Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(2): 523 – 537 (2021)
www.ejabf.journals.ekb.eg

Age, Growth and Mortality of the European Hake *Merluccius merluccius* (Linnaeus, 1758) from El-Kala Coastline (the extreme North -East of Algeria)

Zehaira Boudjadi[1,2] * and Mounira Rachedi[2]
[1] Laboratory of biodiversity and ecosystem pollution, Algeria.
[2] Department of Marine Sciences, Faculty of Natural Sciences and Life, Chadli Bendjedid University, B.P 73, 36000 El-Tarf, Algeria.
*Corresponding Author: zora.boudjadi@gmail.com

ARTICLE INFO
Article History:
Received: Feb. 25, 2021
Accepted: April 11, 2021
Online: April 22, 2021

Keywords:
European hake,
age,
growth,
mortality,
El-Kala Coastline,
Algeria.

ABSTRACT
The present study deals with the age composition, growth and mortality of the European hake *Merluccius merluccius* from El-Kala coastline (extreme North-Eastern Algeria) during the period from April to July 2020. A total of 900 European hake ($13 \leq TL \leq 43$ cm, $15 \leq TW \leq 495$ g) were examined, based on length frequency data. The FISAT II software was used for different analyses, in addition to Von Bertalanffy's growth parameters (L_∞ = 44.08, k = 0.29 and t_o = -0.517) with a growth performance (φ') of 2.75. Total mortality (Z), natural mortality (M) and fishing mortality (F) of European hake from the El-kala coast were estimated at 1.53, 0.61 and 0.92, respectively. The exploitation rate (E = 0.60) indicated an over-exploitation of the European hake stock, which showed high fishing pressure on the hake population in the El-Kala coastline. This, in turn, was argumented for the need of strict management of the hake fishery in the study area.

INTRODUCTION

The European hake *Merluccius merluccius* (Linneaus, 1758) is a demersal teleostean species that belongs to the order Gadidae and family Merlucidae. It has a wide geographical distribution in the eastern Atlantic ocean from Norway and Iceland to Mauritania, including the Mediterranean Sea **(Froese & Pauly, 2016)**. *M. merluccius* occupies different habitats, extending from only a few meters along the coastline to 1000 m depth **(Cohen *et al.*, 1990; Philips, 2012)**. It is a carnivorous species, feeding on fish, crustaceans, algae, and plant detritus **(Cohen *et al*., 1990; Philips, 2012)**.

The European hake is a species of high commercial value, highly prized by fishermen and fishing professionals **(Aldebert & Carriès, 1989; Martin, 1991; Oliver & Massutí, 1995)** and is intensively exploited in both the Atlantic and Mediterranean basins. Its global catch is estimated by 142190 tons in 2017 (**FAO, 2019)**. The Mediterranean Sea produces 15% of the total European hake production (**FAO, 2014)**. On the other hand, its total catch in Algeria increased from 888 tons in 2014 to 511 tons in 2018 (**FAO, 2019)**.

The age and growth of hake have been the main subject of several studies in the Mediterranean **(Figueras, 1965; Bouhlal, 1975; Iglesias & Drey, 1981; Erzini, 1991; Campillo, 1992; Abella *et al.*, 1995; Morales-Nin & Aldebert, 1997; Uçkun *et al*., 2000; Piñeiro & Sainza, 2003; Akalin, 2004; De Pontual *et al*., 2006; Mellon-Duval *et al*., 2010; Khoufi *et al*., 2014; Philips, 2014; Soykan *et al*., 2015; Kahraman *et al*., 2017; Uzer *et al*., 2019; Girgin *et al*., 2020)**. Furthermore, stock distribution and assessment of hake were conducted on by other studies (**Tsangridis *et al*., 1990; Belcari *et al*., 2006; Gücü & Bingel, 2011; Yalçin & Gurbet, 2016; Demirel *et al*., 2017)**. On the other hand, very little works have been carried out in Algeria, for instance; **Bouaziz *et al*. (1998)** in central coasts, **Belhoucine (2012)** in the western coasts and **Betatache-Alik (2015)** in the eastern coast. Nevertheless, no studies has been carried out in the extreme eastern coasts of Algeria (Algerian-Tunisian borders), which is part of a national park classified as a biosphere reserve by UNESCO in 1990. It is a clean environment far from any source of pollution.

MATERIALS AND METHODS

A total of 900 fish were collected from the coastline of El-Kala (marine area of the El-Kala National Park, extreme North-Eastern Algeria), which extends from Cap Segleb (at the Tunisian border) in the East to Cap Rosa in the West (8°15' E and 36° 58' N) (Fig. 1). The coastal marine zone of El Kala in North-Eastern Algeria, classified as a Biosphere Reserve by UNESCO, has the particularity of combining, in a humid bioclimatic stage, the interface of a forest, lake and marine ecosystem.

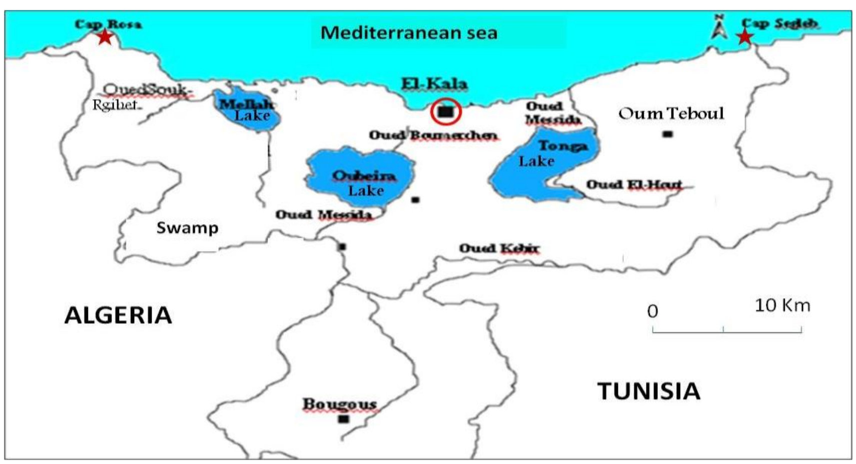

Fig. 1. Location of studied site in the South-Western Mediterranean Sea

The sample was taken from the trawl catch at a depth of 70-90 m, during the period from April to July 2020. At the laboratory, total length (TL) and total body weight (TW) were measured to the nearest 0.1 cm and 0.1 g, respectively. Gender was not included in this study.

