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Anthrophogenic Influence on Biodiversity of Ichthyofauna and Macrophyte Vegetation from Lake Ohrid and Lake Skadar[#]

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Abstract: Lake Ohrid and Lake Skadar have quite different, and also have commonly features. They otherwise are linked by river Drim and they represent part of aquatic system Ohrid – Drim – Skadar. Also, Lake Ohrid and Lake Skadar are transboundary water bodies which R. Albania shares with R. Macedonia (Lake Ohrid), and R. Montenegro (Lake Skadar). To R.Albania belongs by 1/3 from Lake Ohrid and Lake Skadar. Lake Ohrid is an ancient lake, formed by tectonic forces in the Tertiary period. Because the lake is so old and is isolated by surrounding hills and mountains, a unique collection of plants and animals have evolved. These include a number of relict species, or "living fossils", and many endemic species found only in Lake Ohrid. Lake Skadar is the largest lake at Balkan Peninsula which is also rich by number of plant and animal species. In this paper are presented the results from researches of biodiversity of ichthyo fauna and macrophyte vegetation in lakes Ohrid and Skadar. The researches were performed in particular localities from littoral regions which are exposed to the different anthropogenic influence. From the received results it can be concluded that biodiversity of the fish populations and the macrophyte vegetation from the both lakes (Ohrid and Skadar) is different and mostly depend from the ecological condition present in researched localities.

Key words*: Lake Ohrid, Lake Skadar, ichthyofauna, macrophyte vegetation, biodiversity*

Introduction

This paper is result of long-term researches of ichthyofauna and macrophyte vegetation from Lake Ohrid and Lake Skadar. The researches are performed by the Department of Cyprinid fishes and Department of Hydrobotany from the Hydrobiological Institute - Ohrid, R.Macedonia and Department of Biology, Faculty of Science and Mathematics, University of Montenegro.

Lake Ohrid and Lake Skadar are endangered by uncontrolled building, uncontrolled fishing (legal or illegal), influx of unrefined waters with unsatisfactory quality, as well of great touristy pressure. The oscillation of the water level in the littoral regions of both lakes introduced great danger for biodiversity of ichthyofauna and macrophyte vegetation.

These significant aquatic ecosystems (Ohrid and Skadar) belong to different states where prevalent different legal rules. They affect to its correctly and jointly monitoring, as well as to biodiversity and distribution of macrophyte vegetation, and also to the qualitative and quantitative composition of fish populations.

Material and methods

The researches of biodiversity of ichthyo fauna and macrophyte vegetation from lakes Ohrid and Skadar (Figure 1) were performed in particular localities from littoral regions which are exposed to the different anthropogenic influence. The materials for researches of ichthyo fauna were collected from Lake Ohrid and Lake Skadar A total of sampling was realized (by day and night time's experimental fishing) with various fishing gill net. A cast net was used for daytime fishing with mesh size of 13 mm, whereas the night-time fishing was performed with bleak nets (mesh size from 12mm and 13 mm), barbells nets with mesh size of 22 mm, 24 mm, 26 mm and 28 mm, as well as nets with mesh

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size of 45 mm and 50 mm. The height of each fishing gear is basically a hundred heights per each mesh, and the length is about 50 meters. The materials of macrophyte vegetation were collected from both lakes (Ohrid and Skadar) by standard lymnological methods: Lind (1979) and Wetzel & Likens (1979). Collected materials of ichthyo fauna and macrophyte vegetation were processed in the laboratories.

Investigated area

Lake Ohrid (Figure 1) is located in the Sara-Pindus caustic massif. It fulfill the deepest part oh Ohrid valley (40,54'-41,10'N and 20,38'-20,49'E) in the southwest part of Republic of Macedonia, sharing its southwestern basin with Republic of Albania. It has a tectonic origin back in Pliocene and is a remain of ancient Dassaret Lake according to which all Dassaret group of lakes had been named. It is the largest and deepest lake in the group and in the Aegean lake zone representing refugium for numerous species whose close relatives on Balkan Peninsula and wider in southeast part of Europe can be found only on fossil forms (Stankovic 1960).

