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Growth rate of the whiting (Merlangius merlangus euxinus) from the western part of Black Sea

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Introduction

Black Sea whiting appears a key species for the fish part of the ecosystem of basin. It feeds mainly on sprat but during the winter months it consumes also anchovy especially along the Anatolian coast of Turkey and the Caucasian coast in front of Georgia. As it is well known the sprat and anchovy are the two most abundant fish species in the Black Sea. They both feed on zooplankton owing to which their stocks depend to great extend on its abundance during the different years. On the other hand whiting is a food for many commercial fish species as turbot, spiny dog fish, etc. The level of their stocks depends manly on the environmental conditions and fishing effort made.

The zooplankton productivity is determined by many factors mainly the basin's pollution, sea temperature, phytoplankton species composition and its biomass.

The environmental conditions in the Black Sea changed significantly during the last 3 decades (Velikova, Petrova, 1999; Velikova, Moncheva, Petrova, 1999; Velikova et al. 2001). The increased basin's eutrofication there was of primary importance for this. It reached its maximum during the 80-ies. This resulted in alterations in the phytoplankton species composition and the caused by it phytoplankton blooms which increased their frequency, duration and spatial distribution. The occurred alterations were cased by variety of factors out of which greatest importance had the increased concentration of nutrients, mainly nitrogen and phosphorus, the changes in the sea water temperature in winter months that is in contradiction with the mean frequency of the phytoplankton blooms in summer months, the sun spot influence on the ratio between the biomasses of Bacillariophyceae and Dynophyceae and the excessive intensification of commercial fishery disagreeing with the changed ecological conditions of Black Sea. All these predetermine the so called "bottom-up/top-down" effects because of the increased productivity of the basin and the reduction of fish populations abundance cased by commercial fishery from the other hand. The latter have even caused in certain cases complete extinction of some fish species like mackerel for instance, causing in its turn imbalance between particular links of the food webs. This promoted the invasion and mass development of a number of new for the basin species, the ctenophore Mnemiopsis leidyi (Georgieva, Konsulov, 1993) having the greatest negative impact on the fish populations as besides being a competitor for the zooplankton it directly finishes off the eggs and larvae of the spawning fish. The ctenophore entered the Black Sea in the early 80s but the largest biomass it reached in 1989 (Georgieva, Konsulov, 1993). About ten years later a new ctenophore Beroe ovata that is a predator on M. leidyi entered the basin. The changes in the environment together with the intensified fishery brought to catastrophic reduction of many fish species abundance in the early 90s - anchovy, horse mackerel, sprat, whiting, etc. The improvement of the ecological conditions after

1990 as a result of the collapse of the economies of the former socialist countries boarding with the Black Sea and the decrease of the fishing effort on some fish species led to the partial recovering of their stocks.

According to the FAO experts the whiting stocks must be protected from over-fishing because they are of a great importance for the pointed commercial fish species. This calls for permanent monitoring on its both biological and exploitation parameters.

Data for whiting age and growth in the western part of the Black Sea during the period 1976-1982 are pointed by Prodanov (1982; 1984). In the present paper the results from the research work on the whiting during 1983-2000 are discussed.

Material and methods

The age and growth rate of the Black Sea whiting along the Bulgarian Black Sea coast are investigated on the basis of the data for the period 1983-2000. During the mentioned period are collected more than 15 000 specimens.

The age of whiting is defined by otholits. They are examined under microscope with passing light. The otholits are worked in the physiological solution or xilol in accordance of its size.

The length of fish is measured till the end of the tail fin - total length.

The whiting growth rate was investigated by the von Bertalanffy's equations:

$$L_t = L_\infty[1-e^{-k(t-t_0)}] \quad (1)$$

$$W_t = W_\infty[1-e^{-k(t-t_0)}]^n, \quad (2)$$

where: L_t and W_t are the length and weight of fish at age t years; L_∞,W_∞, k, t_o and n-parameters.

