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THESES OF DOCTORAL (PH.D.) DISSERTATION

OPPORTUNITIES FOR THE DEVELOPMENT OF INLAND FISHERIES

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1. Summary and antecedents of the set task

The fish production of the world takes place basically in two systems. Fisheries in its classical sense makes use of the natural progeny of the fish stocks of waters, while aquaculture effectuates more or less expenditure for the sake of increasing the safety and intensity of production. So the success of fishing and the ability to plan it economically depends on a number of factors which cannot or can only hardly be influenced, so the view that production should be transferred to the fresh-water systems that can be controlled better, mainly to the fresh-water aquaculture. Besides all these tendencies, a significant share of the fish production of the world is still given by the fishery of the oceans and the seas – as a result of their territories (Figure 1), at the same time, freshwaters and aquaculture have a more and more important role. These processes show that the quantity of the production of fisheries cannot be increased in a significant degree, because it is a sensitive system, which – on the basis of the previous examples –, can collapse any time, without any serious antecedents. The economic significance of this danger is reinforced by the fact that all over the world, only fish-meal remained as a possibility in the use of animal protein for forage purposes, since protein resources made of hot-blooded animals have been prohibited because of the BSE diseases. This way the fluctuation of the production of sea fishing (which is the major source of fish-meal) can become easily a serious factor in world economy.

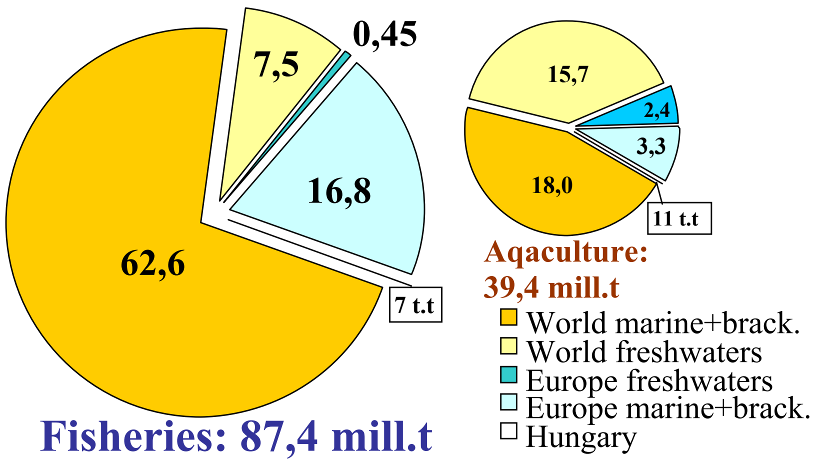

Figure 1 **State of fish production of the world (1998, million tons; Hungary: thousand tons)** *Source: FAO FishStat Plus 2000*

In Hungary, the uncertainty caused by the change of proprietors since the change of regime in the fisheries sector seems to have ceased by these days. By 2002, on the 90% of the fishing grounds under state proprietorship, leasing the fishing rights for 15 years has taken place. During the process of EU accession, the reduction of crop land will be accompanied by a change of cultivation; at this point, the establishment of the fish-pond appears as an alternative. All these tendencies influence the increase of domestic fish production, the signs of which have already appeared (e.g., per capita fish consumption has raised to 3 kg from the 2.7 kg stagnating for years, although marketing work and also the growing supply of supermarkets played a significant role in this.) In the domestic fish production, natural waters have yielded for several years about 7-8 thousand tons. This, from the point of view of outputs, considering the almost 140 thousand hectares of natural waters, is rather low, it means approximately 55-60 kg/ha mixed fish. Although the various natural waters can differ significantly on the basis of yields, yet on the majority of the territories, the results were low. In the case of our extensive still waters and rivers, the reason can undoubtedly be found in the combined effect of the lack of the possibility of reproduction of the fish stock and the over-fishing. Fishery built on planning supposes the best possible knowledge in the given circumstances of the parameters of the water area and its fish stock. Lacking this knowledge, it is not possible to establish the optimal usefulness of the resources, what is more, the management can make faulty decisions – as a result of a lack of information -, which can risk the success of later activities.

