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Shorezone Functionality
Ohrid Lake

Implementing the EU Water Framework Directive in South-Eastern Europe

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Disclaimer

The views and management recommendations expressed in the present report are those of the authors and do not necessarily reflect those of GIZ, the Governments of Albania, Macedonia and Montenegro, nor the national competent authorities in charge of implementing the EU Water Framework Directive. The use of particular designations of hydrogeomorphological areas does not imply any judgement by the publisher, the GIZ, as to the legal status of such water bodies, of their authorities and institutions or of the delimitation of their boundaries.

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Foreword

The EU Water Framework Directive (WFD) sets a framework for the management of surface and ground waters within the territory of the Union, with the aim to preserve or achieve their good ecological and chemical status. Significant progress has been made in recent years by Albania, FYR of Macedonia[1] and Montenegro not only towards transposing the WFD into their national legislation but also implementing it in parts of their river basins, including the sub-basins of Lakes Prespa, Ohrid and Shkodra/Skadar.[2] As a result of this joint transboundary endeavour, the so-called initial characterization of the three lakes has been achieved in 2015, with support of German Development Cooperation and other development partners. The present document marks another important milestone in WFD implementation – the assessment of hydromorphological status. This comprises a mixture of hydrological and morphological assessments.

Whilst the biological, chemical and physico-chemical elements are concerned primarily with the quality of the aquatic environment, hydromorphology is concerned with its physical nature. It examines the physical size of the water body itself as well as the shore/riparian zone – depth variations, surface areas, substrate composition, water inflow, abstractions/discharges, outflow, residence time, water level etc. For classification purposes, a water body can only be considered to be of good or even high ecological status if there are no or very limited hydromorphological alterations from its reference status, and if lake shore functionality is not seriously diminished, e.g. by urban encroachment and the concomitant extension of impervious surfaces.

Within the EU, different methodologies have been applied to assess the hydromorphology of lakes. The approach pursued in the present study – the Shorezone Functionality Index (SFI) – was first developed in Italy and has in the meantime been adopted by several European countries. Even though the SFI has been developed primarily to inform water management, it is of more general importance to all kinds of spatial planning taking place within lake sub-basins, including physical and landscape planning and zoning designations for protected areas. Moreover, it provides a status quo baseline and benchmark against which to measure future developments. The SFI will, therefore, enable planners and developers to take informed decisions for the sake of the sustainable development of the lake areas, to which all riparian countries are committed.

The authors of the study are acknowledged not only for the quality of their work but also for demonstrating that, in water resources management, more comprehensive and meaningful results can be achieved through transboundary collaboration.

Dr Ralf Peveling
Program Manager CSBL

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[1] Upon decision of the General Assembly of the United Nations in 1993, Macedonia is provisionally referred to as "The former Yugoslav Republic of Macedonia", pending settlement of the difference that had arisen over its name. For the ease of reading and without prejudice, henceforth the name Macedonia is used.

[2] The names Shkodra and Skadar are used together or interchangeably.

1 THE SHOREZONE FUNCTIONALITY INDEX

1.1 Introduction

Lakes are extremely important. They are a source of freshwater and provide resources such as fish and support services like water transportation, recreation and tourism.

Today, mitigating nutrient losses caused by anthropogenic nonpoint source pollution is particularly important for improving the water quality of a great number of the world's freshwater lakes. Relationships between land use and in-lake water quality have been observed, which means the whole drainage basin should be considered when managing nutrient loadings in lakes (Nielsen et al. 2012). For example, chemicals – nitrogen and phosphorus being prime examples – that are originally applied to the land for agricultural purposes can work their way into lake waters and, once present, will actively (and often negatively) affect the trophic-evolutionary processes of these waters (Premazzi and Chiaudani 1992; Chapman 1996).

The lake's riparian vegetation plays an important role as a buffer that helps to protect the aquatic ecosystem against degradation caused by human activities (Dosskey et al. 2010). Studies by Osborne and Kovacic (1993) have shown that the riparian zone can efficiently intercept nutrients emanating from nearby agricultural areas, diminishing by over 90% the nitrogen and phosphorus content of both the superficial and sub-superficial waters flowing into the water body (Figure 1).

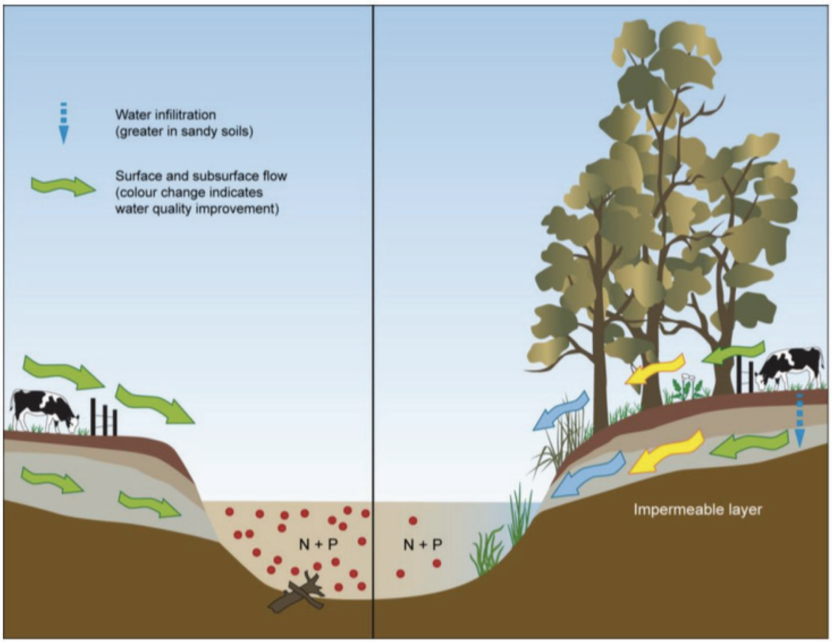

Figure 1. Nutrient interception by riparian vegetation (Dosskey et al. 2010)

The shorezone is a transition zone (ecotone) between a lake and its surrounding territory that can perform important ecosystem services, such as regulating nutrient inputs and protecting against nonpoint source pollution, ensuring the maintenance of ecological processes, providing food and habitat for organisms, and protecting the shoreline from erosion (Figure 2).

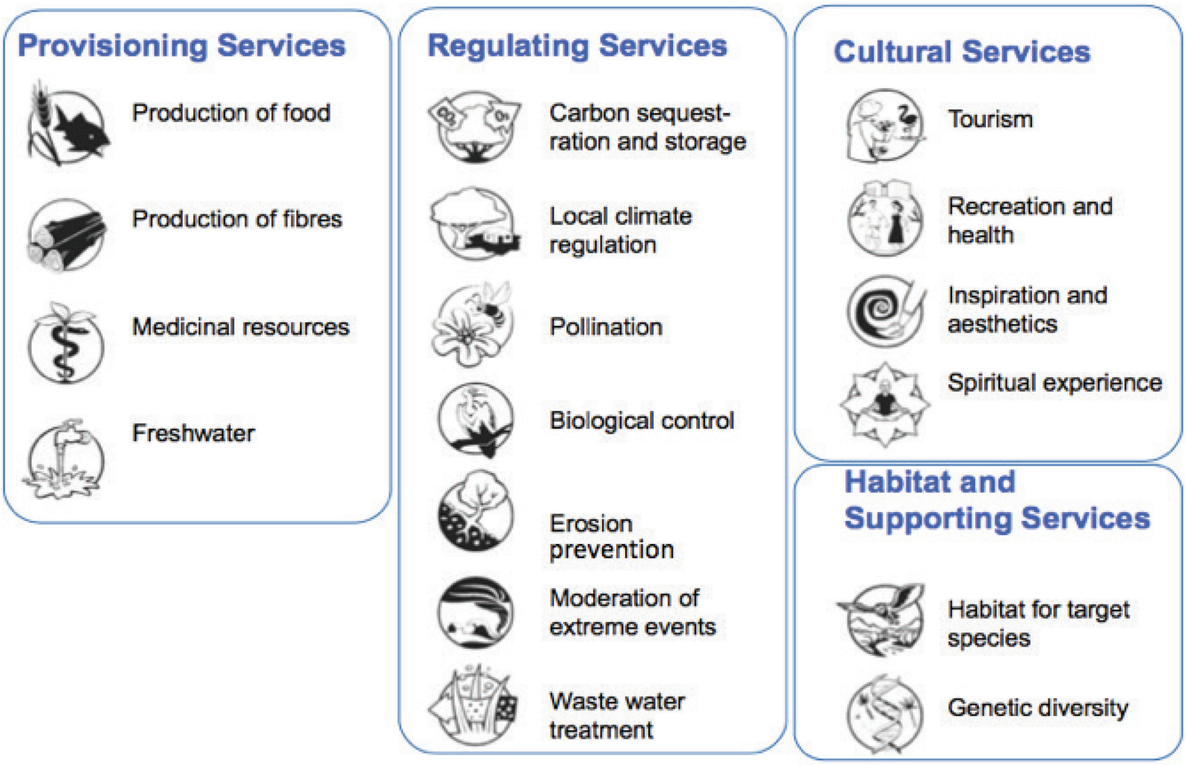

Figure 2. Examples of ecosystem services (TEBB 2012)

While the structure and extension of the shorezone are influenced by the area in question's topography and climate and the geological composition of its soil, the shorezone's water fluxes, nutrient and sediment inputs, and diffusion of animal and plant species are influenced by the lake's riparian vegetation. When unregulated lake-shore developments are built without sufficient planning authority oversight (a problem that particularly affects transboundary lakes), the functional shorezone can therefore be negatively affected.

1.2 The Shorezone Functionality Index

Understanding and evaluating the functions of the lake's shorezone provides the basis for creating a set of indicators that can be used to evaluate shorezone functionality, and it also supports and guides land planning policies and management choices. Furthermore, the need for a new index was also supported by the Water Framework Directive (WFD) 2000/60/CE, which, to determine ecological quality, requires that the evaluations of biological elements and the evaluation of hydromorphological elements be considered in conjunction.

The WFD defines the elements of quality (EQ) for classifying the ecological state of water bodies of any typology. Among the EQ to be determined are biological elements and hydromorphological elements that, for lakes, consist of the hydrological regime (quantity and dynamics of the water flow, water percolation and residence time) and the lake's morphology (variations in depth, characteristics of the substrate, and shore structure) (CIS Wetlands Working Group 2003).

The Shorezone Functionality Index (SFI) was developed in Italy in 2004 by a working group of the Italian Agency for Environmental Protection and Technical Services (APAT), which was coordinated by the Provincial Agency for Environmental Protection (APPA) of the Autonomous Province of Trentino, Italy.

The SFI was originally created as the counterpart to the already existing Fluvial Functionality Index (Siligardi et al. 2007) and was tailored to Alpine lakes. Subsequently, it has been employed by (a) the European Alp Lakes Project to assess lakes in Italy's Lombardy region, (b) the European SILMAS project to assess the lakes along the Alpine Arch (Italy, Austria and Slovenia), (c) the European Eulakes Project, albeit in modified form, to assess the large lakes of central Europe (Austria, Italy, Hungary and Poland) and (d) the University of Villarica, Chile, to train professionals with the Environmental Ministry (Ministerio de Medio Ambiente).

When using the SFI, morphological, structural and biotic parameters are evaluated in the field from an ecological perspective: biotic and abiotic factors are used to evaluate the buffering capacity of riparian vegetation, the complexity and artificiality of the shoreline, anthropogenic uses of the surrounding territory, and the way inputs from the watershed enter the water body.

This semeiotic index is easily surveyed, evaluates the state of the environment and assists in identifying the causes of deterioration by looking beyond the waterbody itself to include all the surrounding territory and drainage basin topography. The index not only provides baseline information on the status of the lake, but can also be used to support decision-makers tasked with planning environments adjacent to lakes and with managing lake water resources.

1.3 Methodology

To develop an initial overall understanding of the status of the lake, the first step of the SFI process involves reviewing existing literature on the hydrogeomorphological (HGM) characteristics of the lake and its drainage basin and on the pressures and current issues affecting these features.

The whole length of the lake is then surveyed, with surveyors navigating alongside the shore to gather information on the ecological parameters (typology, width, continuity and/or interruption of the riparian vegetation), socio-economic parameters (land uses, presence of infrastructure, etc.) and other abiotic parameters (steepness, concavity, shore artificiality, etc.).

Every time a change in one of these parameters is identified, a new form is completed and a new homogeneous shorezone is identified. In this way, the whole of the lake's shorezone is divided into different stretches with similar characteristics.

The data collected in the field is processed using the Shorezone Functionality Index software package (SFINX02) which determines the functionality value for each homogeneous stretch. There are five different categories of functionality, ranging from bad to high (Table 1), as suggested by the WFD 2000/60/CE.[3]

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[3] Editors' note: Contrary to the WFD classification system, whereupon any ecological status less than high (i.e. good, moderate, poor and bad) is considered to be caused by human activity (and should be reversed to the extent possible if less than good), low shorezone functionality may result from either natural causes or human activity. Only in the latter case measures can and should be taken to improve functionality. Nonetheless, even shorezones whose natural functionality is low (and therefore cannot be enhanced) require measures such as sustainable land use practices in the shoreline hinterland to prevent pollutants from being discharged into the lake unimpededly.

Table 1. Functionality levels, category names and reference colours

Level	**Category**	**Colour**	**Water Framework Directive**
I	High	BLUE	Acceptable
II	Good	GREEN	
III	Moderate	YELLOW	Not acceptable except where it is caused by natural processes
IV	Poor	ORANGE	
V	Bad	RED	

Of all the parameters collected in the field, only nine are actually processed using the software: shore artificiality, vegetation cover, presence of interruption within the lake's shorezone, concavity of the shore profile, presence of reeds, presence of arboreal species, presence of road infrastructure, heterogeneity of arboreal vegetation, and presence of non-hygrophilous species. These parameters were selected based on the results of an artificial neural network analysis (ANN), carried out during the development of the index. The ANN showed that these parameters had the greatest influence over the results because of their numerical weight. The remaining parameters are still, however, very important for the report and can also be used to develop the index in future.

The nine parameters are configured as a classification tree (Figure 3a), which shows the level of functionality (described as a sum of the percentages of each functionality level) of each homogeneous stretch.

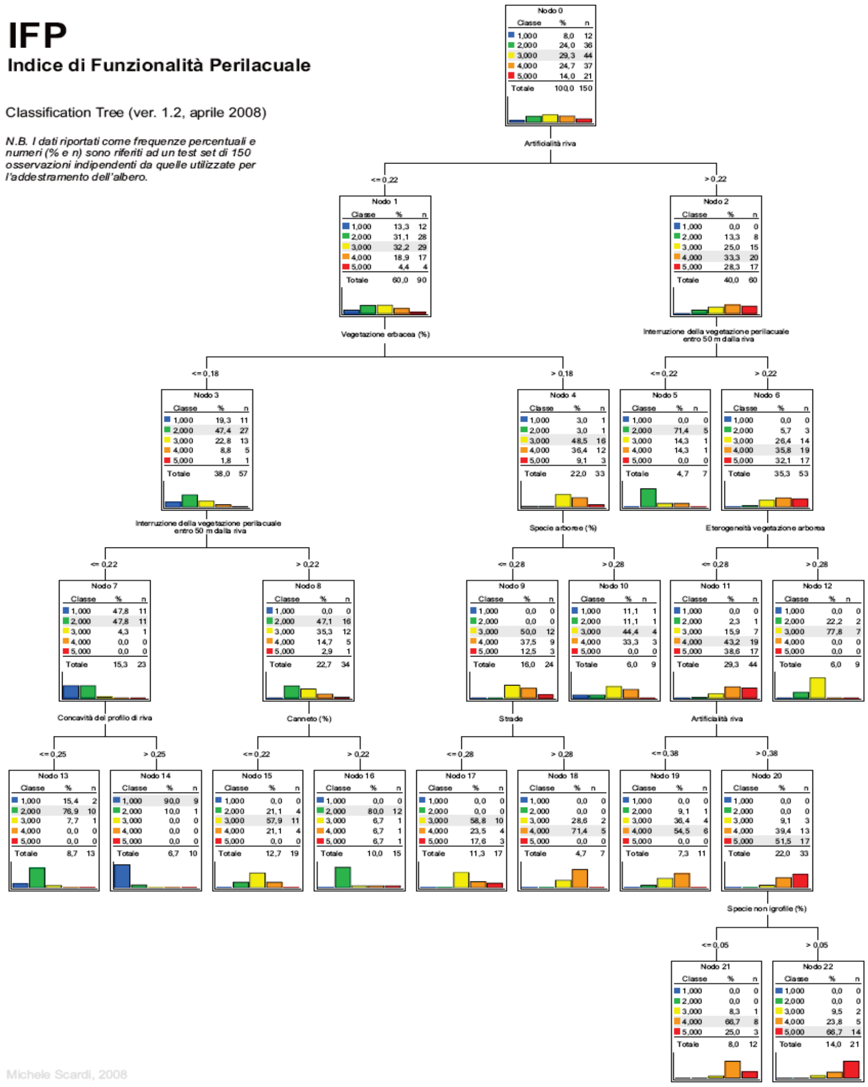
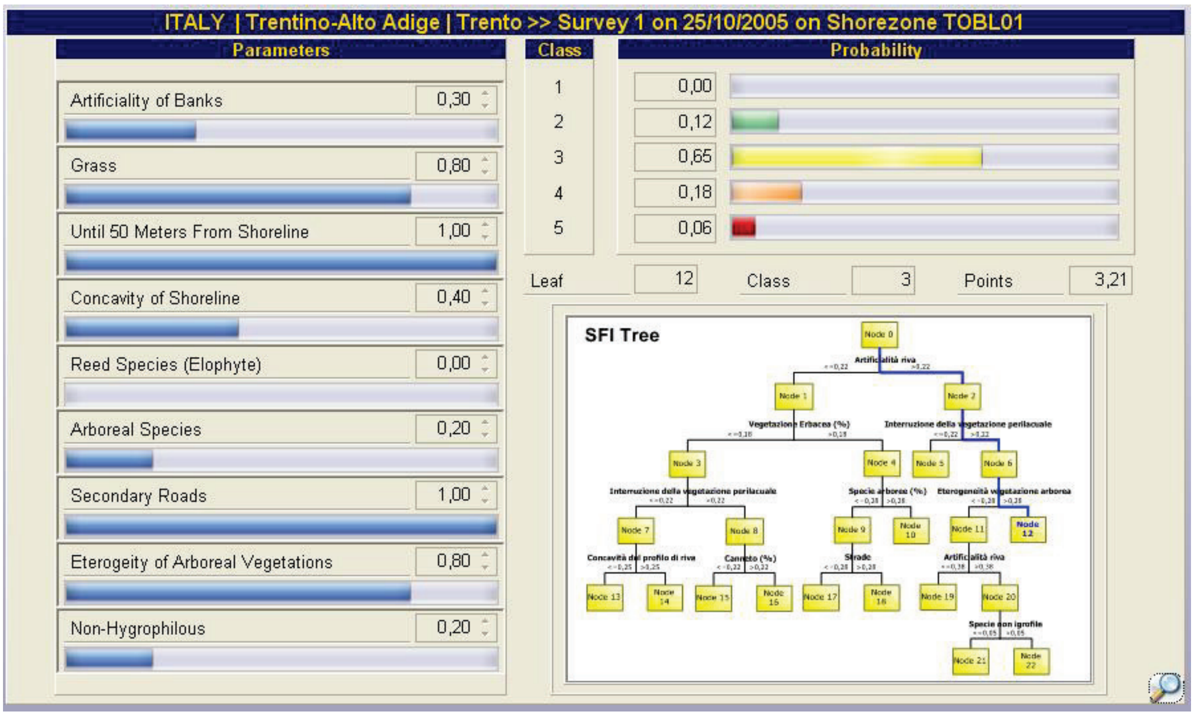


Figure 3a. The classification tree produced by the SFI software

Each node of the classification tree indicates for each homogeneous stretch the probability that it will fall into one of the five categories. Within each leaf, the higher probability percentage will determine the final level of functionality (Figure 3b).



ITALY | Trentino-Alto Adige | Trento >> Survey 1 on 25/10/2005 on Shorezone TOBL01

Parameters	
Artificiality of Banks	0,30
Grass	0,80
Until 50 Meters From Shoreline	1,00
Concavity of Shoreline	0,40
Reed Species (Elophyte)	0,00
Arboreal Species	0,20
Secondary Roads	1,00
Eterogeity of Arboreal Vegetations	0,80
Non-Hygrophilous	0,20

Class	Probability
1	0,00
2	0,12
3	0,65
4	0,18
5	0,06

Leaf 12 Class 3 Points 3,21

Figure 3b. Example of the results output by the SFINX02 software package for a given homogeneous stretch

The results and parameters are then transferred to a GIS platform, which makes it possible to create thematic maps of the parameters surveyed, to carry out spatial analyses, and to identify which locations are weaker or stronger and which are in greater need of or are more suited to restoration actions. The SFI maps are very important as they provide initial direct visualisations of the general status of the lake's shorezone – e.g. indicating the location of remaining areas of high functionality (blue colour) (Figures 4 to 6).

The length of each homogeneous stretch, and therefore of the total lake perimeter for each category, can also be calculated using GIS.

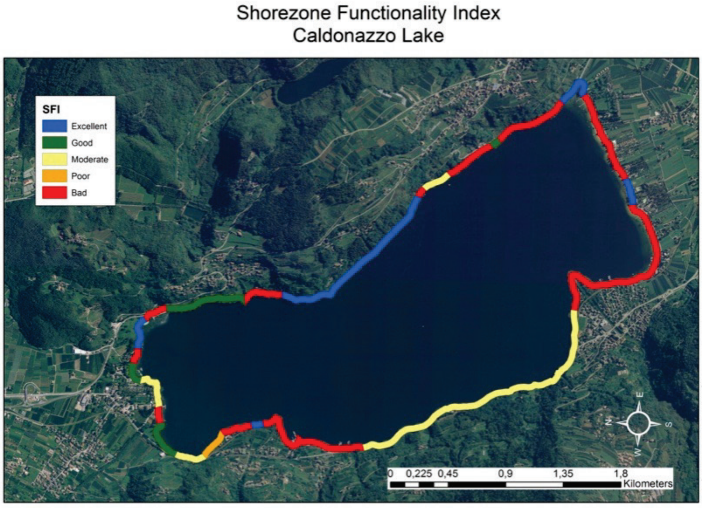


Figure 4. Map showing Shorezone Functionality Index results for Caldonazzo Lake, Italy, which provides an initial direct visualisation of the status of the lake

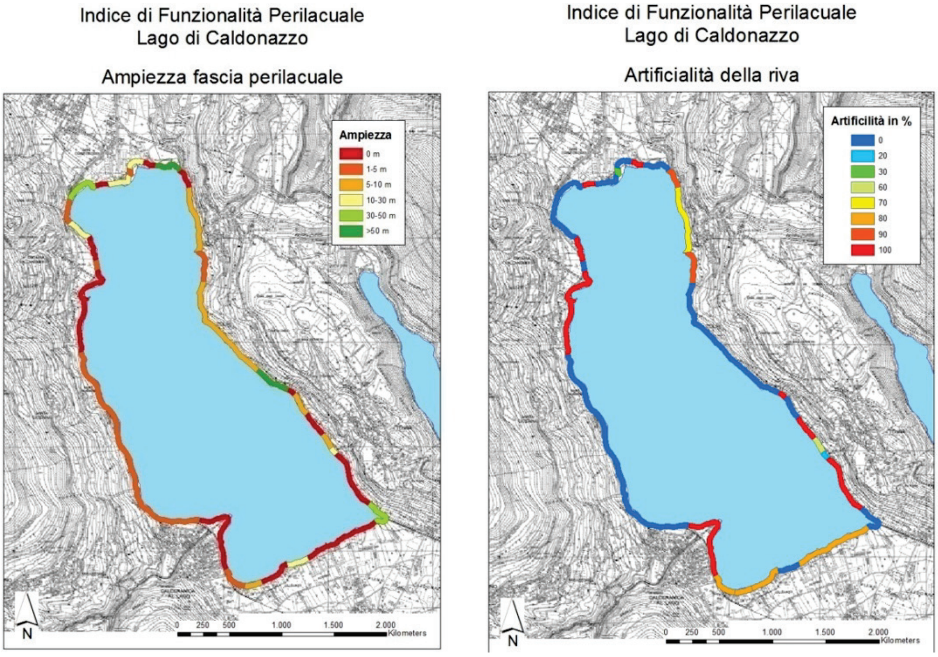


Figure 5. Thematic maps for Caldonazzo lake, with the left-hand map showing the width of the shorezone (red = 0 m, green = more than 40 m) and the right-hand map showing the artificiality of the shorezone (red = wholly artificial, blue = wholly natural)

It is important to keep in mind that the shore’s naturality and functionality are two different concepts. Therefore, a location with a wholly natural shorezone may, in certain cases, have low levels of functionality. For example, steep cliffs that descend directly into the water and have little or no riparian vegetation are often unable to perform any good ecological functions (Figure 6).

