Lake Ohrid and its Watershed: Our Lake, Our Future

A State of the Environment Report

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A Unique Lake...

Lake Ohrid is very old. It was formed 2-3 million years ago by earthquakes that fractured the landscape and created its deep bowl. Because the lake is so old and the surrounding hills and mountains isolated it from other waters, a unique collection of plants and animals have evolved here. Some of these plants and animals were common millions of years ago, but have virtually disappeared from other places in the world. Scientists call these species "relicts" or living fossils. Other species live only in Lake Ohrid and are found nowhere else on the planet. These "endemic" species include the famous Lake Ohrid trout and many other fish, snails, worms, sponges and aquatic plants. Almost 70 % of Lake Ohrid's plants and animals are relic or endemic species.

A view of Lake Ohrid from Samuel's fortress.

People too have made the Lake Ohrid watershed their home for thousands of years. The ancient Illyrians built villages in the Ohrid-Prespa region in the 4th and 5th centuries BC. The castle northwest of Pogradec was constructed during this time. In the first century AD, the town of Ohrid was the cultural center of Macedonia. In medieval times, the famous missionaries, St. Clement and St. Naum, made Ohrid their home and a thriving university, the oldest in Europe, educated over 3500 students. In the 10th century, Samuel ruled over the greater Slavonic region from the fortress on the hill of Ohrid. Today the Lake Ohrid watershed includes three countries, Albania, Macedonia, and Greece, and numerous cities, towns and villages.

...With Common Problems

Because of its high biodiversity and its unique cultural heritage, Lake Ohrid is a lake of tremendous local and international significance. But many forces also threaten it. Since the end of World War II the population in the lake's watershed has grown rapidly. It now approaches 200,000 permanent residents, with many thousands more coming into the basin during the summer tourist season.

Population growth and development have impacted the lake in many ways. These include intense fishing pressures, destruction of the reed beds and other natural habitats around the shoreline of the lake, and the introduction of pollutants, especially phosphorus, into the lake water. Phosphorus is fertilizing the lake, stimulating algae growth that threatens the lake's unique biodiversity and the crystal clear water that is its major tourist attraction.

Runoff from agricultural fields is a significant source of pollution in both Lake Prespa and Lake Ohrid.

THE LAKE OHRID CONSERVATION PROJECT

The common problems of Lake Ohrid encouraged the governments of Albania and Macedonia to come together and sign an agreement on 20 November 1996 to begin the Lake Ohrid Conservation Project. Funding for the project comes from a Global Environment Facility (GEF) grant through the World Bank. The activities of the Lake Ohrid Conservation Project began in 1998 and will continue until mid 2003.

The objective of the Lake Ohrid Conservation Project is to conserve and protect the natural resources and biodiversity of Lake Ohrid by developing and supporting effective cooperation between Albania and Macedonia for the joint environmental management of the watershed.

Four Components of the Lake Ohrid Conservation Project

Component A: ***Institutional Strengthening***

Focuses on increasing the capacity of public officials in the Lake Ohrid watershed to enforce each country's environmental laws, regulations, standards and policies.

Component B: ***Monitoring***

Focuses on establishing a comprehensive bi-national monitoring program to inform the public and local officials about the condition of the lake and to provide the information necessary for effective decision-making.

Component C: ***Participatory Watershed Management***

Aims to mobilize groups within the watershed to create a strategic action plan.

Component D: ***Public Awareness and Participation***

Works to create public awareness and increase community participation to ensure effective and sustainable implementation of the Lake Ohrid Conservation Project.

This State of the Environment Report summarizes the information about the watershed that has been gathered and highlights the environmental problems that currently exist. It also outlines some of the steps that must be taken in the future, by both governments and the citizens of the basin, to begin solving these problems.

There are critical choices to be made – the future of the Lake Ohrid basin depends on the choices that we all make in the coming years.

THE WATERSHED

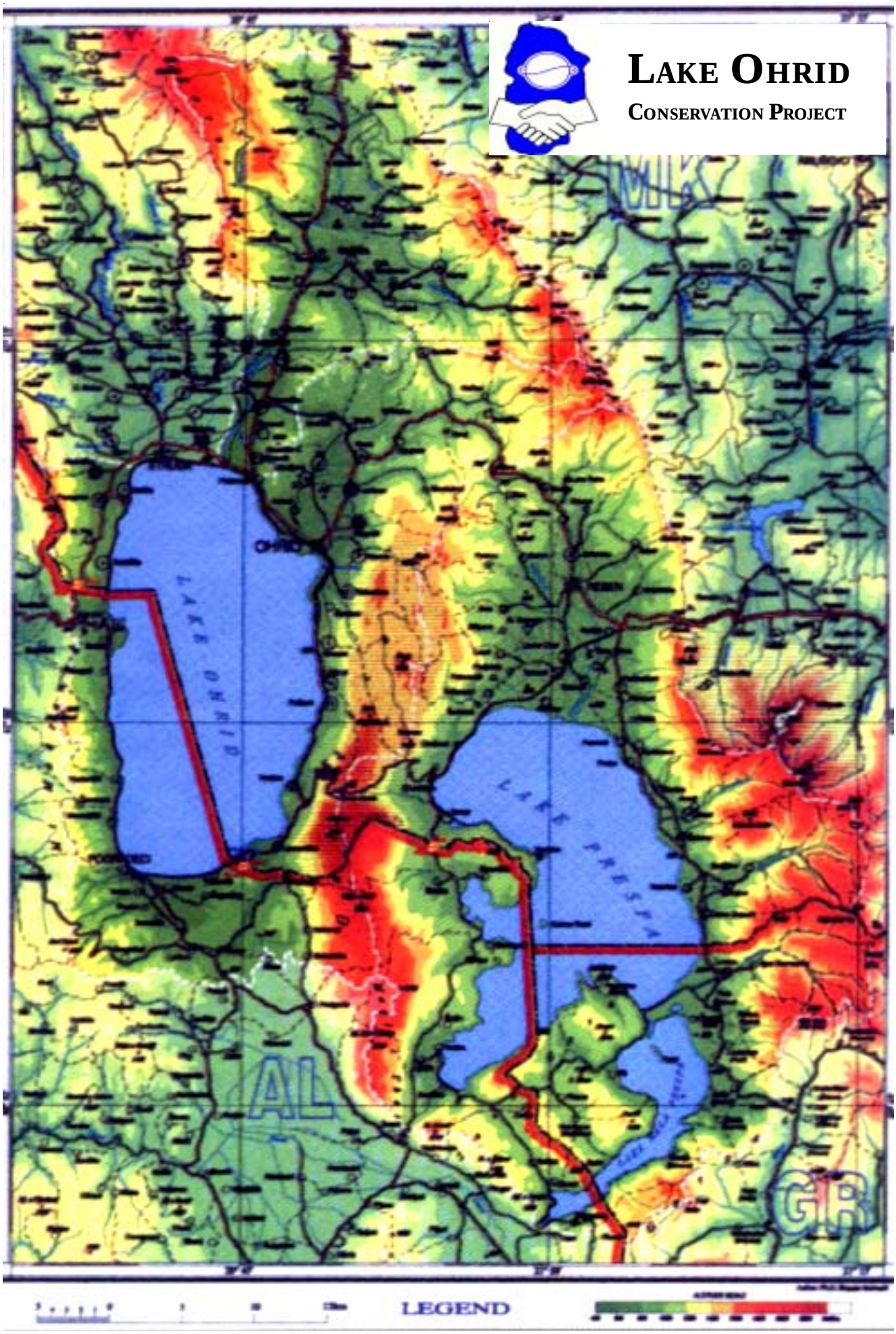
Lake Ohrid has 87.5 km of shoreline and covers an area of 358.2 km^2. Although the average depth of the lake is 164 m, it has a maximum depth of 289 m. The water that fills Lake Ohrid comes from its watershed, or drainage area. The rivers and streams that run down from the mountainsides and out of the valleys into the lake, such as the Cerava River and the Koselska River, deliver about half of its water. The rest 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 mountains to the east, Galicica and Mali i Thate. These mountains are made of karst, a kind of rock that is easily eroded by water. Over thousands of years, holes and channels have formed within the mountain rock. These channels carry water that originated in Lake Prespa to Lake Ohrid. Because Lake Prespa sits 150 m above Lake Ohrid, its waters run "downhill" to Lake Ohrid through the channels in the karst. One of the easiest places to see the water leaving Lake Prespa and entering the underground mountain channels is at the Zaveri swallow hole, along the western shore of Big Prespa Lake, near the villages of Gollomboch and Gorica.

