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Lake Constance

A Natural Environment in Change

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Preface:
Lake Constance is close to our heart

Lake Constance is of great importance – not only for the people living in the region. Every day, four to five million residents from outside the direct catchment area draw their drinking water from the lake. Annually, more than six million tourists and even more day trippers come to the lake to enjoy the multitude of recreational opportunities and relax in the wonderful landscape.
In recent decades, primarily the people have significantly burdened the lake with their increasingly diverse range of uses and demands. Since mid last century, the impacts of waste water and modern agricultural practices have seriously threatened the delicate ecobalance of the lake. In the 1970s and 80s, "overfertilization" of the lake manifested itself through abundant algae carpets, an alarming decline of biodiversity and the danger of complete oxygen depletion in lake's deep water layers.
Yet, these impending threats to the lake were recognized in the nick of time – the point of departure for a success story of effective and exemplary transboundary cooperation. Based on the realization that only concerted actions across all borders can ensure sustainable lake recovery, the bordering countries Germany, with the states of Baden-Wuerttemberg and Bavaria, Austria, with the state of Vorarlberg and Switzerland, with the cantons St. Gallen and Thurgau founded the "Internationale Gewässerschutzkommission für den Bodensee" (IGKB), the International Commission for the Protection of Lake Constance. Since it is only obvious, that the entire water catchment area must be included in the concerted protection of the lake, the Principality of Liechtenstein and the canton Graubünden have also become members of the IGKB. Ever since, the commission has developed strategies and made proposals for the measures to be taken for lake recovery. This policy has proven to be successful, and, in recent decades, governments have consistently implemented all the recommended measures to keep the lake clean. Eventually, it is a boundless delight and also a relief to realize that standing shoulder to shoulder and the tremendous financial effort have paid off: Lake Constance has largely recovered. It is now absolutely imperative to preserve

View from the Pfaender Mountain over Lake Constance; on the left the Rhine delta.

this excellent condition of the lake, to further improve it, to identify threats early enough to counteract them and thus to safeguard the lake's eco-stability – also for the generations to come. In order to achieve this goal, continuous efforts and the close cooperation of all players involved are of paramount importance.

In the long run, lake protection measures can only deliver sustainable success, if people back them, which ultimately requires a deep understanding of all interactions contributing to the lake's ecosystem. On the occasion of the 50-year anniversary of the International Commission for the Protection of Lake Constance, this book aims to provide the reader with a better understanding of lake history and exploration, the ecosystem and in-lake life, the changes the lake went through in the course of time, but also to illustrate the impacts of lake exploitation and the challenges looming in the future.

Clean lake –
reward for international cooperation

View from the east side of Lake Constance towards Lindau in the west.

It is always the same scenario: the smiles on the faces of Japanese or Chinese water experts do not really disguise their doubt: such a large lake with densely populated shores is clean enough to provide drinking quality water? In Japan and even more so in China that would be unthinkable. In the distinctly shallower Lake Biwa, northeast of Osaka, remarkable efforts have been made to improve the water quality. Nevertheless, a breakthrough like in Lake Constance has never been achieved. In Lake Constance the water quality is far better than the physical-chemical thresholds stipulated by the pertinent drinking water regula-

tions. The treatment of lake water to obtain drinking water is limited to the safe eradication of harmful germs and complete elimination of unwanted particles, such as residual plankton or sediment occuring in floodwater situations.

This excellent water quality of the lake, often perceived as a "miracle" elegations from abroad, did not just come about by itself. Rather, it is the reward for decades of enormous effort and more than four billion Euro in investments. All riparian states and cantons, as well as the Principality of Liechtenstein and the canton Graubünden, both situated within the catchment area, contributed to this success story. The International Commission for the Protection of Lake Constance (IGKB) in particular, but also the AWBR, Association of Waterworks of Lake Constance – Rhine (see p. 114) contributed considerably to ensuring that the lake is well on its way to achieving its natural state. In addition to the IGKB, there are a number of other international commissions with different areas of focus, that all strive for the well-being of the lake.