The length-weight relationship (TL-TW) was calculated according to **Froese (2006)** using the equation of TW = a TL^b, where TW is the total weight (g), TL is the total length (cm), a (constant) and b (slope). Parameters a and b were estimated by regression curve analysis, based on the logarithmic transformation of the equation: **Log TW = b × Log TL + Log a (Beverton & Holt, 1957)**.

The growth parameters were calculated according to the equation of **Von Bertallanfy (1938)**: $\mathbf{Lt = L_\infty \times (1 - e^{-k \times (t - t_0)})}$ where Lt is the total length at age t, L_∞ is the asymptotic length, K is the growth coefficient and t_0 is the theoretical age at length zero.

The parameters $\mathbf{L_\infty}$ and **K** were estimated by **the FiSAT II program, version 1.2.2 (Gayanilo *et al*., 2005)**, while t_0 was obtained from the study of **Pauly (1980)** with reference to the empirical expression, where $\mathbf{Log\ (-t_0) = - 0.3922 - 0.2752\ Log\ L_\infty - 1.038\ Log\ K}$

The growth performance index (φ') was also estimated according to **Pauly and Munro (1984)**: where $\mathbf{\varphi' = log\ K + 2\ log\ L_\infty}$

Total mortality (Z) was estimated from the analysis of the length-converted catch curve formulated by **Pauly *et al*. (1995)**. Natural mortality (M) was estimated using the empirical equation described by **Pauly (1983)**: $\mathbf{log\ M = -0.0066 - 0.279 \times (log\ L_\infty) + 0.6543 \times (log\ K) + 0.4634 \times (log\ T)}$, where L_∞ and K are growth parameters of Von Bertalanffy, T is the mean (winter and summer) ambient temperature of the water at the sampling site, considered equal to 20ºC (**Grimes, 2001)**.

The fishing mortality rate (F) was estimated according to **Sparre and Venema (1992)** as follows: **F = Z - M.** The exploitation rate (E) was calculated by **Pauly (1983)**: **E = F / Z**.

RESULTS

A total of 900 European hake (sex combined) were collected during this study. The total length varied between 13 and 43 cm, whereas the total weight was between 15 and 495 g.

As shown in Fig.(2), the size frequency distribution revealed that size class of 18 - 19cm individuals dominated the catches (8.77%), followed by size groups of 19 - 20cm, 22 - 23cm, 23 - 24cm, 24 - 25cm, and 20 - 21cm corresponded to 8.22%, 7.11%, 6.55%, 6.33% and 6.22% of the total lengths, respectively. It was noted that individuals from the middle class (between 15 and 30 cm) were the most fished and best represented.

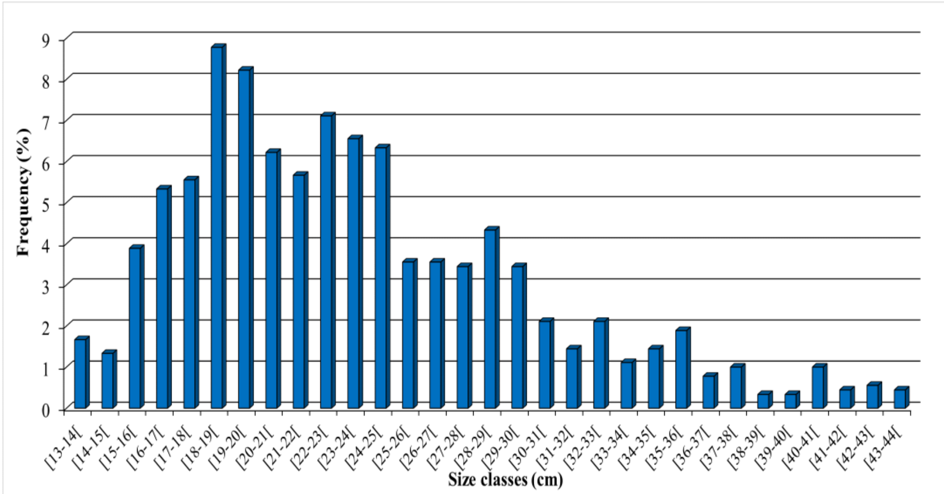

Fig. 2. Length-frequency distribution of *Merluccius merluccius* from El-Kala Coastline.

1. Length-Weight Relationship

The length-weight relationship was calculated as follows: $TW = 0.018\ TL^{2.68}$ (Fig. 3). According to Student's t-test, a minor allometry of this species was observed in the study area. ($r = 0.91$; $p \leq 0.001$).

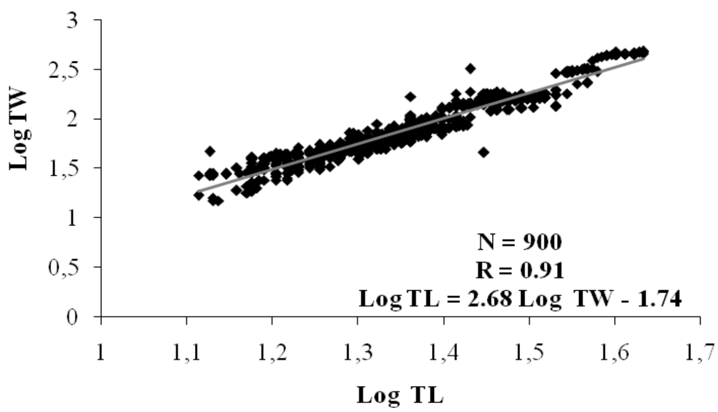

Fig. 3. Length-Weight relationship of *Merluccius merluccius* from El-Kala coastline.

