Weight-length relationships, weight conversion factors and condition factor trends for two stocks of black anglerfish (*Lophius budegassa*) in southern Bay of Biscay, Galician waters and northern Atlantic areas from a decade.

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Bay of Biscay
XV International Symposium on Oceanography of the Bay of Biscay (ISOBAY). 22-26 June 2016. Bilbao

AIM

Updated weight-length relationships, weight conversion factors and condition factor of black anglerfish (*Lophius budegassa*), an **important** species in European bottom **fisheries** (~12.000 t in Atlantic waters) (ICES, 2015), are here presented.
These biological parameters are useful in the process of annual assessment of the state of their stocks in ICES. The **weight-length relationships** are used to predict weight, when only size is available from the commercial landings, or for the calculation of production and biomass of a fish stock. The weight **conversion factor** (total - gutted weights) is also useful due to the commercial landings of this species are available in gutted weight. The evolution of the **condition factor** over the year, indicator of nutritional status evolution, can be related with the spawning process in mature individuals.

MATERIAL & METHODS

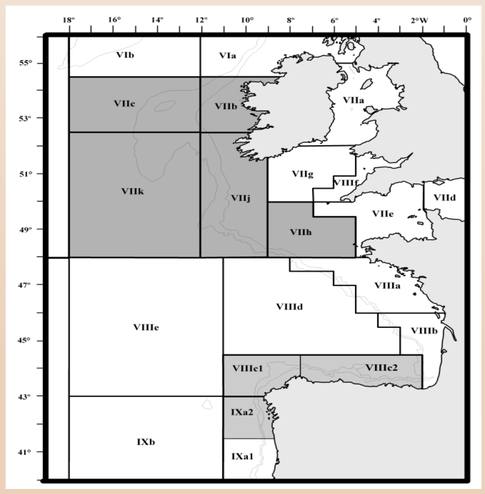


Fig. 1. Sampling ICES Divisions: northern Iberian Atlantic waters (Div. VIIIc-IXa2) (southern stock) and. Celtic Sea, south-western Ireland and Porcupine Bank (Div. VIIb,c,j,h,k) (northern stock).

• The specimens were collected mainly from periodical samplings of landings of Spanish commercial vessels in northern Iberian Atlantic waters (ICES Div.VIIIc-IXa2) and in Celtic Sea, south-western Ireland and Porcupine Bank (Div.VIIb,c,j,h,k), and also from IEO research surveys (“Demersales” and “Porcupine”) performed in September-October each year in northern Iberian waters and Porcupine Bank, respectively.

• The sampling period was **a decade** (January 2006-December 2015) and the collected data from each specimen analyzed in this study were:
- **Lt**: total length (cm):
- **Wt**: total weight (g);
- **Wg**: gutted weight (without liver)(g), also named “scientific” weight;
- **Wgl**: gutted weigh with liver (g), also named “commercial” weight;

• The complete data collection for each individual depended on the sampling source, because there are different ways to land and commercializes this species in the fish markets. Specimens from the Spanish fleet are landed as gutted; however the presence or absence of liver depends on the fish market where they are landed. Therefore, the available range of fish lengths for estimating the weight-length relationship varied according to the type of weight estimated. Thus, **Wt** was available for a total of **3298** specimens, **Wg** for **3130** specimens, and **Wgl** for **3090** specimens. The numbers in detail are in **Table 1, Table 2, Table 3**. The parameters were estimated by SPSS Statistics 17.0.

Weight-length relationships

Power function showed the best coefficient of determination (r^2) of the functions tested for the three weight-length relationships calculated for the total weight (Wt-Lt); gutted weight (Wg-Lt) and gutted weight with liver (Wgl-Lt):

$$W = a\,(Lt)^{b}$$

where: W = Wt or Wg or Wgl

Weight conversion factor

It was estimated for total weight (Wt) - gutted weight (Wg) and for total weight (Wt) - gutted weight with liver (Wgl):

$$a = Wt / W$$

where: W = Wg or Wgl

Fulton´s condition factor

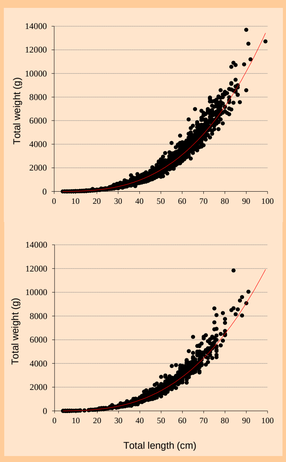
It was estimated quarterly (no enough monthly data) for both males and females over one-year period. For analyzing possible differences between mature and immature individuals, two length ranges were distinguished according to L_{50} value for each sex estimated by Quincoces (2002) for the samples from Div.VIIb,c,j,h,k (41 cm in males, 58.7 cm in females), and the L_{50} estimated by Landa et al. (2014) for those from Div. VIIIc-IXa2 (36 cm in males, 53 cm in females).