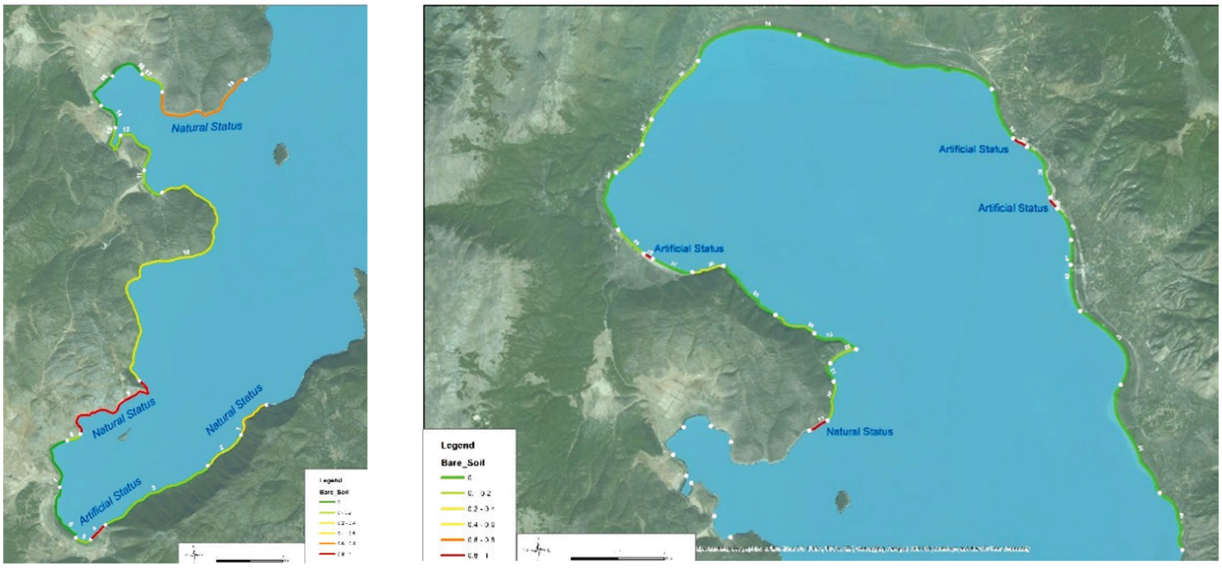
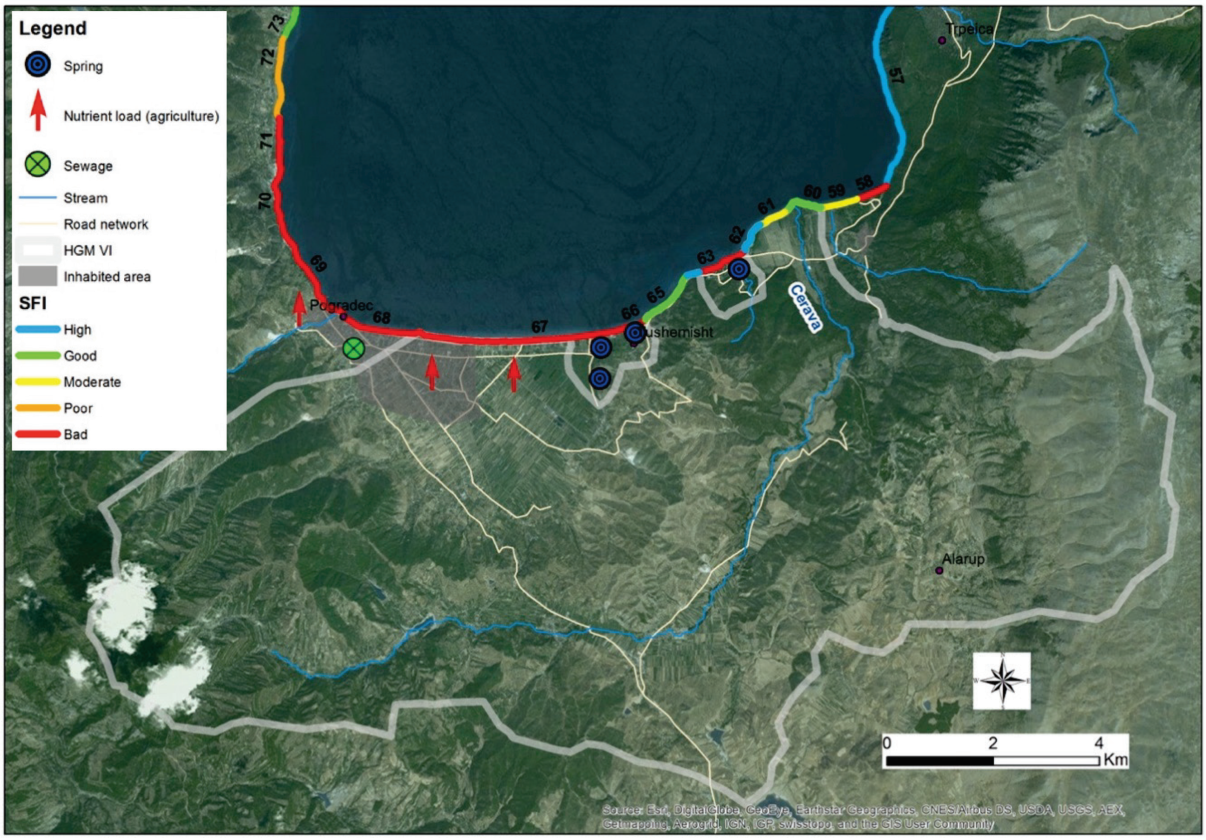


Figure 6. Percentage of “bare soil” at Lake Prespa, resulting in low shorezone functionality (i.e. moderate, poor or bad status). Bare soil may be the result of natural (e.g., steep cliffs) or anthropogenic causes (e.g., artificial sandy beaches). Only in the latter case measures must be taken to restore or enhance its functionality to achieve at least good status.

1.4 The Shorezone Functionality Index as a management tool

The potential of the SFI method lies in its ability to produce a synthetic value for the shorezone functionality of a lake. With the SFI approach, it is possible to complete studies on the internal dynamics of a lake, which are often altered by productive activities, recreation and tourism. By basing a lake's shorezone management on the concept of its functionality, the human uses of the lake can be reconciled with its environmental protection, which facilitates ecologically sustainable urban and rural planning and watershed management. Lake managers and stakeholders can use these results to develop a sustainable ecosystem-based approach to watershed management (Figure 7).



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 7. Example of an identified hydrogeomorphological (HGM) area at Ohrid Lake, Albania. The map shows the boundary of the HGM area (grey line), the presence of environmental stressors (i.e. the nutrient load from agriculture), hydrological factors (streams and springs), and the values produced when applying the Shorezone Functionality Index.

The results of the SFI, which are relatively economical and quick to obtain, provide an immediate general picture of the state of the shores around the lakes. This differs to earlier indices, which were only representative of specific points along the shore. The SFI results can also be used to easily identify the locations of and action needed in potential restoration sites (using the SFINX02 software, different scenarios can be modelled for a specific area and, by changing determinate parameters, it is possible to foresee the impacts public or private activities may have on the water body) as well as the locations of protected areas, sites of important economic value and so on.

The SFI responds to the current need, arising from the requirements of WFD 2000/60/CE, to develop new indices capable of assessing the hydromorphological elements of lake ecosystems, including riparian zones. Future SFI reports on the same lake can also be used to track changes in the shorezone over time. Under this project, a number of different output formats have been developed for end users – be they managers, local stakeholders or tourists – which include the SFI report, the SFI thematic maps and the SFI brochure.

The **SFI report** describes the status of the shores around the perimeter of a given lake, providing useful information on its level of functionality. Managers and stakeholders can then use this information to ensure the proper management of the lake's shores, to identify restoration sites and to test and determine which lines of action will make the restoration work a success. Alternatively, the report can simply be used as a baseline study for benchmarking future developments.[4]

The SFI report describes the lake and all the homogeneous stretches identified, and the way in which it is written ensures that the results are comprehensible to readers who may not be familiar with the Index or the lake. It highlights the shorezone's weaknesses and strengths and indicates specific actions required to improve the lake's functionality. The report covers the following areas:

- The lake's location, origin and history
- Results, statistical analysis and management recommendations
- Application of the Shorezone Functionality Index (description of each homogeneous stretch with photos, SFI results and specific recommendations where applicable).

SFI thematic maps can be created for each parameter collected in the field. A shapefile containing this information is created for each lake and for each SFI study. When the results are imported into a GIS environment, geospatial and geostatistical analyses can be performed. For example, SFI studies carried out on a specific lake in two different years can be compared to extract information on changes in the shore functionality over time.

The **SFI brochure**, which is usually made available in both English and the local language, was developed as a way of communicating SFI results to the general public. The brochure briefly describes the methodology and the lake's main categories, and provides a summary of the statistical results and management suggestions.

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[4] For similar reports on Lakes Prespa and Shkodra/Skadar, see Blinkov et al. (2017) and Bajkovic et al. (2017), respectively.

2 OHRID LAKE

2.1 Location, origin and drainage basin

Figure 8. Location of Ohrid Lake in Europe

Ohrid Lake is a transboundary lake shared by Albania and Macedonia (Figure 8). In the delineation set out in the Water Framework Directive (WFD), the entire catchment basin of Ohrid Lake falls within Ecoregion 6 – Hellenic Western Balkans (Figure 9).

Figure 9. Position of Ohrid Lake on the map of European ecoregions
(Ecoregion 6 – Hellenic Western Balkans)

Ohrid Lake is a high-altitude lake, sitting approximately 693.5 metres above sea level (Popovska and Bonacci 2007). It is separated from Prespa Lake (which is located at a higher elevation of around 850 metres above sea level) by the karstic Galitsica Mountain on its eastern side. A large amount of Prespa Lake's water seeps into the soil, drains away through a network of underground fissures and supplies the springs located on the shore of Ohrid Lake (Popovska and Bonacci 2007). The drainage basins of Ohrid Lake and Prespa Lake form part of the Drin River drainage basin. The Drin River originates on the northern shore of Ohrid Lake and flows northward across Albania where, close to its mouth on the Adriatic Sea (Albania/ Montenegro), one of its main distributaries joins with the Bojana/Buna River, which drains Skadar/Shkodra Lake (Figure 10).

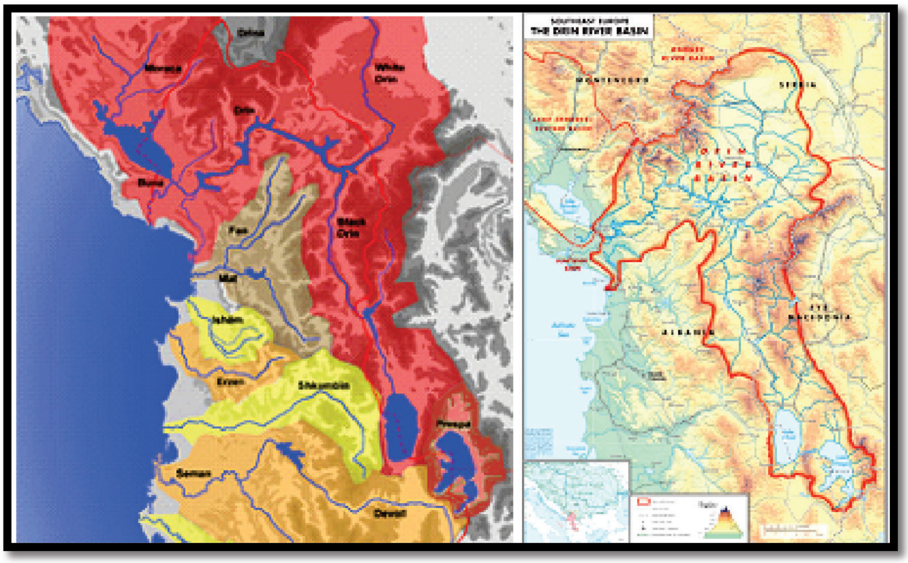


Figure 10. Location of Ohrid and Prespa Lakes within the Drin basin and flow of water from Prespa to Ohrid Lake

2.1.1 Lake origin

Both Lake Ohrid and Lake Prespa are believed to have been formed during the Pliocene, roughly two to three or possibly even five million years ago (Albrecht and Wilke 2008; Trajanovski et al. 2010). While they could potentially therefore be classified as ancient lakes, the definition for ancient lakes is currently under debate. Some authors define them as extant lakes that have existed continuously since before the Pleistocene, while others suggest that they existed since at least before the last glacial/interglacial cycle (>120,000 years; Albrecht and Wilke 2008; Gorthner 1994; Martens et al. 1997). All that said, Ohrid Lake is deemed to have existed continuously since its formation during the Pliocene, which means this lake's status as an ancient lake is not disputed (Salemaa 1994; Albrecht and Wilke 2008).

Most other short-lived lakes exist for less than 100,000 years before they eventually silt up. It is believed that, in the case of Ohrid Lake, this process was delayed by its substantial depth and the small amount of sediment input by its filtered spring inflows. Moreover, the Ohrid-Korça graben to the south of the lake is still tectonically active and might mitigate sedimentation through subduction.

Worldwide, there are only a few lakes with a similarly distant origin.

2.1.2 Drainage basin

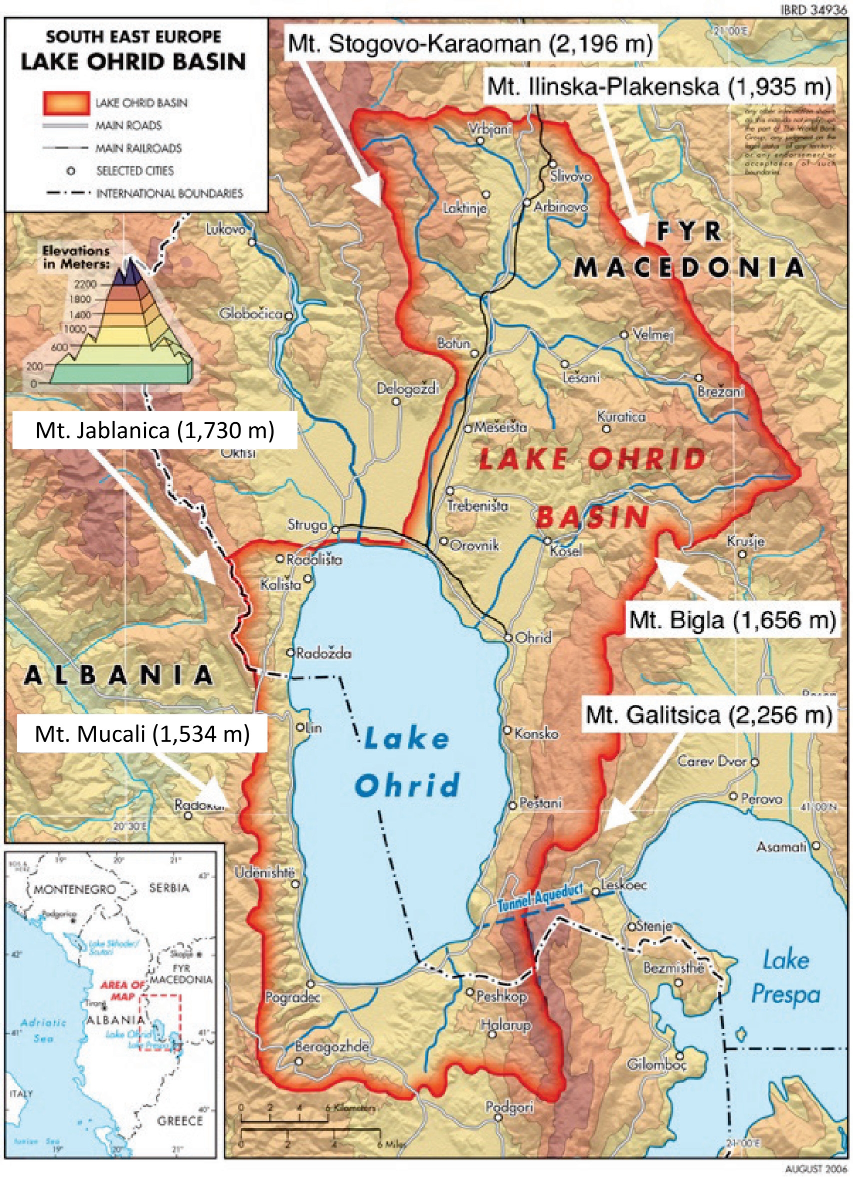


Figure 11. Topography of the Ohrid Lake drainage basin and its main peaks

Three quarters of the perimeter of the Ohrid Lake drainage basin comprises ridges of high mountains. The remaining quarter on the northern side of the basin is open and contains the outlet that constitutes the source of the Drin River (Figure 11).

Ohrid Lake's drainage basin covers an area of 1,057.1 km², some 80% of which falls within Macedonian territory and some 20% within Albania (Table 2).

Table 2. Characteristics of Ohrid Lake drainage basin

Key: m a.s.l. = meters above sea level

	Total area of the drainage basin and lake surface area (km^2)	Drainage basin area (km^2)	Lake surface area (km^2)	Minim. Height (m a.s.l.)	Maxim. Height (m a.s.l.)	Average Height (m a.s.l.)	Slope (%)
Macedonia	1,087.6	842.9	244.7	693	2,256		
Albania	318.3	214.2	104.1	693	1,534		
Total	1,405.9	1,057.1	348.8	693	2,256	1,139	28.5

2.1.3 Ohrid Lake geographical information

The mapping and measurement of Ohrid Lake drainage basin provided the following data:

- Area of the whole territory (drainage basin + lake surface area): 1,405.9 km^2
- Lake's surface area: 348.8 km^2
- Area of the drainage basin: 1,057.1 km^2
- Mean altitude of the watershed: 1,139 m above sea level
- Mean slope of the watershed: 28.5%
- Central point: N 41^{0} 13′ 56″, E 20^{0} 53′ 03″
- Length (from Struga to St Naum): 29.6 km
- Width (from Radožda to Ohrid): 13.3 km

2.2 General form of the lake

Tables 3 to 6 (SFI Form 1) summarise Ohrid Lake's morphological, climatic and physical characteristics.

Table 3. General characteristics

	Indicator	Typology
GENERAL CHARACTERISTICS	Origin	tectonic
	Type	natural large
	Location	mountain
	Latitude (north)	41° 25′ 33″ to 40° 53′ 26″
	Longitude (east)	20° 34′ 58″ to 21° 01′ 36″
	Altitude of the lake	693.5 metres above sea level (Popovska and Bonacci 2007)
	Average altitude of the catchment basin	1,193 metres a.s.l.
	Main geological type of the substrate	calcareous (east), magmatic and metamorphic (north), sediments (central part)

Table 4. Morphological characteristics

	Indicator	Typology
MORPHOLOGICAL	Area of drainage basin (DB)	1,057.1 km^2
	Shoreline length	87.8 km (56 in Macedonia + 31.8 in Albania)
	Area of lake (LA)	348.8 km^2
	Volume	55.5 km^3
	Maximum depth	289 metres
	Average depth	155 metres
	Structure and substrate of the lake bed	sandy-muddy

Table 5. Climatic characteristics

	Indicator	Typology
CLIMATIC	Precipitation	765.9 mm/year
	Average max. January temperature	6°C
	Average max. July temperature	28°C

Table 6. Other characteristics

	Indicator	Typology
OTHER	Average residence time	70–85 years
	Tributary/effluent capacity	8.8 m^3/s
	Spring/groundwater	20.2 m^3/s (Albrecht 2008)
	DB/LA relationship	4.02
	Water-level changes	normal fluctuation
	Thermic cycle	dimictic
	Summer transparency (Secchi disk)	22 metres (A. Matzinger)
	Trophic classification	oligotrophic

2.2.1 Water balance

The water balance of a drainage basin depends on the water inflow (precipitation + river water entering the lake + springs) and outflow (evaporation + river water exiting the lake + seepage). Variations between water inflow and outflow result in water-level oscillations (Table 7).

The water balance is important as it captures the level to which the water input into the lake offsets its outputs. Modifications due to human intervention (e.g. the extraction of water for agricultural use) can strongly affect this balance.

Ohrid Lake is fed primarily by underground springs on its eastern shore (about 53% of total inflow), whereas direct precipitation and river inflow each contribute 23% (Matzinger et al. 2006). A little less than half of the water in Ohrid Lake comes from its tributaries. On the Macedonian side, the Sateska and Koselska Rivers are the largest contributors. While there is substantially less fluvial water input on the Albanian side, the Pogradec and Verdova Rivers are the largest contributors. The remaining inflow comes from the springs that flow into the southern part of the lake at St Naum, Drilon and Tushemisht. These springs are fed by water flowing out of the porous karst mountains of Galitsica and Mali i Thatë to the east. Over thousands of years, holes and channels have formed within the rock that makes up these mountains. Gravity transports water from the Prespa watershed (Prespa Lake sits about 150 metres above Ohrid Lake) down to Ohrid Lake through the channels in the karst.

Table 7. Water balance of Ohrid Lake

Element of water balance (WB)	**Units (m^3/s)**	%	**Units (10^6 m^3)**
INPUT	**37.9**		**1,056.5**
Precipitation on lake surface	8.8	23.2	276.6
River inflow			456.3
Albanian catchment	0.5	1.3	
Macedonian catchment	7.4	19.5	
Temporary inflows	1.0	2.6	
Springs			[324 known springs]
Surface springs inflow	10.3	27.2	
Sublacustrine springs inflow	9.9	26.1	
OUTPUT	**37.9**		**1,101.8**
Surface outflow	24.9	65.7	693.8
Evaporation	13.0	34.3	408.0
Source of data	Albrecht 2008		Popovska 2002

2.2.2 Climatic elements

As a result of its geographical location and proximity to the Adriatic Sea and the existence of orographic barriers, the climate of the Ohrid Lake basin is mostly determined by Mediterranean influences from the south as well as continental influences from the north (Watzin et al. 2003). The specific climatic characteristics of the Ohrid region are significantly influenced by Ohrid Lake and its thermal capacity, which appears to act as a climatic modifier.

Data on precipitation, cloud cover, humidity and temperature are collected daily at the main meteorological stations in Ohrid (positioned 760 m above sea level, HGM area III) (Figure 12).

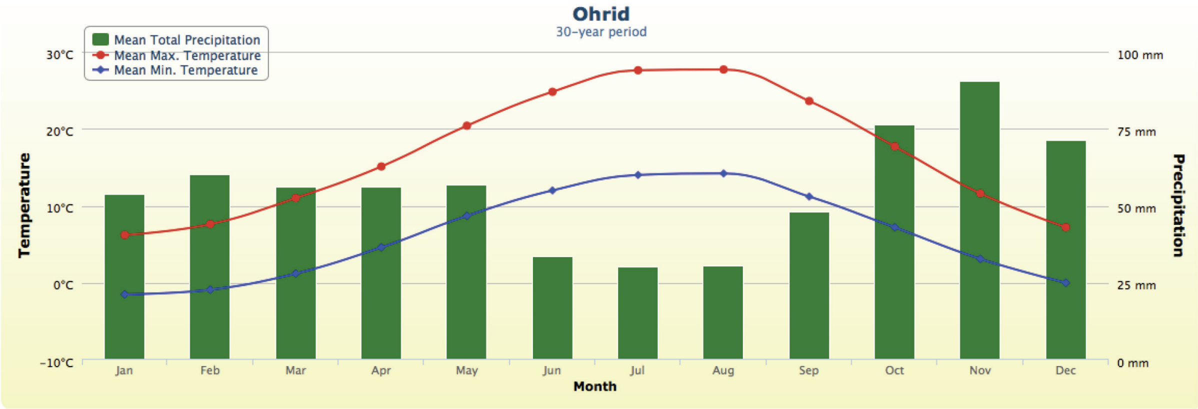


Figure 12. Meteorological parameters for the Ohrid station

The temperature of the Ohrid region is specific to the region and is conditioned by the thermal capacity of the lake and its thermoregulatory influence, which is especially felt during the winter months in the lake's coastal areas (Figure 12 and Table 8). When analysing the data recorded at the Ohrid meteorological station for the period 1950–2000, it is evident that, since 1985, the trend in mean annual values of air temperature anomalies (i.e. departures from the standard average air temperatures for the years 1961–90) has been positive. In other words, over the last few decades, the mean annual temperatures have increased by 0.5–1.0°C.

Table 8. Main climatic parameters for Ohrid Lake from 1971–2000 (World Meteorological Organization)

Month	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual**
Temperature in °C													
Average high	6.2	7.6	11.0	15.1	20.4	24.8	27.6	27.7	23.6	17.7	11.6	7.2	16.7
Average low	-1.5	-0.9	1.2	4.6	8.7	12.0	14.0	14.2	11.2	7.2	3.1	0.0	6.2
Precipitation in mm													
	53.7	60.2	55.9	55.9	56.7	33.5	30.0	30.6	47.9	76.1	90.5	71.3	662.3
Average precipitation days													
	11	12	11	13	12	8	6	6	7	10	12	13	121

The average mean annual air temperature recorded at Struga is 10.7°C and at Ohrid is 11.1°C. According to the world's assessment of the data provided by Macedonia's National Meteorological and Hydrometeorological Service, the highest mean monthly values are recorded in July and August and the lowest in January. The climatic norms are based on reference values that comprise average air temperatures recorded in 1961–90.

Precipitation is typically higher in November and December and later on in May (annual averages at http://www.holiday-weather.com/ohrid/averages). The lowest levels of precipitation occur in July and August. Annual precipitation totals in the Ohrid region stand at 703.1 mm/year at the Ohrid station and 1,194.0 mm/year at the Vevcani station (near HGM area II). Monthly totals for months with the highest precipitation levels are as follows:

- November – 94.6 and 162.6 mm, respectively, in Ohrid and Vevcani,
- December – 83.9 and 154.5 mm, respectively, in Pestani (HGM area IV) and Vevcani (HGM area II),

The monthly precipitation patterns show that precipitation is abundant in the winter period, receiving over 50% of the total annual rainfall.

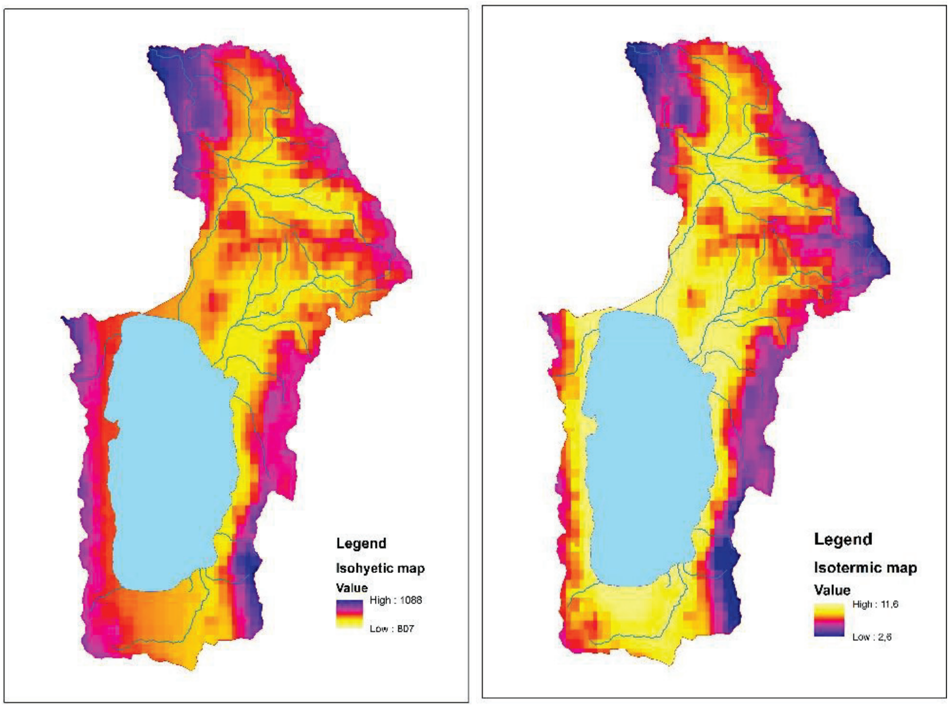
ALBANIA

The location of the land in Albania and the region's Mediterranean and continental influences mean that precipitation is very localised and generally increases with topographical elevation towards the north.

Table 9. Yearly average precipitation at different meteorological stations (Popovska 2013)

Macedonia	Precipitation (mm)	Albania	Precipitation (mm)
Ohrid	703.1	Pogradec	747.8
Struga	793.9	Grice e Madhe	913.3
Saint Naum	888.6	Liqenas	752.1
Radolista	1,048.0	Prrenjas	867.5
Pestani	728.9	Llenge	969.5
Meseista	913.3	Stravaj	1,445.0
Vevcani	1,194.0	Shegeras	608.7
Slivovo	954.6		

A map showing equal rainfall levels over an area (isohyet map) has been drawn up using data provided by the Macedonian State Hydrometeorological Service (Mincev 2016, author's personal work). Note that no rain gauges are located in high-mountain areas. The mean annual rainfall in this region reach over 1,000 mm/year.



Figures 13 and 14. Isohyet and isothermal maps of the Ohrid Lake watershed

The maps in Figure 13 and 14 show that the drainage basin has an average temperature of 9.41°C (minimum 2.6°C, maximum 11.6°C) and average precipitation of 885.26 mm/year (minimum 807 mm/year, maximum 885.26 mm/year).

2.2.3 Hydromorphological elements

Ohrid Lake is hydrogeologically connected to Prespa Lake, which is located at an elevation of between 150–159 metres above Ohrid Lake (depending on water level oscillations).

The two lakes are separated by the Galitsica and Suva Gora mountains, which consist of karstic limestone. Prespa Lake does not have a surface outflow, so its waters seep into the soil and through numerous ponors, most of which are found beneath its western shores. The water resurfaces in Ohrid Lake through its many coastal and sublacustrine karst springs, which are located along its eastern shore (Popovska and Bonacci 2007) (Figure 15).

