the values of the monthly evolution of the condition factor calculated using the Total and Commercial Gutted Weight (i.e. with liver) are shown (Figure 5.1). No results are available for the CF calculated using the Scientific Gutted Weight (i.e. without liver) because of the scarcity of the data. For this purpose, different length rages of males and females were used. In Figure 5.1 only the results on CF study for "mature" fish are presented. The individuals used were males ≥50 cm and females ≥73 cm. These lengths were chosen as an approximation, based on the results obtained in our histological study on length at first maturity (see below), that resulted similar to the obtained by Afonso-Dias & Hislop (1996).

It must be pointed out that because of the scarcity of the sampling on higher lengths in some months, the number of samples was greatly reduced. Thus, for CF_t during February, June and August it was not possible to obtain males ≥50 cm and so values were estimated by means an average of the values of the two contiguous months. Females ≥73 cm were absent during February, May, July, September and November, thus CF_t obtained for those months were also averaged. During the rest of the months the number of samples used was even reduced to 2 individuals.

Males reached their highest CF_t in April decreasing in 14% to a minimum in May. After this, there was an increasing trend of the CF_t until the end of summer (September). Females reached their best condition earlier in the year (March). From March to June the CF_t decreased steadily in almost 26% until a minimum in June increasing again during the summer months towards the end of the year.

In general, mature males and females were at their lowest conditions from March to July and for the rest of the year the body condition was maintained at medium levels almost constantly.

As for the study of the CF_t, for the CF_g study there were not males ≥ 50 cm for June and August, so their values were averaged. Females ≥73 cm were absent during February, June and August, thus CF_g obtained for those months were averaged. As before, during the rest of the months the sample numbers used was reduced even to 2 individuals.

Males were at their highest condition in February and steadily decreased by 18% towards May. For the rest of the 2nd and 3rd quarter the CF_g continually increased by 18% until September and then, markedly decreased in 17% in October. The CF_g obtained for females during the year appeared almost flat and at lower levels than that obtained for males. It must be point out that in October appeared a slight decrease in this flat trend that coincided with that for males.

In general, as explained for the CF_t , males maintained the body condition very low from March to June and for the rest of the year this is maintained almost constant at medium levels. Females body condition did not appear to show any trend, however because the scarcity of the data nothing can be concluded.

6. Reproduction

6.1. Sex ratio

Only individuals sexed *de visu* were considered. That specimina whose sex was uncertain were not considered. A large number of individuals were considered as indeterminate because fish sampled at the fishing ports were almost in their totality gutted. A total number of 1606 individuals were sexed. The smallest fish found was a female of 12 cm of total length and the biggest fish was a female of 128 cm in length. A total number of 915 males and 691 females were identified. The annual sex ratio of the study period is shown in Figure 6.1.1.

When the percentage of females and males was studied during the year, a similar frequencies of males and females until 75-80 cm were observed and only slight departures of the 1:1 sex ratio were detected. From 80 cm towards larger sizes females were dominant and males disappeared when 95 cm of length were reached. Thus, males and females appeared to be similar in abundance for all length ranges until 80 cm where females started to be dominant in these large lengths.

When the frequencies of males by quarter were studied (Figure 6.1.1), small and medium size males appeared to be more abundant during the 1st and 4th quarter while larger ones were more present during the 2nd and 3rd quarters.

6.2. Gonosomatic index

The Gonosomatic index (GSI) was calculated in two ways: $GSI_t = W_{gon}/W_t * 100$ and $GSI_g = W_{gon}/W_g * 100$

Where W_t = Total weight (g), W_g = Commercial Gutted weight (g), W_{gon} = Gonad weight (g)

Monthly evolution of the GSI_t and GSI_g for males and females are shown in Figure 6.2.1. Only eventual "mature" (or "adult") males and females were selected to carry out this study. Thus, as before for CF study, males $\geq$ 50 cm length and females $\geq$73 cm were chosen. But, as for the analysis of the CF monthly evolution there were sampled neither males $\geq$50 cm in February, June and August nor females $\geq$73 cm in February, June, August, October and December to obtain values for the GSI_t study during those months. Thus, the values for these months were estimated averaging the values of the two contiguous months.

The monthly evolution of the GSI_t for males presented highest values in May and lowest values in January-April (minimum in April). The GSI_t values for males increased from April to May by 82 % and then decreased from May to July by 27 %. As for males, females followed the same trend: low values during the 1st quarter of the year and a maximum in May. For the 3rd quarter these values were maintained but started to decrease to a minimum in September. From April to May the increment observed in the GSI_t values was 74 % and then decreased from July to September by 43 %. For the 4th quarter the GSI_t appeared to increase, but it must be keep in mind that these high values are due to only 5 females observed in November; the rest of the values in October and December are extrapolated. It is very notable the pattern that present females from April to September (Figure 6.2.1). The highest values appeared to coincide with the spawning season (May-August) and the minima values with the resting season (post-spawning). In the rest of the year, the GSI_t values for both sexes were kept at low levels except for a marked increment in November (a sampling problem?). For all the year GSI_t values for females were maintained slightly higher than that for males.

The GSI_g monthly evolution for mature White Anglerfish is presented also in Figure 6.2.1. For this GSI_g study, as before for the GSI_t, there were not enough males greater than 50 cm in February, June and August and females greater than 73 cm in February, June, August October and December to obtain values. Thus, for these months the values were estimated as an averaged of those of the contiguous months.

The monthly evolution of the GSI_g for males presented low values from January to April increasing then sharply to a maximum value in May. After this there is a decreasing trend towards July. The GSI_g values for males increased from April to May by 86 % and decreased from May to July by 28 %. As for males, females followed a rather similar trend that for the GSI_t described before. Low values since January to April with a sharp increase in May and high values in July, followed by a minimum in September. From April to May the increment observed in GSI_g values was 52 % and the decrease from July to September was by 46 %. As for the GSI_t, in the 4th quarter the GSI_g appeared to increase, but the high values are due to only 3 females observed in November; the value of October is extrapolated. For the 4th quarter of the year the GSI_{g+1} appeared to increase. As for the GSI_t higher values for males and females appeared from May to July (Figure 6.2.1) coinciding with the spawning season. The rest of the year, GSI_g values for both sexes were kept at low levels excepting (unexpectedly) in November. For all the year the GSI_g values for females were maintained higher than for males.

6.3. Macroscopic and microscopic maturity stages

Five stages of gonad maturation were agreed for Anglerfish. The description of these stages in relation to the relative size and weight and to the external appearance and colour of the gonads is presented in Table 6.3.1. However, it is well known that the use of macroscopical (*de visu*) keys to classified maturity stages is open to a great amount of subjectivism. Also, to discriminate between two continuous stages presents a repeated problem. Thus, histological studies were carried out to solve these difficulties. Five histological maturity stages of the gonads were established by AZTI in relation to those given for the macroscopic analysis (Table 6.3.2). The results of both methods are presented and compared. Only individuals assumed to be "adult" were chosen for both studies. Thus males ≥50 cm and females ≥73 cm were studied. However, to put in perspective the results obtained in relation to the maturity stages monthly evolution, it is necessary to keep in mind that it was possible to analyse only a relevant number (*ca.* 20 or more fish) in seven months for males and in three months for females.

Table 6.3.1. Maturity Stages for White Anglerfish assigned *de visu.*

Maturity stage (*de visu*)	Males	Females
I Immature or Virgin	Tube-shaped testicles, pink or transparent, cover a small proportion of the visceral cavity. Sperm not visible	Band-shaped ovaries, very transparent and without visible oocytes
II Maturing	Testicles cover a great proportion of the visceral cavity, pearl-coloured, some sperm in the lumen.	Ovaries cover a great proportion of the visceral cavity, with creamy colour. The band is longer and has visible oocytes.
III Mature or Prespawning	Pearl-coloured testicles and with the lumen full of sperm.	Orange-coloured oocytes with accentuated vascularization and the presence of some hyaline eggs (hydrated)
IV Spawning	Sperm is easily freed by applying pressure to the abdomen.	An enormous gelatinous yellow 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, possible residual oocytes, reabsorbed.

Table 6.3.2. Maturity Stages for White Anglerfish assigned by means of histology (AZTI maturity stages).

Maturity stage (by histolgy)	Males	Females
I Immature or Virgin	Spermatogonia and Spermatocyte present, Spermatozoids absent.	Only Oogonia, Chromatin nucleolus stage.
II Maturing	Spermatogonia and Spermatocyte present, few Spermatozoids.	Oogonia, Chromatin nucleolus stage, Perinucleolus stage, early vitellogenesis.
III Mature or Pre-spawning	Spermatozoids predominant, Spermatogonia and Spermatocyte present only in the testis cortex.	Vitellogenesis, early nucleus migration and mucus layer present.
IV Spawning	Spermatozoids predominant.	Migratory nucleus stage and Oocyte hidratation. Unable to see Oogonia and the other immature stages. Great mucus layer.
V Post-spawning	Empty seminiferal ducts, residual Spermatozoids and few Spermatogonia.	Post-ovulatory follicles and folicular atresias. Oogonia and Chromatin nucleolus stage.