Flashback to mid last century: lake researchers were sounding the alarm because more and more nutrients were making their way into the lake. In the 1950s and 60s, untreated sewage increasingly contaminated the lake and particularly its shores. Under certain weather conditions, human fesces washed up on the beaches – an unpleasant experience for both the eye and the nose. During that period, flush toilets were replacing pit latrines but waste water treatment plants were still scarce. On top of that, an increase in the number of private household washing machines caused large amounts of laundry detergent phosphates to flow into the lake via the tributaries. In addition, an increased use of agricultural fertilizers and more livestock produced large amounts of high-nutrient liquid manure to wash from the fields and the grassland into the rivers and consequently into the lake. Nutrients and in particular phosphate compounds built up. The lake began to eutrophicate, a term lake biologists use to describe this nutrient accumulation. Soon thereafter, it became obvious that measures needed to be taken. In 1959, the International Commission for the

High nutrient concentrations in the second half of the 20th century caused abundant aquatic plant growth in Lake Constance.

Left: Press release on the foundation of the International Commission for the Protection of Lake Constance on November 11, 1959, from the Stuttgarter Zeitung daily.

Right: Since 2006 the phosphorus concentrations in the Upper Lake have stabilized to 1950s levels.

STUTTGARTER ZEITUNG

Mittwoch, 11. November 1959

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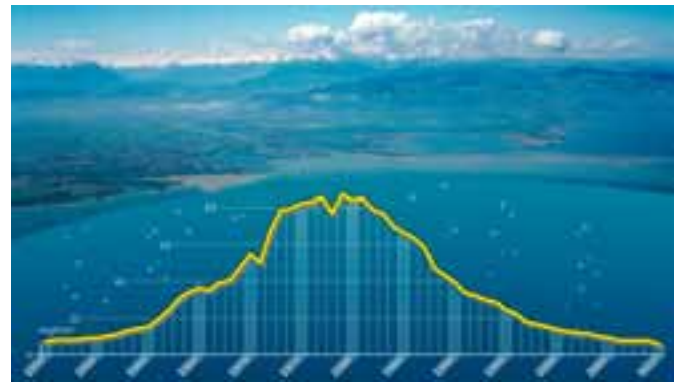
Zum Schutze des Bodensees

Eine internationale Gewässerschutz-Konvention wird ausgearbeitet

Stuttgart (lsw). Rasche Maßnahmen gegen die drohende Verschmutzung des Bodenseewassers hat die von den Anliegerstaaten gebildete Internationale Gewässerschutzkommission bei ihrer konstituierenden Sitzung in St. Gallen beschlossen. Wie das baden-württembergische Innenministerium am Dienstag mitgeteilt hat, soll nach den Beschlüssen der Kommission von Sachverständigen der drei Bodensee-Anliegerstaaten Deutschland, Oesterreich und der Schweiz unverzüglich eine Gewässerschutz-Konvention ausgearbeitet werden, welche bindende Richtlinien zur Reinhaltung des Bodenseewassers enthält. Experten sollen außerdem Herkunft, Art und Behandlung der verschmutzenden Substanzen erforschen und Sanierungsmaßnahmen vorschlagen. Mit dem Ergebnis dieser Untersuchungen wird sich die Kommission in einer weiteren Sitzung im Mai 1960 befassen.



