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# WHITING (*Merlangius merlangus euxinus*) POPULATION PARAMETERS ON THE ROMANIAN AND BULGARIAN LITTORAL BETWEEN 2000–2008

V. MAXIMOV[a]*, V. S. RAYKOV[b], M. YANKOVA[b], T. ZAHARIA[a]

[a]*National Institute for Marine Research and Development 'Grigore Antipa', 300 Mamaia Blvd., 900 581 Constanta, Romania*
*E-mail*: *maxi@alpha.rmri.ro*
[b]*Institute of Fishing Resources, 4 Primorski Blvd., 1000 Varna, Bulgaria*
*E-mail*: *vio_raykov@abv.bg*; *maria_y@abv.bg*

**Abstract**. The whiting, a demersal species which populates the Romanian and Bulgarian shelf of the Black Sea littoral, represents the most important capture of the regional fishery potential as far as the commercial interest is concerned. The present paper reviews the actual state of the demersal fishing in the Romanian and Bulgarian marine area of the Black Sea and the evolution, in time, of this species. Between 2000 and 2008, the whiting represented 20 to 25% of the total catch realised by commercial fishery. The catches of whiting were realised both by trawler ships (fishing by mid-water otter trawl) and net traps (installation for fishing in the shallow coastal areas). The paper presents the qualitative and quantitative structure of the whiting catches from the Romanian and Bulgarian littoral sector, between 2000 and 2008. The growth parameters for the both areas are also presented.

*Keywords*: whiting, fishery potential, catch, growth parameters, the Black Sea.

## AIMS AND BACKGROUND

The Black Sea ichtyofauna has suffered major changes during the past 50 years, qualitatively and quantitatively, as well as the behaviour of various species is concerned. These changes are the consequence of direct anthropogenic activities, through the fishing pressure, and indirect activities, through the deterioration of environmental conditions, especially on the Western shore[1,2]. The characteristics of the Black Sea basin is the fact that the majority of fish species occupy large areas, located in the exclusive zone of the coastal countries[3,4].

The whiting, which populates the continental shelf of the Romanian and Bulgarian exclusive zone at the Black Sea, represents a less important segment of the fishing potential, but it is a crucial intermediary link of the food chain[2–4]. Its role in the biologic processes of the Black Sea is highly important, as it connects the pelagic organisms to those which inhabit the area close to the sea bed. The Black Sea whiting appears a key species for the fish part of the ecosystem.

* For correspondence.

It represents trophic base for many fish species as turbot, spiny dogfish, etc. The level of stocks of the above-mentioned species is highly dependent on conditions of the environment and fishing effort[5]. According to the FAO experts, the whiting stocks must be protected from overfishing because they are of great importance for the turbot, spiny dogfish, etc. This calls for permanent monitoring on its both biological and exploitation parameters[6].

The researches carried out between 2000 and 2008 consisted of studying the spatial distribution of the whiting in the shallow and deep sea waters. In addition, the paper presents the biologic characteristics, with references to the structure divided in classes regarding length, age, sex differences, the relationship between length/weight and the main growth parameters.

## EXPERIMENTAL

The methodology and the techniques used for the collection, verification, processing and analysis of the data, as well as for the evaluation of the fish stocks are those generally accepted for the Black Sea basin and in accordance with the international methodology. For the study of the biological parameters for the main fish species, a sample was collected from the individuals, followed by laboratory analyses, aiming mainly: the structure divided in length, weight and age classes, elements required for the estimation of the growth. The biometric measurements were made for the total length ($L_t$), being read at 5-mm intervals and centralised at inferior centimeters. The weight was determined in grams, with a precision of ±1 g. The age readings were made using the otoliths.

For the determination of the total length ($L_t$) – weight ($W$) (Ref. 7) the following relationship was used:

$$W = a\, L_t b$$

where $W$ is the fish weight; $L_t$ – the total length of the fish; $a$, $b$ – the regression constants. The values of $a$ and $b$ were determined using the method of the smallest squares[8], included in the FISHPARM Programme[7,9,10].