Based on the macroscopic studies and looking at the proportion of the Maturity Stages by sexes, (Figure 6.3.1) immature males (stage I) were found in very low proportions only during June, September and November. Maturing males (stage II) were found all around the year, excepting in February, in variable proportions. The higher numbers of maturing males were observed during September (58 %) and October

(67%) and the lowest occurrences, during June (12 %). Mature or pre-spawning males (stage III) also appeared around the whole year but at higher numbers during May (75%) and July (86%) and in November (65%) and December (78%). In February 50% of males were spawning (stage IV) and in June 32% of them. Post-spawning males (stage V) were not found along the whole year.

No immature females (stage I) were described during the study period. The number of maturing females (stage II) was very high during the whole year, the higher proportions were found during April, May, July and August when almost 100% of the females were maturing. Mature or ready to spawn females (stage III) were only found between November and January being at their highest frequencies in December (23%). In the macroscopic analysis females in spawning condition (stage IV) were not found along the year except in June, when the total number of females studied was very low (8 specimina) being the proportion of spawning females around 13%. Post-spawning females (stage V) were found in March, June and July (1 fish each month).

The maturity stages assigned by histological process were also analysed (Figure 6.3.2.). The total number of males (≥50 cm length) studied along the year was 91 being its monthly frequency range between 1 and 14 fish. In the same way only 51 females (≥73 cm length) were analysed with a monthly frequency range between 0 and 15 fish. Due to this rather low number of fish examined, the proportions of different maturation stages must be considered with caution.

Immature males (stage I) appeared (always in low proportions) in January, March, April, August and September. Only two immature females appeared in April for the size range chosen.

Maturing males and females (stage II) were found almost along the year, although in different proportions. Proportions of maturing males increase from December (10%) to April (30%). Then they decrease to a minimum (10%) in May and June. From August to October maturing males were more frequent reaching 67% of occurrences. Proportions of maturing females were quite high all along the year (50% and more) reaching 100% of the few individuals sampled in July and September.

Mature or pre-spawning males (stage III) appeared also all around the year. In fact, at least one third of males analysed could be considered all around the year as pre-spawners. Their higher frequencies were reached in May, July, August and December. Pre-spawning females were observed only during November (33%), December (22%) and January (17%).

Spawning males (stage IV) occurred in higher proportions during the first semester of the year. They reached a maximum in February (but only 2 fish examined) and June when half of the males studied were spawning. During the rest of the semester appeared in low proportions. They were completely absent from July to October. Spawning females were only found in June (33%) but as for the macroscopic analysis only 3 spawning females were found.

Post-spawning females (stage V) occurred in March (33%) and May (50%), but only 3 and 2 fish per month could be analysed respectively. Males in post-spawning condition were also observed in April-June, September and December, being more frequent in June (20%).

In general, pre-spawning and spawning females were found in very low number during the study period. Taking in account the number of samples employed and the intensity of the sampling, it seems that females in that maturity condition are not easily available to the fishing gear. It may be a migratory factor in females that made them not "catchable". Females might migrate to deeper waters or even move to another grounds or sea areas. However, although number of these females were very scarce, both approaches for the Maturity Study point out that maturing males appeared all around the year and when females are present they appeared at lower frequencies. Immature males (stage I) were present during the first semester of the year and immature females were only recorded in April, but the number of females analysed in the first part of the year resulted always much lower than for males. Although numbers of post spawning females and males were very low, females appeared in early spring (March) while males do a bit later in lower proportion. Thus, the studies seemed to indicate that males have longer spawning periods than females.

6.4. Spawning period

For this analysis, fish were considered "mature" when they were found in whatever of the III, IV or V established stages. Moreover, the peak spawning season should be considered that part of the year in which the highest frequencies of mature fish –above all in spawning stage- and the highest values of Gonosomatic Index (GSI) for both sexes approximately at the same time take place.

Based in the macroscopical study, the annual pattern of occurrences of "mature" individuals appears to be different for males and females (Figure 6.4.1). "Mature" males –i.e. fish in stages III, IV and V- occurred along the whole year. There were at their highest frequencies during May, June and July (around 85%) and in December (near 95%); also in February (100%), but in this month only 2 fish were analysed. The highest proportions of inactive males –i.e. fish in stages I and II- where found in April (62%), September (68%) and October (77%). In relation to the females the highest proportions of mature (about a 25%) were found in March, June, July and in December. Lower proportions (less than 12%) appeared in November and January. In May, August and September all females found were considered as immature.

When the same study was carried out by means of histology, mature males and females seemed to appear in different proportions and time periods. Mature males occurred all around the year in high proportions (always more than 50%, except in September and October (about 40%)). The maximum values (more than 75%) were in May-June and in November-December -also in July, but in this month only 1 fish was analysed). Mature females appeared above all in May and June, but not in high proportions (50% or less), being any case the number of fish analysed very low. In the period July-October the mature females were absent in the sampling, but again the number of fish analysed was very low. In November mature females sharply appeared reaching 33% of the occurrences but decreased in December and more in January. Only one mature female (33% of the analysed fish) was found in post-spawning stage in March.

According to the results of both histological and *de visu* maturity stages studies as well as the analysis of the Gonosomatic Index (GSI) monthly evolution, the spawning period for this species appeared not to be well defined, in great part due to the scarcity of adult fish (mainly females) obtained in the sampling. Any case, as a first approximation, it may be established that the White Anglerfish spawning period in the Bay of Biscay (Div. VIIIa,b,d) takes place between the late spring and the early summer, i.e. from May to July or August. However more detailed studies and a more intensive sampling above all for adult females have to be carried out to determine with more precision the occurrences of pre-spawning and spawning females in order to concrete with more certainty when the spawning period takes place. Moreover, due to the scarcity of the adult females sampled, it cannot be concluded for the moment that an annual maturation cycle must be assumed in females of this species as it is usually assumed for must of the osteichthyans commercial fish in this sea area.

6.5. First maturity by length and age: Maturity ogives

6.5.1. First maturity by length

For the study period, the beginning of the reproduction in males and females was calculated macroscopically and by means of histology. Firstly, the percentages of mature specimina were calculated for the period [1996-1997] based on the stages assigned *de visu* and thus the length-maturity keys were obtained. In the same way length-maturity keys were calculated based on the maturity stages assigned by histology. For this purpose only data from May to July or August were selected, because during these months highest values of the Gonosomatic Index were found and also through the Maturity Study, mature fish were found in more abundance.

The stage "I" (virgin) and "II" (maturing) were considered as "immature" fish. The fish that presented other stages ("III","IV" and "V") were considered as "mature" fish. The length at which 50 % of the males and females became mature (L_{50}) was estimated by a linear regression of the logarithm data transformation of the percentages of mature fish. The function used for this purpose was: Logit = 0.5 * Ln (P/(1/(1-P))

In Table 6.5.1.1 the results of the calculations of the L_{50} by means of macroscopical observations are presented by sexes for the period [1996-1997]. In Figure 6.5.1.1. the observed percentages of mature fish obtained by means of macroscopical data and the logistic function adjusted to this values are also presented.

Table 6.5.1.1. Estimation of the Maturity Ogive parameters (L_{25}, L_{50} and L_{75}) for the period [1996-1997] by macroscopy.

[1996-1997]	L_{25}	L_{50}	L_{75}	Period
Male	47.03	54.55	62.08	May-Aug
Female	82.45	83.63	84.85	May-Aug
Sexes combined	55.80	70.03	84.26	May-Aug

The results of the histological study of the L_{50} are presented in Table 6.5.1.2 by sexes and for the study period [1996-1997]. In Figure 6.5.1.2. the observed percentages of mature specimina obtained by means of histology and the logistic function adjusted to this values are presented.

Table 6.5.1.2. Estimation of the Maturity Ogive parameters (L_{25}, L_{50} and L_{75}) for the period [1996-1997] by means of histology.

[1996-1997]	L_{25}	L_{50}	L_{75}	Period
Male	52.25	52.71	53.17	May-Aug
Female	72.50	73.20	73.91	May-Aug
Sexes combined	51.92	68.15	84.39	May-Aug

From Table 6.5.1.1., 50% of males matured at almost 55 cm length and females close to 83 cm. Thus, males matured at a smaller size than females. The results of the ogives by length obtained by histology show than during the study period, 50% males mature near to 53 cm length and females at 73 cm. The difference in the sizes may be due to the accuracy of the two methods employed. It appeared that histology is a more accurate method to assign the maturity stages and thus its value of the first length of maturity should be preferable. Any case, for both methods, males reached first maturity at significant smaller sizes than females.