The method of Bhattacharya (1967) facilitated to group the sample of *M. merluccius* into 7 cohorts. The values of size by age and the number of individuals in each age class are presented in Table (1).

Ages 2 and 3 were the most present in the catches with 26.18 and 31.41%, respectively. The minimum catch was observed in 7 years old individuals (3.33%).

Table 1. Length-at-age key of *Merluccius merluccius* obtained by Bhattacharya's method.

Species	Age (Years)	Mean total lengths (cm)	Effective		Separation Index
			N	%	
M. Merluccius	1	16.42	138	14.89	n.a.
	2	19.46	241	26.18	2.09
	3	23.56	290	31.41	2.12
	4	28.65	150	16.31	2.13
	5	32.71	31.6	3.43	2.11
	6	35.3	40.3	4.37	2.06
	7	41.75	30.8	3.33	2.20

2. Growth parameters

The estimation of the growth parameters by Von Bertalanffy's equation was: L_∞ = 44.08 cm, K = 0.29 y^{-1}, t0 = -0.517, and the performance index φ' = 2.75 (Table 2).

The parameters of Von Bertalanffy's model aided to construct the absolute linear growth equation as follows: $Lt = 44.08 \times (1-e^{-0.29\ (t\ +\ 0.517)})$.

Von Bertalanffy's absolute linear growth curve (Fig. 4a) shows that individuals grew faster during the first year of life, with a gain in length equal to 15.69 cm, which gradually decreased to 1.67 cm during its seventh year.

Table 2. The von Bertalanffy growth parameters calculated for *Merluccius merluccius* from the El-Kala coastline.

Parameters	L_∞	K	t_o	φ'	N	Age limits (Years)
Sex combined	44.08	0.29	-0.517	2.75	900	1-7

3. Weight growth

The weight growth equation for both sexes was: $Wt = 459.03 \times [1-e^{-0.29(t\ +\ 0.517)}]^{2.68}$.

The asymptotic weight in the total population was W_∞ = 459.03 g, it wass slightly lower than the maximum observed weight (TW = 485 g). Weight gain was maximal during the first year (163.36 g), then decreased to a minimum of 17.46 g at 7 years old (Fig. 4b).

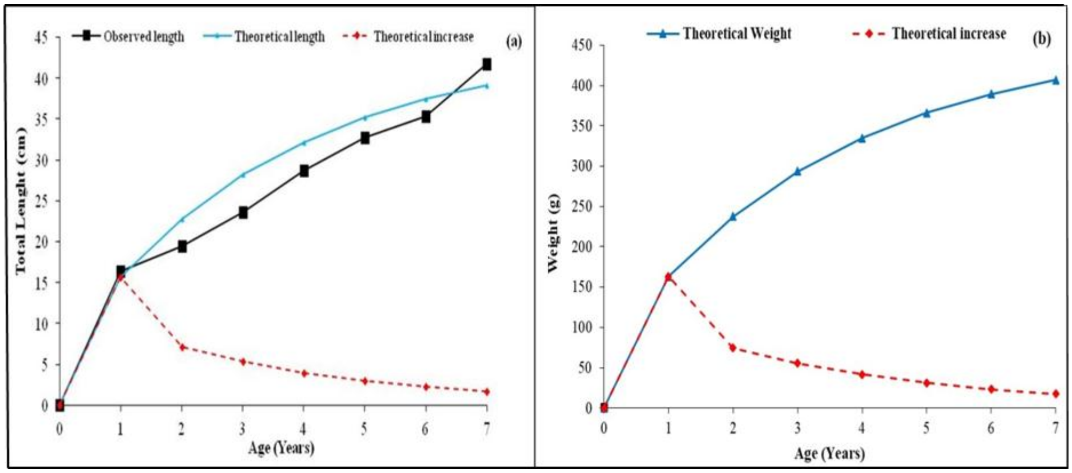

Fig. 4. The linear and weight absolute growth curve of *M. merluccius* from the El-kala coastline.

The calculation of the total mortality (Z) was estimated at 1.53 year^{-1}. However, natural mortality (M) and fishing mortality (F) were estimated at 0.61 and 0.92, respectively. In addition, the exploitation rate was 0.60 which indicates an over-exploitation of the *M. merluccius* species in the study area.

DISCUSSION

This studywas conducted to present the age composition, growth, mortality and exploitation of the *M. merluccius* stock of the El-Kala coastline (extreme North-Eastern Algeria). In this essence, length frequency data was used to analyze these parameters.

The maximum length measured in *M. merluccius* from the extreme North-East of Algeria was 43 cm, whereas it might reach up to 110 cm in its geographic area of distribution **(Bauchot, 1987; Djabali *et al*., 1993)**. This value is much lower than those reported by other authors in Algeria: 65.5 cm on the central coasts **(Bouaziz *et al*., 1998)**, 57 cm on the western coasts of Algeria **(Belhoucine, 2012)** and 81.6 cm on the eastern coasts **(Betatache-Alik, 2015)**. On the other hand, it is superior to other works carried out in the Mediterranean as **Morey *et al.* (2003)**, **Sangun *et al*. (2007)** and **Demirel and Dalkara (2012)** (Table 3). The differences in size could be attributed to the variations in growth performance from one region to another, the sampling randomness (selectivity of the catching gear, sample size) and also the fishing pressure on certain size classes of the species.

The length-weight relationship in this study showed that *M. merluccius* expressed minor growth with a slope equal to 2.68. **Bouaziz *et al*. (1998)**, found that weight grows at the same rate with length on the central coast of Algeria, while **Belhoucine (2012)** and **Betatache-Alik (2015)** noted a major growth respectively on the West and East coasts of Algeria (Table 3). In the Mediterranean, and more precisely, on the Turkish coast, only **Sangun *et al*. (2007)** and **Demirel and Dalkara (2012)** reported "b" values similar to those of the current study (Table 3). However, many studies have recorded positive allometry in the Mediterranean **(Uçkun *et al.*, 2000; Moutopoulos & Stergiou, 2002; Ozaydin *et al.*, 2007; Akalin, 2014; Khoufi *et al.*, 2014; Soykan *et al.*, 2015; Uzer *et al.*, 2019; Adamidou *et al.*, 2020)**. On the other hand, isometric growths have been reported in the Mediterranean in the studies of **Morey *et al.* (2003)**, **Kahramam *et al.* (2017)** and **Gül *et al.* (2019),** and in the Atlantic in the studies of **Piňeiro *et al.* (2003)** and **Costa (2013)** (Table 3). This divergence of results between areas could be related to sample size, diets, seasons, maturity stages, or sampling methods of different studies.