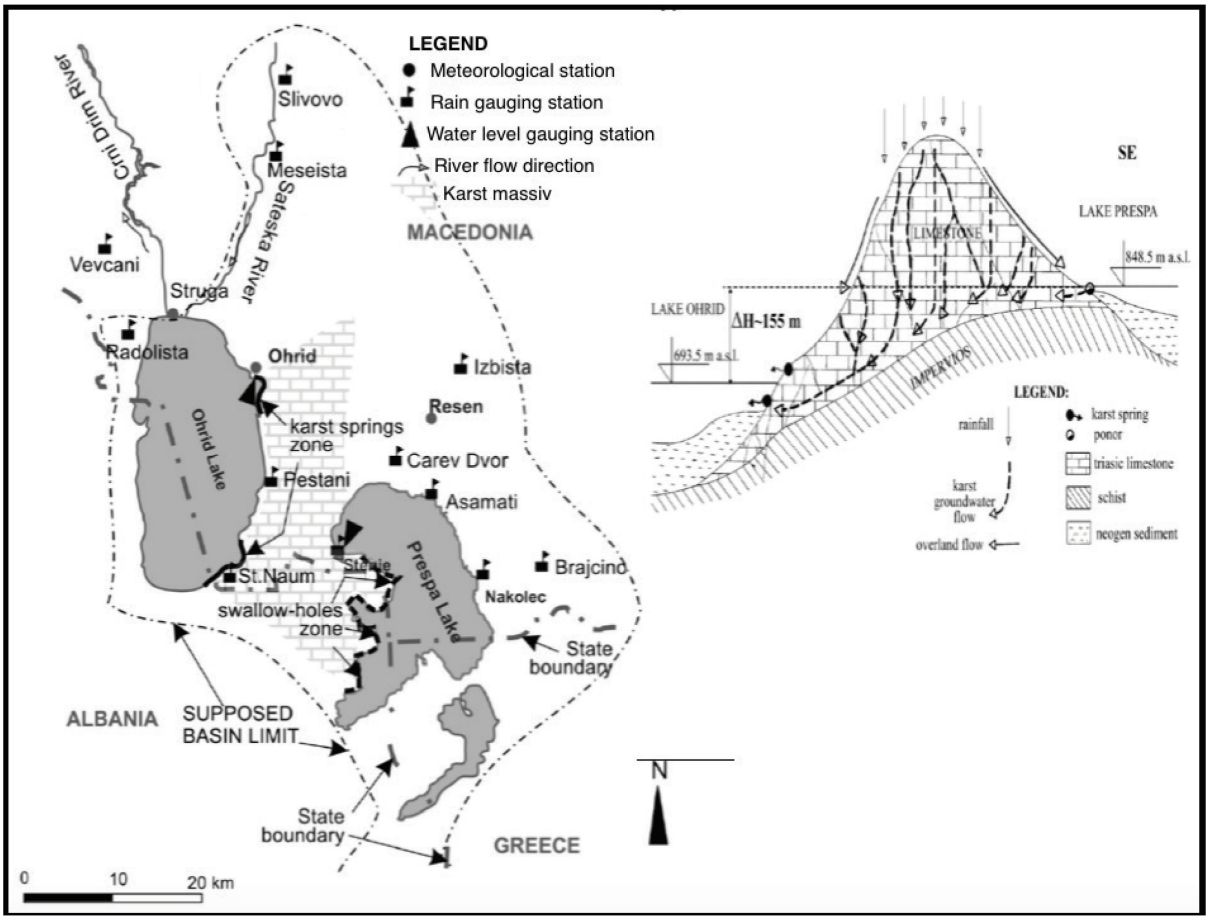


Figure 15. Water pathways from Prespa Lake and rainwater falling on Galitsica Mountain to Ohrid Lake (Popovska and Bonacci 2007)

2.2.4 Water level oscillation

While nearby Prespa Lake experiences major oscillations in its water level, oscillation in Ohrid Lake is insubstantial.

Data on water-level oscillation in Ohrid Lake for the period 1951–2000 (Popovska and Bonacci 2007) show level changes of 1.6 m, with the lake's elevation varying between 693.0 m and 694.6 m above sea level, and an average elevation of 693.5 m above sea level (Figure 16).

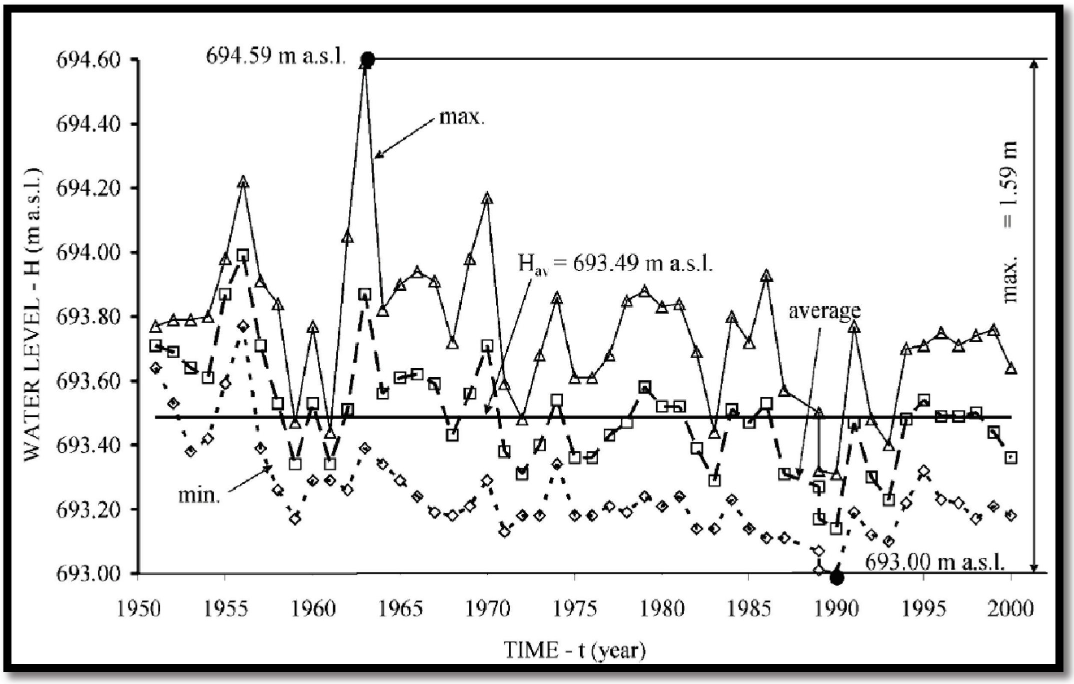


Figure 16. Ohrid Lake water-level oscillation (Popovska and Bonacci 2007)

Lake water-level oscillation and precipitation reach maximum and minimum levels in different seasons. Maximum precipitation occurs in the form of snowfall in November, when the lake's water levels are at their lowest. The snow remains throughout the winter at altitudes above 1,000–1,500 m a.s.l. but begins melting in April. The meltwater enters the lake, which then reaches its maximum water level in June (Popovska and Bonacci2007) (Figure 17).

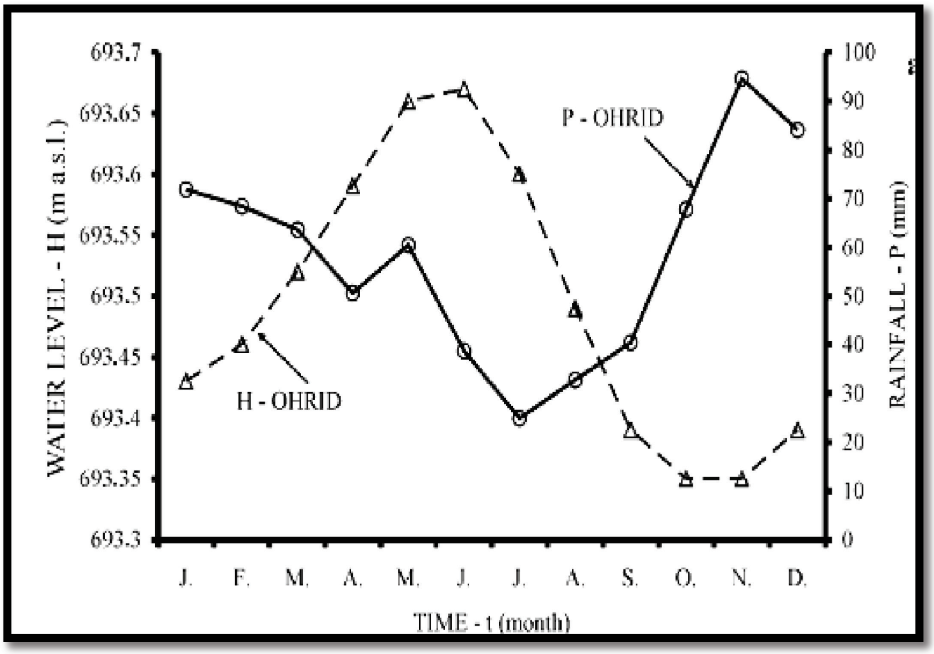


Figure 17. Overview of average monthly water-level variations (dotted line) and average monthly rainfall (solid line) for the period 1961–90 observed on Ohrid Lake (at the Ohrid gauging station and at Ohrid meteorological station) (Popovska and Bonacci 2007)

2.2.5 Springs

Karst springs are a very important source of water for Ohrid Lake (Table 10). Hydrogeological investigations have discovered numerous karst springs not only along the lake shore, but also at greater depths. Matzinger et al. (2006) determined that 49% of the inflow from karstic aquifers comes from sublacustrine springs and 51% from surface springs.

The most important inflows on the Albanian side are the Tushemisht and Drilon springs, the springs in the vicinity of Lin village and the Çerava, Pogradec and Verdova Rivers. The estimated average discharge from the Tushemisht karstic spring is 2.5 m^3/s and, an unknown quantity of water enters the lake through sublacustrine springs located along the shore between Saint Naum monastery and the Tushemisht springs (Hidrologjia e Shqipërisë 1985).

Table 10. Presence of springs, their location and annual yield (Micevski 2002) ("/" indicated no data available)

Location	HGM area	Number of springs	Average annual yield m^3/s
St Naum (Macedonia)	IV	15	7.4
Tushemisht and Drilon (Albania)	V	80	2.5–3.0
Biljana (Macedonia)	IV (border with III)	40	1.0–2.0
Bej Bunar (Macedonia)	IV (border with III)		0.5 (now dry)
Biljana sublacustrine (Macedonia)	IV (border with III)		

The hypothesis that the water from Prespa Lake is seeping into the karst massif of the Galitsica and Suva Gora mountains and draining into Ohrid Lake and/or its watershed was first published by Cvijić (1906). The validity of this hypothesis was recently proven with isotope-based tests (Anovski et al. 1997, 2001; Eftimi and Zoto 1997).

2.2.6 Main rivers

Besides the karst springs, Ohrid Lake has 40 tributaries, most of which are creeks and rivers that only flow temporarily during heavy rains and periods of snowmelt. The main fluvial tributaries of the lake in the Former Yugoslav Republic of Macedonia are the Sateska Reka, Koselska Reka, Grasnica, Racha, Karas Kafa and Mali Vlajrivers (Table 11 and Figure 18).

In Albania, the main tributary is the Çerava River. The Çerava's drainage basin lies mainly within Albanian territory; however, the river eventually passes into Macedonia where it enters Ohrid Lake.

Table 11. Basic hydrological data for the main tributaries

River	Drainage basin (km^2)	Length (km)	Average discharge (m^3/s)
Sateska	411.47	36.4	6.1
Koselska Reka	195.35	30.7	1.3
Grasnica	38.82	14.0	0.4
Çerava	86.12	23.0	0.2

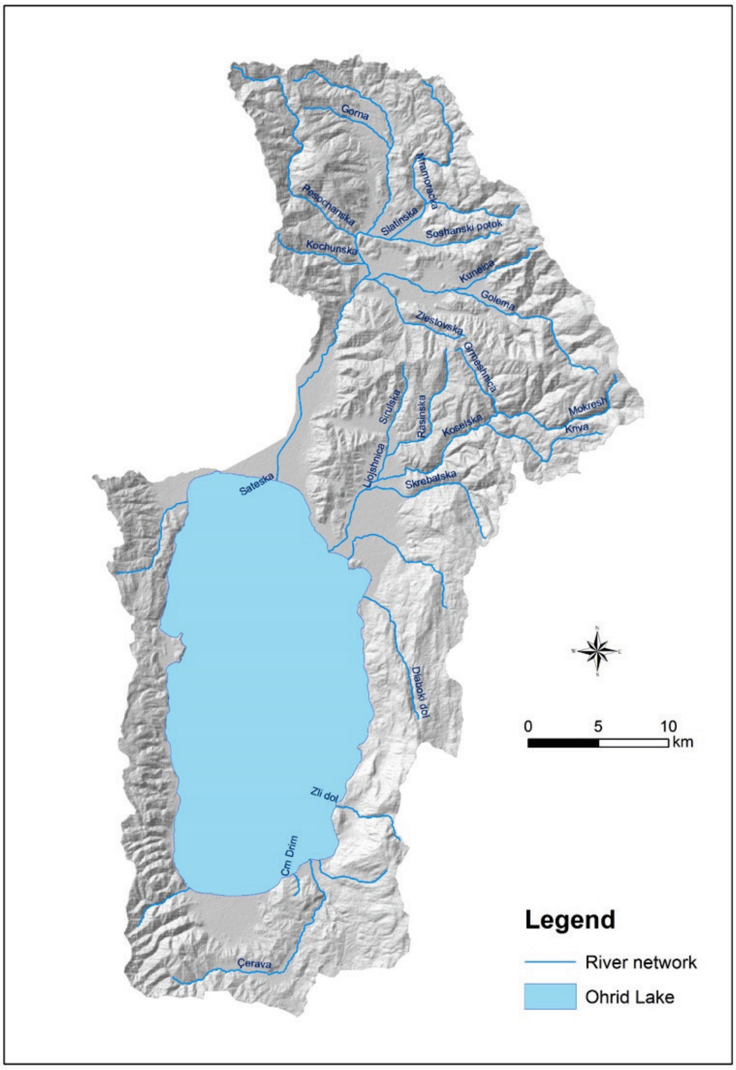


Figure 18. Main tributaries of Ohrid Lake

In 1962 the Sateska River was diverted away from its natural discharge into the Black Drin River and redirected into Ohrid Lake in order to drain the Struga marshland and support hydroelectric power generation on the Black Drin. The diversion of the Sateska almost doubled the size of the Ohrid Lake watershed and greatly increased the lake's siltation (the mean annual intensity of sediment yield is over 100,000 m^3). As a result, the levels of pollution in the lake – especially of phosphorus – have significantly increased (Blinkov et al. 2004; Trendafilov et al. 2006).

The Çerava River is the largest river on the Albanian side that flows into Ohrid Lake. It is located along the southern part of the lake and originates from several springs in the mountainous area of Guri i Kamjes, located at an altitude of 1,538 m a.s.l. The river mainly flows eastwards up to Çerava village and then, near Lubanishte village on the Macedonian side, it turns northwards. The river is 18 kilometres long and drains an area of 87 km^2, and its average discharge has been estimated at 1.5 m^3/s. The Pogradec River is a small stream that flows through the city of Pogradec from its source located in the mountains around the city. In total, the river drains an area of 10.6 km^2 and, during heavy storms, the steep 9.2% gradient of its riverbed makes it a flooding risk-factor for the city. To protect the city against floods, the river channel was lined with concrete in all urban areas. According to the hydrology data for 1974–90, the annual average discharge of the stream is 0.25 $m^3\ s^{-1}$. Another small stream that drains into the south-western section of Ohrid Lake is the Verdova River, which is around eight kilometres long and drains an area of 8.4 km^2 (Hidrologjia e Shqipërisë 1985).

The hydrological monitoring system for the Ohrid Lake basin comprises lake and river hydrological stations, and a water-level gauge located in Ohrid Lake.

2.2.7 Water output

Two-thirds of Ohrid Lake's water output passes into the Black Drin River at Struga town (Watzin et al. 2002) and then flows northwards all the way to the Lake Skadar/Shkodra area and the Adriatic Sea. Since 1962, the river's outflow has been controlled with a weir, which regulates the water level. According to an agreement between Yugoslavia and Albania in 1962, the maximum water level in Ohrid Lake is not permitted to exceed the value of 693 m a.s.l. and the minimum water level to fall below 691.65 m a.s.l. (Watzin et al. 2002). The remaining one-third of the lake's water is lost through evaporation (Watzin et al. 2002).

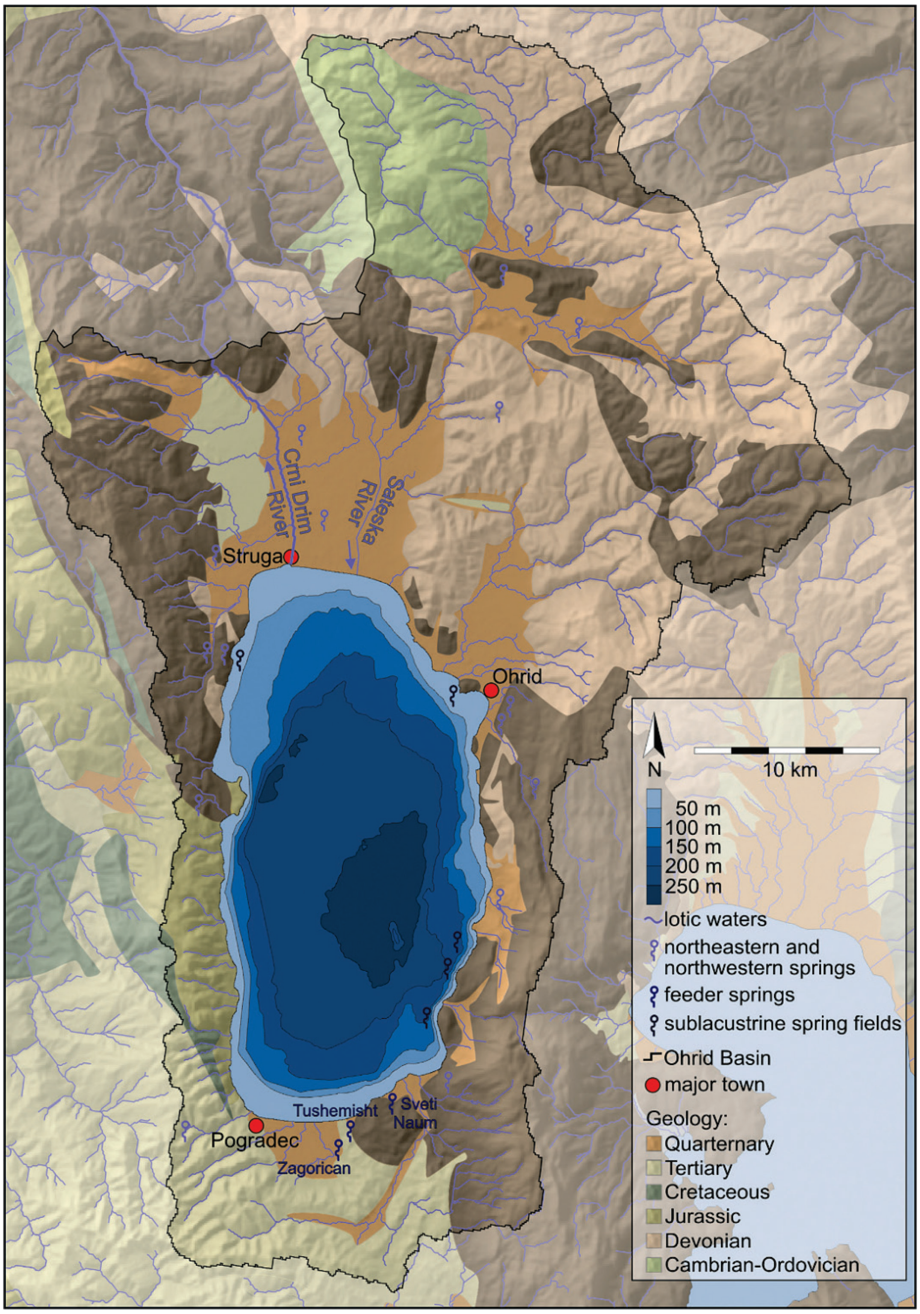


Figure 19. Map of the Ohrid Lake basin showing its major hydrological and geological features (Hauffe et al. 2011)

2.2.8 Water transparency

Data on water transparency was collected in 2007 (Matzinger et al. 2007), with transparencies recorded to a depth of 22 metres.

2.3 History

The shores of Ohrid Lake have been inhabited since prehistoric times. Archaeological findings indicate the area was first settled in the Neolithic period around 6,000 years BCE, and over the centuries numerous cultures have settled here. Indeed, the city of Ohrid is one of the oldest human settlements in Europe.

Ohrid's rich past (and thus cultural importance) and its natural beauty together have the potential to make the area an appealing tourist destination.

There are three urban centres on the lake's shores: Ohrid and Struga on the Macedonian side and Pogradec in Albania. There are also several fishing villages, but nowadays tourism has become a more significant source of income for these communities. The total number of settlements near the shorezone is 24 (14 in Macedonia and 10 in Albania). The lake's catchment area has a population of around 170,000 people, and approximately 131,000 of these people live directly by the lake (43,000 in Albania and 88,000 in Macedonia) (Spirkovski et al. 2000).

The largest proportion of tourists visiting the Ohrid region come from countries in the Balkan Peninsula. Tourists from Germany and the Netherlands are, to a lesser extent, also present in the region (Spirkovski et al. 2000).

2.3.1 Human pressure on the lake

The largest source of phosphorous that enters Ohrid Lake is households, with industry and agriculture being minor contributors. In particular, there are three small creeks close to the towns of Ohrid and Pogradec that have effectively become open sewers, and these add high amounts of bioavailable phosphorous directly into the lake (Shumka et al. 2014) (Figure 20).

As evidenced in the sediment records, a second major household-related contributor of phosphorous comprises numerous small sources – mainly households located directly by the lake shore and possibly leaking sewers or septic tanks (Shumka et al. 2014).

It is, however, the lake's largest tributary, the Sateska River, that carries the largest amount of phosphorus into the lake. As a result of erosion in the catchment area, Sateska River deposits more than 100,000 m^3/year of sedimentary layers in the lake. A total of 38.1 tonnes of this material is phosphorus, much of which accumulates close to the river's mouth. A significant area of the basin is experiencing high levels of erosion: in 5.28% or 53.96 km^2 of the territory, erosion control measures are deemed to be urgent. In addition, some 278 km^2 of territory is experiencing moderate levels of erosion, and erosion control measures and activities are recommended in these areas, too (Blinkov et al. 2004).

The average transparency of the Sateska River ranges from 45 cm to 65 cm. Moreover, much of the suspended material carried by the Sateska is deposited around the mouth of the river and an island is now forming in the area. Chemical pollution is the result of heavy metals and organic pollutants binding with suspended sediments (recent research shows that 60–90% of these kinds of pollutants bind to sediments, while the remainder is dissolved in water). Among other things, this pollution reduces the amount of oxygen in the lake's water, which is the main reason why it is losing its flora and fauna and why its biodiversity is declining (Shumka et al. 2014).

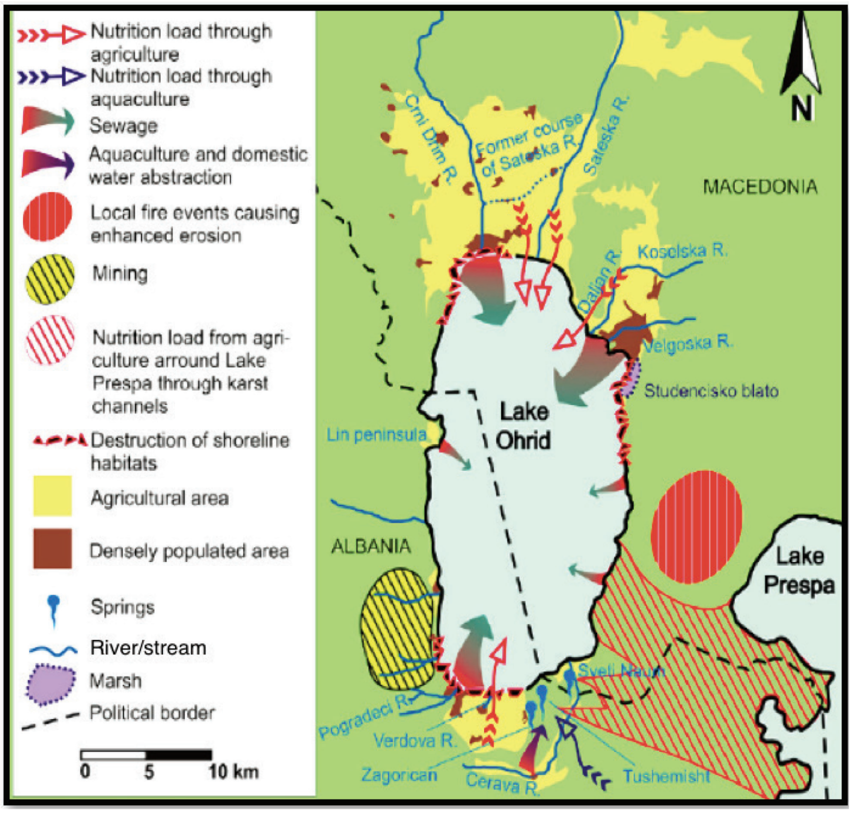


Figure 20. Map of the human pressures affecting Ohrid Lake (Kostoski et al. 2010)

The continuity of monitoring efforts on Ohrid Lake reflects the requirement of the EU Water Framework Directive (WFD) with regard to the operation of long-term monitoring programmes for special lake systems. Ohrid Lake is one of the world's few ancient lakes and globally is a biodiversity hotspot with a high natural value. Hydrological interventions have impacted on the lake system at many levels. A variety of agrochemicals are used in both countries with little or no control. In Macedonia several kinds of pesticide have been banned but they can still be illegally obtained and used. Indeed, traces of these banned chemicals have been found in tissue samples of fish, which means they may also threaten human health. Uncontrolled and excessive fertiliser use causes nutrient pollution and thus eutrophication. In the Macedonian section of Ohrid Lake, 65% of the wastewater generated in the Ohrid–Struga area is treated (in a 120,000-person-equivalent capacity plant) and discharged into the Black Drin.

Bacterial pollution is an issue at the points where streams and rivers discharge into the lake, as these watercourses carry human and animal waste from upstream villages. However, sewage collection and treatment in the Ohrid Bay area means that the waters in this zone are safe for both swimming and drinking. Waste produced by certain of the industries active on the Macedonian side of the watershed may be contaminating some of Ohrid Lake's tributaries. The unsustainable exploitation of the lake's fisheries has diminished its fish stocks, with the more commercially valuable species such as the Ohrid trout (*Salmo letnica*) being most affected. Fishing pressures are different on the two sides of the lake, which reflects the two countries' differing socio-economic situations and regulatory regimes.

Population growth and rapid urbanization in both Albania and Macedonia lead to an increase in the amount of sewage flowing into Ohrid Lake. Furthermore, heavy metal contamination from, for example, Albania's chrome or iron-nickel mines also remains a major problem, and long-term consequences of this contaminated waste entering the lake cannot be ruled out (Watzin et al. 2002).

Another problem is that solid waste is washed into the lake because sanitary landfills, like those at Bukovo/Koselska or Tushemisht, are rare or do not meet modern standards. Rubbish dumped into the lake accumulates over the years and eventually alters habitats.

In general, Ohrid Lake appears to harbour far fewer invasive species than do other Balkan lakes (Albrecht et al. 2009). It is, however, obvious that highly impacted littoral parts, such as Ohrid Bay or areas near the Lin Peninsula, have in recent times become home to several non-indigenous gastropod species (Albrecht et al. 2010). The number of observations of non-indigenous species will probably rise over the coming years and such species will need to be carefully monitored.