6.5.2. First maturity by age

The age at which reproduction begins in males and females was also calculated macroscopically and by histology for 1996-1997. As for the study of maturity at length, firstly, percentages of mature males and females were calculated for 1996-1997 based on the stages assigned *de visu* and histologically. Thus, Age-Maturity Keys were obtained. As for maturity at length, only data from May to August was selected and all fish excepting virgins and maturing (i.e. in maturity stages "I" and "II") were considered as mature.

The results of the calculations by means of macroscopy of the A_{50} are presented by sexes for the period 1996-1997 in Table 6.5.2.1. In Figure 6.5.2.1 the observed percentages of mature fish obtained by means of macroscopy and the logistic function adjusted to these values are presented. Table 6.5.2.2 shows the results of the histological analysis for the study period. In Figure 6.5.2.2 the observed percentages of mature specimina obtained by means of histology and the logistic function adjusted to this values are presented.

Table 6.5.2.1. Estimation of the Maturity Ogive parameters (A_{25}, A_{50} and A_{75}) for the period [1996-1997] by macroscopy.

[1996-1997]	A_{25}	A_{50}	A_{75}	Period
Male	3.97	4.71	5.45	May-Aug.
Female	10.35	10.67	11.00	May-Aug.
Sexes combined	7.49	7.95	8.41	May-Aug.

From Table 6.5.2.1., 50% males matured at almost 5 years old and females close to 10 years old. Results of the Maturity ogives at age obtained by histology show than during 1996-1997, 50% males matured near to 5 years and females at 7 years (Table 6.5.2.2). By the two methods, males reached first maturity at much younger ages than females.

Table 6.5.2.2. Estimation of the Maturity Ogive parameters (A_{25}, A_{50} and A_{75}) for the period [1996-1997] by means of histology.

[1996-1997]	A_{25}	A_{50}	A_{75}	Period
Male	4.96	5.00	5.06	May-Aug.
Female	7.00	7.05	7.10	May-Aug.
Sexes combined	5.88	5.99	6.09	May-Aug.

When the results obtained by macroscopic and microscopic methods are compared, great differences appeared in the estimations of females' Maturity Ogive parameters. This may be due to the scarcity of specimina with both age and maturity stage assigned and also because there is a clear lack of biological data of "mature" females. In our sampling only one female with hydrated oocytes was registered. The absence of data lead us to overestimate *de visu* the Length and Age at first maturity. Apart from the scarcity of the data, macroscopic methods overestimated the number of mature females. Thus, some females were considered as post-spawners while by histology they were established as starting their maturation. Also, females considered *de visu* as maturing were described as pre-spawners by histology means. Thus, the histological methods appeared to be more adjusted to the reality of the species especially when the spawning period has not been established yet and contiguous maturity stages may be confused.

DISCUSSION

1. Growth in weight at length. The growth in weight related to the total length of White Anglerfish was not different for males and females. Only it was detected a different relationship between males and females when the gutted weights were compared annually. Differences in Length-Total and Commercial Gutted Weights were also detected during the first quarter of the year and for the last relationship during the 4th quarter. Because of the significant number of samples and length ranges used, it appears to be a different weight growth pattern for males and females during this time of the year, which coincides, with the time previous to the spawning period and when the recovering of the spawn takes place. In the same way and on an annual basis, Total, Commercial Gutted and Scientific Gutted Weights were differently related for males and females comparing for the same length ranges. Thus, it appears to be a different growth pattern along the year for males and females.

2. Mean lengths at age. Mean lengths at age of males were similar for males and females until age 5 when females started to be much larger than males. Based on the microscopy method males mature at smaller sizes than females and also at younger ages. There is a difference of 2 years in the sexual maturation between sexes. Males mature at 5 years and females around 7 years. Looking at the sizes it appears that coincide with the results observed for the mean length at age. Difference in length growth between sexes appears to take place in fish older than 5 years when sexual maturity takes place for males and later for females It appears that when the reproductive effort stars the pattern of growth of females and males starts to change.

3. Growth parameters. The growth pattern observed in males and females appears to fit adequately to the von Bertalanffy growth equation. Females reached older ages and greater lengths than males. The estimate of the instantaneous growth rate (K) was higher in males than in females. As females reached sizes greater than males, they are expected to grow longer but quite slower than males in the first ages.

4. Condition factor. For mature females (≥73 cm) and males (≥50 cm), the optimal condition of the individuals occurs in winter and started to decrease in April and May recovering again in July and August. As it was expected, this pattern is the opposite to the one presented by the Gonosomatic Index (GSI) monthly evolution. The highest values for the condition of the gonads (GSI) were registered from May to July. These opposite trends indicate when it is expected to find the maturing time of this species. In this case it was established to occur from May to July-August. However, it must be keep in mind the relative scarcity of the sampling on higher lengths in some months, and for this reason, the conclusion did not resulted absolutely clear.

5. Sex ratio. When all samples were together considered, in an annual basis, males appeared in a rather similar abundance to females in length classes until 75-80 cm while females started to be clearly dominant in bigger lengths. The intensity get in the annual sampling as well as the presence of all length classes in the sampling leaded to think that these departures are real differences. Thus it must be concluded that the relative more abundance of females in the big fish catches is due to the distinct growth pattern between sexes and neither to the different catchability of sexes nor to eventual limitations in the sampling.

6. Maturity evolution and spawning period. The maturity stages assigned *de visu* resulted in post-spawners scattered distributed along the year and in very high frequencies of maturing and pre-spawning fish. When these results are compared to those of the microscopical analysis, it appears that, because of a lack of experience at the beginning of the, this is problem of discrimination between immature, maturing, pre-spawning, and post-spawning. The presence of maturating stages along almost the whole year appeared to be a problem of macroscopical differentiation between this stage and the pre-spawning stage. Thus, some maturing individuals that by eye were distributed along the year in very high frequencies using histology were considered as pre-spawning, spawning and in some cases post-spawners already recovering from the spawn.

The emergency of maturing females during the 2nd and 4th quarters of the year, while in the macroscopic analysis were not present was due to the facility to identify by means of histology oocytes with migrated nucleus and oocytes hydrating. However, macroscopic methods appeared to overestimate the presence of maturing individuals along the year. Thus, microscopy appeared as the most accurate method to clearly distinct between the different maturity stages. Thus, these were constricted to a concrete time of the year and in sequential proportions.

Maturation of White Anglerfish takes places during the late 2nd quarter and early 3th quarter of the year (May to July-August). The peak spawning season takes place likely during May-July. Probably the small males proportion that start to spawn in November are the largest fish in size. Males start spawning earlier in the year than females and in a longer period than females. When spawning occurs, males start at higher proportions. The post-spawning period starts in March probably for the largest females and finish in December. In our sampling post-spawner females appeared only until May while males still appeared in September and reappeared in December. These could due to the lack of female sampled in these maturity stages more than a real short post-spawning period.

Data on maturing and spawning maturity stages are in very close agreement with the peaks observed for the GSI_t and GSI_g evolution. Both series of data confirm that the reproductive activity for these species in the Bay of Biscay (Div. VIIIa,b,d) takes place from May to July-August and that after that the reproductive activity at least for males keeps going. However, it must be also keep in mind, as for the Condition Factor study, the relative scarcity of the sampling in some months for both sexes, and for this reason, the conclusions did not resulted absolutely definitive. A more complete sampling by month of both sexes and above all for big fish is needed to confirm the preliminary results obtained in the present work.

7. First maturity at length and at age. Based on the both macroscopic and microscopic methods males mature at smaller sizes than females and also at younger ages. According to the microscopic method, males (50%) mature at a length 20 cm less than females, i.e. about at 53 cm length, females at 73 cm and both sexes combined at 68 cm. In relation to the maturation at age, there is also a clear difference (2 years) in sexual maturation between sexes. Males mature at around 5 years, females at around 7 years and both sexes combined at *ca.* 6 years.

Comparing these results to those used by the SSDS Working Group (ICES CM, 1998b), White Anglerfish appeared to mature at older ages (and lengths) that it has been considering until now.

MATURITY AT AGE (%)	AGE (years)							
	0	1	2	3	4	5	6	7+
SSDS WG (1998)	0	0	0	2	24	80	97	100
Present study [1996-1997]	0	0	0	0	0	0	54	100

The big discrepancy observed in a parameter (first maturity at age) so important in the analytical assessment of this stock seems to demand the necessity of following biological studies directed to the reproduction of White Anglerfish in order to confirm or reject the new values obtained.