Table 3. The length-weight relationships for *Merluccius merluccius* from various areas.

Study Area	Authors	N	Total length (cm)	A	b
	Algeria				
central region of the Algerian coast, Mediterranean	Bouaziz *et al.*, 1998	333	7.5 - 65.5	0.0060	3.020 (=)
Oran Bay, west Algerian coast, Mediterranean	Belhoucine, 2012	648	13.6 - 57	0.0059	3.045 (+)
East coast of Algeria (Gulf of Béjaia, Bay of Jijel & Gulf of Annaba), Mediterranean	Betatache-Alik, 2015	720	8.6 – 81.6	0.00189	3.33 (+)
	Other regions				
Aegean Sea, central, Turkey	Uçkun *et al.*, 2000	36	13.6 – 43.5	0.005	3.194 (+)
Aegean Sea, Greece	Moutopoulos et Stergiou, 2002	52	18.0 – 50.2	0.004	3.2 (+)
Western Mediterranean	Morey *et al.*, 2003	6	7 – 23.2	0.0048	3.055 (=)
Atlantic, Spain, Portugal	Piňeiro *et al.*, 2003	391	6.0 – 78.0	0.0733	2.981 (=)
North-East Mediterranean Coast (Turkey)	Sangun *et al.*, 2007	9	13.2 - 31	0,337	2.353 (-)
Aegean Sea, central, Turkey	Özaydin *et al.*, 2007	711	2.7 – 48.8	0.981	3.189 (+)
Marmara Sea, Turkey	Demirel and Dalkara., 2012	15	10.6 – 24.5	0.010	2.886 (-)
Atlantic, Portugal	Costa, 2013	935	7.0 – 93.3	0.0038	3.172 (=)
Tunisian coasts	Khoufi *et al.*, 2014	409	12 – 93.5	0.003	3.115 (+)
Edremit Bay, Turkey	Akalin, 2014	375	7.6 – 46.2	0.0067	3.307 (+)
Aegean Sea, central, Turkey	Soykan *et al.*, 2015	108	5.2 – 45.5	0.00341	3.24 (+)
Marmara Sea, Turkey	Kahramam *et al.*, 2017	77	10.4 – 53.3	0.0079	2.9896 (=)
Aegean Sea, Turkey	Uzer *et al.*, 2019	253	5.2 – 51.2	0.0034	3.224 (+)
Marmara Sea, Turkey	Gül *et al.*, 2019	453	5 – 57	0.0082	2.9718 (=)
Northern Aegean Sea, Turkey	Adamidou et *al*., 2020	45	21.3 – 44.8	0.0037	3.20 (+)
Extreme North-East of Algeria	**Present study**	**900**	**13 – 43**	**0.018**	**2.68** (-)

Note: (+) positive allometry; (-) negative allometry; (=) isometric growth.

The age classes of the *M. merluccius* population in the extreme North- East of Algeria were estimated to be 1 to 7 years old. The present results are similar to those reported by **Betatache-Alik (2015)** on the East coast of Algeria and those of **Girgin *et al*. (2020)** in Turkey (Northeast Mediterranean). However, **Bouazziz *et al.* (1998)** recorded, in the central region of the Algerian coast, 9 and 5 cohorts, respectively for females and males. However, **Kahramen *et al.* (2017)** and **Uzer *et al.* (2019)** recorded a maximum age of 6 years in Turkey, respectively in the Marmara Sea and the North Aegean Sea. In contrast, **Belhoucine (2012)** and **Khoufi *et al*. (2014)** reported a maximum age of 8 and 12 years, respectively in the Oran Bay (West Algerian coast) and the Tunisian coast, while in the Northeast Atlantic the estimated age ranged from 0 to 10 years.

Table (4) shows the growth parameters (L_∞, k, t_0 and φ') of this study compared to results of other studies (Table 4). The asymptotic length in the present study (L_∞ = 44.08 cm) is close to that observed for Males by **Bouazziz *et al*. (1998)** on the central coasts of Algeria (L_∞ = 48. 72 cm), though much less than those reported by **Belhoucine (2012)** in western Algeria (L_∞ = 59.27 cm) and **Betatache-Alik (2015)** in eastern Algerian coast (L_∞ = 99.28 cm) and **Khoufi *et al*. (2014)** on the Tunisian coast (L_∞ = 110 cm). This can be explained by the different environmental conditions, biological features, feeding, intra- or interspecific competition **(Panfili *et al.*, 2002)**, In addition it can be related to the age at maturity, sample size or sampling methods.

The growth coefficient (K) recorded in the study area (K = 0.29 ans^{-1}) is close to that recorded in the region, which varies from 0.13 to 0.321 on the Algerian coast **(Bouazziz *et al.*, 1998; Belhocine, 2012; Betatache-Alik, 2015)** (Table 4). In the Mediterranean, the growth coefficient of *M. merluccius* oscillates between 0.087 to 0.4 ans^{-1} **(Bouhlal, 1975; Alemany & Oliver, 1995; Recasens *et al.*, 1998; Esteban, 2002; Colloca *et al.*, 2003; Khoufi *et al.*, 2014; Garcia-Rodriguez & Akalin, 2014; Philips, 2014; Soykan *et al.*, 2015; Kahraman *et al.*, 2017; Gül *et al.*, 2019; Uzer *et al*., 2019; Girgin *et al.*, 2020)** (Table 4). According to **Murugan *et al.* (2014)**, asymptotique length (L_∞) and growth coefficient (K) are negatively correlated. Some differences must be detected between growth parameters among areas because of the diversity and availability of dietary items, hydrographical and climatic conditions **(Gulland, 1970; Bartulovic *et al.*, 2004)**.