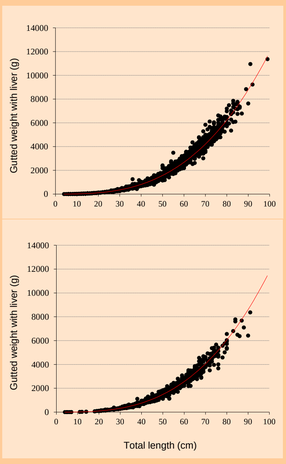
$$f = Wg / Lt^{3}$$

RESULTS & DISCUSSION

The pooling of data from a broad sampling period (a **decade**), was considered the most appropriate, as the data of one or a few years did not provide adequate representation of the range of lengths landed of this species.
The **parameters** here obtained are **similar** to those from previous studies of black anglerfish whose values are used in the process of stock assessment (Pereda et al., 1998; Quincoces, 2002). However, the number of specimens here collected is higher, in addition to representing a broader range of lengths. These improvements in sampling contribute to obtaining more representative and robust parameters.

Weight-length relationships





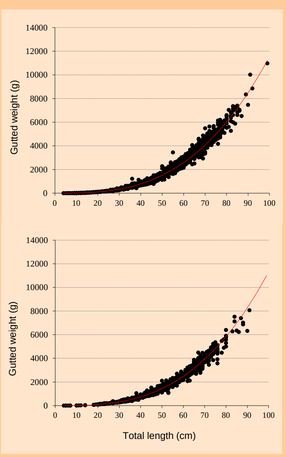


Table 1, Fig. 2. **Total weight (Wt) - total length (Lt)** relationships

Stock	Author	ICES Div.	Area	Coefficients a	Coefficients b	n	r^2	Length (cm) min	Length (cm) max	Weight (g) min	Weight (g) max
VIIIc-IXa	**Present study**	**VIIIc-IXa**	**Southern Bay of Biscay & Galician waters**	**0,020**	**2,916**	**2035**	**0,986**	**5**	**99**	**4**	**13700**
	Pereda et al. (1998)	VIIIc-IXa	Southern Bay of Biscay, Galician & Portuguese waters	0,021	2,920	1030	0,973	5	89	3	10950
VII-VIIIa,b,d	**Present study**	**VIIb,c,h,j,k**	**Celtic Sea, Southwestern Ireland & Porcupine**	**0,025**	**2,841**	**1263**	**0,987**	**4**	**91**	**1**	**11840**
	Quincoces (2002)	VIIIa,b,d	Northern Bay of Biscay	0,021	2,915	592	0,935	14	84	40	10430
	Pereda et al. (1998)	VIIIa,b,d	Northern Bay of Biscay	0,015	3,004	590	0,994	14	84	40	10430

Table 2, Fig. 3. **Gutted weight with liver (Wgl) - total length (Lt)** relationships

Stock	Author	ICES Div.	Area	Coefficients a	Coefficients b	n	r^2	Length (cm) min	Length (cm) max	Weight (g) min	Weight (g) max
VIIIc-IXa	**Present study**	**VIIIc-IXa**	**Southern Bay of Biscay & Galician waters**	**0,017**	**2,929**	**1938**	**0,992**	**4**	**99**	**1**	**11365**
	Pereda et al. (1998)	VIIIc-IXa	Southern Bay of Biscay, Galician & Portuguese waters	0,012	3,019	602	0,989	11	93	15	10800
VII-VIIIa,b,d	**Present study**	**VIIb,c,h,j,k**	**Celtic Sea, Southwestern Ireland & Porcupine**	**0,013**	**2,984**	**1152**	**0,974**	**4**	**91**	**1**	**8368**
	Quincoces (2002)	VIIIa,b,d	Northern Bay of Biscay	0,026	2,818	1229	0,961	14	85	37	8990
	Pereda et al. (1998)	VIIIa,b,d	Northern Bay of Biscay	0,015	2,963	1138	0,996	14	85	36	8990