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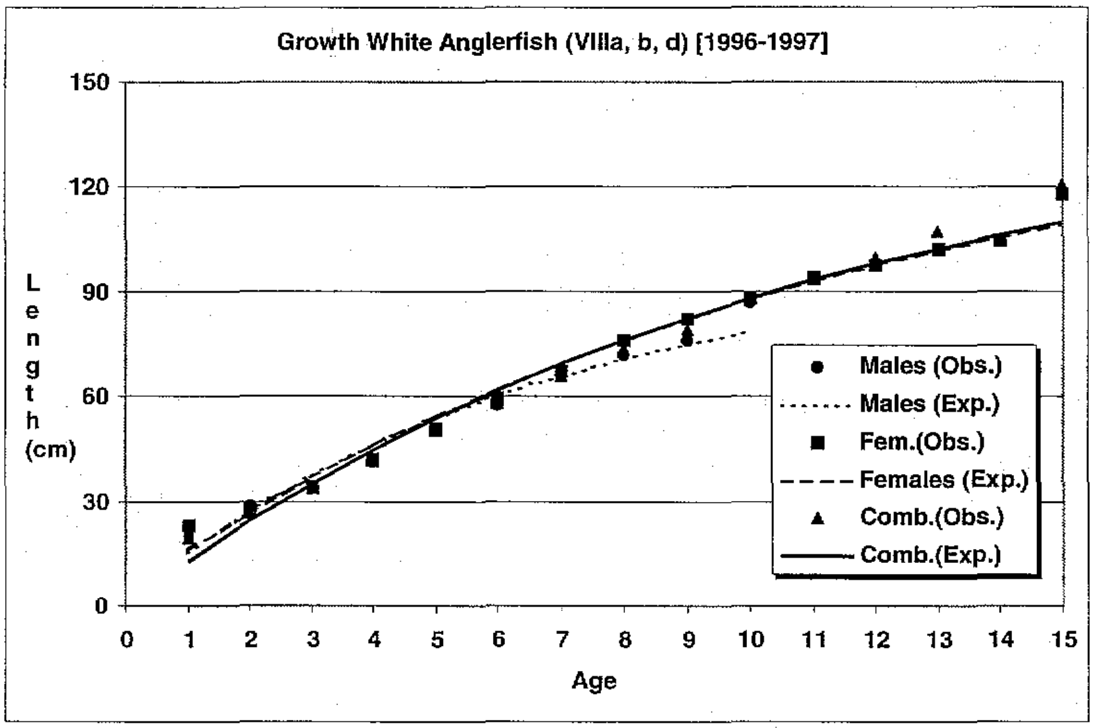
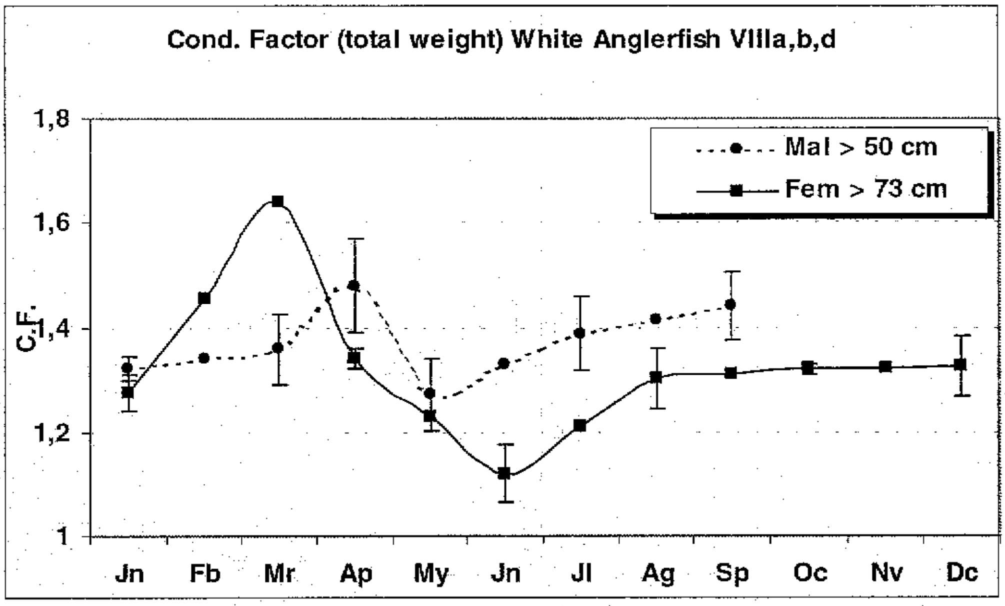


Figure 4.3.1. Von Bertalanffy growth pattern for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].



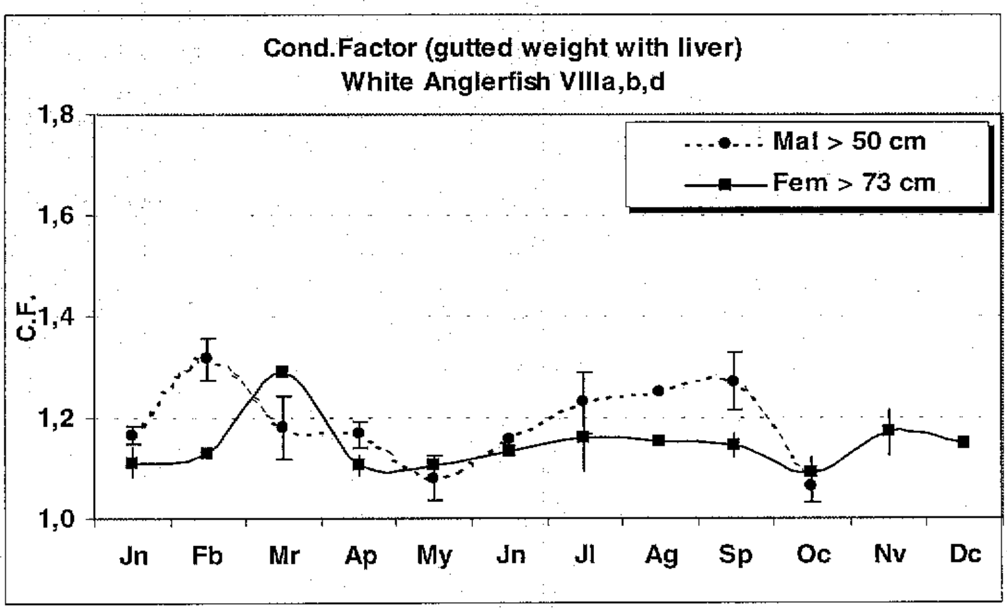
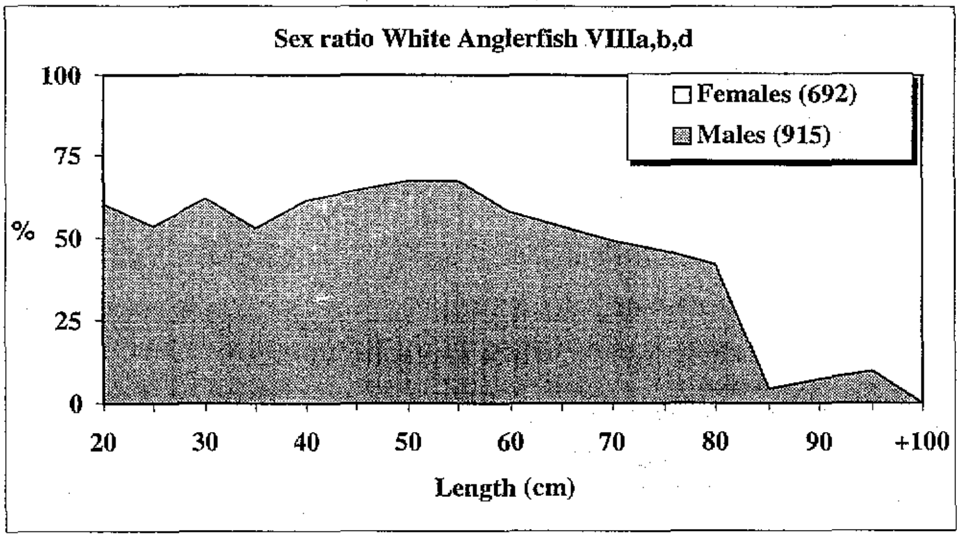
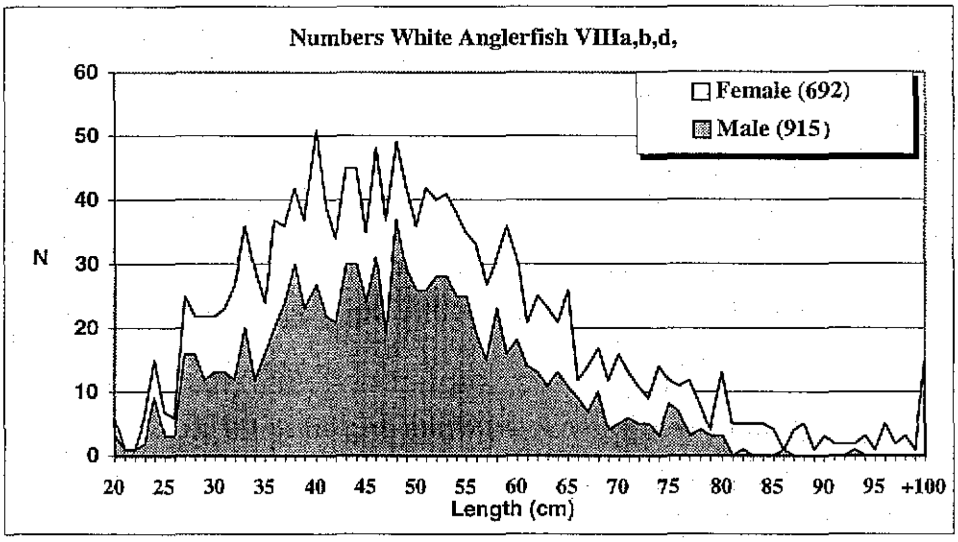


Figure 5.1. Condition factor monthly evolution calculated using: (above) the Total Weight and (below) the Commercial Gutted Weight (i.e. with liver) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].