It is known that many factors have an impact on the success of the fishery, as well as some information in connection with the water area and the fish stock are necessary, the knowledge of which make it possible to manage the fishery in a planned way. One part of the information is available, while the other part is incomplete or not deep enough. The necessary data are dissimilar depending on their nature, can be obtained from different places, by different methods. Concerning our domestic waters, certain researchers have made and make the different population biological surveys proportionate to their own resources and the amount of the received supports, but a comprehensive survey is still missing, the lack of which means serious problems even now, before accession to the Union. Namely, the Water Framework Directive, among others, prescribes the complex mapping of the natural waters, which – taking as a basis the present situation – demands huge material and human resources investment from the research. As the first step of this work, the unified surveying method had to be developed, with the help of which the work could be made.

2. The materials and method of the surveys

Our own surveys involved two dead channels in the flood-plain at the upper Tisza (Boroszlókerti Oxbow and the Marótzugi Oxbow), as well as the reach of the river Tisza between Tiszadob (494 river station) and Dombrád (610 river station). The devices for the taking of samples were the following: row of gill-net with panel, electric fishing machine with direct current and fish-weir. As the first step for executing the field surveys and processing data, I developed a complex model (*Figures 2 and 3*), which contains in a unified system the steps of estimating the fish stock. I made the sampling on the basis of this. Part of the model is a fish faunistic survey, as well as a morphological survey of the water area. The information gained from these are important for making more accurate the system of devices of the samplings for stock estimation (duration, number of net-rows) and for assigning its place (places representing the best way the physical characteristics of the given water area). The major stages of stock-survey: A) faunistical survey, B) physical survey of the bed, and C) sampling with the help of gill-nets. This is followed by the evaluation by the computer module. For the processing of field data collection, I developed a computer module, which – with the help of auxiliary programs (macros) – executes the summing up of the results of the samplings, faunistic and biomass calculations, then presents the results in graphical and table form. As a result of its design, the module is also suitable for studying all the species of fish occurring in our country.

The definition of population-biological indices took place by calculating the Shannon Diversity Index (SDI) and the Relative Uniformity (RE); calculations of stock dynamics are the information that can be obtained about the mortality, biomass and production of the fish stock of a water area (*Table 1*). These, projected to the whole water area, give information about the state and changes of the fish biomass. In the case of all species that were caught in evaluable quantity, I represented the results of all the three samplings even graphically, according to the following points of view: frequency of body length of the caught fish, frequency of body length of fish caught by the certain net panels, as well as the quantity, ratio of the certain age groups. By graphic representation, it becomes possible to compare the results of catching measured at different times with data from literature, as well as with the ideal theoretical values (of normal distribution).

