Weight-length relationships, weight conversion factors and condition in two stocks of megrim (*Lepidorhombus whiffiagonis*): Celtic Seas - northern Bay of Biscay (7.b-k, 8.abd stock) and northern Iberian waters (8.c, 9.a stock)

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Abstract

Somatic parameters of megrim (*Lepidorhombus whiffiagonis*), an economically important flatfish species relevant in the benthic community, are of a great interest in fish biology and required for a deeper knowledge of its life history traits and an adequate stock assessment process and fishery management.

Le Cren's condition factor (K), weight-length relationships and weight conversion factors are studied from a time-series of more than two decades (1998 to 2019) in a wide European distribution area of megrim with relevant fishing activity and belonging to two stocks: northern Bay of Biscay-nBB and Celtic Sea-CS stock, and southern Bay of Biscay-sBB and Galician waters-Gw stock. Around 30,000 specimens, mostly collected from commercial landings by IEO and AZTI, were sampled. Total fish length, total weight and commercial gutted weight were obtained and five-year periods were defined in the time-series.

The influence of several factors, as seasonality, temporality, fish sex and maturity on the megrim condition were analyzed for each stock, showing the season a more relevant effect. A clear seasonal pattern found in K is described in detail in both populations for the first time based on a multi-year period. That pattern was more prominent in females and less marked in immature, related with the needs for reproduction process. The lowest condition in May in nBB-CS and a month earlier in sBB-Gw (both after the spawning period) was observed, followed by a progressive increase (favorable feeding conditions) to the highest values in November-February, and showing the relevance of K as indicator of the nutritional/reproductive status of megrim.

Total weight-length, gutted weight-length and total weight-gutted weight relationships were fitted for each megrim stock and their temporal variations were analyzed. The large sample size, size range and time-series available allowed obtaining robust somatic parameters of combined sexes for the total weight-length relationships (a=0.0049, b=3.1012; a=0.0041, b=3.1682, respectively in nBB-CS stock and sBB-Gw stock), for the gutted weight-length relationships (a=0.0046, b=3.1033; a=0.0042, b=3.1510, respectively in nBB-CS and sBB-Gw stock), and the weight conversion factors (1.049; 1.056, respectively in nBB-CS and sBB-Gw stock). They are considered to best fit the current biometric relationships and most appropriate to be used in the stock assessment of the status of both stocks.

A historical analysis of the temporal variability of the weight-length relationships including previous studies showed different trends between stocks.

Our findings can contribute to facilitating better exploitation, management and conservation of this species.

Keywords

Bay of Biscay; condition factor; weight-length relationships; weight conversion factor; somatic growth; *Lepidorhombus whiffiagonis*; megrim;

1. Introduction

The megrim, *Lepidorhombus whiffiagonis*, is a common benthic flatfish and an important commercial species in the European multispecific bottom trawl fisheries. Its catches rose to ~16000t in Atlantic waters in 2019 (ICES, 2020a; ICES, 2020b). It is mainly found on fine sand bottoms from 50 m to 700 m depth and distributed from the Iceland to Cape Bojador and in the Mediterranean (Whitehead et al., 1986; Sánchez et al., 1998; Fenández-Zapico et al, 2017; Abad et al, 2020). The International Council for the Exploration of the Sea (ICES) identifies four megrim stocks in European Atlantic waters for assessment and management purposes, i.e., megrim in Div. 8.c and 9.a (Iberian Atlantic waters), megrim in Div. 7.b–k and 8.a,b,d (Celtic Seas and northern Bay of Biscay), megrim in Div. 4.a and 6.a (northern North Sea and West of Scotland), and megrim in Div. 6.b (Rockall) (ICES, 2020a; ICES, 2020b).

The stock assessment procedures of megrim in ICES utilize the biological knowledge available to predict variations in the population parameters. Weight-length relationships as well as the weights conversion factors (total-gutted weight relationship) are commonly used in those procedures, and allow predicting weights of individuals from measurements of length or of other weights, and for estimation of the stock biomass. Besides, the condition factor, indicator of the well-being of a species, is a somatic index whose seasonal variation over the year is widely considered an index for the reproduction timing and the nutritional variation in a species. Thus, understanding the biological parameters of the stocks is of great importance. However, there are scarce studies on condition and weight-length relationships of megrim in Iberian Atlantic waters (Alperi, 1991, 1992; Pérez, 1998) and in Celtic Seas and northern Bay of Biscay (Dizerbo et al., 1946; Dwivedi, 1964; Conan et al., 1981; Aubin-Ottenheimer, 1985; Fontenla and Patiño, 1991; Pérez, 1998; Santurtún et al., 1998). Besides, these studies are mostly working documents or project reports. In fact, the estimates currently in use in assessment (Pérez, 1998; Santurtún et al., 1998) were obtained in an European Union study project (BIOSDEF) (Pereda et al., 1998), more than twenty years ago. It is quite evident the need research on biological traits of this species and for a robust and updated information on these biological parameters before their incorporation into the assessment process of megrim stocks, that will lead to a more adequate management of them.

This study pursues the following main aims:

i) to deepen the knowledge, on the one hand, of the megrim reproductive process through the analysis of the condition factor, and on the other hand, of the weight-related biological parameters of megrim, studying their seasonal, inter-annual, sexual and maturity-related variability in a wide area of its distribution, from western Irish waters to western Iberian Peninsula;

ii) to provide robust and updated weight-length relationships and weight conversion parameters of this species in relevant European fishing areas in both stocks, i.e., Celtic Seas - northern Bay of Biscay and Iberian Atlantic, that can be incorporated in the oncoming stock assessment process and fishery management.

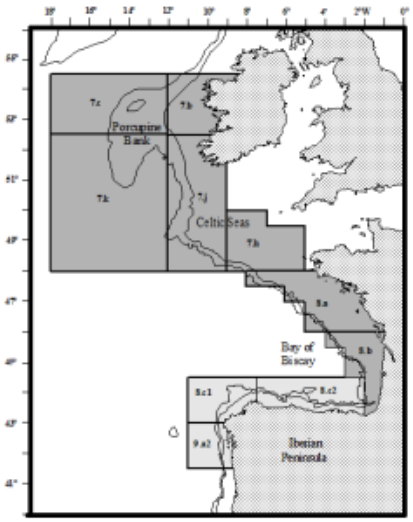


Figure 1. ICES Divisions of northeast Atlantic studied: i) Celtic Sea, south-western Ireland, Porcupine Bank (Div. 7.b,c,j,h,k) and northern Bay of Biscay (Div. 8.a,b) (northern stock, dark gray); ii) northern Iberian Atlantic waters corresponding to southern Bay of Biscay (Div. 8.c) and western Galician waters (Div. 9.a2) (southern stock, light gray).

