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GROWTH, MORTALITY AND MATURATION OF *Lepidorhombus boscii* IN PORTUGUESE WATERS

by

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ABSTRACT

Based on a study carried out between 1989 and 1993, sampling *Lepidorhombus boscii* at Portuguese commercial harbours and survey trawlings along the Portuguese coast, we could obtain, by otolith age reading, the age-length keys for 1990, 1991, 1992 and 1993. The obtained growth parameters, for males, are L_∞=36.13 cm, K=0.187 and to=-1.507 and, for females, L_∞=43.14 cm, K=0.130 and to=-2.174. The obtained length-weight relationship parameters are, for females, a=0.0031, b=3.299 and for males, a=0.0055, b=3.080. Mortality, considering this time period, was calculated as Z=0.58, M=0.27 and F=0.31. Considering only females, Z=0.43, M=0.21 and F=0.22. For males Z=0.87, M=0.29 and F=0.58. In what concerns maturity, we obtained the first maturation length as being 20 cm for females, corresponding to 3.2 years, and 19 cm for males, corresponding to 2.8 years. The spawning period occurs between January and March. The length composition obtained from commercial landings shows 25% individuals caught under minimum landing size.

INTRODUCTION

Lepidorhombus boscii (Risso, 1810) and *Lepidorhombus whiffiagonis* (Walbaum, 1792) are demersal species commercially exploited in Portuguese waters. The management of these species in southern areas are characterised by the scarce biological available data. In northern countries, studies are devoted mainly to *L. whiffiagonis* (STEINARSSON, 1979; DU BUIT, 1984; FONTELA & PATIÑO, s/d; AUBIN-OTTENHEIMER, 1987; PERONNET & RIVOALEN, J.-J., 1989; DAWSON, 1990; DAWSON, 1992; POULARD, *et al.*, 1993) where this species is more abundant. *L. boscii,* more abundant in Portuguese waters than *L. whiffiagonis*, has been less studied. Since the pioneer work of DWIVEDI (1964), who compared some samples from the Atlantic and from the Mediterranean, other studies appeared as the ones from FUERTES (1977; 1978) who studied growth and validation of otolith

reading, as well as mortality, in Northwest Spain, BELLO & RIZZI (1987) studied growth in the Adriatic, DAWSON (1991) studied growth in Keltic Sea. Other studies were presented, as selectivity (ASTUDILLO & SANCHEZ, 1989), feeding (MACPHERSON, 1979; MORTE & SANZ, 1994), bioaccumulation (PELLEGRINI & BARGHIGIANI, 1989) and spatial distribution in Celtic Sea (BOON, 1984) and in Spanish North coast (SANCHEZ *et al.*, 1991).

In Portugal, there are also studies on the batimetric distribution and relative abundance (FIGUEIREDO, 1989; SILVA, 1992) and growth studies based in small samples (CARDADOR, 1992; CASTILHO *et al.*, 1993). SANTOS (1990), presented growth studies based on samples obtained from the Northern fishing harbours and, later, with fish from all the Portuguese coast (SANTOS, 1993; 1993a; 1994: 1995), presenting also data on fecundity and mortality. The parasitology of this species was studied by EIRAS & SANTOS (1992; 1992a).

With this work we intend to present relevant data to help *Lepidorhombus boscii* management in European waters. So, based on a large number of fishes, collected along the Portuguese coast we present the growth parameters, the length-weight relationship, total, natural and fishing mortality, and data on age and length of first maturity. We present also some data on commercial landings.

MATERIAL AND METHODS

We observed 3408 *Lepidorhombus boscii* caught in portuguese waters from 1989 to 1993, with sizes ranging from 7 to 44 cm. The samples were obtained during research surveys performed by the IPIMAR (Instituto Português de Investigação Marítima) and were obtained also from commercial fisheries at the fishing harbours of Póvoa de Varzim, Matosinhos and Aveiro. Figure 1 shows the fishing area and the mentioned fishing harbours.

The fish obtained from commercial fisheries were caught by otter trawling operating in Portuguese coast and we got samples every month, from January 1989 to December 1993. The fish, preserved on ice on board, were observed in the 24 h following landing.

The fish from research surveys (November 1991; July 1992; October 1993) were caught by the R/V Noruega with a Norwegian Campbell Trawl Net - NCT, the codend with 19.7 mm nylon mesh. Trawlings were performed along the Portuguese West coast (36º50'N to 42ºN) and along the Portuguese South coast (7º30'W a 9º30'W). All the fish from this samples were observed immediately after catch.

All the fishes were measured (total length, mm) and all the fish from commercial captures were weighed (total weight, g). Sex and maturation stage were recorded. From selected fishes *sagitta* otoliths were removed. This ones were cleaned and stored dry in plastic tubes.

We observed the otoliths from 1712 fishes (789 females and 923 males), according to the method used by FUERTES (1977), under stereoscopic magnifier, in a mixture of water and

glycerol. This author stated also the validation to the otolith interpretation for this species, as required by BEAMISH & McFARLANE (1983). The otoliths from older fish were observed after using the burning technique (CHRISTENSEN, 1964). All the otoliths were observed twice and the ones with high discrepancy or confuse annual marks were rejected. According to our own previous observations on the reproduction of this species in portuguese waters, we assumed the 1st March to be the transition date for the following year class, as did FUERTES (1978) in his paper. We used the TOMLINSON & ABRANSON (1961) method to obtain the von Bertalanffy growth parameters, taking sexes apart, as usual with flatfishes (RIJNSDORP, 1992; BEVERTON, 1992; SANTOS, 1990; 1993; 1994; 1995).