Figure 21a. Major threats in the Ohrid region (Shumka et al. 2014)

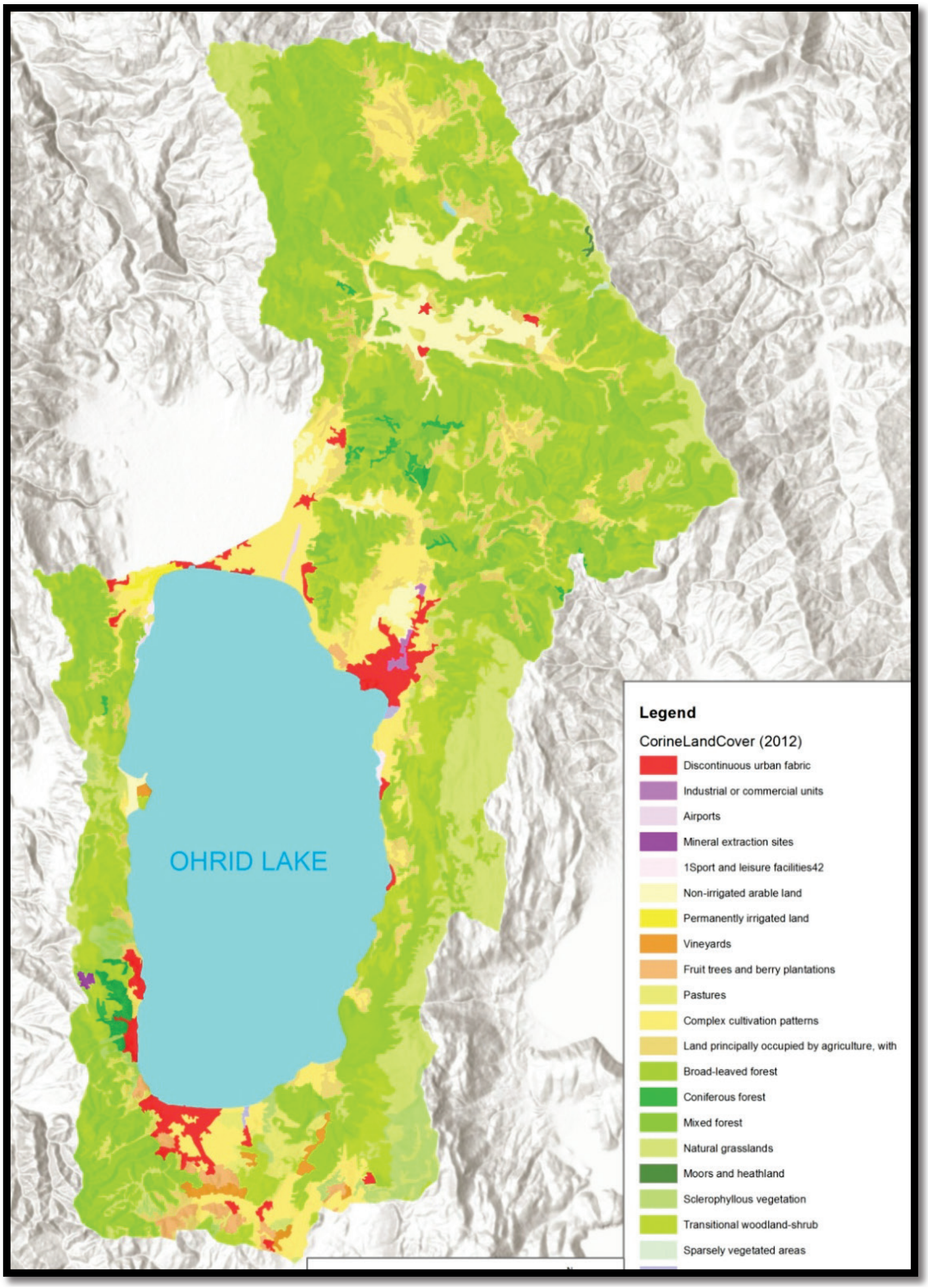


Figure 21b. Land cover map (Corine map 2012)

2.3.2 Protection and management requirements

The natural and cultural heritage of the Ohrid region has several layers of legal protection. The protection of cultural heritage is regulated by the Law on Cultural Heritage Protection (Official Gazette of the Former Yugoslav Republic of Macedonia No. 20/04 and No. 115/07), bylaws and a law that designates Ohrid's historic city centre as cultural heritage of particular importance (Official Gazette of the Former Yugoslav Republic of Macedonia No. 47/11). The protection of natural heritage is regulated by the Law on Nature Protection (Official Gazette of the Former Yugoslav Republic of Macedonia No. 67/2004, No. 14/2006 and No. 84/2007), which covers areas both inside and outside of protected areas. There is also the Law on Managing the World Cultural and Natural Heritage of the Ohrid Region (Official Gazette of the Former Yugoslav

Republic of Macedonia No. 75/10). It is important to keep such legal instruments updated and ensure their implementation so that the Ohrid region's heritage remains properly protected.

In 1979–80 Ohrid and Ohrid Lake were listed as a UNESCO World Heritage site because of its natural and cultural values (Figure 22). However, the Albanian side of the lake was not considered at that time. A process was initiated in September 2013 to include the whole lake. However, at the time of writing the present report, this process was ongoing.

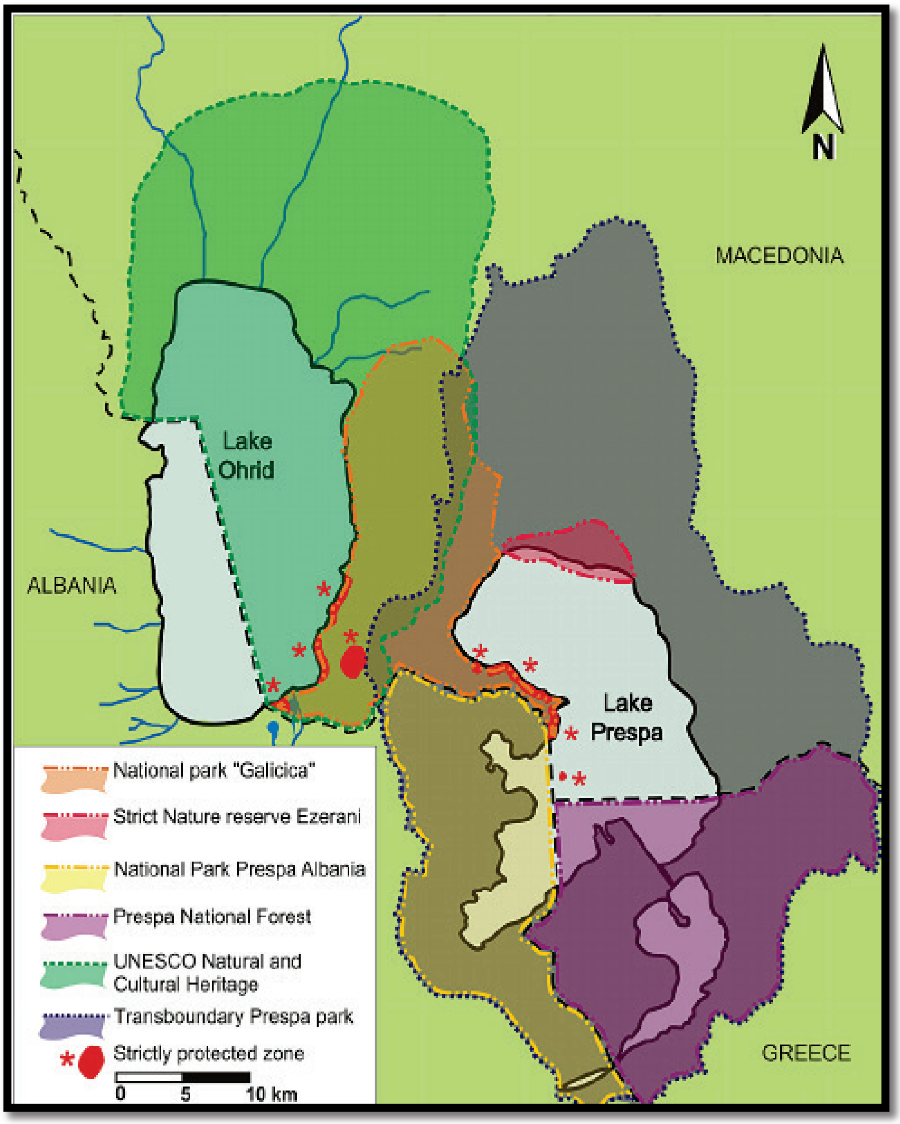


Figure 22. Map of protected areas of natural heritage (Kostoski et al. 2010)

2.4 Lake management

The management of the lake is shared between Albania and Macedonia.

2.4.1 Lake management in the Former Yugoslav Republic of Macedonia

Competences

The main national body competent for water is the Ministry of Environment and Physical Planning (MoEPP). Macedonia's Law on Waters regulates matters related to:

- "surface waters, including permanent and intermittent watercourses (…), **lakes**, reservoirs and springs; groundwaters, the riparian lands and wetlands;
- the management of waters, riparian lands and wetlands, which also includes water resource distribution, water protection and conservation, and protection against the harmful impact of waters;
- water management structures and services;
- the organisational arrangements and financing of water management; and
- the manner, conditions and procedures under which water can be used or discharged"

  (excerpt from Law on Waters, n°87, art. 1, 2008).

According to the Law on Waters of Macedonia, the shore belt of a lake or an impoundment is a 50-metre-wide zone that is measured from the line of the highest determined water level. Local municipalities are tasked with determining the riparian belt, whereas the MoEPP is tasked with evaluating efforts to this regard.

According to Article 131 on the Regulation and Maintenance of Surface Waters, among other things it is prohibited to remove sand, gravel and stones from the banks of water bodies, to cut trees or destroy vegetation on the banks, to dump waste material, etc. The state water-economy inspector (from the environmental inspectorate) is tasked with monitoring and, in cases where the laws are broken, ensuring the relevant penalties are applied to guilty parties.

Part of the western coast of Prespa Lake falls within Galitsica National Park. Therefore, according to the Law on Nature Protection, the national park's administration is also obliged to manage the riparian zone. Likewise, a section of Ohrid Lake's eastern coast falls within Galitsica National Park.

The management of lakeside land has, because of recent legal changes, been transferred to local municipal administrations (LMAs). While LMAs provide permits for urban facilities on the beaches and inspect the work of concessionaires, it is the Ministry for Transport and Communication (MTC) that manages the provision of **concessions** for these beaches.

According to the Law on Spatial and Urban Planning, LMAs are obliged to draw up new urban plans for their **urban** construction activities. The MTC then approves these plans – or not – in line with guidance or assent given by the MoEPP. Plans must be prepared as part of Strategic Environmental Assessments, which require the MoEPP's approval. As such, the MoEPP is able to postpone, request changes to or even stop a development that may threaten the lake and its shore.

Monitoring and research

Ohrid Lake has one outflow – the Black Drin River – which has a weir to control the lake's water level. A. D. ELEM (JSC Macedonian Power Plants) is responsible for maintaining the weir and for managing the water level, a process that must consider the two reservoirs and hydropower plants located on the Black Drin River downstream. According to the latest legislative changes, the State Hydrometeorological Service is the competent body for monitoring water quality. With the UNDP's support, a unit for monitoring Prespa Lake's water quality in line with WFD requirements has been established at the municipal level.

Given the Ohrid-Prespa region's ecological importance, numerous studies have been carried out on its lakes and their catchment areas. The Public Scientific Institution's Hydrobiological Institute was established in Ohrid in 1935 and was the first scientific institution in the Balkans. The Institute has previously undertaken a number of projects and programmes that have involved monitoring the lake's water quality and it has carried out numerous studies on the riparian zone. The Biology Institute under the Faculty of Natural Sciences and Mathematics at the University of Saints Cyril and Methodius in Skopje has also carried out several studies in these areas.

GIZ's 2015 report *Initial Characterisation of Lakes Prespa, Ohrid and Shkodra/Skadar* includes detailed information on monitoring sites and the current status of the lake.

Access to the shoreline

In general, the shoreline is state-owned. In cases where sections of the shoreline fall within a private plot and the development of this section is mooted, the state is entitled to preserve this shoreline by nationalising it. According to the Law on Waters, citizens are entitled to freely access the riparian belts of lakes, and the LMAs are duty-bound to ensure this access is maintained.

2.4.2 Lake management in the Republic of Albania

Competences

The competent national body for water quality monitoring is the Ministry of Environment (MoE), while the Ministry of Agriculture, Rural Development and Water Administration (MARDWA) is in charge of water administration.[5] The country's Law on Water regulates matters related to:

- surface waters, including watercourses, lakes, reservoirs, springs and groundwaters;
- riparian lands and wetlands, including water protection and conservation, and protection against the harmful impacts of water;
- water management structures and services;
- organisational arrangements and the financing of water management;
- the manner, conditions and procedures with which water can be used or discharged.

The main law covering lake management issues in Albania is the Law on the Integrated Management of Water Resources No. 111/2012, which is fully harmonised with WFD 2000/60/EC of the European Parliament. This Law aims to protect and improve water environments and water resources, ensuring their rational exploitation, fair distribution and protection from pollution, and it provides for the establishment of the central and local institutional frameworks required to implement national management and administration policies. According to this law, all of the Republic of Albania's water resources, including its lakes, are state owned and must be administered by state bodies. The main central authorities for the administration and management of water resources are the Council of Ministers (CoM), the National Water Council, MARDWA, MoE and the Technical Secretariat of the National Water Council.

The **Council of Ministers**, through the Prime Minister's Office, adopts bylaws proposed by the National Water Council on water management and approves the composition and functioning of the Technical Secretariat of the National Water Council. The CoM also approves the composition of the National

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[5] Reform of water administration ongoing at the time of publication of the present report

Water Council and regulates its operations, and it appoints a special commission for the management of transboundary waters. The CoM approves river basin management plans following their approval in principle by the National Water Council, and it approves the National Strategy for Water Resources Management.

The **National Water Council** is the central decision-making body responsible for the management of water resources. The National Water Council is the inter-ministerial body chaired by the Prime Minister.

The **Ministry of Environment**, in collaboration with line ministries, develops and implements policies, strategies, programmes and projects aimed at ensuring the integrated management of water resources and the quantitative and qualitative preservation and further consolidation of these resources. The **Ministry of Agriculture, Rural Development and Water Administration** is tasked with the main duties involved in managing the nation's water bodies.

At the local level, the authorities tasked with the management of water resources are the River Basin Councils and the River Basin Agencies. The Technical Secretariat of the National Water Council is the executive organ of this Council. River basin councils, which are responsible for managing water resources in given basins at the local level, report to the Technical Secretariat of the National Water Council. River basin agencies, which are set up in each watershed, are embedded in the central government structure.

Protected areas

Law No. 9806 of 6 June 2002 on Protected Areas provides the legal basis for the management of protected areas in Albania. It provides the framework for the designation, conservation, administration, management and sustainable use of protected areas and their natural and biological resources. The law pays special attention to the management of water areas and other natural resources within protected areas. It also provides the legal basis for the organisation of administrative structures and management committees for certain categories of protected area. It also defines the procedures for setting up and operating the management committees.

Monitoring and research

Monitoring is conducted to assess the effectiveness of water resources management measures. Water monitoring programmes are essential for assessing the main sources of pollution and eutrophication that are altering the current or potential ecological status of the lake ecosystem. Discharges from tributaries flowing into this ecosystem must also be monitored. A detailed monitoring plan for physical and chemical parameters is provided in the framework of the transboundary monitoring system for both Lake Ohrid and Prespa. Based on archival data of the Institute of Hydrometeorology, Tirana, a programme to monitor lake water levels is in place for both lakes (with water gauge measurements taken every two to three days). The monitoring of water quality and ecological status of water bodies on the Albanian side of the lake has been conducted since 1951 under the responsibility of different state institutions.

Currently, the Fishery Inspectorate is responsible for monitoring the lakes' fish stocks. The most recent (2013-2015) and comprehensive assessment of fish assemblages of Lake Ohrid has been conducted with support of GIZ (Spirkovski et al. 2017). State-owned forests and pastures are managed by the central government, whereas the forests and pastures defined as common property are managed by the commune authorities. Urban areas also fall under the autonomous commune organisation for the national park territory.

GIZ's 2015 report *Initial Characterisation of Lakes Prespa, Ohrid and Shkodra/Skadar* includes detailed information on the monitoring sites and current status of the lake (Peveling et al. 2015).

Access to the shoreline

The lake's shoreline is state property. Should any part of the shoreline fall within a privately owned plot and should the owner of this plot decide to develop this section of shoreline, the state is empowered to nationalise the section to maintain access. According to Albanian law, access to the riparian belts of lakes is free. As such, local governments are obliged to ensure continued free access to these areas.

3 RESULTS AND RECOMMENDATIONS

3.1 Hydrogeomorphological areas

Seven hydrogeomorphological (HGM) areas were identified during the fieldwork. They are characterised by different geological, hydrological and morphological features (Figure 23) which either represent an advantage for or a limitation to the natural growth of a functional shorezone. However, at Ohrid Lake the main modifier influencing the structure and functionality of the lake shorezone is anthropogenic pressure.

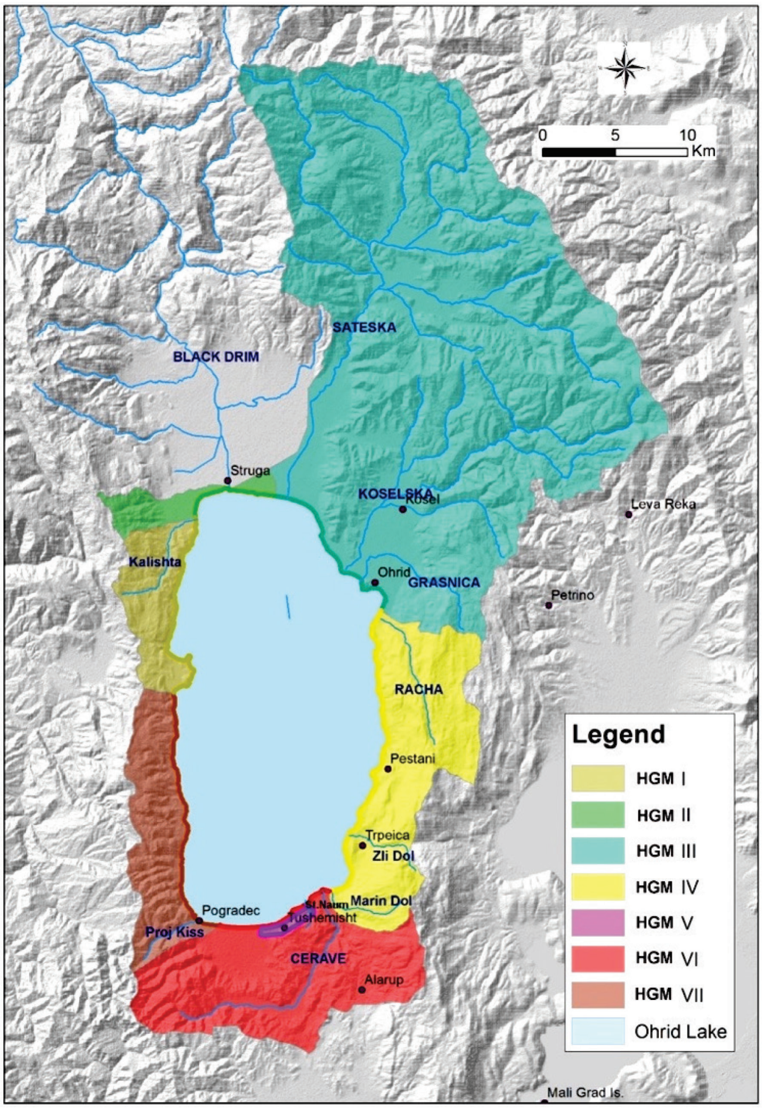


Figure 23. Map of Ohrid Lake's HGM areas

The ratio between the HGM drainage area and the HGM shore length shows which HGM areas are most liable to be affected by different types of land use (Table 12). Water coming from the drainage basin of HGM areas III and IV, both of which comprise flat land, is more likely to concentrate nutrients along a relatively short section of shoreline.

Table 12. Key shoreline data for each HGM area

HGM areas	Drainage basin (km²)	Shore length (km)	Ratio of drainage basin to shore	Stretch number ID
I – North Jablanica	40.7	16.1	2.5	1–10, 80–87
II – Black Drin River outlet	18.2	7.2	n/a (outlet)	11–15
III – Northern plains	677.5	13.4	50.6	16–35
IV – Karstic Mountains	115.9	23.5	4.9	36–59
V – Springs	2.3	8.9	0.2	63, 66
VI – Southern plains	130.8	8.7	15.0	60–62, 64–65, 67
VII – South Jablanica	62.8	18.8	3.3	68–79

3.1.1 HGM area I – North Jablanica mountain range (Macedonia)

The mountain range running north–south alongside the lake comprises two different geological substrates. For this reason, this range has been divided into two separate HGM areas, the northern part (HGM area I) is mainly formed of permeable limestone, while the southern part (HGM area VII) consists of ophiolites (Figure 24; Hoffmann et al. 2010).

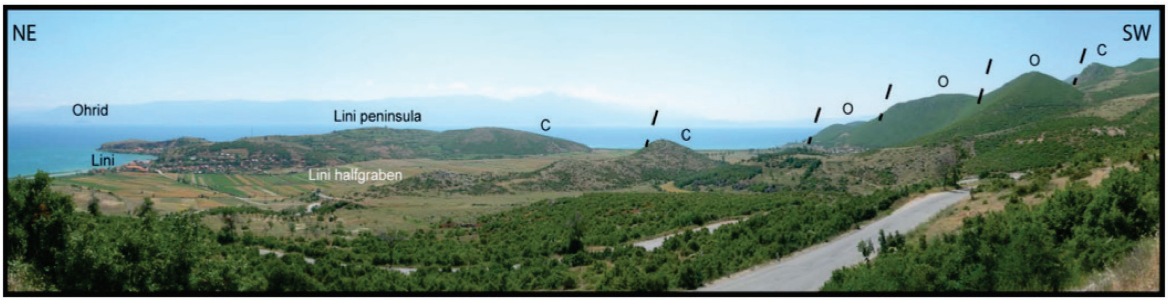


Figure 24. Panoramic view of the Lin half graben (Albania, looking south-east). Note the terraced landscape resulting from the faulting of ophiolites (O) and Late Cretaceous and Triassic carbonates (C) (Hoffmann et al. 2010)

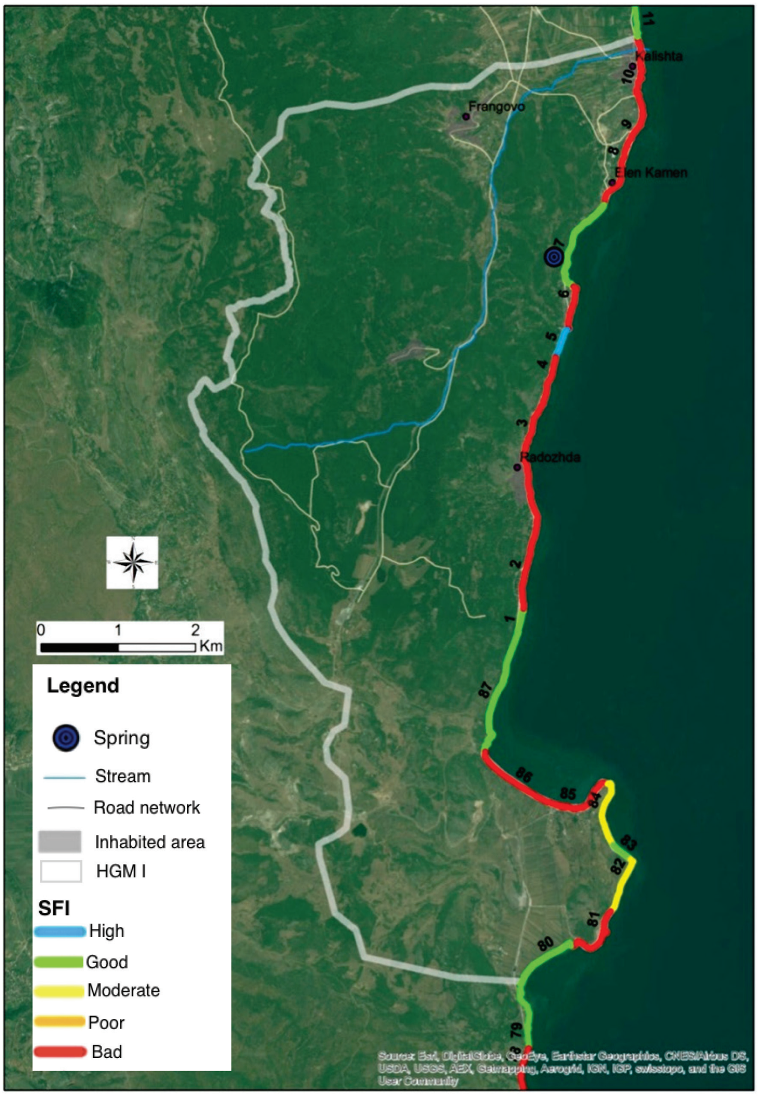


Figure 25. Map of HGM area I

HGM area I (Figure 25) is located in the most north-westerly part of the lake. It starts in Albania, includes Lin peninsula, and runs northwards up to the Macedonian town of Kališta. The area is characterised by the presence of the Jablanica mountain range, which is mainly composed of permeable limestone (Mount Jablanica reaches 1,730 metres above sea level). HGM area I contains 16.1 km of shoreline and covers an area of 40.7 km^2, most of which is covered by natural forest.

Hills descend here almost directly into the lake, leaving little scope for the development of riparian vegetation close to the shoreline. The surrounding territory is naturally covered with low-growing oak forest on the Macedonian side, while on the Albanian side this has been replaced by agricultural fields and grazing areas and only ash and hornbeam trees have been recorded.

With the exception of the Albanian–Macedonian border area, which has remained undeveloped, the shore is experiencing mild anthropogenic pressures: a number of villages are sited along the shore and the main road runs a few metres away from the shoreline thus limiting the width of the shorezone.

With the exception of the shoreline containing tourism infrastructure (stretching from Hotel Relax to Hotel Erlin and the town of Lin), most of the Albanian shore can be classified as typology 3 (cliff with limited vegetation). The presence of reeds in this area is particularly important as they provide habitat for spawning fish and fry. A rearing facility for koran fish (Ohrid trout) is located close to the border. Fingerlings are released into the lake when 6 months old.