Table 3 , Fig. 4. **Gutted weight (Wg) - total length (Lt)** relationships

Stock	Author	ICES Div.	Area	Coefficients a	Coefficients b	n	r^2	Length (cm) min	Length (cm) max	Weight (g) min	Weight (g) max
VIIIc-IXa	**Present study**	**VIIIc-IXa**	**Southern Bay of Biscay & Galician waters**	**0,017**	**2,922**	**1941**	**0,993**	**4**	**99**	**1**	**10972**
	Pereda et al. (1998)	VIIIc-IXa	Southern Bay of Biscay, Galician & Portuguese waters	0,015	2,965	667	0,988	5	89	2	8885
VII-VIIIa,b,d	**Present study**	**VIIb,c,h,j,k**	**Celtic Sea, Southwestern Ireland & Porcupine**	**0,013**	**2,971**	**1189**	**0,989**	**4**	**91**	**1**	**8070**
	Quincoces (2002)	VIIIa,b,d	Northern Bay of Biscay	0,015	2,942	325	0,960	14	79	36	8730
	Pereda et al. (1998)	VIIIa,b,d	Northern Bay of Biscay	0,013	2,989	243	0,996	14	85	37	8990

The dispersion of the values **(Fig. 2, Fig. 3, Fig. 4**) is greater when using the total weight than using gutted weight, mainly due both to the influence of the stomach contents and to the gonad weight in the total weight.

Table 4. **Total weight (Wt) - gutted weight with liver (Wgl)** conversion factors

Stock	Author	ICES Div.	Area	Coefficient a	n	r^2	Total weight (g) min	Total weight (g) max	Gutted weight (g) min	Gutted weight (g) max
VIIIc-IXa	**Present study**	**VIIIc-IXa**	**Southern Bay of Biscay & Galician waters**	**1,186**	**1938**	**0,992**	**1**	**13700**	**1**	**11365**
	Pereda et al. (1998)	VIIIc-IXa	Southern Bay of Biscay, Galician & Portuguese waters	1,158	549	0,994	25	10950	15	9650
VII-VIIIa,b,d	**Present study**	**VIIb,c,h,j,k**	**Celtic Sea, Southwestern Ireland & Porcupine**	**1,187**	**1152**	**0,990**	**1**	**11840**	**1**	**8368**
	Quincoces (2002)	VIIIa,b,d	Northern Bay of Biscay	1,177	593	0,981	40	10430	37	8990
	Pereda et al. (1998)	VIIIa,b,d	Northern Bay of Biscay	1,208	590	0,990	40	10430	37	8990

Table 5. **Total weight (Wt) - gutted weight (Wg)** conversion factors

Stock	Author	ICES Div.	Area	Coefficient a	n	r^2	Total weight (g) min	Total weight (g) max	Gutted weight (g) min	Gutted weight (g) max
VIIIc-IXa	**Present study**	**VIIIc-IXa**	**Southern Bay of Biscay & Galician waters**	**1,236**	**1941**	**0,992**	**1**	**13700**	**1**	**10972**
	Pereda et al. (1998)	VIIIc-IXa	Southern Bay of Biscay, Galician & Portuguese waters	1,193	665	0,995	3	10950	2	8885
VII-VIIIa,b,d	**Present study**	**VIIb,c,h,j,k**	**Celtic Sea, Southwestern Ireland & Porcupine**	**1,233**	**1189**	**0,990**	**1**	**11840**	**1**	**8070**
	Quincoces (2002)	VIIIa,b,d	Northern Bay of Biscay	1,251	244	0,990	40	10430	36	8730
	Pereda et al. (1998)	VIIIa,b,d	Northern Bay of Biscay	1,278	244	0,993	40	10430	36	8730

Weight conversion factors

The weight conversion factors are very useful because the black anglerfish are landed as gutted (without liver) in some Spanish fish markets, and as gutted (with liver), in other ones. It is important to calculate them for a better **estimation of the total annual landing** of this species.

Almost **identical** Wt-Wgl conversion factors were obtained in both areas (1.186-1.187) (**Table 4**), and also almost identical Wt-Wg factors (1.236-1.233) (**Table 5**). This parameter seems not to be influenced by the area where the specimens are. When a wide range of weights and high sample size is analyzed, weight conversion factors seem to be quite homogeneous.

The weight conversion factors here estimated are also **within the range of values of previous studies**: 1.158-1.208 (Wt-Wgl); 1.193-1.278 (Wt-Wg). The variability of values among studies may be influenced by the difference in the time period studied, but these differences seem to be more related to the different range of values analyzed in each study.