Total mortality was obtained by the analysis of the year-class proportion over time (FUERTES, 1977; VAN DER VEER *et al.*., 1990). Natural mortality was computed as the average value of the results obtained using the methods presented by TAYLOR (1959), PAULY (1980) and HOENIG (1983). The annual average water temperature required by Pauly's equation was taken from MARTINS (1993) and confirmed with data from CARDADOR (1988) and also from FROUIN *et al.* (1990). Fishing mortality was obtained mathematically from M and Z.

Maturation was assessed using a five stage scale (HOLDEN & RAITT, 1975; SANTOS, 1995). The spawning period and the first maturation length were obtained for females, from the proportion of pre and post-spawning fishes observed each month and also with the ILES (1964, *in* RIJNSDORP, 1989) method. The first maturation age was obtained combining the growth equation and the first maturation length.

From commercial observed catch, we present also an estimate of the amount of fish caught for each length-class.

RESULTS

From otolith interpretation, we discarded 12% from a total of 1712 pairs, whose reading was not conclusive. We obtained the age-length tables for 1990, 1991, 1992 and 1993 (tables 1 to 4).

The average values obtained for length at age, as well as the standard deviation, for males and females, are in table 5.

The average value for male and female length is different, being females larger than males at the same age. Statistical comparison for this values is presented in table 6.

The von Bertalanffy growth equations, for female and male *L. boscii* caught along the portuguese coast are (figure 2):

$$\text{females} \rightarrow L_t = 43.142 \left[1-e^{-0.130\,(t+2.174)} \right]$$

$$\text{males} \rightarrow L_t = 36.133 \left[1-e^{-0.187\,(t+1.507)} \right]$$

The maximum observed value for length was 44 cm for females and 37 cm, for males, similar to the ones obtained for L_{∞}. We recorded 14 years as the highest age observed.

Comparing the obtained growth parameters with the ones referred in the literature, we found high variability, as presented in table 9.

The length-weight relationships obtained for male and female *L. boscii* are presented in figure 3 and are as follows:

$$\text{females} \rightarrow W=0.0031 \cdot L^{3.299} ;(n=1494; r^2=0.98; p<0.01)$$

$$\text{males} \rightarrow W=0.0055 \cdot L^{3.080} ;(n=1510; r^2=0.98; p<0.01)$$

The ANCOVA test, applied to the log form of these equations, showed significant differences ($F=112.2$; $\nu_1=1$; $\nu_2=3001$; $p>0.05$).

Comparing the obtained results with the ones referred in the literature, we found similar values for this equation (table 10).

From the age-length keys, we obtained the age composition for *L. boscii*, between 1990 and 1993. The values, in percentage, are in table 11.

In table 12 we present the obtained values for Z, calculated from the age composition, for each year, with sexes apart and also for male and female together. The average value for Z, considering the time lag between 1990 and 1993, is Z=0.58, with both sexes. For males only, Z=0.87 and for females, Z=0.43.

Using several methods to access the natural mortality (M), we obtained the values presented in table 13. Males showed higher natural mortality than females, with all the used methods. The average value for M is 0.21 for females, 0.29 for males and is o.27, considering both sexes together.

Fishing mortality, computed from total and natural mortality, is presented in table 14. The global value, for the time period between 1990 and 1993, with both sexes, is F=0.31. Considering only the females, F=0.22 and males F=0.58. In table 14 we can also verify some variability in the fishing mortality values.

The first maturation length, determined from the analysis of the proportion of maturation stages for each length-class, shows this value as being 20 cm for the females, as presented in table 15. For the males, the reduced number of individuals caught at advanced maturation stages was not enough to determine this value. However, we found spawned males from 19 cm.

Using this values with the von Bertalanffy growth equation, we could find for females the age of first maturation as being 3.2 years and, for males 2.8 years.

The seasonal variation of the maturity stages is presented in table 16, for the females, with data from 1989 to 1993.

We can observe pre-spawning females from September, increasing its proportion

from November till March, with the peak in February. Spawned females appear from January till May. These observations allows us to set the spawning period to occur in February/March, possibly extending to April/May. Using the method from ILES (1964, *in* RIJNSDORP, 1989) we can observe more than 50% pre-spawning females in December and more than 50% spawned females in March, producing the same results.

The analysis of the commercial catch of *L. boscii* sampled at the Portuguese fishing harbours between 1989 and 1993, (table 17), shows a considerable portion of the population being fished under the minimum landing size, 20 cm. Also, only about 50 % of the catch is over 21 cm.

DISCUSSION AND CONCLUSIONS

For the growth equation, we obtained L_{∞} de 43,14 cm for females and 36,13 cm for males. K is 0,130 for females and 0,187 for males. For the length-weight relationship, a=0.0031 for females and 0.0055 for males, and b=3.299 for females and 3.080 for males. The growth is faster for females and this ones show themselves heavier than males, for the same length. The obtained values, compared to the ones referred in the literature, fall within the range of values presented for the Atlantic Ocean by several authors.

