Hydrobiological Laboratory Kastanienbaum 1916–2016

Naturforschende Gesellschaft Luzern

eawag
aquatic research

Doctoral theses written in Kastanienbaum

Gächter, R. – Phosphorhaushalt und planktische Primärproduktion im Vierwaldstättersee (Horwer Bucht), **1968** ◦◦◦ Stadelmann, P. – Stickstoffkreislauf und Primärproduktion im mesotrophen Vierwaldstättersee (Horwer Bucht) und im eutrophen Rotsee, mit besonderer Berücksichtigung des Nitrats als limitierenden Faktors, **1971** ◦◦◦ Bloesch, J. – Sedimentation und Phosphorhaushalt im Vierwaldstättersee (Horwer Bucht) und im Rotsee, **1974** ◦◦◦ Krummenacher, T. – Die Nährstoffbilanz des Alpnachersees, **1976** ◦◦◦ Ruhlé, C. – Die Bewirtschaftung des Seesaiblings (Salvelinus alpinus salvelinus L.) im Zugersee, **1976** ◦◦◦ Reinhard, M. – Die Bildung von chlorhaltigen organischen Verbindungen bei der Chlorung von natürlichem Wasser, **1977** ◦◦◦ Bundi, T. – Untersuchungen zur Aufnahme von Kupfer durch Chlorella pyrenoidosa in Abhängigkeit der Kupferspeziierung, **1980** ◦◦◦ Meng, H. J. – Über die Ursachen von Saprolegniosen in schweizerischen Gewässern, **1980** ◦◦◦ Bossard, P. – Der Sauerstoff- und Methanhaushalt im Lungernsee, **1981** ◦◦◦ Staub, E. A. – Diagenese im rezenten Sediment des Vierwaldstättersees und ihre Veränderung durch die Eutrophierung Tiefenprofile biologisch-chemischer Parameter im Sediment und Porenwasser, **1981** ◦◦◦ Polli, B. – Die immunologische Abwehrreaktion von Fischen gegen Saprolegnia, **1982** ◦◦◦ Joller, T. – Untersuchung vertikaler Mischungsprozesse mit chemisch physikalischen Tracern im Hypolimnion des eutrophen Baldeggersees, **1985** ◦◦◦ Kuhn, E. P. – Mikrobieller Abbau von Nitrilotriacetat und von substituierten Benzolen bei der Flusswasser/Grundwasser-Infiltration Laborstudien, **1986** ◦◦◦ Peter, A. – Untersuchungen über die Populationsdynamik der Bachforelle (Salmo trutta fario) im System der Wigger, mit besonderer Berücksichtigung der Besatzproblematik, **1987** ◦◦◦ Wüest, A. – Ursprung und Grösse von Mischungsprozessen im Hypolimnion natürlicher Seen, **1987** ◦◦◦ Laczko, E. – Abbau von planktischem Detritus in den Sedimenten voralpiner Seen: Dynamik der beteiligten Mikroorganismen und Kinetik des biokatalysierten Phosphoraustausches, **1988** ◦◦◦ Höhener, P. – Der Stickstoffhaushalt von Seen, illustriert am Beispiel des Sempachersees, **1990** ◦◦◦ Haderlein, S. B. – Die Bedeutung mineralischer Oberflächen für die Mobilität von substituierten Nitrophenolen und Nitrobenzolen in Böden und Grundwasser, **1992** ◦◦◦ Ventling-Schwank, A. R. – Reproduktion und larvale Entwicklungsphase der Felchen (Coregonus sp.) im eutrophen Sempachersee, **1992** ◦◦◦ Dönni, W. – Verteilungsdynamik der Fische in einer Staustufe des Hochrheins mit besonderer Berücksichtigung der Oekologie des Aals (Anguilla anguilla L.), **1993** ◦◦◦ Zeh, M. – Reproduktion und Bewegungen einiger ausgewählter Fischarten in einer Staustufe des Hochrheins, **1993** ◦◦◦ Bosma, T. N. P. – Simulation of subsurface biotransformation, **1994** ◦◦◦ Perlinger, J. A. – Reduction of polyhalogenated alkanes by electron transfer mediators in aqueous solution, **1994** ◦◦◦ Friedl, G. – Die Mineralogie des Mangankreislaufs in eutrophen Seen eine Untersuchung mit EXAFS-Spektroskopie, **1995** ◦◦◦ Heijman, C. G. – Reductive transformation of nitroaromatic compounds under iron-reducing conditions, **1995** ◦◦◦ Brüschweiler, B. J. – Cytotoxicity and interactions of organotins and heavy metals with cytochrome P4501A in fish hepatoma cells, **1996** ◦◦◦ Friedl, C. – Populationsdynamik und Reproduktionsbiologie der Bachforelle (Salmo trutta fario L.) in einem hochalpinen Fliessgewässer, **1996** ◦◦◦ Guthruf, J. – Populationsdynamik und Habitatwahl der Aesche (Thymallus thymallus L.) in drei verschiedenen Gewässern des schweizerischen Mittellandes, **1996** ◦◦◦ Lemcke, G. – Paläoklimarekonstruktion am Van See (Ostanatolien, Türkei), **1996** ◦◦◦ Mengis, M. – Nitrogen elimination in lakes by N2 and N2O emission, **1996** ◦◦◦ Schaller, T. – Redox-sensitive metals in recent lake sediments proxy-indicators of deep-water oxygen and climate conditions, **1996** ◦◦◦ Bucheli, T. D. – Occurrence and behavior of pesticides during storm water infiltration, **1997** ◦◦◦ Glod, G. – Cobalamin-mediated reductive dehalogenation of chlorinated ethenes, **1997** ◦◦◦ Brunke, M. – The influence of hydrological exchange patterns on environmental gradients and community ecology in hyporheic interstices of a prealpine river, **1998** ◦◦◦ Müller, R. – Einfluss elektromagnetischer Felder auf Kristallisationsvorgänge praktische Anwendungen der Schlammbehandlung von Kläranlagen und in Trinkwassersystemen,

“To be able to dedicate oneself wholly to knowledge, or at least to the sincere search for truth – therein surely lies one of the greatest things allotted to humankind.”

Richard Vollenweider (1922–2007)

Micrasterias rotate, Zygnematales order, from sphagnum moss (non-planktonic), consisting of two branched half-cells.

The fruits of our labours

Erwin Leupi
President NGL

It was the Lucerne Society for Natural Sciences which laid the foundation for the Kastanienbaum laboratory on Lake Lucerne, furnishing the building with its scientific content and bringing the first real natural sciences research into being 100 years ago, after an incubation period of 60 years. One should remember that Kastanienbaum is only one offshoot of our forefathers' thirst for knowledge, as a great deal of hard work also went into creating the other fruits of their labour. In 1880 they set up the first cantonal meteorological station in Lucerne. The prehistoric commission conducted the first systematic dig in Wauwilermoos in 1895, and a remarkable alpine garden on the Rigi Scheidegg was created 1906 and nurtured. In response to the homeland preservation movement that developed around the end of the century, they created a Nature Conservation Commission in 1906, compiled inventories of glacial erratics and interesting trees, submitted parliamentary postulates for the protection of Horw cove, which was rich in aquatic life, as well as proposing a plant protection law. The Society contributed a large number of artefacts to the natural history collection at the cantonal grammar school, and the collection was later established as the Lucerne Natural History Museum. And in 1916, Kastanienbaum's history was born.

These budding projects bore fruit of such importance that they could no longer be supported by the local community alone. The founders developed concepts and proposals, and generated financial resources, then handed these over, in turn, to the public domain. The institutions in question were the Swiss meteorology stations, the cantonal Federal Commission for the Protection of Nature and Cultural Heritage, cantonal archaeology, the Lucerne Natural History Museum and the EAWAG research laboratory.

A retrospective view also points the way into the future. All of these successes arose not from the Society as a whole, but through the efforts of individuals, for whom the Society provided a supportive framework, communicative networks, opportunities for synergy, and the means to implement their ideas. The Society brings together those who delight in new ideas, think freely and enjoy creative work. The fascination for science has always been the glue which has held the Society together and has given the members the strength to act, in spite of innumerable disputes, social emergencies, politics or lack of resources. Interestingly enough, the formal conditions have remained the same throughout the long history until the present. The monthly reading circle of yesteryear was the equivalent of the internet today; the meetings with up to 100 participants which took place in the Wilden Mann in Lucerne were the precursors of today's panel meetings; the 1930s slide-show trailers for the Lucerne cinema are echoed in the modern-day website; the former accolades for teaching staff became the NGL Award of today.

But what does the future hold for a regional society amid the turbulent surroundings of digital communication and intercontinental research? History informs us that although the structures, situations and resources may change, the pioneers continue to forge ahead. For current examples of our passion for innovation, see the website "ngl.ch" and enjoy an excursion into our most recent information-volume 39, "Der Vierwaldstättersee – eine Sehfahrt" (only available in German).

And now we have come full circle back to Lake Lucerne, with grateful thanks to our forefathers and a strong sense of pride in the inspirational energy of our Society. Celebrating this anniversary reaffirms our excellent friendship with Kastanienbaum, even though many of the lake researchers may only stay here for a limited time to work on their projects and thus no longer call this their home.

A 100th anniversary year: reflections on tradition and innovation

Janet Hering
Eawag Director

The major anniversary of our Kastanienbaum site prompts us both to reflect on past accomplishments and to consider future opportunities. Looking back, we see that Switzerland has an outstanding tradition of lake research. Classical figures include François-Auguste Forel (1841–1912), Richard Vollenweider (1922–2007) and, more recently, Dieter Imboden (*1943). All three of these great scientists profoundly expanded our understanding of biological, chemical and physical processes in lakes. In the setting of the Kastanienbaum laboratory, Dieter Imboden (a physicist) and his colleagues in biology, chemistry and geology conducted multidisciplinary research long before the importance of such cross-cutting approaches was widely recognized.

Today, the portfolio of tools that we can use to explore processes in lakes has expanded enormously. In addition to using microscopes to identify algae in water samples collected from boats, we can obtain nearly-continuous information on species composition with high spatial resolution using a flow cytometer on a fixed mooring. Using sonar technology, we can obtain unprecedented information on the bottom topography of our lakes (as was done for Lake Lucerne in 2008). We can complement traditional taxonomic studies with modern genomics, allowing the identification of cryptic species. Genomic as well as classical methods have been used to probe the diversity of whitefish in Swiss lakes and to establish a link between eutrophication, loss of habitat and loss of species.

This combination of fundamental and applied research provides valuable input to societal decision-making and natural resources management. When former Eawag Director Werner Stumm opened the new Kastanienbaum laboratory building in 1977, he highlighted the importance of providing information to support planning and implementation in the area of water protection. Eawag produces a series of fact sheets that provide objective information on issues with continuing relevance (such as phosphorus inputs and eutrophication) as well as on emerging issues including antibiotic resistance and – with the Swiss Centre for Applied Ecotoxicology – microplastics. Eawag also sponsors and hosts the Fisheries Advisory Service (FIBER), located in Kastanienbaum.

The Kastanienbaum site is an integral part of Eawag's activities in research, education and expert consulting. "KB", as the former hydrobiological laboratory is affectionately known internally, reflects the importance of lake research for both Eawag's history and its future.

"For the federal government, Eawag and its research centre in Kastanienbaum are key partners in all questions related to water and water bodies. Thanks to their high-quality research, teaching and advisory services, they have gained an outstanding global reputation in the field of water quality and sanitation. This contributes greatly towards Switzerland's high international standing when it comes to water-related issues – something which was very apparent to me on a visit to South Africa last year, for example. I would like to wish all researchers continued curiosity, endurance and energy!"

Doris Leuthard, Federal Councillor

Researchers on the steamship Schwan ca. 1916.

Research and water protection

It started with a handful of dedicated, distinguished Lucerne citizens and their fascination for the lake's secrets – and grew into an internationally renowned research institute in Kastanienbaum. Today, it is not only the institute's reputation which is international, but also its staff. What has remained constant is the commitment of the employees to research, teaching and consulting as well as the close cooperation of the disciplines with each other, authorities and society.

In 1862, three hundred years after the publication of "Beschreibung des Vierwaldstättersees" (Description of Lake Lucerne) by J.L. Cysat, the Lucerne theology student Josef Stutz wrote a paper about the lakes on the earth's surface, among them a description of Lucerne's Rotsee. Shortly thereafter, the Lucerne Society for Natural Sciences commissioned the measurement of the depth of several Lucerne lakes. The pharmacist and Society president Otto Suidter-Langenstein, inspired perhaps by the research work of François-Alphonse Forel on Lake Geneva, sought to awaken interest in hydrology with lectures about this emerging scientific discipline.