The springs at St. Naum carry water from Lake Prespa into Lake Ohrid.

Like Lake Ohrid, Big and Small Prespa Lakes also get their water from their watershed. These lakes have smaller drainage areas and they are filled mostly by the rivers flowing into them. About every 11 years, all the water in Lake Prespa is replaced by new water. In contrast, it takes about 70 years for all the water in Lake Ohrid to be replaced. Water flows out of Lake Ohrid near Struga, into the Black Drim River. This river eventually runs all the way to the sea.

Left: Mount Galicica towers above Lake Ohrid in Macedonia.

Next Page: The Lake Ohrid watershed (in deeper colors) includes parts of Albania, Macedonia and Greece.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Human Activities in the Basin – Stresses on the Ecosystem

There are about 106,000 residents in the Macedonian part of the watershed and about 61,000 residents on the Albanian side of the watershed. This population is 5 or 6 times as large as it was at the end of World War II. Most residents live in several large towns – Ohrid, Struga, and Resen in Macedonia and Pogradec in Albania, but there are also many small villages and communities scattered throughout the watershed.

Wastewater

While people are a natural part of ecosystems, some of our activities can have harmful effects on other species, especially when we live in dense settlements. In many towns and cities, human waste is discharged into streams or the lake. Human waste contains nutrients that act as fertilizers and harmful bacteria that can pollute streams and lakes. The detergents we use to wash our clothes also contain high concentrations of nutrients.

Human waste and wastewater is not treated in Albania. In Pogradec, the waste generated by about 30% of the town is collected but it is simply discharged into Lake Ohrid near Tushemisht. Because Pogradec has been growing, the volume of wastewater is also increasing, and currently, the wastewater produced by over 60,000 residents makes its way into Lake Ohrid. This situation poses a threat to the health of both the inhabitants and the tourists in Pogradec.

In Macedonia, the Regional Sewerage System for the Protection of Lake Ohrid collects wastewater from about 65% of the Ohrid-Struga region and delivers it to the treatment plant Vranista. After treatment, the wastewater is discharged into the River Black Drim. The first phase of the plant was completed between 1985 and 1987 and it has been operating since June 1988. The plant has the capacity to treat the wastes produced by about 120,000 people. A general development plan for the regional sewerage system through 2025 was made in 2001. In two additional construction phases, an additional 44 km of sewer, which will treat most of the shoreline on the Macedonian side of the lake, will be added to the system.

In the Lake Prespa region, only the town of Resen has a sewerage collection and treatment facility. The wastewater treatment plant Ezerani has the capacity to treat the wastes of about 12,000 residents and serves about 80% of the town.

The sewer line is extended in the town of Ohrid.

Agriculture

Farmland can also be an important source of pollution to Lake Prespa and Lake Ohrid. Fertilizers, soil particles, and pesticides wash into rivers and streams and eventually to the lakes. Much of the farmland in the watershed is irrigated, and the excess water, carrying sediments, fertilizers and pesticides, also drains back to the lake. In both Albania and Macedonia, fertilizer and pesticide use is substantial, including pesticides that can be highly toxic to both people and the plants and animals living in the lake.

Pesticides used on apple trees may end up in the fish in Lake Ohrid.

Around Big Prespa Lake, agriculture is a particular problem. The fields are widespread, the lake level is dropping, and the cultivated land extends right down to the edge of the lake. Fortunately, pesticides are not used extensively around much of Big Prespa Lake.

Industry

Industry also contributes pollution to the lake in many forms. In Pogradec, the metal parts factories and a phosphate detergent plant discharge wastes to the lake without treatment. To the east of Pogradec, there are a number of old mines that used to produce chromium, nickel, iron, and coal. Only one of these remains in operation, but the mining sites still have many large piles of waste material that is exposed to the rain. Rainfall washes pollutants from the piles into the lake.