The average value for total mortality, Z=0.58, (both sexes together) as well as the values for males, Z=0.87 and for females, Z=0.43, are similar to the values presented by FUERTES (1977). The average value for natural mortality, 0.21 for females, 0.29 for males and 0.27, considering both sexes together are also similar to the values presented by FUERTES (1977). The fishing mortality, with both sexes, F=0.31 and F=0.22 for females and F=0.58 for males, show some variability along time. Males showed higher mortality than females, as a result of its higher catchability (CARDADOR, 1988) or as derived from theoretical models URSIN (1967).

The first maturation length, 20 cm , as well the first maturation age, 3.2 years for the females are in the lower range of values present in the literature for other flatfish (ROFF, 1981; 1982; 1991).

The spawning period for *L. boscii* occur, in the Portuguese coast, in February/March, possibly extending to April/May.

The analysis of the commercial catch of *L. boscii* sampled at the Portuguese fishing harbours between 1989 and 1993, (table 17), shows a considerable portion of the population being fished under the minimum landing size, 20 cm. Also, only about 50 % of the catch is over 21 cm.

REFERENCES

ALPERI, J., 1990. Population Parameters of Megrims (*Lepidorhombus whiffiagonis* and *L. boscii*) in the Cantabrian Sea. *Working Group Meeting on the Assessment of the Stocks of Hake.* (VIIIc I.C.E.S. DIVISION).

ASTUDILLO, A. & F. SANCHEZ, 1989. Selectividad de las artes de arrastre para el gallo (*Lepidorhombus sp.*) en aguas del Cantabrico. *Inf. Tec. Inst. Esp. Ocean.* **72**: 27p.

AUBIN-OTTENHEIMER, G., 1987. Bilan des Connaissances sur la Cardine (*Lepidorhombus whiffiagonis*). *Etude de stock de Mer Celtique. Rev. Trav. Inst. Pêches marit.*, **49**(3-4): 205-214.

BEAMISH, R. J. & G.A. McFARLANE, 1983. The Forgotten Requirement for Age Validation in Fisheries Biology. *Transactions of the American Fisheries Society*, **112**: 735-743.

BELLO, G. & E. RIZZI, 1987. On the growth of the four-spotted scaldfish *Lepidorhombus boscii* from the Southern Adriatic. *IN* Rapport de la cinquième consultation technique sur l'évaluation des stocks dans l'Adriatique et la Mer Ionienne. *FAO, Rapp. Pêches*, **394**: 142-146.

BEVERTON, R. J. H., 1992. Patterns of reproductive strategy parameters in some marine teleost fishes. *Journal of Fish Biology*, **41** (Supplement B): 137-160.

BOON, M., 1984. The UK megrim fishery in ICES sub-area VII: a preliminary analysis. *ICES CM 1984/G:17, Demersal Fish Committee.*

CARDADOR, F., 1988. *Estratégias de exploração do stock de pescada (Merluccius merluccius L.) das águas Ibero-Atlânticas*. Instituto Nacional de Investigação das Pescas, Lisboa: 140p.

CARDADOR, 1992. Portuguese data on megrim. *Working Document for the Working Meeting on the Assessment of hte Stocks of Hake*. Copenhagen, 9p.

CASTILHO, R., M. DINIS & K. ERZINI, 1993. Age and growth of the megrim *Lepidorhombus boscii*, Risso of the Portuguese continental coast. *Fisheries Research*, **16**: 339-346.

CHRISTENSEN, J., 1964. Burning of otoliths, a technique for age determination of soles and other fish. *J. Cons. Perm. Exp. Mer*, **29**(1): 73-81.

DAWSON, W. A., 1990. Maturity and spawning distribution in megrim (*Lepidorhombus whiffiagonis*) from the Celtic Sea and north Biscay. *Working Document for the Hake, Megrim and Monk Working Group.*

DAWSON, W., 1991. Preliminary study of the age and growth of Megrim (*Lepidorhombus whiffiagonis*) and Four Spot Megrim (*Lepidorhombus boscii*) from the Celtic Sea, (ICES division VII). *Working document for the hake, megrim and monk working group.*

DU BUIT, M. H., 1984. Prédation de la cardine (*Lepidorhombus whiffiagonis* W.) au nord et à l'ouest de L'Ecosse. *J. Cons. int. Explor. Mer*, **41**: 194-198.

DWIVEDI, S.N., 1964. Ecologie, morphologie et biologie comparees des deux especes du genre *Lepidorhombus: L. megastoma* (Donovan) et *L. boscii* (Risso). Etude de leurs races et populations. *Rev. Trav. Inst. Peches Marit.*, **28(4)**: 321-399.

EIRAS, J.C. & P. J. SANTOS, 1992. New host record (*Lepidorhombus boscii* Risso, 1810) for *Lernaeocera luscii* Basset- Smith, 1896 (Copepoda, Pennellidae). *Crustaceana*, **63**(1): 91-92.

EIRAS, J.C. & P.J.SANTOS, 1992a. Presumptive viral erythrocytic necrosis (VEN) in fishes off the portuguese coast. *Bull. Eur.Ass. Fish Pathol.* **12**(2): 45-47.