The parameter n is estimated from the relationship between the length and weight by age groups:

$$W_t = q.L_t^n \quad (3)$$

The pointed out parameters are calculated by the least square method.

The mean value of the coefficient of whiting natural mortality (M) is determined by the following equations:

M(1%) = -ln(0.01)/Tm,

Alagaraja (1984) (4)

where: Tm is the utmost age to reach the whiting

$$t_C = \frac{\ln(nk+M)-\ln M}{k} + t_0 \quad (5)$$

Kutty, Quasim (1965)

where: tc - optimum exploited age, k and to – parameters in von Bertalanffy equations.

$$M = \frac{1.521}{t_{mass}^{0.72}} - 0.155 \quad (6)$$

Rikhter, Efanov (1976)

where: t_{mass} - the age of mass sex maturation

Results and Discussion

The otholits of whiting are comparative massive for its size. In spite of this year's circles clearly outline when they are examined with passing light. They present successive alternating dark and light concentric zones.

According Prodanov (1980, 1984) tarnsparent areas reflect the slow growth of whiting during winter months when the species are spawning intensively and dark areas - quickly growth during spring-summer months. That is why a completed year's circle may be watched during the spring when starting new intensive growth. This gives reason of Prodanov (1984) to mark as finished respective biological ages - 1, 2, 3 - the individuals that are caught during November - April and 1+, 2+, 3+ - the individuals caught during May-October.

On the table 1 and 2 are presented the mean lengths and weights of whiting by age groups.

As it is seen from the table 1, the length growth of whiting is biggest during the first year of life. The mean length of one year old fishes is 11.82 cm. During the next year the mean increment sharply decreases and the mean length of two years olds is 14.90 cm. The least are the length increments in the 5 and 6 year olds, respectively 1.60 and 1.29 cm.

The weight growth of whiting is considerably more uniform - table 2. During its first year the species attain at average 11.71 g. Some detention is observed only in the second year, when the individuals mature in large numbers. The year increment is at average 10.70 g and the mean weight of two year olds is 22.41 g. In the next years the increment varies from 11.56 g in the 2 year olds to 12.42 g in the 5 year olds.

The whiting from the western part of the

Table1. Mean total length by age groups of whiting (Merlangius merlangus euxinus) in the western part of the Black Sea during the period 1983-2000

Year	1	2	3	4	5	6
1983	11.85	14.68	16.92	18.84	20.61	21.90
1984	11.92	14.73	17.05	19.06	20.77	22.10
1985	11.95	14.82	17.18	19.22	20.86	22.25
1987	12.05	14.91	16.75	18.69	20.55	21.75
1988	12.20	14.65	16.71	18.55	20.30	22.10
1989	11.90	14.75	16.65	18.40	20.10	22.20
1990	12.25	14.86	16.53	18.25	19.93	22.45
1991	11.95	14.73	16.86	18.73	19.855	21.40
1992	12.40	15.10	17.08	19.26	20.47	21.65
1993	12.60	15.15	17.15	19.22	20.40	21.43
1994	11.35	15.25	17.23	19.38	20.76	21.55
1995	11.96	15.38	17.41	19.53	20.86	21.90
1996	11.80	14.55	16.88	19.14	20.55	21.40
1997	11.46	14.23	16.55	18.83	20.32	20.85
1998	11.10	14.95	17.55	19.15	21.03	21.35
1999	10.85	15.25	17.25	19.33	21.30	21.68
2000	10.96	15.53	17.35	19.48	21.55	22.15
Mean	**11.82**	**14.90**	**17.00**	**19.00**	**20.60**	**21.79**

Table 2. Mean weight by age groups of whiting (Merlangius merlangus euxinus) in the western part of the Black Sea during the period 1983-2000