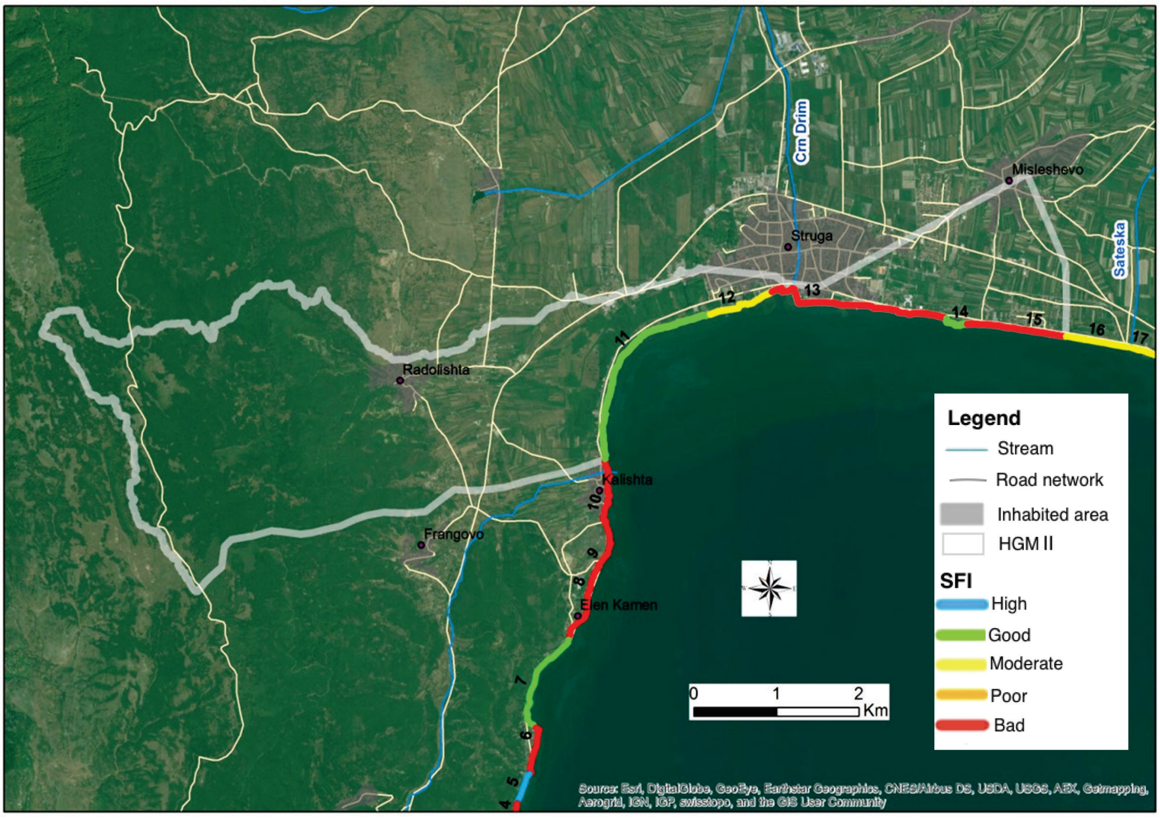
Figure 26. Example of a typology 3 shorezone (cliff with limited vegetation)

In its natural state, the Macedonian shorezone would offer a high or good level of functionality. However, almost the entire Macedonian shorezone is inhabited, so the prevailing shore typology identified is 6 (artificial shores; see Figure 27).

Figure 27. Example of a typology 6 shorezone

The Macedonian section of the lake environment has been recognised as a UNESCO natural and cultural heritage site.

3.1.2 HGM area II – Black Drin River outlet (Macedonia)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 28a. Map of HGM area II

HGM area II (Figure 28a) is located on the northern side of the lake, entirely within Macedonian territory, and its shorezone runs 7.2 km from the village of Kalištato the far side of Struga town.

The Black Drin River, which originates in Ohrid Lake, crosses HGM area II on its way north to the Adriatic Sea. Its outflow has been controlled since 1962 with a weir located in Struga (output = 24.9 m^3/s).The area is therefore not part of the Ohrid Lake drainage basin, as the precipitation in this area does not end up in the lake, but rather in the Black Drin River, which flows away from the lake.

The surrounding territory is flat, comprising lake/alluvial sediments, and is experiencing substantial anthropogenic pressure. Intensive farming is practiced on HGM area II's western side, while the eastern side comprises the urban area of Struga town. In general, the shoreline comprises sustaining walls and tourist beaches (typology 5; see Figure 28b) and has therefore lost its functionality. Although terrestrial riparian vegetation is not established on the western corner of the lake, the presence of reeds in the littoral zone constitutes a small area of remaining functional habitat for aquatic species.

Figure 28b. Example of shore that displays a high level of human impact

3.1.3 HGM area III – The northern plains (Macedonia)

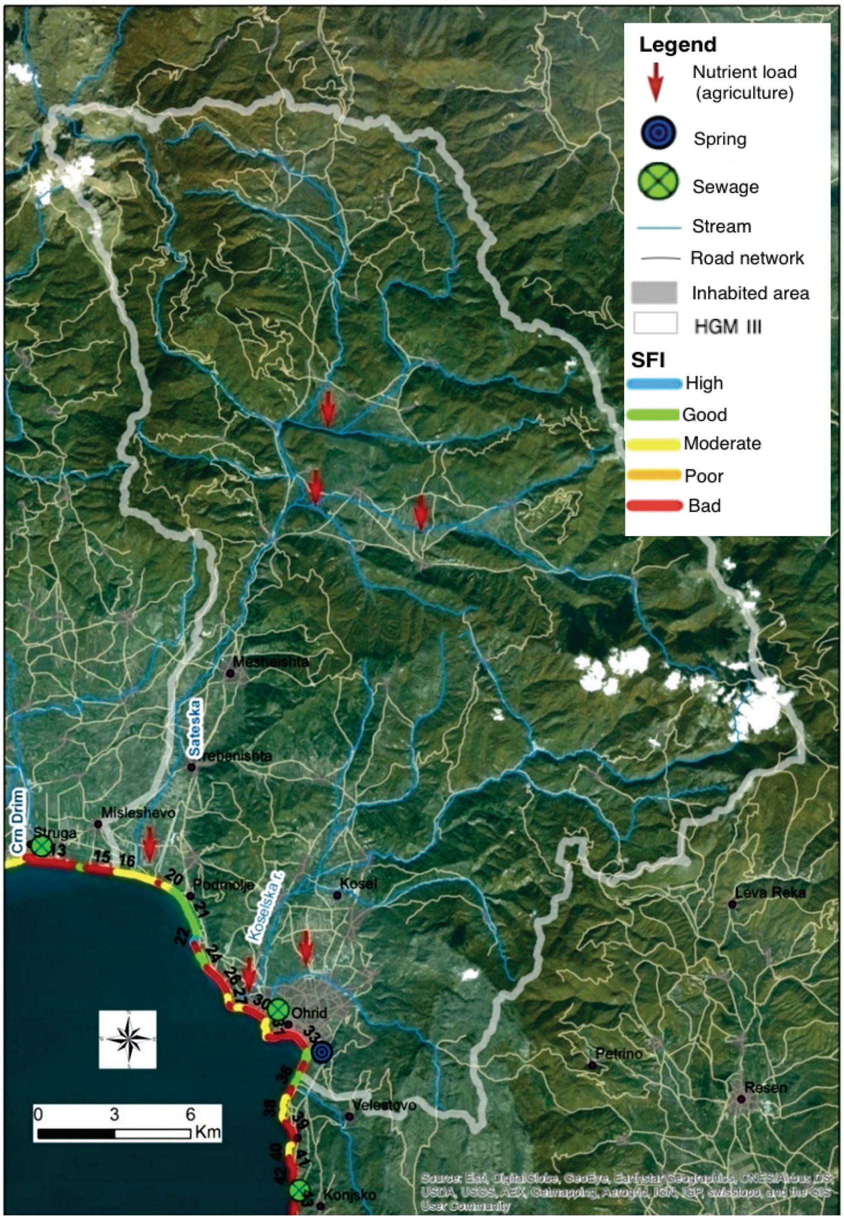


Figure 29. Map of HGM area III

HGM area III (Figure 29) is the largest area that contributes water to Ohrid Lake. Area III consists of a large lake/alluvial plain, surrounded by a ring of mountains composed of metamorphic rock and limestone (Hoffmann 2013). It has a total area of 677.5 km^2.

HGM area III includes the drainage basins of three lake tributaries: the Sateska River (with a drainage basin of 411.47 km^2), which was diverted away from its natural discharge into the Black Drin River and redirected into Ohrid Lake in 1962; the Koselska Reka River (with a drainage basin of 195.35 km^2); and the Grasnica River (with a drainage basin of 38.82 km^2).

On their way to the lake, these three rivers collect large quantities of nutrients. These run off the basin's large areas of farmland into the rivers and ultimately into the lake, which threatens the water quality of the lake. At the mouth of Koselska Reka River, sediment deposition has formed a sandbank that stretches 10 metres out into the lake.

Mountain ridges partially encircle this HGM area, with the highest peaks being Mount Stogovo-Karaorma (2,196 m above sea level) in the north-west, Mount Plakenska (1,935 m above sea level) in the north, and Mount Bigla (1,656 m above sea level) in the north-east. At lower elevations where the terrain is flatter, the environment has been heavily modified and converted into farmland or urban areas.

This area's shorezone reflects major anthropogenic pressures. The old main road connecting Struga town to Ohrid city has been built a few metres away from the shore and therefore significantly limits the width of the functional shorezone. The width of riparian vegetation is usually in the region of 5 to 10 metres and is limited by the road itself and retaining walls made of permeable stone which protect and support the road (shorezone typology 5, SFI = 3). Near the promontory that separates the Struga plain from Ohrid plain, a consolidated belt of reeds increases the overall width of the functional zone and thus improves the overall results (good functionality, SFI = 2).

Almost half of the shoreline in HGM area III has lost its functionality. Its natural status has been modified by the construction of sustaining mortar walls, installed to facilitate settlement and the development of tourism infrastructure (shorezone typology 6, SFI = 5).

There are numerous springs in HGM area III. Water from Prespa Lake seeps through the permeable limestone of the Galitsica mountain range and resurfaces through springs in the area. The water from some of the springs around Ohrid city is used to supply the urban water system. Other springs like Bej Bunar to the north-west of Ohrid city, have recently been destroyed to make way for road construction (Kostoski et al. 2010).

Table 13. Springs in HGM area III

	HGM area	**Number of springs**	**Average annual yield (m^3/s)**
Biljana (Macedonia)	III	40	1.00–2.00
Bej	III		0.50
Biljana sublacustrine	III – inside lake		
Studenchishta (wells)	III		0.09

This area has been recognised as a UNESCO natural and cultural heritage site.

3.1.4 HGM area IV – Karstic mountains between Ohrid Lake and Prespa Lake (Macedonia)

HGM area IV (Figure 30) is located on the eastern side of Ohrid Lake and is characterised by the Galitsica mountain range (Mount Galitsica reaches 2,256 m above sea level) that separates Prespa Lake from Ohrid Lake.

The area comprises 115.9 km2 and a lake shoreline totalling 23.5 km in length.

Other than being a UNESCO natural and cultural heritage, HGM area IV corresponds with the confines of Galitsica National Park.

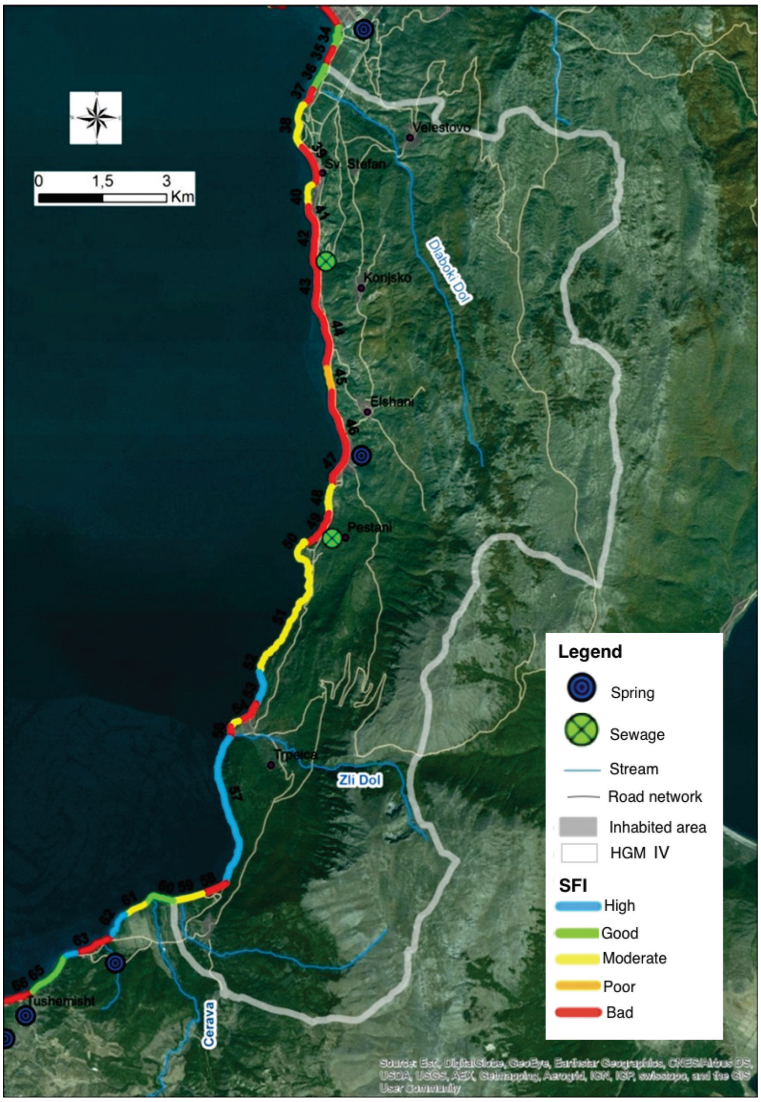


Figure 30. Map of HGM area IV

The surrounding territory is used for non-intensive farming and becomes increasingly natural as one move towards the southern end of the lake. Human settlements are concentrated closer to the shore, and a number of villages and tourism facilities are located directly along the shoreline. Because of the high level of human pressure in the shorezone, it is mainly classified as typology 6 (artificial shorezone; see Figure 31).

Figure 31. Example of the predominant shorezone typology 6

After Gradishte (site of the Bay of Bones Museum), as the road moves further inland and away from the shore, the shorezone regains its naturality. This area is part of a designated strictly protected area, which includes the shoreline between Gradishte and Lubanishta (Kostoski et al. 2010). Here, the shorezone is mainly typology 4 (cliff; see Figure 32) and has a low level of functionality due to natural causes (category 3 – moderate).

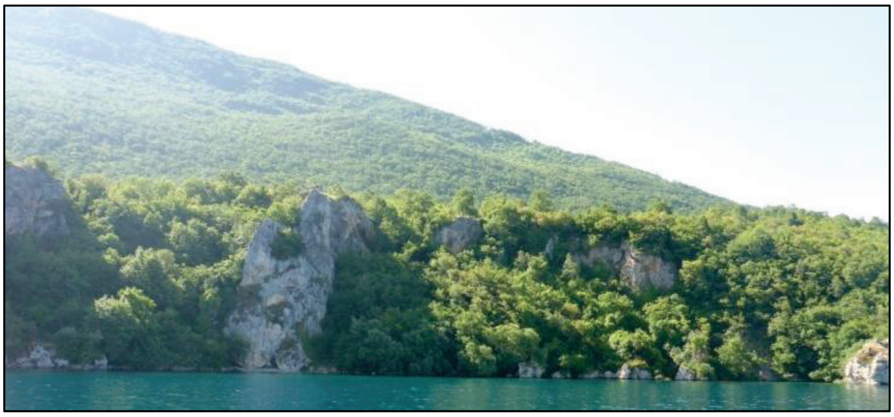


Figure 32. Example of the predominant shorezone typology 4

The longest natural stretch with a high functionality (stretch 57) is located towards the southern end of HGM area IV and corresponds with the Osoj Hill area. Stretches 48, 51, 52, 53, 55 and 57 fall within the Strict Protected Zone of Galitsica National Park and comprise cliffs and contain springs.

3.1.5 HGM area V – Springs in St Naum (Macedonia) and in Drilon-Tushemishte (Albania)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 33. Map of HGM area V

HGM area V (Figure 33) consists of a small promontory formed of the same calcareous rock found in HGM area IV, which marks a natural border between Macedonia and Albania. It is separated from the Galitsica mountain range by the Çerava River (HGM area VI).

While this HGM area is small, comprising 2.3 km² and a shoreline 8.9 km in length, it is very important because of the St Naum (Macedonia) and Drilon-Tushemisht (Albania) springs, which together input the largest amount of karstic water into the lake.

The St Naum springs are the outlets of water that has seeped down from Prespa Lake, located to the east. In total there are 30 coastal and 15 underwater springs here that feed into the lake. The total average annual yield of these springs is 7.4 m³/s, making it one of the most important inputs of water into the lake.

Table 14. Springs in HGM area V

	HGM area	**Number of springs**	**Average annual yield (m³/s)**
St Naum (Macedonia)	V	45	7.4
Tushemisht and Drilon (Albania)	V	80	2.5–3.0

St Naum is characterised by a high level of naturality, in part due to its location alongside the Macedonia–Albania border, and its shorezone functionality is classified as either high or good.

3.1.6 HGM area VI – Southern plains and the Çerava River (Albania)

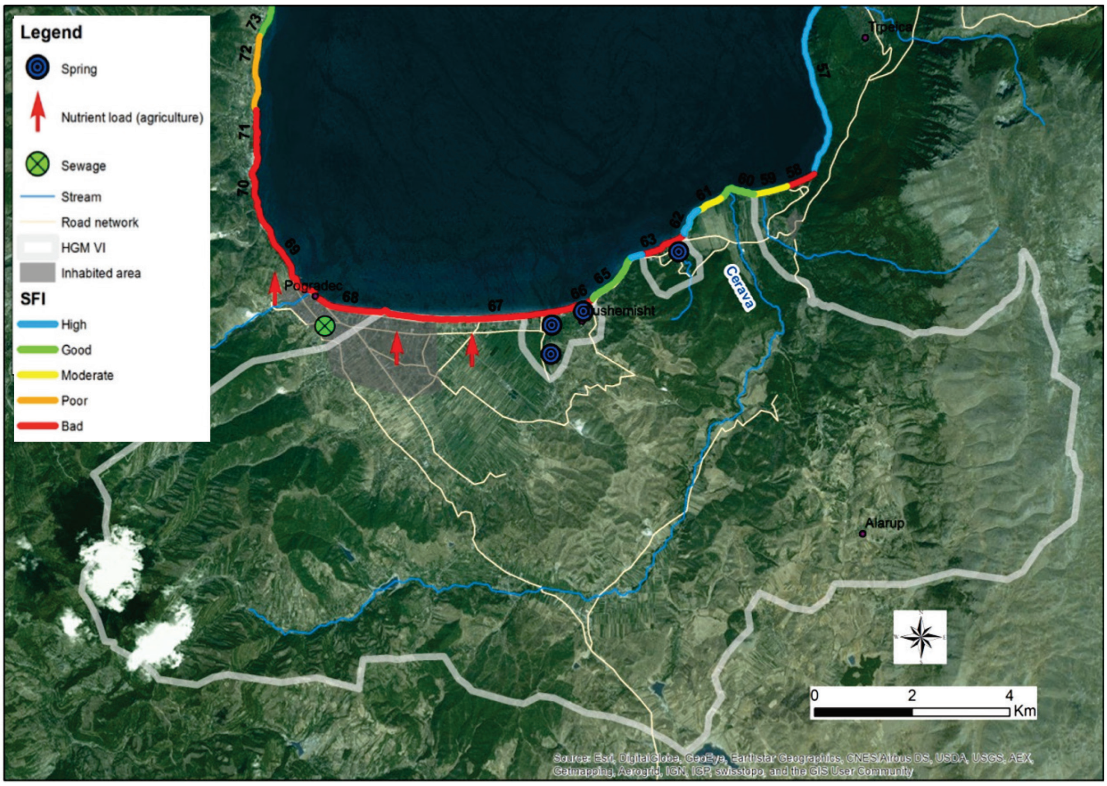


Figure 34. Map of HGM area VI

HGM area VI (Figure 34) includes the drainage basin of the Çerava River and the plains located in the southern part of the lake, south and south-west of Pogradec city. It covers an area of 130.8 km² and, after HGM area III (which covers 677.5 km²), it is the second largest HGM area identified in the lake drainage basin.

The Çerava River is 23 kilometres long. Its drainage basin covers an area of 86.12 km² and, on average, it discharges water at a rate of 0.2 m³/s into the lake.

The plains in this area contain lake/alluvial substrate and are heavily used for agriculture. The lakeside area has been developed with tourist infrastructure and artificial beaches to accommodate the tourism industry. Further inland, a mountain chain consisting mainly of Triassic conglomerates (Hoffmann 2013) encloses the area on its southern side.

Most of the 8.7 kilometres of shoreline in HGM area VI are under strong anthropogenic pressure (typology 6; see Figure 35) and now contain numerous artificial beaches and tourist resorts. These shores cannot perform any ecological functions and are therefore not able to filter out the nutrient load that washes into the lake here from the surrounding farmland.

Figure 35. Example of the typology 6 shorezone, which is predominant in this area

It is only in the area close to the mouth of the Çerava River that the shorezone regains its naturality, with shorezone functionality here ranging from moderate to high (Figure 36).

Figure 36. Example of typology 1 shorezone

3.1.7 HGM area VII – South Jablanica mountain range (Albania)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 37. Map of HGM area VII

The mountain range running north–south along the western side of the lake is formed of two different geological substrates. For this reason, it has been divided into two separate HGM areas: the northern part (HGM area I) is mainly formed of permeable limestone, while the southern part (HGM area VII; Figure 37) consists of ophiolites (Hoffmann et al. 2010). The highest peak in HGM area VII is Mount Mucali at 1,534 metres above sea level.

HGM area VII runs northwards from the town of Pogradec up to the Lin peninsula. It covers a total area of 62.8 km^2 and has a shoreline totalling 18.8 km. Human pressure is greater in the southern part of HGM area VII but is present along the whole shoreline. Untreated sewage enters the lake via the small Pogradec River that passes by Pogradec city. A short distance north of the city, the remnants of a former mining industry continue to constitute a potential source of sediments. The remaining surrounding territory is covered with small trees or shrubs. A main road runs close to the shore for most of the shoreline and is often supported by sustaining concrete walls that run right along the shoreline (Figure 38). Illegal buildings previously built right on the shoreline have recently been demolished, but the remnants of these constructions are still visible in several stretches. The functionality of this area is bad (category 5), as it is not able to provide any ecological functions.

Figure 38. Example of a typology 7 shorezone, which is predominant in this area

3.2 Main shorezone typologies

Seven shorezone typologies have been identified at Ohrid Lake. They partly correlate with the natural topography of the land surrounding the lake (e.g. steep cliffs or plains) and partly with the degree of human pressure exerted on the lake. In these typologies, the presence or absence of reeds greatly influences the width of the shorezone and therefore its functionality value.

3.2.1 Typology 1: wide belt of riparian vegetation (trees and reeds)

Typology 1 is characterised by a belt of riparian vegetation (shrub and trees) accompanied by reeds in the littoral zone, and it provides a high value of complexity and functionality (SFI = 1) (Figure 39). As the Albanian side of the lake has experienced particularly high levels of anthropogenic pressure, this typology is found only on the Macedonian side, scattered along the shoreline in a few pockets that remain in pristine condition. Typology 1 shorezone falls into the high category for functionality.

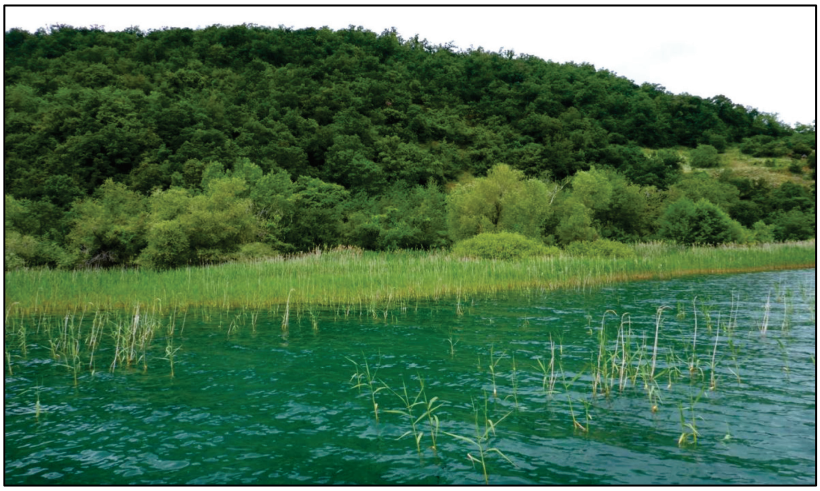


Figure 39. Established riparian trees and a belt of reeds

3.2.2 Typology 2: narrow belt of riparian vegetation (no reeds)

In typology 2, the belt of riparian vegetation is narrower, often due to the natural slope of the terrain that limits the growth of riparian vegetation to the first few metres from the shoreline. Reeds are lacking in this typology, which decreases the potential width of the functional shorezone even further (Figure 40). However, typology 2 shorezone still provides some complexity and good functionality (SFI = 2). This typology is found scattered around the lake, on both its Macedonian and Albanian sides.

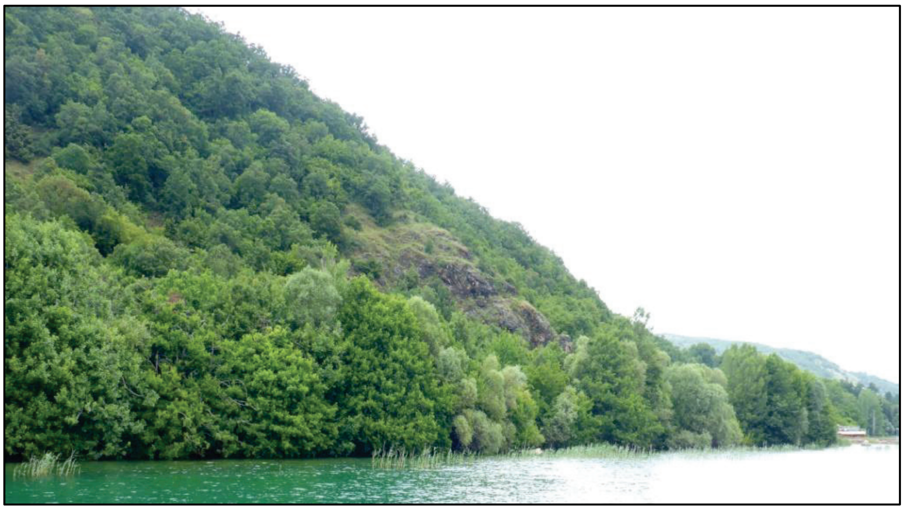


Figure 40. Narrow belt of riparian trees

3.2.3 Typology 3: cliffs with limited vegetation

Typology 3 is characterised by cliffs that directly abut the lake. Even where the cliffs are not high, they constitute an obstacle for the development of coastal hygrophilous vegetation and, as a result, the shorezone mainly comprises bare rock and scattered shrubs (Figure 41). This is another example of a natural place that has limited functionality (average functionality: SFI = 3). This typology occurs in HGM areas I and IV.

Figure 41. Rocky shores with sparse vegetation – natural but not functional

3.2.4 Typology 4: reeds, with little or no terrestrial riparian vegetation

The terrestrial environment of the lakeside plains has been intensively farmed, with the natural riparian vegetation removed and replaced with crops. In the water, however, the shallower bathymetry in this area promotes the growth of reeds, which can grow in wide belts hundreds of metres wide (Figure 42). These wide reed belts perform a number of ecological functions: they provide habitat for aquatic fauna and they remove some of the nutrient load that runs off the land into the lake. These shorezones are therefore considered to have good or moderate functionality (SFI = category 2 or 3).

Figure 42. Reeds, with little or no terrestrial riparian vegetation

3.2.5 Typology 5: thin belt of riparian trees, high artificiality

In typology 5, the belt of riparian trees and/or shrubs is, similar to typology 2 but more limited in width (Figure 43). However, in this case human pressure is the main factor limiting the growth of riparian vegetation. At Ohrid Lake, for example, a tarmac road runs a few metres parallel to the shoreline, which not only interrupts the shorezone but also constitutes a moderate pollution risk for the lake. The shorezone functionality for this typology is moderate (SFI = 3).