At sea level of 693.17 m it has a surface area of 358.18 square kilometers of which 240 belong to Republic of Macedonia and 118 to Republic of Albania. Maximal length of Lake Ohrid is 30.48 km, maximal width 15 km and means width of 11.79 km. Maximal dept is 288.7 m, mean depth of 163.71 m, volume of 58.64 cubic kilometers and retention time of about 83.6 years.

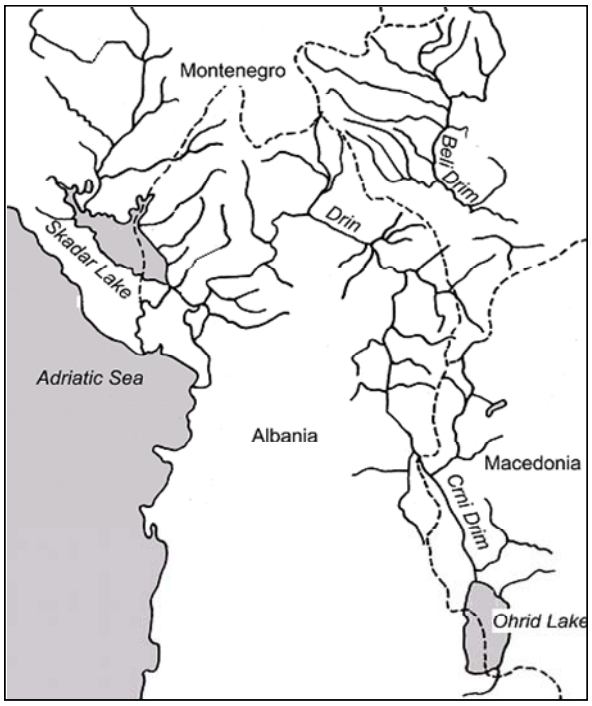

Figure 1. Map of the Lake Ohrid and Lake Skadar

Lake Ohrid is an oligotrophic, cold oligomictic, calcareous, graben, marl lake, mostly fed with spring water from sublacustrine and coastal carstic springs according Cvijic (1911). Considerable amount of this spring water (over 56%) originate from neighboring Lake Prespa, located on about 150 m higher sea level, and separated from Lake Ohrid by carstic massif of Galicica mountain.

There are 40 tributaries (23 on Albanian and 17 in Macedonia side) flowing in to Lake Ohrid of which most are torrents and are flowing temporally.

Lake Ohrid belong to lakes that had been researched (more or less continuously) since the end of the 19th century. Great number of these researches is for the systematic of enormous relict and endemic species which inhabiting Lake Ohrid. Most of the researches done later have confirmed the relictness, endemicity and sublacustrine speciation of this in most cases, unique ancient lake and its living world.

Lake Skadar (Fig.1.) is the largest lake at Balkan Peninsula and it is located at 19^{o} 15' of the East longitude and 40^{o} 10' of the North latitude, at the very south of the Montenegro. It is on the border with the Albania, to which belongs one third of lake area. The lake is extending in the NW-SE direction and it is approximately 44 km long. The shape of this lake is oval, with the maximal width of 14 km at the average water level. At the average water level, the surface altitude is 5 m above the sea level, and its surface area is approximately 370 km^2. At the maximal water level, the surface area is about 600 km^2 and it rises up to 9 m above the sea level and small depth, which is about 8 m average (Karaman & Beeton, 1981).

Considering its climate, the Lake Skadar area belongs to the Mediterranean zone with the characteristic sub-tropical climate. The lake receives water from surface water courses and from underground sublacustrine springs ("eyes"). The largest tributary of the Lake Skadar is the River Moraca, which brings in about 62% of water mass, and the main outflow from the lake is the River Bojana, the average flow rate of which is over 300 cubic meters per second. Mean water temperatures vary from 5 to 7 °C in the winter months, and they rise up to 28 C° during the summer. The

transparency of the water is from two to three meters in the summer and up to five meters in the winter. On the saprophic evaluation, it belongs to the β-mesosaprobic waters (Filipovic, 1997). In 1983, it has been proclaimed National Park in Montenegro, and in 1995, it was included in the Ramsar list of wetlands of international importance. In 2005, Albanian part of the Lake was proclaimed as Nature park.