Finally, the growth performance index (φ') recorded in this study was equal to 2.75, which is close to the results of **Bouaziz *et al.* (1998)** (φ' = 2.882 and φ' = 2.956 for males and females respectively), **Belhoucine (2012)** (φ' = 2.897) on West Algerian coast and Philips (2014) (φ' = 2.81) in Egypt (Table 4). **Betatache-Alik (2015)** reported a slightly higher value on the East coast of Algeria (φ' = 3.12). However, higher values were obtained by other authors in the Mediterranean ($2.81 \leq φ' \leq 3.47$) and Atlantic ($3.16 \leq φ' \leq 3.27$) (Table 4). These slight differences between the performance index values can be explained by sampling data (commercial or survey campaign data), sample size, as well as the size of the largest individual, period of sampling (seasonal and interannual variation), the prevailing hydroclimatic and environmental conditions, methodological approaches adopted for the calculation of growth performance index (φ') (reading otoliths, size frequency analysis, mark-recapture,…).

Table 4. The Von Bertalanffy growth parameters and growth performance index values obtained from different areas for *Merluccius merluccius.*

Study area	References	sexes	L_∞	K	t_o	φ'	Method
	Algeria						
Central region of the Algerian coast, Mediterranean	Bouaziz *et al.,* 1998	♂	48.72	0.321	-0 .074	2.882	FISAT (ELEFAN)
		♀	80.64	0.139	-0.422	2.956	FISAT (ELEFAN)
Oran Bay, West of Algeria, Mediterranean	Belhoucine, 2012	♀ + ♂	59.27	0.22	-0.823	2.897	FISAT (ELEFAN)
East Coast of Algeria (Gulf of Bejaia Bay, Jijel Bay & Gulf of Annaba, Mediterranean	Betatache-Alik, 2015	♀ + ♂	99.28	0.13	-0.31	3.12	FISAT (ELEFAN)
	Other regions						
Gulf of Tunis, Tunisia	Bouhlal, 1975	♀ + ♂	69.5	0.176	0.600	2.93	FISAT (ELEFAN)
Tunisian coasts	Khoufi *et al.,* 2014	♀ + ♂	110	0.198	0.500	3.29	Otolith
Gulf of Lions	Recasens *et al.,* 1998	♂	72.8	0.149	-0.383	-	Otolith
		♀	100.7	0.124	-0.350	-	
Mediterranean, Alicante Bay, Spain	Garcia-Rodriguez and Esteban, 2002	♀ + ♂	106.8	0.200	0.003	3.36	FISAT (ELEFAN)
Central Mediterranean	Colloca *et al.,* 2003	♂	45,7	0,400	0,100	-	Otolith
		♀	93,2	0,130	-0,350	-	
Mediterranean, Egypt	Philips, 2014	♀ + ♂	74.193	0.119	0.281	2.817	Otolith
Balearic sea	Alemany and Oliver, 1995	♂	48,72	0,321	-0,07	2,88	Otolith
		♀	126,9	0,184	-0,04	3,47	
North-eastern Mediterranean sea, Turkey	Girgin *et al.,* 2020	♀ + ♂	84.44	0.135	-0.469	2.98	Otolith
Northern Aegean, Turkey	Uzer *et al*,. 2019	♀ + ♂	102.6	0.099	-0.80	3.01	Otolith
Aegean Sea, central, Turkey	Soykan *et al.,* 2015	♀ + ♂	54.53	0.315	-0.223	2.97	Otolith
Marmara Sea, Turkey	Gül *et al.,* 2019	♀ + ♂	57.5	0.27	-0.57	-	FISAT (ELEFAN)
Marmara Sea, Turkey	Kahraman *et al.,* 2017	♀ + ♂	103.97	0.087	-0.926	2.97	Otolith
Edremit Bay, Turkey	Akalin, 2014	♀ + ♂	53.90	0.377	-0.045	3.040	Otolith
Strait of Gibraltar, Spain	Piñeiro and Saínza, 2003	♀ + ♂	80.80	0.350	-1.700	3.36	Otolith
Atlantic, North-east	Godinho *et al.,* 2001	♀ + ♂	110.6	0.089	-0.970	2.99	Otolith
Atlantic center, Morocco	El Habouz *et al.,* 2011	♀ + ♂	115.4	0.14	-0.919	3.27	FISAT (ELEFAN)
Atlantic, North, Morocco	Belcaid and Ahmed, 2011	♀ + ♂	72.45	0.280	-0.720	3.16	FISAT (ELEFAN)
Extreme North-East of Algeria	**Present study**	♀ + ♂	**44.08**	**0.29**	**-0.517**	**2.75**	FISAT (ELEFAN)

According to **Ralston and Williams (1988)**, mortality estimates associated to growth parameters are important to understand population dynamics. The current results suggest that fishing mortality (F) and natural mortality (M) of *M. merluccius* in the study area was equal to 0.92 and 0.61 respectively, suggesting an exploitation rate greater than 0.5 (E = 0.6) indicating an overfishing. It can be seen from Table (5), that since the work of **Djabali *et al.* (1991)**, until that of **Betatache-Alik (2015)** on the Algerian coast, the exploitation rate of *M. merlucius* jumped from 0.54 to 0.89, expressing an increase in fishing pressure on European hake stocks in Algerian coast. It can not be indicated that this exploitation has decreased in this study, given that the studies carried out did not cover the present study area, which is located in the extreme North-East of Algeria (Algerian-Tunisian borders). Moreover, other authors have reported high fishing pressure on the *M. merluccius* population in Turkish coasts **(Gurbet *et al.*, 2013; Soykan *et al.*, 2015; Kahraman *et al.*, 2017; Uzer *et al.*, 2019)**. **Kahraman *et al.* (2017)** suggested that the Eastern Mediterranean stocks of European hake were overexploited.

