ESTIMATION OF GROWING PARAMETERS FOR THE MAIN DEMERSAL FISH SPECIES IN THE ROMANIAN MARINE AREA

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ABSTRACT

Establishing the correlation between the length/weight relation and the estimation of the grow rhythm for the major clupeid species constitutes a basic characteristic used both to answer and to argument the recommendation to protect the stocks and to limit the length of the standard fishes at first catch. The research is based on the annual length and weight samples, taken for each specie and overall, which were gathered in research expeditions in the Black Sea, during 2003-2005 period.
Analysis results were obtained for the major demersal species: *Psetta maxima maeotica* (turbot), *Squalus acanthias* (picked dogfish), *Merlangius merlangus euxinus* (whiting), *Mullus barbatus ponticus* (red mullet) and *Neogobius melanostomus* (round goby).

KEY WORDS : Species, parameters, length, weight, age, turbot, picked dogfish, whiting, red mullet, round goby, length/weight relation, growing parameters, growth curve, mortality coefficients

1. INTRODUCTION

Establishing the correlation between the length/weight relation and the estimation of the growth rhythm for the major clupeid species constitutes a basic characteristic used both to answer and to argument the recommendation to protect the stocks and to limit the length of the standard fishes at first catch.

The growth represents the positive aspect of the fish stock dynamic, the study of growth is focused primarily on the determination of length function of age. This is the reason why all stock evaluation methods use ageing structured data.

Growth parameters (L_∞, k, t_0) are numeric values in a Von Bertalanffy's equation used to estimate the fish body length when reaching a certain age.

Growth parameters can be biologically interpreted as following:

L_∞ – average body length of an infinite old fish, named asymptotic length;

k – curving parameter that determines how fast is the fish reaching L_∞ length. Some species, with short life cycle, reach L_∞ in a year or two and have a high value oh "k"; other species have a line growth curve with a small "k" value and need many years to reach L_∞;

t_0 – initial phase parameter that determines the moment when the fish has 0 lengths.

Fish grows in length as he gets older, but its growth rate (length vs. unit time) decreases, reaching near 0 when he is very old. First method to estimate growth parameters were suggested by BERTALANFFY in 1934; using L_∞ for estimation of "k" and t_0. This growth model has been considered "the first stone" in fishing biology studies as it is used as a sub-model in other more complex models that define fish population dynamics.

Growth parameters are different among species and can vary from a fish stock to another being able to take different values in its diverse areas of spread. Similar, successive cohorts may grow differently depending on medium conditions. In addition, growth parameters take different values for two genders.

When we use these parameters to describe mortality rate they are called "mortality rates" and reflect the number of disappearances per time unit. The easiest way to describe changes in number of fish in the analyzed stock is to determine no of "larve eclozate" in the same period of time in the same cohort. It is considered that mortality in a cohort, Z value, it is composed of mortality due to fishing ("F" fishing mortality) and that having natural causes ("M" natural mortality).

2. MATERIAL AND METHODS

Data material used in this research has been gathered from four traditional activity areas of the Romanian shipping fleet, according to the international statistic divisions FAO 37 (Black Sea).

In order to obtain the total length (L_t) array variation, measurements have been made with the ichtiometers starting from the extremity of the mouth, up to the point of the longest radium from the caudal. The medium weight of the fish samples for each length class was determined by weighting all the fish samples in the analyzed class.

Studies were consistent for a number of de 5,551 exemplars (41 samples), of which 17.56% belong to *Psetta maxima maeotica* (975 exemplars), 4.18% - *Squalus acanthias* (232 exp.), 48.17% - *Merlangius merlangus euxinus* (2.674 exp.), 12.25% - *Mullus barbatus ponticus* (680 exp.), 17.84% - *Neogobius melanostomus* (990 exp.).

For 3-5 standard samples for length frequency was considered one sample for age frequency, calculated after the stratified method (for each class of length, a constant number of age material – scales or, in some cases, otolith – was taken into account, for approx. 10 samples. Scales were taken from the region above the median lateral line. Otoliths were taken from the internal ear of the fish, placed at the scalp base.

In order to determine the total length (L_t) / weight relation (W) we used the relation (CARLANDER, 1977):

$$W = a \times L_t^b \qquad (1)$$

where: W is the weight of the fish's body; L_t – total length of the fish; a and b – regression constants.

Values for *a* and *b* constants were determined using the method of the smallest squares (SNEDECOR, 1968), included in the *FISHPARM* program (PRAGER, SAILA and RECKSIEK, 1987, 1989, 1994).