Figure 43. Thin belt of riparian trees, high artificiality

3.2.6 Typology 6: artificial shore

The shorezone of Ohrid Lake has been heavily modified to accommodate tourism (Figure 44). Artificial beaches line sections of the shore and impermeable retaining mortar-bonded walls often abut directly on the shoreline to enable the construction of tourism infrastructure. Retaining walls have also been built along the shore to facilitate the construction of the road that encircles the lake. Some ornamental trees have been planted for aesthetic reasons but, unfortunately, they are often exotic rather than autochthonous riparian species. Therefore, they fail to improve the already poor functionality of these areas. For this reason, the shorezone functionality for this typology, which is present in all parts of the lake, is bad (SFI = 5).

Figure 44. Shoreline with strong anthropogenic disturbance

3.2.7 Typology 7: impermeable walling with reeds

Impermeable walls have been built in Ohrid Lake, particularly along the Albanian shore, to enable the construction of roads and buildings. Since impermeable walls interrupt the continuum between the littoral and the terrestrial zone, the functionality of the shores is deemed to be bad (SFI = 5) even in places where some riparian vegetation is present (Figure 45).

While SFI assessments do not consider aquatic vegetation growing further into the lake, the presence of reeds is still important as they provide habitat for aquatic species.

Figure 45. Impermeable wall fronted with reeds

The typology differs from typology 5 because the sustaining walls featuring in the latter are permeable, thus connecting the terrestrial and the aquatic environment.

3.3 Shorezone Functionality Index results

3.3.1 The lake as a whole

The whole 87.8-kilometre-longperimeter of Ohrid Lake was surveyed and the Shorezone Functionality Index methodology applied. The shorezone was then divided into homogeneous stretches – i.e. stretches with similar characteristics. In total, 64 homogeneous stretches were identified in Macedonia along its 56 kilometres of coastline and 23 in Albania along its 31.8 kilometres of coastline (Figure 46).

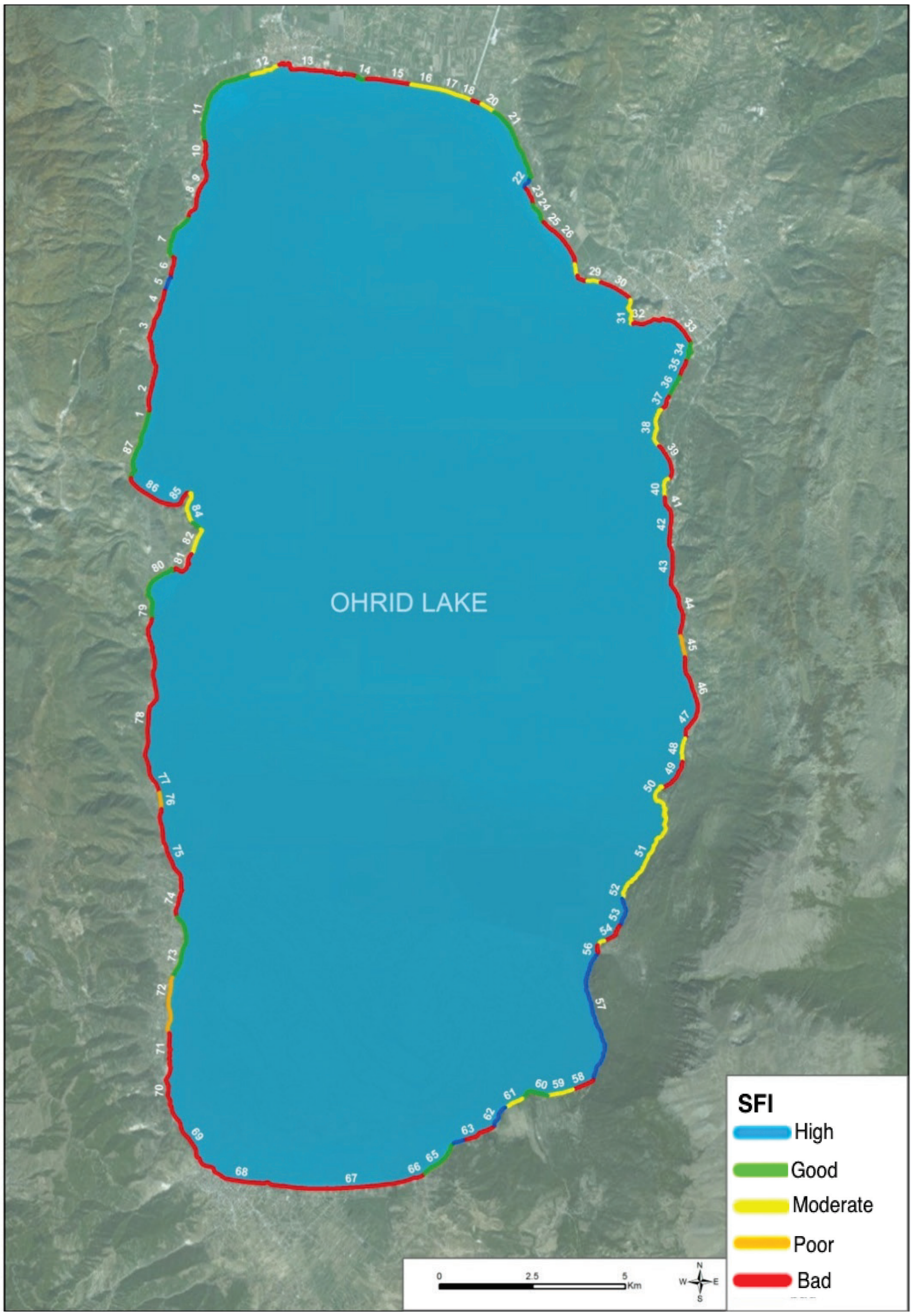


Figure 46. Shorezone Functionality Index for Ohrid Lake

Table 15. Total number, length and percentage of length of sections with various SFI values (Macedonian and Albanian territories combined)

SFI value	No. of stretches identified	Total km	Percentage
1 – high	6	6.2	7.0
2 – good	15	16.1	18.3
3 – moderate	19	13.9	15.9
4 – poor	3	2.6	3.0
5 – bad	44	49.0	55.8
TOTAL	87	87.8	100.0

Overall, 75% of the whole perimeter of the lake falls into the moderate, poor or bad category (Figures 47 and 48). This means that most of the shoreline cannot perform ecological functions such as nutrient removal, shore stabilisation or provision of habitats for aquatic and terrestrial species. The lake is therefore highly vulnerable to both diffuse and point source pollution from urban, industrial, agricultural and other installations and activities, e.g. nutrient run-off from farmland, discharges from both active or closed mining sites and tailings or inflow of polluted and/or nutrient-rich river water.

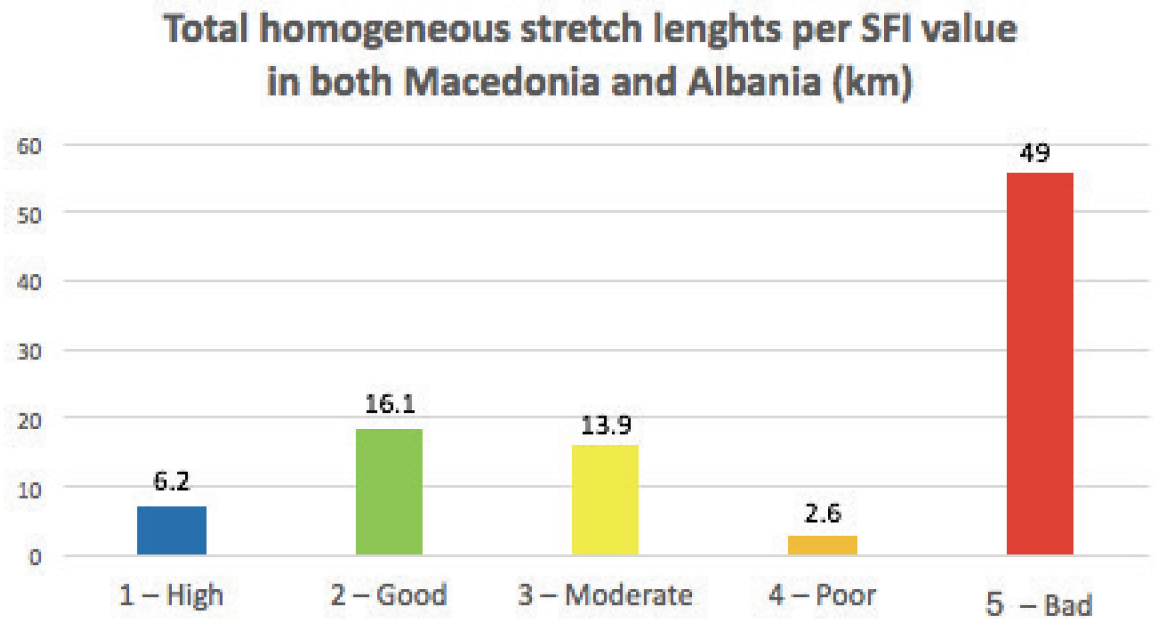


Figure 47. Total combined length (kilometres) of homogenous stretches at Ohrid Lake per SFI value (Macedonian and Albanian territories combined)

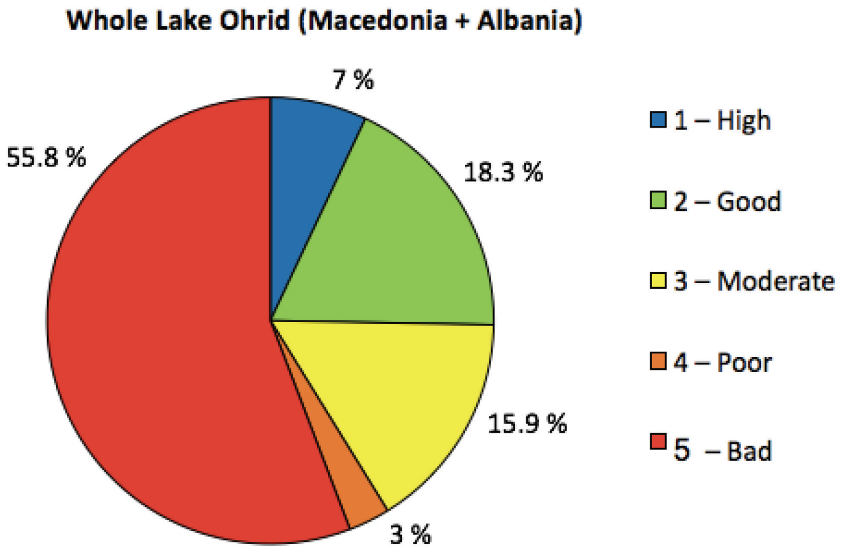


Figure 48. Ohrid Lake's SFI value percentages (Macedonian and Albanian territories combined)

SFI category 1 – high

The six stretches falling into the high functionality category are located in Macedonia and together constitute 7% of the total perimeter of the lake. With the exception of the 3.7-kilometre-long stretch no. 57, located by Osoj Hill (HGM area IV), the remaining five stretches are small oases where human presence has not impaired shorezone functionality. These five are located, respectively, in HGM areas I (no. 5, 0.4 km long), III (no. 22, 0.3 km long), IV (no. 53, 1.5 km long) and VI (no. 62, 0.8 km long; no. 64, 0.6 km long). These stretches display high levels of naturalness and an absence or limited amount of human pressure. Stretch no. 57 alone which is located within Galitsica National Park makes up 60% of the category 1 shorezone.

SFI category 2 – good

The good category is found in isolated stretches all along the perimeter of the lake. Together these stretches total 16.1 km or 18% of the lake's coastline. In these areas, human disturbance is the main factor limiting the width of the riparian vegetation. Generally, this is due to the presence of fields under cultivation and roads running very close to the shoreline. The presence of reeds in the littoral zone increases the width of the functional area and therefore its overall functionality.

SFI category 3 – moderate

The majority of stretches falling into this category are located in Macedonia, i.e. in HGM areas III and IV. These stretches are areas where the width of the riparian vegetation is very limited (generally between 5 and 10 metres wide) either due to human pressure (e.g. roads built close to the shoreline) or to natural causes (e.g. small rocky cliffs abutting the lake in HGM area IV).

SFI category 4 – poor

The three stretches falling into this category make up 3% of the total perimeter of the lake. While these stretches' terrestrial zones are experiencing high levels of human pressure, reeds still grow in their littoral zones. The ecotone connection between the littoral and terrestrial environment is interrupted by areas of bare soil or semi-impermeable sustaining walls.

SFI category 5 – bad

Because of high levels of anthropogenic pressure exerted in all parts of Ohrid Lake, most of its homogenous stretches fall into the bad category (56% of the whole perimeter of the lake). In these 'bad' stretches, the functionality of the shorezone is mostly entirely absent.

3.3.2 Shorezone land use

Information on the types of human use of the lake's shorezone (i.e. the circumferential strip from the shoreline to 50 metres inland) and the surrounding territory (the circumferential strip from the shoreline to 200 metres inland) was also collected during the survey (Figure 49).

Figure 49. Human use of the lake's shorezone (0 to 50 metres from the shoreline)

The urbanized areas that directly affect the lake's shorezone (0 to 50 metres inland from the shoreline) are the basin's main urban centres of Struga, Ohrid and Pogradec, and also smaller villages with tourist beaches (dark grey, 29.6% of the lake´s whole perimeter).

The highest percentage (about 57%) of the lake's perimeter is classified as sparsely urbanized (orange), i.e. it contains sparse settlements, cultivated fields and/or roads running along the shore. Only

12.9% of the total perimeter was classified as natural habitat (green) – i.e. where anthropogenic disturbance was absent.

It should be noted that this parameter looks at the overall status of the homogeneous stretches identified and the values corresponding to the most prevalent typology. If a one-kilometre-long homogeneous stretch contains a small urbanized area and this settlement does not impact on its surrounding environment, it would be assessed using the 'presence of interruption' parameter.

Figure 50 depicts prevalent human activities in an area running from the shoreline to 200 metres inland. The map indicates impairments to the shorezone's functionality occurring as a result of the modification of the surrounding soil that may increase the input of nutrients, organic matter or pollutants and change the natural permeability of the soil. The predominant human use present in each identified homogeneous stretch is adopted as the use for that stretch (Figure 50).

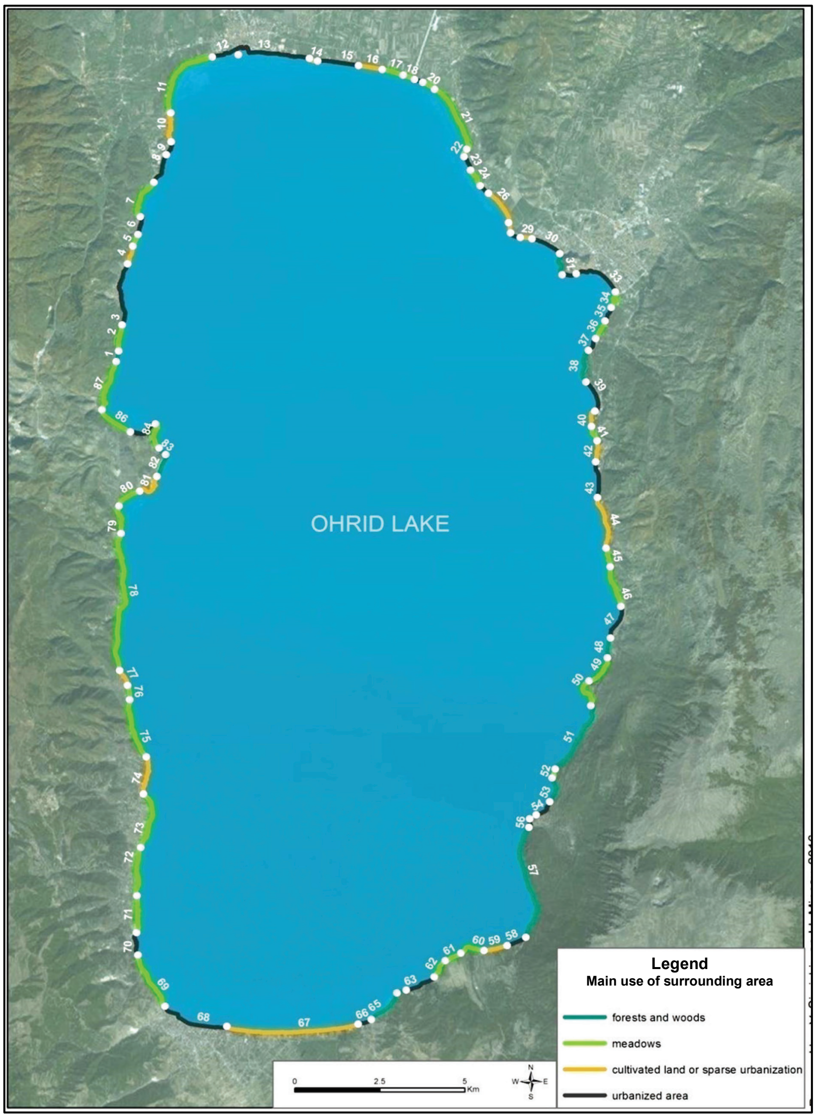


Figure 50. Human use of the surrounding area (0–200 metres inland from the shoreline)

The forest and woods category (dark green) occurs only in the part of the lake that falls within the confines of Galitsica National Park, which is located in the south-eastern corner of the lake (HGM area IV).

Apart from meadows as such, the meadows category (light green) also includes extensively farmed land (e.g., small-scale animal husbandry and/or agriculture). Anthropogenic pressures here are considered to be insignificant. This land use category occurs mainly on the south-western side of the lake (HGM area VII) and – in smaller stretches – in HGM areas III and IV.

The cultivated land or sparse urbanization category (orange) includes more intensively farmed land where the use of fertiliser is more likely. The category also comprises areas with sparse urbanization in the surrounding territory (shoreline to 200 metres inland).

The urbanized area category (black) occurs in and around the basin's major cities (Struga, Ohrid and Pogradec) and centres of tourism, whereas natural areas are located in its national parks. Most of the shore around the lake has been affected by the development of tourism infrastructure (mainly beaches), which are present at points around almost all of the lake's perimeter (urbanized area category).

Figure 51 depicts the prevalence of tourism-related infrastructure (such as hotels, resorts, restaurants and campsites; cycling and pedestrian paths; piers and beaches) in a 200 m-wide area. Values range from zero (no infrastructure within homogenous stretch) to 1 (infrastructure present all along the stretch).

Figure 51. Tourism-related infrastructure (Range: 0 = none to 1 = 100% along entire stretch)
(0.1 = hiking trail; 0.2 = single hotel; 0.5 = pedestrian/cycle path alongside lake; 1 = beach or tourism infrastructure)

3.3.3 SFI results in Macedonia

The Macedonian section of Ohrid Lake's shorezone was divided into 64 stretches, which were determined by assessing the different levels of human pressure exerted there and the presence of exotic and/or hygrophilous species.

Table 16. Total number, length and percentage of length of sections with various SFI values (Macedonian territory)

SFI value	**No. of stretches identified**	**Total km**	**Percentage**
1 – high	6	6.2	11.0
2 – good	9	9.4	16.8
3 – moderate	17	12.2	21.9
4 – poor	1	0.6	1.1
5 – bad	31	27.5	49.2
TOTAL	6	55.9	100

In all, 64 stretches totalling nearly 56 kilometres were identified during the study (Table 16). The shortest stretch (no. 55 with 0.2 km) is the beach at Trpejca village, while the longest stretch (no. 57 with 3.7 km) is located between Trpejca bay and the village of Ljubanista.

The overall results (total length of homogenous stretches per SFI value and percentage of SFI values) are shown in Figures 52 and 53.

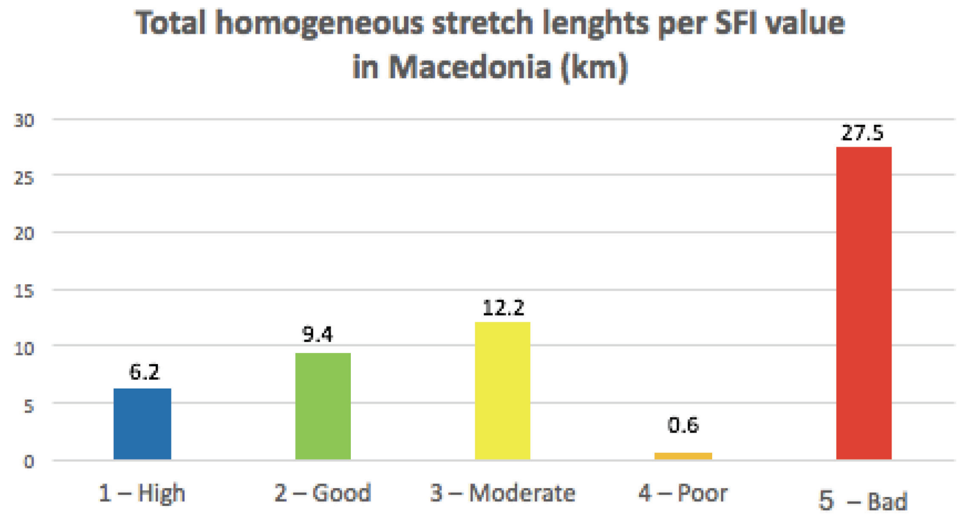


Figure 52. Total length (in metres) of homogenous stretches per SFI value on the Macedonian side of Ohrid Lake

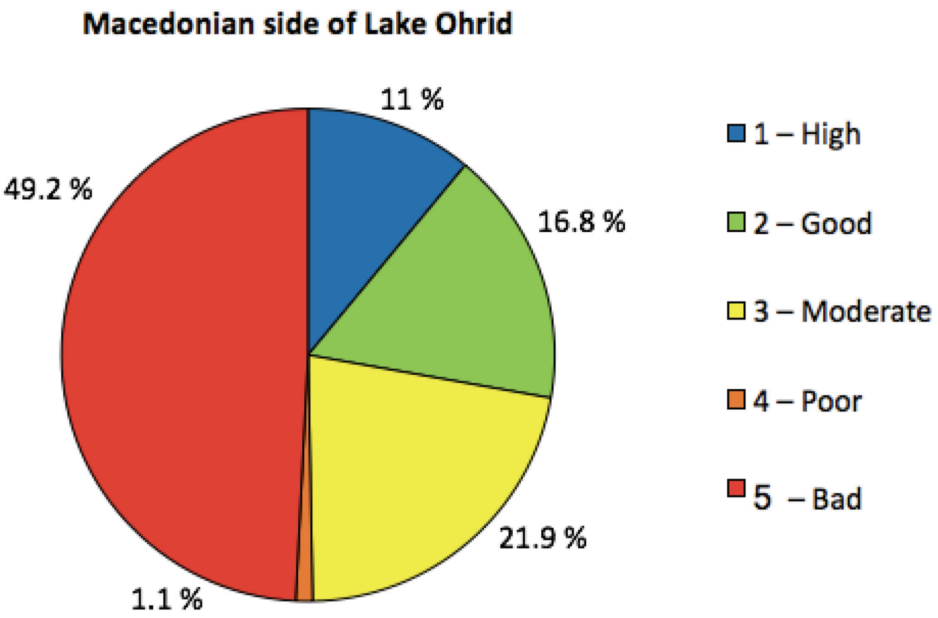


Figure 53. Percentages of the SFI values for the Macedonian side of Ohrid Lake

Classification of stretches according to their status

SFI category 1 – high

Six stretches fall into the high category and their combined length totals 6.2 km or 11% of the Macedonian shore. The average length of the stretches with this value is one kilometre. Five of the stretches lie along the east coast of the lake (mainly HGM area IV), most commonly within the Galitsica National Park. The other stretch is located on the west coast (HGM area I). In most of these stretches, riparian vegetation displays a certain level of disturbance. This is particularly true of the reed belt, which is only fully developed at stretch no. 22 (HGM area III, near the Andon Doukov resort). In the remaining stretches reeds are often completely absent or significantly degraded.[6] The riparian vegetation for most high-status stretches comprises well-preserved diversified native riparian vegetation (usually present in 70% to 100% of the whole length of the stretch). The stretches are, however, short sections located between beaches and hotels. In the surrounding territory, fragments remain of the former, and probably far richer, riparian forest. Most of the stretches display moderate but continuous human influence, mainly owing to the presence of the tourism industry in the region. Only stretches no. 1 (Radožda on the border with Albania: SFI category 2 – good), no. 53 (cliffs north of Trpejca village) and no. 57 (cliffs along Mal Osoj – Little Osoj, part of Osoj hills – in Galitsica National Park) show no obvious signs of anthropogenic pressure.

SFI category 2 – good

Nine stretches, totalling 9.4 km in length or 16.8% of the Macedonian shore, fall into category 2. The average length of the stretches in this category is one kilometre. One stretch is located on hilly terrain on the west coast of the lake (HGM area I), three stretches on the northern shore (HGM area II), and the remaining five

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[6] Editors' note: Reed grasses can have detrimental or beneficial effects on ecosystems. At Lake Micro Prespa, for example, high nutrient input and water abstraction lead to the encroachment of reeds which now cover the entire Albanian part of the lake, thereby degrading its (former) ecological status. At Lake Ohrid under natural conditions, reeds would not grow widely because of the oligotrophy of the lake. Nowadays, however, reed belts have developed locally owing to increased nutrient input from agriculture and wastewater in the littoral zone. Contrary to Micro Prespa, this would be considered as beneficial because reeds add structural diversity, provide spawning and breeding habitats for fish and birds, respectively, and reduce nutrient load.

along the north-eastern shore (HGM area III). Most of the stretches are situated on flat or nearly flat land. All of these stretches contain well-developed riparian forest and reed belts. Stretch no. 7 (between Livadishte and Elen Kamen in HGM area I) has well-preserved riparian vegetation whereas, in the remaining stretches, native riparian vegetation is rare and of low diversity. The state of the reed belt is neither excellent nor poor, but comes somewhere between the two. There are, however, well-developed strips of reed between the villages of Kališta and Struga (HGM area III). It is important to note that, in most of these stretches, the reed belt is likely to deteriorate further, which will undoubtedly lead to the downgrading of their status.

SFI category 3 – moderate

A total of 17 stretches, with a total length of 12.2 km or 21.9% of the Macedonian shore, fall within the moderate category. The stretches in HGM area II (two stretches), HGM area III (five stretches) and HGM VI (two stretches) are situated in urbanized areas, and the four stretches in HGM area IV are experiencing moderate anthropogenic pressure. The absence of riparian vegetation in stretches 38, 50 and 52 is not caused by human activity but is in fact due to the local topography as these stretches contain cliffs which inhibit the development of hygrophilous vegetation. This is a classic example of situations where the naturalness of an area does not equate to a higher level of functionality. Anthropogenic impacts are absent in stretches with cliffs, but are moderate or significant in the other stretches in this category.

Reed belts are absent in almost all of the category 3 stretches, with the exception of stretch no. 40 located in Desktop Odmoraliste (HGM area IV) where reeds form around 50% of the riparian vegetation. Riparian vegetation is also relatively well developed in stretches 18 (HGM area III) and 48 (HGM area IV), whereas it is largely fragmented or completely absent in the remaining stretches.

SFI category 4 – poor

Only one stretch is classified as category 4. Located in Eleshec village (HGM area IV), it is 0.6 km long and constitutes 1.1% of the Macedonian shore. The stretch comprises a wide belt of reeds. However, the belt is largely disconnected from the terrestrial zone, which is barren and cut off in large part by a sustaining stone wall. Even though the terrestrial and the littoral zones are not connected, reeds are important as habitats for aquatic fauna.

