

# Belts of Macrophyte Vegetation in Lake Ohrid

*Marina Talevska & Sonja Trajanovska*

Department of Hydrobotany, PSI Hydrobiological Institute Ohrid, 50 Naum Ohridski Street, 6000 Ohrid, Republic of Macedonia;  
Email: mtalevska2000@yahoo.com

**Abstract:** In this paper we made a review of results from long-term studies on the main belts of macrophyte vegetation in Lake Ohrid: the belt of *Phragmites*, the belt of *Potamogeton*, and the belt of *Chara*. More specifically, we analysed the surface area, biomass and production of these belts along the Macedonian shoreline of Lake Ohrid (from the locality Radozda to St. Naum). The analysed data confirmed that these three belts play a significant role in the circulation of materials in the littoral zone and Lake Ohrid as a whole.

**Key words:** Macrophytes, Lake Ohrid, surface area, biomass, production

## Introduction

The macrophyte vegetation in the littoral zone of Lake Ohrid is presented by all macroscopic forms of aquatic vegetation: vascular plants, aquatic ferns and mosses and some macroscopic algae (the algae *Cladophora* and species of the families Characeae and Nitellaceae) (STANKOVIĆ 1960, ČADO 1962, TALEVSKA 2002, 2003, TALEVSKA & TRAJANOVSKA 2002, 2004, SCHNEIDER et al. 2014).

The macrophyte plants have significant role in the lake littoral zone. They are an important producer of oxygen, supply the lake with different materials during and after the vegetative period, and constitute natural biological filters of the lake water against various pollutants (TALEVSKA 1996b, 2005). In addition, macrophytes provide habitat, food and shelter for many aquatic organisms, and they are spawning sites for some fish and nesting places for certain birds (TALEVSKI & TALEVSKA 2002, 2003, TALEVSKA & TALEVSKI 2012, 2015).

The macrophyte vegetation in Lake Ohrid has been regularly studied since 1985. The distribution and production of emergent vegetation (*Phragmites*, *Typha*) in the lake was studied by TALEVSKA (1996a, b, 2008a). Data on the distribution, biomass and production of *Potamogeton perfoliatus* L. was reported by TALEVSKA (2004, 2005, 2006a, b, 2007). Data about the distribution of family Najadaceae in

Lake Ohrid was published by TALEVSKA (2008b), while data about *Elodea canadensis* – by TALEVSKA (2011). Comprehensive studies on diversity and distribution of macrophyte vegetation in the lake were conducted by TALEVSKA (2002, 2003) and TALEVSKA & TRAJANOVSKA (2002, 2004). Extensive research, including taxonomy, ecology, distribution and production, on Charophyta was carried out by TRAJANOVSKA (2002a, b, 2004, 2005, 2009) and TRAJANOVSKA et al. (2004, 2015). The role of macrophyte vegetation as spawning grounds of cyprinids was investigated by TALEVSKA & TALEVSKI (2012, 2015) and TALEVSKI & TALEVSKA (2002, 2003).

Our aim in this paper was to make a review of the long-term studies on surface area, biomass and production of the main belts of macrophyte vegetation in Lake Ohrid: the belts of *Phragmites*, *Potamogeton* and *Chara*.

## Materials and Methods

### Study area

Lake Ohrid is a transboundary water body shared between the Republic of Macedonia and the Republic of Albania, and one of the largest natural lakes in Europe (STANKOVIĆ 1960). It is located in the

southwestern part of the Republic of Macedonia, at an altitude of 690 m a.s.l. The lake has a surface area of 358 km<sup>2</sup>, maximal length of 30.3 km, maximal width of 15.6 km, maximal depth of 288.7 m, length of coastline 87.53 km, and a transparency of water of 21 m (MATZINGER et al. 2007, ALBRECHT & WILKE 2008).

The analyses of features of the belts of macrophyte vegetation in Lake Ohrid were based on studies performed at a total of 60 localities, covering almost the whole lake's coastline in the territory of the Republic of Macedonia, from Radozda to St. Naum, respectively (Fig. 1).