Protection of Lake Constance (IGKB) was founded in St. Gallen. Its main focus has always been the protection of the lake. At the time of the Commission's foundation, the most important task was to establish waste water treatment plants within the entire catchment area of the lake. In spite of a growing population this measure led to a reduction of nutrients flowing into the lake. On November 10, 1961, the "Agreement on the Protection of the Lake from Contamination" came into effect and formed the legal foundation for the protection measures jointly agreed upon by the bordering countries still binding to this day.
The most important indicator for the condition of the lake is the phosphorus content (see p. 60). Despite all efforts, phosphorus concentration continued to increase until reaching a maximum of 87 milligram total phosphorus per 1000 liters water in 1979. After that, sewage treatment measures began to take effect and the phosphorus concentration in the lake decreased again. It certainly helped that legislation reduced the phosphorus content permissible in cleaning agents (Regulation on Maximum Phosphorus Concentration 1980 in Germany and Austria and the Phosphorus Prohibition Act 1986 in Switzerland).
Since 2005, the total phosphorus content has diminished to the concentration measured before the eutrophication: from 2005 until 2008 it remained basically unchanged at about 8 milligram per cubic meter. This comprehensive purification program was not for free, though. A total investment of more than four billion Euro was necessary to bring the lake back to its close-to-natural state. The reduction of nutrients since the beginning of the eighties soon impacted lake life especially plankton living in the water as well as the organisms in the sediment. Since the mid

eighties, lake biologist are observing a shift in the variety of algae. With the end of the "fat" years, algae are becoming predominant that can cope with low phosphorus supply. On the lake bottom, it took considerably longer until the expected changes materialized. Only recently have the gradual changes of the bottom fauna and the shift of the vertical nutrient distribution in the sediment become apparent. Experts take this as clear evidence that the sediment nutrient level is also on the decline.

The decades of efforts to reduce water pollution have finally translated into measurable achievements. But in view of the increasing environmental burden induced by the increasing use of the Lake Constance area, we must not sit on our hands, if we want to maintain a high standard of water quality. One of the recent challenges lake researchers face are micropollutants, not so much because they are an acute danger but rather pose potential risks (see p. 123). It is still not fully understood how even the smallest traces of herbicides, medication residues and endocrine disrupters impact the ecosystem.

Thanks to the extensive water pollution abatement, the lake can not only fulfill its purpose as a drinking water reservoir for 4.5 Million people but also serve as an attractive recreation area. Lake Constance is an international success story of how the water of such a large and extensively used lake can be kept clean when the right measures are taken. For years, Lake Constance scientists, research institutes and public authorities have been transferring this know-how on how to tackle and solve similar problems to other countries, for example at the World Exposition 2008 in Spanish Saragossa where captivating video presentations on "Endangerment and Recovery of Lake Constance" were shown.

In addition, environmental protection organizations have been disseminating research results gathered on Lake Constance all over the world. A good example is the foundation named "Living Lakes", initiated at Lake Constance in 1998, which has steadily expanded its global network with other freshwater lakes. One special focus of this network is the exchange of experience with non-government organizations, scientists and public authorities, which all take up the cause for the protection of the lakes in their respective countries. Within the framework of an Eastern European lake network, subsidized by the EU, this foundation has just recently started an initiative to care for lakes of the new Member States of the European Union.

Through all the achievements in recent decades, Lake Constance has become a benchmark for successful water pollution abatement worldwide. One should not rest on these laurels – the challenges to surmount in the coming decades still seem overwhelming. They require a shoreline revitalization, whose natural function has been heavily impacted by walls and concrete. This project, kicked off by the IGKB, initiated a comprehen-

The expansion of the transport infrastructure has resulted in many massive bank reinforcements.

sive program to revitalize walled shorelines (see p. 126). Nevertheless, there is a long and costly road ahead to transform "concrete shores" back to their natual state. Here again, Lake Constance may one day serve as a beacon worldwide.
In view of global warming, lake regeneration is of paramount importance. With increasingly more frequent mild winters, lake water often warms up faster and earlier in the year, a trend that has been recently observed. A comparatively warm winter does not produce sufficient cold, and thus heavy water which can sink down to the depth of the lake. In recent decades, lake water analyses clearly indicate that deep water regeneration, along with deep water layer oxygenization depend largely on sufficient lake cooling during winter. Not since the cold winter of 2005/2006, so conducive to the oxygenization of the lake, have the winters been cold enough to fully circulate cold water to all water layers.