Industries in Macedonia include automobile spare parts, electrical parts, and textile, ceramic, and metal processing plants and food production. All of these industries produce waste that may be contaminating the Sateska, Velgoska, Koselska, and Golema Rivers. Food processing plants that discharge waste such as apple pulp are a significant problem in the Prespa watershed.

Solid Waste

Solid wastes can be a source of contamination to the lake if they are not disposed of properly. As this waste material breaks down, highly contaminated liquids can seep down into the underground water and adjacent streams and make its way to the lake.

In Pogradec, waste is collected and deposited at a site in the valley near Gurras, along both sides of the road leading to the former coal mine of Alarup. This dump has no provisions to treat the waste or keep it from contaminating the groundwater. A proposal has been developed to construct a landfill, Cerava-1, at a site about 15 km from Pogradec, but not all experts agree that this site is appropriate.

In Ohrid, waste is collected and taken to the landfill Bukovo, about 25 km outside of town. In Struga, waste is collected and taken to the landfill Kafasan. This landfill is situated 12 km southwest of Struga, near the village Mali Vlaj. Waste from the town of Resen, and in the summer months from the tourist resorts of Asamati and Pretor, is collected and taken to the landfill Alcevski Koshari, about 3 km north of town. None of these landfills is lined or has a drainage system to collect and treat the contaminated wastes.

The River Velgoska is littered with solid waste.

A warm, sunny day and cool clear water draw a crowd along the shores at Kaneo.

Tourism

Tourism can be considered a special kind of "industry." A healthy tourist industry requires hotels, restaurants, and other appropriate services for the tourists. Because the tourists come to experience the water, many of these developments are right along the shoreline. The tourists also produce wastes that must be treated and disposed of properly.

Both the Macedonian and Albanian shorelines are tourist destinations, and both have suffered from the political instability in the wider Balkan region since 1991. In Ohrid, the number of foreign tourist overnight stays has been reduced up to 70%. As the political situation improves, Ohrid is uniquely positioned to appeal to the growing market in cultural tourism, with the many historic sites, monasteries, and other national treasures in the area. Lake Ohrid could also be promoted within the ecotourism market, but an essential prerequisite for this kind of tourism is a healthy and unpolluted environment, with clean water.

Shoreline communities in Albania have grown dramatically in the last 10 years.

Socioeconomics

Pressures on the environment are greatest when socioeconomic conditions are difficult and unemployment rates are high. Under these circumstances, resources are often not available for environmental protection and improvement. Currently, the unemployment rates in both Albania and Macedonia are high. Many people of working age do not have full time jobs with benefits. There are many causes for this situation, but as the political transition continues, solving this problem is central to healthy communities and healthy environments.

THE ECOLOGY OF LAKE OHRID

In lakes, there are three main groups of plants, tiny floating cells called phytoplankton, slippery algae that grows on the tops of rocks and stones, and the rooted reeds and submerged plants growing in the shallow water muds and sands. If you have a garden, you know that adding fertilizer will make plants grow. It is the same in lakes. The fertilizer we are adding to Lake Ohrid and Lake Prespa is the phosphorus in detergents and in human and animal waste, in runoff from the land, and in the rivers and streams draining into the lakes. This phosphorus is stimulating plant growth, and as a result, the water in the lakes is becoming greener. Some plants are better able to take advantage of the extra phosphorus and these plants are thriving, even outcompeting the other plants.

A microscopic view of the tiny phytoplankton in Lake Ohrid.

Fuzzy green algae grows on the surface of these rocks.

So many plants may grow in the lake that the fish and other animals in the lake can't eat them all. When the uneaten plants die, they sink to the bottom and decompose, with the help of bacteria. This decomposition uses up oxygen, sometimes so much that there is not enough oxygen left for the fishes and other living things in the lake. The decomposition of other organic matter coming into the lake in runoff and waste discharges also uses up oxygen. If these animals can't move away, or the zone of low oxygen is very widespread, the animals will die. You may have seen this as a "fish kill" in the lake.

Even if the animals don't die from oxygen starvation, fertilization will affect them. The plants in Lake Ohrid are the base of the food web. The kinds of tiny animals that eat these plants will also change as their diet is altered and the changes are passed on to each new level in the food web, all the way up to the fishes, birds, and wildlife. Very small increases in

Reeds thrive along undeveloped shorelines.

nutrient concentration can result in dramatic changes in species composition in the lake. It is possible that in the coming years, the community of plants and animals in the lakes may be very different than the one that is present today because each successive link in the food web is faced with a different food environment. Lakes that have lots of nutrients tend to have a much lower diversity of species because only very tolerant species can survive in the nutrient-rich environment.

We call all these changes that start with nutrient enrichment "eutrophication." Eutrophic lakes have lots of plant growth and are frequently characterized by cloudy or green water. All lakes become more eutrophic over the centuries as rivers and streams deliver sediments and nutrients to them and the lakes gradually fill in. This aging is a natural process, but when people add to the nutrients with their untreated wastes and by using the land in ways that wash nutrients and soils into the water, this process speeds up.

Historically, Lake Ohrid has been known as an "oligotrophic" or clear water lake. Because Lake Prespa is a shallow lake, it is naturally a little more eutrophic than Lake Ohrid. Scientists think that Lake Ohrid may have "aged" by thousands of years in just the last few decades because of the actions of people. Lake Prespa is becoming highly eutrophic and suffers from cloudy, green water and low oxygen concentrations in the summer.

Phosphorus

Scientists in both Albania and Macedonia have been tracking these changes, starting by measuring the concentration of phosphorus in the lakes. The concentration of phosphorus in Lake Prespa shows that this lake is already eutrophic. The concentration of phosphorus in the middle of Lake Ohrid is still low enough for this lake to be considered "oligotrophic," but the amount has been increasing over time. The concentration now may be 3 or 4 times the concentration measured before World War II. Considering the very large volume of water in Lake Ohrid, this is a very significant change. If this trend is verified by additional monitoring, Lake Ohrid can be expected to change dramatically in the next few decades.

The Cerava River carries phosphorus and other pollutants into Lake Ohrid.

One of the largest single sources of phosphorus is the untreated sewerage from the town of Pogradec. Runoff from pastures and agricultural land is another big source. Some of the rivers and streams that discharge into Lake Ohrid and Lake Prespa are a third big source, and scientists have been measuring the amount of phosphorus in these streams for the last few years. An estimate of the total amount, or load of phosphorus to the lake is critical in order to predict its future condition. Preliminary estimates suggest that this load may be 3-5 times greater than it should be to keep Lake Ohrid in a clear water state.