SFI category 5 – bad

The most common category identified along the Macedonian shore is category 5 – bad. In all, 31 stretches totalling 27.5 km in length or 49.2 % of the whole Macedonian shore are classified as bad. The average length of these stretches is 0.8 km.

Category 5 stretches are found at points all the way round the lake's perimeter, and particularly in areas near or within the region's main cities and villages.

Good riparian vegetation cover (covering 60% of the area of homogeneous stretches) was registered in only two stretches: no. 2 near the Watchtower at Radožda and no. 8 lying between Ellen Kamen and Hotel Izgrev. In 17 other stretches riparian vegetation is either absent (nos. 3, 6, 13, 19, 25, 28, 32, 33, 35, 37, 39, 42, 43, 47, 54, 58 and 63) or present at very low coverage (0.05–0.30% cover).

Reed belts were hardly present. Poorly developed stands of reeds were recorded in three stretches only (no. 4 where reeds make up to 50% of the total vegetation of the stretch, no. 9 up to 15%, and no. 10 up to 20%), while the remaining 30 bad-status stretches have no reed belt at all. Almost all the stretches are experiencing high levels of anthropogenic influence, which are most commonly artificially formed sand or masonry (concrete and stone) beaches, urban or rural docks, ports and roads.

Conclusions

- Ohrid Lake's coastal zone in Macedonia is experiencing a high level of anthropogenic influence.
- In the majority of the stretches, disturbances in functionality are due to these anthropogenic influences (primarily related to tourism).
- Most of the stretches (31) fall into the bad category, and these constitute the majority of the shoreline (49%). The presence of these category 5 stretches in each HGM area is summarised below:

HGM area	Total length (km)	Category 5 length (km)	Percent of HGM classified as Category 5
I	16.25	9.72	59.8
II	7.23	3.57	49.4
III	13.38	5.96	44.5
IV	23.47	10.42	44.4
V	1.39	1.39	100.0
VI	5.87	2.52	42.9
VII	18.73	13.99	74.7

- Of the remaining 33 stretches, 23% are classified as either poor or moderate, and only 18% of the lake's perimeter has shorezone classified as either good or high functionality.
- Most of the stretches (45%) are shorter in length than one kilometre, 13 (20%) are between one and two kilometres long, five (about 8%) between two and three kilometres, and only one (1.5%) exceeds three kilometres in length.
- The impaired state of the lake's coastal zone is, among other factors, due to the fragmentation of riparian and reed vegetation. This process likely began a long time ago and has accelerated owing to continued and often unsustainable tourism development which is largely ignorant of the ecological importance of the lake.

3.3.4 SFI results in Albania

In total, the Albanian shorezone of Ohrid Lake is 31.8 km long and contains 23 stretches, which are differentiated mainly by different levels of human pressure and the presence of reeds and riparian vegetation (Table 17). The shortest stretch (no. 83) is 0.3 km long, while the longest (no. 7) is 4.4 km long.

Table 17. Total number, length and percentage of length of sections with various SFI values (Albanian territory)

SFI value	No. of stretches identified	Total km	Percentage
1 – high	0	0	0
2 – good	6	6.7	21.0
3 – moderate	2	1.7	5.3
4 – poor	2	2.0	6.3
5 – bad	13	21.4	67.4
TOTAL	23	31.8	100.0

The overall results (total length of homogenous stretches per SFI value and percentage of SFI values) are shown in Figures 54 and 55.

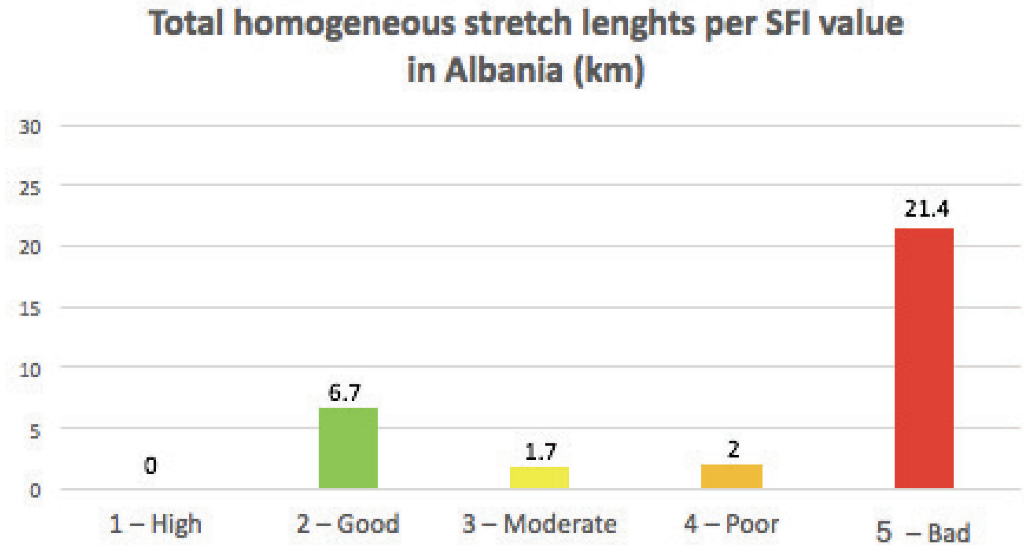


Figure 54. Total length (in metres) of homogenous stretches per SFI value on the Albanian side of Ohrid Lake

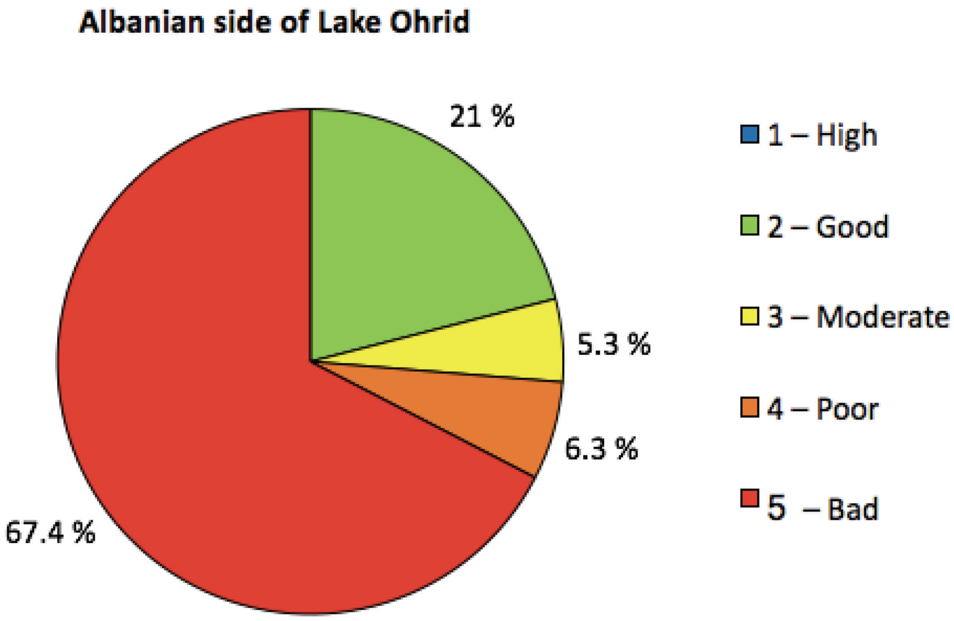


Figure 55. Percentages of the SFI values for the Albanian side of Ohrid Lake

Classification of stretches according to their status

SFI category 1 – high

Almost all of Ohrid Lake's Albanian shoreline is highly impacted by human activity. Tourism facilities have often been built directly on the shore. In some parts, mining (for chrome, iron and nickel) has significantly impaired the shoreline's functionality. Neither the SFI software nor expert opinion classified a single stretch of the Albanian shorezone as having high functionality.

SFI category 2 – good

Six stretches, with a total length of 6.7 km or 21% of the Albanian shoreline, fall into the good category. These stretches constitute small oases where terrestrial and aquatic fauna find sufficient habitat to live and reproduce. Reed belts in the littoral zone increase the width of the functional shorezone whereas riparian vegetation is generally scarce.

Three stretches occur in natural hilly terrain where anthropogenic pressure is almost absent. They are located at the eastern border with Macedonia (HGM area V), in the Lin Peninsula and at the northern border with Macedonia (HGM area I). The other three stretches are located adjacent to agricultural fields but have a thin strip of riparian vegetation and wide reed belts (HGM area VII).

Length-wise, category 2 stretches are fairly short, with three stretches between one and two kilometres and three shorter than one kilometre.

SFI category 3 – moderate

Only two stretches fall into the moderate category. They are located in the Lin Peninsula (HGM area I) and, taken together, are 1.7 km long and represent 5% of the entire Albanian shoreline.

The shores of these two stretches, which are located close to each other, are made up of cliffs that steeply descend into the lake and thus offer barely any appropriate space for riparian vegetation to grow. Anthropogenic pressure in these stretches is low.

Both riparian and littoral vegetation in the two stretches are discontinuous and/or insufficiently wide to provide good shorezone functionality. Interruptions in the shorezone are evident, with a large percentage of these shorezone areas comprising bare soil and the riparian vegetation predominantly comprising bushes.

SFI category 4 – poor

Only two stretches, totalling two kilometres or 6.3% of the Albanian shoreline, fall into the poor category (HGM area VII).

The main road between Lin and Pogradec runs through these stretches close to the shoreline and is supported by an impermeable concrete wall. Scattered shrubs grow on part of the terrain between the wall and the shore. A thin belt of reeds is present in the littoral zone, providing habitat and a certain level of functionality.

Stretch no. 72 (1.5 km long) is situated near an abandoned iron and nickel mine, the tailings of which may put the flora and fauna of the shoreline nearby at risk, and stretch no. 79 (0.5 km long) has been partially restored after the demolition of an illegal resort built close to the shoreline.

SFI category 5 – bad

The most common category recorded along the Albanian shoreline is category 5. In all, 13 stretches, totalling 21.4 km or 67% of the whole Albanian shore, were classified as bad.

Stretches in this category tend to be long, as the human pressure is constant. For example, in the southern flat area between the border and Pogradec city (HGM area VI) and in Pogradec itself (HGM area VII) the shore is either mortar-bonded walling or beach.

The construction of the main road that runs along the western side of the lake (HGM area VII) has had a negative impact on shorezone functionality. Construction of the sustaining wall and destruction of local riparian vegetation resulted in the total loss of natural habitat. Tourism infrastructure and moorings are further diminishing shorezone functionality. Some initial restoration efforts are, however, visible on the shore, where illegal constructions have been demolished.

Conclusions

- Ohrid Lake's coastal zone in Albania is experiencing a high level of anthropogenic influence.
- Only 21% of the entire Albanian shorezone is classified as good. These good status areas are experiencing limited anthropogenic impact.
- Most of the stretches (67% of the shorezone) are classified as bad, which is due to the level of direct anthropogenic impact they are experiencing. These stretches comprise 40.8% of HGM area I (3.1 km of this area's total perimeter of 7.6 km), 100% of HGM area VI (1.5 km of perimeter), 78% of HGM area VI (3.9 km of this area's total perimeter of 5.0 km), and 74.8% of HGM area VII (14.0 km of this area's total perimeter of 18.7 km). In the majority of the stretches, disturbances in functionality are due to anthropogenic influences (primarily related to tourism and infrastructure development).
- Stretches that fall in category 5 are often grouped contiguously: 66–71, 74–75, 77–78 and 85–86.
- No stretches fall into the high category.

3.4 Management recommendations

3.4.1 Common recommendations

Restoration and/or protection

- Category 1 (high) stretches should be protected in accordance with environmental and water legislations and human activity restricted to preserve their high functionality. Transboundary surveillance should be harmonised.
- Category 2 (good) stretches should be monitored for changes. Future human activities must be kept to a minimum and be ecologically friendly. Riparian and marshland vegetation should be restored within and around the zone (e.g. removal of non-native species and restoration of native riparian species).
- Riparian vegetation should be planted or enhanced to create a buffer zone separating the Drilon springs from nearby agricultural fields. This serves to reduce the nutrient load of these important waters.
- Areas where illegal buildings have been demolished (as observed in Albania) should be restored to good or high functionality, using native riparian vegetation.
- Reeds are an important component of lake ecosystems because they provide habitat for spawning fish and fry (i.e. they provide an ecosystem service to the lake's fisheries; see footnote 4). Yet their presence along the lake shore is threatened. It is, therefore, recommended to protect existing reed belts and, in particular, to preserve the reeds present in the stretches indicated in Figure 56, in order to maintain a network of reed belts all around the lake.

Planning and further research

- Integrate SFI results and management implications with existing or upcoming management plans (MPs) for the Lake Ohrid sub-basin (or parts of it), notably (i) the MPs for the Natural and Cultural Heritage of the Ohrid Region (Macedonian plan and World Heritage Supplement to the MP for

Pogradec Protected Landscape), (ii) the Lake Ohrid Watershed Management Plan (under the GEF Project Enabling Transboundary Cooperation and Integrated Water Resources Management in the Extended Drin River Basin), (iii) the Management Plan for the Transboundary Biosphere Reserve Ohrid Prespa and (iv) the Galitsica National Park Management Plan.

- It is recommended to revise the legal basis of the newly defined tourism development zones.
- The amount of pollution entering the lake from rivers, which receive large quantities of pollutants and nutrients from agricultural fields, is significant. A project should therefore be carried out to define the Fluvial Functionality Index for the lake's four main tributaries – the Sateska, Koselska, Grasnica and Çerava rivers (shared by Macedonia and Albania) – as well as the Verdova River (in Albania).

Infrastructure measures

- Appropriate wastewater collection and treatment facilities should be restored and/or installed for the urban centres of Struga and Ohrid.

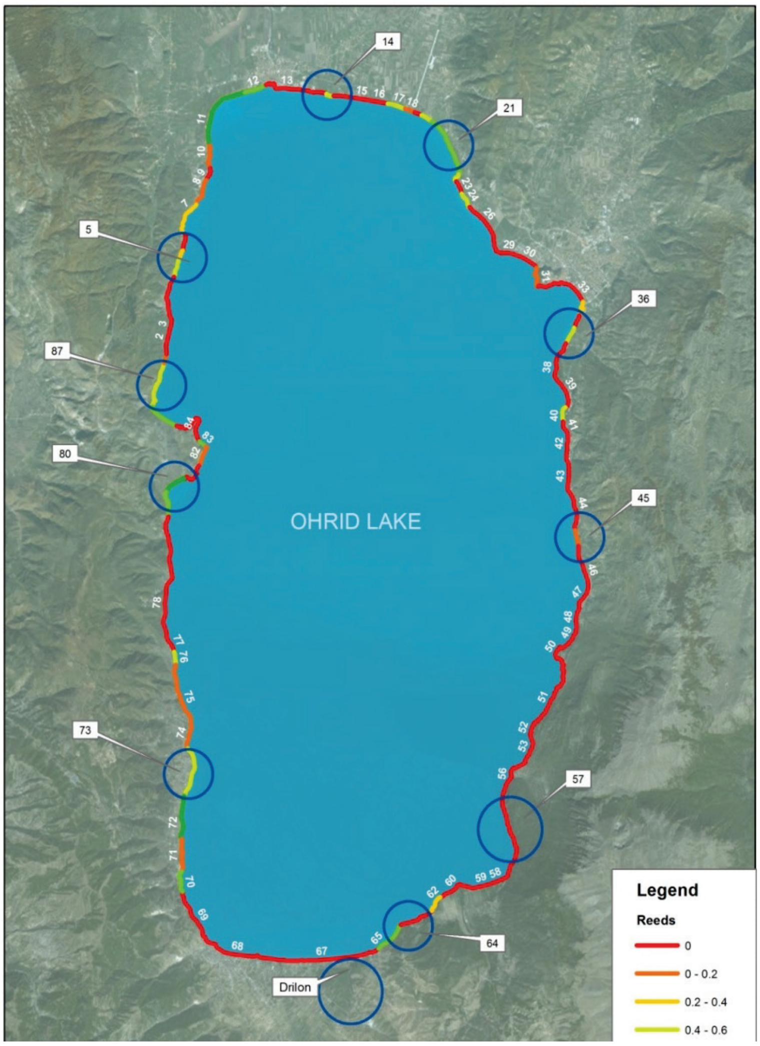


Figure 56. The presence of reeds and the stretches or areas suggested for protection

3.4.2 Recommendations for Macedonia

In the Macedonian part of Ohrid Lake, high levels of human impact can be observed along the entire shoreline. Various measures to reduce the anthropogenic influence and to improve shorezone functionality are therefore required. These measures should focus on the following lines of action:

Restoration and/or protection

- Category 1 (high) stretches lacking official protection (5, 22, 53, 57 and 62) should be designated as protected areas in line with Macedonia's Law on Nature and Law on Water. Human activity must be forbidden in these stretches because of their high functionality.
- For category 2 (good) stretches (especially nos. 1, 7, 11, 14, 21, 24, 34, 36 and 60) and category 3 (moderate) stretches that are under slight anthropogenic influence (nos. 12, 16, 17, 18, 20, 27, 29, 31, 32, 38, 40, 48, 50, 51, 55, 59 and 61) it is recommended to:
    - monitor these stretches for changes in shorezone functionality;
    - ensure that future human activities are limited and ecologically friendly;
    - enhance or restore riparian and helophyte vegetation within and around the zone;
    - replace non-native with autochthonous hydrophilic tree species;
    - restore abandoned construction or industrial sites and
    - revise the legal basis of the newly defined tourism development zones.

Planning and further research

- Given UNESCO's recognition of Ohrid Lake and its surroundings, a significant number of plans and projects have been proposed to protect the area's natural and cultural heritage (see 3.4.1, *Planning and further research*). The implementation of all these plans will contribute to enhancing the status of the lake's shorezone, and the reports produced as part of these initiatives can be used to inform the future planning of the lake.
- Rivers are significant sources of the pollution that ends up in the lake, as they collect large quantities of pollutants and nutrients from agricultural fields. It is therefore recommended to carry out a project to define the Fluvial Functionality Index for the lake's four main tributaries: the Sateska, Koselska, Grasnica and Çerava rivers (shared by Macedonia and Albania).
- It is important to harmonise or align the SFI with the watershed management plan that will be produced for Ohrid Lake (see 3.4.1, *Planning and further research*).

Infrastructure measures

- Appropriate wastewater collection and treatment facilities should be restored and/or installed in the urban centres of Struga and Ohrid.

3.4.3 Recommendations for Albania

In the Albanian part of Ohrid Lake, high levels of human impact can be observed along the entire shoreline. Various measures to reduce this anthropogenic influence are therefore required. These measures should focus on the following lines of action:

Restoration and/or protection

- Because of their scarcity in the overall shoreline, areas that currently have good functionality should be preserved. For this, the reed belts in stretches 65, 73, 79 and 83 should be rigorously protected (see footnote 4). Stretches 80 and 87 also need greater care and attention. The former is very fragile because of the shore-side road that passes through it and will be greatly affected by any further disturbances. The latter contains the site of the Ohrid trout rearing facility.

- Attention should be paid to category 4 stretches 72 and 76. Although classified as poor, they can be improved with little effort by preserving and extending their reed belts, as these are currently very narrow and limited in length.
- A number of sites where illegal buildings for tourism have been demolished remain to be restored. When recovering these sites, care should be taken to plant hygrophilous plants because of the role they can play in enhancing shorezone functionality.
- Nutrient inputs originating from the Ohrid trout rearing facility should be monitored.
- There are still problems with the lake's water quality. The Verdova River, which transports nutrient-rich runoff from surrounding farmland, inputs the highest amount of pollutants into Ohrid Lake. To tackle this situation, riparian vegetation should be allowed to grow along this river, even in the higher part of its watershed and especially in sections close to agricultural fields. In this way, the water can undergo an initial natural purification process before it reaches the lake. Scientific publications show how a diversified belt of riparian vegetation can absorb up to 90% of nutrients coming from the surrounding territory as runoff during rain events. Furthermore, untreated wastewater should be properly collected and the water of Verdova River treated before being discharged into the lake.
- The Drilon springs should be protected against any major intervention that might upset the delicate balance of this site. Riparian vegetation should be maintained in order to separate the springs from nearby agricultural fields and thus diminish the nutrient load entering these important waters. Fish farms that discharge directly into Drilon's waters should either be moved or provided with purification tanks. On the southern side of the lake (the Pogradec plain), fertilisers applied to fields can wash directly into the lake because functional riparian vegetation is totally absent in the shorezone here. As the tourist industry relies on the lake having clear and clean water, this nutrient-rich runoff is highly problematic. It is therefore recommended to restore the strip of land located on the land-side of the main road and running parallel to the shore. Restoration will require the planting of a belt of diversified native riparian vegetation, at least 30 metres wide. This belt will not only improve the aesthetic value of the area for tourists and provide habitat for native animals, but will also help to filter nutrient-rich water running off surrounding territory before it enters the lake.

Planning and further research

- A major threat to preserving the condition of Ohrid Lake's waters is contamination from mining. New strategies should therefore be drawn up looking at ways to minimise contamination derived from old mine workings and mine tailings deposited around the old railway station.

Infrastructure measures

- Solid waste should be properly treated and disposed of. For this, awareness-raising activities must be undertaken in local communities to inform local people about solid waste issues and appropriate disposal.

4 SFI APPLICATION FOR OHRID LAKE

4.1 Fieldwork

The SFI was established according to the methodology described in *Lake Shorezone Functionality Index (SFI) – A tool for the definition of ecological quality as indicated by Directive 2000/60/CE* (Siligardi et al. 2010).

The fieldwork was supervised by the SFI expert Barbara Zennaro who, for the first few days of the fieldwork, focused on the intercalibration of the different teams (including the Montenegrin team for Lake Skadar/Shkodra) to ensure the highest possible levels of consistency between the work undertaken on the two sides of the lake.

Field work activities – Macedonia

SFI assessments were carried out on 14–16 June 2016 by Dr Ivan Blinkov (Hydromorphology), Mitko Kostadinovski (Botany), Dr Renata Kusterevska (Botany) and Ivan Mincev (GIS).

Fieldwork activities – Albania

SFI assessments were carried out on 16 June 2016 by Dhimiter Peci (Botanist), Valbona Simixhiu (GIS specialist) and Barbara Zennaro (SFI specialist). The boat was provided by Prespa National Park, and one of the Park's team, Mr Gani Bego, accompanied the researchers during the survey, offering valuable insights into the pressures and dynamics affecting the lake.

4.2 Methodology

The survey of the lake was carried out by boat. Both the Albanian and Macedonian teams were equipped with maps, GPS-enabled cameras and tablets installed with relevant applications. Data on the socio-ecological and geological parameters were recorded for each homogeneous stretch, and coordinates and photos were also taken. Subsequently, the data captured in the evaluation sheets were entered into the SFI software package and the SFI category calculated. The database was then imported into a GIS system to create the maps and extrapolate other spatial information.

For each homogenous stretch, an ID card was prepared containing the following information:

- Field form number
- Length of homogeneous stretch
- Delineation
- SFI result
- Personal evaluation
- Description of stretch
- Notes
- Map with location
- Representative photo
- SFI classification tree (produced using the software).

4.3 Homogeneous stretches 1 – 87

Individual homogenous stretch descriptions are supplied in digital form on an USB flat card (see pouch in back cover).

5 References

Academy of Science of Albania, *Hidrologjia e Shqipërisë*, 1985.

Albrecht C. and Wilke T., *'Lake Ohrid: biodiversity and evolution'*, *Hydrobiologia*, 615, 2008, pp. 103–140.

Bajkovic I., Hadžiablahović S., Cakovic D., Medenica B., Zaimi K., Elbasani O., Peci D., Simixhiu V., Zennaro B., *Shorezone Functionality Skadar/Shkodra Lake – Implementing the EU Water Framework Directive in South-Eastern Europe*. Technical Report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Eschborn. Pegi Sh.P.K. Book Publishers, Tirana, 2017, 83 pp.

Blinkov I., Trendafilov A., Nedeski B. and Cvetkoski J., *Biological measures for erosion control in the Sateska River basin,* World Bank Project – Protection of Ohrid Lake, BIOEKO Skopje, PE Macedonian Forests, Regional Office Galitsica, Ohrid, 2004.

Blinkov I., Trendafilov A., Miladinovic M. and Trendafilov B., *Spatial Plan for the Prespa–Ohrid Region, Expert Study: Forestry and Erosion Control,* Spatial Planning Agency, 2004.

Blinkov I., Elbasani O., Kostadinovski M., Krstic S., Kusterevska R., Mincev I., Peci D., Simixhiu V., Zaimi K., Zennaro B., *Shorezone Functionality Prespa Lake – Implementing the EU Water Framework Directive in South-Eastern Europe*. Technical Report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Eschborn. Pegi Sh.P.K. Book Publishers, Tirana, 2017, 78 pp.

Chapman, D., *Water Quality Assessment*, E & FN Spon, London, 1996.

CIS Wetlands Working Group, *Horizontal Guidance Document on the Role of Wetlands in the Water Framework Directive*, 7 October 2003, p. 63.

Dosskey M.G., Vidon P., Gurwick,N.P., Allan C.J., Duval T.P. and Lowrance, R., *'The role of riparian vegetation in protecting and improving chemical water quality in streams',* Journal of the American Water Resources Association, 46, 2010, pp. 261–277.

Ganoulis J., Murphy I.L. and Brilly M. (eds), *Transboundary Water Resources in the Balkans: Initiating a Sustainable Co-operative Network,* 2000.

Gorthner A., *'What is an ancient lake?', in: Speciation in Ancient Lakes,* edited by Martens K., Gooderis B. and Coulter G., Arch. Hydrobiol. – Ergebnisse der Limnologie, 44, 1994, pp. 97–100.

Hauffe T., Albrecht C., Schreiber K., Birkhofer K., Trajanovski S. and Wilke T., *'Spatially explicit analysis of gastropod biodiversity in ancient Lake Ohrid',* Biogeosciences, 8, 2011, pp. 175–188.

Hoffmann N., '*The active tectonic landscape of Lake Ohrid* (former Yugoslav Republic of Macedonia/Albania)', Annals of Geophysics, 56, 6; doi: 10.4401/ag-6254, 2013.

Hoffmann N., Reicherter K., Fernandez-Steeger T. and Grutzner G., '*Evolution of ancient Lake Ohrid: a tectonic perspective*', Biogeosciences, 7, 2010, pp. 3377–3386.

Imeri A., Mullaj A., Gjeta E., Kalajnxhiu A., Kupe L., Shehu J. and Dodona E., *'Preliminary results from the study of flora and vegetation of Ohrid Lake'*, Natura Montenegrina, Podgorica, 9(3), 2010, pp. 253–264.

Kostoski G., Albrecht C., Trajanovski S. and Wilke T., *'A freshwater biodiversity hotspot under pressure – assessing threats and identifying conservation needs for ancient Lake Ohrid'*, Biogeosciences, 7, 2010, pp. 3999–4015.

Martens K., '*Speciation in ancient lakes (review*)', Trends Ecol. Evol., 12, 1997, pp. 177–182.

Matzinger A., Schmid M., Veljanoska-Sarafiloska E., Patceva S., Guseska D., Wagner B., Müller B., Sturm M. and Wüst A., *'Eutrophication of ancient Lake Ohrid: Global warming amplifies detrimental effects of increased nutrient inputs'*, Limnology and Oceanography, 52, 2007, pp. 338–345.

Matzinger A., Spirkovski Z., Patceva S. and Wüst A., '*Sensitivity of Ancient Lake Ohrid to Local Anthropogenic Impacts and Global Warming'*, J. Great Lakes Res., 32, 2006, pp. 158–179.

Mersinllari M., *General Data on Vegetation of Ohrid and Prespa Watershed Area*, Proceedings of International Symposium, Korça, Albania, 1997, pp. 147–155.