Year	1	2	3	4	5	6
1983	11.68	20.05	33.10	46.24	58.06	72.97
1984	11.67	20.08	33.15	45.79	57.78	73.33
1985	11.61	20.87	32.78	44.93	58.12	71.93
1986	12.07	21.16	33.46	45.61	59.16	72.84
1987	11.78	21.48	34.12	46.23	59.78	73.16
1988	12.25	20.96	33.87	45.94	58.96	73.24
1989	11.95	21.42	33.09	45.13	58.10	71.83
1990	12.37	21.76	32.96	44.76	57.13	73.90
1991	11.76	20.95	33.20	45.30	56.70	69.45
1992	12.35	23.76	34.40	46.20	57.15	69.70
1993	12.55	23.85	34.90	46.10	56.95	68.80
1994	11.40	23.90	35.15	46.30	57.50	69.00
1995	12.10	24.40	35.70	47.00	58.20	70.10
1996	11.65	23.18	33.76	45.05	56.87	68.13
1997	11.38	22.45	33.30	44.50	56.10	67.80
1998	10.89	23.58	35.75	48.35	59.45	67.35
1999	10.63	24.30	35.10	49.76	60.13	68.60
2000	10.75	25.20	35.55	50.83	61.85	69.45
Mean	**11.71**	**22.41**	**34.07**	**46.33**	**58.22**	**70.64**

Black Sea reaches 25 cm length and 75-80 g in weight. The utmost age is 6 years. Prodanov (1984) reports for specimen with length 37.4 cm, which has been agreed as 7 year old.

The oceanic whiting reaches 7-8 years at age (Burdak, 1964; Hislop, Pirie, 1972; Krzykawski, Romaski, 1972) and rarely 9 years (Malkov, Efremov, 1976).

On the base of data for whiting growth rate

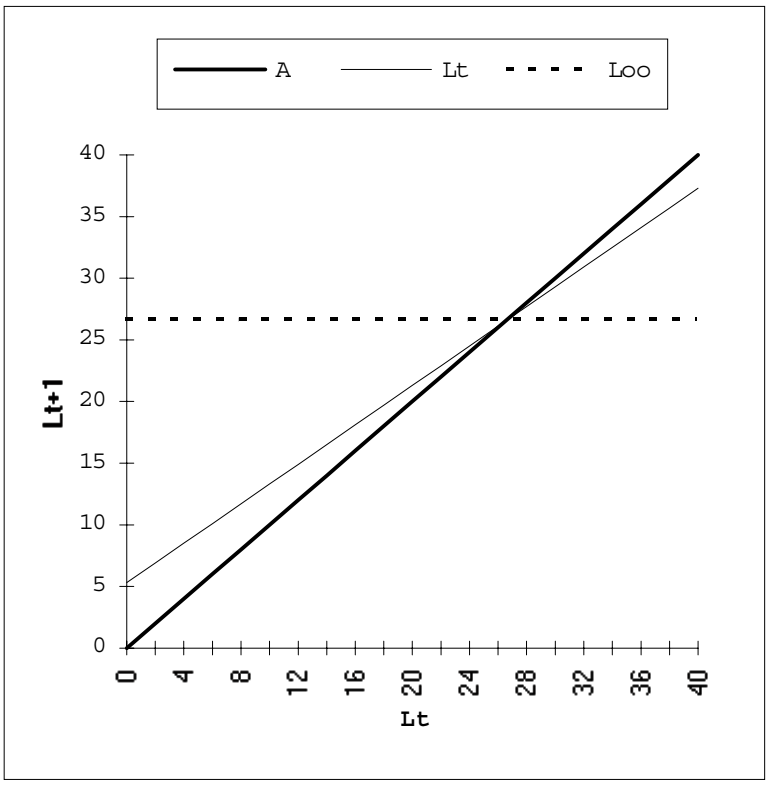

Fig. 1. Graphic presentation of determining the value of Loo (equation 1)