In order to estimate the growth parameters (L_∞, k, t_o) the following equations have been used (Von Bertalanffy, 1938):

$$Lt = L\infty\left[1 - e^{-k(t-to)}\right] \qquad (2)$$

$$Wt = W\infty\left[1 - e^{-k(t-to)}\right]^3 \qquad (3)$$

$$to = t + \frac{1}{k}\ln\left(1 - \frac{Lt}{L\infty}\right) \qquad (4)$$

where: L_t is the length for age t (in cm); W_t - weight at age (in gr); L_∞ / W_∞ – length / weight maximum value; k – growth parameter; t – age (years); t_0 – hypothetical age when L = W = 0 ; e – natural logarithm base.

For the evaluation of the L_∞, k, t_o parameters was used the FISHPARM program (PRAGER *et al.*, 1987, 1989, 1994) and the following equations (PAULY, 1984):

$$L_{t+1} = a + b\,L_t \qquad (5)$$

$$L\infty = \frac{a}{1-b} \qquad (6)$$

$$k = -\ln b \qquad (7)$$

$$L\infty = -\frac{a}{b} \qquad (8)$$

where: L_t and L_{t+1} are medium length in consecutive years; a and b – regression coefficients.

3. RESULTS AND DISCUSSION

3.1. Length / Weight relation

This relation abides most precisely by the changes in weight during the body grow period and may be considered an indirect point to asses the rhythm of growth. The proportion between length and weight is used to compare the state of weight increase of the same specie in different periods and geographic spread areas (NIKOLSKI, 1962). This correlation has a parabolic expression through a second-degree equation.

Considering that the major clupeid species taken into account and analyzed in this research are subject to several management recommendations, we looked for a constant annual value of the weight length relation for the 2003 - 2005 period.

a. **Turbot** (*Psetta maxima maeotica* P.)

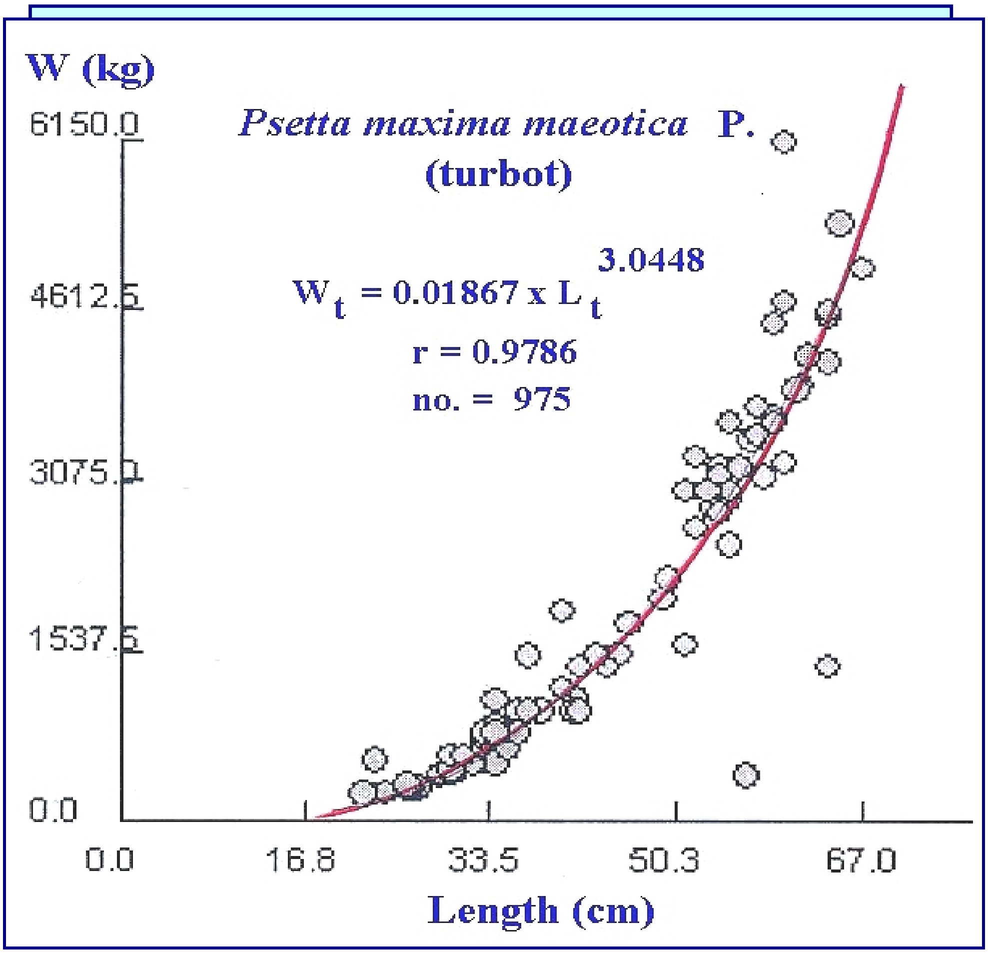
The regression coefficients *a* and *b* were calculated based on samples taken by the Romanian trawler ships during 2003 -2005, for a number of 975 species. The relation is a regression, and the ″b″ coefficient, which shows the grow character, had values in a range between 2.8328 and 3.1558. For turbot, the length/weight relation has the following expression (Table 1 and Fig. 1):