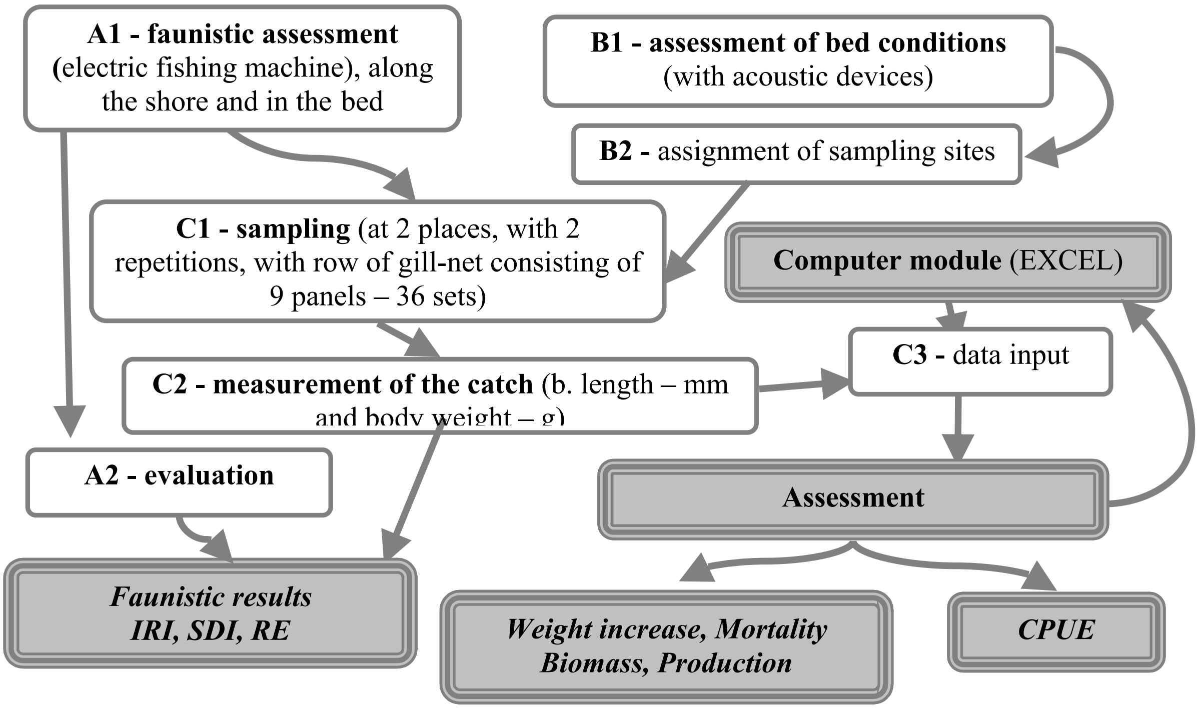

Figure 2 **Construction of the model for studying the fish stock**

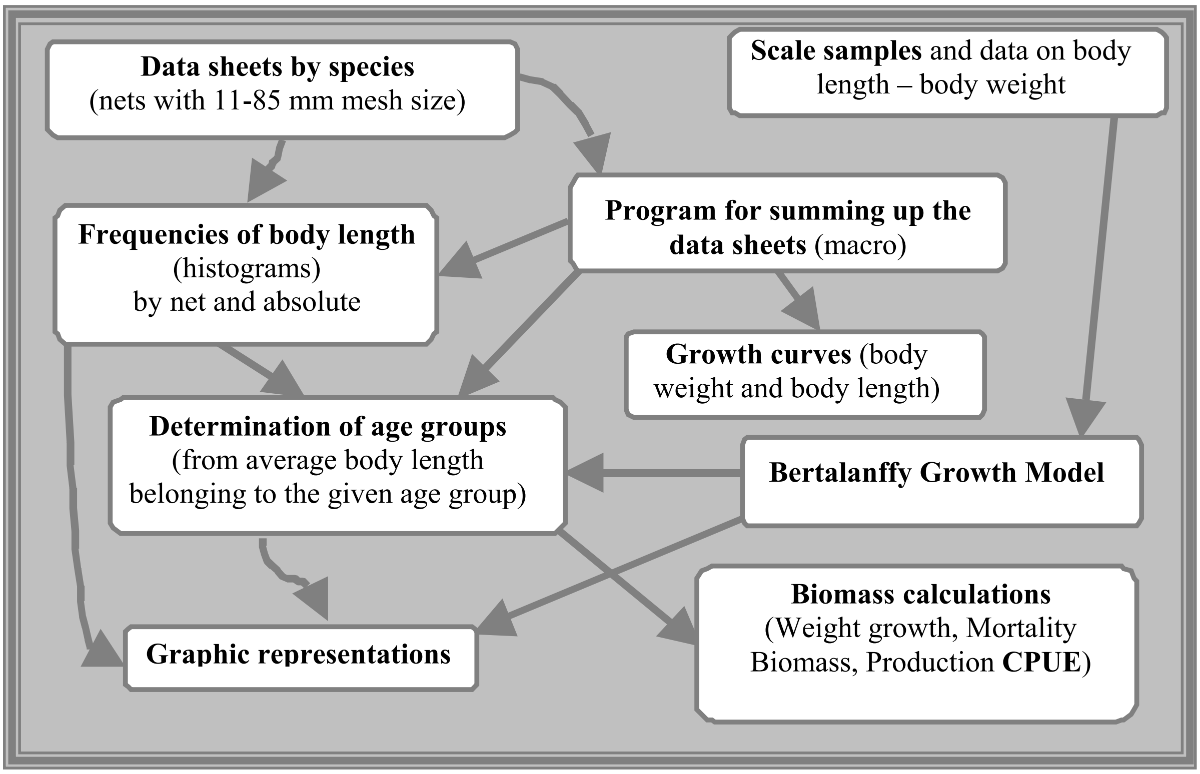

Figure 3: **Computerized part of the model for studying the fish stock**

Table 1 **The output table of the model**

Parameters	Age-groups					
	1	**2**	**3**	**4**	**5**	**…**
n: number of fish						
W (avg.): average weight of the given age-group(kg)						
B: biomass of the moment(kg)						
Z: complete mortality of the moment						
G: coefficient of weight growth						
G-Z, or **Z-G:** change of the biomass during a time unit (growth, or decrease)						
Batl $_{G-Z}$**:** yearly avg. biomass in case of growth (kg)						
Batl $_{Z-G}$**:** yearly avg. biom. in case of decrease (kg)						
P $_{G-Z}$**:** yearly production – in case of growth (kg)						
P $_{Z-G}$**:** yearly production – in case of decrease (kg)						
P% $_{G-Z}$**:** yearly production – in case of growth (%)						
P% $_{Z-G}$**:** yearly production – in case of decrease (%)						