Results and Discussion

The autochthonic fish populations of Lake Ohrid (Talevski, 2001; 2001a, 2004; Talevski et al., 2009) comprises 20 native species which belong to four families: Salmonidae - 5 species, Cyprinidae - 12 species, Cobitidae - 2 species and Anguillidae -1 species. Also, in Lake Ohrid is constated *Eudontomyzon stankokaramani,* Karaman, 1974, and it is catched 1 exemplar (specimen) in port Ohrid from Talevski in 2001 (but it is not described).

On basis of reference data and our research in Skadar Lake watershed, about 50 fish species have been described by now (Karaman and Beeton, 1981). Autochthonous fauna is composed of 36 species. Among them there are several marine migratory species. Alochthonous fauna is presented with 14 species, mainly from the so called "Chinese complex", while only three species from European fauna were introduced here. The main economic species of fish in the Skadar Lake is bleak, and also carp and eel. Participation of bleak in total annual catches amounts to 50%. The ecology of this species is interesting and very complex. According to 1947 – 1977 statistics the annual catch averaged 500 tons to decrease to only 100 tones over the last years.

The anthrophogenic influence on biodiversity of ichthyofauna is very expressed in the last 50 years of the 20 century Talevski, 2004a; Talevski & Talevska, 2002, 2004). In this period the number of the alohtonic (introduced) fish species in the Lake Ohrid is very considerably. In this period are introduced *Alosa fallax* La Capede, 1803 (Tocko, 1959), *Rhodeus amarus* Bloch, 1782, (Talevski, 1996), *Carassius auratus gibelio,* Bloch, 1783, (Tocko, 1982b), *Gambuzia holbrooki* Girard, 1859, *Lepomis gibbosus* Linnaeus, 1758, catched 1 exemplar (specimen) in surrounding of willage Trpejca from Talevski in 1998, (but it is not described), *Oncorhynchus mykiss* (Tocko, 1982) *Pseudorasbora parva* Temmini & Schlegel, 1846 and others.

In some parts of the Lake Ohrid anthropogenic influence provoke changes to the water quality and the structure of the bottom. As a result of this negative impact new macrophytes associations appear, which, if they continue with their development in some locations (Trpejca, Pestani) can cause changes among fish species that spawn in those regions, and so salmonid spawning grounds will be convert with a cyprinid spawning grounds.

Tourism development and use of plenty boats and ships which caused water pollution, and disturb spawning grounds, affects the return of the spawners in their natural and long existing spawning grounds and at the same time decrease the number of potential spawners and the surface of the existing spawning areas. This is very important if we know that almost all cyprinid species spawn at time when there are maximum numbers of tourists in these areas, with their biggest negative influence. It is worth to mention that for monitoring of the fish spawning grounds it is necessary to use great number of fishing gears and other equipment (scientific echo-sounder), which should provide better and more results.

An important issue in the Feasibility study for Lake Ohrid Conservation Project, which was not elaborated with its significance, was the problem of the fish population in Lake Ohrid. But since 1995, when the study was completed, the total annual fish catch has significantly decreased, and also were evident in changes in the population structure of some fishes in the Lake. For this purpose an integration of the results from the Albanian side is necessary to complete the whole situation. Based on the results shown in this report and also from the previous knowledge it is quite obvious that for the fish population in this lake it is necessary to establish a joint Macedonian - Albanian project in terms of fish stock assessment and determining a strategy for its protection and optimal exploitation.

The respective composition of the experimental catch in localities and period of the experimental fishing in Lake Ohrid is various and dependent on the fishing gear being used for the experimental fishing, the type of the ground and the overgrowth of the lake bottom with macrophyte vegetation, the weather conditions during which the fishing was performed, as well as many other factors that influence the qualitative and the quantitative composition of the experimental catch.