A poor base for natural sciences

In 1895 the limnological commission of the Swiss Society for Natural Sciences, with the vigorous support of the Lucerne middle school teacher Hans Bachmann (p. 15), developed a programme for investigating Lake Lucerne. From the chemistry of the water to temperature, colour and clarity as well as the water level, many data still in use today were gathered. In its own section were zoological and botanical investigations. But the fascination held by Suidter and Bachmann for the lakes was not shared by everyone, not even all the members of the Lucerne Association of Natural Sciences. In 1895 Bachmann wrote: "Unfortunately, the rich earth from which spring the abundant flowers and fruit of the sciences has never been very favourable for us in Lucerne and has not borne much fruit."
But gradually Bachmann, together with the physics teacher Xaver Arnet and the Lucerne cantonal chemist Emil Schumacher, was able to interest more people in the lake's secrets. He succeeded in forming a financial commission for investigations, the members of which included the director of the Gotthard railway, two members of the governing council, the manager of the steamship company and the directors of the Rigi and Pilatus railways. In the bulletins of the Lucerne Association of Natural Sciences, articles about the lake became increasingly frequent. Bachmann's chief interest was in plankton, and he developed his own techniques that he used not only in Lake Lucerne, but also on his extensive journeys in Scotland and Greenland.

Success thanks to generous friends

In 1912 Bachmann put forward a proposal for a "Project for a Swiss Station for Fishing and Hydrology on Lake Lucerne"

Plankton samples still in existence dating back to when the laboratory was established.

to the Federal Department of Home Affairs in Bern. This included not only the plans, but also detailed costings for the construction of a three-story structure (CHF 331,250) along with the estimated annual running costs (CHF 51,000). To give additional thrust to his visionary ideas, he organised internationally recognised hydrobiology courses. In 1914, World War I broke out and this visionary project disappeared into a drawer in the federal parliament building. Nonetheless, Bachmann remained determined and found an interested patron in Fritz Schwyzer. The medical doctor had returned from America in 1911 and built a country home in Kastanienbaum (p. 15). Thanks to his donation, the Lucerne Association of Natural Sciences was able to open its first small laboratory whilst the war was still going on. Schwyzer was so modest that he begged his friend Bachmann in a letter to remove his plaque from the new building. "We will take the plaque out of its frame and keep it safe in a case in the cabinet", Bachmann assured him in his reply.

Richard Vollenweider (left) in the laboratory, around 1950.

New apparatus and methods required

Officially opened on 18 June 1916, and now in private ownership, the six-by-ten-meter building reached by footbridge still stands virtually unchanged on the lake just in front of the "Ortliegg" settlement area (p. 13). The Lucerne Association of Natural Sciences was given a motorboat by the Geneva lecturer Gandolfi-Hornyold and a rowboat by the concordat commission of Lake Lucerne. Upstairs is the workroom and the aquarium room as well as a darkroom. The attic provided space for equipment. Initially, the facility was equipped with the kinds of lake and ocean research apparatus which were in common use in other countries at the time. This equipment proved to be too imprecise, however, so together with the Lucerne optometrist and precision mechanic Hans Friedinger, the researchers designed and developed new equipment – among others the Theiler bailing bottle, which made it possible to take water samples at desired depths, thanks to a novel mechanism. These devices also became known abroad through publications in professional journals, and in the 1930s Friedinger's workshop for scientific apparatus printed its own catalogue of equipment and prerequisites for hydrobiology and sent its products all over the world – a nice example of successful cooperation between science and business.

Too much sewage = pollution

In addition to questions of technology and methodology, the laboratory users – among them many guests from abroad – concerned themselves with the limnology of phytoplankton in the early years. Among these were Professors Saunders and Worthington from Cambridge, who spent several weeks in Kastanienbaum. The work was not limited to Lake Lucerne: thanks to Bachmann's travels and contacts many comparative studies of lakes all over the world were published. Moreover, the members of the hydrobiological commission, most of whom were carrying out the research in their spare time, investigated some 60 alpine lakes, and studies on the Rotsee, the Baldeggersee and the Hallwilersee were also published. In these three lakes, the changes in nutrient content and the plankton population – as well as the mass development of Planktothrix rubescens – were explained early on. The cause was the flow of sewage into the lake, which was first described as pollution in 1917. For several decades, the Rotsee was included in the laboratory's experimental programme, pursued in cooperation with the cantonal laboratory and the Lucerne department of building and construction. This was the beginning of a long-term, solution-oriented partnership between research, administration and politics. Thanks to a private donation, the cantonal food inspector Ernst Hurter was employed from 1920 to 1926 as a laboratory assistant. He published papers on the development and control of mosquitoes.

Biology teachers in a continuing education programme (1966).

Understanding processes

In contrast to what was sometimes the perception, lake research before World War II was not purely descriptive. There was certainly an interest also in processes and in understanding them. One such example was a nocturnal steamship trip, on which those taking part in one of Bachmann's hydrobiological courses traced the vertical movement of plankton. Paul Steinmann and other fish researchers developed fundamental knowledge, that of whitefish, for example, which researchers still have recourse to today. The poisoning process in fish was also studied, and simulated with lethal experiments which today would be unthinkable. In 1920, we see Steinmann describing in detail "the final twitches and wide-open mouths" of whitefish poisoned with benzene.

In spite of all the enthusiasm, the never-ending quest for funding and recognition for lake research remained a challenge. The later Eawag director Otto Jaag (p. 17) complained that in 1933 the ETH Zurich was the only Swiss university at which limnology was taught. He did admit, however, that the limnologists themselves tended to argue with, rather

Saving electricity in spite of the cold

The work in the first laboratory was sometimes difficult because the house on the lake could not be heated sufficiently, and electricity was expensive during WWI. An entry in the laboratory report of 23 October reports: "Surbeck and Steinmann are stopping their investigations. As the snowy weather on the 20th brought with it very low temperatures, and it took until evening on 21st to bring the temperature up to 11°c. We thus had to leave the heat on during the nights of the 21st and 22nd, while saving as much energy as possible during the day. A total of 93 kilowatt-hours of electricity were used." By way of comparison, at that time one kWh cost around 10 Rappen, and so 93 kWh was just under 10 francs – a good daily wage for a tradesman. Incidentally, Eawag's solar installations in Dübendorf and Kastanienbaum produced around 150,000 kWh of electricity in 2015.

Exploring Lake Lucerne
With the help of the Lucerne Society for Natural Sciences and Hans Bachmann, a "Programme of Limnological Study of Lake Lucerne" is drafted by the Swiss Society for Natural Sciences.

than support, each other: "This development must be described as disastrous, for even then there were undeniably serious signs of degeneration in our flowing and standing water bodies, and even groundwater", he wrote. It is thus even more astonishing that the Lucerne Association of Natural Sciences managed to replace the laboratory, which was bursting at the seams, in record time in 1938 with a spacious new structure: a good 500 meters south of the old site a new boathouse was built, with a microscope room, laboratory and teaching room. In 1964 it was expanded slightly, and was renovated again in 2007.

The end of voluntary research

In 1940, following the death of Hans Bachmann, seminary teacher Heinrich Wolff became honorary custodian of the laboratory. He published papers on water fleas and other subjects, including his investigations in the high alpine lakes on the San Bernardino Pass. During the war years he organised holiday courses for students from Zurich and Basel as well as for grammar school and secondary school teachers. Cooperation with Eawag and its director Otto Jaag thus began in 1952. In 1953 Wolff resigned from his honorary post for professional reasons, discouraged at the fact that research with only a few private patrons could no longer compete with that abroad. Wolff's assistant, secondary teacher Richard Vollenweider, left Kastanienbaum in 1954 to take up a position in the limnology institute in Pallanza. (p. 16).

Joy and sadness in the Lucerne Association of Natural Sciences

The Lucerne Association of Natural Sciences found itself thereafter no longer able to maintain research work of sufficient quality. The board of directors decided to transfer the laboratory to Eawag, which was still an institute of the ETH at the time. For Eawag director Otto Jaag the transfer was by no means a foregone conclusion. "Considerable courage was needed to tackle this new responsibility", he wrote, "for the laboratory was in many respects in poor condition. It took many weeks of work just to give it a general clean-up." Eawag took over the station in 1960, following a trial period. The Stiftung der Wirtschaft zur Förderung des Gewässerschutz (industry foundation for the development of water protection) made it possible to acquire the necessary funds for equipment and a new boat. The Hans Bachmann was too long for the boathouse, which was promptly extended. The first head of the Eawag limnology department in Kastanienbaum was Heinz Ambühl (p. 18), who had studied for his PhD under Otto Jaag. Eawag's acquisition of the laboratory was the fulfilment of Bachmann's dream of a national institute. The handover was, however, not com-

Colette Grieder and Head of Fisheries Science, Wolfgang Geiger, investigate a barbell near Beznau (ca. 1973).

pletely pain-free for the Lucerne Association of Natural Sciences: "We residents of Lucerne must add something here: we are very sad to lose our hydrobiological laboratory, which has stood at the centre of our scientific activities for 44 years. At the same time, we are also genuinely pleased that this institute has been taken into such worthy keeping and that its continuation is safeguarded", said Wolff in his memoirs of 1964.

Eutrophication and the first lake models

The research carried out from 1960 onwards in Kastanienbaum was, until the mid-1970s, mostly concerned with chemical and biological processes in Lake Lucerne and other lakes of central Switzerland. Major insights were gained into the role of the nutrients phosphorous (P) and nitrogen (N) and their reaction processes in eutrophication from the over-supply of nutrients in lakes. Investigations into botanical and zoological plankton, sediments and lake-bed organisms documented the progressive worsening of the lakes' condition in the sixties and seventies. It was obvious that only a marked and permanent reduction in phosphorous concentration in the lakes could bring about improvement. The Federation, cantons and communities soon took notice of these findings, introducing phosphorous precipitation in the wastewater treatment plants in the drainage basins of the lakes, or built rings of sewage systems around them in order to prevent the inflow of waste water away. Eawag researchers in Kastanienbaum tracked the results of these measures on various lakes. On Lake Lucerne they began in 1961 to carry out monthly biological and chemical sampling, and established a database of immense value in terms of long-series studies of the ecological effects of lake remediation. Research into the physical, chemical and biological processes of complex lake ecosystems began to take an increasingly prominent role. As early as 1972, a first paper was published detailing an approach for modelling this system numerically in order to predict the response of a lake to changes, and to choose appropriate measures for water protection.

The "oxytester" developed by Heinz Ambühl for measuring oxygen and other values (around 1963).

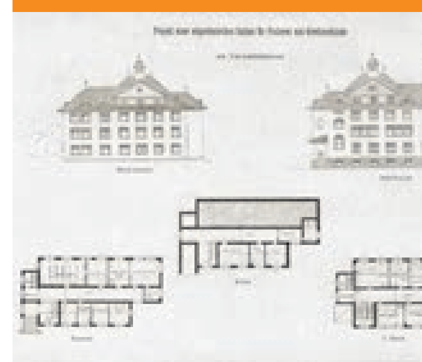
Only the first stage of the new building realised

Hans Bachmann's and Otto Jaag's plans for a larger institute began to be implemented in 1970 by the new Eawag director, Werner Stumm, and by Heinz Ambühl. After the Seeheim property was acquired in 1968 and barracks were used as a temporary solution, the new building, constructed on terraces on the hill, was moved into at the end of 1976. Because of cost-saving measures at federal government level, only the first stage of the plans had been realised, and a freeze on new posts meant that the only way Eawag could safeguard operations at the new premises was to transfer staff from Dübendorf to Lake Lucerne. The many teacher-training study blocks and middle school class biology weeks were stimulating, but costly. The Seeheim and the microscope room were often bursting at the seams, and the presence of the groups meant that other research was restricted. In 2008 the Directors decided to discontinue the courses for middle schools. Summer schools for students, professional courses (www.eawag.ch/peak), public tours

1912

Big plans

Hans Bachmann submits plans to the federal government for a "Federal Station for Fisheries and Hydrology on Lake Lucerne". The imposing structure in "Winkel" was to have been built in the cove at Horw. The projected cost: 331,250 francs. The plans disappear into a drawer in the government offices through the First World War.



and short visiting programmes for groups ensure that Eawag continues to offer a great many opportunities for insights into its activities and the results of its research.