2. Materials and methods

2.1. Sampling

The main megrim catching areas of the Spanish commercial fleet, Celtic Sea, south-western Ireland, Porcupine Bank (ICES Div. 7.b,c,j,h,k) and northern Bay of Biscay (Div. 8.a,b), belonging to the stock 7.b-k, 8.abd; and northern Iberian Atlantic waters, corresponding to the southern Bay of Biscay and Galician waters (ICES Div. 8.c, 9.a.2), belonging to the stock 8.c, 9.a, were sampled (Fig. 1).

Sampling data were provided by Instituto Español de Oceanografía-IEO (from 7.b-k, 8.c, 9.a.2) and AZTI (from 7.b-k, 8.abd). They comprise a time-series of 22 years, from 1998 to 2019. A total of 29986 individuals were sampled. The 99.7% came from the landings of the commercial fleet and only a small sample (100 individuals <20 cm in length) came from two research fishing surveys “Demersales”, carried out by IEO in northern Iberian Atlantic waters, during September-October 2017 and 2019.

The available time-series allowed us to analyze the temporal variation of the parameters for periods of 5 years (quinquennium): 2000-04, 2005-09, 2010-14 and 2015-19. In northern Iberian, information was also available for the period 1998-99.

Total length [Lt (cm), length class of 1 cm], total weight [Wt (g)], gutted weight [Wg (g)], sex and maturity were collected from each specimen. The quarter was the sampling unit used to get the whole range of the length distribution of the commercially captured megrim. The sampling source influenced the type of weight data, ungutted (total) or gutted weight, that was available for each individual, which depends on the duration of the fishing trip and the landing harbour. Because the specimens landed by the Spanish fleet in some harbors are gutted, the available range of fish lengths for estimating the weight-length relationship varied according to the type of weight estimated. The numbers of specimens studied are shown in detail in Table 1, Table 2, and Table 3.

2.2. Data analysis

2.2.1 Condition factor

Le Cren's (1951) relative condition factor (K) was monthly estimated by sex and combined sexes:

$K = Wg / a\ Lt^b$

where: K = Le Cren's condition factor; Wg = gutted weight (g); Lt = total length (cm); a, b = parameters of the regression.

The temporal variation of the condition in each stock was related to variables associated to the stock size and the intensity of fishing exploitation, Thus, biomass, annual abundance of the stock, annual abundance indices from Spanish, French and Irish annual surveys and commercial CPUE or LPUE, abundance of age groups in the stock (i.e., age groups of 1-2 and 3-5 years-old) and fishing mortality (F) were analyzed. This information was obtained from the stock assessment information (ICES, 2020a).

2.2.2 Weight-length relationships

Weight-length relationships for combined sexes were calculated for the total weight and gutted weight. Regression functions were tested and the power function showed the best coefficient of determination (r^2) for the two weight-length relationships studied (Wt-Lt; Wg-Lt):

$W = a(Lt)^b$

where: W= total weight [Wt (g)], or gutted weight [Wg (g)]; Lt = total length (cm); a, b = parameters of the regression.

2.2.3 Weight conversion factor

Weight conversion factor for combined sexes was estimated by the linear function that relate the total and gutted weights with values "0" to intercept with the x-axis:

$Wt = aWg$

where: Wt = total weight (g); Wg = gutted weight (g); a = parameter of the regression.

The temporal factor, year and quinquennium, relevant for stock assessment process, was considered in the weight-length and in the weight-weight models. The "five-year period (quinquennium)" showed a more adequate sample representativeness than the "year". The role of the quinquennium was analyzed in each stock using the following Linear Models (LMs), and the and LMs were performed using the stats library in the R statistical software version 4.0.5 (R Foundation for Statistical Computing, 2021):

*log(Wt) ~ log(Lt) * quinquennium*

*log(Wg) ~ log(Lt) * quinquennium*

*Wt ~ Wg * quinquennium*

3. Results

3.1 Condition factor

3.1.1 Seasonal, temporal and sexual factors influencing condition

The megrim condition by month shows a clear pattern, with the lowest values in May in Celtic Seas and northern Bay of Biscay and a month earlier, in April, in northern Iberian waters (Figure 2). A sharp decrease from the maximum values of condition in November - February to the minimums values is observed in both stocks. However, the recovery of the condition increases progressively during the following seven months to reach the maximum values again.

A more detailed seasonal analysis of the condition is shown by quarter and sex, considering the sexual dimorphism in growth of megrim (Conan et al., 1981; Rodriguez and Iglesias, 1985). Mature males and females showed significant differences among quarters ($p<0.05$) with a more outstanding seasonal variability in females, which showed an increase from the smallest values in the second quarter (0.94 and 0.93, in Celtic Seas - northern Bay of Biscay and northern Iberian waters, respectively) to the highest values in the first quarter in Celtic Seas - northern Bay of Biscay (1.07) and in the fourth quarter in northern Iberian waters (1.10). The seasonal difference in the condition values between the quarters with lowest values and highest values was ~6-8% in mature males, while it was around double (~14-19%) in mature females. In immature specimens, the seasonal variability was only possible to compare in females. Immature females condition was significantly smaller ($p<0.05$) also in the second quarter, but without seasonal differences as outstanding as in mature females (Figure 2).

Temporal differences ($p <0.001$) in condition were observed among the quinquennia in both stocks. Similar values of 0.99-1.02 and 1.01-1.02, in Celtic Seas - northern Bay of Biscay and in northern Iberian waters, respectively, were obtained for the most recent three quinquennia (2005-09, 2010-14, 2015-19). They showed a more representative sampling of the population than the previous periods studied (1998-99, 200-04): the sample size in those periods was significantly smaller and a range of fish sizes was also narrower. This may prove the lower condition of about 0.99 and 0.97 obtained in those earlier periods.