For the estimation of the growth parameters the following equations were used[10,11]:

$$L_t = L_\infty(1 - e^{-k(t-t_0)});\ W_t = W_\infty(1 - e^{-k(t-t_0)})^n;\ t_0 = t + (1/k)\ln(1 - L_t/L_\infty)$$

where $L_t$ is the length at age $t$ (cm); $W_t$ – weight at age $t$ (g); $L_\infty/W_\infty$ – maximum length/weight; $k$ – growth parameter; $t$ – age (years); $t_0$ – hypothetic age when $L = W = 0$; $e$ – the basis of natural logarithms.

For the evaluation of $L_\infty$, $W_\infty$, $k$, $t_0$, the FISHPARM (Refs 7, 9 and 10) Programme was used and the following equations[11]:

$$L_{t+1} = a + bL_t;\ L_\infty = a/(1 - b);\ k = -\ln b;\ L_\infty = -a/b$$

where $L_t$, $L_{t+1}$ are average sizes in consecutive years; $a$, $b$ – regression coefficients.

For the estimation of the mortality coefficients, the following equations were used:

Estimation of the natural mortality coefficients ($M$) with the empiric relation proposed in Ref. 12:

$$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln k + 0.4634 \ln T,$$

where $T$ is the average water temperature in the stock distribution area;

The estimation of the total mortality ($Z$) using the Pauly relation[11]:

$$Z = \frac{nk}{(n+1) \lg e \, \frac{L_\infty - L_c}{L_\infty - L}}$$

where $Z$ is total mortality; $L_\infty$, $k$ – growth parameters; $L$ – the average length of the individuals captured; $L_c$ – average length, first capture; $n$ – number of individuals; $T$ – average annual water temperature (ºC).

## RESULTS AND DISCUSSION

### DISTRIBUTION AREA, CONDITIONS AND MIGRATION ROUTES OF THE WHITING *Merlangius merlangus euxinus* (N o r d m a n n, 1840) POPULATIONS

In the Black Sea, the whiting is one of the most abundant species among the demersal fishes. It does not undertake distant migrations, spawning mainly in the cold season within the whole habitat area. The whiting produces pelagic juveniles, which inhabit the upper 10-m water layer for about a year. The adult whiting is cold-living, preferring temperatures 6–10ºC. Fishes at the age less than 6 years are predominant in the whiting populations, the older year classes are found in catches individually. It occurs all along the shelf, dense commercial concentrations are formed by 1–3-year old fishes in the water down to 150 m depth, most often at 60–120 m depths. Such concentrations on the shelf of Bulgaria, Georgia, Romania, the Russian Federation and Ukraine are not met every year, appearing at periods of 4–6 years – in the years of appearance of highly productive year classes. In these countries, whiting is very rarely the target species for fisheries and yielded as by-catch during trawl fisheries for other fish species or while non-selective fisheries with fixed nets in the coastal sea areas. This whiting fishery is most developed in Romanian waters (Fig.1).

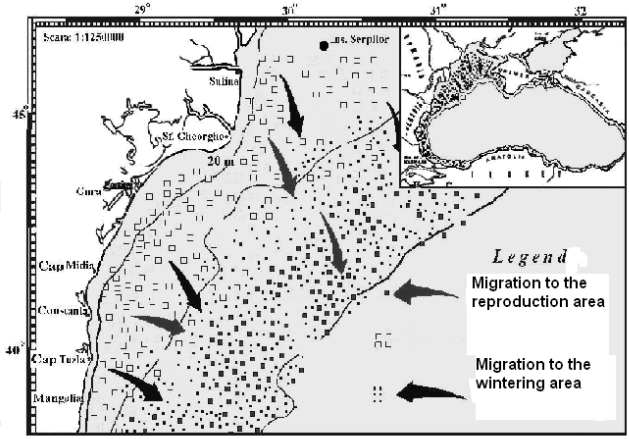



**Fig. 1**. Whiting migration routes and feeding sectors of the whiting

Whiting represents by-catch of the sprat fishery (by active fishing gears) and is not fished independently in Bulgarian and Romanian Black Sea waters[1,4,13,14].