Research and consulting – even for the policy-makers

In 1976 the whole department for fisheries science moved to Kastanienbaum. Questions of lake management were superseded by new focal areas of research, such as the population dynamics of whitefish and roach, and extended to include analysis of environments in lakes and flowing waters. An increasing number of investigations at the level of ecosystems were carried out. Work on known deficits, such as insufficient residual water, contributed to the inclusion of comprehensive protection plans for water in the new federal water protection act of 1991. When the law was revised in 2011, Eawag's research findings had significant impact, and were instrumental, for instance, in mitigating the negative consequences of the torrential water return beneath hydroelectric power plants (p. 26). The cantons around Lake Lucerne commissioned a study between 1988 and 1994 which identified ways to implement integral water protection in the catchment area of the lake. Together with the Federal Office for the Environment, the Federal Agency for Water Management and cantonal departments, a broadly-based, multidisciplinary investigation concept for water bodies was developed, namely the module level concept. The overarching goal remains that of maintaining biodiversity in all types of waters, although fish management issues, e.g. the reduction in the catch or questions about the usefulness of stocking with young fish, are not ignored in the process.

In the area of the chemical and physical analysis of water bodies, Eawag places great value on state-of-the-art analytical equipment, not only in Dübendorf, but also in Kastanienbaum. Measuring devices for the analysis of metal concentrations and algae production were acquired as early as 1975. Today the laboratory is home to modern isotope analysis and laboratories for molecular genetic studies.

Many disciplines under one roof

Under the leadership of Dieter Imboden, (p. 19), René Gächter and Peter Baccini, the "Multidisciplinary Limnological Research - MLR" group was founded in 1977 and became a department in 1978. Researchers from the engineering, physics, biology and geology disciplines worked together under one roof – still one of the strengths of the Kastanienbaum research site. One of the first major projects was a long-term study on the toxic effects of heavy metals in lake water and sediment (p. 33). The multidisciplinary department developed concepts for cleaning up lakes with an overabun-

In moonboots on the lake – moving a measuring buoy ca. 1988.

dance of nutrients, as well as a mathematical lake model. These calculations provided the theoretical basis for the aeration equipment which, beginning in 1982, was installed in the Baldeggersee, Sempachersee and Hallwilersee, and later in the Pfäffikersee and Greifensee as well as in a number of smaller lakes. In the same period, Eawag, in cooperation with the cantons, was usually involved in the limnological monitoring of the lakes and the individual measures taken. The environmental physicists made major contributions to the understanding of the water mixing mechanisms in lakes – principles used today in a number of ways, for example to judge the effects of large-scale heat extractions (p. 34), as well as the processes in the border zone of sediment-water and actual sediment. The MLR department can be regarded as one of the seeds of the environmental science course introduced in 1987 at the ETH Zurich.

New knowledge thanks to new methods

Thanks not only to the well-equipped laboratories, but most of all to the cooperation of scientists with specialised technicians, methods that have led to pioneering research results have continually been developed and refined at Kastanienbaum: The identification of different carbon isotopes in methane has been the key to unlocking microbiological nutrient networks, and nitrogen isotopes can track changes in ocean currents a long way back in time (p. 40). Gene analysis has become increasingly more precise and faster, which makes it possible to follow the formation of new species almost »live” (p. 22). Experiments in mesocosms and automated sampling enable researchers to demonstrate that not only is biodiversity determined by the environment but the reverse is also true, where variety and the population size of its residents also have an effect on their environment (p. 30).

Catholic Kastanienbaum

It has to be said that the one-hundred-plus employees of today in Kastanienbaum do work in a somewhat peripheral location. However, their natural surroundings are incomparable. In addition, the employees benefit from far more days off every year than their colleagues in Dübendorf. Being a Catholic community, Lucerne enjoys extra public holidays such as the Feast of Corpus Christi, Ascension of Mary, etc. The strict Catholicism of some of the Lake's influential people was brought home to René Gächter, for one. As the very first doctoral student in Kastanienbaum, hired by Prof. Ambühl, Gächter slept in the upper story of the boathouse. Visits from women were strictly forbidden. Newly married, he complained about this regulation, and was told by Ambühl to first to introduce his wife to all the neighbours so as not to jeopardise the good reputation of the laboratory.

1913

International courses
To demonstrate the need for a major institute, Hans Bachmann organises hydrobiological courses with participants from all over the world in 1911 and 1913. In 1915, the Governing Council of Lucerne issues a permit to the LSNS to build a "boathouse with a hydrobiological laboratory" on the lake bed in front of the Kastanienbaum estate belonging to Mrs Fischer-Meyer.


4
5
1
2
3

1916

The hydrobiological laboratory today

1) Boat house/harbour: core of the hydrobiological laboratory from 1938, workstations for students, meeting rooms
2) Seeheim (former villa): seminar hall, offices, basic accommodation for up to 24 people, public garden
3) Badhüsli (bathhouse)
4) Laboratory building (1976): aquarium rooms, workshops, molecular laboratory, analytical laboratories, offices, cafeteria.
5) "Castagnettas" extensions (2012): offices, library

Name and operator

1916/1950
Kastanienbaum Hydrobiological Laboratory on Lake Lucerne (1916)
Hydrobiological Station (1950)

1969
Limnological Field Station

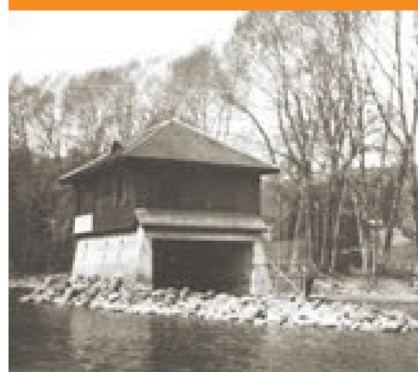
1976
Lake research laboratory Kastanienbaum (SFLK)

1981
Kastanienbaum lake laboratory

1992
Limnological Research Centre (FZL)

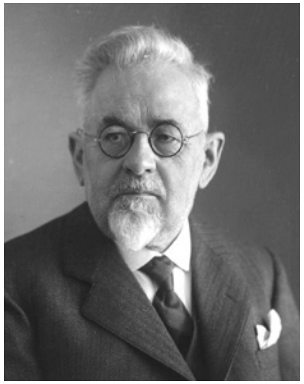
2010
Center for Ecology, Evolution and Biogeochemistry (CEEB)

Generous doctor
Made possible by a generous donation from medical doctor Fritz Schwyzer (p. 15), the Lucerne Society for Natural Sciences celebrates the opening of the newly built small laboratory at its annual meeting on 18 June 1916. Donors also include the City and Canton of Lucerne, the "Zentralschweizerische Kraftwerke" (Electric Power Company of Central Switzerland), the "Konkordatskommission für die Fischerei des Vierwaldstättersees" (Lake Lucerne Concordat Commission for Fishing), the banker Bidler-Brunner and the Director of the regional office of the Swiss National Bank in Lucerne, Eduard Humitzsch.

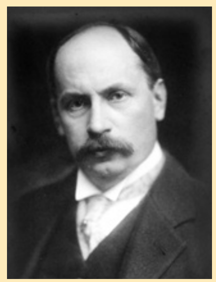


Propagation stages of volvox-like green algae. The 16 daughter cells of the original cells have divided again. Every daughter cell has formed a complete, gel-coated colony with flagellated miniature cells.

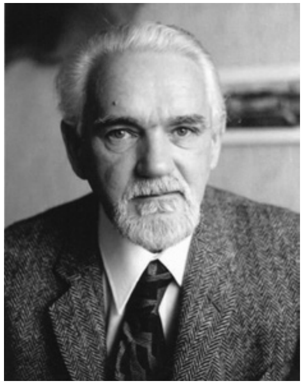
Hans Bachmann (1866–1940) – "loathed imprecise treatment of the subject"



This jubilee year of "his" hydrobiological laboratory in Kastanienbaum is also the 150th anniversary of Hans Bachmann's birth. Born in Lieli, above Lake Baldegger in the canton of Lucerne, he graduated from the teachers' seminary in Hitzkirch and became a primary school teacher. Returning to education in adulthood, he passed the Swiss high-school leaver's examination and then studied biology at the University of Basel under the zoologist Friedrich Zschokke, among others. In 1895 he was awarded his doctorate, although he had already been teaching natural history since 1892 at the Lucerne cantonal high school. His contemporaries describe him as "having an unquenchable thirst for knowledge" and as a uniquely charismatic teacher who understood how to inspire enthusiasm for biology in his students, both in the classroom as well as on field trips. He was both friend and paternal educator, but could also be relentlessly demanding. Heinrich Wolff, laboratory administrator after Bachmann's death, wrote "He recognized only genuine, solid and straightforward presentation of natural history material and loathed any kind of imprecise, secretive or sugar-coated treatment of the subject." His work on the phytoplankton of fresh waters, especially that of Lake Lucerne (1911) was a milestone for hydrobiology at the time. Again and again he persuaded others to work on research projects with him. Together with bacteriologists, zoologists, fishing experts and the Lucerne cantonal laboratory, he shed light on the increasing deterioration of the sanitary water quality and fishing conditions of surface waters, and became an expert and consultant on waste water issues. From 1915 until his death he was president of the hydrobiological commission of the Swiss Society for Natural Sciences. In 1924, the ETH awarded him an honorary doctorate and the city of Lucerne made him an honorary citizen. It is a wonder how he managed all his research, lectures, excursions and offices in addition to his duties as teacher. His wife was certainly a great support. Ida Bachmann (Berchtold) had great organizational talent and was a superb hostess: "The friends of the Bachmanns will never forget the happy hours of socialising, spiced with subtle humour, that they experienced at Musegg", wrote Wolff[4].



Fritz Schwyzer (1864–1929) – friend and generous benefactor
Written under the photograph of Fritz Schwyzer, son of the director of the Swiss Northeastern Railway, are the words "Stifter und Förderer des Hydrobiol. Laboratoriums Kastanienbaum" (Benefactor and patron of the hydrobiological laboratory in Kastanienbaum). There is no record anywhere of the actual value of the doctor's donation in 1916 to the Lucerne Society for Natural Sciences. His friend Hans Bachmann simply sent him all the bills. The native of Zurich had earned his doctorate in Würzburg in 1887 with a dissertation on bacilli and then worked as a pathologist and researcher. In 1892 he spent a year in Berlin, where Robert Koch was at that very time laying the foundation for modern microbiology. From 1893, Fritz Schwyzer worked in New York. One of his publications appeared in 1901 in the New York Medical Journal and dealt with chronic poisoning by fluoridated water containing fluoride – a theme taken up by Eawag a century later. In 1911 he and his wife Jeanne Schwyzer (Vogel) put down roots in Waldwinkel in Kastanienbaum. Jeanne Schwyzer (1870–1944) founded the Luzerner Verein für Frauenbestrebungen (Lucerne association for women's endeavors), conducted citizenship courses for women, supported the creation of alcohol-free restaurants and worked in 1929 on the women's petition for the right to vote. From 1934 to 1940 she was the first woman to sit on the board of the Swiss Volksbank.

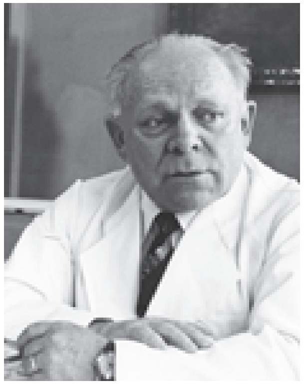


Richard A. Vollenweider (1922–2007) – a native of Lucerne and the world's unhealthy lakes

In the 1980s Richard Albert Vollenweider was regarded as the leading contemporary limnologist. In 1986, he and Eawag Director Werner Stumm were awarded the Tyler Prize, considered the Nobel prize of environmental sciences, for his work on eutrophication (excessive concentration of nutrients) of inland waters. In his congratulatory telegram, the then president of the United States, Ronald Reagan, wrote "You have done so much to halt the pollution of the Great Lakes. Every American and Canadian owes you a debt of gratitude".
Even as a young boy, he would set off with a magnifying glass and containers in search of botanical specimens. He was also very musical, playing the violin, piano and trumpet. Vollenweider's career in lake research really started in 1949, when the biologist and secondary-school teacher began working part-time as an assistant in the hydrobiological institute in Kastanienbaum. Early on, he became interested in the growth of algae and bacteria, successfully applying the emerging radiocarbon method for the determination of photosynthesis. After stints in Pallanza (Italy), Uppsala (Sweden), Alexandria (Egypt) and Paris, by 1968 he was working in the Canada Center for Inland Waters in Burlington and as Professor at the University of Hamilton. In that year he published his model for the "tipping over" of lakes with excessive nutrient loads. His book "Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication" (Paris, 1968) brought him international renown. Although he was now an authority, he remained modest, even as advisor to the OECD[5] and various countries: "I have written a bestseller in the area of the eutrophication of inland waters, without really meaning to", he wrote to a friend.
Vollenweider not only recognised the direct connection between phosphorous concentration and trophic levels of water bodies, he recommended practical classification systems for these and began to regard water bodies as open systems with input and output of nutrients. Working from this basis, he succeeded in developing mathematical models for the prognosis for algae growth.
Richard Vollenweider's greatest achievement lay in his successful efforts to derive practical applications from theoretical considerations, and for this he banked on the cooperation of scientists and government, "for goodwill alone accomplishes nothing", he said. His work with the Great Lakes between Canada and the USA afforded opportunities in this regard, after which the world's ailing lakes and rivers followed. He often visited his friends Heinz Ambühl and Otto Jaag in Kastanienbaum. He died in Burlington in 2007.