3. Results, major conclusions of the dissertation

The chemical composition of the waters is in accordance with the natural state. Concerning heavy metals, since the concentration of copper and lead is approaching the upper level of the allowed limit, it can be supposed that the high level of enrichment of these materials can be linked to the increase of the amount of materials getting into the Tisza in the period of cyanide pollution and following it. The results of the biological studies reflect especially different states at the examined waters. The stock of flowery water flora can be estimated to be about the 30% of the whole water area at the Boroszlókerti Oxbow, 10% at the Marótzugi Oxbow. The stock of plankton surveyed at the territory of the water surfaces is basically synchronous with the environmental conditions.

In the course of the faunistic survey of the oxbow, 17 species from the Boroszlókerti Oxbow, 27 species from the Marótzugi Oxbow were found. The first is average, the second is a prominently high number. According to the indices calculated on the basis of the three samplings of the population biological surveys, the Shannon diversity index for species (SDI value) of the Boroszlókerti Oxbow can be said to be average, while the relative evenness of species (RE) is low. In the course of the three samplings, no major differences occurred in the SDI and RE values, so the present fish stock of the backwater is balanced. In the case of Marótzugi Oxbow, the values are different. The reason for this is the fact that the amount of the fish caught differed significantly.

The biomass, growth and production of the fish stock of Boroszlókerti Oxbow are rather small (Table 2). The biomass per hectare estimated to be 48.7 kg and the production level at 25.8% are low, even regarding the domestic conditions. Among the reasons, first of all, we have to mention the restricted nature of the possibilities of reproduction of the fish stock. Because of the relatively low biomass value and the less valuable fish stock, the development of the fish stock is to be suggested in any case, since this is supported by the calculations of the food bases. Development should mean the introduction of rare fish, or the introduction and the amelioration of the conditions for the spawning of fish. This latter combination is supported by the fact that it is more economical regarding the expenses, and the amount and quality of the natural progeny can be formed in accordance with the characteristics of the water area.

It can be stated on the basis of data of catches of Marótzugi Oxbow (*Figure 4*) that the certain age-groups have different dynamic characteristics, that is to say, they show increasing or decreasing tendencies. On the basis of the data, the total biomass of the dominant species (*Table 3*) is 128.9 kg/ha, its production is 19.7%, which data can be said to be average related to the domestic natural waters with similar potentialities. The structure of fish species on the territory is unfavourable, in case the proportion of the rare fish is modest. This condition can be improved, on the one hand, by introductions, on the other, by the establishment of natural places of breeding – that has been discussed above as well. Besides these, the presence of rheophil fish species can first of all be discovered in the fish stock of Marótzugi Oxbow. This means that this backwater has the most live connection with the river Tisza, since in the last ten years, most of the floods took place here.

Table 2 **Population dynamic parameters of the dominant species**

Boroszlókerti Oxbow		**For the whole territory**			**For 1 hectare**		
		Biom. (kg)	**Prod.** (kg)	**Prod.** (%)	**Biom.** (kg)	**Prod.** (kg)	**Prod.** (%)
1.	4. Roach	234,3	42,2	18,0	19,5	3,5	1,5
2.	7. Rudd	54,1	47,3	87,5	4,5	3,9	7,3
3.	15. Bleak	104,0	17,0	16,3	8,7	1,4	1,4
4.	33. Prussian carp	101,2	37,8	37,3	8,4	3,1	3,1
5.	43. Bullhead	91,0	6,6	7,2	7,6	0,5	0,6
Total:		**584,6**	**150,8**	**25,8**	**48,7**	**12,6**	**25,8**