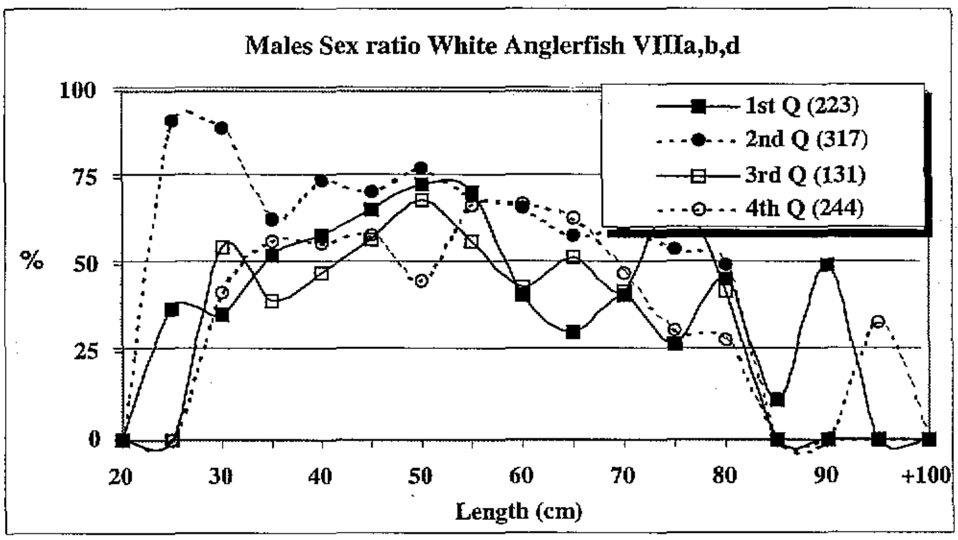
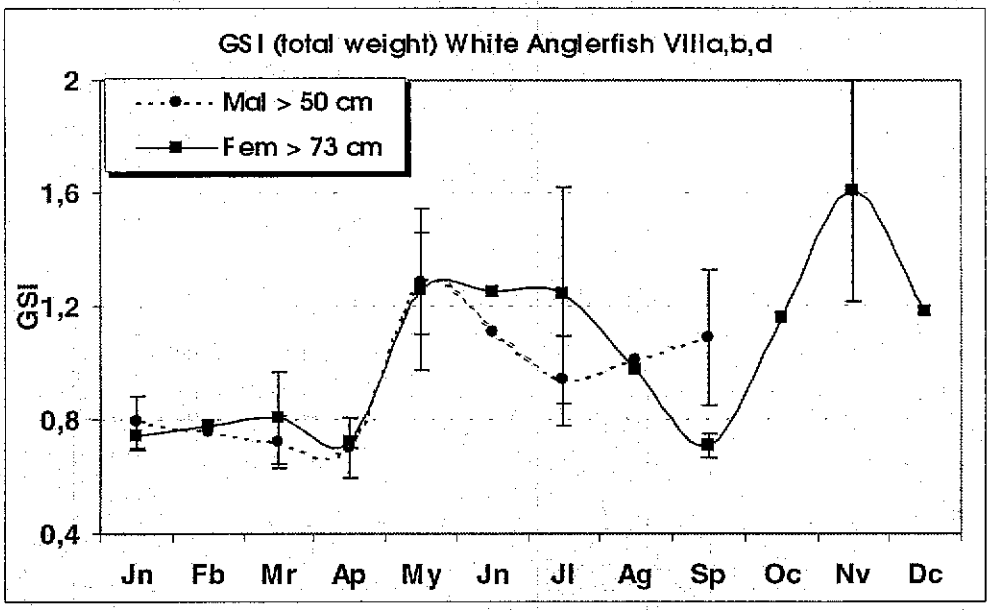


Figure 6.1.1. Sex ratio for White Anflerfish (Div. VIIIa,b,d) in the period [1996-1997].



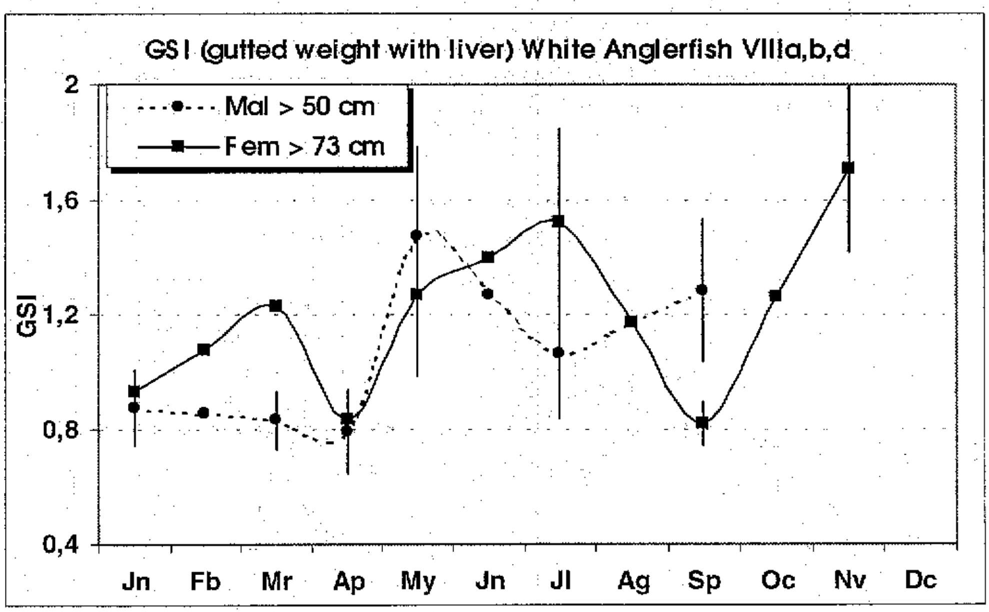


Figure 6.2.1. Gonosomatic Index monthly evolution calculated: (above) the Total Weight and (below) the Commercial Gutted Weight (i.e. with liver) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].