FIGUEIREDO, M., 1989. Distribuição batimétrica do lagostim e espécies associadas de interesse comercial, ao longo da costa continental portuguesa. *INIP Relat. Tec. Cient.* **12**: 53p.

FONTELA, J. & PATIÑO, B., s/d. Population Parameters of Megrim (*Lepidorhombus whiffiagonis*) in the VII, VIIIc and IXa ICES Division. *Working Group Meeting on the Assessment of the Stocks of Hake.*

FROUIN, R. A. FIÚZA, I. AMBAR & T. BOYD, 1990. Observations of a poleward surface current off the coast of Portugal and Spain during winter. *J.Geoph.Res.*, **95** c1: 679-691.

FUERTES, J., 1977. Age, growth and mortality of *Lepidorhombus boscii* (Risso) off the Galician coast, NW Spain. *ICES, C.M.*1977/G:7: 15p.

FUERTES, J., 1978. Edad y crecimiento del gallo (*Lepidorhombus boscii*) en el litoral gallego. *Inv. Pesq.* **42**(2): 241-253.

HOENIG, J., 1983. Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin*: **81**(4): 898-902.

HOLDEN, M. & D. RAITT, 1975. Manual de ciencia pesquera. Parte 2 - Métodos para investigar los recursos y su aplicación. *FAO Doc. Tec.* **115** (Rev.1): 211p.

MACPHERSON, E., 1979. Estudio sobre el regimen alimentario de algunos peces en el Mediterraneo occidental. *Misc. Zool.* **5**: 93-107.

MANNINI, P., B. REALE & P. RIGHINI, 1990. Osservazione sulla biologia e la pesca di *Lepidorhombus boscii* (Risso)(Osteichthyes, Scophthalmidae) nel Tirreno Settentrionale. *Oebelia*, **16(1)**: 245-255.

MARTINS, C.G., 1993. OCEANUS, 2.0. Ministério da Educação, *Dep. de Programação e Gestão Financeira*, 2 disquetes.

MORTE, M. & A. SANZ, 1994. Aportaciones al conocimiento de la dieta de *Lepidorhombus boscii* en el golfo de Valencia. *VIII Simposio Ibérico de Estudos del Bentos Marino*, livro de resumos: 88-89.

PAULY, D., 1980. On the inter-relationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. du Conseil*, **39**: 175-192.

PELLEGRINI, D., & C. BARGHIGIANI, 1989. Feeding behaviour and mercury content in two flatfish in the Northern Thyrrhenian Sea. *Mar. Poll. Bul.* **20**(9): 443-447.

PERONNET, I. & J.-J. RIVOALEN, 1989. Mise au Point d'une Technique de Determination de L'age Pour la Cardine (*Lepidorhombus whiffiagonis*) A Partir des Rayons Epineux de la Nageoire Caudale. Validation de la Methode par Comparaison avec les Resultats Obtenus par Otolithometrie. *Conseil International pour L'Exploration de la Mer. CM1989/G:32. Comité des Poissons Démersaux.*

POULARD, J. C., PERONNET, I. & RIVOALEN, J.J., 1993. Depth and Spatial Distributions of *Lepidorhombus whiffiagonis* (Walbaum, 1792) by Age Group in Celtic SEa and Bay of Biscay. *ICES STATUTORY MEETING*, G:43 Poster.

RIJNSDORP, A., 1989. Maturation of male and female North Sea plaice (*Pleuronectes platessa* L.). *J. Cons. int. Explor. Mer.*, **46**: 35-51.

RIJNSDORP, A., 1992. *Long-term effects of fishing in North Sea plaice. Disentangling genetic and phenotipic plasticity in growth, maturation and fecundity*. Academisch proefschrift, Universiteit van Amsterdam: 220p.

ROFF, D., 1981. Reprodutive uncertainty and the evolution of iteroparity: why don't flatfish put all their eggs in one basket? Can. J. Fish. Aquat. Sci., 38: 968-977.

ROFF, D., 1982. Reprodutive strategies in flatfish: a first synthesis. *Can. J. Fish. Aquat. Sci.*, **39**: 1686-1698.

ROFF, D., 1991. The evolution of life-history variation in fishes, with particular reference to flatfishes. *Neth. J. Sea Res*, **27(3/4)**: 197-207.

SANCHEZ, F., F. PEREIRO, & E. RODRIGUEZ-MARÍN, 1991. Abundance and distribution of the main commercial fish of the Northern coast of Spain (ICES Division VIIIc and IXa) from bottom trawl surveys. *ICES C.M. 1991/G*: 53.

SANTOS, P., 1990. Age and growth of four-spotted megrim *Lepidorhombus boscii* from the N coast of Portugal. *25th EMBS, abstracts vol.* Ferrara, Italy.

SANTOS, P.T., 1993. Ecological observations on the four-spot megrim (*Lepidorhombus boscii* RISSO) of the Portuguese coast. *2nd Flatfish Symposium, Texel, The Netherlands, Abstracts vol.*

SANTOS, P.T., 1993a. Age-length keys and growth parameters for four-spotted megrim (*Lepidorhombus boscii*) caught in the Portuguese fisheries. Working Document for the Working Groups on the Assessment of Southern Shelf Demersal Stocks. *1993 ICES meeting, Copenhagen*: 7p.