Micevski E., '*Geological and hydrogeological characteristics of Ohrid–Presparegion'*, Makedonski Vodi IX (32), 2002, pp. 21–29.

Naumoski T.B., Jordanoski M. and Veljanoska-Sarafiloska E., '*Physical and chemical characteristics of Lake Ohrid'*, in: First International Symposium for Protection of the Natural Lakes in Republic of Macedonia, Ohrid, Republic of Macedonia, 31 May–3 June 2007, pp. 103–112.

Nielsen A., Trolle D., Søndergaard M., Lauridsen T.L., Bjerring R., Olesen J.E. and Jeppesen E. *'Watershed land use effects on lake water quality in Denmark'*, Ecol. Appl. 22(4), 2012, pp. 1187–1200.

Osborne, L.L. and Kovacic D.A., '*Riparian vegetated buffer strips in water quality restoration and stream management'*, Freshwater Biology, 29, 1993, pp. 243–257.

Peveling, R., Brämick, U., Densky, H., Parr, B., Pietrock, M., Adhami, E., Bacu, A., Beqiraj, S., Djuranović, Z., Djurašković, P., Gusheska, D., Hadžiablahović, S., Ilik-Boeva, D., Ivanovski, A., Kashta, L., Koçu, E., Kostoski, G., Lokoska, L., Mirta, Y., Mrdak, D., Palluqi, A., Pambuku, A., Patceva, S., Pavićević, A., Peruničić, J., Rakaj, M., Rakočević, J., Saliaga, V., Veljanoska-Sarafiloska, E., Spirkovski, Z., Shumka, S., Talevska, M., Talevski, T., Tasevska, O., Trajanovska, S., Trajanovski, S., *Initial characterisation of Lakes Prespa, Ohrid and Shkodra/Skadar – Implementing the EU Water Framework Directive in South-Eastern Europe*. Technical Report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Eschborn. Pegi Sh.P.K. Book Publishers, Tirana, 2015, 99 pp.

Paparisto K., Demiri M., Mitrushi I. and Qosja X., *Flora e Shqipërisë*, Vol. 1, Institute of Biological Research, Tirana, Albania, 1988, p. 453.

Popovska C. and Bonacci O., '*Basic data on the hydrology of Lakes Ohrid and Prespa'*, Hydrol. Process., 21, 2007, pp. 658–664.

Popovska C., *Hydrology of Ohrid and Prespa Lake,* Macedonian Academy of Sciences and Arts and the Academy of Sciences of Albania, Regional International Conference on Prespa and Ohrid Lakes, Struga and Pogradec, 28–29 October 2013.

Premazzi G. and Chiaudani G., *Ecological Quality of Surface Waters – Quality Assessment Schemes for European Community Lakes*, Environmental Institute, University of Milan, ECSC-EEC_EAEC, Brussels and Luxembourg, 1992.

Qiriazi P., Doko D. and Gruda G., *Tourist potentials of Albanian part of Prespa*, General characteristic of Prespa-Ohrid region, 1998.

Roth B.M. Kaplan I.C., Sass G.G., Johnson P.T., Marburg A.E., Yannarell A.C., Havlicek T. D., Willis T.V., Turner M.G. and Carpenter S.R. '*Linking terrestrial and aquatic ecosystem: the role of woody habitat in lake food webs.*' Ecological Modelling 203, 2007, pp. 439–452.

Salemaa H., '*Lake Ohrid: Speciation in ancient lakes'*, edited by Martens, K., Goddeeris B., and Coulter G., *Arch. Hydrobiol.* – Ergebnisse der Limnologie, 44, 1994, pp. 55–64.

Shumka S., Pinguli E., Merolli A., Damo R., Stojanovski B. and Blinkova M., *Study: Integrated Ecosystem Approach for the Lake Ohrid Basin as a Tool for Conservation and Protection of Natural Resources*, Local Development Agency (Macedonia), Europartners Development (Albania) and Eco Partners for Sustainable Development, 2004.

Siligardi M., Avolio F., Baldaccini G., Bernabei S., Bucci M.N.S., Cappelletti C., Ciutti F., Floris B., Franceschini A., Mancini L., Minciardi M.R., Monauni C., Negri P., Pineschi G., Pozzi S., Rossi G.L., Spaggiari R., Tamburro C. and Zanetti M., *IFF 2007 Indice di funzionalità fluviale*, Manuale APAT, 2007.

Siligardi M., Bernabei S., Cappelletti C., Ciutti F., Dallafior V., Dalmiglio A., Fabiani C., Mancini L., Monauni C., Pozzi S., Scardi M., Tancioni L. and Zennaro B., '*Lake Shorezone Functionality Index',* APPA Manual, 2010.

Spirkovski Z., Krstanovski Z., Selfo L., Sanxhaku M. and Puka V.I., *'The Monitoring Programme of the Lake Ohrid Conservation Project'*, in: Ganoulis, J., Murphy, I. L. and Brilly, M. (eds), *Transboundary Water Resources in the Balkans: Initiating a Sustainable Co-operative Network*, 2000.

Spirkovski Z., Paluqi A., Ilik-Boeva D., Talevski T., Trajcevski B., Ritterbusch D., Brämick U., Pietrock M. and Peveling R., *Fish and Fisheries Lake Ohrid – Implementing the EU Water Framework Directive in South-Eastern Europe*. Technical Report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bonn, Eschborn. Pegi Sh.P.K. Book Publishers, Tirana, 2017, 99 pp.

Trajanovski S., Albrecht C., Schreiber K., Schultheiß R., Stadler T., Benke M. and Wilke T., '*Testing the spatial and temporal framework of speciation in an ancient lake species flock: the leech genus Dina (Hirudinea: Erpobdellidae) in Lake Ohrid'*, Biogeosciences, 7, 2010, pp. 3387–3402.

Trendafilov A. and Blinkov I., *Development of a regional (MKD, SCG, BG, TUR) GEF PDF – A project on Sustainable Land Management: Community-based Rehabilitation of Degraded Land in Balkan Mountains*, Baseline Assessment of Ohrid region, 2006.

Wagner B.W. and Wilke T., *'Evolutionary and geological history of the Balkan lakes Ohrid and Prespa*', Biogeosciences, 8, 2011, pp. 995–998.
http://www.biogeosciences.net/8/995/2011/bg-8-995-2011.pdf

Watzin M.C., Puka V. and Naumoski T.B. (eds.), *Lake Ohrid and its Watershed –State of the Environment Report,* Ohrid Lake Conservation Project, Tirana, Republic of Albania, and Ohrid, The Former Yugoslav Republic of Macedonia, 2002.

UNESCO, *Natural and Cultural Heritage of the Ohrid Region*,
http://whc.unesco.org/en/list/99

6 Appendix

6.1 Glossary of terms

Shorezone

The area that includes the littoral (maximum depth of one metre) and riparian zones, and extends inland up to 50 metres from the shoreline, with the exception of interruptions or particular lake morphology that may limit its width – see Figure 57 (Siligardi et al. 2010).

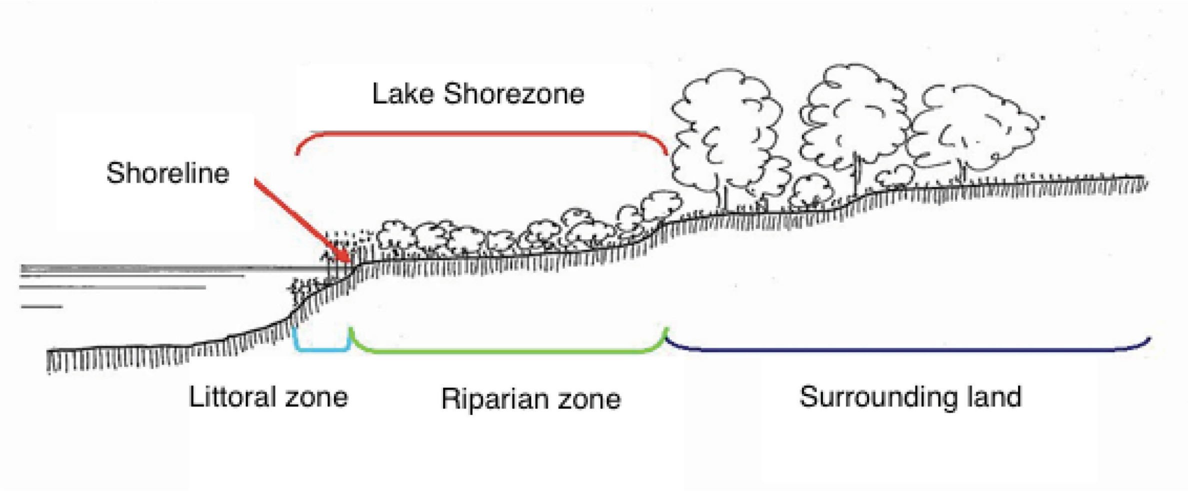


Figure 57. Structure of the lake shorezone

Riparian zone

This is the area immediately adjacent to a body of water, which functions as a transition zone between the lake and its surrounding territory. It is important because it regulates inputs (nutrients and sediments), which improves lake water quality by (a) filtering the runoff from the catchment area and removing pollutants (the vegetation in the riparian zone can remove up to 90% of the nutrients passing through) and (b) aiding sedimentation (the vegetation slows the water flowing into the lake). The riparian zone also provides habitat for aquatic and terrestrial animals, including food, shade (temperature control), shelters, and areas for hunting and breeding, and it promotes bank stabilisation and thus protects the shoreline from erosion.

Littoral zone

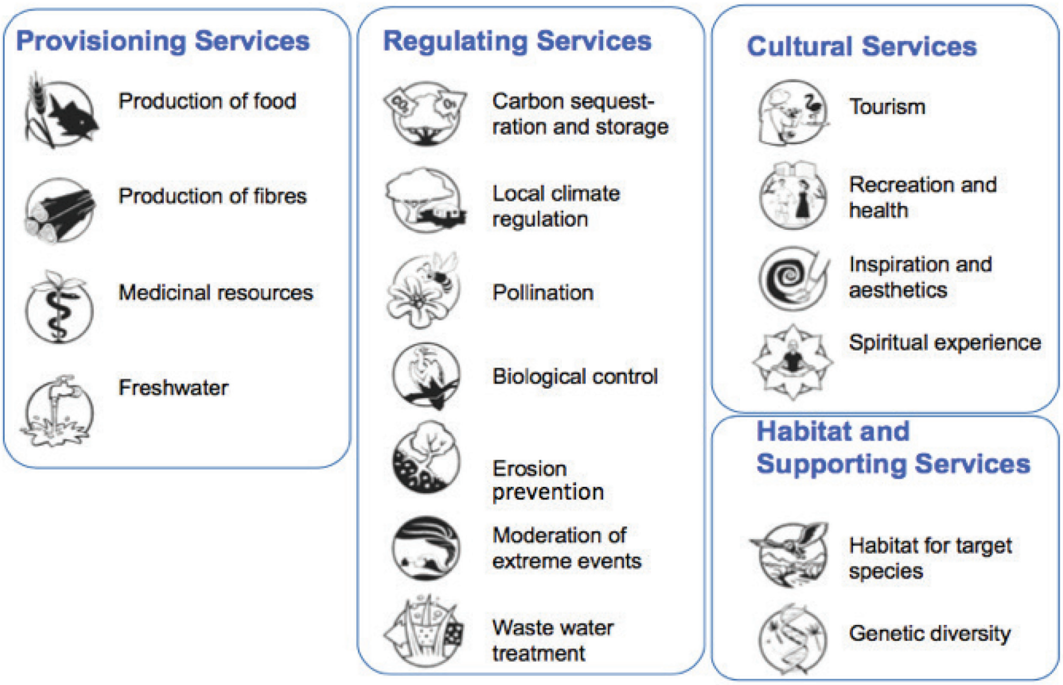
This is the submerged section of the lake alongside the shore that generally coincides with the area where submerged macrophytes are present. This area often hosts many aquatic and non-aquatic animals. Many fish species choose this area for egg deposition and development (Rooth et al. 2007) and it is an important area for nutrient cycling. It also protects the shoreline from erosion and, by reducing wave action, promotes good water clarity.

Shoreline

This is the point along the shore where water and soil make contact. It can be bare (naturally or artificially), herbaceous or have a more complex vegetation such as stumps, logs, root systems, reed beds or other.

Ecosystem services

These are the functions of the ecosystem that contribute either directly or indirectly to the wellbeing of society. They are divided into provisioning services (e.g. production of food or fibres), regulating services (e.g. erosion prevention, wastewater treatment), cultural services (e.g. tourism), and habitat and supporting services (e.g. habitats for target species) (TEEB 2012).



Drainage basin (also drainage area, catchment basin/area, watershed)

This is an area of land where all surface water derived from rain or melting snow/ice converges on a single point at a lower elevation, where the surface water then joins another body of water such as a river, lake, reservoir, estuary, wetland, sea or ocean.

Drainage basins are an important factor in an area's ecology because, as water flows over the ground and along rivers towards the outlet of the basin, it can pick up nutrients, sediment and pollutants. These can impact on ecological processes along the way and can also affect the water of the receiving source.

The modern use of artificial fertilisers containing nitrogen, phosphorus and potassium has been shown to affect the mouths of drainage basins. The minerals are carried by the drainage basin to its mouth and can accumulate there, disturbing the natural mineral balance. This can cause eutrophication where plant growth is accelerated by the additional material.

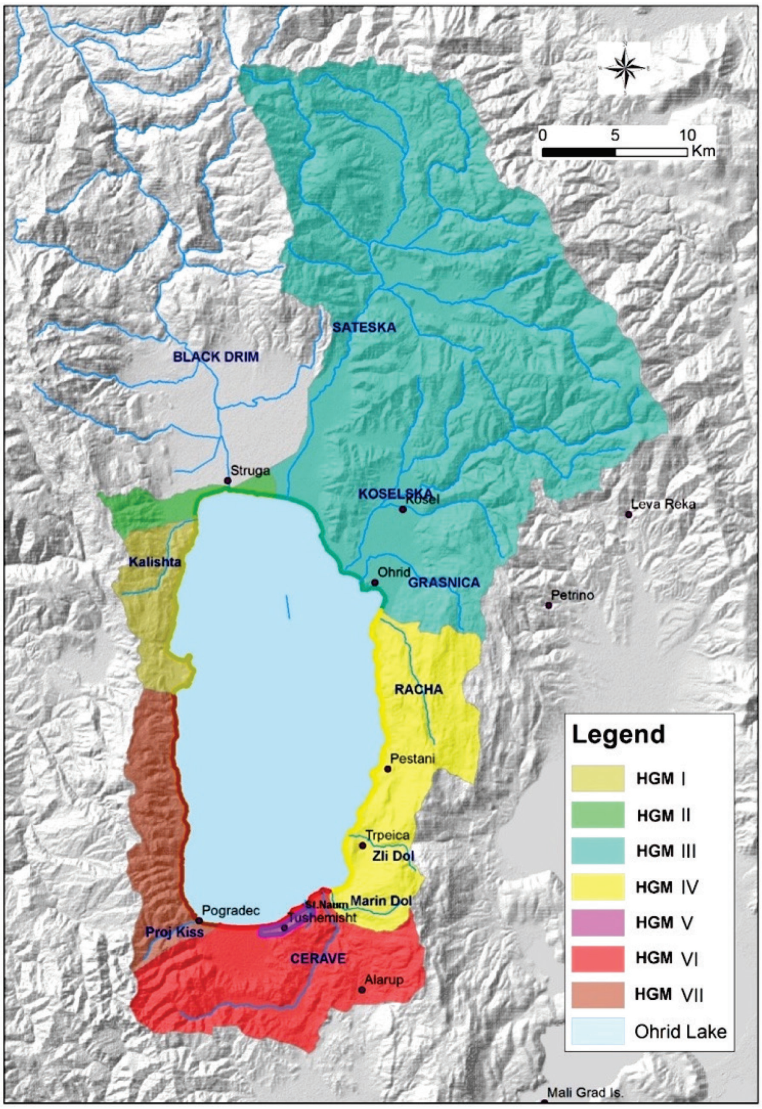
Drin River Basin

The area of land where all surface water converges on the Drin River as it works its way towards the Mediterranean Sea. The Drin originates in the drainage basin of Prespa Lake (Greece, Albania and Macedonia), the waters of which feed into Ohrid Lake. The latter (Albania and Macedonia) then feeds into the Black Drin River, which traverses Albania, entering the White Drin River Basin to form the Drin River. The waters of the Drin River Basin subsequently join the waters coming from the Skadar/Shkodra Lake drainage basin (that stretches across Albanian and Montenegrin territory), which then pass downriver and finally debouch into the Adriatic Sea.

Hydrogeomorphological (HGM) area

An area with specific hydrological, geological and morphological characteristics that differentiate it from nearby areas. HGM parameters considered in this study include topography (drainage slopes that affect runoff, and the presence of reeds in the littoral zone), bedrock type (the presence of soft or hard rock, which affects water percolation), soil types and vegetation presence (which affect runoff/percolation and the concentration of nutrients from natural/anthropogenic sources).

HGM areas around Ohrid Lake



Average residence time

The average time that water spends in a particular lake, from the time it enters the lake to the time it exits.

Thermic cycle

How often lake-bottom and surface waters mix within a year.

6.2 List of GIS Shapefiles

No	Description of dataset	Scale	Year produced	GIS format	File format
1	SFI stretches point	1:10,000	2016	shapefile (shp)	Point vector format with attribute database
2	SFI stretches line	1:10,000	2016	shapefile (shp)	Line vector format with attribute database of SFI software
3	Hydrogeo-morphological areas	1:25,000	2016	shapefile (shp)	Polygon vector format with attribute database
4	Stream network	1:25,000	2015	shapefile (shp)	Line vector format with attribute database
5	Stream catchments	1:25,000	2015	shapefile (shp)	Polygon vector format with attribute database
6	Springs	1:25,000	1990, updated 2016	shapefile (shp)	Point vector format with attribute database
7	Settlements	1:25,000	2016	shapefile (shp)	Point vector format with attribute database
8	Nutrient load	1:25,000	2016	shapefile (shp)	Point vector format with attribute database
9	Road network	1:100,000/ 1:25,000	1995, updated 2016	shapefile (shp)	Line vector format with attribute database
10	Sewage	1:100,000/ 1:25,000	2016	shapefile (shp)	Point vector format with attribute database
11	Topographic maps	1:25,000	2004	TIFF (GeoTIFF)	Raster format
12	Digital Elevation Model (DEM SRTM)	30 minute	2014	TIFF (GeoTIFF)	Raster format

6.3 Parameters assessed in the field and included in the SFI stretch shapefiles (line)

Each row represents a column in the GIS database and each box represents a question. Note that some questions require a single answer so the box has only one row (e.g. width), whereas other questions seek to collect a range of information (e.g. composition of lake shorezone), so the box has multiple rows.

Name	Parameter	Category	Significance	Comments	Area considered
Stretch_N	Stretch ID	-	-	Stretch ID as collected in the field	
Length	length			Calculated a posteriori	
SFI		1 to 5		SFI result	
Width	Width of functional lake shorezone (LS)	0 to 5	0 = 0 m 1 = 1–5 m 2 = 5–10 m 3 = 10–30 m 4 = 30–50 m 5 = >50 m	Includes both littoral and riparian zone up to 50 metres inland	LS
Tree_%	Presence of trees within LS	%	0 = none 1 = 100% of LS 0.x = inter-mediate values (e.g., 0.2 = 20% presence) Values add up to 1 (100%)		LS
Shrub_%	Presence of shrubs within LS	%			LS
Reed_%	Presence of reeds within LS	%		Water lilies, water chestnut and other vegetation with floating leaves not considered (see description of individual stretch)	LS
Grass_%	Presence of (natural) grasses within LS	%		Grass beneath vertical projection of trees not considered	LS
Bare Soil_%	Presence of bare soil within LS	%		Rocks, beaches, impermeable walls and fertilised managed gardens considered as bare soil	LS
Hygroph	Hygrophilous species	%	0 = none 1 = 100% of LS Values add up to 1 (100%)		LS
No_Hygroph	Non-hygrophilous species	%		Bare soil and exotic species fall into this category	LS
Exotic_Sp	Exotic species	%	0 = none 1 = 100% of LS 0.x = intermediate values		RIP
Heteroge	Heterogeneity of arboreal and riparian vegetation	0 to 1	See table below*	Manual, p. 45	RIP

Cont_tree	Continuity of arboreal and shrub vegetation	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when interruption >10%	Identify longitudinal interruptions (artificial or rocks/bare soil)	RIP
Cont_reeds	Continuity of wet reed zone	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when interruption >10%		LIT
Cont_dryRe	Continuity of dry reed zone	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when interruption >10%		RIP
Interrupti	Interruption	0 to 1	0 = none 0.1–0.9 = inter-mediate 1 = along whole stretch	Linear (e.g. beach is a continuous interruption) or scattered (e.g. fields within 50-metre area)	50
Use_0_50m	Typology of anthropogenic use of LS	0/0.5/1	0 = natural habitat 0.5 = sparse urbanisation/ meadows 1 = urbanised area	The most prevalent typology considered	50
Use_0_200m	Surrounding territory	0 to 3	0 = natural habitat 1 = meadow/small cultivation 2 = intensive cultivation/sparse urbanisation 3 = urbanised	The most prevalent category considered	200
Infr_Roads	Infrastructure: provincial/state roads	0 to 1	0 = none 0.1–0.9 = present only in parts of stretch 1 = along whole stretch		200
Infr_train	Infrastructure: railroads	0 to 1			200
Infr_park	Infrastructure: parking	0 to 1			200
Infr_touri	Tourism-related infrastructure	0 to 1			200
Slope	Average slope	0 to 5	0 = flat 1 = noticeable 2 = obvious 3 = significant 4 = strong 5 = extreme	(e.g., extreme or strong could be cliffs)	50
Consistenc	Consistency	0/1	0 = consistent 1 = not consistent	To evaluate superficial vs hyporheic flow	50 + LIT

Concavit	Shore profile: concavity	0 to 1	0 = none 0.1–0.9 = intermediate 1 = along whole stretch	See examples in the manual, p. 61	SHO
Convexit	Shore profile: convexity	0 to 1			SHO
Complexit	Complexity	0 to 1	0 = none 0.1–0.9 = intermediate 1 = along whole stretch	Evaluates the presence of ecological niches 0 = e.g. impermeable walling	SHO or SHO LIT where applicable
Artificia	Artificiality	0 to 1	0 = none 0.1–0.9 = intermediate 1 = along whole stretch		SHO
Run_Off	Runoff	0 to 1	0 = diverging 0.1–0.9 = intermediate 1 = converging	0.5 = parallel to the shore	200
PersonalEv	Expert judgment	1 to 5	1 = high 2 = good 3 = moderate 4 = poor 5 = bad	Surveyor evaluates overall functionality of shorezone, results of which are used in the future development and control of the methodology; NB: discrepancies with calculated values may indicate errors in data collection or entry	LS
Surveyors				Surveyors that carried out survey	
DateSurvey				Date the survey was carried out	
Shore_Type		1 to 6	1 = wide belt of riparian vegetation 2 = narrow belt of riparian vegetation 3 = thin layer of shrubs 4 = Reeds followed by bare soil/crops 5 = bare soil/grass/high anthropogenic impact 6 = artificial shore	Categories identified a posteriori	SHO

Floating		0 to 2	0 = absent 1 = present 2 = no information	Information extracted from description of stretches a posteriori	
Comments				Various info extracted from description of stretches a posteriori	
Oak		0 to 2	0 = absent 1 = present 2 = no information	Information on the presence of oak trees extracted from description of stretches a posteriori	

* Heterogeneity of arboreal and riparian vegetation

0	Native trees and shrubs are absent, or exotic species are prevalent
0.1	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, but only 1 species is dominant, e.g. pine tree
0.2	Native trees and shrubs are prevalent, but only 1 species is dominant
0.3–0.4	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, and there are at least 2 or 3 species equally present
0.5	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, and there are more than 3 species equally present
0.6	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrub area, but 1 species only is dominant
0.7–0.9	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrub area, and at least 2 or 3 species are equally present
1	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrub area, and more than 3 species are equally present

KEY

LS = lake shorezone (both riparian and littoral)

RIP = riparian only (terrestrial)

LIT = littoral only (aquatic)

50 = area between shoreline to a line 50 metres inland

SHO = shoreline (i.e. the point of contact between the land and the lake)

200 = area between shoreline to a line 200 metres inland

SHO LIT = lakeward boundary of reed belt

6.4 Sample SFI field form

For more information on this form, please refer to the following manual, available free of charge on the APPA Trento website: Siligardi, M., *Lake shorezone Functionality Index, APPA manual*, 2010.

Date	Form no
Lake	
Delimitation of stretch	
Photos no	
Surveyors	
Lake shorezone	
1. Width of lake shorezone	
0 m	0
1–5m	1
5–10m	2
10–30m	3
30–50m	4
>50m	5
2. Characterisation of lake shorezone vegetation **2.1 Cover/composition % (expressed from 0 to 1)**	
Trees %	
Shrubs%	
Reeds%	
Grasses%	
Bare soil%	
2.2 Hygrophilous and non-hygrophilous vegetation (expressed from 0 to 1)	
Hygrophilous	

Non-hygrophilous	
2.3 Presence of exotic species	
Exotics	
2.4 Heterogeneousness of arboreal-shrub vegetation	
Diversified	1
Intermediate (from 0.9 to 0.7)	
Monospecific	0.6
Autochthonous hygrophilous arboreal-shrub species >2/3	
Diversified	0.5
Intermediate (from 0.4 to 0.3)	
Monospecific	0.2
Autochthonous hygrophilous arboreal-shrub species <2/3 and autochthonous arboreal-shrub <2/3	
Autochthonous prevalence	0.1
Exotic prevalence	0
Arboreal-shrub vegetation absent	0
3. Continuity of the lake shorezone vegetation	
Arboreal and shrub zone	
Absent	0
Discontinuous	0.5
Continuous	1
Wet reed zone	
Absent	0
Discontinuous	0.5
Continuous	1
Dry reed area	
Absent	0

Discontinuous	0.5
Continuous	1
4. Presence of interruption in the lake shorezone	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
5. Typology of anthropogenic uses within the lake shorezone	
Uncultivated meadows or unpaved streets, etc.	0
Sparse urbanisation, cultivated meadows, etc.	0.5
Urbanised area	1
SHORE AND SURROUNDING TERRITORY	
6. Main use of nearby territory	
Woods and forest	0
Meadows, forests, arable land, uncultivated farmland	1
Seasonal and/or permanent cultures, and sparse urbanisation	2
Urbanised area	3
7. Infrastructure	
Provincial/state roads	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Railroads	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Parking	
Absent	0

Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Tourism-related infrastructure	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
8. Emerged portion of the lakeshore zone **8.1 Average slope**	
Flat	0
Slightly noticeable slope	1
Obvious but can be overcome without problem	2
Significant but can be overcome with trails or ramps	3
Strong slope, roads or trails with bends	4
Extreme, vehicles cannot negotiate it	5
8.2 Comparison between the slopes of the emerged and submerged areas	
Not consistent	0
Consistent	1
9. Shore profile **9.1 Concavity and convexity**	
Concavity	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Convexity	
Absent	0
Intermediate (from 0.1 to 0.9)	

Present along the whole stretch	1
9.2 Complexity	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
10. Shoreline artificiality	
Absent	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
11. Apparent channelling of runoff	
No prevalent direction for the flow	0
Intermediate (from 0.1 to 0.9)	
All the runoff converges on a single point	1
12. Personal evaluation	
High	1
Good	2
Moderate	3
Poor	4
Bad	5