Condition factor (CF)

CF in **immature** individuals (Lt < L50) are **similar** to those of **mature** (Lt ≥ L50) in the **first and second quarters**, in both sexes and in both studied areas **(Fig. 5)**. However in the **third and fourth quarter**, CF in **immature** is clearly **higher** than in mature.

Mature individuals

No high differences over the year in both **Div.VIIb,c,h,j,k** and in **Div.VIIIc-IXa** are found, although **slightly lower** values appear in the **first quarter** in **Div.VIIb,c,h,j,k** and in the **third quarter** in **Div.VIIIc-IXa.**

Our results in Div.VIIb,c,h,j,k show a small inter-quarterly difference in mature individuals, showing slightly lower CF in the first quarter. The peak of the spawning season in Div.VIIIa,b,d takes place from May to July (Quincoces, 2002), although individuals begin to spawn from January. Thus, both our slightly lower values in first quarter in Div VIIb,c,h,j,k, as those of the fourth quarter of Quincoces (2002) in Div. VIIIa,b,d could be related to a slightly worse condition during the months previous to spawn.

Regarding matures in the stock Div.VIIIc-IXa, a slightly lower condition was found in both sexes from September to November (Pereda et al., 1998), similar (though slightly later) to the values from July to October here found. A spawning period from December and July was estimated in Div.VIIIc-IXa (Landa et al., 2014). Therefore this slightly lower values found in these months could be also related to a slightly worse pre-spawning condition.

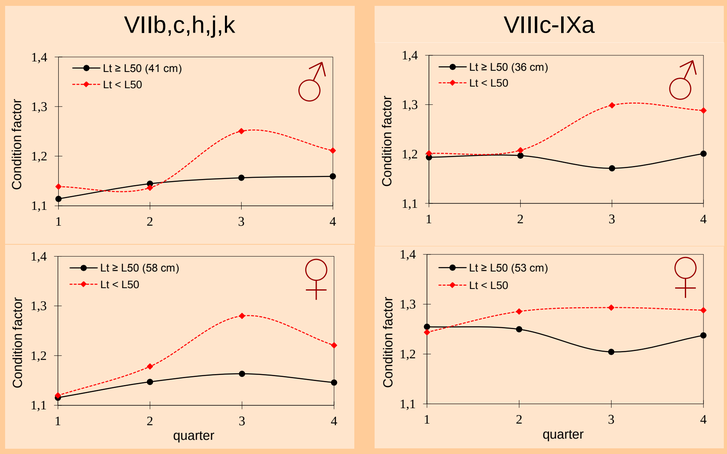


Fig. 5. Evolution of the **condition factor** for each sex and area

Immature individuals

In general, **immatures** in both **Div.VIIb,c,h,j,k** and **Div.VIIIc-IXa** show a **better** CF in the **third and fourth quarter**. Regarding the **immatures** in stock VIIb-k and VIIIa,b,d, Quincoces (2002) also found in **Div.VIIIa,b,d** a evolution of CF over the year **similar** to that here shown in Div VIIb,c,h,j,k, with also **higher** CF in the **third quarter** (summer). Therefore, the immatures of both sexes show a better condition mainly in summer in both stocks. Immature specimens do not transfer energy to gonad development, but the **good condition in summer** may be related to the best environmental conditions and food intake that may favor a more active metabolism. The **highest feeding intensity in spring and summer** in immature black anglerfish found by Preciado et al. (2006) in Div.VIIIc-IXa supports it.

ACKNOWLEDGEMENTS

We thank C.Fariña, M.Ámez, J.Barrado, J.R.Gutiérrez, O.Gutiérrez, R.Gancedo, MªJ.Llevot, L.Cañas, P.Sampedro, M.Torres, N.Somoza, P.Córdoba, A.Vázquez, S.Fernández, R.Gancedo, I.Loureiro and other colleagues for their help in the laboratory sampling. We thank J.Valencia, I.Bruno, F.Baldó, B.Pérez, J.Fernández, F.González, J.Murillo, S.Alcázar, S.Parra, J.Fernández, J.M.García, V.Duque, S.Mourelle, B.Bea, H.Araujo, J.Rodríguez, M.Blanco, I.Castillo, J.C.Arronte, R.Robledo for their collaboration in the samplings on board of IEO research surveys “Demersales” and “Porcupine”, and to the coordinators and crews in the surveys.
The study was partially supported by Data Collection Regulation (DCR) program of the UE and we are also grateful to the IEO coordinator of that program.

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