Nonetheless, at the end of the usual spring circulation in 2007, the oxygen content amounted to 8 milligram per liter even above lake bottom. Before, when the lake still contained significantly more nutrients than today, a number of winters with insufficient circulation would have caused a dangerous drop in the oxygen concentration above the lake bottom. In a lake rich in nutrients, a large number of dead organisms sink into the deep water layers, where they are decomposed by microorganisms using oxygen. But since the lake is poor on nutrients, it produces less decomposable organic material. The danger of low-oxygen deepwater may not be completely averted but it is distinctly diminished. This clearly leads to the conclusion that the extensive water pollutant abatement campaign of recent decades has made the lake fit for the challenges of climatic changes.

IGKB: The International Commission for the Protection of Lake Constance

According to international law, Lake Constance is a curiosity: the lake's surface area is the only region in Europe whose borders are not accurately determined by its adjacent countries and cantons. Therefore, good cooperation between the bordering countries is all the more important for lake protection. And they do cooperate well. The International Commission for the Protection of Lake Constance (IGKB, Internationale Gewässerschutzkommission für den Bodensee) is the lake's most important "patron saint". It is the utmost priority of the commission, founded in 1959, to document the changes Lake Constance is going through, and assess its environmental burdens. The determination of this current state lays the foundation for all subsequent protection measures required for which the IGKB then issues detailled recommendations to all the member states. After all, only regular measurements and analyzes can ensure the effectiveness of the previously taken measures – a task the IGKB is crucially involved in.
The member states of the IGKB are:

- The State of Baden-Wuerttemberg
- The Free State of Bavaria
- The Republic of Austria with the State of Vorarlberg
- The Swiss Confederation with the Cantons Thurgau, St. Gallen and Graubünden

The Half-cantons of Appenzell, Ausser- and Innerrhoden all agree with the water protection measures stipulated by the IGKB; the Principality of Liechtenstein sends a representative to the Commission.

Commissions at Lake Constance

Commissions for protection, utilization and development of Lake Constance:

IGKB: The International Commission for the Protection of Lake Constance monitors the condition of the lake with integrated water body protection as the main objective.

IBKF: The International Proxy Conference for the Lake Constance Fishery, founded as early as 1893, regulates issues on lake fishery management

IBK: Since its foundation in 1973, the periodic International Lake Constance Conference assembles the government heads of the bordering countries. Topics are environment, education, culture, transportation, economy, health and public relations.

ISKB: The International Commission for Navigation Regulations on Lake Constance, originated in 1973, enacts and enforces common standard procedures for lake navigation.

IRR: The International Rhine Regulation, founded in 1892 by Austria and Switzerland, is responsible for flood control along the Alpenrhein (alpine section of the Rhine), from the embouchure of the Ill river to Lake Constance. It coordinates the extension of the Rhine channel into the lake.

IRKA: The International Government Commission Alpenrhein, founded in 1995, jointly settles issues of water body protection, efficient energy utilization, flood protection measures and spatial planning around the Alpenrhein.