On the Albanian side, the water in the Cerava and Pogradec Rivers and in Drilon Springs carries the highest loads of phosphorus. On the Macedonian side, the Rivers Velgoska, Koselska, and Sateska are the most polluted and deliver the most phosphorus to Lake Ohrid. The River Velgoska flows through the northern part of the city of Ohrid and carries both municipal and industrial waste. The River Koselska flows through a predominantly rural area, but it also receives some municipal and industrial wastewater. The River Sateska, which was diverted into Lake Ohrid in 1962, flows

through both agricultural and urban areas and carries a very high load of both phosphorus and sediment, which is deposited in shallow waters of Lake Ohrid at the mouth of the river. The load of phosphorus coming from the Sateska River may be about the same as that coming from the sewerage of Pogradec.

The springs at Saint Naum, like Drilon Springs, carry water from Lake Prespa into Lake Ohrid. Very few measurements have been made of this spring water, but these measurements show that the concentration of phosphorus is elevated.

The rivers in the Prespa basin, including Golema, Brajcinska, and Kranska, carry very high phosphorus loads. In the summer, the oxygen concentration in these waters can also be very low. The high nutrient concentrations in the Prespa tributaries reflect the surrounding agricultural watershed. Fertilizers and animal waste regularly wash off the fields and pastures with rain water and irrigation and enter the streams and the lake. This is why Lake Prespa is so eutrophic. Because Lake Prespa is the source for the water in the St. Naum and Drilon springs, it is likely that much of this phosphorus eventually makes its way to Lake Ohrid.

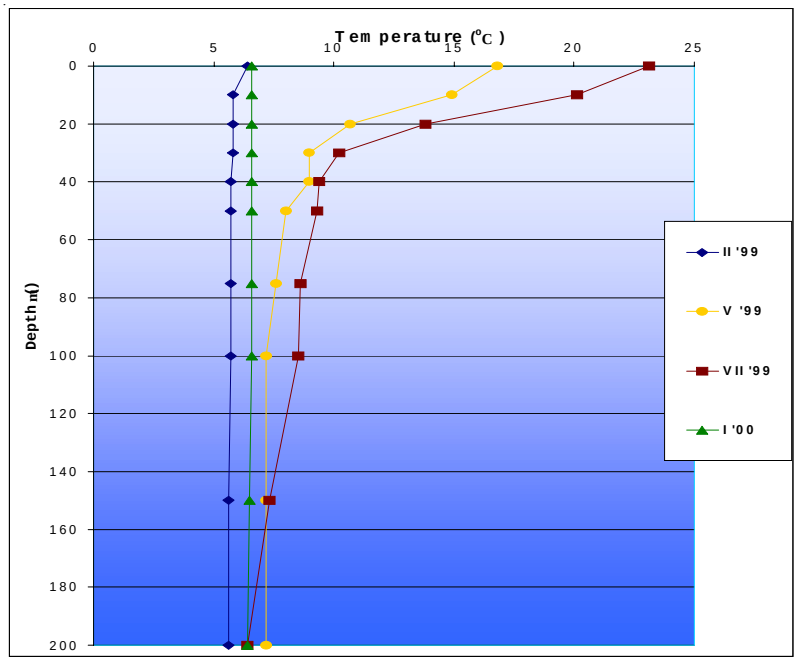
Dissolved oxygen

To understand oxygen in Lake Ohrid and Lake Prespa fully, you also need to understand temperature. Lake Ohrid is a very large lake, so the sun warms the water in it slowly. In the spring and summer, water at the surface becomes noticeably warmer, but because the lake is so deep, the sun cannot warm all the water down below. Therefore, layers of water of different temperatures form in the lake. The water near the surface, in a layer called the epilimnion, is warmest. It actually floats on top of the coldest water down below, in a layer called the hypoliminion. The transition zone between these two layers is called the metaliminion. This layering of the water is called stratification.

Oxygen can dissolve into the lake water in the epilimnion from the air. The tiny phytoplankton that are photosynthesizing and growing in the upper layers of the lake also put oxygen into the water. But the hypolimnion has no opportunity to gain oxygen from the air. As oxygen is used by the animals in these deeper waters and by the bacteria decomposing the dead plants and animals that sink down into the water, oxygen concentrations can drop substantially.

In the fall, when air temperatures decrease, the surface waters cool off and the layers can mix. Once every 6 or 7 years, when there is a very cold and windy winter, the layers of water totally mix and oxygen is carried down from the surface to replenish the deeper layers of Lake Ohrid.

Lake Prespa is much shallower than Lake Ohrid. It does not show such strong stratification because the wind can completely mix the warmer surface water down into the lake. Only in spring and summer can the waters become somewhat stratified. During this period, the oxygen concentration decreases dramatically. In fact, in summer, the dissolved oxygen concentration can drop to near zero at the bottom of the lake because there is so much decomposing plant material in the water. By mid-fall, oxygen concentrations have generally recovered to levels found at the surface.



In February 1999 (blue line), the temperature of the water in the middle of Lake Ohrid is nearly the same from the surface to the bottom. But by May (yellow line), the water at the surface has been warmed by the sun. In July (red line), the surface waters are nearly 15° warmer than the deeper water. The following January (green line) cold weather has again created uniform temperatures from top to bottom.

Microsopic viewof Pandorina morum, a species of phytoplankton that thrives in eutrophic waters.

The waters in much of Lake Prespa are green with phytoplankton in the summer. These tiny floating plants are responding to the phosphorus by multiplying rapidly. Submerged plants, or weeds also grow thick in the nearshore zone. This situation will not change until the phosphorus inputs to the lake are reduced substantially.