One family

Enjoying research is not only the privilege of the doctoral students who today celebrate in the bathhouse of the institute. As early as 1911, as Hans Bachmann invited students to his first hydrobiological course, the mood of the 42 participants from various countries was cheerful and congenial. One of them described this in the International Review of Hydrobiology as follows: "in spite of the great variety and the large number of participants, the students quickly made friends; and even the contact between lecturers and "students" was also extremely collegial. The limited space available on land and water may have contributed to this. Certainly, by the end of the course everyone had become part of one family under the care of the course director, Prof. Bachmann."



Otto Jaag (1900–1978) – a professor influences environmental policy

Otto Jaag, initially a primary school teacher in Beringen, canton of Schaffhausen, studied natural sciences in Geneva and received his doctorate in 1929 with a thesis on lichens. At the ETH Zurich he worked at the Institut für Spezielle Botanik and as adjunct professor for hydrobiology. He became a professor in 1941, and in 1952 he took over the leadership of Eawag. With great personal commitment Jaag, as head of an extra-parliamentary commission, had already sought a balance of interests in the introduction of the inland waters protection article in the constitution. The people then approved this article in 1953 with a significant majority of 81.4%, and in 1957 the associated Act on Water Protection came into force. Jaag's educational work played an important part in securing this unequivocal public recognition of the need for water protection in Switzerland. His campaigning was needed: the economic boom after WWII, combined with increasing consumption of energy and resources, were not without consequences for Swiss waters. Environmental protection agencies did not yet exist. In 1960, barely ten per cent of the population were connected to a central water treatment plant. Jaag recognised that the water protection law had remained toothless and fought for its revision, especially for an active subsidy policy at federal government level. This came to fruition in 1962 with a new subsidy article and in 1971 with a new Act that helped make the construction of sewers and water treatment plants a reality. In Switzerland nowadays, around 97% of sewage is treated in modern wastewater treatment plants.

At Eawag, Jaag established a department of limnology and also increased the Institute's consulting and teaching activities, particularly for the civil engineers. In 1955 he expanded the Institute with the addition of the Department for Waste Management Research, a result of the obvious connection between the waste management practices of the time and the pollution of surface waters and ground water. Jaag went on to strengthen Eawag's natural sciences sections by taking over the hydrobiological laboratory at Kastanienbaum in 1960. Alongside its substantial consultancy work at municipal, cantonal and federal level, Eawag was, at this time, also reflecting increasingly on its mandate as a research institute. This is apparent in the first dissertations and academic papers – for instance, on nutrient pollution in lakes or the self-cleaning mechanisms of water bodies – that emerged from Kastanienbaum. Thanks to his proactive networking, Director Jaag found the necessary finances for the expansion of this research station.

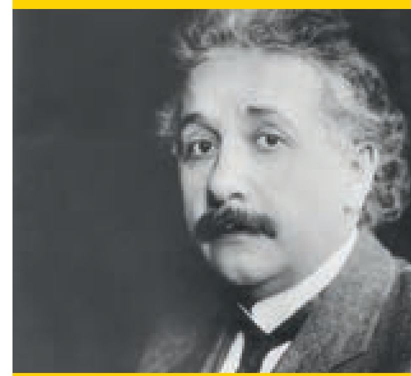
Difficult scientists

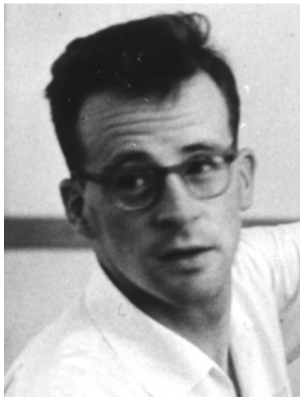
Prof Otto Jaag worked hard to establish connections with practitioners in the "real world", and was successful in doing so. He sought tirelessly to bring together conflicting interests to work towards a common goal, and in spite of his enthusiasm for clean water, he was never one to launch a vitriolic attack on its many polluters. On the other hand, he did not hesitate to make critical comments and to defend academic freedom: "Scientists are individualists. They have their scientific duty in mind, and in pursuing this they have little consideration for each other or the opinions of practitioners. This is the basis of the reliability and incorruptible objectivity of their work. It would not occur to anyone to ask scientists to allow their perspective to be diverted by practical considerations. This means, however, that they can easily come into conflict with each other or with practitioners."

1924

On good terms with Albert Einstein

In October 1924, the dynamo Hans Bachmann organises and leads the annual meeting of the Swiss Society for Natural Sciences at the Lucerne Kursaal. He is awarded an honorary doctorate by the ETH. The guest speakers in Lucerne are Francis William Aston, inventor of the mass spectrometer, and Albert Einstein (pictured). Hans Bachmann corresponded with both men personally.



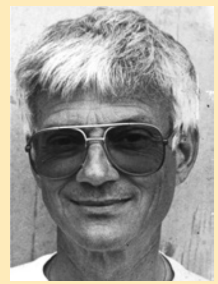


Heinz Ambühl (1928–2007) – no such word as "can't"!

Inspired by his charismatic teacher Paul Steinmann at the Aarau cantonal high school, Heinz Ambühl read biology at the ETH. His dissertation, Die Bedeutung der Strömung als ökologischer Faktor (The significance of current as an ecological factor), supervised by Otto Jaag, established a new benchmark and paved the way for him to do research work at Eawag after several years as the cantonal water chemist in the canton of Aargau. For the first time ever, his refinement of chemical analysis enabled the determination of growth-limiting plant nutrients in the microgram range. In 1960 he became the first director of the Eawag department of hydrobiology in Kastanienbaum and took on more and more teaching assignments. 1972 saw his appointment as associate professor at the ETH. Ambühl's lectures were superb learning experiences, and he was in his element on limnology field trips and courses.

In Kastanienbaum, he was instrumental in expanding hydrobiological topics to include practical, interdisciplinary limnological issues. At that time, many aspects of research such as fish biology and fish management, ecotoxicological themes or multidisciplinary studies using mathematical models were starting points for the creation of new areas of study, many of which have now become departments in their own right. Ambühl also served as an expert in the International Commission for the Protection of the Rhine and Lake Constance, and later also in the Danube Commission. When the construction of the first atomic power plant was under consideration, his research was partially responsible for the "thermal pollution" of surface waters being taken seriously, resulting in restrictions on the levels of waste heat from power plants being discharged into rivers via the cooling water. This issue has become even more relevant in the light of climate change. Long before computer-based search programme, for literature existed, he organized some 20,000 original works, along with hundreds of technical terms, in a peek-a-boo information retrieval system, which he made available to Eawag. The publication of scientific results was also not left to chance; up until 1984 he edited the Swiss Journal of Hydrology, now known as the prestigious journal "Aquatic Sciences".

In instances where the required analytical methods or technology did not exist, Heinz Ambühl would sit down without further ado and come up with his own ingenious method or apparatus. His some thirty doctoral candidates and numerous degree candidates could count on his support, without his wishing to include his name among the publication authors. When it came to practical research with far-reaching consequences, like the clean-up of the Swiss midland lakes, he made the projects a priority and put all his energy into realising these pioneering projects. Not led off course by novel experimental possibilities, he resolutely carried out long-range ecosystems studies and collected long-term data that now serve as a limnological gold mine for climatic models and other research work[6].



Rene Gächter (*1939) – mentor and motivator

Together with biologist Rene Schwarzenbach (*1945), Rene Gächter headed the Multidisciplinary Limnological Research Department from 1998 until Eawag underwent a complete restructure in 1992. If one was to name a single scientist as the father of lake aeration, it would be Rene Gächter. He conducted in-depth research into the turnover of substances in lakes, and especially the interactions between sediments and deep water layers. His dissertation looked at the phosphorus balance in Horw Bay in Lake Lucerne. He was one of the first to regard lakes not merely as isolated systems, but also took into account the influences of the entire catchment area. With his altruistic and occasionally almost ascetic manner, he both motivated and helped the young scientists in his charge. He not only provided help and advice to countless doctoral students in terms of subject matter, but also supported them in obtaining funds for further projects or getting published. Although he has long since retired, Rene Gächter is still much in demand as an author and consultant, most recently to the Chinese in respect of Dianchi Lake, the eutrophic drinking water reservoir in Kunming, partner city of Zurich.

Dieter Imboden (*1943) – looking at things from a different angle

Originally from Horgen in Canton Zurich, Dieter Imboden studied physics in Berlin and Basel, where he wrote his doctoral thesis on theoretical solid-state physics and graduated in 1971. He began working at the ETH Zurich in 1974, where he qualified as a professor 1982 with a thesis on the modelling of environmental processes, and became a full professor in 1988. A year earlier, along with Director Werner Stumm and other Eawag researchers, he was among the driving forces behind the launch of the new environmental science diploma programme at the ETH.

He first became active in Kastanienbaum back in 1971, where he was involved in establishing research in environmental physics at Eawag. He soon designed his first lake model, which is still in use today in an evolved form. Until he became a professor, he was a member of the Steering Committee of the Multidisciplinary Lakes Research Group, and he headed the new Department for Environmental Physics at the institute in Kastanienbaum until 1992. From time-to-time, he also conducted research at the Scripps Institute for Oceanography in California. For many years, his area of research pertained to the chemistry and physics of water bodies and their mixing and transport processes, especially in large lakes such as Lake Baikal and the Caspian Sea. Between 1992 and 1996, Dieter Imboden headed the Department of Environmental Sciences at the ETH.

He was the President of the Swiss National Science Foundation (SNSF) from 2005 to the end of 2012. His textbooks on organic environmental chemistry and the mathematical modelling of natural systems have become standards in the field. His lecture on system analysis established the use of quantification methods drawn from the field of physics in the multidisciplinary approach to environmental issues. As a meticulous scientist, strategist and man of action all in one, characteristics that in many other people would be mutually exclusive, Dieter Imboden has contributed hugely to the field of aquatic research. He has built bridges between the natural sciences, humanities and social sciences. His credo of looking at things from an unfamiliar perspective whenever possible, as well as simply giving things a try on the basis of "planning as you go along", has opened many doors for him, as well as for his students.

"The ecological enhancement of the lakes in central Switzerland has been going on for over 30 years. And for just as many years, I have been familiar with the great commitment and solution-oriented analysis of the Eawag researchers at Kastanienbaum, which they put to excellent use in advising the canton of Lucerne on such sensitive questions as the phosphorus balance, specific mixing processes and oxygen dynamics in the lakes."

Thomas Joller, doctorate from the Department of Multidisciplinary Limnological Research in 1985; Head of the Environment and Energy Department of the canton of Lucerne until July 2015.

1938

New building erected in record time

From 1930 onwards, the laboratory is taking samples from the middle of the lake (in the Kreuztrichter area) every two weeks and space is increasingly becoming a problem. Moreover, the owner of the meadow between the street and the laboratory not allowing people to cross her land to get to the laboratory. In the spring of 1938, the LSNS forms a building commission and looks for a site for a new building. The boathouse and laboratory, which still exist today, are built within a very short time and inaugurated with a small celebration in the Kastanienbaum Hotel on 25 September 1938. The lunch costs 3.50 francs per person.