### Sampling and laboratory analyses

The sampling of macrophytes was performed by Van Veen grab, using the method of transects with transverse profiles (WETZEL 1975, LIND 1979, WETZEL & LIKENS 2000). Plants were collected at various depths and distances from the coast, from the appearance to the disappearance of vegetation along one profile.

The collected plants were identified in the laboratory using different floras and keys for vascular macrophytes (HAYEK 1924–1933, JORDANOV 1963–1970, JOSIFOVIĆ 1970–1977, TUTIN et al. 1964–1980, MICEVSKI 1985–2005) and for charophytes (CORILLION 1957, 1975, WOOD & IMAHORI 1964, 1965, GOLERBAH & KRASAVINA 1983, KRAUSE 1997, SCHUBERT & BLINDOW 2003). The samples were preserved in alcohol.

The surface area, biomass and production of macrophytes were determined by application of standard methods (WETZEL 1965, WESTLAKE 1965, WETZEL & LIKENS 2000). The biomass was studied within one vegetation period, and its maximal values were recorded in the middle of the summer period. Based on the surface area and biomass of the studied macrophytes, we calculated the total annual biomass of the three belts.

### Data analyses

The data on the belts of macrophyte vegetation in Lake Ohrid used in our study cover the period from 1985 to 2007. The analyses of data were based on the following studies: TALEVSKA 1996a, b, 2005, 2006a, b, TRAJANOVSKA 2002a, b, and TRAJANOVSKA et al. 2004.

## Results and Discussion

In the littoral region of Lake Ohrid, the macrophyte vegetation is distributed in belts: the belt of algae *Cladophora*, the belt of reed *Phragmites*, the belt of pondweed *Potamogeton*, and the belt of stonewort

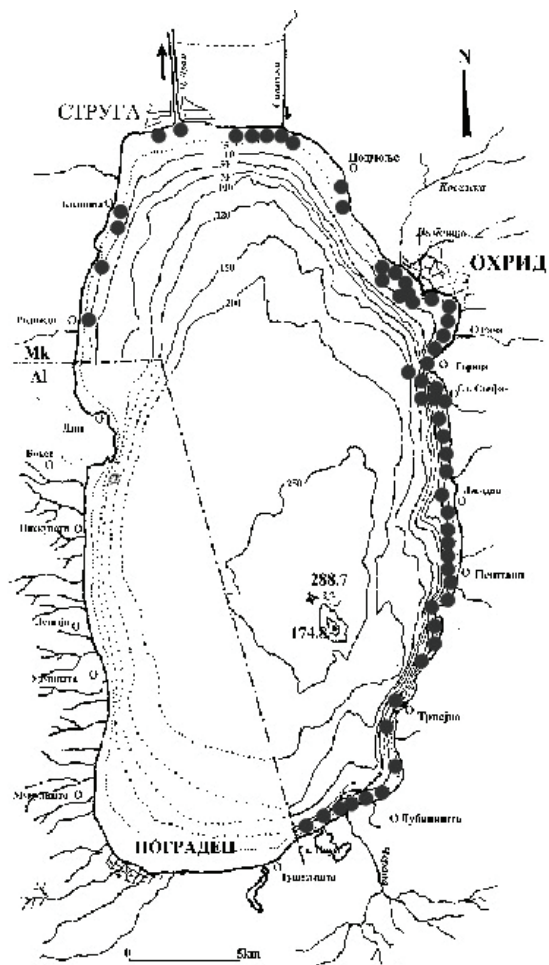


Fig. 1. Map of Lake Ohrid with studied localities

*Chara* (JAKOVLEVIĆ 1936, STANKOVIĆ 1960, ČADO 1962, MICEVSKI 1969, TALEVSKA 2002, 2003, TALEVSKA & TRAJANOVSKA 2002, 2004, SCHNEIDER et al. 2014).

The belt of the algae *Cladophora* is the closest to the shore and it is distributed more-or-less continuously around Lake Ohrid.