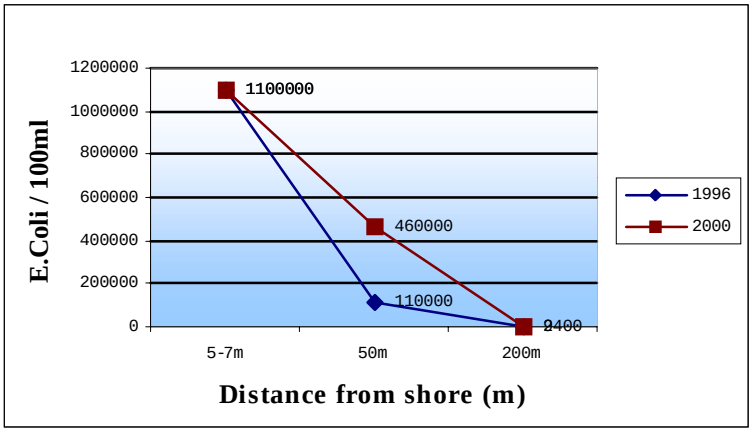
The near shore waters of Lake Ohrid adjacent to Pogradec and Tushemisht also show obvious phytoplankton and aquatic weed growth in the summer. In fact, in many near shore locations on both the Albanian and Macedonian sides of the lake, the aquatic plants have been responding to the fertilization by phosphorus. In the last several years, both Albanian and Macedonian scientists have documented a shift in the composition of the plants to favor those species that grow well in eutrophic conditions. Species that prefer more oligotrophic conditions are becoming less abundant. These changes provide further evidence that the Lake Ohrid ecosystem is changing and underscore the need to reduce the phosphorus inputs to the lake.

Bacterial pollution

One of the biggest potential risks to human health for the communities living along Lake Ohrid is contamination with disease-causing bacteria and viruses that enter the lake in human sewage. When these organisms are present, there is a significant risk of illness for people drinking the water or swimming in it. Bacteria abundances are generally highest in the summer and after heavy rains. In exceptionally heavy rains, the capacity of the existing sewerage systems can be exceeded and additional untreated wastes are discharged to the lake.

In 1988, the first phase of the sewage collection and treatment system was completed along the shoreline in Ohrid Bay in Macedonia.

Millions of E. coli, *a bacteria in human sewage, live in just a few drops of water near the shore of Pogradec in the summertime. The number of bacteria decline away from the shoreline, but even at 200 m, a few drops of water can hold thousands of bacteria.*



After this system began operating, there were dramatic improvements in the water quality in Ohrid Bay. The number of harmful bacteria in the water decreased one thousand fold. The water in Ohrid Bay is now generally safe for both drinking and swimming. These improvements make a strong case for continuing to implement sewage treatment systems along the entire shoreline of the lake.

On the Albanian side of the lake, the highest level of bacterial pollution occurs near the town of Pogradec, where raw sewerage flows directly into the lake. Large numbers of harmful bacteria have been found up to 200 m from the shoreline. In the years 1996 to 2000, Albanian scientists found an increase in the abundance of harmful bacteria in Lake Ohrid waters close to shore. This is probably because the population has been increasing in Pogradec. This situation will not improve until a sewerage collection and treatment facility is constructed for the town. But once a system is completed, the improvement along the Pogradec shoreline should be rapid, mirroring the improvements found in Ohrid Bay in the late 1980s.

Away from the major towns, bacteria pollution is most commonly found where streams and rivers discharge into the lake. These streams carry human waste and animal waste from the inland villages to the lake. All of these sources must be considered in order to keep Lake Ohrid waters clean for everyone's use and enjoyment.

Metal pollution in Lake Ohrid

In addition to eutrophication, Lake Ohrid also shows metal pollution near the sites of the old chromium, iron, nickel and coal mines outside Pogradec. The preliminary samples that Albanian scientists have collected at the Guri i Kuq mine show concentrations of metals in the near shore lake water that are very high. It is likely that the muds and sands in these near shore locations are also contaminated, and this may pose a risk to the invertebrates, fish and birds living in this section of the lake. People who catch and eat fish in the area may also be at risk and it is possible that local drinking water sources have been contaminated. Long-term exposure to elevated levels of chromium, copper, cobalt, nickel, and other metals have been shown to have harmful effects on human health. As scientists continue to gather data at these sites, they will be able to fully evaluate the risks to people and to wildlife.

An abandoned mine along the south shore of Lake Ohrid in Albania may still be polluting lake waters.

The Living Community of Lake Ohrid

There are two unique communities of plants and animals in Lake Ohrid, the near shore, or littoral zone community, and the offshore, or pelagic community in the deep waters in the middle of the lake. Each of these communities is characterized by different groups of organisms.

In the littoral zone, rooted plants grow up from muddy and sandy bottoms and slippery algae grow on the surface of the rocks and other hard surfaces. These plants (scientist call them macrophytes) often grow in distinct zones or belts along the shoreline. In the deeper water (5-15 m), algae and rooted aquatic plants grow like an underwater garden. Some have floating leaves at the surface. Closer to shore, the reeds appear and grow right up to the edge of the water. In many places, a particular kind of slimy algae called *Cladophora* grows on most surfaces.

In areas of the shoreline that receive river input, runoff from agricultural land, or sewerage inputs, the littoral zone community can be thick with these aquatic plants. Those species that like lots of phosphorus are choking out the other plants. *Cladophora* likes lots of phosphorus, and it thrives when runoff carries phosphorus into the lake in the summertime.

The reed zone is an especially important habitat for many other organisms and provides many benefits for people. The reeds' roots hold the mud together and the stems slow the waves, reducing the erosion of the shoreline. The plants also remove some of the phosphorus and other

Cladophora, a green algae, explodes after rainfall in Ohrid.

pollutants running into the water. They provide living and hiding spaces for many species of fish and water birds, and they are the spawning grounds for fishes such as the bleak and carp. Fish and ducks like the reed zone because the plants help hide them from their predators. When the reeds die back in the wintertime, they add organic matter to the lake that feeds other organisms like snails and worms. These small animals are the food that the fish and waterfowl eat. As development has occurred along the shoreline, people have cut or burned away the reeds. This practice threatens the fish and wildlife of the lake and must be controlled.

The bottom-dwelling animals in Lake Ohrid are very unique. Many of these small invertebrates (animals without bones) are found nowhere else but Lake Ohrid. For example, Lake Ohrid is the only place where the rounded sponge *Ochridospongia rotunda* is found. Its closest relatives are in Lake Baikal, another ancient lake in Russia that was formed by earthquakes. More than 85% of the snails in Lake Ohrid are also unique to Lake Ohrid.