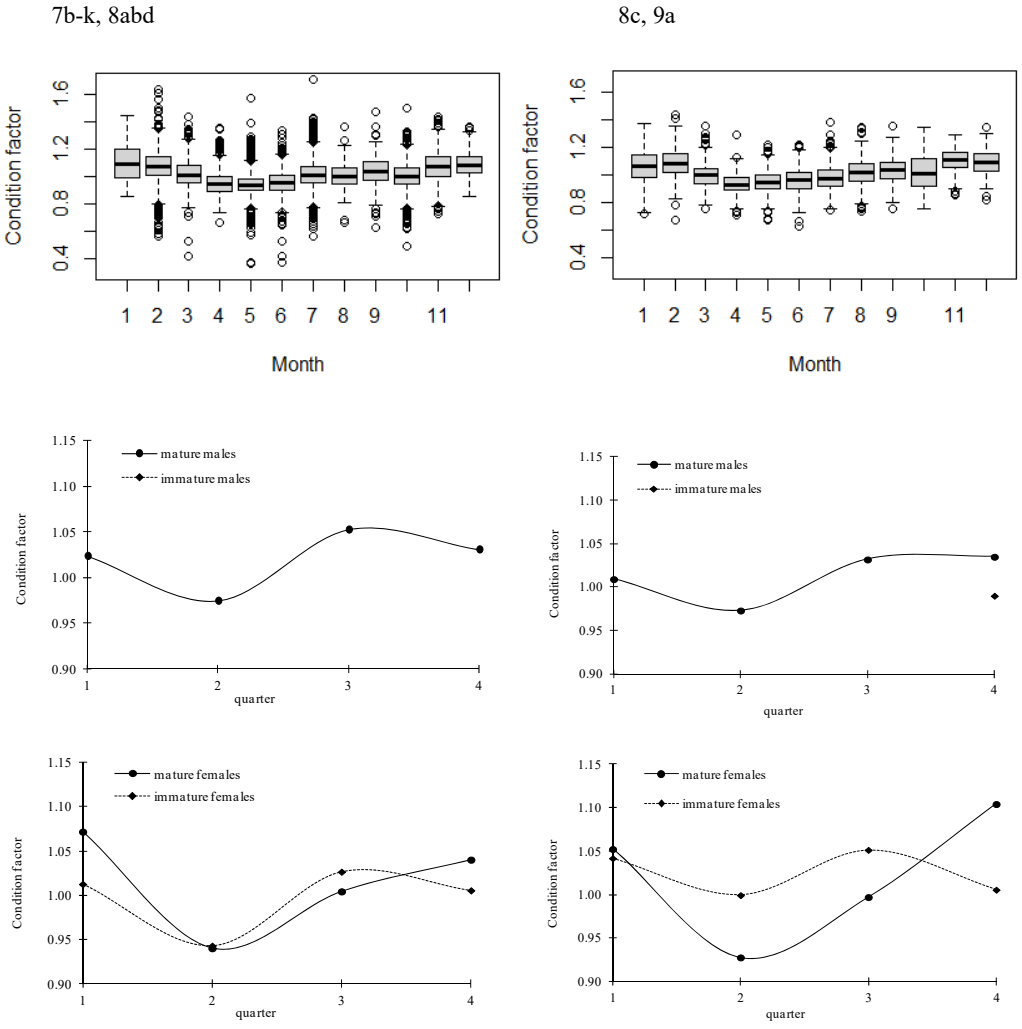


Figure 2. Seasonality of the Le Cren's condition factor by megrim stock: Celtic Seas and northern Bay of Biscay (left column) and northern Iberian (right column). Monthly box plot (top panel) and quarterly mean values by sex: males (central panel) and females (bottom panel), differentiating mature and immature individuals.

3.2. Weight-length and weight conversion factor for stock assessment

3.2.1. Weight-length relationships

In Celtic Seas - northern Bay of Biscay stock (7.b-k, 8.abd), the regression lines by quinquennium showed significant differences ($p<0.001$), both in the total weight-length relationship and in the gutted weight-length relationship (Figure 3). The differences among quinquennium slopes were < 3%.

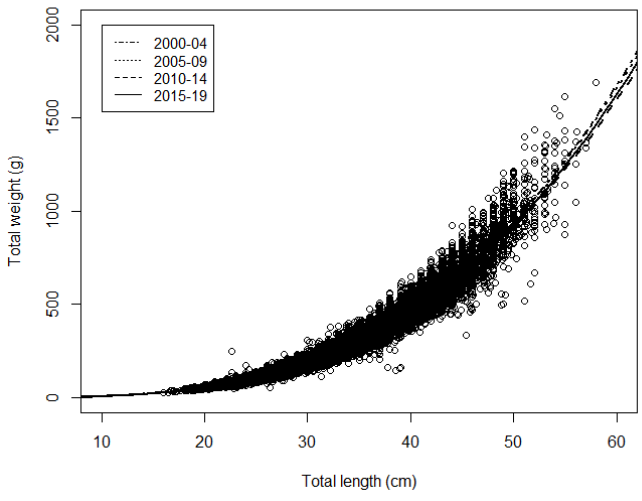
For the Iberian Atlantic stock (8.c, 9.a), significant differences ($p<0.001$) also were found among quinquennia both in the total weight-length relationship and in the gutted weight-length relationship (Figure 3). Quinquennium slopes showed differences up to 12%, being also 2000-04 the period with the highest difference. That quinquennium also was based on the smallest sample size, short range of sizes sampled and relatively smaller specimens. The distribution of the samples per quarter was notably different from the other quinquennia. In 2000-04 quinquennium, 88% of the individuals were sampled in the first semester, while that % was clearly lower (47-68%) in the other quinquennia. A significant inverse correlation (r: -0.9, $p <0.05$) was obtained between the slope of Wg-Lt per quinquennium and the number of specimens sampled in the first semester of each quinquennium, demonstrating the influence of seasonality on the overall slope value for an annual or multi-year period.

3.2.2. Weight conversion factors

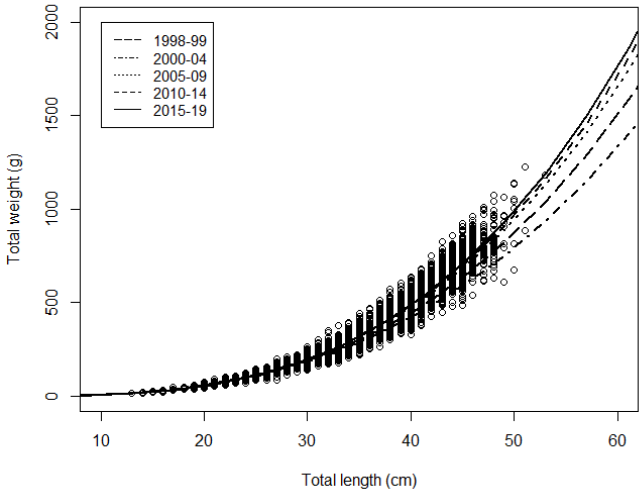
In Celtic Seas - northern Bay of Biscay stock (7.b-k, 8.abd), no significant differences among the three first quinquennia were found, but the most recent one (2015-19) showed significant differences ($p<0.05$) of only ~0.1% among slopes (Figure 3).