SANTOS, P.T., 1994. Growth and reproduction of the population of the four-spot megrim (*Lepidorhombus boscii* RISSO) of the Portuguese coast. *Netherlands Journal Of Sea Research* (3/4)(em publicação).

SANTOS, P.T., 1995. *Biologia e pesca do areeiro-de-quatro-manchas Lepidorhombus boscii na costa Portuguesa*. Dissertação de doutoramento apresentada à Faculdade de Ciências da Universidade do Porto, Policopiado.

SCHERRER, B., 1984. *Biostatistique*. Gaetan Morin Editeur: 850p.

SILVA, A., 1992. Preliminary data on four-spotted megrim (*Lepidorhombus boscii*) and megrim (*L. whiffiagonis*) from Portuguese groundfish surveys. Working Doc. *ICES Meeting on the Ass. South. Demersal Stocks*: 18p.

TAYLOR, C., 1959. Temperature and growth. The Pacific razor clam. *J.Conseil Int. Expl. Mer*, **25(1)**: 93-101.

TOMLINSON, P. K. & ABRANSON, N. J., 1961. Fitting the von Bertalanffy Growth Curve by Least Squares. Cal. Dept. Fish & Game. *Fish Bull.* **116**:16 p.

URSIN, E., 1967. A Mathematical Model of Some Aspects of Fish Growth, Respiration, and Mortality. *J. Fish. Res. Bd. Canada*, **24**(11): 2355-2453.

VAN DER VEER, H. W., CREUTZBERG, F., DAPPER, R., DUINEVELD, G. C. A., FONDS, M., KUIPERS, B. R., VAN NOORT, G. J. & WITTE, J. IJ., 1990. On the Ecology of the Dragonet *Callionymus lyra* L. in the Southern North Sea. *Netherlands Journal of the sea Research*, **26**(1): 139-150.

WHITEHEAD, P.J.P., M.-L. BAUCHOT, J.-C. HUREAU, J. NIELSEN & E. TORTONESE (Eds.), 1986. *Fishes of the North-eastern Atlantic and the Mediterranean.* Vol. III. UNESCO.

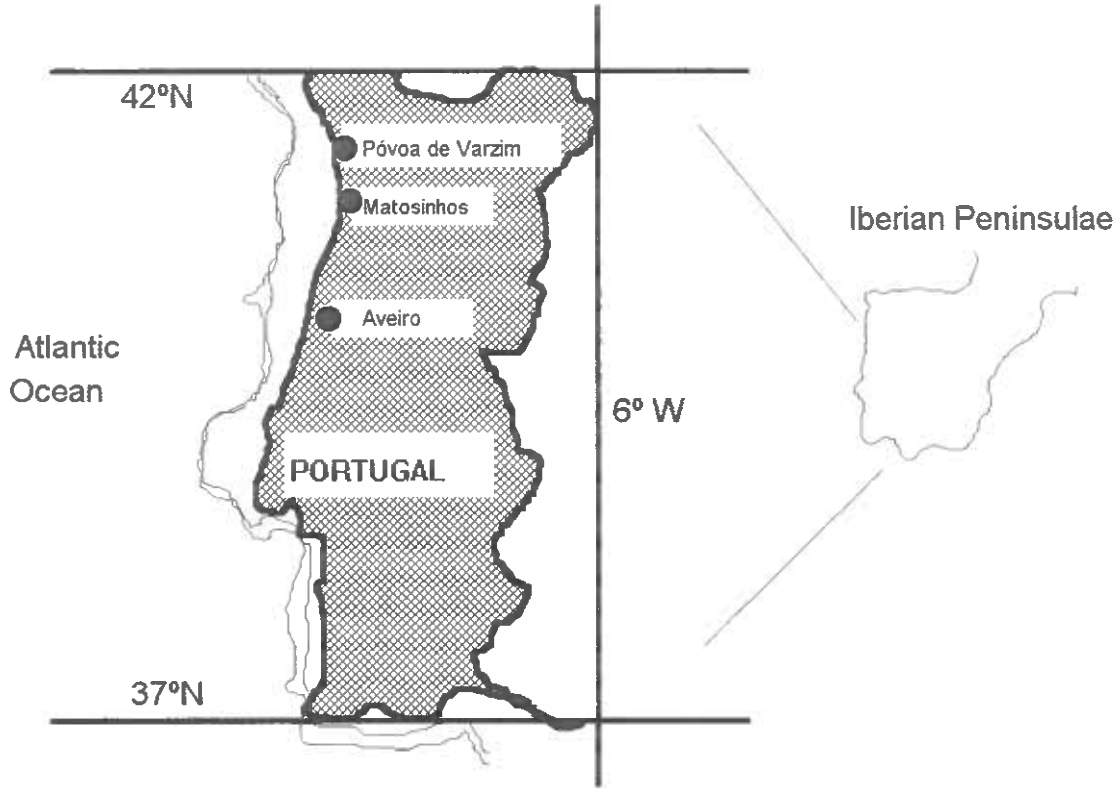

Fig. 1 - The Portuguese coast, showing the 500 m and 700 m bathimetric. Sampling was made at signalled fishing harbours and with survey cruises inside the 700 m bathimetric.