On rocky bottoms, small mussels are very common. They attach themselves to the rocks with sticky threads that they secrete. On sandy bottoms, a diversity of worms, snails, crustaceans and other organisms live on and burrowed in the substrate. Scientists in Macedonia have discovered that this community of small organisms has changed significantly in areas where human pollution has entered the lake. The implications of these changes for the fish and wildlife that feed on these organisms are not yet known.

Fishes in the shallow water include a variety of minnows, as well as fishes sought by anglers like bleak and carp. During spawning, many other fishes come into the littoral zone, including the Lake Ohrid trout. These fish are a link between the shallow water habitats and the deeper water.

Millions of bleak once schooled along the shoreline from Peshtani to Ohrid in winter.

In the deeper water, or pelagic community, the tiny phytoplankton form the base of the food web. Tiny floating animals called zooplankton eat these tiny plants. In turn, these small animals are eaten by the small fishes in the lake, which eventually end up in the larger fishes like the Lake Ohrid trout.

Scientists monitoring the lake in Macedonia have found that both the phytoplankton and zooplankton communities in Lake Ohrid are changing. New species more characteristic of nutrient enriched conditions have been discovered, and the species composition in locations close to river inputs and near the towns and villages is changing to one that is dominated by more eutrophic species. These changes reflect the changes in water quality in the lake, and underscore the need to control the pollution coming into the lake.

The fish in Lake Ohrid are an important part of the economy of both Albania and Macedonia. There are six species that are regularly harvested by fishermen, including the famous Lake Ohrid trout, the smaller belvica, the bleak, carp, eel, and roach. Over

Moonflowers grace this meadowland near Lake Prespa.

the last decade, between 200,000 and 300,000 kg of fish have been taken from the lake each year. Data gathered by scientists in Macedonia suggest that this level of harvest may be more than the lake can sustain. The numbers of fishes on the wintering grounds and returning to the spawning grounds each year are declining noticeably. In decades past, large schools of bleak wintered in Ohrid Bay, as well as in front of Peshtani and Trpejca in the east and Radozda in the north. Today, bleak only winter in front of Trpejca and Radozda. The number of nests of Lake Ohrid trout on the spawning grounds on the Macedonian side of the lake has also changed dramatically. The average size and number of the fish has decreased and the gender balance is changing.

In addition to harvest pressures, the native fish of Lake Ohrid are also threatened by the introduction of non-native species into the lake. Rainbow trout represents a particular concern because it may displace the native trout. Although this fish was first introduced in the 1970s, fish farms represent a current threat for new introductions.

There is also some preliminary evidence that the pesticides used by farmers in the watershed may threaten fish in the lake. These pesticides have been found in the tissues of fish collected from the lake. Not only are these pesticides harmful to the fish themselves, but they also pose hazards to the people who eat the fish, especially women of childbearing age and small children.

The shoreline and watersheds of Lake Ohrid and Lake Prespa also provide critical habitat for a great variety of wildlife. These include frogs, turtles, and birds that are directly dependent on the lake, and many inland species that rely on the forests and plains. The coastal wetlands provide critical habitat for hundreds of thousands of wintering water birds, including rare and threatened species such as the Dalmatian pelican, ferruginous duck, spotted eagle, and imperial eagle.

Habitat loss and fragmentation, and human disturbance pose the biggest threats to the continued existence of these animals. Habitat restoration efforts could help bring these species back to healthy population levels.

Shoreline habitat loss and degradation threaten the Dalmatian pelican and other water birds in the Lake Ohrid watershed.

MANAGEMENT CHALLENGES AND HOT SPOTS

Because the littoral zone receives the direct impacts of the people living along the shoreline, it tends to be the most impacted environment in most lakes. Lake Ohrid is no exception to this pattern. The habitat destruction and water quality impairment is most severe in the littoral zone, especially in those areas adjacent to the population centers in both Macedonia and Albania.

Development has dramatically reduced the reed zone along Lake Ohrid.

On both Lake Ohrid and Lake Prespa, the destruction of the reed zone has removed valuable spawning, nesting, feeding and resting habitat for fish and wildlife and is negatively impacting water quality. Practices, such as grazing, cutting, and burning the reeds used to be common around Little Prespa Lake and in many areas on Lake Ohrid. In locations where the natural vegetation has been removed, soil commonly washes into the lakes and is deposited on the lake bottom. Although some laws have been passed to protect the reed zones on the Macedonian side of the lake, population growth and socioeconomic pressures are leading to continued destruction of the reeds and other lake habitats. The importance of these environments for both wildlife and human welfare is still not reflected in economic planning and decision-making.

Evidence of the ecological impacts of human activities is apparent in the aquatic plant community and in the phytoplankton, zooplankton, and bottom invertebrate communities in the near shore waters. Near Pogradec, the phytoplankton densities are much higher than elsewhere along the coastline and both these tiny plants and the rooted aquatic plants in this region are dominated by pollution-tolerant species. Elsewhere, near Ohrid, Struga and the tourist establishments on the Macedonian shore, eutrophic species are also beginning to dominate.

The solution of the problems in the littoral zone will take a coordinated and aggressive management approach that reduces the pollutants coming into the lake from both sewerage and industrial discharges and from river inputs and runoff from the land. This approach must also reverse the habitat destruction where the land meets the water, especially in the reed zone. Areas that have not been degraded should receive special protection because these areas are sustaining the remaining fish and wildlife populations in the lake.

The water in the area of Pogradec represents the single largest water quality challenge on the lake. Pollution from the untreated human sewage flowing into the lake is adding greatly to the eutrophication problem, and seriously threatening human health through contamination by harmful bacteria and viruses in the fecal material.

In 2001, the German government, through the Kreditanstalt fur Wiederaufbau (KfW) and the Swiss government through Staatssekretariat fur Wirtschaft (SECO) provided funding to design and construct a sewerage collection and treatment system for Pogradec and the surrounding villages. The new system will collect wastes from households and businesses in Pogradec, Verdove, and Bucimas. Wastewater will be delivered to a new treatment plant that will be constructed southwest of Tushemisht, near Bucimas. The treated water will then be discharged into the lake near Tushemisht.

The new sewage treatment system will treat the wastewater of about 60% of this region. Construction will begin in 2003 and be completed by 2005. A possible extension after 2010 would allow the treatment of all the wastewater produced in the Pogradec area. If the new treatment plant reduces the phosphorus content of the load it receives by 80% as designed, then when the treatment plant comes on line, about 24% of the total annual phosphorus load to the lake will be removed, a very significant amount.