Table 5. Different results of total, natural and fishing mortality as well as the exploitation rate in different area.

Author	Area	Z (y^{-1})	M (y^{-1})	F (y^{-1})	E
Djabali *et* al., 1991	Algeria	0.66	0.3	0.36	0.54*
Bouaziz *et* al., 2001	Algerian center coasts	0.78	0.27	0.51	0.65*
Belhocine, 2012	West coast of Algeria	0.86	0.23	0.63	0.73*
Betatache-Alik, 2015	East coast of Algeria	2.28	0.24	2.04	0.89*
Gurbet *et al*., 2013	Central Aegean Sea	2.24	0.58	1.66	0.74*
Soykan *et al*., 2015	Central Aegean Sea	1.539	0.579	0.959	0.62*
Kahraman *et al*., 2017	Marmara sea	2.01	0.19	1.81	0.9*
Uzer *et al*., 2019	North Aegean Sea	2.21	0.57	1.61	0.72*
Present study	**Extreme North-East of Algeria**	**1.53**	**0.61**	**0.92**	**0.60**

**Calculated values from available data.*

For better management of natural stocks of *M. merlucius* in southern Mediterranean and especially on Algerian coasts, more informations are required to cover dynamic parameters, which are ensured by studies of growth and exploitation of hake stocks. However, reducing the fishing effort in the region is recommended for a sustainable exploitation of this fishery resource.

REFERENCES

Abella, A.; Auteri, R. and Serena, F. (1995). Some aspects of growth and recruitment of hake in the northern Tyrrenian sea. Rapport de la 1ère réunion du groupe de travail DYNPOP du CIESM. Tunis, 10: 27-28.

Adamidou, A.; Pardalou, A. and Tsikliras, A. C. (2020). Length-Weight Relationships of 31 Fish and Invertebrate Species in the Northern Aegean Sea (Eastern Mediterranean sea). Thalassas: Int. J. Mar. Sci., 36: 303-307.

Akalın, S. (2004). Edremit Ko¨rfezi'nde Bakalyaro'nun (*Merluccius merluccius* Linnaeus, 1758) Biyo-ekolojik o¨zelliklerinin aras¸tırılması. PhD thesis. Ege University, Turkey, 13pp.

Akalin, S. (2014). Investigations of the age and growth characteristics of European Hake *Merluccius merluccius* L., 1758) in Edremit Bay. Ege JFAS., 31(4): 195-203.

Aldebert, Y. and Carriès, C. (1989). L'exploitation du merlu dans le golfe du Lion. Bull. Soc. Zool. Fr., 114: 15-20.

Aldebert, Y. and Recasens, L. (1996). Comparison of methods for stock assessment of European hake *Merluccius merluccius* in the Gulf of Lions (NW Mediterranean). Aquat. Living. Resour., 9: 13-22.

Alemany, F. and Oliver, P. (1995). Growth of female European hake in the Balearic Sea: a proposal of new growth model with higher growth rates. Rapport CIESM., 34: 236.

Bartulovic, V.; Glamuzina, B.; Conides, A.; Dulcic, J.; Lucic, D.; Njire, J. and Kozul, V. (2004). Age, growth, mortality and sex ratio of sand smelt, *Atherina boyeri*, Risso, 1810 (Pisces: Atherinidae) in the estuary of the Mala Neretva River (Middle-Eastern Adriatic, Croatia). J. Appl. Ichthyol., 20: 427-430.

Bhattacharya, C. G. (1967). A simple method of resolution of a distribution into Gaussian components. Biometrics., 23: 115-135.

Bauchot, M. L. (1987). Poissons osseux. 891- 1421pp. In : W. Fischer, M.-L. Bauchot and M. Schneider (eds.) Fishes FAO d'identification pour les besoins de la pêche (rev.1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Commission des communautés Européennes & FAO, Rome.

Belcaid, S. and Ahmed, S. (2011). Growth, mortality and exploitation of European hake *Merluccius merluccius* in the Moroccan. North Atlantic Sea. Egypt. J. Aquat. Res., 37(2): 139-145.

Belcari, P.; Ligas, A. and Viva, C. (2006). Age determination and growth of juveniles of the European hake, *Merluccius merluccius* (L., 1758), in the northern Tyrrhenian Sea (NW Mediterranean). Fish. Res., 78: 211-217.

Belhoucine, F. (2012). Etude de la biologie de la croissance et de la reproduction d'un poisson téléostéen le merlu (*Merluccius merluccius* L., 1758) et son utilisation comme indicateur biologique de la pollution par les métaux lourds (Zinc, Plomb et Cadmium) dans la baie d'Oran (Algérie). Thèse de Doctorat. Universite d'Oran.189pp.

Betatache-Alik, O. (2015). Biologie de la reproduction et dynamique du merlu, *Merluccius merluccius* (Linnaeus, 1758) de la côte Est Algérienne. Mémoire de Magister, Université de Béjaïa. 233pp.

Beverton, R. J. H. and Holt, S. J. (1957). On the dynamics of exploited fish populations. Fish. Invest., 19: 1-533.

Bouaziz, A.; Semroud, R.; Djabali, F. and Maurin, C. (1998) : Estimation de la croissance du merlu *Merluccius merluccius* (Linnaeus, 1758) de la région centre de la côte algérienne par analyse des fréquences de tailles. Cah. Options Mditerr., 35: 35-41.

Bouhlal, M. (1975). Contribution à l'étude biologique et dynamique du merlu *Merluccius merluccius mediterraneus* (L. 1758) du golfe de Tunis. Thèse 3ème cycle de biologie marine, Université de Tunis, Faculté des sciences, 177pp.

Costa, A. M. (2013). Somatic Condition, Growth and Reproduction of Hake, *Merluccius merlucciu*s L., in the Portuguese Coast. J. Mar. Sci., 3: 12-30.

Cohen, D. M.; Inada, T.; Iwamoto, T. and Scialabba, N. (1990). FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fisheries Synopsis No. 125. FAO, Rome.