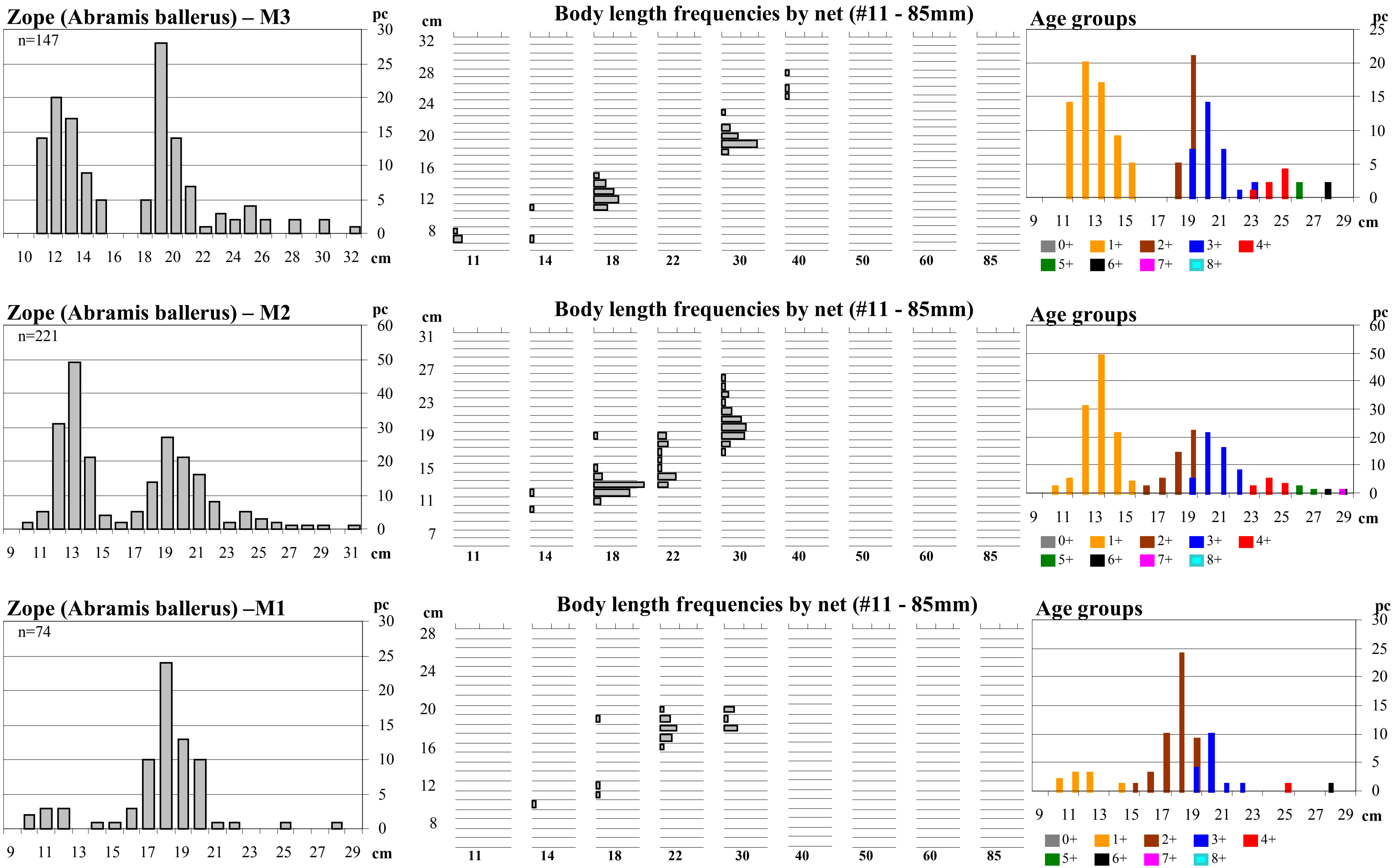

Figure 4 **Body length frequencies and age distribution of Zope *(Abramis ballerus)* (Marótzugi Holt-Tisza)**

Table 3 **Population dynamic parameters of the dominant species**

Marótzugi Oxbow		**For the whole territory**			**For 1 hectare**		
		Biom. (kg)	**Prod.** (kg)	**Prod.** (%)	**Biom.** (kg)	**Prod.** (kg)	**Prod.** (%)
1.	4. Roach	41,5	15,9	38,3	3,9	1,5	3,7
2.	7. Rudd	3,0	0,8	27,9	0,3	0,1	2,7
3.	15. Bleak	137,4	39,4	28,7	13,1	3,8	2,7
4.	17. Silver Bream	2,1	0,6	26,4	0,2	0,1	2,5
5.	18. Carp Bream	275,5	24,4	8,9	26,2	2,3	0,8
6.	20. Zope	770,3	161,3	20,9	73,4	15,4	2,0
7.	43. Bullhead	123,7	24,3	19,6	11,8	2,3	1,9
Total:		**1353,5**	**266,7**	**19,7**	**128,9**	**25,4**	**19,7**