Soon, a new sewage treatment system will improve the water quality near Pogradec.

In 1999, representatives of the Macedonian and Albanian governments signed a joint statement endorsing the plans for the Pogradec wastewater treatment project. Although the Macedonian delegation (and the Hydrobiological Institute) would have preferred that the wastewater be pumped outside of the Ohrid Basin, this option was not judged feasible in the first phase. The parties agreed that if the necessary improvements in the water quality of Lake Ohrid do not occur after the new system has come on line, then both parties will join their efforts to find additional funding for the construction of additional measures to take the waste outside the catchment area.

In the future, scientists in both Albania and Macedonia will work together to collect the data to evaluate water quality and to determine how much phosphorus load the lake can handle and still remain in an oligotrophic, or clear water condition.

The six mines and one mineral enrichment plant located near the shores of Lake Ohrid to the east of Pogradec also present a management challenge. It is possible that the high levels of metal contamination at these sites are having toxic effects on the fish, birds and other aquatic life in the area and might pose a risk to people who live in this area by contaminating the drinking water. A fuller evaluation of these risks and plans to contain or remove the waste must be pursued.

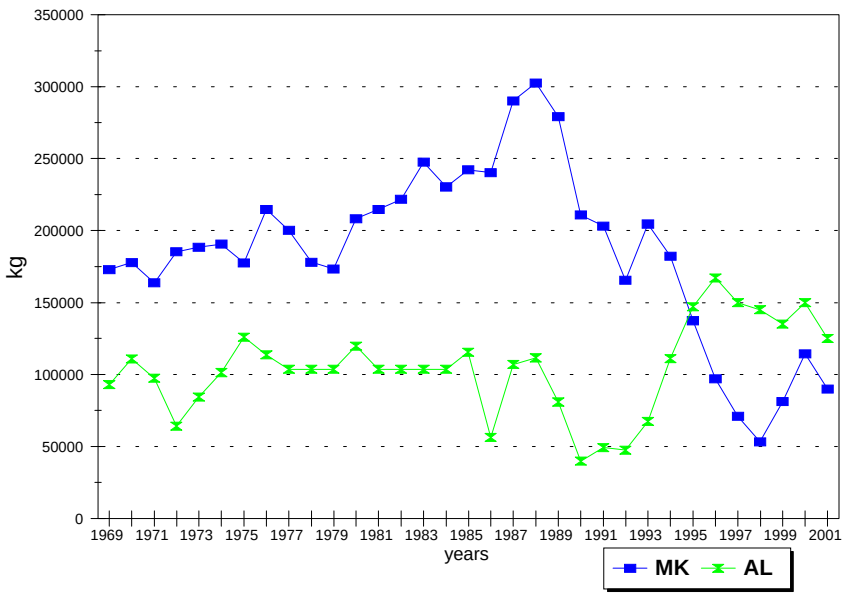
Mine waste along the shoreline exports metals to Lake Ohrid each time it rains.

The Sateska River is choked with sediment that threatens the littoral zone in Lake Ohrid.

The Sateska River presents a particular management challenge for the littoral zone on the Macedonian side of the lake. In 1962, the river was diverted from its natural discharge into the Black Drim River into Lake Ohrid in order to drain the Struga marshland and support hydroelectric power generation on the Black Drim River. The diversion of the Sateska almost doubled the size of the Lake Ohrid watershed and greatly increased the phosphorus and sediment loading to the lake. The impacts in the littoral zone include substantial filling of the lake bottom and persistent problems with nutrient enrichment and low oxygen concentrations in the lake water.

The Republic of Macedonia has investigated rediversion of the Sateska back into the Black Drim River and various measures to slow the erosion of the riverbanks and delivery of sediment to Lake Ohrid. Although it is currently unclear as to when or if a full rediversion project might be implemented, some erosion control measures using reforestation are being implemented as part of the Lake Ohrid Conservation Project. The restoration of the Sateska River and the adjacent littoral zone of Lake Ohrid remains an urgent management priority.

The declining fish populations in Lake Ohrid represent a final urgent management priority. Trout, carp and bleak have all suffered from human impacts to their spawning and wintering grounds, but the human pressures on the trout population in Lake Ohrid seem to be most extreme probably because of the greater demand and higher economic value of this fish. Although the overall catch of trout has only declined slightly in the last several years, there has been a dramatic shift in the harvest. Beginning in 1992, the landings in Albania increased dramatically, while those in Macedonia began to fall. The differences in fishing pressures in the two countries are the results of differences in the social and political situation and the fishing regulations in each country. While there are limits on the catch in Macedonia through concessions and licenses granted by the government, there are no restrictions on the number of boats allowed on the lake or the number of nets a fisherman can employ in Albania. The allowable net size in Albania is also smaller than in Macedonia.



Although the harvest of fish from Lake Ohrid has remained high over the last 30 years, recently the landings in Macedonia (blue line) have declined, while the landings in Albania have increased (green line).

In Macedonia, the fishing industry is managed through five-year concessions granted by the government to fishing companies. A company that is granted a concession must restock the lake through an approved plan and must pay 10% of the wholesale value of the catch to the government for the purposes of improving the fishing conditions on the lake.

In Albania, the fishing industry is in the process of being organized into fishing associations by village. Associations will be formed in Pogradec, Lin, Hudenischt and Tushemisht. The regulations that will govern these associations are still being developed.

Because overfishing seems to be the major cause of the decline of the trout population, controls on the number and size of fish must be implemented and coordinated on both sides of the lake. Each species of fish in the lake is one single, linked population and these populations must be managed holistically, with similar regulations in both Macedonia and Albania.

Scientists are working to predict the number of fish that can be harvested sustainably, without depleting the population over time. Sustainable levels of harvest of all the commercially valuable fish populations in Lake Ohrid, including the trout, bleak and carp, must be developed. Once these levels have been determined, then the harvest regulations in both Albania and Macedonia must be harmonized to ensure that these levels are achieved. Vigorous enforcement of the appropriate regulations will also be necessary. Efforts that improve water quality and restore the littoral zone and shoreline habitats will also have positive benefits for all the fish of Lake Ohrid.