The history of Lake Constance

The site of a Franconian palace as the namesake for Lake Constance

No, Lake Constance was not named after Constance, Bregenz, Kreuzlingen or Friedrichshafen. "Bodensee", the German name for Lake Constance dates back to the small town on the northwest end of the lake where, in the 9th century, the Franconian royal palace of Bodman became the lake's namesake. As the community of Bodman-Ludwigshafen boasts, the Carolingian Kings Louis The German and Charles the Fat liked to sojourn at the lakeshore near Bodman in a castle-like palace, a so-called "Pfalz". That is why "Bregenzer See" (Lake Bregenz), the name common at the time gradually fell to oblivion. The Romans named the lake after their Castle Brigantium (Bregenz). However, they only named the Upper Lake Lacus Brigantinus. For unknown reasons they named the Lower Lake Lacus Venetus. Nonetheless, the naming process was not without its share of difficulties: In the 9th century, Walahfrid, Abbot of the Reichenau Monastry, wanted to retain the already established name "Bodamicus" but not to associate it to the site of the Franconian palace in Bodman. In a document dating back to the year 839, he simply altered the name's origin to the Greek word "Potamus" meaning river. The lake's name would henceforth be Lacus Potamicus, the "river lake" or "Rhine lake". The people living along the lake at the time did not really care about official nomenclature, though. Over time, they changed the Latin Lacus Bodamicus into the German word "podmensê", which evolved from "bodmensê" to "Bodmensee" then to "Bodemsee", and finally to "Bodensee". In the state of Baden-Wuerttemberg, people immodestly refer to the lake as the "Swabian sea", although this "sea" does not actually belong to the Swabian but the Alemannic-speaking area. In countries where English or romance languages are spoken the important lakeshore town of Constance apparently lent the lake its name because in these languages the "Bodensee" is called Lake Constance, Lac de Constance or Lago di Costanza.

Left page: A popular tourist destination – the Meersburg castle.

Romans on the shores of the lake

In the 4th century Ammianus Marcellinus, one of the most influential Roman historians of Late Antiquity, vividly described the Alpine Rhine and Lake Constance. The following excerpt is a good example of the imperial mindset of the Romans:
"Soon after breaking free from the confines of the narrow river bed, the stream gushes against high riverbanks and empties into a vast oval lake, which the Rhaetian residents call Brigantia. It measure 460 Stadions* in length and about as many in width. The dense and rugged forests block access to the shore except where the efficiency of Romans has created a wide road, in spite of the resistance of the Barbarians, the rugged nature of the environment, and the adverse climate."

*Ancient Greek linear measurement equal to an Olympic stadium, approximately 190 meters or 210 yards long