Table 1 - Age-length key for *L. boscii,* caught in portuguese waters in 1990.

length	total	age							
class(cm)	otoliths	1	2	3	4	5	6	7	8
11	4	3							
12	5	4	1						
13	6	6							
14	17	10	2						
15	35	12	3						
16	27	12	3						
17	15	4	5						
18	17	5	8						
19	13		7	1					
20	10		7	2					
21	7		4						
22	5		3	1					
23	7			2	1				
24	5		2	1					
25	7		1	1	2				
26	3								
27	1				1				
28	3								
29	1								
30	8				5				
31	1								
32	0								
33	0								
34	0								
35	0								
36	0								
37	2								
total	199	56	46	8	9	0	0	0	0

Table 2 - Age-length key for *L. boscii,* caught in portuguese waters in 1991.

length	total	age										
class(cm)	otoliths	1	2	3	4	5	6	7	8	9	10	13
11	1		2									
12	1		2									
13	0											
14	12	7	5									
15	13	5	8									
16	15		14									
17	18		14	3								
18	22	6	14									
19	19		9	8	1							
20	16		5	8	3							
21	14		6	5	2							
22	11			9	2							
23	11		2	4	5							
24	16		1	4	5	5						
25	12			1	4	3	1					
26	12			1	3	3	3					
27	7				2	2	3					
28	10				3		3	3				
29	11					3	6	1				
30	10						1	5	1	1		
31	4						3		1			
32	2								2			
33	2					1			1			
34	1								1			
35	4							1		2	1	
42	1											1
total	245	18	82	43	30	17	20	10	6	3	1	1

Table 3 - Age-length key for *L. boscii*, caught in portuguese waters in 1992.

length	total	age										
class(cm)	otoliths	1	2	3	4	5	6	7	8	9	10	14
11	0											
12	3	3										
13	8	8										
14	25	25										
15	56	52	4									
16	31	17	14									
17	36	6	30									
18	26	7	16	3								
19	39	2	22	15								
20	28		11	16	1							
21	17		4	13								
22	35		5	18	11	1						
23	17			9	6	2						
24	18			5	10	3						
25	10			4	3	1	2					
26	13			1	8	2	1		1			
27	11			1	4	2	2	2				
28	10					2	4	3	1			
29	8					3	2	3				
30	4						2	1	1			
31	7						2	4	1			
32	2						1		1			
33	3							1	1	1		
34	0											
35	1										1	
37	1								1			
44	1											1
total	410	120	106	85	43	16	16	14	7	1	1	1

Table 4 - Age-length key for *L. boscii,* caught in portuguese waters in 1993.

length	total	age									
class(cm)	otoliths	1	2	3	4	5	6	7	8	9	10
11	5	5									
12	15	14									
13	21	17									
14	31	28									
15	33	28									
16	31	15	10								
17	38	6	19								
18	32	2	26	1							
19	21		11	2	1						
20	31		1	1							
21	25		5	2	1						
22	18			1	7						
23	22		1	3	1						
24	21		1	3							
25	15					1	1				
26	15				4		2				
27	10					3	5				
28	14					2	4	4			
29	14					2	2	3			
30	9						1	5		1	
31	9						1	2	2		
32	1								1		
33	2									1	1
total	433	115	74	13	14	8	16	14	3	2	1

Table 5 - Mean length (cm) at age and standard deviation (s) for female and male *L. boscii* caught in portuguese waters between 1989 and 1993.

Age	Females	s	Males	s
0	10.57	1.48	9.04	0.75
1	14.50	1.76	13.32	1.64
2	18.17	2.42	17.17	1.93
3	21.48	1.61	20.25	2.29
4	23.92	1.72	22.76	2.37
5	25.45	1.84	24.67	2.72
6	28.19	3.69	26.92	2.68
7	30.10	3.05	28.53	3.03
8	31.87	4.26	31.16	3.50
9	32.90	2.21	29.11	2.83
10	34.27	4.30	31.80	3.44

Table 6 - Statistical comparison (*t*-test) between male and female mean length at age (cm): n is the observed number of *L. boscii* females and males.

Age	t	p	n
1	6.83	<0.05	188-200
2	7.42	<0.05	522-520
3	7.18	<0.05	260-270
4	5.61	<0.05	190-206
5	2.75	<0.05	123-140
6	3.03	<0.05	114-125
7	2.29	<0.05	36-44
8	0.48	>0.05	14-14
9	4.88	<0.05	24-20
10	1.51	>0.05	10-14