In Skadar Lake occurs 14 alochthonus fish species: *Oncorhynchus mykiss* Walbaum, 1792 (Drecun, 1962); *Salvelinus fontinalis* Mithchill, 1815 (Marić, 1991); *Thymallus thymallus* Linnaeus, 1758 (Ristić, 1967); *Carassius gibelio* Bloch, 1782 (Vuković, Kažić and Knežević, 1975); *Ctenopharyngodon idella* Valenciennes, 1844 (Vuković & Knežević, 1978); *Mylopharyngodon piceus* Richardson, 1845 (Knežević and Marić, 1986); *Megalobrama terminalis* Richardson, 1844 (Ivanović, 1973); *Pseudorasbora parva* Schlegel, 1842 (Knežević, 1981a); *Hypophthalmichthys molitrix* Valenciennes, 1844 (Ivanović, et al., 1974; Knežević & Jovanović, 1973); *Hypophthalmichthys nobilis* Richardson, 1845; *Tinca tinca* Linnaeus, 1758 (Knežević, 1981b); *Perca fluviatilis* Linnaeus, 1758 (Knežević & Marić, 1979); *Gambusia holbrooki* Girard, 1859 (Drecun, 1957); *Ameiurus nebulosus* Lesueur, 1819 (Knežević, et al., 1978)

The changes occurred in Skadar Lake after the new species introduction are so enormous, that one can speak about the ichthyofauna reconstruction. All introduced species have not adapted the same way. Four species only have achieved a significant numerousness, and German carp (*Carassius gibelio*) and perch (*Perca fluviatilis*) have multiplied to the level that they have become economically interesting. Their elimination from this region is practically impossible. Survival of other species depends on fish-stocking.

Generally, the numerousness of all species is decreasing lately. With some species population numerousness has drastically dropped, and these species may vanish (Salmonidae, for instance). For more than fifteen years now two species of acipenserids have not been caught, therefore it may be concluded that they are not the inhabitants of Skadar Lake any more.

Further dropping of some species in number, especially the ones that have approached the phase of vanishing, must urgently be stopped by undertaking the measures of protection.

Adverse changes in Skadar Lake are result of: poor management, pollution, overexploitation of the aquatic biota and future engineering works to control water level. The quality of the water entering the lake is of immediate concern, since it is recognized that pollution must be entering Lake Skadar from point sources on the tributaries, e. g. industrial and domestic pollution on the Moraca river or units from the fish factory and villages in the Crnojevica River or from the village along the coast of the lake, e. g. Virpazar, and increased use of agricultural fertilizers, and pesticides, especially on the Zeta Plain and Cemovsko Polje plain. It is anticipated that fish production will change drastically because of adverse effect of pollution, introduction of exotic species, overfishing or major changes in the water level. Use for transportation may increase some in future. Probably the greatest increased use will be for tourism and recreation. There will be an increased need for homes near the lake and a related increased demand to use the lake for a water supply. These uses are closely related to preservation of the natural state of the lake and its aquatic vegetation as a refuge for young fish, feeding and spawning of fish. It is obvious that no foreing biota e.g. fish and others animals should be introduced into the lake without very careful study of the consequences. This is important to determine the extent to which increased use is compatible with preservation of the natural state.

When having in mind the aim of conservation (protection) of a particular fish species in a given ecosystem, then the approach to this objective should be quite comprehensive, where besides the fishery statistics and monitoring in changes of spawning grounds, special attention should be paid to the population dynamics of particular species which are economically, as well as biologically important.

The macrophytic plants play a significant role in the cycling of materials in the littoral zone of lakes. They are important producers of oxygen, and supply the lake bottom and surrounding waters with organic materials during the vegetative period, especially in the period of decay. They also serve as natural mechanical and biological filters as they clean the lake water of various organic and inorganic pollutants.

In Lake Ohrid, where the bottom of the littoral region gradually decreases in depth, the macrophyte vegetation is distributed in zones. Emergent macrophytes, and floating macrophytes grow at smaller depths and closer to the coastline, whereby submerged macrophytes grow at bigger depth. In Lake Ohrid can be found about one hundred macrophytic plants which belong in thirty families.

Macrophyte vegetation in Lake Ohrid (on the Macedonian side) has been distinguished in more-or-less continuously belts (zones) around the whole lake (Talevska 1996, 2002,2003; Talevska & Trajanovska 2002, 2004).