Marine, cold water demersal species, the whiting is encountered at the Bulgarian and Romanian littoral, on rocky sea bottoms in autumn and in spring, but mostly during the summer in the mitiloid and faseolid muddy area, at depths of 20 to 120 m. During the cold period of the year it is encountered near the shore, and during the warm season it moves offshore and approaches the coast with the cold water counter-currents.

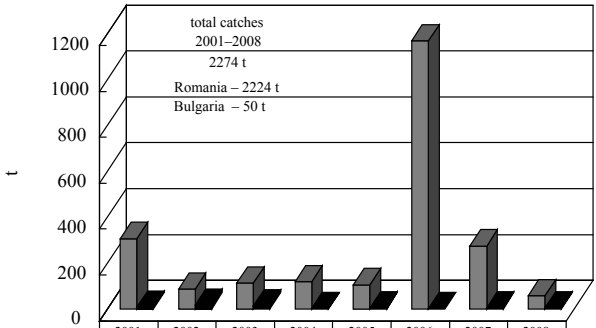
The reproduction takes place almost all year long, but the maximum intensity is reached between November and March. Between January and April, the eggs and larvae are found in the superficial layers of the water, while the rest of the year they float at depths of about 40 m.

The whiting does not have a great industrial value, but it is an important intermediary link of the food chain. Its role in the biological processes of the Black Sea is crucial, as it connects the pelagic organisms to those that populate the area close to the sea bed. This role is determined by the fact that the species feeds mainly with pelagic organisms and is then consumed by the predators from the sea bed area. Whiting fishing is done with marine nets, pelagic trawls and hooks[1–4].

## EVOLUTION OF THE MAIN WHITING CATCHES

The whiting represents a complementary catch of the Romanian and Bulgarian fishermen. The level of fishing productivity is different from year to year, depending on the fishing effort (number of boats, nets, effective fishing days) and on the evolution of the hydro-climatic conditions and the anthropogenic factors. The catches realised between 2001 and 2008 ranged between 56 t in 2008 and 1167 t

in 2006, in the Romanian sector, and 2 t in 2004 and 13 t in 2003, in the Bulgarian sector (Fig. 2) (Refs 2, 4, 6, 12,15 and 16).




| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Romania | 306 | 85 | 113 | 118 | 105 | 1167 | 274 | 56 |
| Bulgaria | 8 | 16 | 13 | 2 | 3 | 0 | 4 | 4 |

**Fig. 2**. Total catch (kg) of whiting at the Romanian and Bulgarian Black Sea coasts, 2001–2008

BIOLOGIC PARAMETERS OF THE WHITING (*Merlangius merlangus euxinus* N o r d m a n n, 1840)

The determination of the biologic parameters represents an important objective for the establishment of the demographic structure, the growth parameters, as well as other parameters required for the study of recruitment, mortality, effective and biomass, divided in age classes.

Overall, between 2004 and 2008, the whiting population on the Romanian littoral was homogeneous, the length ranging between 40 and 230 mm/2.03–82.92 g, the dominant classes being those of 90–145 mm/5.50–23.84 g. The average body length was 107.45 mm, and the average weight 10.58 g (Fig. 3) (Refs 2–4 and 6). In front of the Bulgarian coast whiting catch length composition ranged between 50 and 230 mm and individual weight between 3.08–86.2 g. The highest percent belongs to the 115–120 mm group, followed by 135–140 mm and 155–160 mm. The length group 85–90 mm accounts around 6% of the whiting by-catch. The rest of the length groups is very weakly presented in the landings (Fig. 3) (Refs 12, 15 and 16).

If between 2004 and 2005 the length in the Romanian sector ranged between 65–170 mm/2.51–38.76 g, with the dominant classes of 90–145 mm/6.73–23.74 g, in 2006, this variation was extremely high, between 70–230 mm/2.91–82.92 g, the dominant classes being those of 95–140 mm/6.5–21.25 g. In 2007 and 2008, the length structure varied between 40–180 mm and 1.71–44.62 g, the dominant classes was 75–135 mm/3.26 – 19.35 g (Fig. 3) (Refs 4 and 6).