In Iberian Atlantic stock (8.c, 9.a), the three most recent quinquennia (2005-09, 2010-14, 2015-19), with a broad range of sampled sizes, did not show significant differences ($p> 0.05$) among themselves. However, the oldest analyzed periods (1998-00, 2001-04), with a narrower range sampled, showed significant differences ($p <0.001$) with respect to the others. The differences were up to 1.7% among slopes (Figure 3).

stock 7.b-k, 8.abd



stock 8.c, 9.a



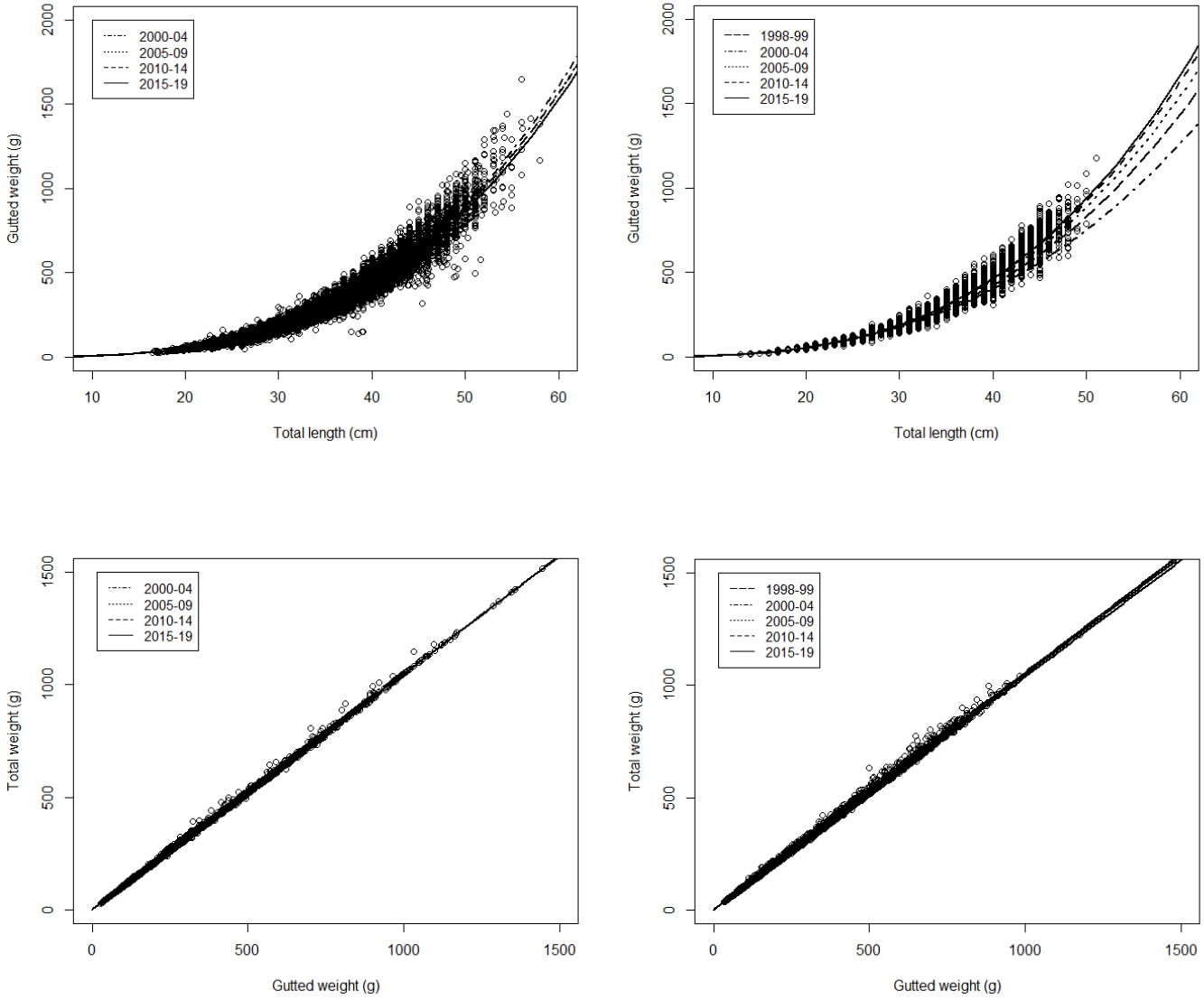


Figure 3. Relationships estimated for *L.whiffiagonis* stock 7.b-k, 8.abd (left column) and stock 8.c, 9.a (right column): total weight–total length (top panel); gutted weight–total length (central panel) and total weight–gutted weight (bottom panel).

4. Discussion

This study presents results of great interest on the one hand for a deeper knowledge of the biology of megrim in a wide area of its geographical distribution. On the other hand, it provides results of biological parameters of two important megrim stocks, one of them (Celtic Seas and northern Bay of Biscay stock) being the main one in annual landings (> 12000 t) of megrim and representing ~75% of its landings in Atlantic waters (ICES, 2020a). The large sample size and time-series, and the inter-institutional collaboration AZTI-IEO collecting complementary data, have allowed obtaining robust weight-length relationships and weight conversion factors, and analyze their temporal variation. Having that updated information in those fishing areas here studied is of primary importance for an accurate and reliable assessment of the stock status, allowing a better management of their populations.

4.1 Condition factor

4.1.1 Seasonal, temporal and sexual factors influencing condition

The results of the present study show for the first time a clear, complete and coherent seasonal pattern of the condition in a wide European study area corresponding to two megrim stocks, with similarities between both and based on a multi-year period, which eliminate the possible effect of the year on the indices.