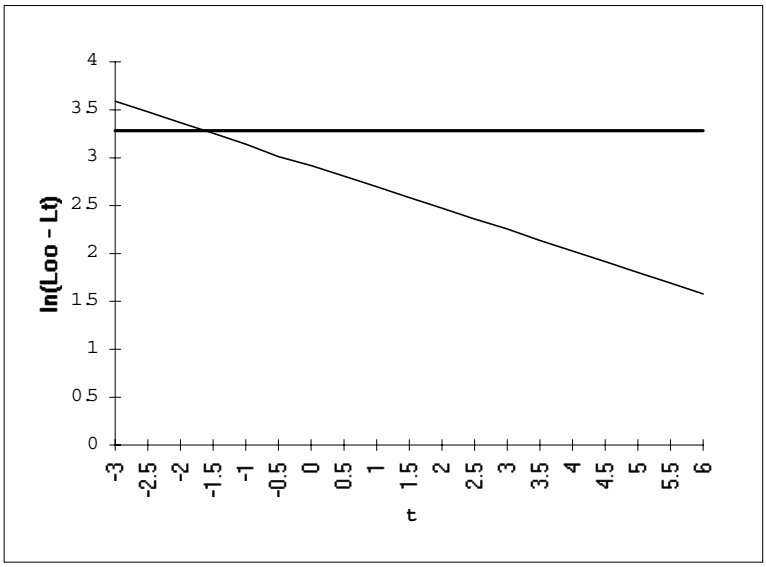

Fig. 2. Graphic presentation of determining the values of k and to (equation 1)

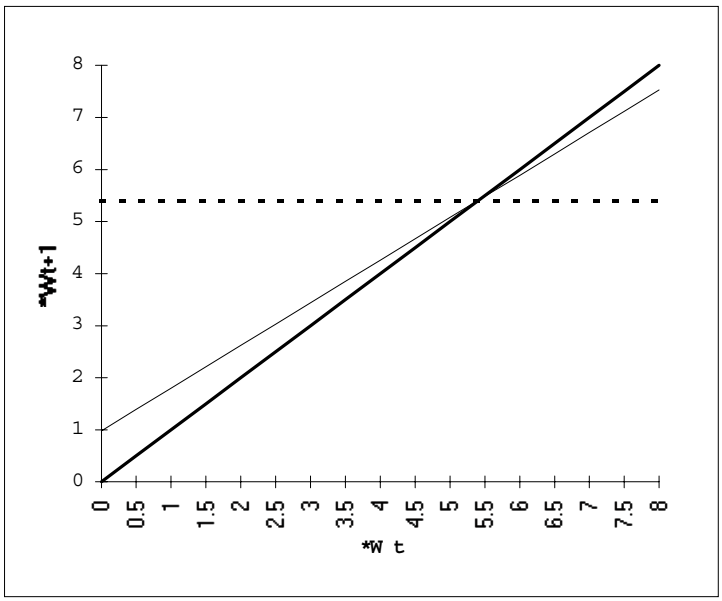

Fig. 3. Graphic presentation of determining the value of Woo (equation 2)