The analysis of age components during the entire Romanian fishing season emphasised the presence of individuals aged between $0;0^+$ to $4;4^+$ years, with a domination of individuals aged between$1;1^+$ years and $2;2^+$ years (Fig. 4). The

variation between sexes indicates a clear domination of the females (57.53%) (Refs 1–4, 6).

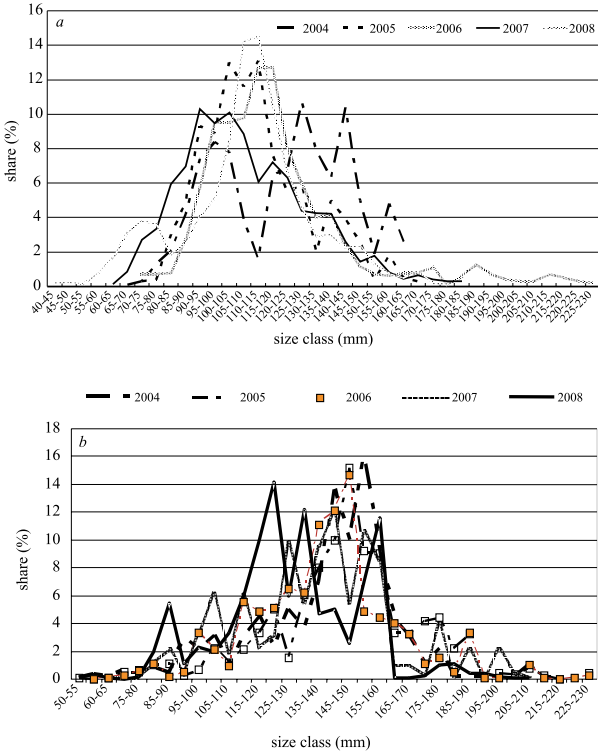
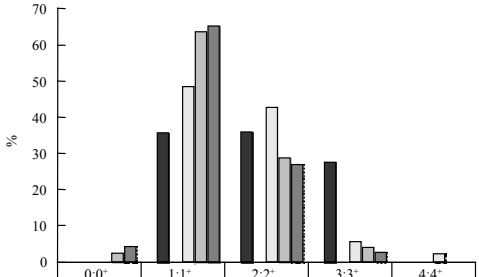



**Fig. 3**. Structure by length (mm) classes of the whiting caught in the Romanian (*a*) and Bulgarian (*b*) littoral between 2004–2008




| | 0:0+ | 1:1+ | 2:2+ | 3:3+ | 4;4+ |
|---|---|---|---|---|---|
| 2004 | | 36 | 36.2 | 27.8 | |
| 2005 | | | | | |
| 2006 | | 48.7 | 43 | 5.8 | 2.5 |
| 2007 | 2.8 | 63.8 | 29.1 | 4.3 | |
| 2008 | 4.5 | 65.4 | 27.2 | 2.9 | |

**Fig. 4**. Structure by age (%) classes of the whiting caught in the Romanian littoral between 2004–2008

The analysis of age components during the entire Bulgarian fishing season emphasised the presence of individuals aged between 0;$0^+$ to 5;$5^+$ years, with a domination of individuals aged between 2;$2^+$ years and 3;$3^+$ years[12,15,16] (Fig. 5).

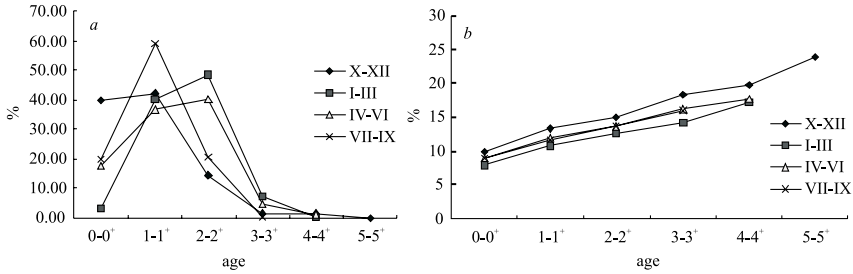



**Fig. 5**. Structure by age classes (%)(*a*) and average length (cm) by age and months (*b*) of the whiting fished in the Bulgarian littoral between 2003–2007

DETERMINATION OF THE VITAL PARAMETERS

The concept of stock is strongly connected to the values of the length/weight relationship and the mortality rates. A fish stock evaluation method is that which analyses the variation of a stock biomass under the influence of the growth and mortality phenomena. Thus, an intermediary step in fish stock evaluation is the establishment of the length/weight relationship coefficients, of the growth parameters and mortality rates.