The spawning season of megrim is restricted to winter/spring months with a peak of spawning between February and April in southern European Atlantic waters and centered on March in northern Iberian waters (Dwivedi, 1964; Aubin-Ottenheimer, 1985, 1986; Fontenla and Patiño, 1991; Pérez, 1998; Santurtún et al., 1998; Robson, 2004) based on maturity stage frequencies and gonadosomatic index analyses. Therefore, our results on seasonal condition of mature individuals in both stocks support the findings on spawning period of aforementioned studies which were based on other indices. The results here obtained indicate a decrease in the megrim condition during one or two months after March, when spawning peaks. The condition of the megrim would be recovering in summer, with a more active metabolism favored by potentially better environmental and nutritional conditions. A better condition would be reached in autumn and winter, with a greater stored energy for spawning at the end of the first quarter. The only previous known studies where the condition factor of megrim was analyzed seasonally in these areas are those of Santurtún et al. (1998) and Pérez (1998), both based on around 1-year period. Our results agree with Santurtún et al. (1998) that show a lowest condition in the second quarter and highest in the fourth-first quarters in northern Bay of Biscay (Div. 8.abd). The study of Pérez (1998) in Div. 7.b-k based on nine months of information, shows a decrease of the condition from February-March to April-June, also in agreement with that here found.

4.2. Weight-length and weight conversion factor for stock assessment

4.2.1. Weight-length relationships

In both stocks, Celtic Seas - northern Bay of Biscay stock (7.b-k, 8.abd) and Iberian Atlantic stock (8.c, 9.a), the parameters of the total weight-length relationship and gutted weight-length relationship from the most recent quinquennium (2015-19) are underlined in Table 1 and Table 2. They show a complete representation of the commercially exploited size range of megrim. The estimated parameters of combined sexes of megrim for the total weight-length relationships (a=0.0049, b=3.1012; a=0.0041, b=3.1682, respectively in 7.b-k, 8.abd stock and 8.c, 9.a stock) and for the gutted weight-length relationships (a=0.0046, b=3.1033; a=0.0042, b=3.1510, respectively in 7.b-k, 8.abd stock and 8.c, 9.a stock) are considered to best fit the current biometric relationships and most appropriate to be used in the stock assessment process of the status of both stocks, replacing the old values from 1998 currently used (Table 1, Table 2). The differences between the relationships currently proposed for stock assessment and the old ones are shown in Figure 4.

A remarkable aspect to consider when estimating length-weight relationships is the seasonal distribution of the samples collected. The markedly different slope in the gutted weight-length relationship for the period 2000-04 observed here (in Iberian Atlantic stock) allows to advice that when noticeable seasonal variations in length-weight relationships are detected in a species (due to the natural seasonal feeding / reproductive process), they should have taken into account in further sampling designs and relationship estimations. A poorly representative sampling in the quarters that show differences in the somatic relationships with respect to the rest of year, may lead to differences among the relationships comparing years or multi-year periods. However, that population could really have fewer differences among years or multi-year periods (or no significant differences) if the quarters had been similarly sampled among the comparing years (or multi-year periods).

4.2.2. Weight conversion factors

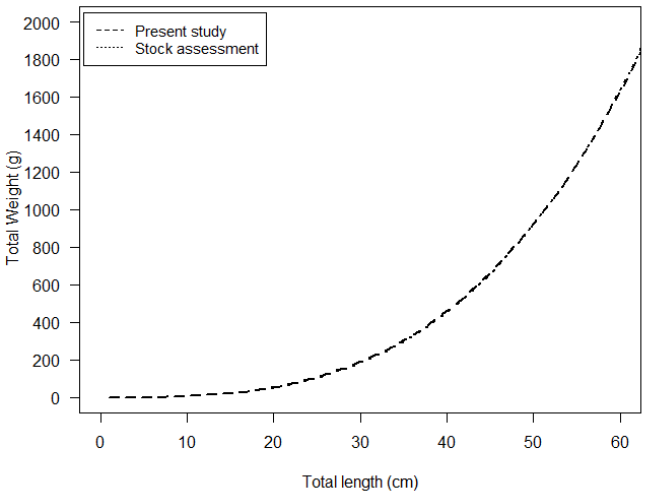
In Celtic Seas - northern Bay of Biscay stock (7.b-k, 8.abd), the similarity among the weight conversion factor from all quinquennia allowed to consider the value 1.049 for the overall period (2000-19) (underlined in Table 3), comprising the overall

commercial range of sizes, as the most appropriate to be used in the stock assessment process, replacing that old value (1.060) from 1998 currently used (Pérez, 1998).

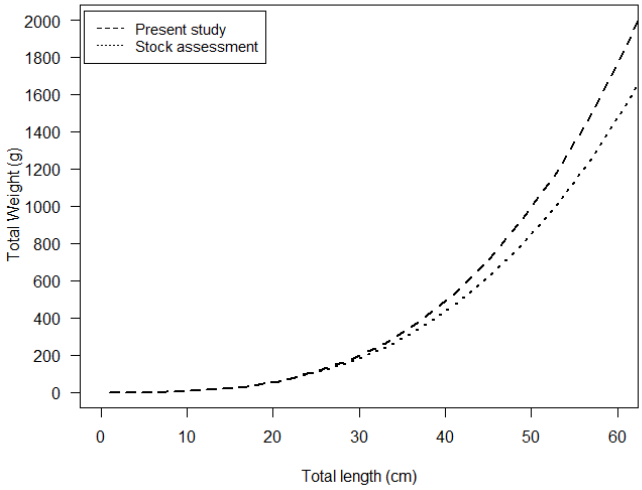
For the Iberian Atlantic stock (8.c, 9.a), the weight conversion factor (1.056) was selected from the period (2005-19), corresponding to the three most recent quinquennia, without differences among them (underlined in Table 3. It was that best represents the overall commercial range of sizes and considered as the most appropriate to be used in the stock assessment process, also replacing that old value (1.050) currently used (Pérez, 1998).

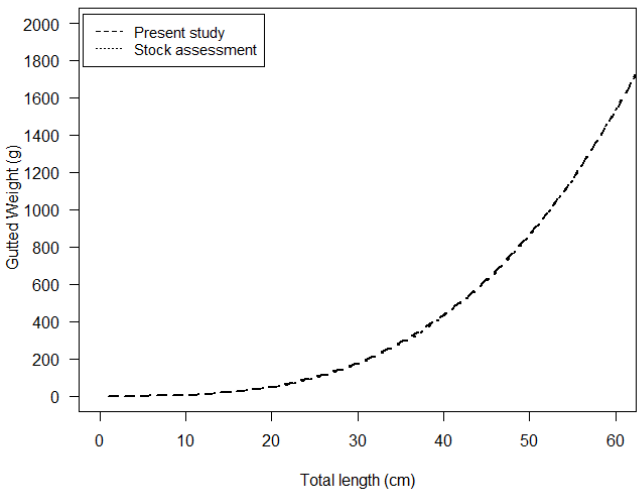
The small differences between the conversion factor currently proposed for stock assessment and the old ones (1 % and 0.6 % for 7.b-k, 8.abd and 8.c, 9.a stocks, respectively) are shown in Figure 4.