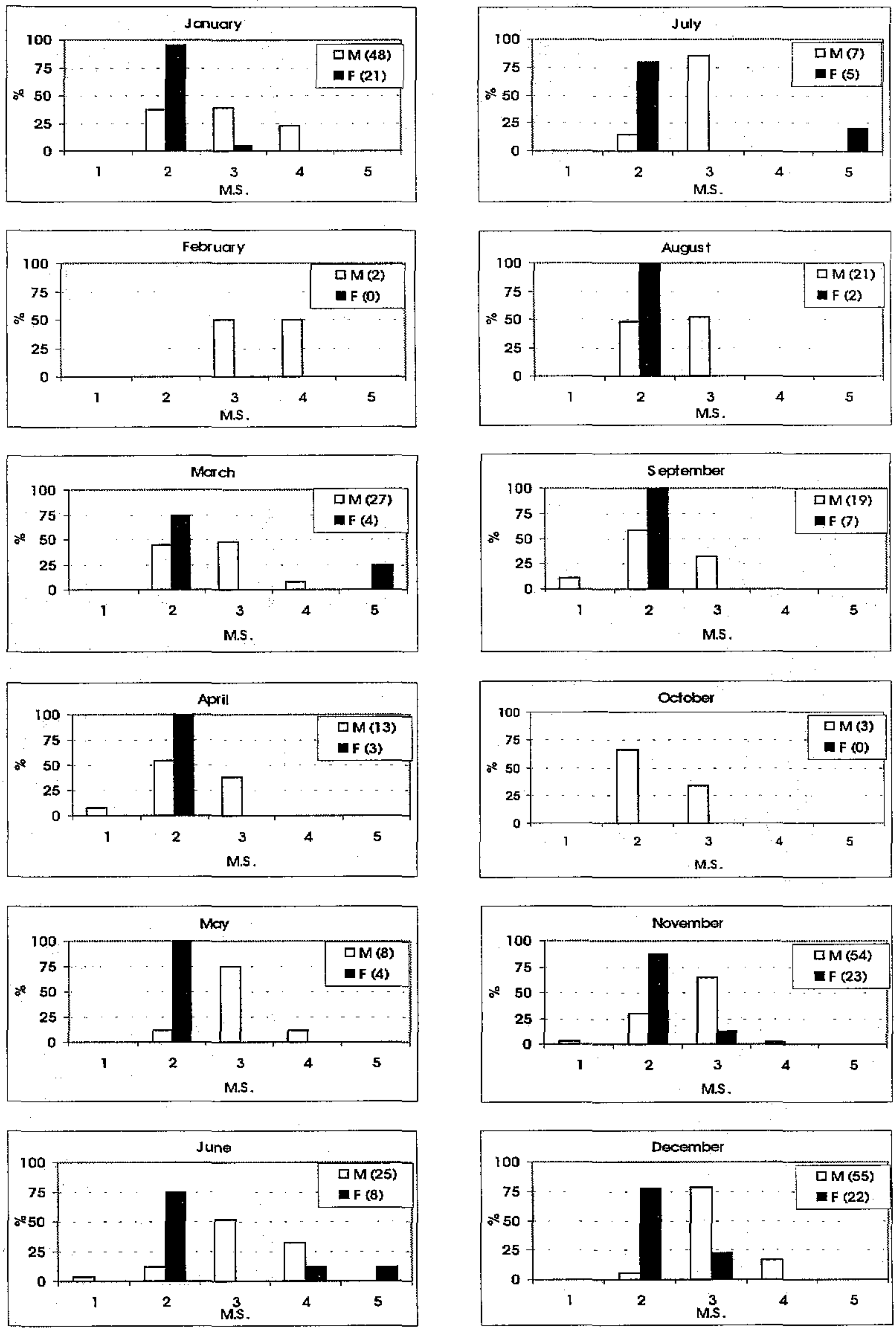


Figure 6.3.1. Maturity stages assigned *de visu* for male (≥50 cm length) and female (≥73 cm) White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997]. Maturity stages: 1) Immature, 2) Maturing, 3) Mature and Pre-spawning, 4) Spawning, 5) Post-spawning.

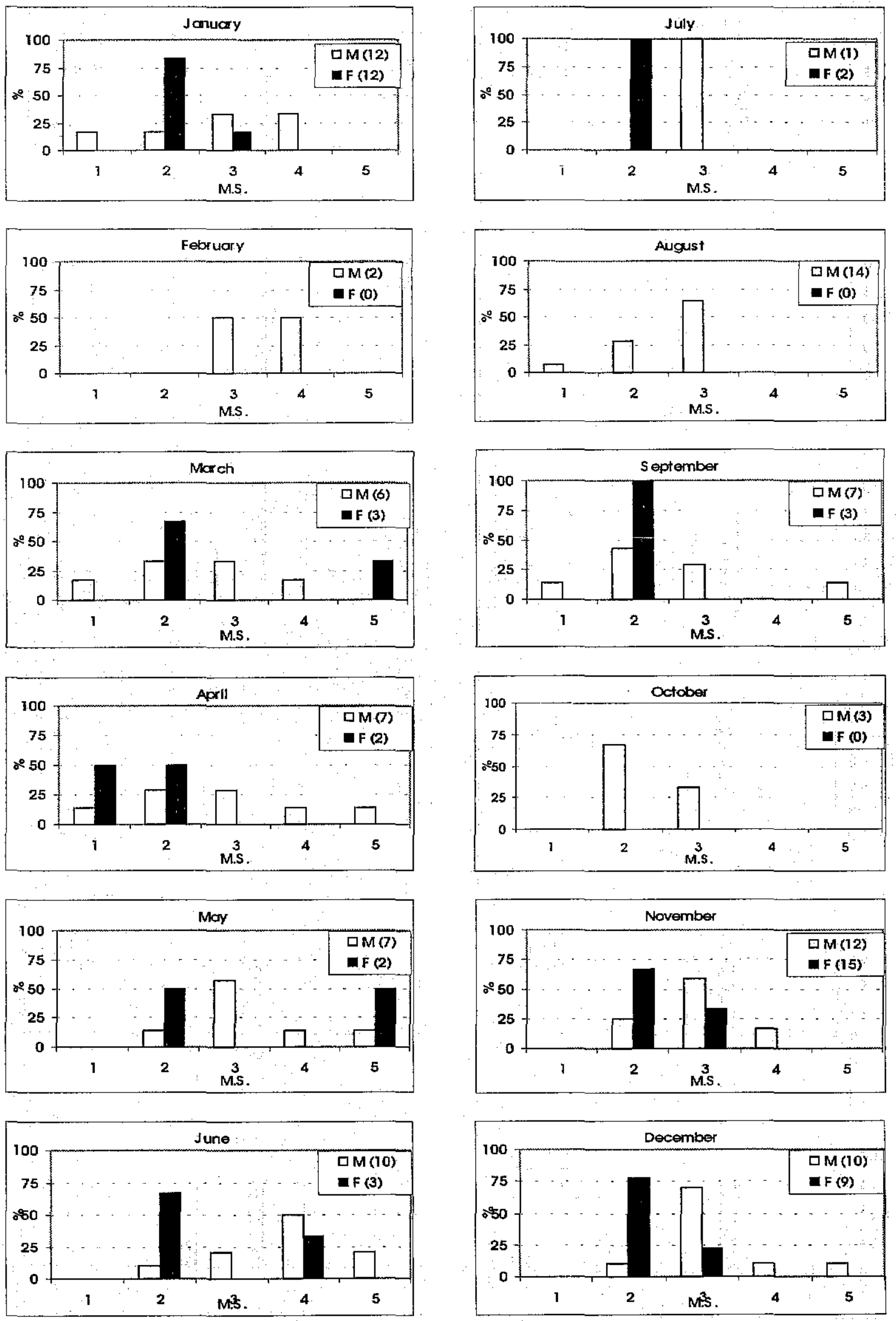
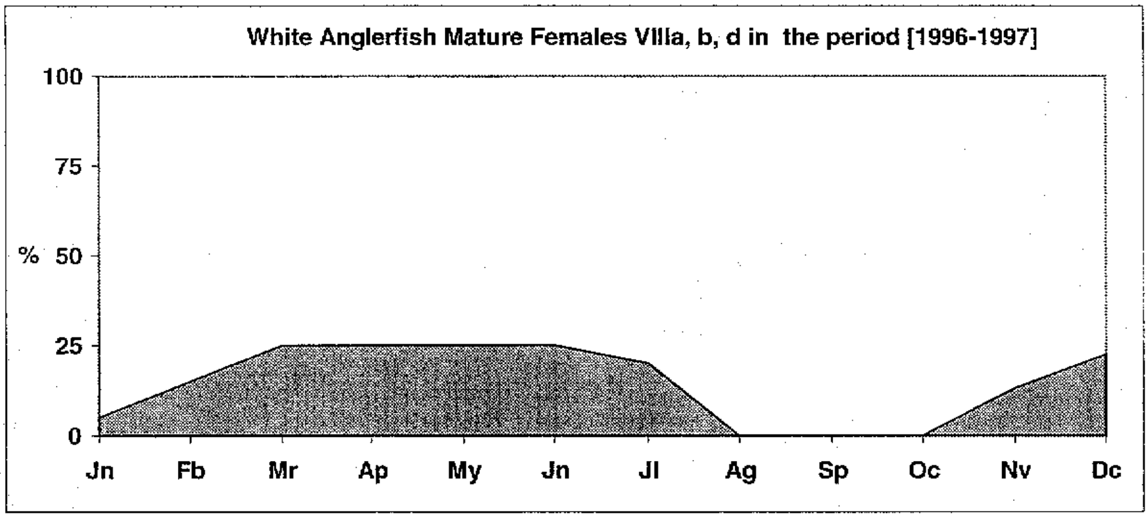


Figure 6.3.2. Maturity stages assigned by means of histology for male (≥50 cm length) and female (≥73 cm) White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997]. Maturity stages: 1) Immature, 2) Maturing, 3) Mature and Pre-spawning, 4) Spawning, 5) Post-spawning.