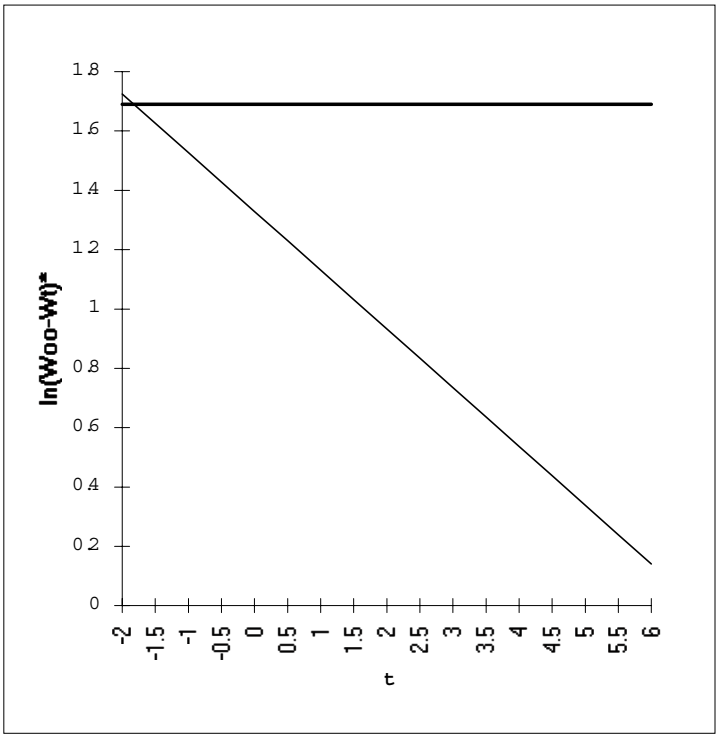

Fig. 4. Graphic presentation of determining the values of k and to (equation 2)

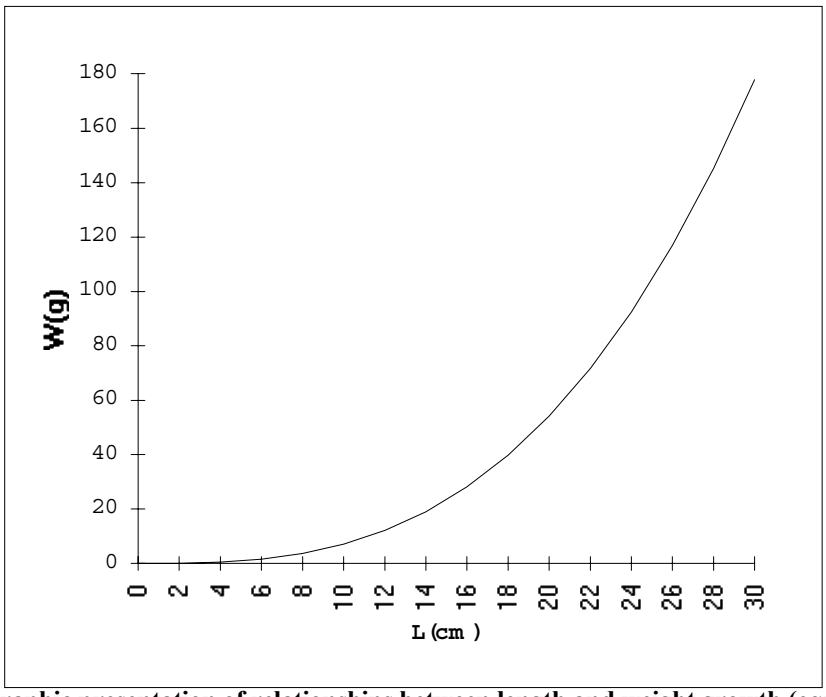

Fig. 5. Graphic presentation of relationships between length and weight growth (equation 3)