From the studied water areas, in the Bertalanffy growth surveys made at Marótzugi Oxbow , the dominant Zope (*Abramis ballerus)* and its predator, the Pike-perch (*Stizostedion lucioperca*) appeared (*Figures 5 and 6*). I found that in the oxbow, the growth of both species is allometric, their body weight grows faster than their body length. This proves the existence of the satisfactory food base. The growth of the Zope (*Abramis ballerus)* can be said to be rather good on the territory, its intensity is similar to that of the stock of Tisza, which, besides the same genetic background, depends to a large extent on the potentialities of the habitat. The population reaches in the first year the body length of 10 cm, while the length of 20 cm is reached by the age of 4. The adequate population intensity of the Pike-perch (*Stizostedion lucioperca*) can be explained by the good environmental potentialities of the oxbow. Its growth is better in the oxbow than in the Upper-Tisza. The Pike-perch (*Stizostedion lucioperca*) reaches the catching size at the territory by the age of 3-4.

For promoting that floods take place more often in the case of oxbows, there is a solution that explores the possibilities of water supply, taking into account the potentialities of the field. As a part of this, I studied the spring water-levels of the years 1991-2000. It can be stated that in the ten-year period, because of the present situation, water replacement could have been provided seven times, by this, the supply of the fish stock of the oxbow, its natural reproduction and the return of the progeny to the river could have been promoted.

By comparing fishery and angling data from the literature, we can state that the calculated biomass data is below the angling and absolute biomass data of 1996, but there are no significant differences between the fishery results. This is thought-provoking even because on the one hand, the period of the survey was shorter (4 complete months and the moderate fishing activity of two months), on the other, the fish decay resulting from the cyanide catastrophe hit the Upper Tisza, that is to say, the reach studied.

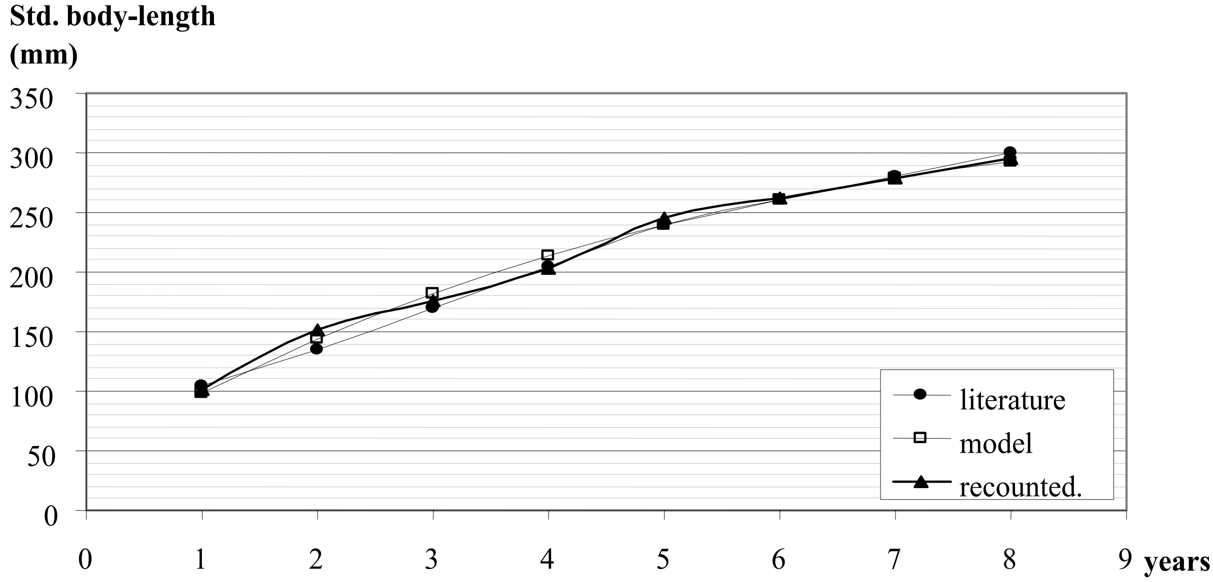

Figure 5 **Growth of the Zope (*Abramis ballerus)* on the basis of the Bertalanffy model, the recounted body lengths and literature data**