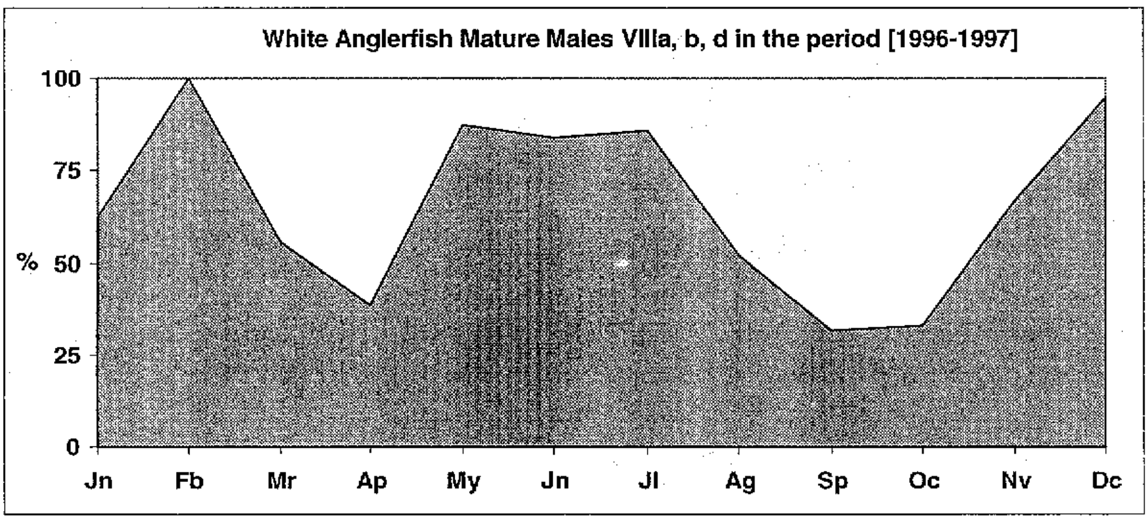
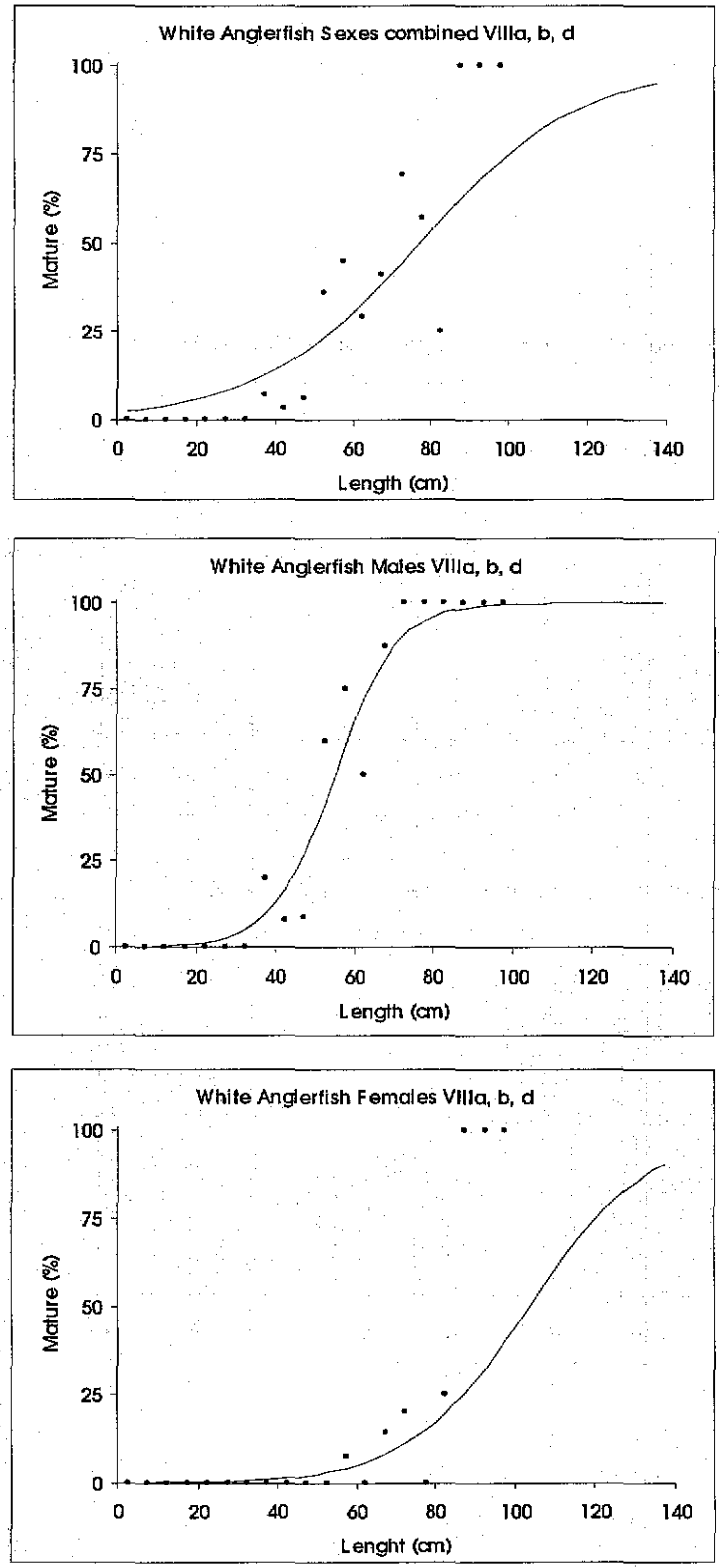


Figure 6.4.1. Percentages of "mature" (based on macroscopical observations) White Anglerfish (Div. VIII a,b,d) in the period [1996-1997]. Above: Females (≥73 cm length). Below: Males (≥50 cm length). "Mature" fish are considered fish in Mature and Pre-spawning, Spawning and Post-spawning stages (see text).



Macroscopic study
Sexes combined

L50 = 70.03 cm
L75 = 84.26 cm
L25 = 55.80 cm

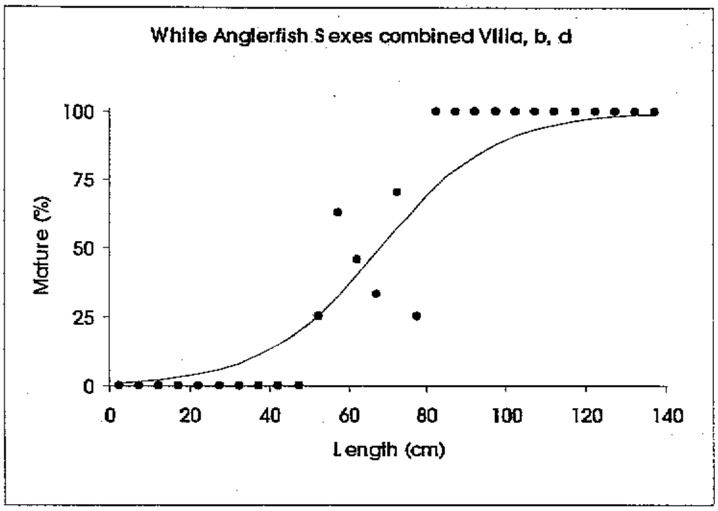
Macroscopic study
Males

L50 = 54.55 cm
L75 = 62.08 cm
L25 = 47.03 cm

Macroscopic study
Females

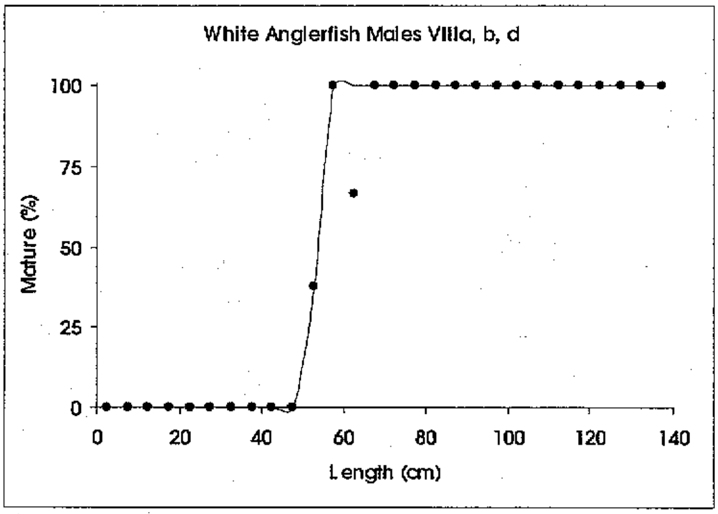
L50 = 83.63 cm
L75 = 84.85 cm
L25 = 82.45 cm

Figure 6.5.1.1. Maturity ogives by length (based on macroscopical observations) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].