Colloca, F.; Gentiloni, P.; Belluscio, A.; Carpentieri, P. and Ardizzone, G. D. (2003). Estimating growth parameters of the European hake (*Merluccius merluccius*) through the analysis and validation of annual increments in otoliths. Arch. Fish. Mar. Res., 50: 175-192.

Campillo, A. (1992). Les Pêcheries Françaises de Méditerranée: Synthèse des Connaissances. Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), IFREMER Report, 206pp.

Demirel, N. and Murat-Dalkara, E. (2012). Weight-length relationships of 28 fish species in the Sea of Marmara. Turk. J. Zool., 36: 785-791.

Demirel, N.; Gül, G.; Dalkara, E. M. and Yüksek, A. (2017). Ecosystem approach to sustainability level of European hake stock in the Marmara Sea. The Scientific and Technological Research Council of Turkey, Final Report, 04/2017.

Pontual, H.; Groison, A. L.; Piñeiro, C. and Bertignac, M. (2006). Evidence of underestimation of European hake growth in the Bay of Biscay, and its relationship with bias in the agreed method of age estimation. ICES J. Mar. Sci., 63(9): 1674-1681. DOI: 10.1016/j.icesjms.2006.07.007

Djabali, F.; Boudraa, S.; Bouhdid, A.; Bousbia, H.; Bouchelaghem, E. H.; Brahmi, B.; Dob, M.; Derdiche, O.; Djekrir, F.; Kadri, L.; Mammasse, M.; Stambouli, A. and Tehami, B. (1991) : Travaux réalisés sur les stocks pélagiques et démersaux de la région de Béni-Saf. FAO Fish. Rep., 447, 160-165.

Djabali, F.; Brahmi, B. and Maamass, M. (1993). Poissons des côtes algériennes. Pelagos (NS). 215pp.

El Habouz, H.; Recasens, L.; Kifani, S.; Moukrim, A.; Bouhaimi, A. and El Ayoubi, S. (2011). Maturity and batch fecundity of the European hake (Merluccius merluccius, Linnaeus, 1758) in the Eastern Central Atlantic. Sci. Mar., 75 (3): 447-454.

Erzini, K. (1991). A compilation of data on variability in length-age in marine fishes. Fisheries stock assessment Title XII, Collaborative Research Support Program. Working Paper, 77, University of Rhode Island, 36 pp.

FAO. (2014). Food and Agriculture Organization (FAO) Fisheries and Aquaculture Department. [Accessed on 14 September 2018] http://www.fao.org/fishery/ species/ 2238/en

FAO. (2019). Fishery Statistical Collections Global Capture Production 1950-2016. Available at: http://www.fao.org/fishery/statistics/globalcapture production/query/en. (Accessed: 6 February 2019).

Figueras, A. (1965). Age et croissance du Merlu *M. merluccius* L. de la Méditerranée occidentale (Costa Brava, N.E. de l'Espagne). Débats et Documents techniques du Commission Général des Pêches pour la Méditerranée 8 (16).

Froese, R. (2006). Cube law, condition factor, and weight-length relationships: History, meta-analysis, and recommendations. J. Appl. Ichthyol., 22: 241-253.

Froese, R. and Pauly, D. (2016). FishBase. World Wide Web electronic publication, Pauly D. (Eds), www.fishbase.org, (06/2016).

Gayanilo, F. C.; Pauly, D. and Sparre, P. (2005). FISAT User's Guide. FISAT II. En ligne : http//www.fao.org/fi/statist/fisoft/fisat/downloads.

García Rodríguez, M. and Esteban, A. (2002). How fast does hake grow? A study on the Mediterranean hake (*Merlucciusmerluccius* L.) comparing whole otoliths readings and length frequency distribution data. Sci. Mar., 66(2): 145-156.

Girgin, H. and Basusta, N. (2020). Growth characteristics of European hake, *Merluccius merluccius* (Linnaeus, 1758), inhbiting northeastern Mediterranean. Acta Adriat., 61(1): 79-88.

Godinho, M. L.; Afonso, M. H. and Morgado, C. (2001). Age and growth of hake *Merluccius merluccius* (L. 1758), from the northeast Atlantic (ICES division Ixa). Oceanography., 17 (3-4): 255-262.

Grimes, S. (2001). Les aires marines protégées, passage obligé pour la préservation de la biodiversité marine d'Algérie ? Séminaire International d'Alger sur la biodiversité marine des pays musulmans. INOC/MPRH , 22-24 nov.2001, Alger.

Gücü, A. C. and Bingel, F. (2011). Hake, *Merluccius merluccius* L., in the northeastern Mediterranean Sea: a case of disappearance. J. Appl Ichthyol., 27: 1001-1012.

Gül, G.; Murat-Dalkara, E.; Yüksek, A. and Demirel, N. (2019). Age and growth of European hake, *Merluccius merluccius* in the Sea of Marmara. COMU J. Mar. Sci. Fish., 2(2): 147-154.

Gulland, J. A. (1970). The fish resources of the ocean. FAO Fish Tech Paper No. 97, FAO, Rome, 425pp.

Gurbet, R.; Akyol, O. and Yalçin, E. (2013). Exploitation and mortality rates of European hake (*Merluccius merluccius*) in the Aegean Sea (Izmir Bay, Turkey). J. Appl. Ichthyol., 29(3): 569-572.

Iglesias, S. and Dery, L. (1981). Age and growth studies of hake (*Merluccius merluccius* L.) from ICES Divisions Villc and Ixa. 1981. ICES CM 1981/G: 38 pp.

Kahraman, A. E.; Yildiz, T.; Uzer, U. and Karakulak, F. S. (2017). Age composition, growth and mortality of European hake *Merluccius merluccius* (Linnaeus, 1758)

(Actinopterygii: Merlucciidae) from the Sea of Marmara, Turkey. Acta Zool. Bulg., 69(3): 377-384.

Khoufi, W.; Dufour, J. L.; Jaziri, H.; Elfegri, S.; Elleboode, R.; Bellamy, E.; Ben Meriem, S.; Romdhane, M. S. and Mahé, K. (2014). Growth estimation of *Merluccius merluccius* off the northern coast of Tunisia. Cybium, 38(1): 53-59.