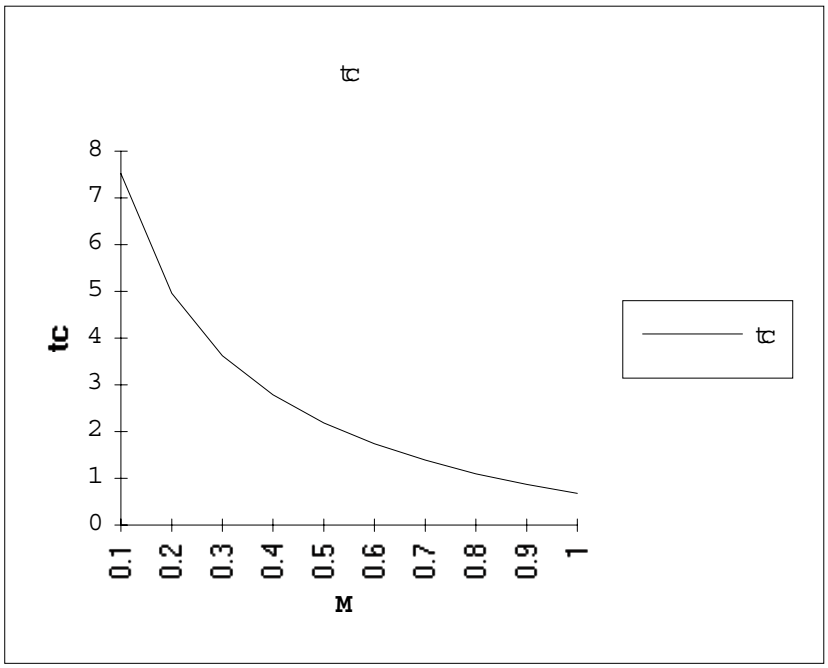

Fig. 6. Relationship between tc and mean value of M

by age groups, which are shown on tables 1 and 2, were calculated the values of parameters of von Bertalanfy's equations. They are as follows: (figures 1, 2, 3 and 4).
$L\infty$ = 26.63 cm; k = 0.22345551;
t_o = -1.619695714; r = 0.9997 equation (1)
$W\infty$ = 140.03 g; k = 0.201116;
t_o = -1.866047; n=3; r = 0.9999 equation (2)
$W\infty$ = 141.34 g; k = 0.198076; t_o = -1.821957; n=2.930148; r = 0.9999 equation (2)

The values of parameters in relationships between the weight and length by age groups are: (figure 5)
a = 0.008351292; n = 2.930147906;
r = 0.9998

The obtained results are quite different from those determined by P r o d a n o v (1980, 1984) for the period 1976-1980. According to pointed author the same parameters in von B e r t a l a n f f y's (1934) equations are:
$L\infty$ = 31.42 cm; k = 0.145; t_o = -2.393;
r = 0.9997 equation (1)
$W\infty$ = 231.87 g; k = 0.135; t_o = -2.412;
n=3; r = 0.9999 equation (2)

According to Alagaraja's conception the mean value of M is 0.768. Following the equation of Richter and Efanov we calculated that the same value of M is also 0.768 because the age of which the whiting in large numbers reproduce is two years. According to equation of Kutty and Quasim the pointed value of M is 0.538 (tc=2) – figure 6. Hence the average assessment for the mean value of M is 0.691. The pointed value of M had been calculated by P r o d a n o v (1984) and P r o d a n o v et al. (1997). According to the first assessment the mean value of M is 0.685 and the second - 0.70.

Conclusions

The values of parameters in von Bertalanffy's equations during the period 1983-2000 are as follows:
$L\infty$ = 26.63 cm; k = 02235 to = -1.6197
$W\infty$ = 140.03 g k = 0.2011 to = -1.8661 n=3
$W\infty$ = 141.34 g k = 0.1981 to = -1.8120 n=2.9302

During the same period the mean value of natural mortality coefficient is 0.691.

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Нарастване на меджида (Merlangius merlangus euxinus) от западната част на Черно море

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(Резюме)

Меджидът заема особено място в рибната част на черноморската екосистема. От една страна, той е хищник спрямо трицоната, а от друга - жертва спрямо калкана, морската котка, черноморската акула и пр. Поради това е наложително да се извършва постоянен мониторинг върху неговите биологични особености през отделните години. В статията са дискутирани нарастването и смъртността на меджида от естествени причини през периода 1983 - 2000 г. На базата на съществуващите данни за линейното и тегловното нарастване по възрастови групи са изчислени стойностите на параметрите в уравненията на von Bertalanffy. Средната стойност на коефициента на смъртността от естествени причини е изчислена чрез методите на Kutty, Quasim (1965); Rikhter, Efanov (1976); Alagaraja (1984). Изчислената стойност на упоменатия коефициент е 0.691.