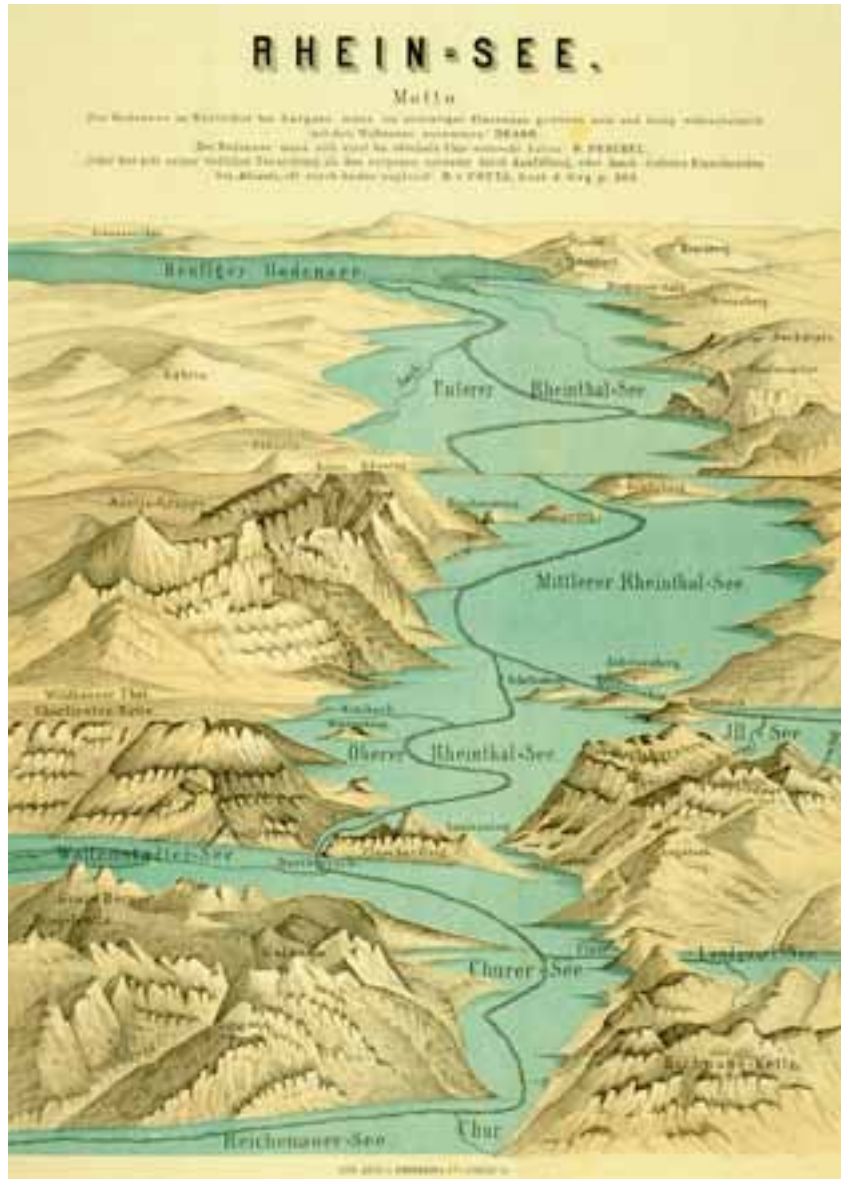
The formation of Lake Constance

At one time Lake Constance was gigantic. After the last ice age, the so-called Würm glacial period approximately 14,000 years ago, the lake extended south into the Alpine Rhine valley all the way to modern day town of Chur in Switzerland. This so-called "Rhine valley lake" covered an area twice the size of today's lake. However, this "marriage" of river and lake lasted only 4000 years – by this time this part of the lake had silted in due to the immense natural sediment load the Rhine washed in from the Alps and also due to a great number of landslides filling up the valleys. The progressive silting in of Lake Constance continues to this day, although man has avidly fought against the consequences by regulating the Rhine (see p. 43). The larger surface area of the ancient lake was also caused by the higher lake water level. After the glacier melt it was 415 meters above sea level because a moraine had formed a dam at the western end of the lake near Hemishofen. But this barrier eroded shortly after the glaciers in the Lake Constance area melted and the lake water level sank to today's average of 395 meters above sea level (see p. 31).
However, the silting in of the Rhine valley lake is only one interlude in the long evolutionary story of Lake Constance. Much earlier, several "predecessor-lakes" existed, which extended way up into today's Rhine valley. Lake Constance and its predecessor lakes were formed during an upfolding at the end of the Tertiary when the African tectonic plate drifted north pushing against the European land mass. The repercussions of this collision can be admired to this day as the Alps. The pressure of the upfolding rock masses depressed the earth crust and gave way to a so-called foreland trough on the north face of the Alps. This trough filled with debris, molasse as geologists call it, which the rivers draining to the north gradually deposited.
This deposit of molasse ended about ten million years ago because the alpine