- Belt of Cladophora,

- Belt of reed, Phragmites,
- Belt of pondweed, Potamogeton, and
- Belt of stonewort, Chara

From emergent macrophytes in Lake Ohrid are present: *Phragmites australis* (Cav.) Trin. ex Steud. (which is dominant representative), *Typha latifolia* L., *Typha angustifolia,* L., *Shoenoplectus lacustris* (L.) Palla, and others.

Between the reed belt and the land, in some places, the floating leaf plants *Nuphar lutea* (L.) Smith. and *Polygonum ampibium* L. occur.

Submerged macrophytes which are present in Lake are: *Potamogeton perfoliatus* (which is dominant representative), *Potamogeton lucens* L., *Potamogeton crispus* L., *Potamogeton pectinatus* L., *Potamogeton acutifolius* Link, *Myriophillum spicatum* L., *Myriophillum verticilatum* L., *Ceratophyllum demersum* L., *Ceratophyllum submersum* L., *Vallisneria spiralis* L., *Zannichellia palustris* L., *Elodea canadensis* Rich.& Michx., *Najas major* All., *Najas minor* All., *Chara tomentosa* L., and other species from Characeae.

In Lake Ohrid, the macrophyte vegetation shows the relatively great diversity of species in different parts of littoral (Talevska, 2003; Talevska & Talevski, 2004; Talevska, 2009). The differences in number of macrophyte species are result of different ecological conditions in the different parts of littoral zone in Lake Ohrid: configuration of the lake bottom (littoral's slope), type of soil, exposition of winds and intensity of waves, temperature, light, quantity of nutrient amount etc.

Presence of a great number of macrophyte species is evidenced in the North and in the South coastline of Lake where are optimal ecological conditions for their intensive growth and development. It is similar in the localities where tributaries fall into Lake Ohrid: Grasnica (where river Velgoska fall into the Lake), and Sateska (where river Sateska fall into the Lake), Daljan (where river Koselska fall into the Lake). In these areas of the littoral zone wastewater inputs keep the nutrient levels high, the slope of the bottom is gradual, and it is mostly sandy and muddy. Lower number of macrophyte species is evidenced along North-East and East coastline of Lake where slope of the littoral's bottom is steeper, it is mostly stones and rocks, and input of nutrients is lower, respectively anthropogenic influence is of a weaker intensity in these areas of the littoral region.

In some areas of Lake Ohrid, the impact of negative human activities has obviously impacted the vegetation (Talevska & Trajanovska, 2001; Talevski & Talevska, 2002,2004; Talevska & Talevski, 2006). Namely, the reed zone along the shore of Macedonia (Radozda-St. Naum), now significantly reduced by cutting and burning of the reeds to obtain more developable space for hotel complexes, sports centers, beaches, and other uses, and connections with the shoreline channels and wetlands have also been interrupted. Also, some plant species, especially some of the floating leaf plants (*Nuphar lutea* (L.) Smith. and *Polygonum amphibium* L.), which in previous years were present in more locations in the littoral of Lake Ohrid and in the Ohrid wetland, are now very rare, and in danger of disappearance. Than, new associations are likewise expanding, especially the submerged plants *Vallisneria spiralis* L., *Potamogeton lucens* L., *Potamogeton crispus* L., which grow with great intensity at certain localities. Also, the invasive nonnative submerged plant *Elodea canadensis* Rich.& Michx. - American waterweed (introduced in the Lake in 1958) has expansion in more localities on the Macedonian side of the Lake. Uncontrolled expansion of this plant species in the future has the potential to greatly impact the native macrophyte vegetation.

The plant world of the Lake Skadar is characterized by floristic diversity, but also by three characteristics group of macrophytes: emerged, floating and submerged macrophytes. Macrophyte vegetation of the lake presumably play an important role in nutrient cycling and provide shelter and substratum for the development most of animals and plants species. The dominant species are: *Phragmites communis, Scirpus lacuster, Numphar luteum, Nymphea alba* and *Trapa natans* (Lakusic &Pavlovic 1981; Ristic & Vizi 1981; Lakusic 1983).

The total number of aquatic macrophytes for the whole area of Lake Skadar is 164 species belonging to 66 genera and 43 families.