The catch of Lake Ohrid trout is threatened by overfishing and the degradation of traditional spawning habitats.

Fishermen gather on the shoreline in Ohrid.

Overall Assessment of the State of the Lake Ohrid Ecosystem

When all the evidence scientists have gathered is combined, it provides a very clear picture of a unique and fragile ecosystem that is changing significantly and is at risk of serious decline. A key ecological characteristic of Lake Ohrid throughout its history has been its clear water. But in the last few decades, human activities in the watershed have changed this condition. They may have "aged" Lake Ohrid more in the past several decades than in the previous thousands of years.

Although the shores of Lake Ohrid have been inhabited since prehistoric times, there has been a dramatic increase in the human population in the basin in the last few decades. The beautiful vistas, temperate climate, and rich cultural and natural heritage will continue to attract both residents and visitors to the basin. Therefore, a comprehensive management plan that accommodates this growth while protecting the environment is urgently needed, or the very qualities that attracted the people in the first place will be lost.

Population growth and agricultural activities are changing Lake Prespa and Lake Ohrid and compromising their health.

The condition of Lake Ohrid is intimately tied to its watershed. Agricultural activities, forestry practices, mining, municipal development, and the tourism establishments, especially those along the shoreline, are all producing pollutants that can make their way into the lake through rainfall and runoff. These pollutants add to the pollution coming from sewerage. Once the sewage collection and treatment system in Pogradec is completed, sewerage may no longer be the largest contributor of phosphorus to Lake Ohrid; runoff from the watershed may be.

Agriculture is a major contributor of phosphorus, pesticides and sediments to both Lake Ohrid and Lake Prespa. Its impacts could be reduced by implementing "best management practices" on the farms in the watershed in both Albania and Macedonia. These practices include actions for managing manure and reducing soil erosion, especially around streams. Better management practices on pasturelands with high densities of livestock and irrigated croplands could be implemented to reduce the phosphorus coming from these areas. Reduced pesticide use in orchards and irrigated fields would slow the inputs of these harmful chemicals.

In developed areas, urban planning and zoning in critical areas of the cities and towns could help select appropriate locations for environmentally sound new developments, and help reduce the pollution coming from existing communities. New tourist establishments must fit into these plans to protect the ecological health of the lake.

Although the concentrations of phosphorus measured by scientists in Lake Ohrid still suggest an oligotrophic condition in this lake, the living organisms show a different story. A very different make-up of plants and animals has become established along the shoreline in developed areas, especially from the River Sateska to Radozda near Struga, in the vicinity of Ohrid and near St. Naum in Macedonia, and near Tushemisht and Pogradec in Albania. The "bioindicator" species that make up this community are sending a message that the unique biodiversity of the lake

may be permanently altered unless more aggressive management actions are taken in the future to reduce the amount of pollution entering the lake.

The water quality of Lake Prespa has also been affected by human activities. Although this lake is naturally more nutrient-enriched than Lake Ohrid, agricultural activities and human wastes have greatly accelerated this eutrophication. Irrigation may also be contributing to the lower water levels in the lake. Lake Prespa is choked with algae and aquatic plants and low oxygen levels occur every summer. Because Lake Prespa drains into Lake Ohrid through the porous mountains between the lakes, a water quality restoration plan must address the pollution problems in the watersheds surrounding both lakes.

The changes in the condition of Lake Ohrid have appeared slowly because the volume of water in the lake is so large. Likewise, improvements will also occur slowly, as new water flows into the lake. It takes about 70 years to replace all of the water in Lake Ohrid. Therefore, aggressive action to keep the lake in an oligotrophic condition is the best management strategy.

In the 1980s, the construction of a sewage collection system for the Macedonian towns along Ohrid Bay dramatically reduced the levels of harmful bacteria and viruses in the water in this section of the lake. This was a very important and positive step for the health of the people using the lake for drinking water and recreation. Unfortunately, there are still sections of the coast in both countries where harmful bacteria from human waste poses a significant risk to those who rely on Lake Ohrid for drinking water or for recreational activities. The problem is most acute in the region around Pogradec, Albania, but the sewerage system that has been designed for the town should solve this problem. It will also reduce the phosphorus loading to the lake.

The commercially important fish species in Lake Ohrid, especially Lake Ohrid trout, have been harvested at unsustainable levels in recent years and the populations of trout are in immediate danger of collapse. Human activities along the shoreline also threaten the spawning and wintering grounds of both the Ohrid trout and other fishes, including the bleak and the carp.

To preserve and restore the fishery, Albania and Macedonia must manage the fish populations jointly, with similar requirements in both countries. A sustainable level of harvest for each commercial species in the lake must be established, and vigorous enforcement must follow. Critical aquatic habitats, including the spawning habitats along the shoreline, must also be protected with strict regulations. Without immediate action, the livelihood of the fishermen on both sides of the lake may disappear.

There is cause for optimism. The Lake Ohrid Conservation Project has brought local authorities from both countries together in positive ways and both individuals and groups on both sides of the lake are increasingly aware of their role in the ecosystem. The new transboundary communication has served both countries well during the ethnic and political tensions in the border regions during the past year few years. In the future, a legal basis for the Lake Ohrid Conservation Project in the laws of both Macedonia and Albania could further strengthen the program and move it into the next phase.

Lake Ohrid and Lake Prespa are *your* lakes. What you do matters. The lakes need your stewardship. Get involved. The Green Centers in Pogradec, Ohrid, and Struga are there to help you. They can connect you with organizations actively working to restore the watershed and protect the lakes. By working together, we can all help ensure healthy lakes for ourselves and for future generations.

The Green Center on the waterfront in Ohrid. Green Centers have also been established in Struga and Pogradec.

You can help too!

- Buy and use low phosphate laundry detergents.
- Keep livestock out of streams and rivers.
- Plant grass, shrubs or trees along eroded stream banks.
- Wash your car away from the lake and other waterways.
- Work with local officials to manage the fishery harvest sustainably.
- Put all your trash in the solid waste bins in your town or community.
- Protect stream and lakeside vegetation – to prevent erosion and provide wildlife habitat.
- Never pour hazardous materials or oil down your sink or toilet or on the ground.
- Minimize your use of chemical fertilizers and avoid use of pesticides and herbicides altogether.
- Get involved! Learn about our lakes and support local efforts to protect them.

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