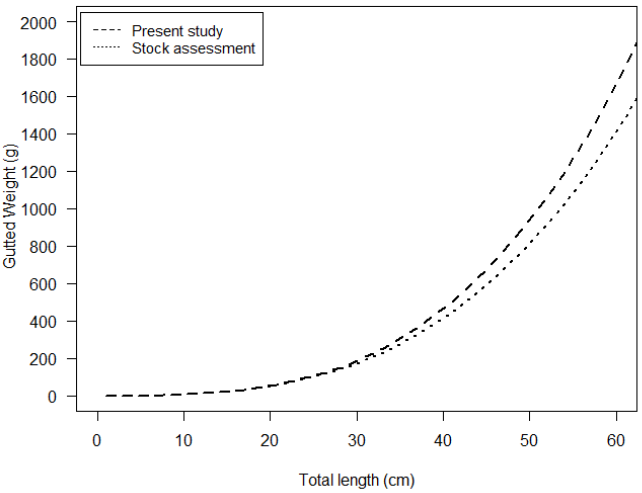
stock 7.b-k, 8.abd



stock 8.c, 9.a







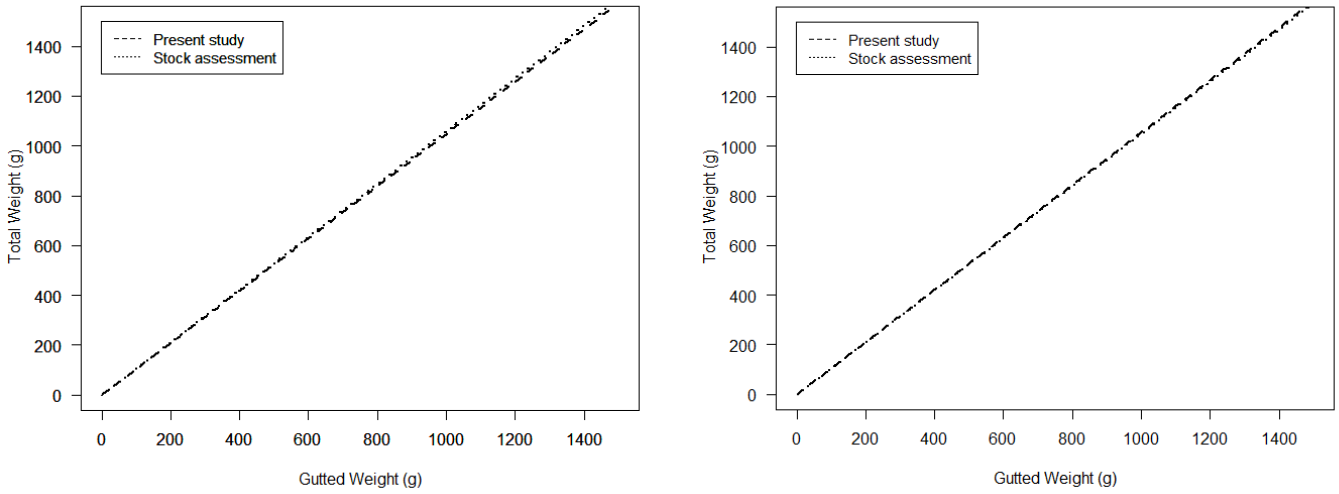


Figure 4. Differences between the relationships from the present study proposed for stock assessment and those currently used from 1998, for *L.whiffiagonis* stock 7.b-k, 8.abd (left column) and stock 8.c, 9.a (right column).

4.2.3. Historical perspective

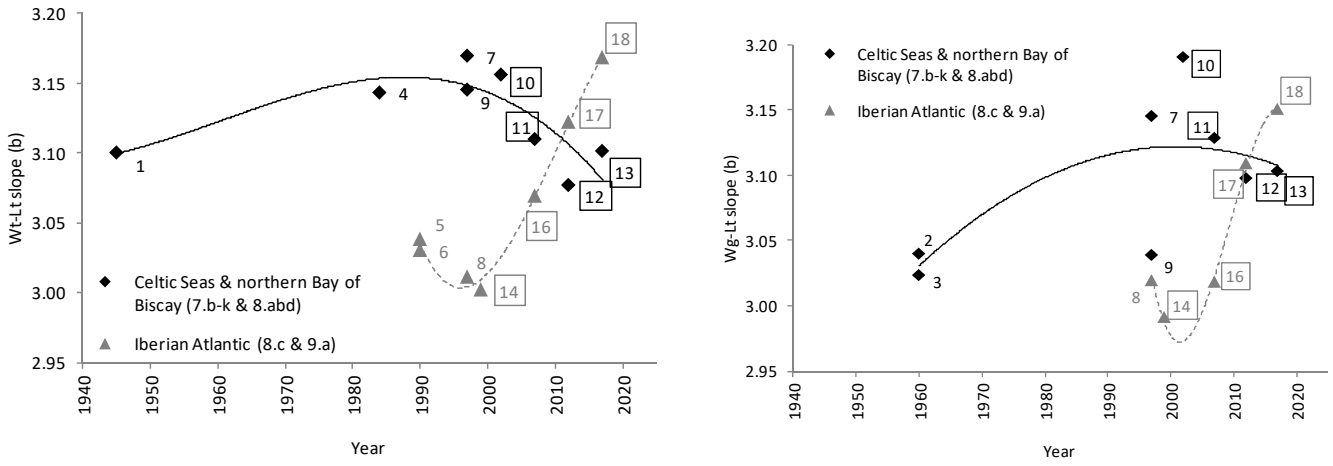


Figure 5. Slope (parameter b) from the total weight - total length relationship (left) and from the gutted weight - total length relationship (right) of *L. whiffiagonis* estimated in the North-eastern Atlantic in this study (number in square) and from previous studies: 1, Dizerbo, Forest and Letaconnoux (1946); 2, Dwivedi (1964) in 7.bj; 3, Dwivedi (1964) in 8.ab; 4, Aubin-Ottenheimer (1985); 5, Alperi (1991); 6, Alperi (1992); 7, Pérez (1998) in 7.b-k; 8, Pérez (1998) in 8.c,9.a; 9, Santurtún et al. (1998); 10, Present study in 7.b-k, 8.abd (2000-04); 11, Present study in 7.b-k, 8.abd (2005-09); 12, Present study in 7.b-k, 8.abd (2010-14); 13, Present study in 7.b-k, 8.abd (2015-19); 14, Present study in 8.c,9.a (1998-99); 15, Present study in 8.c,9.a (2000-04); 16, Present study in 8.c,9.a (2005-09); 17, Present study in 8.c,9.a (2010-14); 18, Present study in 8.c,9.a (2015-19).