*Length/weight relationship*. This relationship expresses most accurately the changes in the fish weight during the length growth of its body and can be a means of indirect estimating the growth rate, the length/weight ratio is used at comparing the weight gaining state of the same species during various periods and in various sectors of its spreading areal[14].

The coefficients of the length/weight relationship, determined annually in 2007–2008 established the following equation for the whiting (Fig. 6) (Refs 5, 6, 8, 12 and 16).

$$W_t = 0.004706 \times L_t^{3.136302},\ r = 0.998; \quad W_t = 0.0048 \times L_t^{3.1063},\ r = 0.999$$

(A) Romanian waters (B) Bulgarian waters

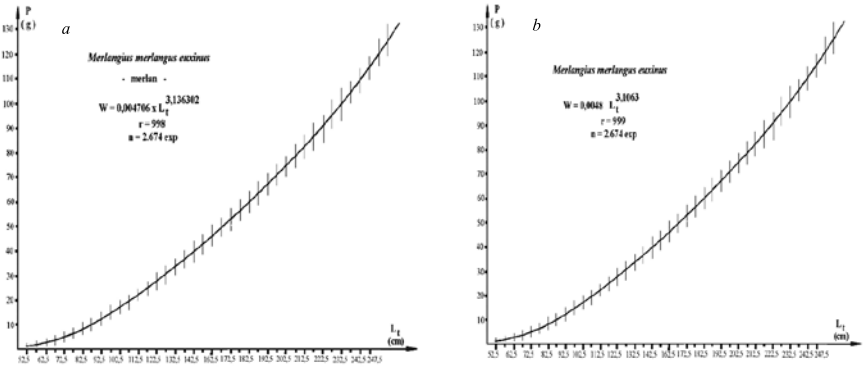



**Fig. 6**. Length/weight relationship of whiting in the Romanian (*a*) and the Bulgarian (*b*) Black Sea coast

*Growth parameters*. Growth represents the positive aspect of a fish stock dynamics, the study of growth being especially the determination of the body size in accordance with age. That is why all fish stocks evaluation methods use mainly data structured on age.

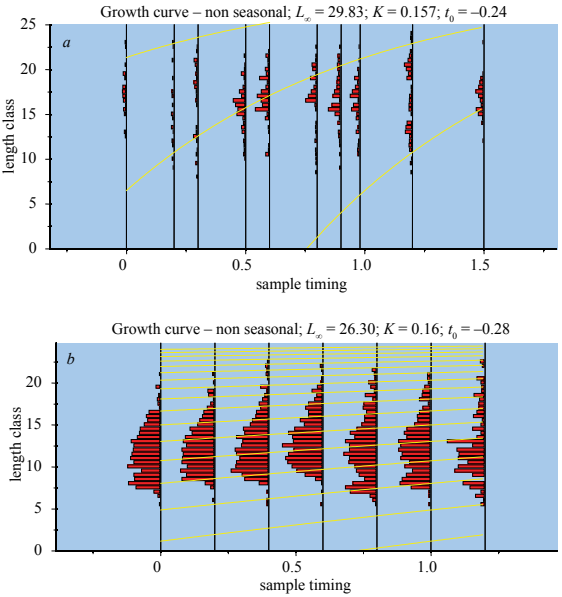



**Fig. 7**. Growth curve parameters of whiting of the Bulgarian (*a*) and the Romanian (*b*) Black Sea coast

The growth parameters obtained through Romanian calculations, between 2004 and 2008, indicate a fast growth rate in the first years, with values of the catabolism ($k$) coefficient ranging between 0.135–0.185 (Refs 4 and 5).