The boats that carry the researchers

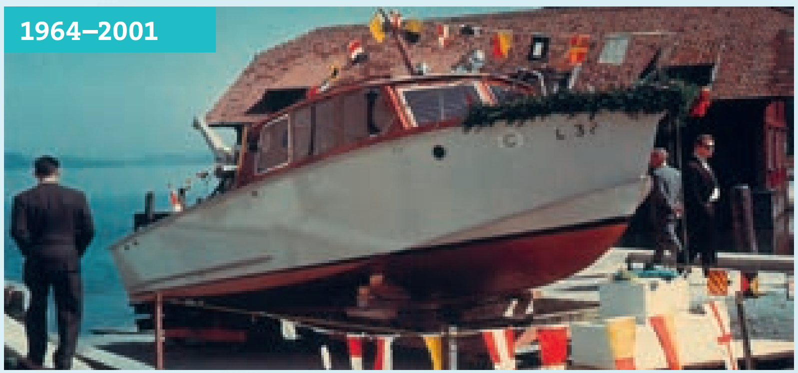
until 1916

Schwan, (trans. Swan) in use until 1916. Schwan was originally a screw steamer called Brünig. Having sunk in 1871, she was subsequently recovered, reconstructed and renamed Schwan. Prior to her conversion from a steamer to a petrol-powered motor vessel in 1920, Schwan was used regularly – thanks to the kindness of the director of the Lake Lucerne shipping company – by the Lucerne Society for Natural Sciences (NGL) and Hans Bachmann for limnological excursions, generally at a cost of CHF 50 per day. She was decommissioned in 1933.

1916–1955

Charlotte, 1916–1955, Wooden. H. Wolff and R. Vollenweider demonstrating measurement and sampling tools on the small motorboat in front of the first laboratory. Charlotte was a present from the Duke of Gandolfi-Hornyold, who was also a lecturer in Geneva. The NGL was also given a rowing boat by the Lake Lucerne Concordat Committee.

1964–2001



Hans Bachmann, 1964–2001. Wooden, licensed to carry up to 12 people, 9 metres long. Decommissioned after developing a leak on the lake in 2001. Hans Bachmann was Eawag's first boat to be fully designed as a research boat. Director Otto Jaag persuaded the "Stiftung der Wirtschaft zur Förderung des Gewässerschutzes in der Schweiz" (industry foundation for the protection of Swiss waters) to pay for the boat. It turned out to be longer than planned, and the boat house had to be extended.

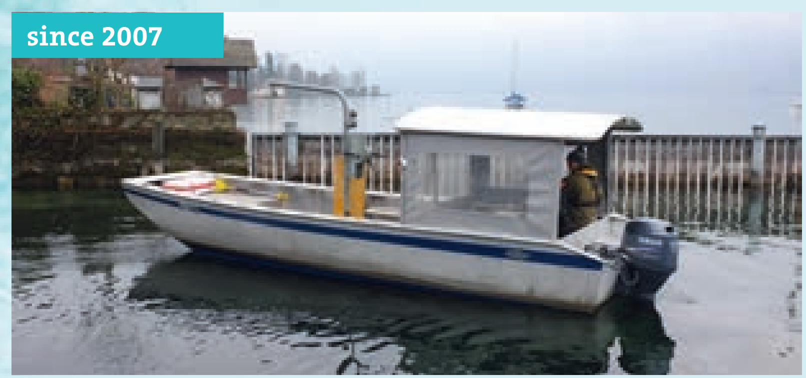
1964 – 1989

Gloeocapsa, 1964–1989. Wooden, 6 persons, 6.8 metres long, 85-horsepower outboard motorboat, lakeshore boat with small crane that was mainly used for taking plankton samples. Here, she is being used with a model ecosystem (Limnocorral) on Lake Lucerne. Gloeocapsa was also financed by the industry foundation for the protection of Swiss waters.

Salm 1–3, since 1979. GFK, Meier Dintikon, 5 persons, 7 metres long, 1.8 metres wide. Commissioned in 1979. Deployed for sampling on many different lakes, such as on the photo, which shows sediment traps being sunk on Lake Silvaplana. Two of the Salm boats were temporarily connected to create a platform which could be used to install a larger crane system.

Thalassa, since 1988. Steel, from the Succes shipyard in the Netherlands, fitted out by Hensa in Altendorf. 12 persons, 10 metres long, 3 metres wide, approximately 8 tonnes. Thanks to the crane at her stern and her powerful hydraulics, Thalassa can perform heavy work on lakes. Lakes she has sailed on include Lago Maggiore and Lake Neuchâtel and she is often used for student field work. Procured by Dieter Imboden when he took up the new environmental physics professorship at the ETH.

Perca, since 2004. 9 metres long, 3 metres wide, 3.3 tonnes, 12 persons. Perca fluviatilis is the Latin name for the European perch. This boat is a replacement for the decommissioned Hans Bachmann. She is primarily used for limnological field work and sampling on Lake Lucerne.



Salm II, since 2007. Aluminium, Chavanne boat builders, 6 persons, 6.9 metres long, 2 metres wide, 1070 kg. Like Salm 1–3, she is easily loaded onto a trailer for use on a variety of waters. Construction is identical to the **Gloeocapsa II,** commissioned in 2009. The name is a reference to Otto Jaag (p. 17), who spent a considerable amount of time studying these types of cyanobacteria, in particular their ability to perform photosynthesis even in very low light levels.

Species come and go

The wide variety of fish, especially whitefish, has fascinated researchers in Switzerland for a long time. This diversity has arisen in "only" 10,000 years since the last ice age. It is now known how species develop thanks to their adaptation to various ecological conditions, such as food supply or spawning grounds. It is also known to some extent why species disappear again, for example as the result of eutrophic conditions in water.

Whitefish reference collection in the Bern Natural History Museum.

In 1905 Walther Nufer, like Hans Bachmann (p. 15) a student of the zoologist Friedrich Zschokke at the University of Basel, wrote a detailed report about the fish in Lake Lucerne. For Nufer, who later spent time at the hydrobiological laboratory in Kastanienbaum, was chiefly interested in gaining "as precise an understanding as possible of the living conditions under which the fish exist." Such knowledge, he said, formed the basis for an efficient fisheries management, which was why one should also pay closer attention to the other aquatic animals and plants – which his colleague Bachmann then did. Lake Lucerne seemed to Nufer to be very suitable for such research: "In spite of many factors hostile to fish, such as the intensive steamboat and motorboat traffic and the steadily extending modifications along the lake shore", it had "the great advantage of being unpolluted by poisonous wastewater from factories.

Preserved whitefish

In 1950 the Aargau high school teacher Paul Steinmann published a monograph on whitefish in Switzerland. He also carried out research in Kastanienbaum on many occasions. His whitefish collection is still in existence today, and serves as a reference for new investigations (p. 24). Although many of the species described by Steinmann have died out in the meantime, there is still a broad diversity: at least 24 endemic whitefish species altogether are known in Switzerland, and of these up to six are endemic to a particular lake. Ecological differences are manifested in body size and form, number and form of the gill rakes, as well as in the form of the jaw and the colour of fins and backs. The various species feed on various benthic or pelagic organisms, have different mating times and lay eggs at different depths.

Lake Walen and Lake Victoria

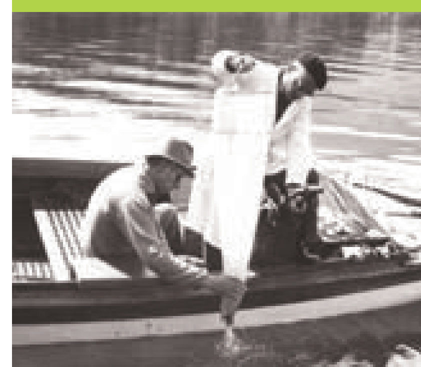
Thanks to modern methods of genetic analysis, evolution researchers in Kastanienbaum can now describe the fluctuations in this diversity, also known as adaptive radiation, even more precisely. Probably the most impressive radiation is that of the cichlid in Lake Victoria, Africa, where, over a period of only 15,000 years, some 500 cichlid species have developed. In an extensive project with 27 other research institutes all over the world, the scientists showed that the ancestors of the cichlid underwent an especially large number of mutations in their genes during a period of low selection pressure. Prof. Ole Seehausen explains this phenomenon: "At that time, this variation was probably not of much use, but it became extremely useful when the fish colonized the East African Lakes. Here, the diverse ecological niches suddenly provided opportunities for a wide variety of adaptations."

The researchers stress therefore that protecting species diversity is very much dependent on maintaining genetic diversity. They also established a relationship between habitat size and diversity. Along with surface area and the level of incident solar radiation, the depth of the lake is the most influential factor where diversity is concerned. Deep waters, as long as they can be populated by fish, are the best precondition for diverse ecological niches. It was also determined that it is the local speciation processes that are crucial for diversity, rather than the immigration of existing species. It is also the case in the subalpine lakes, such as the Brienz, Thun and Walen lakes, that depth guarantees a greater variety of endemic species. The scientists have, however, discovered a further connection when it comes to Swiss whitefish species: the higher the nutrient content in a lake in former times, the smaller the genetic differentiation between the species still present today.

1953

Financial problems lead to resignations

To remain competitive with research abroad, an expansion of the laboratory and new equipment become urgently needed. In addition, paid scientists finally needed to be hired, because until this point all staff has worked voluntarily, even the laboratory manager and seminar teacher Heinrich Wolff (left in picture, wearing the hat). But the LSNS is unable to come up with the money. Wolff resigns from the institute, and a year later, so does his assistant, Richard Vollenweider (right; page 16). After that, very little research is conducted in the laboratory.



Every little helps

In 1912, Hans Bachmann wanted to build a "Federal Station for Fishing and Hydrology on Lake Lucerne" at a cost of CHF 331,250. Nothing came of this, however, and the "small but solid" boathouse with its upstairs laboratory would have cost less than a tenth of the original sum when it was constructed in 1916. As it was wartime, every donation was welcome. The book of honour listed donations starting at 15 francs, as well as payments in kind. The Swiss fishing association donated two aquariums, the famous geologist Albert Heim gave a geological profiled map of Lake Lucerne, the concordat commission contributed a used rowboat, and the Messerli stationery store in Lucerne pitched in with "writing materials". The lecturers on the hydrobiological courses in 1913 bequeathed "30 glass dishes, 18 hand towels, 600 preparation slides and 100 dropper bottles" to the laboratory.

Projet Lac – the great fish inventory

The largest fish inventory ever to be carried out in Switzerland is seeking to get to the bottom of the situation in the alpine and subalpine lakes. The catch statistics of fishermen can only partially mirror the true picture in terms of diversity. Using standardized methods, the distribution of fish from lake to lake can be compared, and conclusions can be drawn as to how best to preserve the remaining levels of biodiversity.

The Swiss Fisheries Act and the Water Framework Directive of the EU require that the distribution of fish species be documented, and that the statistics must highlight which species need protection. The biodiversity strategy of Switzerland also prioritises the preservation of ecosystems and their services, as well as species and genetic diversity within species. In reality, however, the only data that are available are fishery statistics. The species and numbers of fish caught are known, as are the numbers of fish which have been introduced, but the actual level of diversity is unknown.

Coinciding with the international year of biodiversity in 2010, Eawag, the University of Bern and the Bern Natural History Museum initiated "Projet Lac" with support from the Federal Office for the Environment, other research institutes and cantonal governments. Using standardised methods, the larger lakes were fished systematically, the species determined, measured and photographed, gene sequences established and catch quantities recorded. "For the first time ever," explains Ole Seehausen, "we were able to gain a true picture of the level of biodiversity that still remains in the lakes today" (p. 45). "We also wanted to find out why species diversity and composition vary so much from lake to lake, and what ecological factors lead to the disappearance of species." By 2014, investigations had been carried out on 26 subalpine lakes, and more than 79 fish species inventoried. A collection of fish and tissue samples at the Natural History Museum in Bern serves as a reference for future research work. The final reports have already been published for a dozen lakes: (www.eawag.ch/projet-lac). Here are two examples:

Burbot from Lake Lucerne.

Loss of habitats in Lake Murten

The inventory in Lake Murten brought sobering news: more than a third of the fish species described in 1840 have disappeared. One third of the lakeshore important for the fish is today artificial and built up. In addition, below a depth of 20 meters there is too little oxygen for fish species that live at greater depths. At the same time, species formerly unknown in Lake Murten were found, like the Italian rudd or Prussian carp. It also became clear that professional and hobby fishing have a selective effect on species composition. The fishermen catch disproportionate numbers of zander, pike and catfish. Carp-like and smaller fish species are hardly ever fished. This has an influence on the age structures of the lake populations.

Even the smallest specimens are carefully identified and measured.