$$\mathbf{W = 0.01867 \times L_t^{3.0448}\ ;\quad r - 0.9786}.$$

Table 1

Parameters of the length – weight relations, for turbot

Years	**Parameters**			**Range of length (cm)**
	a	**b**	**r**	
2003	0.0350	2.8328	0.9377	23.5 – 68.5
2004	0.0103	3.1558	0.9989	23.5 – 71.5
2005	0.0107	3.1459	0.9991	29.5 – 71.5
Average	**0.01867**	**3.0448**	**0.9786**	**23.5 – 71.5**



b. Picked dogfish (*Squalus acanthias* L.)

The length/weight relation was calculated analyzing data during 2003-2004 period, which included measurements for over 232 pares of data. The relation is a regression, and the ″b″ coefficient, which shows the grow character, had values in a 3.214. For picked dogfish, the length/weight relation has the following expression (Fig. 2):

$$\mathbf{W = 0.0000001995 \times L_t^{3.214}\ ;\quad r\ -\ 0.997.}$$

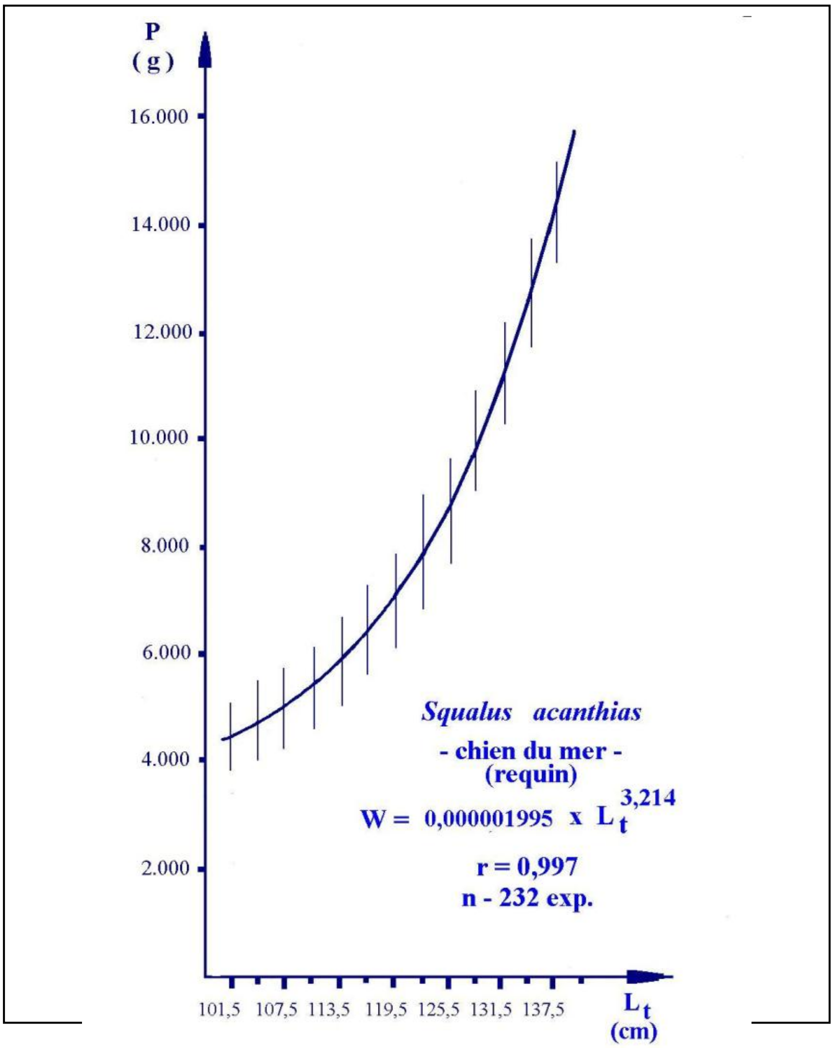


Fig. 2 – Length / Weight relation for picked dogfish (*Squalus acanthias* L.)

c. **Red mullet** (*Mullus barbatus ponticus* L.)