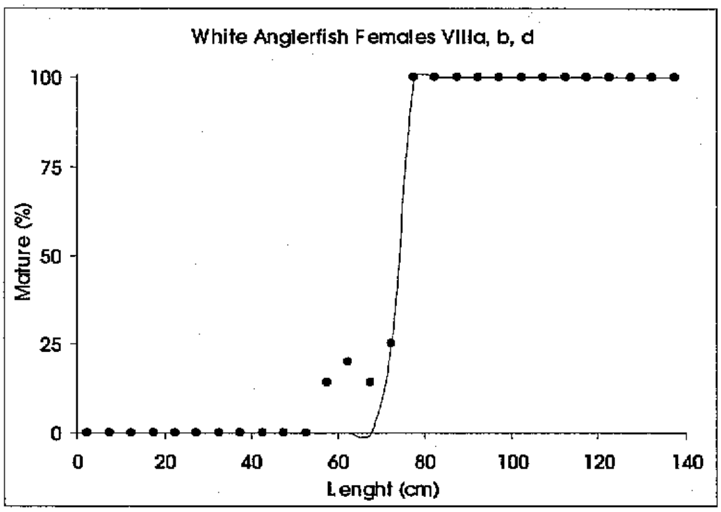
Microscopic study
Sexes combined

L50=68.15 cm
L75= 84.38 cm
L25=51.92 cm



Microscopic study
Males

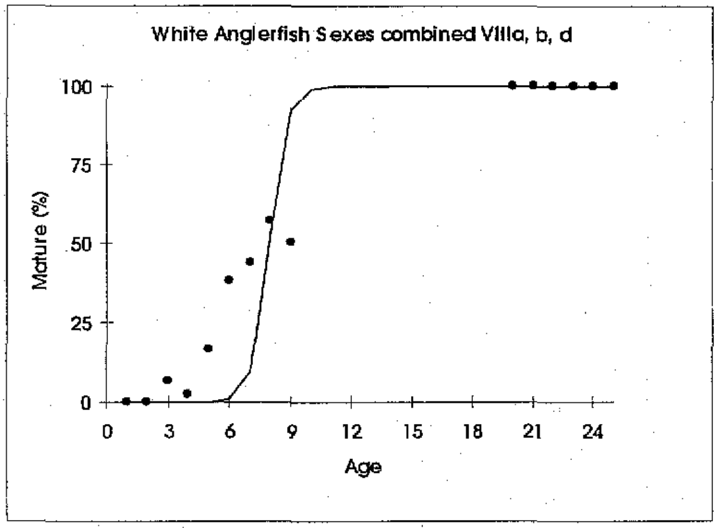
L50=52.71 cm
L75= 53.17 cm
L25=52.25 cm



Microscopic study
Females

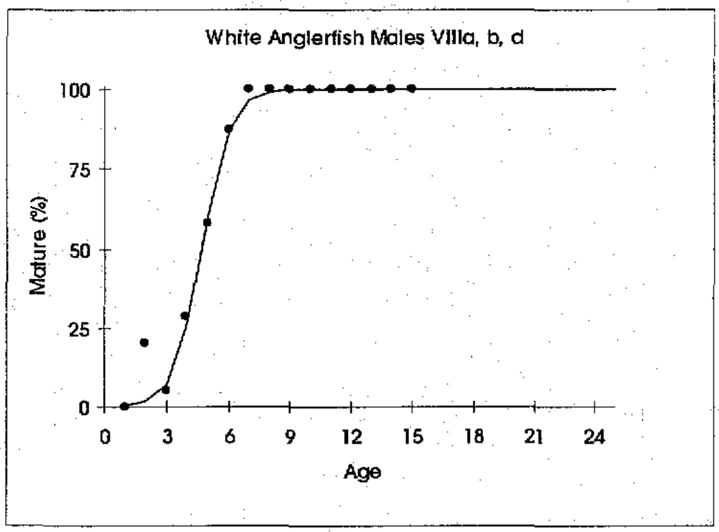
L50=73.20 cm
L75= 73.91 cm
L25=72.49 cm

Figure 6.5.1.2. Maturity ogives by length (based on histological observations) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].



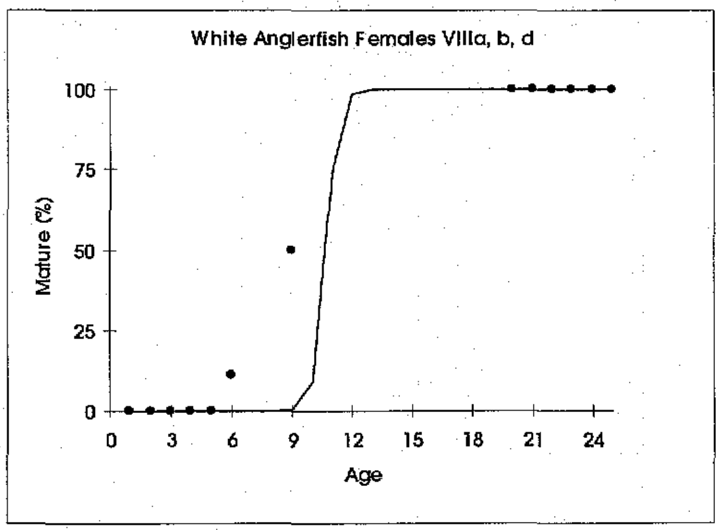
Macroscopic study
Sexes combined

A50=7.95
A75=8.41
A25=7.49



Macroscopic study
Male

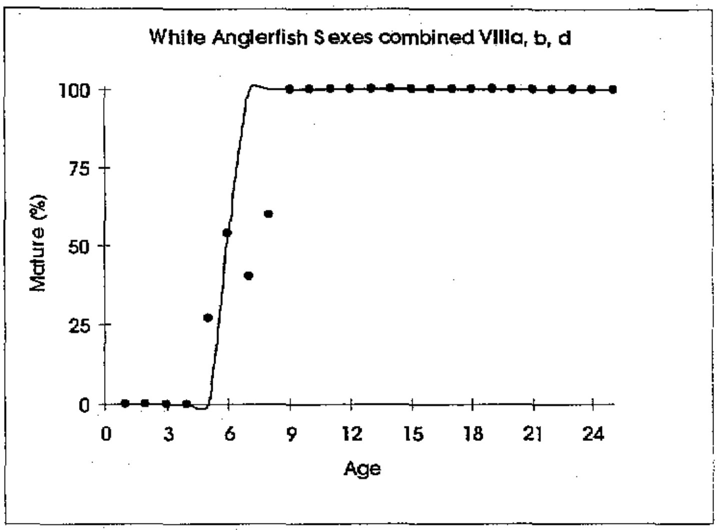
A50=4.71
A75=5.45
A25=3.97



Macroscopic study
Female

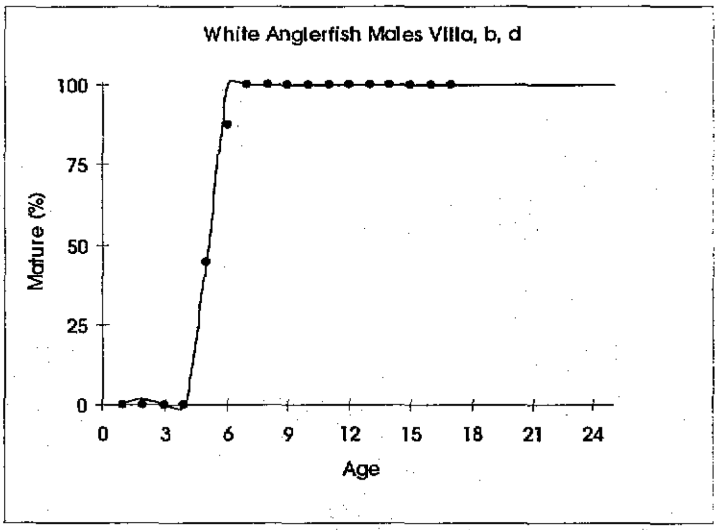
A50=10.67
A75=11.00
A25=10.35

Figure 6.5.2.1. Maturity ogives by age (based on macroscopical observations) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].



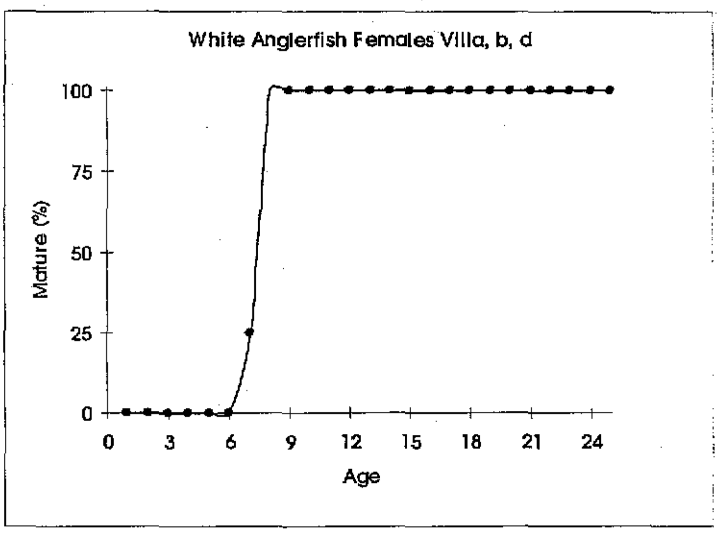
Microscopic study
Sexes combined

A50=5.99
A75=6.09
A25=5.88



Microscopic study
Male

A50=5.01
A75=5.06
A25=4.96



Microscopic study
Female

A50=7.05
A75=7.00
A25=7.10

Figure 6.5.2.2. Maturity ogives by age (based on microscopical observations) for White Anglerfish (Div. VIIIa,b,d) in the period [1996-1997].