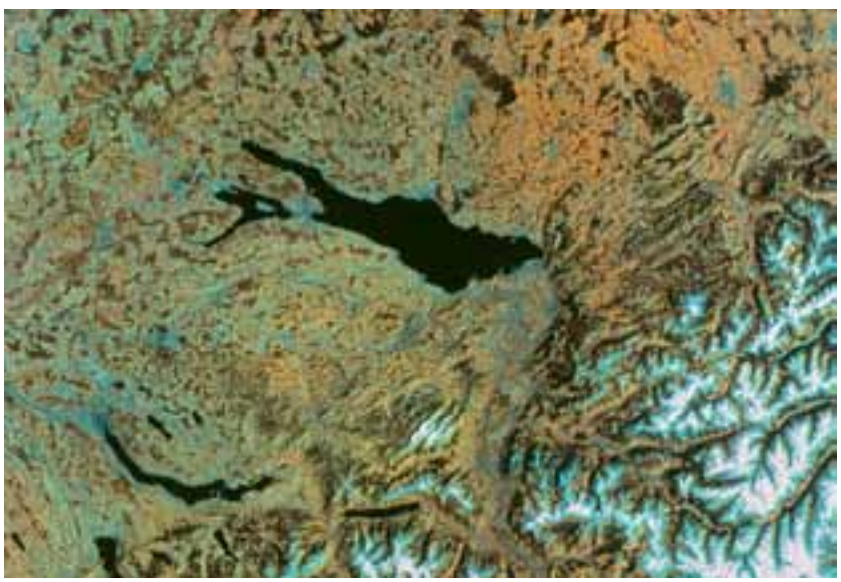
foothills raised. At that time, Lake Constance lay at 800 meters above sea level. The Rhine drained into the ancient Danube, the drainage divide was located east of the Aare river in Switzerland. It was just at the end of this period of alternating warm and cold climates, some two million years ago, that the watershed flowed towards the west to the Saône then towards the Rhône and later it changed its flow again and emptied into the North Sea. During the cold periods, ice masses covered the Lake Constance area and scoured the subsurface. In warm periods the basin filled with water. The emerging ancient lakes must have varied in shape and size. That is why, as geologists emphasize, the lake is a product of glacial erosion and not of a graben (down-faulted block), although there is no doubt, that the upfolding Alps and the resulting depression on the north side of the mountain range contributed to the formation of the lake.

Lake Constance – three sections – one lake

Geographic nomenclature is known to be quite tricky. Since it usually traces its roots back to a long historic tradition, it often occurs that demarcations are neither clear nor uniform. This is also true for Lake Constance.
Apparently, the lake is not a uniform waterbody subdivided into individual bays. Through its shape alone, the lake is clearly divided in two large sections: The deep Upper Lake, which is often seen as the official Lake Constance and the



This is how it could have looked in the past – view from the south onto the predecessor of Lake Constance.



Top: Famous panoramic view – the artist point at Langenargen.

Bottom: Lake Constance viewed from space.

significantly shallower Lower Lake (for the lake characteristics see p. 30). These in many respects disparate lake sections are both connected by the "Seerhein", "Lake Rhine", which after flowing through Constance empties into the "Rheinsee", "Rhine Lake" to make the name confusion even worse ...

Nomenclature for the Upper Lake is not exactly unambiguous, either. Actually, this lake section extends from Ludwigshafen and Bodman in the West to Bregenz in the East thus encompassing the "Überlinger Lake" and the actual Upper Lake, which begins on a line Meersburg–Constance at the so-called "sill of Mainau". Another part of the Upper Lake is the "Konstanzer Trichter", a funnel-shaped narrowing also referred to as Constance Bay. Often enough, and this really leads to confusion, the Upper Lake is taken as the main basin, that is without Lake Überlingen and the "Konstanzer Trichter". There is no doubt that the Upper Lake demarcates the beginning of Lake Constance. While the Old Rhine empties into the lake at the Swiss-Austrian border, the man-made new Rhine channel now extends far into the Fussach Bay in Austria (see p. 42).

From Upper Lake to Lower Lake: If you view the lower lake from the air, the shape slightly resembles Lake Constance as a whole. Just as Lake Constance is divided in the west by the Bodanrück hills, the Lower Lake is separated by the Mettnau peninsula. This environmentally significant promontory extends from Radolfzell eastwards and demar-

cates the “Gnadensee”, which is bounded by the “Markelfinger Winkel” in the West and the Reichenau Island in the East. East of the Reichenau dam extends the bay of the “Wollmatinger Ried” and to the south the “Ermatinger Becken”. These shallow waters are a true haven for water fowl particularly in the winter but also in the summer.
In addition to the Gnadensee, two more sections form the Lower Lake: Zeller Lake, the basin between the peninsulas Mettnau and Höri and the Rhine Lake, which in a strict sense, can be considered as the Lower Lake. The Rhine Lake extends south of Reichenau Island westwards and is bounded by the Höri peninsula on the German side and by the Swiss lakeshore in the south. Eventually, Lake Constance ends at Stein am Rhein, where it drains into the Rhine. To summarize the sequence: Starting from the Upper Lake, Lake Constance drains into the “Lake Rhine” at Constance, from there it flows into the “Rhine Lake” and then into the Upper Rhine.