The relation has the below structure for samples taken during the 2003 - 2004 period, for 680 pares of data, length/weight relation has the following expression (Fig. 3):

$$\mathbf{W = 0.008421 \times L_t^{3.1211}\ ;\quad r\ –\ 0.9967.}$$

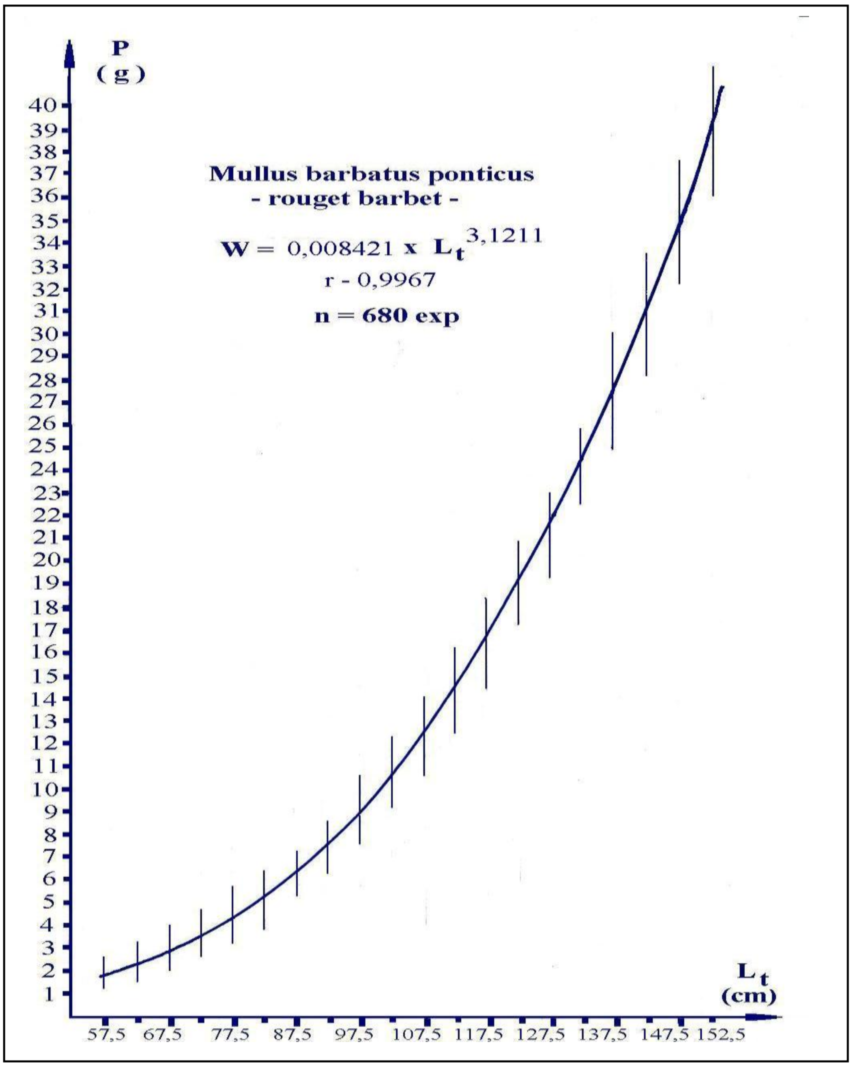


Fig. 3 – Length / Weight relation for red mullet (*Mullus barbatus ponticus*)

d. **Whiting** (*Merlangius merlangus euxinus* N.)

For whiting the length/weight relation has a curved shape without major inflexions (Fig. 4). The two parameters, *a* and *b* in the equation have been calculated for samples taken during the 2003-2005 period, 2.674 pares of data. The generated equation has the following structure:

$$\mathbf{W = 0{,}004706 \times L_t^{\;3{,}136302}\;;\quad r\;-\;0.999}$$

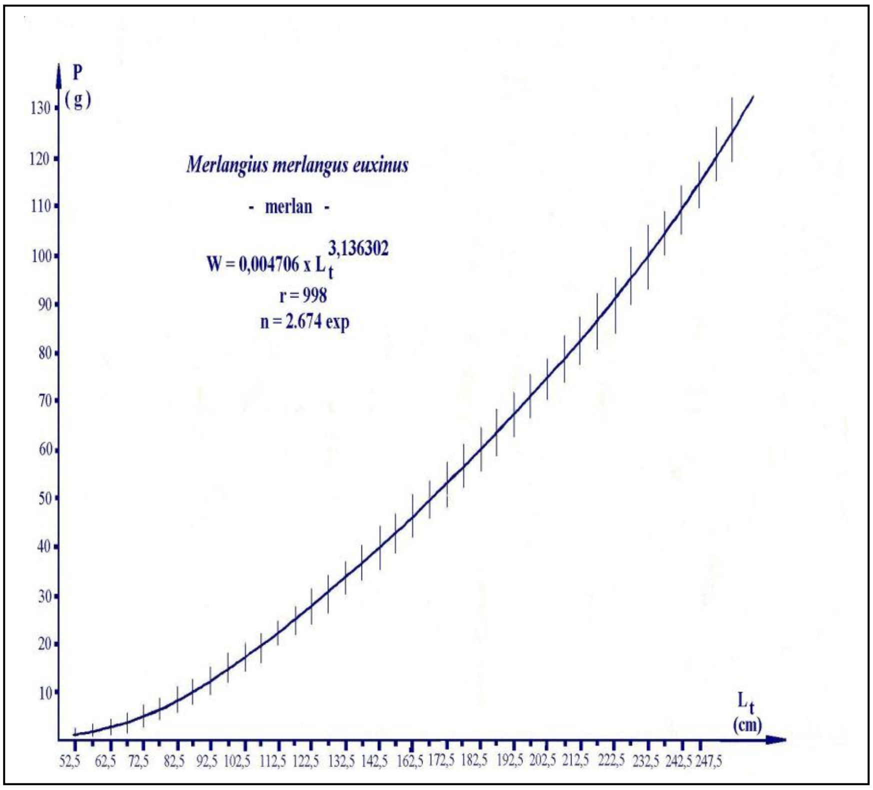


Fig. 4 – Length / Weight relation for whiting (*Merlangius merlangus euxinus*)

e. **Round goby** (*Neogobius melanostomus* L.)

Based on the annual samples, obtained in research expedition during 2003 - 2004 periods, analyses for 990pieces of sardine made possible to establish the following equation (Fig. 5):

$$\mathbf{W = 0.040482 \times L_t^{\ 2.7671} ; \quad r \ - \ 0.994}$$

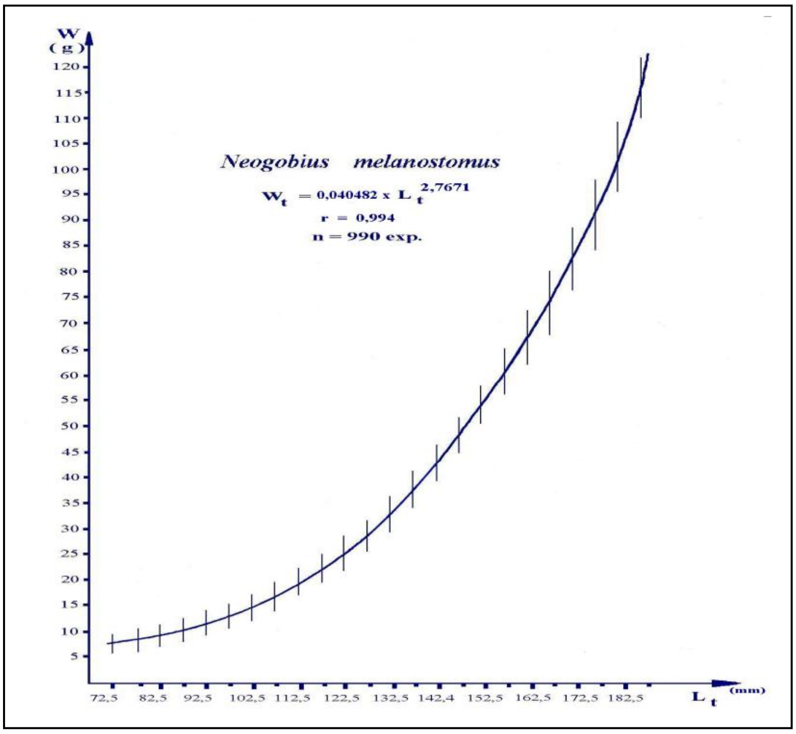


Fig. 5 – Length / Weight relation for round goby (*Neogobius melanostomus*)

3.2. Length / age, weight / age
Growth parameters

Calculated in different years, by different authors, the parameters of growth present differentiate values induce either by population situation or by natural reasons, or even due to the method used by the authors.

The process of estimation the growth rhythm is constitute in a basic parameter that comes to answer and to argument the recommendation to protect the stocks and to limit the length of the standard fishes at first catch. Analyzing the influence result of this restriction, doubled by the Y/R (production / recruitment) rule, we can obtain, in general lines, information over the dimensions of the stock and its exploitation level.

a. **Turbot** (*Psetta maxima maeotica* P.)