Engadine fish under pressure

Fishing in Lake Sils, in the Engadine, and Lago di Poschiavo is also seen to have had a strong impact on species diversity in the past: the introduced Arctic char and lake char compete with the native trout. Brook trout from other catchment areas have crossed with the native species, resulting in the loss of genetic diversity. Only a few pockets of Adriatic trout remain, and what are probably the last specimens of marble trout in Switzerland. On the other hand, a population of Black Sea trout is just about managing to survive in Lake Sils. Fishermen were intrigued to know why ever-reducing numbers of Arctic char are caught in Lake Sils, whereas the catch in Lago di Poschiavo is increasing. The surprising answer from the standardised net catches is that Arctic char density is similar in both lakes, and their sizes are also comparable. It must therefore be concluded that the fish in Lake Sils are more difficult to catch than those in Lago di Poschiavo. This can perhaps be attributed to different feeding habits in the two lakes.

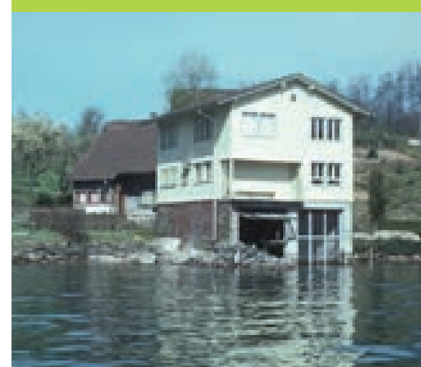
An oversimplified comparison

Professional fisherman are currently calling for more phosphorous to be added to the lakes. The elimination of this nutrient by wastewater treatment plants has been carried too far, they say, and there is not enough food for the edible fish to eat. Although Projet Lac was not designed to investigate whether “more phosphorous = more whitefish”, it can nevertheless be said that this is an oversimplified view of the situation. Lake conditions are highly complex and vary from lake to lake. Less phosphorous does not always mean more fish. Very nutrient-poor lakes like Lake Walen do in fact have high concentrations of fish. Most of the fish are, admittedly, smaller than in the “bumper” years before water protection measures began to take effect, and they live partially at depths that are not reached by the fishermen. Higher levels of phosphorous can have negative effects, promoting the growth of toxic algae or introduced species, and the resulting depletion of oxygen in the water affects the propagation of native deep-water fish – in particular whitefish and char.

1958/60

Eawag takes over

The supervisory board of the LSNS reluctantly offers the laboratory to the ETH; from 1959, Eawag runs it on a trial basis under the leadership of Otto Jaag. Under the contractual obligation to retain the building for hydrological research and to keep the name Hydrobiological Laboratory Kastanienbaum, the ETH, or the former ETH annex facility Eawag, accepts the gift in 1960.



Help for impaired watercourses

About one quarter of all the watercourses in Switzerland can be classed as heavily impaired, man-made or culverted. In central Switzerland this figure reaches over 40%. Since 2011, the revised water protection act has required the cantons and communities to allow brooks more space, upgrade them ecologically and reduce the negative effects of hydropower use. Aquatic research provides principles and instruments to help achieve these goals.

Eawag employees taking fish samples in the Reuss plain in 1976. The "Flood protection and renaturalisation of the Reuss" project currently being fought for should bring greater diversity to the area once again.

At the beginning of the 20th century, it was hoped that grading and damming rivers would provide total protection against flooding, but this has proved elusive. Damage as a result of extreme events has markedly increased in recent decades, partly because of significant pressures from urbanisation. At the same time, habitats and networks have disappeared, which are essential in order for ecosystems in flowing waters to function properly. Accordingly, in 2002, Eawag water researchers launched the Rhone-Thur Project in collaboration with colleagues from the Swiss Federal Institute for Forest, Snow and Landscape Research, the ETH Zurich (Laboratory of Hydraulics, Hydrology and Glaciology)[7], the Ecole Polytechnique Fédérale de Lausanne (Laboratory of Hydraulic Constructions)[8], partners from the federation and the cantons as well as the Universities of Zurich and Neuchatel and the flood-plain help centre, together with private environmental and consulting engineers. The work was followed up with a further two projects: "Integrated river-basin management" and "Bed-load and habitat dynamics". In all three projects, experts from ecology, river engineering and the social sciences worked successfully together.

Handbooks for practical implementation

The primary goal of the first phase was to widen channels and open out canalised rivers for a combination of river engineering and ecological purposes. In addition, the scientists investigated the ecological effects of fluctuating return flows (surge/low flow) below hydroelectric power plants on surface waters and ground water. In addition to scientific publications, two handbooks for practitioners were

Widening of the Moesa near Grono (GR) and the embanked River Wigger upstream of Zofingen (AG).

published. These provided guidance on planning hydropower construction projects with the involvement of a wide range of specialists, and gave advice on how to evaluate revitalisation projects in terms of their success. Assessments of the revitalisation of the Emme, Moesa, Rhone and Thur rivers have shown that greater habitat diversity has been created as a result. At the same time, the project has also revealed the significant extent to which this success is dependent on the presence of natural stretches of water in the headwaters or tributaries.
In the second phase of the project, the focus was on habitat diversity and longitudinal and cross-linking of the watercourses. Investigations of bullhead, a weak swimmer, reveal that even small man-made obstructions upriver can lead to genetic impoverishment. The results from this phase have been summarised in the form of eight fact sheets for practitioners.

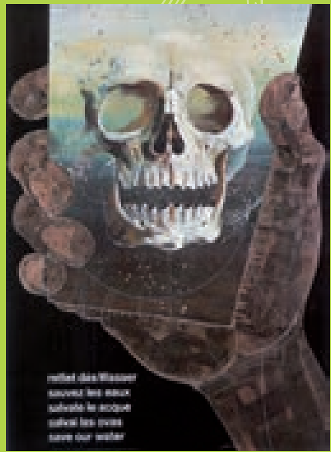
Getting the gravel moving again

The main focus of the current project, "Hydraulic Engineering and Ecology", is on the restoration of the bed-load regime. Whilst river engineers use hydraulic engineering measures to transport bed loads through damns or artificially introduce them downriver, water ecologists investigate how such interventions affect the aquatic food network and the reproduction of fish species that lay their eggs in gravel. The researchers take measurements in the field and then simulate the altered conditions in experimental channels. The fish ecologists in Kastanienbaum also analyse whether a stabilisation of fluctuating flow conditions below hydroelectric power plants has a positive effect on the ecological function of the waters affected. The initial findings indicate that when river construction leads to an impoverished water body, a lack of important habitats exists. In such circumstances, the return to a natural or semi-natural flow regime has little effect on this situation.

With the Swiss Rivers Programme, initiated in 2013, Eawag and the Federal Office for the Environment continue to encourage exchange of knowledge between science and practice and support the implementation of water protection with practically-oriented, interdisciplinary research.

1961

Save our waters
Pollution of the lakes and rivers becomes very apparent. "Bathing prohibited" signs can be seen at many locations. Only 10 percent of the population is connected to a sewage treatment plant. In Lucerne, together with the Head of Ciba, Robert Käppeli, among others, Eawag Director Otto Jaag organises the "Water Protection – Duty of our Generation" rally. Hans Erni designs the accompanying poster.



Creating pathways for the fish

More than a hundred thousand artificial barriers with a height of over fifty centimetres impair fish migration in Switzerland. Researchers from Kastanienbaum investigate the most suitable options for opening up interrupted passageways and look at what other factors determine whether the fish actually swim through these channels.

The plight of the salmon is well-known: they want to migrate, but in spite of the improved water quality, very few manage to navigate all the artificial barriers upstream on the Rhine. Most other fish are also dependent on spatially separated habitats in the course of their development, for example habitats for young fish or for spawning. The fish and aquatic ecologists at Eawag are therefore investigating how the longitudinal connectivity of brooks and rivers can be improved in order to bring isolated populations together and repopulate sections of water with low fish density.

Too steep or with too-high steps

Whereas technical fish ladders or, in recent times, bypass channels have been installed at hydroelectric power plants, smaller rises or drops can be made passable by block ramps. Constructions which resemble a natural cascade waterfall or rapids are considered suitable for fish passage. However, in closer investigations with tagged fish this has proved to be the case only when such ramps are properly designed: those with more than a five per cent drop or with vertical steps, for example, are unsuccessful. In addition, of course, the ramps have to be geared to the swimming strength of the fish species that occur naturally in the relevant watercourse. In the Swiss Central Plateau they need to be passable not only by brook trout, but also by fish like the chub, minnow or even the bullhead, which is a weak swimmer.

These barbel avoid swimming through the grate and can thus be kept from the dangerous passage through the turbines.

Weirs and unnatural flow

Concentrating on chub and the chain of power plants on the upper Rhine, a team of researchers has recently investigated whether the fish ladders actually promote genetic mixing of the fish. The findings demonstrated that a functioning fish ladder strongly reduces the separating effect of a weir: a man-made barrier without fish ladders effectively separates the fish by the equivalent of 100 kilometres in an unimpeded stretch of river. In the case of barriers with fish ladders, the equivalent distance is not actually zero, but is around 12 kilometres. In other words, if a chub wants to swim from Basel to Eglisau, it has to overcome 10 power plant steps and theoretically swim not 90 km, but the equivalent of 210 km.

Tagging fish with small transponders enables researchers to follow their migration closely with antennae. Such investigations on the Alpine Rhine have brought to light that it is not only the dams – in this case Reichenau – but also

In the flow passage at the VAW[7], tests are carried out on various guidance systems to determine how fish can be steered into a danger-free bypass.

the artificially strong flow that deter the fish: certainly, the lake trout from Lake Constance make the upward journey far more often at weekends, when there are no surges from intermittent releases of water at the power plants further upstream, than on weekdays.

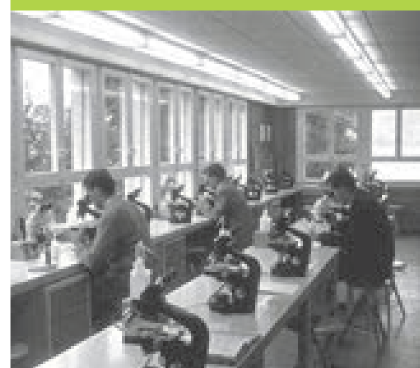
Much to be done for downstream migration

While well constructed and maintained fish ladders, block ramps or bypass channels are used by the fish to travel upstream, still very little is known about how they find their way downstream. At the Ruppoldingen power plant on the Aare, for instance, fewer than 10 per cent of the fish tagged during an Eawag study swam down through the bypass channel; about the same number took the risky pathway through the turbines. Together with the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) and the Verband der Aare-Rhein-Kraftwerke, an on-going study seeks to determine how large control units can lead the fish away from the turbines towards the bypasses – the fish-friendly water slides – and safely into the water below.

1963/64

Complete renovation and expansion

The small institute is expanded with the assistance of the "Stiftung der Wirtschaft zur Förderung des Gewässerschutzes in der Schweiz" (Industry Foundation for the Promotion of Water Protection in Switzerland). The foundation not only finances part of the renovation, but also two new boats and some research and stereomicroscopes – 20 of each. Eawag holds regular courses for teachers of different school levels, as well as specialist courses for staff of cantonal water protection agencies. Internships for students from the ETH and universities are also offered.



Looking over evolution's shoulder

Environmental changes can lead to the emergence of new species or the extinction of existing ones. The opposite is also true: organisms themselves alter the ecosystems and influence the ecological community. Eawag scientists research such ecological and evolutive interactions both in the natural environment and through experiments.

For the last 150 years the three-spined stickleback has spread rapidly throughout central Switzerland. David Marques from the Fish Ecology and Evolution Department and colleagues from the University of Bern have shown that this fish adapts very quickly to new habitats. In Lake Constance, for instance, there are two different forms of stickleback, one form typical for the lake, the other for its inflowing streams. Using sophisticated genetic analysis, the biologists have shown that the two stickleback forms have begun to diverge into two species on the basis of their adaptation to the conditions in the lake and the river. "It was completely unexpected for the species to diverge over such a short period, given that the sticklebacks breed at the same time and at the same sites", says Marques. "Species usually emerge when populations propagate in areas that are separate from one another, for example at different depths of water."

Using mesocosms, Blake Matthews researches how changes in the environment drive evolution and also the opposite: how evolutive processes influence the environment.

Eutrophication makes for species loss

If environmental conditions change, species can merge. As a study under the direction of evolutionary ecologist Ole Seehausen shows, the eutrophication of Swiss lakes between 1950 and 1990 led to the mixing of independent whitefish species. Because at this time many lakes had a paucity of oxygen in deep water and on the lake bottom, bottom-feeding species lacked ecological niches in which to feed and propagate. They had to move into shallower water. There they crossed with related species and lost their genetic and functional uniqueness within a few generations.