A complete study covering a large area of distribution of the species and a wide period, thus allowing the analysis of its temporal variability, was not available until now. The parameters estimated here are in the range of those obtained in previous works, mostly grey literature (Table 1, Table 2, Table 3) and are considered the most appropriate to be used in the upcoming stock assessment in each megrim stock.

In the total weight-length relationship, the parameter b (slope) of the Atlantic studies varies between 3.01 and 3.17, with the exception of that from Conan et al (1981) which presents a lower value (2.95), probably due to being based on a narrow megrim sizes (only up to 36 cm). In the same way, the low slope of 2.84 of the present study corresponding to the five-year period 2000-

04 in the stock 8.c, 9.a (Table 1) also seems to be related to the lower sample size range (only individuals up to 39 cm) and to the aforementioned reasons. The Mediterranean studies show a greater slope (3.23-3.26) than the Atlantic ones, partly due to the lower megrim abundance and individuals reaching smaller maximum sizes in Mediterranean than in Atlantic (close to 60 and 50 cm in stock 7.bk-8.abd and 8.c, 9, a, respectively). The Mediterranean parameters of Merella et al. (1997), based on only 11 small individuals (up to 18 cm), should be considered with caution.

Regarding the gutted weight-length relationship, the slopes of the studies vary between 2.98 and 3.15, lower values than those based on total weight (Table 2). Fontenla and Patiño (1991), analyzed a smaller range of megrim sizes and smaller maximum lengths than the other studies, and estimated the lowest value of the slope (2.98).

In relation to the total weight- gutted weight relationship, the slopes of the studies, with values between 1.04 and 1.06, are more similar to each other compared to those observed in the aforementioned somatic relationships (Table 3).

In addition to the variability among quinquennia of the parameters above mentioned, a temporal variability of the slope ('b' parameter) over the decades is observed when the results of the present study and previous ones are compared (Figure 5). A rise of the slope value from those few figures available in the years '40 (in total weight) and '60 (in gutted weight) to the highest values found in the late '90 -early '00, is observed (Figure 5). From the BIOSDEF study (Pérez, 1998; Santurtún et al., 1998) and including the results of the present study, periodic parameters are available from middle '90 until now, evidencing a more detailed downward trend in 'b' parameter in Celtic Seas - northern Bay of Biscay (stock 7.bk, 8.abd) both in the total weight-length and gutted weight-length relationships (Figure 5). However a sharper opposite upward trend in the slope is observed in both relationships in southern Bay of Biscay (stock 8.c,9.a). The different time trend of the slope between both stocks in the last decades would indicate the need for more monitoring and research on this matter. In the comparison exercise (Figure 5), we consider only the parameters from the studies covering the whole size range of population and were not partially biased in this respect. Thus, the parameters of Connan et al (1981) in stock 7.b-k, 8.abd, and those of the present study corresponding to the quinquennium 2000-04 in stock 8.c, 9.a (Table 1) are not included in that figure.

In **conclusion**, the seasonality of condition factor in both stocks shows its relevance as indicator of the reproductive and nutritional status of megrim. This collaborative study AZTI-IEO provides new biological parameters in the main fishing stock of megrim and the main fishery areas for the fleets catching megrim, necessary for an accurate annual stock assessment process and stock management of megrim. The new somatic parameters from weight-length relationships and weight conversion factor are available to be used in the next stock assessment in ICES (benchmak-2021/WGBIE-2022) and it is recommended that they replace the ones used so far, which are outdated. The observed temporal variability in the somatic parameters obtained here from two decades of sampling and the information from previous studies, constitutes a solid basis for future studies that will allow to have a broader perspective of these variations found. The continue monitoring of these parameters is essential to detect possible long-term shifts due to the fisheries pressure or environmental variations and to deeper understanding of the specific causes of these variations.

Ocean / Sea	Stock	Author	ICES Div. / GSA	Area	Period	Sex	Coefficients a	Coefficients b	n	r^2	Length range (cm)	Weight range (g)
Atlantic	7.b-k, 8.abd	**Present study**	**7.b-k, 8.abd**	**Celtic Seas & northern Bay of Biscay**	**2015-19**	**combined**	**0.005**	**3.10**	**5481**	**0.98**	**18-57**	**45-1342**
					2010-14	**combined**	**0.005**	**3.08**	**4383**	**0.97**	**19-59**	**47-2374**
					2005-09	**combined**	**0.005**	**3.11**	**8242**	**0.98**	**16-56**	**27-1514**
					2000-04	**combined**	**0.004**	**3.16**	**3276**	**0.98**	**16-54**	**28-1549**
		Pérez (1998)	7.b-k	Celtic Sea, southwestern Ireland	1997	combined	0.004	3.17	1117	0.99	16-63	-
		Santurtún et al. (1998)	8.abd	Northern Bay of Biscay	1996-97	combined	0.004	3.15	537	0.99	16-53	28-1090
		Aubin-Ottenheimer (1985)	7.efgh, 8.a	Celtic Sea & northern Bay of Biscay	1984	females	0.004	3.14	-	0.99	12-54	-
		Conan et al (1981)	7.ghj	Celtic Sea	1980-81	combined	0.008	2.95	192	0.99	10-36	9-330
		Dizerbo, Forest and Letaconnoux (1946)	8.ab	Northern Bay of Biscay	~1945	combined	-	3.10	-	-	-	-
	8.c, 9.a	**Present study**	**8.c, 9.a2**	**Southern Bay of Biscay & Galician waters**	**2015-19**	**combined**	**0.004**	**3.17**	**1687**	**0.98**	**13-49**	**14-1065**
					2010-14	**combined**	**0.005**	**3.12**	**3026**	**0.97**	**20-50**	**53-1153**
					2005-09	**combined**	**0.006**	**3.07**	**2104**	**0.97**	**19-53**	**48-1225**
					2000-04	**combined**	**0.012**	**2.84**	**288**	**0.97**	**20-39**	**56-399**
					1998-99	**combined**	**0.007**	**3.00**	**353**	**0.98**	**18-50**	**38-815**
		Pérez (1998)	8.c, 9.a2	Southern Bay of Biscay & Galician waters	1997	combined	0.006	3.01	663	0.99	12-52	-
		Alperi (1991)	8.c2	Cantabrian Sea	1990	combined	0.006	3.04	189	0.98	17-45	-
		Alperi (1992)	8.c2	Cantabrian Sea	1989	combined	0.006	3.03	87	0.99	17-45	-
Mediterranean	-	Santic et al. (2012)	17	Northern Adriatic Sea	2006	females	0.003	3.23	671	0.94	10-35	8-313
	-	Merella et al. (1997)	5	Western Mediterranean	1995-96	combined	0.003	3.26	11	1.00	9-18	-