Using the research results during the 2003-2005 periods, we have obtained the following parameters of the growth equation for turbot in Black

Sea area. The growth parameters obtained for turbot a consistent growth rhythm in the first years with values of the catabolism coefficient in between 0.117 - 0.200.

Obtaining the growth parameters using the Von Bertalanffy's equation we obtained negative values for t_0 (between - 1.143 and -1,370), values that indicate appreciation of the age at fist maturation at 3-5 years.

Von Bertalanffy's equation was obtained in the following structure (Fig. 6, Table 2):

$$\mathbf{L_t = 76.84\ [\ 1 - e^{-0.149\ (t + 3.81)}\ ];}$$

$$\mathbf{W_t = 8{,}374.65\ [1 - e^{-0.149\ (t + 3.81)}]^3}$$

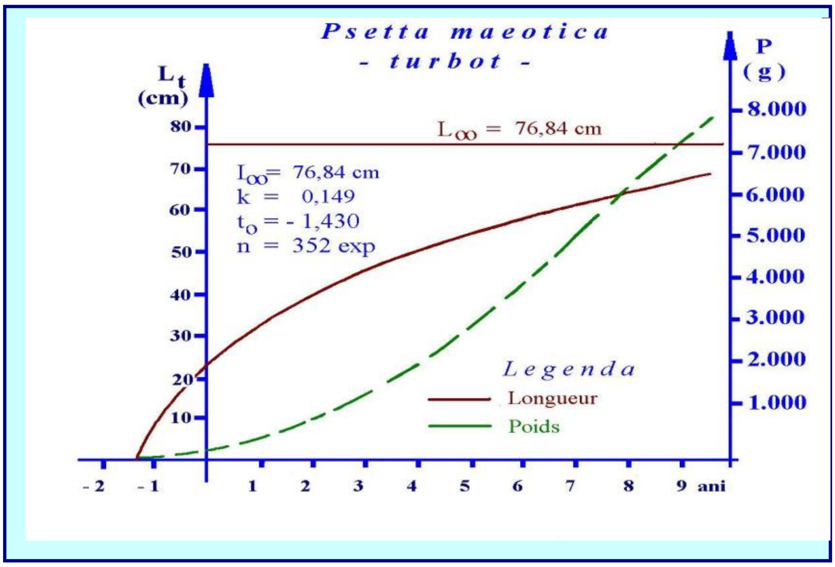


Fig. 6 – The growth curve for turbot (*Psetta maxima maeotica* P.)

Table 2

Growth parameters of *Psetta maxima maeotica* (turbot) at the Romanian littoral, of the Black Sea during the period 2003 - 2005 (Von Bertalanffy)

Years	**Parameters**				**Range of length (cm)**
	L_{oo} (cm)	**W_{oo} (g)**	**k**	**t_0**	
2003	76.84	8,374.65	0.184	- 1.370	23.5 – 71.5
2004	76.80		0.117	- 1.355	23.5 – 71.5
2005	80.00		0.200	- 1.143	29.5 – 71.5
Average	**77.88**	**8,374.65**	**0.167**	**- 1.289**	**23.5 – 71.5**

Also, the growing parameters, for turbot, were calculated through other methods, the so the data in table 3 resulted.

Table 3

Growth parameters of *Psetta maxima maeotica* (turbot)

Method	L_{00} (cm)	k	t_0
Gulland & Holt	80.98	0.15	
Ford – Walford	80.92	0.15	
Chapman	81.22	0.15	
Age composition		0.197	- 1.49
Empiric formulas	76.84		

b. **Picked dogfish** (*Squalus acanthias* L.)

The growth parameters indicate values for the catabolism coefficient (k) in a range between 0.160 and 0.36. Calculations based on Von Bertalanffy equation bring negative values for t_0 (between -0.75 and -1.57) (Fig. 7 and Table 4).