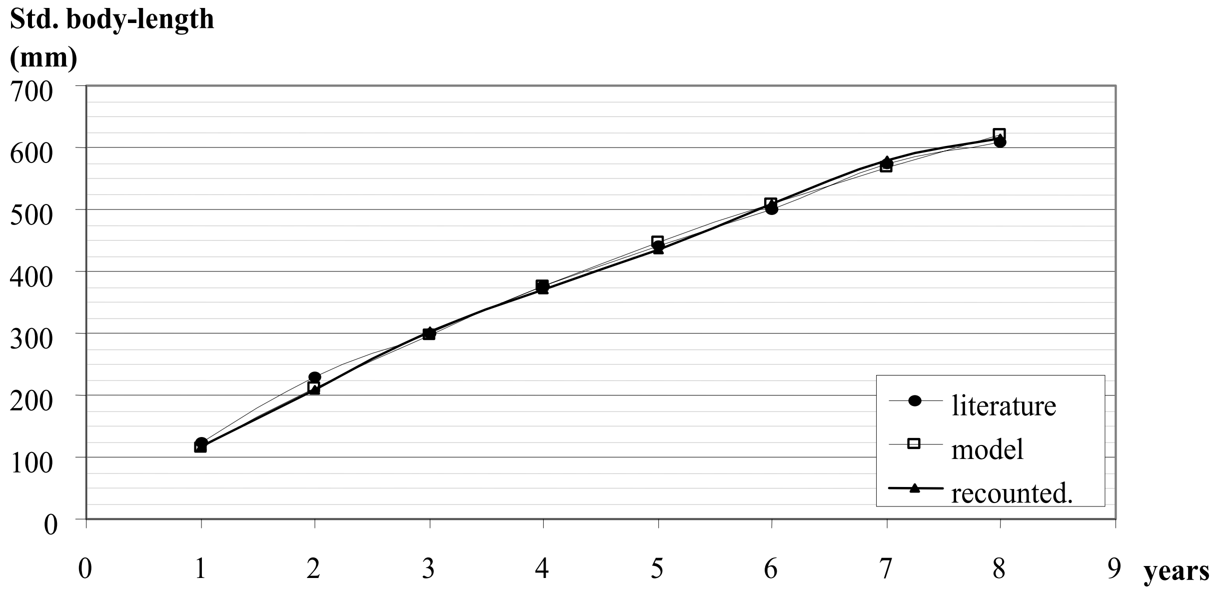

Figure 6 **Growth of Pike-perch *Stizosteidon lucioperca* on the basis of the Bertalanffy model, the recounted body lengths and literature data**

The method developed for the morphologic survey of the water areas is a fast, exact procedure (the performance is 4-5 ha/hour), which gives new, so far unknown data of any water areas (bed shaping, place of impediments, keeping, expansion of the cover of water plants), on the other hand, it creates the possibility of using GIS-based data maps and spatial informatics in the fishery (*Figure 7*).