Lake Constance in comparison

The Great Lakes of North America cover a total surface area of 242,000 square kilometers. The 1,640 meters deep Lake Baikal contains approximately 23,000 cubic kilometers of water, thus about a fifth of the earth’s freshwater volume. In comparison, the dimensions of Lake Constance with a surface of 536 square kilometers and a depth of 254 meters are rather modest. For central Europe, though, that is quite a respectable size. Here, it is the lake with the third largest lake surface. Larger are only Lake Geneva with a surface of 582 square kilometers and a depth of 310 meters and the Hungarian Lake Balaton. Where surface area is concerned, Lake Balaton is ranked second with 594 square kilometers. Significantly shallower, Lake Balaton has a maximum depth of only 12.5 meters. Lake Constance advances to second place overall even past Lake Balaton, when the total water volume of about 50 cubic kilometers is taken as the main criterion. The water volume of Lake Constance amounts to 0.04 percent of the water in all freshwater lakes in the world. The aforementioned lake data are not fixed dimensions but rather mean values, which may fluctuate for Lake Constance (see p. 30) and even more so for shallow lakes. The Neusiedler See east of Vienna is an extreme example. This lake measuring an average size of approximately 300 square kilometers, completely dried up in 1868. Eighty years before, it had covered a surface at least 500 square kilometers – at the time almost as large as Lake Constance.

Who owns Lake Constance?

Three countries share Lake Constance: Germany with the states of Baden-Wuerttemberg and Bavaria, Switzerland with the cantons St. Gallen and Thurgau and Austria with the state of Vorarlberg. For such a large lake in the heart of Europe one would think the international borders on and around the waterbody are clearly defined. Interestingly, they are not, but that is exactly why the transboundary cooperation works so smoothly. Lower Lake borders are clearly defined. In 1854, the Grand Duchy of Baden and the Swiss Canton of Thurgau agreed on the centerline of Rhine and Rhine Lake as the border between the two countries. In 1878, a clearly defined border was established in the "Konstanzer Trichter" (Constance Bay) between the German Constance and the Swiss Kreuzlingen. This was reconfirmed by a German-Swiss treaty in 1938. It is also evident that Lake Überlingen, the lake section between Meersburg and Bodman, belongs solely to the State of Baden-Wuerttemberg.
In contrast, the water territories of the Upper Lake between Meersburg and Constance (excluding the Konstanzer Trichter) and Bregenz are not legally regulated. Lawyers, historians, and politicians of all bordering countries have dealt extensively with this issue. What works flawlessly in day-to-day cooperation, international law experts have summarized in three theories:
1. The "condominium theory" according to which the Upper Lake is treated as the common property of all bordering countries up to the shoreline, i.e. excluding facilities, such as ports or beaches which are the sole property of the respective riparian state.

2. The "submerged shore theory" according to which an underwater slope up to a water depth of 25 meters (center water line) (see p. 137) falls under the jurisdiction of the bordering country, whereas the rest of the lake is considered a condominium, i.e. the joint property of all riparian states.

3. The "geographic division theory", according to which the territorial sovereignty of the riparian states lies along the centerline of the lake and a condominium territory therefore does not exist.

Since none of these theories have been adopted at an international level, the sovereign rights of the lake are not clearly defined. Nonetheless, day-to-day transboundary cooperation works smoothly. The bordering countries all agree that submerged near-shore territory belongs to the respective bordering state. The large remaining waterbody is considered the joint property of the three riparian states and managed collectively which works very well thanks to the close cooperation of all players in numerous international commissions.

Excerpt from the historic Brandmayer map from 1863 – old Constance on the left and Mainau Island on the right.