Just as environmental changes influence the species structure of an ecosystem, so can species alter their habitats. Take, for example, the Asian clam, which was carried into Lake Constance after the year 2000: per square meter lake bottom one finds up to 900 clams, according to a bachelor's thesis being supervised by Eawag. The clams almost completely carpet the lake bottom in places, and filter altogether around 1.85 million litres of water per second.

At this rate, the clams can filter the whole lake in a year. “One must assume that the Asiatic clam has a strong influence on the availability of food for zooplankton in the lake”, says Jukka Jokela from the Aquatic Ecology Department. Does this mean that the invasive species is indirectly responsible for the current low levels of catches reported by Lake Constance fishermen? Jokela is reluctant to draw this conclusion: “That would require more data and analysis of clam dynamics.”

Natural dynamics in artificial ecosystems

In order to understand the evolutive processes and the interactions between species and their environment, Eawag researchers carry out experiments in artificial ecosystems. Experiments are beginning in 2016 in a new facility in Dübendorf with 36 experimental ponds, while Blake Matthews from the Aquatic Ecology Department constructs contrasting habitats using mesocosms – outdoor tanks with a capacity of between 300 and 1000 litres filled with lake sediments and water. “In these containers we can alter and analyse specific parameters under controlled conditions, and see how these affect the food webs and ecosystem processes”, says the biologist.

In these mesocosms Matthews investigates, for instance, how the stickleback forms in Lake Constance alter their habitat and how these changes retroact on the evolutive processes in the sticklebacks. He found that the lake sticklebacks and the river forms influence the presence of plankton or cyanobacteria as well as the nutrient concentration differently. This impinges on the next generation as well. The survival rate of the young fish is reduced when adult river sticklebacks have previously lived in the mesocosms. As a result, the surviving juvenile lake sticklebacks grow more quickly than the river sticklebacks.

Three-spined sticklebacks in Lake Constance differ from one another, not only as female (left) and male (right). There are also two different forms: one is typical for the lake, the other for the lake’s tributaries.

The lake as private property?

Vandalism at research institutes is apparently not a recent phenomenon. In 1917 the hydrology commission of the NGL complained that the buoy anchored by the steamship administration had only lasted a year. Then it had to be removed, apparently as the result of deliberate damage. “Let’s hope that after the restoration of our installation more respectful behaviour on the part of those oarsmen who see the lake as their own private property will be seen”, noted the chronicler. Nowadays, buoys are sometimes painted with a skull in order to frighten vandals away – with success.

1967

Acquisition of Seeheim

The Seeheim property is taken on, enabling the institute to offer overnight accommodation for course participants. However, use of the villa remains limited, because the former owner retains residency rights. The number of staff members on the site rises from two to six. The Governing Council of Lucerne places land reserves on the other side of the street at the disposal of ETH/Eawag. There, a new building is planned.

When the lakes gasped for air

Untreated wastewater and leached nutrients from farming have caused excess levels of nutrients in surface waters for decades. Massive populations of algae deplete the oxygen in the water when they decompose. This has resulted in repeated fish kills. The sequence of causal factors, now clearly understood, had first to be determined, and then measures to tackle the problem had to be developed.

The history of the hydrobiological laboratory at Kastanienbaum is entwined with the biological and chemical changes in the lakes of central Switzerland, caused by the inflow of too much untreated waste water. The unpleasant odours emanating from the decomposition of masses of algae, and thousands of fish perishing miserably were the most obvious signs. This phenomenon was first called "pollution" as early as 1917, in the Rotsee. In addition to residential and industrial wastewater, the nutrient-rich water from agriculture contributed to the nutrient overload – and a number of lakes are still suffering today from these various types of infiltration.

In 1983 the distinct day-night cycles of biological activity of zooplankton in Lake Lucerne were measured in long tubes three metres in diameter.

Forerunner in sustainability

The lake laboratory researched the pathways and quantities of the inflowing substances and the resulting internal processes in the lakes. The scientific results were unequivocal: the nutrient overload could only be stopped by a permanent decrease in phosphorous concentrations. What was needed was an expansion of sewer systems and water-treatment plants – in this matter the collaboration between the lake researchers in Kastanienbaum and the engineers at Eawag in Zurich was already in place before Eawag took over the laboratory. The new water protection act of 1971 made connection to the sewer system mandatory and added the polluter and precautionary principle demanded by Eawag. The revision of the federal ordinance on wastewater discharge (1975) made phosphate precipitation in the watersheds of the lakes compulsory. These measures, together with the ban on phosphate-containing textile detergents (1985) – also based on investigations by Eawag – made it possible to halt the downward spiral of nutrient overloading. The phosphate concentration in the lakes began to decrease. Water protection measures were thus carried out which would later be identified as sustainable.

Artificial lungs cannot yet be turned off

Some patients were faring so badly, however, that emergency help was also needed. Consideration was given to tackling the algae with herbicides – a proposition that Eawag quickly declared unsuitable. The lake researchers then began to carry out experiments and make calculations with deep-water aeration. Together with the cantonal experts in Lucerne and Aargau, aeration and circulation systems were built in the Baldegg, Sempach and Hallwill Lakes in the 1980s. The aim, successfully achieved, was to make the lake water habitable for fish all the way down to the lake bed. Sadly, the natural propagation of whitefish species that lay their eggs on the lake bed remains only a vision in some locations even today. The algae from the years of abundance have drifted down and are still using up oxygen, so that the thin layer between sediment and lake water is not sufficiently oxygenated. In waters which were less heavily overloaded with nutrients, such as the Pfäffiker Lake in the canton of Zurich, the remedial systems that were established in the lakes – basically a matter of symptom control – are no longer needed. The complete palette of preventative measures, from wastewater treatment to the construction of rainwater clarification tanks to financial incentives for farmers to reduce fertilizer quantities, have taken hold.

Air and, if needed, pure oxygen is introduced into the depths of the lake with diffusors

Large-scale experiments with heavy metals

As early as the 1960s, investigations of sediment demonstrated increasing pollution due to heavy metals. Little was known about their effect on aquatic life, however. Only laboratory experiments with non-realistic, greatly increased concentrations provided hints that organisms could be harmed. In 1976, the lake research laboratory began the Melimex study (=Metal-LIMnological Experiment): three circular tubes, twelve meters in diameter and reaching to the lake bottom, were installed. One remained as it was, in the other two the heavy metal concentration was artificially increased over a period of 15 months. The experiment provided interesting results: it was found that the plankton communities moved in the direction of resistant organisms, but did not thereby increase heavy metal concentrations in the food chain, as is the case with chlorinated hydrocarbons, for instance. The researchers came to the important realization that heavy metal concentration levels in a lake depend not only on influxes, but to a large extent also on the biological production of the lake. There were other questions posed in the experiment to which they did not arrive at definitive answers. Or they had to admit that the enclosed volumes of water within the lake could not fully replicate the natural conditions of the lake as a whole. It was realized for instance, that zinc from the separating foil used at the start of the experiment leached into the water, and zinc was actually one of the metals being investigated.

Pavilion to solve the space problem

A laboratory pavilion is built with a temporary construction permit. The staff headcount increases to 12 people. The Eawag department for Fisheries Science is created in Dübendorf, Zurich, where Eawag has just moved into its new building. The institute, run at the time as an ETH annex facility – but independent within the ETH domain from 1993 onwards – was previously spread across up to seven locations in the Zurich university district and, besides the laboratory in Kastanienbaum, as well as running a test facility and workshop next to the Werdhölzli Waste Water Treatment Plant.

Water as a source of energy

Aquatic scientists have been called upon in recent years to study the ecological impact of hydropower on the aquatic environment. What is the impact of pumped storage hydropower plants on lakes, for instance, or that of small hydropower plants on streams? Can artificial flooding below dams be used to restore marshlands? One topic that has received much attention recently is the problem of thermal pollution.

Back in the 1960s, engineers involved in the planning of Switzerland's first nuclear power plants contacted Eawag and the Kastanienbaum Laboratory to ask what elevation in the Aare river's ambient water temperature would be acceptable when releasing used cooling water from the power plant. The aquatic scientists eagerly took on the task and soon coined the term "thermal pollution". The researchers' findings provided a basis for the decision to make use of cooling towers at nuclear power plants and to limit the release of used cooling water into the aquatic environment. Federal lawmakers also amended the Swiss Water Protection Ordinance to limit the thermal impact of discharging used cooling water to a deviation maximum of 3 °C (or 1.5 °C in the case of trout waters) and an absolute water-temperature maximum of 25 °C. The summer heatwave of 2003, and high summer temperatures since, have led operators of cooling water facilities to demand a relaxation of the regulations. The task of determining whether such demands could lead to the "death of rivers by thermal shock" (cf. Prof. Heinz Ambühl, p. 18) will require new research efforts.

Realistic demand scenarios for the use of lake heat

Harnessing the heat stored in lakes is becoming an increasingly attractive option in the context of sustainable energy production goals. In Switzerland, the issue of exploiting the vast potential of lake heat has gained special prominence owing to the immediate proximity of major Swiss cities and settlements to large lakes, including Lake Zürich, Lake Lucerne and Lake Geneva. While individual power plants have already begun operation, the volumes of heat involved have so far remained small. Eawag recently carried out a study to assess the ecological impact of extracting much larger volumes of heat from Lake Constance. Rather than starting with a maximum fluctuation range of 2–3°C for lake water, the researchers worked out a realistic demand scenario. An extrapolation from a per capita energy demand of around 1 kilowatt and a total lakeshore population of 1 million gave a total extraction volume of 1 gigawatt, or 2 watts per square meter of lake surface area. Although this is 30 times the current extraction volume, it is still low when compared to the natural temperature fluctuations in Lake Constance. For instance, outgoing longwave radiation alone accounts for heat losses of around 170 gigawatts, and evaporation accounts for around 20 gigawatts.

Based on the demand scenario and a mathematical model of turbulence to estimate the spatial and temporal distribution of temperatures in the lake, the researchers concluded that the temperature of the lake's surface water would fall by a maximum of only 0.2 °C if 1 gigawatt of thermal energy were extracted for heating purposes. The model also indicated that the impact-related temperature fluctuation in the lake could be minimised by adjusting the water extraction and discharge depths, the volumes of water extracted and the temperature difference between the extracted and the discharged water.

Added de-stratification benefits

Extracting larger volumes of cooling water and replacing them with used cooling water may indeed extend the summer stagnation period, but only by an average of 1 day per gigawatt of heat discharged into the lake. Given that

Thermal energy from Lake Constance – here with Mount Säntis – could be used without producing adverse impacts on the ecosystem.

most scenarios assume higher levels of heat extraction in the winter, making use of the thermal energy can even be expected to promote (desirable) de-stratification in the autumn and spring. The optimal planning of large combined water extraction and discharge systems could therefore help to introduce a situation in which the effects of additional cooling in the winter and additional heating in the summer are to some extent mutually compensating.
The ecological effects of a significantly expanded use of lake energy on the large and deep Lake Constance can therefore be expected to be minimal, "especially when we consider the benefits of a corresponding reduction in our use of fossil fuels", suggests Prof. Alfred Wüest. As the director of the study, Wüest is now hoping that a number of the planned lake-heat projects are allowed to go forward, for instance, the large-scale project on Lake Geneva, which is to meet heating and cooling needs at the ETH Zurich, the University of Lausanne and the United Nations complex.

The story of Kastanienbaum

The local painter Marcel Nuber has illustrated the story of Kastanienbaum on the street-side façade of the Eawag boathouse (p. 45): "Many years ago, two Italians spent the night on a beautifully located house belonging to the town of Horw. As they left, they gave their host two chestnuts by way of a thank you, with instructions to plant them. He did so and watched with great joy as two luxuriant trees grew, which he tended with care until they bore fruit. He continued to plant new chestnuts, so that a forest of fertile, vigorous chestnut trees grew during his lifetime. Since then, the chestnut trees have continued to spread; the simple name "Kestenbaum" remained for the house." Around 1900 there were whole groves of chestnut trees on the Horw peninsula, although only a few remain today.

1976

New building on the hillside
Towards the end of 1976, the newly built laboratory is occupied and commissioned on 2 June 1977. The terraced-style building designed by architect Roland Mozzatti houses laboratories, aquarium rooms and offices. Only the first stage is built. The fisheries sciences department relocates from Dübendorf to Lake Lucerne. A total of 25 employees now work in Kastanienbaum.

History and stories on the lake floor

Settlement and industrialization in the Joux Valley, a tsunami on Lake Lucerne and earthquakes in Eastern Anatolia: using the layers of sediment which build up in lakes over time, researchers can reconstruct the effects of past environmental influences and human activity.