Growth equation of Von Bertalanffy was obtained:

$$\mathbf{L_t = 146.30\ [\ 1 - \ e^{-0.160\ (t + 0.75)}\ ]\ ;}$$

$$\mathbf{W_t = \ 1{,}895.00\ \ [1 - \ e^{-0.160\ (t + 0.75)}]^3.}$$

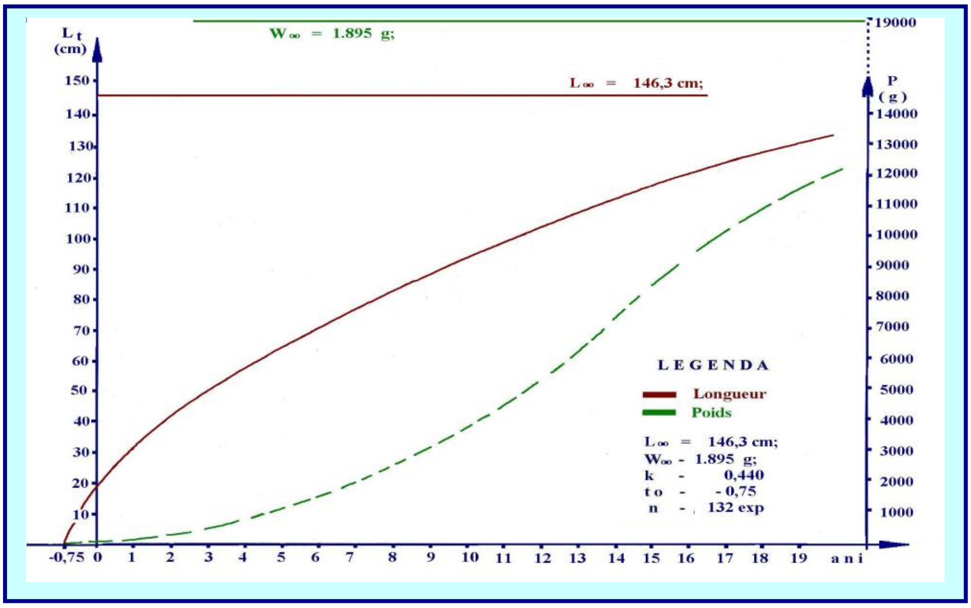


Fig. 7 – The growth curve for picked dogfish (*Squalus acanthias* L.)

Table 4

Growth parameters of species *Squalus acanthias* (picked dogfish), and *Merlangius merlangus euxinus* (whiting) at the Romanian littoral of the Black Sea

Method	**L_{00} (cm)**	**k**	**t_0**
Picked dogfish (*Squalus acanthias*)			
Empiric formulas	146.3	0.16	- 0.75
Whiting (*Merlangius merlangus euxinus*)			
Age composition	26.30	0.16	- 2.19

c. **Whiting** (*Merlangius merlangus euxinus*)

The growth parameters obtained for whiting show a consistent growth rhythm in the first years with values of the catabolism coefficient in between 0.160 (Table 4).

Obtaining the growth parameters using the Von Bertalanffy's equation we obtained negative values for t_0 -2.19, values that indicate appreciation of the age at fist maturation at 3 years.

Von Bertalanffy's equation was obtained in the following structure:

$$\mathbf{L_t = 26.30\ [\ 1 - e^{-0.160\ (t + 2.19)}\ ];}$$

d. **Red mullet** (*Mullus barbatus ponticus* L.)

Obtained during 2003 -2004, the growth parameters indicate a fast rhythm of growth in the first year, with catabolism coefficient's values in between 0.162 and 0.379. Using the Von Bertalanffy equation, we obtain negative values for t_0 (between – 1.390 and – 1.550), facts that prove the appreciation of the first ageing at 1-3 years.

Growth Von Bertalanffy's equation has been obtained in the following structure (Fig. 8):