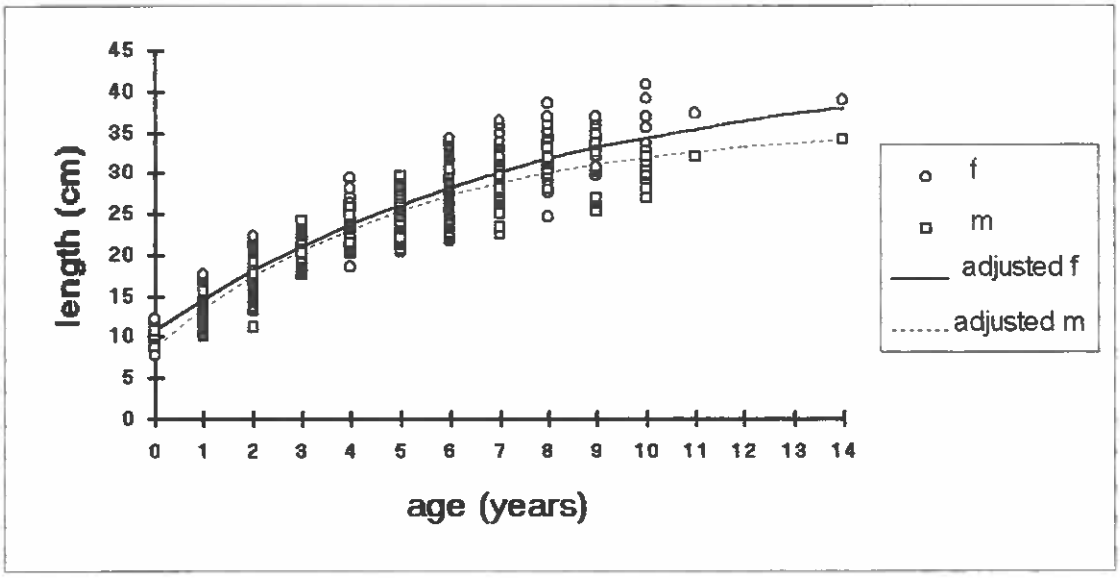

Figure 2 - von Bertalanffy growth curves and the age-length observed values for female (f) and male (m) *L. boscii* caught in portuguese waters, between 1989 and 1993.

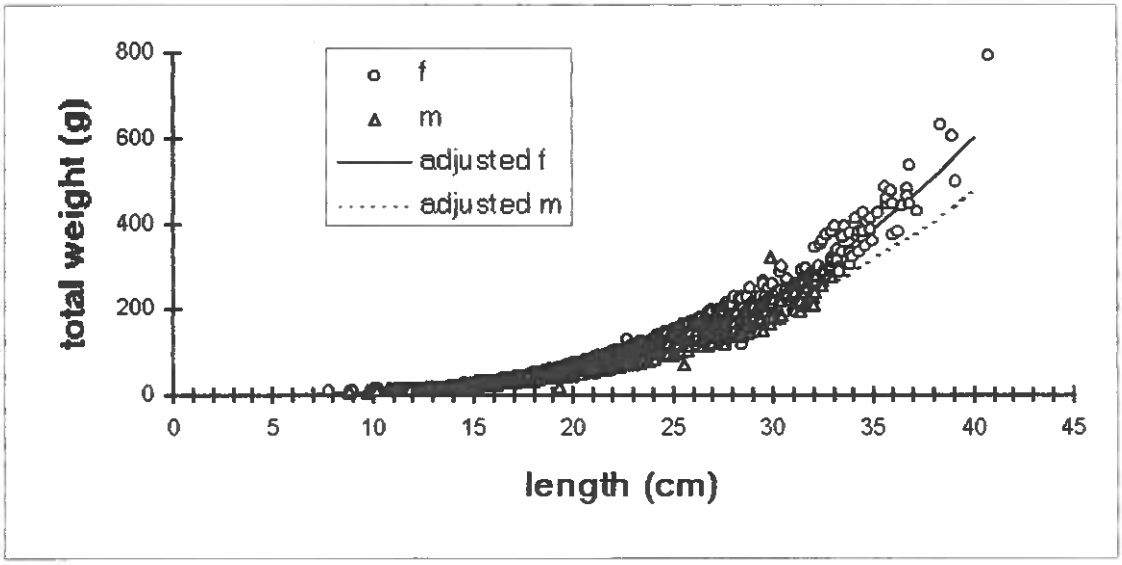

Figure 3 - The length-weight relationship and the observed values for length and weight, for female (f) and male (m) *L. boscii* caught in Portuguese waters between 1989 and 1993.

Table 9 - Growth parameters for *L. boscii,* from several authors.

Area	L_{∞}	K	t_o	sex	References
Portuguese Coast	43.14	0.130	-2.174	f	this work
	36.13	0.187	-1.507	m	
Portuguese North Coast	33.32	0.282	-0.396	f	SANTOS (1990)
	29.06	0.350	-0.230	m	
Portuguese Coast	39.77	0.157	-1.858	f	SANTOS (1994)
	34.79	0.198	-1.436	m	
Portuguese Coast	44.00	0.140	-1.520	f	CASTILHO *et al* .(1993)
	37.50	0.140	-1.930	m	
Galicia Coast	42.88	0.150	-1.360	f	FUERTES (1978)
	34.71	0.190	-1.370	m	
Adriatic Sea	28.50	0.260	-0.850	f	BELLO & RIZZI(1987)
	27.60	0.210	-1.270	m	
Tirrenean Sea	38.00	0.195	----	m+f	MANNINI *et al* .(1990)
Cantabric Sea	44.39	0.120	-2.180	f	ALPERI (1990)
	37.73	0.140	-2.200	m	
Celtic Sea	42.12	0.090	-4.960	f	DAWSON(1991)
	29.91	0.200	-2.330	m	

Table 10 - The length-weight relationship parameters for female (f) and male (m) *L. boscii* according to the literature.