In the belt of the reed *Phragmites*, the dominant species is the common reed *Phragmites australis* (Cav.) Trin. ex Steud., which forms natural discontinuous belt around the lake. This belt is comprised of numerous individual complexes with different shapes and sizes, and generally occupies the bottom of the upper littoral, between 0.5 and 5 m depth. The width of the belt varies from 2 m in the eastern coastline to 130 m in the northwestern and northern coastline (TALEVSKA 1996a, b). There are also other emerged plants, such as: *Typha latifolia* L., *Typha angustifolia* L., and *Schoenoplectus lacustris* (L.) Palla, in the belt of the reed. These plants form almost pure associations in particular localities (TALEVSKA 2008a).

Very rarely, floating plants in form of islands are present between the reed belt and the coast in some places. This is especially evident in front of the village of Radozda (in the north-west shore of the lake), where the yellow water-lily, *Nuphar lutea* (L.) Sm., and the water smartweed, *Persicaria amphibia* (L.) Gray, occur.

The pondweed *Potamogeton* also forms an almost continuous belt around the lake at depths from 0.5 to 9 m. This belt is developed better than the reed belt. It is dominated by the perfoliate pondweed (read head grass), *Potamogeton perfoliatus* L., almost exclusively at some places. The width of the perfoliate pondweed belt varies from 15 m in the eastern coastline to 1,290 m in the northern coastline (TAJEVSKA 2004, 2005). Other submersed plants that occur in this belt include: *Potamogeton lucens* L., *Potamogeton crispus* L., *Stuckenia pectinata* (L.) Börner, *Potamogeton acutifolius* Link, *Potamogeton gramineus* L., *Potamogeton pusillus* L., *Potamogeton nitens* Weber, *Potamogeton salicifolius* Wolfg., *Myriophyllum spicatum* L., *Myriophyllum verticillatum* L., *Ceratophyllum demersum* L., *Ceratophyllum submersum* L., *Vallisneria spiralis* L., *Zannichellia palustris* L., *Elodea canadensis* Michx., *Najas marina* L., *Najas minor* All., and *Ranunculus trichophyllus* Chaix ex Vill. (TAJEVSKA 2003, 2005, 2007, 2008b, 2011, SCHNEIDER et al. 2014).

The stonewort *Chara* belt is the deepest and the best developed belt of macrophyte vegetation in Lake Ohrid. It occupies the bottom of the lower littoral, at depths from 0.5 to 18.5 m. The width of this belt varies from 3.5 m in the eastern coastline to 1,580 m in the northern coastline (TRAJANOVSKA 2002a, 2005). The predominant species in this belt is *Chara tomentosa* L. which often forms relatively pure associations. The width of the belt of *Chara tomentosa* varies from 15 m in the eastern coastline to 1,145 m in the northern coastline (TRAJANOVSKA 2002a, b, 2004). The following species from Charophyta can be found in the belt of stonewort as well: *Chara aspera* Deth. ex Willd., *Chara contraria* A. Braun ex Kütz., *Chara denudata* A. Braun, *Chara dissoluta* A. Braun ex Leonhardi, *Chara globularis* Thuiller, *Chara gymnophylla* A. Braun, *Chara hispida* L., *Chara imperfecta* A. Braun, *Chara intermedia* A. Braun, *Chara virgata* Kütz., *Chara kokeilli* A. Braun, *Chara vulgaris* L., *Chara ohridana* Kostic, *Nitellopsis obtusa* (N. A. Desv.) J. Groves, *Nitella opaca* (Bruzelius) C. Agardh, *Nitella syncarpa* (J. L. Thuillier) Kütz., *Nitella flexilis* (L.) C. Agardh, and *Nitella hyalina* (De Candolle) Agardh (BLAŽENČIĆ 2004, TRAJANOVSKA 2005, 2009, SCHNEIDER et al.

2014, TRAJANOVSKA et al. 2015).