Linnaeus, C. (1758). Systema Naturae per Regna Tria Naturae secundum Classes, Ordinus.

Martin I. (1991). A preliminary analisis of some biological aspects of hake (*Merluccius merluccius*) in the Bay of Biscay. C.M. 1991/G: 54: 14pp.

Mellon-Duval, C.; De Pontual, H.; Métral, L. and Quemener, L. (2010). Growth of European hake (*Merluccius merluccius*) in the Gulf of Lions based on conventional tagging. ICES. J. Mar. Sci., 67: 62-70.

Morales-Nin, B. and Aldebert, Y. (1997). Growth of juvenile *Merluccius merluccius* in the Gulf of Lions (NW Mediterranean) based on otolith microstructure and length-frequency analysis. Fish. Res., 30: 77-85.

Morey, G.; Moranta, J.; Massuti, E.; Grau, A.; Linde, M.; Riera, F. and Morales-Nin, B. (2003). Weigth-length relatioships of littoral to lower slope fishs from the Western Mediterranean. Fish. Res., 62: 89-96.

Moutopoulos, D. K. and Stergiou, K. I. (2002). Length-Weight and length-lenght relationships of fish species from the Aegean Sea (Greece). J. Appl Ichthyol., 18(3): 200-203.

Murugan, S.; Rahman, M. A. U.; Lyla, P. S. and Khan, S. A. (2014). Growth and Population dynamics of flathead grey mullet, *Mugil cephalus* (Linnaeus, 1758) from Parangipettai waters (Southeast coast of India). Thalassas., 30(2): 47-56.

Oliver, P. and Massuti, E. (1995). Biology and fisheries of western Mediterranean hake (*M. merluccius*). In: Alheit J., Pitcher T. (eds) Hake: Biology, Fisheries and Markets. Chapman & Hall, London, pp. 181-202.

Ozaydin, O.; Uckun, D.; Akalin, S.; Leblebici, S. and Tosunoglu, Z. (2007). Length-Weigth relationships of fishes captures from Izmir bay, Central Aegean Sea. J. Appl. Ichthyol., 23(6): 695-696.

Panfili, J.; De Pontual, H.; Troadec, H. and Wright, P. J. (2002). Manuel de sclérochronologie des poissons. Coédition Ifremer-IRD, Brest, France, 464pp.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 Fish stocks. J. Cons. Int. Explor. Mer., 39: 175-192.

Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Pap., No. 234, 52 pp.

Pauly, D. and Munro, J. L. (1984). Once more on the comparison of growth in fish and invertebrates. Fish. byte., 2(1): 21.

Pauly, D.; Moreau, J. and Abad, N. (1995). Comparison of agestructured and length converted catch curves of brown trout *Salmo trutta* in two French rivers. Fish. Res., 22(3-4): 197-204.

Philips, A. E. (2012). Feeding behaviour of the European hake *Merluccius merluccius* Linnaeus, 1758 (Family: Gadidae) from Egyptian Mediterranean waters of Alexandria. Egypt. J. Aquat. Res., 38(1): 39-44.

Philips, A. E. (2014). Age composition of the European hake *Merluccius merluccius* (Linnaeus, 1758) from the Egyptian Mediterranean waters of Alexandria. Egypt. J. Aquat. Res., 40(2): 163-169.

Piñeiro, C. and Sainza, M. (2003). Age estimation, growth and maturity of the European hake (*Merluccius merluccius*) from Iberian Atlantic waters. ICES J. Mar. Sci., 60: 1086-1102.

Recasens, L.; Lombarte, A.; Morales-Nin, B. and Torres, G. J. (1998). Spatiotemporal variation in the population structure of the European hake in the NW Mediterranean. J. Fish Biol., 53: 387-401.

Ralston, S. and Williams, H. A. (1988). Depth distribution, growth, and mortality of deep slope fishes from the Mariana Archipelago. NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-113, 47pp.

Sangun, L.; Akamca, E. and Akar, M. (2007). Weigth-length relationships for 39 fish species from the North-Eastern Mediterranean coast of Turkey. Turkish J. Fish. Aquat. Sci., 7: 37-40.

Soykan, O.; Ilkyaz, A. T.; Metin, G. and Kinacigil, H. T. (2015). Age, Growth and reproduction of European hake (*Merluccius merluccius* (Linn., 1758)) in the central Aegean Sea, Turkey. J. Mar. Biolog. Assoc. U.K.., 95(4): 829–837.

Sparre, P. and Venema, S. C. (1992). Introduction to tropical fish stock assessment. Part I, Manual FAO Fish. Tech. Pap., No: 306/1, Rev 1, FAO, Rome.

Tsangridis, A.; Filippousis, N. and Diapouli, E. (1990). Assessment and management of hake stock in the Saronikos Gulf (application of length-based methods on trawl catches). Geotechnic Scientific Issues., 1: 15-28.

Uçkun, D.; Togulga, M. and Taskavak, E. (2000). A preliminary study on the growth of th common hake (*Merluccius merluccius* L., 1758) in Izmir Bay, Aegean Sea. Acta. Adriat., 41(2): 25-34.

Uzer, U.; Öztürk, B. and Yildiz, T. (2019). Age composition, growth, and Mortality of European hake *Merluccius merluccius* (Actinopterygii : Gadiformes: merlucciidae) from the Northern Aegean Sea, Turkey. Acta. Ichthyol. Piscat., 49(2): 109-117. DOI: 10.3750/ AIEP/02465

Von Bertalanffy, L. (1938). A quantitative theory of organic growth. Hum. Biol., 10: 181-213.

Yalçın, E. and Gurbet, R. (2016). Environmental influences on the spatio-temporal distribution of European Hake (*Merluccius merluccius*) in Izmir Bay, Aegean Sea. Turkish J. Fish. Aquat. Sci., 16(1): 1-14. DOI: 10.4194/1303-2712-v16-1-01