Table 1. Parameters of the total weight - total length relationship for *L. whiffiagonis* estimated in the present study and previous studies. The underlined parameters are considered as the most appropriate to be used in the next stock assessment process.

Ocean / Sea	Stock	Author	ICES Div.	Area	Period	Sex	Coefficients a	Coefficients b	n	r^2	Length range (cm)	Weight range (g)
Atlantic	4.ab, 6.a	Dwivedi (1964)	4.a	Northern North Sea	1957-62	females	0.006	3.052	256	-	-	-
	7.b-k, 8.abd	**Present study**	**7.b-k, 8.abd**	**Celtic Seas & northern Bay of Biscay**	**2015-19**	**combined**	**0.005**	**3.103**	**4757**	**0.98**	**18-58**	**43-1383**
					2010-14	**combined**	**0.005**	**3.098**	**8221**	**0.969**	**19-58**	**45-1649**
					2005-09	**combined**	**0.004**	**3.129**	**7406**	**0.976**	**18-56**	**38-1444**
					2000-04	**combined**	**0.003**	**3.191**	**2140**	**0.984**	**16-51**	**27-1123**
		Pérez (1998)	7.b-k	Celtic Sea, southwestern Ireland	1997	combined	0.004	3.145	-	-	-	-
		Santurtún et al. (1998)	8.abd	Northern Bay of Biscay	1996-97	combined	0.006	3.039	3199	0.992	16-55	23-1145
		Fontenla and Patiño (1990)	7	Celtic Sea	1990	combined	0.008	2.980	507	-	18-47	-
		Dwivedi (1964)	7.bj	Western Ireland	1957-62	females	0.006	3.040	148	-	-	-
		Dwivedi (1964)	8.ab	Northern Bay of Biscay	1957-62	females	0.006	3.024	180	-	-	-
	8.c, 9.a	**Present study**	**8.c, 9.a2**	**Southern Bay of Biscay & Galician waters**	**2015-19**	**combined**	**0.004**	**3.151**	**1611**	**0.97**	**13-49**	**13-1014**
					2010-14	**combined**	**0.005**	**3.109**	**2983**	**0.971**	**20-50**	**51-1087**
					2005-09	**combined**	**0.007**	**3.018**	**667**	**0.977**	**19-51**	**46-1176**
					2000-04	**combined**	**0.011**	**2.840**	**233**	**0.972**	**20-39**	**54-386**
					1998-99	**combined**	**0.007**	**2.991**	**353**	**0.983**	**18-50**	**36-787**
		Pérez (1998)	7.b-k	Celtic Sea, Southwestern Ireland	1997	combined	0.006	3.020	-	-	-	-

Table 2. Parameters of the gutted weight - total length relationship for *L. whiffiagonis* estimated in the present study and previous studies. The underlined parameters are considered as the most appropriate to be used in the next stock assessment process.

Ocean / Sea	Stock	Author	ICES Div.	Area	Period	Sex	Coefficient	n	r^2	Total weight range (g)	Gutted weight range (g)
Atlantic	7.b-k, 8.abd	**Present study**	**7.b-k, 8.abd**	**Celtic Seas & northern Bay of Biscay**	**2000-19**	**combined**	**1.049**	**13662**	**0.999**	**27-1444**	**28-1514**
					2015-19	**combined**	**1.048**	**3725**	**0.993**	**43-1169**	**45-1232**
					2010-14	**combined**	**1.049**	**2860**	**1.000**	**45-1305**	**47-1368**
					2005-09	**combined**	**1.049**	**5183**	**1.000**	**38-1444**	**39-1514**
					2000-04	**combined**	**1.049**	**1894**	**1.000**	**27-1123**	**28-1178**
		Pérez (1998)	7.b-k	Celtic Sea, southwestern Ireland	1997	combined	1.060	-	-	-	-
		Santurtún et al. (1998)	8.abd	Northern Bay of Biscay	1996-97	combined	1.043	532	0.999	-	-
		Aubin-Ottenheimer (1985)	7.efgh, 8.a	Celtic Sea and northern Bay of Biscay	1984	females	1.041	-	-	-	-
	8.c, 9.a	**Present study**	**8.c, 9.a2**	**Southern Bay of Biscay & Galician waters**	**2005-19**	**combined**	**1.056**	**5300**	**0.999**	**13-1176**	**14-1225**
					2015-19	**combined**	**1.056**	**1611**	**0.999**	**13-1014**	**14-1065**
					2010-14	**combined**	**1.057**	**2983**	**0.999**	**51-1087**	**53-1153**
					2005-09	**combined**	**1.055**	**667**	**0.999**	**46-1176**	**48-1225**
					2000-04	**combined**	**1.037**	**233**	**0.998**	**54-386**	**56-399**
					1998-99	**combined**	**1.048**	**353**	**0.999**	**36-787**	**38-815**
		Pérez (1998)	7.b-k	Celtic Sea, Southwestern Ireland	1997	combined	1.050	-	-	-	-
		Alperi (1991)	8.c2	Cantabrian Sea	1990	combined	1.051	-	-	-	-
		Alperi (1992)	8.c2	Cantabrian Sea	1989	combined	1.049	-	-	-	-

Table 3. Parameters of the total weight - gutted weight relationship for *L. whiffiagonis* estimated in the present study and previous studies. The underlined parameters are considered as the most appropriate to be used in the next stock assessment process.

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