According to the analysed data, the belts of macrophyte vegetation are better developed along the western, northwestern and northern coastline of Lake Ohrid than along the eastern and southern coastline. This phenomenon is mainly due to the configuration of the lake bottom (littoral slope), the type of ground, exposure to winds and waves and the quantity of nutrients, as well as due to other ecological factors. The largest surfaces of reed, perfoliate pondweed and stonewort are reported from the localities of the coastline where littoral slope is gradual, the bottom is sandy and muddy, the exposure of the winds and waves is low, and the input of nutrients is high (TAJEVSKA 1996a, 2003, 2004, 2006a, 2007, TRAJANOVSKA 2002a, 2005). This is evident especially along the northwestern and northern coastline (between the localities Radozda, Struga and Ohrid).

Relatively smaller surfaces of these three belts were registered along the northeastern and especially along the eastern coastline of the lake. In these regions, the littoral slope is steeper, while the bottom mostly comprises stones and rocks and the exposure to the winds and waves is high. At the same time, the nutrient input is lower. We should also mention that in some regions of the eastern coastline there are not any reed and perfoliate pondweed, while stoneworts are slightly present.

The results show that the whole surface area of the studied macrophytes along the Macedonian shoreline (from Radozda to St. Naum) is in total 2,144.64 ha (Table 1), which is 8.98% of the surface area of Lake Ohrid. More specifically, the total surface area of the reed belt is 74.35 ha, or 0.31% (TAJEVSKA 1996a, b), this of the perfoliate pondweed belt is 1,021.13 ha, or 4.28% (TAJEVSKA 2005, 2006a), while this of the stonewort belt is 1,049.16 ha, or 4.39% (Table 1). The surface area of *Chara tomentosa* as dominant species of the stonewort belt is 296.31 ha, while the surface area of *Chara tomentosa* and *Chara* spp. is 448.07 ha and this of *Chara* spp. – 304.79 ha (TRAJANOVSKA 2002a).

**Table 1.** Surface area, annual biomass and production of belts of macrophyte vegetation in Lake Ohrid for the period from 1985 to 2007 (average values)

Belts	Surface area (ha)	Annual biomass (t)	Production (kg·m <sup>-2</sup> )
Belt of reed	74.35	2,269.31	3.89
Belt of pondweed	1,021.13	2,747.85	0.24
Belt of stonewort	1,049.16	10,551.71	1.84
<b>Total</b>	<b>2,144.64</b>	<b>15,568.87</b>	<b>5.97</b>

The total annual biomass of *Phragmites australis* in Lake Ohrid is 2,269.31 t (TALEVSKA 1996b), this of *Potamogeton perfoliatus* – 2,747.85 t (TALEVSKA 2005), and this of stoneworts – 1,0551.71 t, out of which the biomass of *Chara tomentosa* is 2,980.5 t (TRAJANOVSKA 2002b, TRAJANOVSKA et al. 2004). Therefore, the total annual biomass of studied macrophytes from Lake Ohrid has been estimated at 15,568.87 t (Table 1). These results show that the biomass of belts of macrophytes have a significant role in cycling of materials in the lake.

Although the emergent, floating and submerged macrophytes take part in the organic production of lakes (MOSS 1988), in general, the submerged macrophytes have a lesser role in production than the other two groups of plants (WETZEL 1975). Our results also confirm this fact. The annual production of the aboveground organs of reed is 3.89 kg·m<sup>-2</sup> dry weight and floating macrophytes are less presented (TALEVSKA 1996a, b), while the annual production of the perfoliate pondweed is 0.24 kg·m<sup>-2</sup> dry weight (TALEVSKA 2005, 2006b) and this of stoneworts – 1.84 kg·m<sup>-2</sup> dry weight (TRAJANOVSKA 2002b) (Table 1). It is evident that the annual production of the submerged macrophytes (stoneworts and especially the perfoliate pondweed) is lower than that of the emergent plants (reed) in this aquatic ecosystem.

## Conclusions

The results from the analysed long-term studies on the surface area, the total annual biomass and the production of main belts of macrophyte vegetation in Lake Ohrid have confirmed the significant role of the belts of *Phragmites*, *Potamogeton*, and *Chara*, in the circulation of materials in the littoral zone and Lake Ohrid as a whole. Therefore, certain measures for permanent monitoring of the macrophyte vegetation and its protection from the negative anthropogenic influence are necessary to be undertaken in the future.

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