Area	a	b	Sex	References
Portuguese	0.0031	3.299	f	this work
Coast	0.0055	3.080	m	
Portuguese N	0.0025	3.359	f	SANTOS (1990)
Coast	0.0045	3.156	m	
Portuguese	0.0020	3.250	f	CASTILHO *et al.*(1993)
Coast	0.0040	3.110	m	
Mediterranean	0.0050	3.150	f	DWIVEDI (1964)
	0.0034	3.280	m	
Galician	$4x10^{-5}$	3.120	f	FUERTES (1978)
Coast	$6x10^{-5}$	3.030	m	
Adriatic	0.0032	3.260	f	BELLO & RIZZI (1987)
	0.0034	3.240	m	
Tirrenean Sea	0.0040	3.260	f	MANNINI *et al.*(1990)
	0.0090	3.020	m	
Cantabric Sea	0.0068	3.005	f	ALPERI (1990)
	0.0039	3.180	m	

Table 11 - Age composition (in percentage) for *L. boscii* caught in Portuguese waters between 1990 and 1993.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	13	14
1990	48.9	37.6	6.1	7.5	0.0	0.0	0.0	0.0				
1991	7.6	34.4	18.3	13.4	7.9	9.0	4.8	2.6	1.3	0.4	0.4	
1992	27.9	26.4	21.2	10.7	4.0	4.0	3.5	1.5	0.2	0.2		0.2
1993	28.2	30.9	13.9	8.4	4.0	7.6	5.2	1.1	0.5	0.2		

Table 12 - Total mortality (Z) obtained between 1990 and 1993, for *L. boscii* caught in Portuguese waters.

Year	Females	Males	Females+Males
1990	0.54	1.46	0.81
1991	0.37	0.49	0.44
1992	0.39	0.65	0.49
1993	0.41	0.88	0.56
Average	0.43	0.87	0.58

Table 13 - Natural mortality (M) for *L. boscii,* caught in portuguese waters between 1989 and 1993, using different methods.

	Method			Average
	PAULY (1980)	HOENIG (1983)	TAYLOR (1959)	
females	0.29	0.20	0.14	0.21
males	0.39	0.28	0.20	0.29
f+m	0.34	0.25	0.18	0.27

Table 14 - Fishing mortality (F) obtained between 1990 and 1993 for *L. boscii* caught in portuguese waters.

Year	females	males	females+males
1990	0.33	1.17	0.54
1991	0.16	0.20	0.17
1992	0.18	0.36	0.22
1993	0.20	0.59	0.29
Average	0.22	0.58	0.31

Table 15 - Proportion of maturation stages by length-class of female *L. boscii*, caught between December to March, from 1989 to 1993.

Length-class (cm)	Pre-spawning	Post-spawining	Pre-spawning + Post-spawning
17	0.0	14.3	14.3
18	0.0	0.0	0.0
19	12.5	12.5	25.0
20	38.5	30.8	69.2
21	31.6	57.9	89.5
22	31.6	57.9	89.5
23	44.4	44.4	88.9
24	32.3	51.6	83.9
25	54.2	37.5	91.7
26	75.0	25.0	100.0
27	65.2	34.8	100.0
28	75.0	25.0	100.0
29	77.8	22.2	100.0
30	50.0	50.0	100.0
31	50.0	0.0	50.0
33	50.0	0.0	50.0
40	100.0	0.0	100.0

Table 16 - Proportion of the maturation stages along the year for female *L. boscii*, caught in the portuguese coast, from 1989 to 1993.

	Immature	In Maturation	Pre-spawning	Post-spawning
Jan	4.4	15.6	68.9	11.1
Feb	4.0	23.0	36.0	37.0
Mar	11.3	7.5	18.8	62.5
Apr	28.6	11.9	0.0	59.5
May	16.7	30.0	0.0	53.3
Jun	43.1	56.9	0.0	0.0
Jul	51.7	48.3	0.0	0.0
Aug	60.0	40.0	0.0	0.0
Sep	60.4	31.3	8.3	0.0
Oct	43.2	48.6	8.1	0.0
Nov	32.8	36.2	31.0	0.0
Dec	18.8	16.5	64.7	0.0

Table 17 - Proportion of each length-class in the total commercial *L. boscii* catch sampled at fishing harbours between 1989 and 1993.

Length class (cm)	Percentage	Accumulated Percentage
10	0.0	0.0
11	0.3	0.3
12	0.1	0.4
13	0.6	1.0
14	0.4	1.5
15	1.9	3.4
16	2.2	5.6
17	3.8	9.4
18	6.4	15.8
19	8.9	24.7
20	10.7	35.5
21	14.1	49.6
22	13.0	62.5
23	9.7	72.3
24	7.3	79.5
25	4.5	84.0
26	4.6	88.6
27	3.8	92.4
28	2.7	95.1
29	1.7	96.8
30	0.7	97.4
31	0.6	98.0
32	0.1	98.1
33	0.3	98.4
34	0.2	98.7
35	0.1	98.8
36	0.2	99.0
37	0.1	99.1
38	0.1	99.2
39	0.1	99.3
40	0.2	99.6
41	0.1	99.7
42	0.1	99.8
43	0.1	99.9
44	0.1	100.0