**Table 1**. Growth parameters, determined annually: Romanian waters 2004–2008 and Bulgarian waters – 2007

| | $L_\infty$ | $k_0$ | $t_0$ |
|---|---|---|---|
| | Romanian coast $L_t = 26.3\ (1 - e^{-0.160\ (t + 2.19)})$ | | |
| 2004–2008 | 25.25–27.35 | 0.135–0.185 | –1.98/–2.40 |
| | Bulgarian coast $L_t = 29.83\ (1 - e^{-0.157(t + 2.49)})$ | | |
| 2007 | 29.83 | 0.157 | –2.49 |

*Mortality*. The parameters used when describing mortality are named 'mortality rates' and reflect the number of disappearances during the time unit. The numeric losses of a stock are due to natural causes (natural mortality – $M$) and fishing ($F$), together forming the total mortality ($Z = M + F$).

Natural mortality represents the effect of external pressure, except from fishing, and varies from one species to another, and even within the same species, depending on the studied area, the predators and competitors density, the abundance of which is influenced by fishing. Natural mortality is an indicator difficult to determine due to the number and complexity of factors causing it. The values of $M$ were determined, using the Pauly relation and other formulae (Table 2).

**Table 2**. Mortality rates estimation of whiting from the Romanian and Bulgarian Black Sea waters

| Method | $Z$ | | $M$ | |
|---|---|---|---|---|
| | Romanian waters | Bulgarian waters | Romanian waters | Bulgarian waters |
| Beverton & Holt | 0.414 | 0.494 | | |
| Pauly | | | 0.680 | 0.350 |
| Powell&Watheral | | | 0.410 | 0.410 |
| Catch-curve method (B&H) | 0.530 | 0.474 | | |

In order to preserve the fish stock at the desired level and with an adequate age structure, the mortality control through fishing is required.

As shown in Table 3, calculated asymptotic length in Bulgarian waters reaches 29.83 cm for 2007 which is higher than this calculated for Romanian waters for the same year – 26.3 cm, since the growth rate is almost the same in investigated areas[4,5,16,17]. Significant differences as regards mean lengths at age were observed between both regions. In all of the observed age classes mean values are higher in Bulgarian part of the marine area. This could be the result of differences in the

trawling areas and deepest trawling areas off the Bulgarian coast, where older specimen with higher individual sizes could be found.

**Table 3**. Mean and asymptotic length of whiting in the Romanian and Bulgarian Black Sea waters

| Age | $1^+$ | $2^+$ | $3^+$ | $4^+$ | $5^+$ | $6^+$ |
|---|---|---|---|---|---|---|
| Romanian coast $L_t = 26.3\ (1 - e^{-0.16\ (t + 2.19)})$ | | | | | | |
| $M_l$ | 10.5 | 12.8 | 14.8 | 16.6 | 18.0 | 19.2 |
| Bulgarian coast $L_t = 29.83\ (1 - e^{-0.157\ (t + 2.49)})$ | | | | | | |
| $M_l$ | 12.6 | 15.0 | 17.20 | 19.06 | 20.6 | 22.0 |

## CONCLUSIONS

Maximum age observed was $6^+$ years for the Bulgarian Black Sea coast and $4^+$ for the Romanian coast. The age groups of $1^+$, $2^+$ and $3^+$ were the most abundant in the samples from the Bulgarian and Romanian Black Sea waters during the period investigated (max. $2^+$ age group). The oldest age group ($6^+$) is presented in the catch with relatively low percentage values, which clearly indicate for a low survival of the group.

Using non-seasonal method we established maximum theoretically length 29.83 cm and lower growth coefficient $K$= 0.157 for the Bulgarian Black Sea coast and maximum theoretically length 26.30 cm and lower growth coefficient $K$= 0.16 for the Romanian coast. The slope ($b$ value) of the length-weight relationships (LWRs) was similar for Romanian (3.1363) and Bulgarian Black Sea coast (3.1063), indicating that weight of whiting (*Merlangius merlangus euxinus*) increased allometrically with length.

Objectives concerning sustainability evoked the need for assessment of the other fish stocks (usually presented as by-catch in sprat-targeted catches: turbot, whiting, sea mammals, seabirds and ecosystem considerations '*top-down*' and '*bottom-up*' relationships.

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