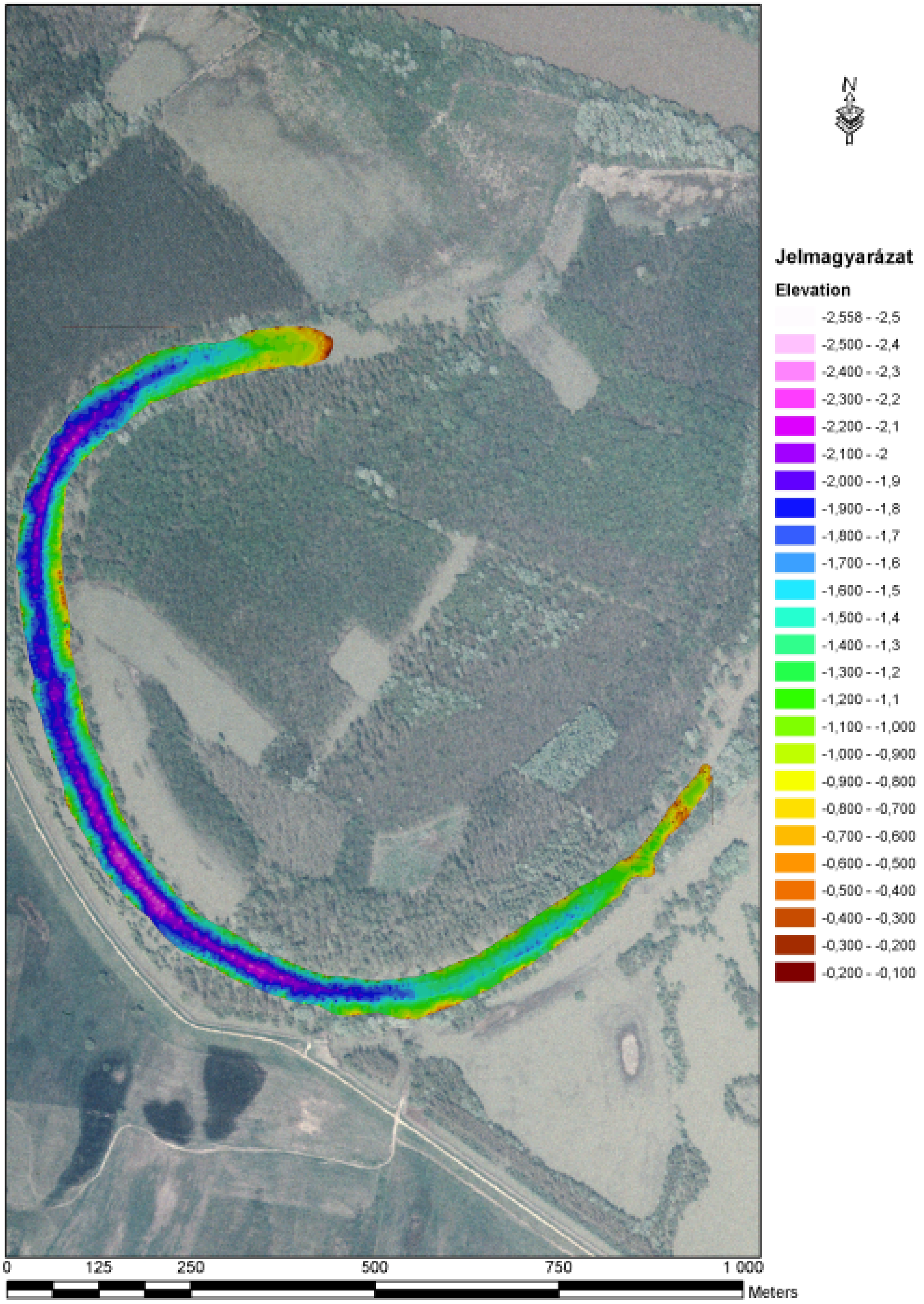

Figure 7 **Morphologic survey with colour scale (Marótzugi Oxbow)**

4. Summary of the new scientific results

1. The developed model for the survey of stocks is suitable for evaluating the results of sample fisheries made at other natural waters, in case the were performed on the basis of sampling procedures used in practice (electric fishery, row of gill-net with panels).
   The model (completed with hydrobiologic and water management parameters), as well as the system of instruments for the morphologic survey of the water areas makes such a complex method with the help of which in one year, information about the natural waters directly usable in fisheries can be obtained in an effective and economic way.
   The number of species occurring in the model can be enlarged, this way, it is suitable not only for the study of species characterizing the domestic fauna.

2. The study of the growth of the Abramis ballerus and the Stizostedion lucioperca has made valuable contributions to the domestic literature, especially in the case of the oxbows in the flood bed along Tisza, about the fish stock of which quite few population dynamic data are available.

3. On the basis of the study of the fish stock of the floods and the backwaters on the flood bed, it can be stated that within the fish stock of those backwaters that have been flooded more frequently and for longer periods, species which like flood-tie currents occur in greater numbers.

4. The distribution of the results of sterlet catches serves as another proof for the disadvantageous impact of the Tiszalök barrage on the migratory species of fish.
   The growth curves also containing data about the sterlet, and in the case of the glanis and the pike among the predatory species, species in great numbers and of big size, as well as data about species that have not occurred so far in the literature (flat, red-winged and ring bream, wall-rue) give further data for further studies of the stocks in Tisza of these species.

5. The method developed for the morphologic survey of the water areas is a fast, exact procedure (the performance is 4-5 ha/hour), which gives new, so far unknown data of any water areas, on the other hand, it creates the possibility of using GIS-based data maps and spacial informatics in the fishery (*Figure 7*).
   I chose the major elements of the system (GPS, fish radar, field computer) so that it could be used in shallow – even 0.4 m deep – water, too.
   The connection of the instruments (interface) and the developed software are new developments, and it makes possible the unified work of the system in a reliable way.

5.The practical applicability of the results

Considering the fact that the survey making the basis of the disertation is explicitly practical, so all of the new scientific results can be directly used in practice. It can be regarded as especially essential that a hydrobiologic, morphologic unified and complex system containing researches of fish stock came into being, with which the study of a given water area can be made effectively.

The results of the research create a methodologic and technical background for the fish faunistic and population biologic surveys still performed in different ways in our country, and by applying these methods together, all basic information about natural waters which help decision-making concerning fisheries can be obtained effectively.

6. List of publications treating the subject of the dissertation

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