$$\mathbf{L_t = 16.32\ [\ 1 - e^{-0.373\ (t + 1.39)}\ ];}$$

$$\mathbf{W_t = 30.16\ [1 - e^{-0.373\ (t + 1.39)}]^3.}$$

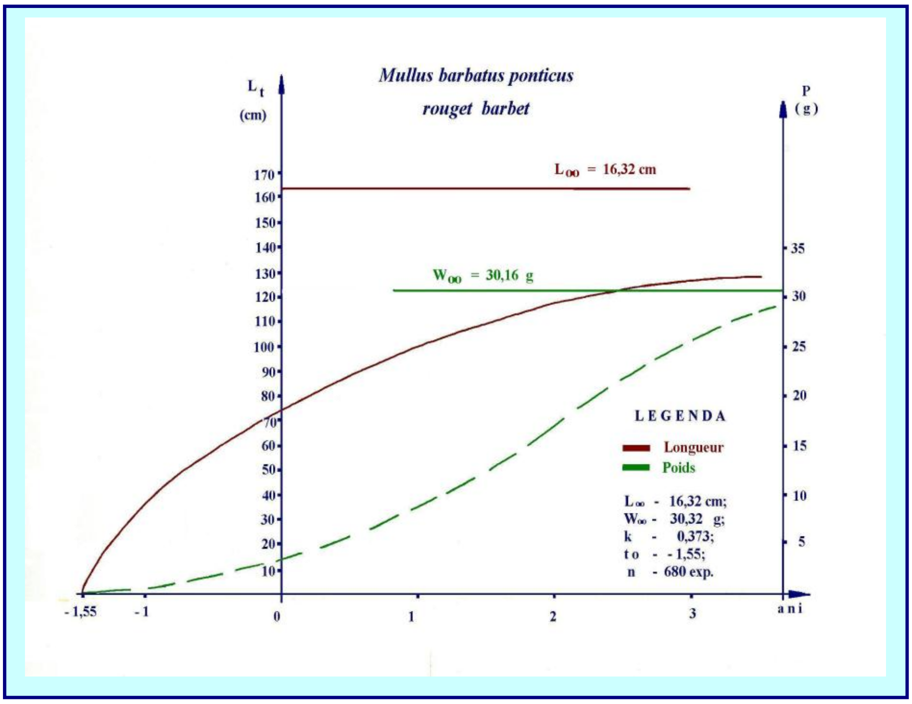


Fig. 8 – The growth curve for red mullet (*Mullus barbatus ponticus*)

Also, the growing parameters, for red mullet, were calculated through other methods, the so the data in table 5 resulted.

Table 5

Growth parameters of *Mullus barbatus ponticus* (red mullet) at the Romanian littoral of the Black Sea

Method	**L_{00} (cm)**	**k**	**t_0**
Gulland & Holt	23.20	0.162	
Ford – Walford	23.30	0.162	
Von Bertalanffy	16.32	0.379	- 1.39
Age composition	16.32	0.373	- 1.55

e. **Round goby** (*Neogobius melanostomus*)

Based on the length/weight relation analyse, the growth parameters were obtained using the Von Bertalanffy's equation, for each studied year. Accordingly, for the 2003-2004 periods, this relation has the following structure (Table 6):

$$L_t = 20.00\ [\ 1 - e^{-0.230\ (t + 2.26)}\ ]\ ;$$

Table 6

Growth parameters of *Neogobius melanostomus* (round goby) at the Romanian littoral, of the Black Sea

Method	**L∞** (cm)	**k**	**t_0**
Gulland & Holt	19.20	0.24	
Ford-Walford	19.76	0.23	
Chapman	19.76	0.24	
Von Bertalanffy	20.0	0.22	-2.4
Age composition		0.23	-2.26
Empiric formulas	20.0	0.23	

3.3. Mortality coefficients

In the dynamics of a stock, the growing is the positive aspect, while the disappearance process is the negative one. In order to maintain the fish stock at the desired level, the mortality control through fishing is needed. The growing was described with the help of a model and some parameters, the same data being used for mortality. There are some methods for estimating mortality, and these are :

- the estimation of Z: Heincke method (RICKER, 1975); Robson and Chapman method (ROBSON and CHAPMAN, 1961); and Beverton and Holt equations (BEVERTON and HOLT, 1956);
- the determination of M through Pauly method (PAULY, 1980), Rikhter and Efanov formula (RIKHTER and EFANOV, 1976); and Ault & Ehrhardt method (AULT & EHRHARDT, 1991).

The natural mortality differs from one species to another, and even at the same species, depending on the area, predator density, competition, fishing. In table 7 are given the values of the mortality coefficients for the main demersal species, calculated for the period 2003 – 2004.

Table 7

Mortality coefficients for main demersal species at the Romanian littoral of the Black Sea

Method	Z	M
Turbot		
Beverton and Holt	0.295	
Pauly		0.22
Method	**Z**	**M**
Richter and Efanov		0.19
Ault & Ehrhardt	0.225	
Picked dogfish		
Beverton and Holt	0.379	
Pauly		0.24
Richter and Efanov		0.22
Ault & Ehrhardt	0.359	
Whiting		
Beverton and Holt	0.494	
Pauly		0.35
Richter and Efanov		0.41
Ault & Ehrhardt	0.474	
Red mullet		
Beverton and Holt	0.401	
Pauly		0.4
Richter and Efanov		0.37
Ault & Ehrhardt	0.441	
Gobius sp.		
Beverton şi Holt	0.329	
Pauly		0.252
Richter and Efanov		0.253
Ault & Ehrhardt	0.309	

4. CONCLUSIONS

- length/weight relation abides most precisely by the changes in weight during the body grow period and may be considered an indirect point to asses the rhythm of growth.
- estimation the growth rhythm is constitute in a basic parameter that comes to answer and to argument the recommendation to protect the stocks and to limit the length of the standard fishes at first catch. Analyzing the influence result of this restriction, doubled by the Y/R (production / recruitment) rule, we can obtain, in general

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