And in this lake, macrophyte vegetation has been distinguished in zones (belts), which are more or less continued around the Lake.

In zone of emerged plants dominant plant species are: *Phragmites communis* Trin. *Scirpus lacuster* (L.) Palla, *Typha angustipholia* L. There are present and plants such as *Butomus umbellatus*

L. *ssp.scutarensis* Lak., *Sparganum erectum* L., *Eleocharis pallustris* (L.) R.et Sch., *Cyperus longus* L.Roripa silvestris (L.) Pess. and the others.

Floating macrophytes which are dominant in Lake Skadar are: *Nymphaea alba* L., *Nuphar lutea* (L.) Smith., *Nymphoides peltata* (S.G.Gmel) O.Ktze., *Trapa natans* L., *Polygonum amphibium-erectum* L., *Potamogeton natans* L., *Lemna minor* L., *Lemna major* L., *Lemna trisulca* L., and others.

It shall to mention that in this lake is present aquatic plant *Trapa longicarpa* M.Jank. *ssp. scutarensis* M.Jank (kasaronja-water chestnut) which is endemic-relict specialized Skadar subspecies. Due to great scientific and practical importance (role in biocenosis and organic production, great nutricity of fruits), it is necessary to put special attention and undertake measures for strict protection and control of this plant and its habitats, as a unique element of Montenegrian vascular flora.

Submerged macrophytes which are dominant in Lake are: *Potamogeton perfoliatus* L., *Potamogeto lucens* L., *Potamogeton crispus* L., *Potamogeton pectinatus* L., *Potamogeton pusilus, Myriophillum spicatum* L., *Myriophillum verticilatum* L., *Ceratophyllum demersum* L., *Ceratophyllum submersum* L., *Vallisneria spiralis* L., *Najas major* All., *Najas minor* All., *Chara sp. Nitella sp.* and others.

In Lake Skadar there are differences in diversity of macrophyte vegetation among particular regions of lake's shore. Namely, the southern and southwestern shorelines are rocky and quite steep and are exposed to strong, frequent north winds. Macrophyte vegetation is very scarce there as a result, and that which is found is generally limited to the area at the mouth of the Crmnica River at Virpazar, Godinje Bay and other small bays which offer some protection from the wind. Along the eastern lake shore extended reed beds (*Phragmites*) have developed 36 associations of macrophyte plants have been listed for the whole lake. In this lake the differences in the number of macrophytic species are the result of differences in the temperature and light regime, the type of soil, the configuration of the lake bottom, the water level, and the level of nutrients.

Due to the great importance of macrophyte vegetation in whole process of material and energy cycling in the lake ecosystem, as well as a habitat, food, shelter and breeding site for many species of fishes in the following period it will be necessary to devote more attention to the its protection.

Conclusions

From the performed long-term researches of ichthyofauna and macrophyte vegetation from Lake Ohrid and Lake Skadar, the obtained results may be summed up in more conclusions:

Lake Ohrid and Skadar cyprinids are mainly phytophyllic species, in relation to the grounds where they lay their eggs. Any change in the qualitative and quantitative composition of the macrophyte vegetation inevitably causes a change in the spawning site. The laying of eggs at the same site in the new conditions necessarily results in less efficient natural spawn (less hatched larvae, and with that and less adult individuals).

The growth of tourism and the more and more increased use of boats that pollute the lakes and disturb the tranquillity of the fish spawning sites, have an immense impact on the decreasing of the number of individuals that return to the former spawning sites. This is even more important if we regard the fact that almost all cyprinids spawn at sites and periods when the number of tourists is the greatest, and that also refers to the extent of their impact.

The anthropogenic pressure in respective parts of the lakes provokes changes in the composition of the bottom and the quality of the water. As a result of such undesirable impacts, new macrophyte associations started to occur, which provided they proceed with such intensity at certain localities, may result in change of the species that spawn in those areas, respectively from salmonid spawning sites to convert into cyprinid species spawning sites. Anthropogenic influence on biodiversity of ichthyofauna is very expressed in the last 2/2 of the 20 century when great number of fishes species was introduced in both lakes (Ohrid and Skadar), and in this way has negative affect to autochthonous fish populations.

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