"Lake sediments are valuable natural archives", says Nathalie Dubois, head of the Eawag Sedimentology group. "Depending on the local influences, a variety of substances are deposited on the lake bed over time." Scientists like Dubois who can interpret the various layers can glean a great deal of information about the past. Together with colleagues, she recently investigated how the economic development of the Joux Valley (canton of Vaud) is reflected in the sediments of Lake Joux. The researchers extracted sediment cores from the lake bed and examined them in detail in the laboratory. They evaluated the sediments' composition optically, measured the magnetic susceptibility and density of the layers, carried out X-ray fluorescence scans and geochemical analyses and dated the sediments with the help of carbon, lead and caesium isotopes.

Extraction of a sediment core from the frozen Lake Trüb (canton of Nidwalden). It will be used to reconstruct historic flooding and study the links between particular weather conditions and heavy precipitation.

Erosion due to forest clearance

"The cores date back around 1200 years", says Dubois. Up until the 13th century, alternating layers of dark brown mud and lighter carbonate deposits indicate climatic fluctuations. The plant constituents of the overlying layers show a different pattern of long-chain hydrocarbons. This is due to a marked increase in inputs of organic matter to the lake, which the scientists have been able to date back to the period from 1300 to 1450. During this period, numerous settlers arrived in the valley and cleared the forests, with the result that large amounts of organic matter from the bare soil were washed into Lake Joux. The increasingly wet climate – heralding the Little Ice Age – also contributed to the erosion.

Heavy metals from the watchmaking industry

As economic development progressed, erosion started to decline from 1600 onwards. The composition of the sediments changed. In 1777, the bursting of a dyke churned up the layers and caused the water level in the lake to drop. This, combined with growing evaporation due to warmer climatic conditions, led in the 19th century to increased precipitation of calcium carbonate. The new dam constructed in

1942 stood firm. The coarse deposits in the sediment cores from this time suggest that construction waste was dis charged into the lake. The dam also altered the flow dynamics of Lake Joux, creating areas of stagnant water. Together with increased inputs of phosphorus from detergents, this contributed to the eutrophication of the lake. The carbon isotope composition of the sediment layers from this period indicates increased growth of aquatic plants. In the layers from the 1950s onwards, researchers found lead, zinc, iron and copper, which they believe originated in part from the local watchmaking industry.

Traces of Chernobyl in Lake Bienne

With the help of sediment cores, Eawag researchers were also able to establish what caused a tsunami, documented as having occurred in 1687 on Lake Lucerne. A mudslide took place on an underwater slope in the Muota delta, and the falling mud in the depths created a four-metre high tidal wave causing massive flooding. In the sediments in Lake Bienne, experts from Eawag and the Spiez radiation protection laboratory found radioactive caesium, which had found its way into the lake in 1999 from the Mühleberg nuclear power plant. These deposits were much smaller, however, than those caused by the Chernobyl disaster in 1986, which the researchers also detected. In addition, they found plutonium from global nuclear weapons tests in the 1960s. At Lake Van in Turkey, scientists are researching the history of the climate and earthquakes in the Middle East. Sediment cores of more than 800 metres in length shed light on 500,000 years of history. "Sediment analysis can indicate how the environment or the climate are affected by current activities, or the resilience of ecosystems to human-induced disturbances", Dubois says.

With the help of this sediment core from Lake Greifen (canton of Zurich), Empa and Eawag researchers measured changes in deposits of brominated flame retardants. The annual layers are clearly visible.

160 bottles of toilet descaling agent

When sediments are bored into, the resulting hole has to be continually stabilised with a gelatinous substance. But when an international research team under the co-direction of Eawag wanted to bore into the bed of the Turkish Vansee in the summer of 2010, this did not work. Instead of mixing with water, the stabilizing substance dispersed in flakes as a result of the lake water's high pH of 9.6. But where does one go to find the necessary acid to lower this pH in Eastern Anatolia as fast as possible? The inventive scientists immediately purchased the little town's entire reserve of toilet descaling agent - 160 bottles - and brought them to the boring site. That was sufficient for the first day, after which they were able to obtain citric acid in powder form. The bores were successful.

1978

Cross-discipline

The new department for Multidisciplinary Limnological Research (MLF) is founded. In Lake Baldegger and Lake Lucerne, experiments are conducted using giant hoses to investigate the effects of heavy metals and excessive concentrations of nutrients on the chemistry, biology and sediment of lakes.

Impetus for a holistic approach to water management

Clean water in formless rivers; dry streambeds below hydroelectric plants: waterbody research at the Institute in Kastanienbaum has had far-reaching impacts and has given rise to developments such as the modular stepwise procedure and the greenhydro project, which have now become the industry standards for evaluating surface waters and for the certification process for green electricity.

The mid-1980s saw the start of efforts to improve water quality in many areas of Switzerland. The investments in waste water treatment and preventative measures proved successful. However, it became increasingly clear that lakes and rivers should not just be protected against pollution, but should also be able to serve a diverse range of functions – as habitats for plants and animals, as places for recreation and fishing, and as sources of drinking water. Additional uses, such as the exploitation of hydropower and flood protection, should be made as sustainable as possible.

Holistic mindset

The water researchers in Kastanienbaum and their colleagues at Eawag in Dübendorf therefore began investigating the extent to which watercourses, in particular, are negatively affected by usage, correction and construction. Instead of assessing surface waters purely in terms of chemical parameters, they teamed up with the Federal Offices for the Environment and Water Management, as well as cantonal water protection agencies, to develop a standardised method for evaluating the condition of streams and rivers. They had previously worked on a proposal for the revision of the Water Protection Act in 1991 and defined the minimum residual water volumes that should be safeguarded in a body of water.

The evaluation procedure is divided into different modules, such as hydrology, ecomorphology, biology and ecotoxicology. It can be applied on an extensive level or on a finer level for the individual body of water. This gave rise to the term "Modular Stepwise Procedure", a method that is still being refined, and is used by the government and cantons to examine and assess surface waters in Switzerland.

Greenhydro sets standards

In 1997, Eawag began pursuing completely new avenues with the greenhydro project. The aim of the initiative was to develop the scientific fundamentals for a hydropower ecolabel, and to help bring the label to fruition. Although the institute in Kastanienbaum had already been conducting interdisciplinary research projects for some time, the social sciences joined the proceedings on an equal footing with engineering and natural sciences. The researchers collaborated with private companies, experts from government agencies, as well as representatives from the electricity industry and environmental organisations. In addition to ecological issues, such as hydrology and networking, a variety of economic, institutional and legal questions also had to be solved.

Roles perceived differently

Bernhard Truffer, one of the project managers at the time, and the current Head of the Environmental Social Sciences department said: "The biggest challenge on the green electricity project was combining the many different views and interests of the social stakeholders with the equally divergent approaches and role expectations of the different scientists in a way that would enable us to work towards a

Social, institutional and political factors have become an essential part of water management at Eawag, as seen here on a course for sustainable water management in Dübendorf.

generally acceptable result." This objective was achieved: in the form of greenhydro, they developed a successful method that is still used today for assessing and certifying sustainable hydropower, not just in Switzerland but also in Germany, the United Kingdom, the Netherlands and Sweden. The newly established association for environmentally sound electricity (Verein für unweltgerechte Elektrizität) then launched the naturemade star label for green electricity at the end of 2000.

The green energy initiative was the first interdisciplinary project at Eawag. It was followed by others, such as the Rhone-Thur project (S. 26). Deputy Director Ueli Bundi said in 2001: "There may be easier ways to achieve short-term academic success, but researchers and their institutions will have to legitimise themselves to a greater degree by helping to solve important issues in society." The Water Agenda 21 network, established in 2008, helps them meet this requirement and represents a further step towards a holistic rather than sectoral approach to water management.

"Anyone who had the good fortune to study at Kastanienbaum benefited hugely from the unique interdisciplinary cooperation both between the researchers and with the worlds of industry and politics. The added value this generates is immense."

Claudia Friedl, St Gallen, doctorate from the Department of Fisheries Science in 1996, Member of the National Council

1986

Taking the bull by the horns
An analysis of the ETH domain by the firm Hayek uncovers weakness in Kastanienbaum. The satellite department is subcritically staffed, the report states. The potential scenarios range from dispensing with the laboratory, to maintaining the status quo, to fortifying it. Consequently, after the federal government's freeze on new appointments ends in 1991, 20 new positions are created, in part through relocations from Dübendorf. The Sandoz fire in Schweizerhalle, with its impact on the Rhine and the support provided to the federal government by Eawag, may have contributed to the expansion.

Detective techniques bring new insights

What do the words “isotope signature” and “carbon labelling” mean to you? Among the methods used today in the laboratory in Kastanienbaum are the modern versions of fingerprint identification and invisibly coloured bank notes. But instead of tracking criminals and their escape routes, these methods allow environmental sleuths to understand climate change and food webs.

Picture yourself on a steamship in the middle of Lake Lucerne: you scoop up a small water sample in a bottle on a string, then an aquatic expert tells you whether the water has flowed into the lake from the Gotthard Pass or the Brünig Pass. How is this possible? The magic word is “isotopic signature”. This is the ratio of atoms of the same element that are stable but not exactly the same mass, for instance oxygen ^{18}O to ^{16}O. This ratio varies according to the source of the water, primarily due to the variations in geology in the drainage basin. Researchers can determine this ratio relatively easily in a mass spectrometer. These isotopic signatures are also built into the biomass of algae and other aquatic organisms, so that entire food chains and other interconnections can be reconstructed. Let us illustrate this by way of an example:

“My time at the Limnological Research Center in Kastanienbaum had a formative influence on my professional and personal future. I learnt a huge amount, especially with regard to methodology. This knowledge still serves as a basis for my work today, both in the design of field experiments and in the analysis of data sets. My personal network was just as important, however, and I still benefit a great deal from it. Last but not least, I have now been living in the Kastanienbaum region, where my research took me all those years ago, for more than 25 years.”

Werner Dönni, Lucerne, doctorate from the Department of Fisheries Science in 1993, owner of the Lucerne-based company, Fischwerk.

When the sea changed direction

One of the oldest known weather systems in the world is the North Atlantic Oscillation (NAO), the periodic variation of atmospheric pressure difference between the Azores and Iceland. It dictates not only whether the winters in Europe will be cold and dry or wet and warm, but also influences the oceanic currents in the North Atlantic. During positive phases, the oceanography of the northwest American continental shelf is dictated by a relatively warm water mass at 10 degrees Celsius, which is salt and nutrient-rich, originating from the Gulf Stream. If the NAO is in a negative phase, the Labrador Current is dominant, a relatively cold water mass at 6 degrees Celsius, which is relatively nutrient-poor and originates from sub-polar regions.

An international team with Carsten Schubert (p. 46) has now demonstrated that a drastic change to a «warm water mode» occurred in the western North Atlantic in the early 1970s. To arrive at this conclusion, the researchers made use of the nitrogen isotope signatures in corals. Deep-sea corals hundreds of metres below the surface feed on sinking organic particles from above. The deep-sea corals thus enable researchers to reconstruct of the oceanic current ratios over the last few decades, as corals display annual rings, like trees. The change thus identified in oceanic currents has coincided with global warming and is a unique occurrence within the past 2000 years, a fact which the team was able to establish using the same methods, but with fossilised rather than living corals.

Sampling was performed from a platform on Lake Cadagno in Canton Ticino (southern Switzerland).

Living off borrowed oxygen

In contrast to oceans, freshwater lakes – and tropical reservoirs – are significant sources of methane emissions. Methane, a greenhouse gas, arises from the degradation of organic material settling on the lake bottom. Emissions from seasonally or permanently stratified lakes with anoxic bottom waters are greatly reduced. It had always been assumed until recently that the methane decomposition processes which occur in such lakes are the same as those in marine systems. But a new study carried out on a Ticino mountain lake by researchers from Eawag and the Max Planck Institute for Marine Microbiology in Bremen shows that this is not the case. The scientists demonstrated that methane is almost completely consumed in the anoxic waters of Lake Cadagno, but they did not detect any known anaerobic methane-oxidizing bacteria – or archaea, which are primarily responsible for marine methane oxidation. Instead, water samples collected from a depth of around 12 metres were found to contain abundant aerobic proteobacteria. To ascertain how such bacteria are able to survive in these anoxic waters, the scientists used another new method: labelling single molecules – in this case, methane molecules – with "heavy" 13C atoms, which indicate the decomposition of the methane. This, in conjunction with labelling the genes of methane bacteria with a fluorescing dye, enabled the researchers to show at a microscopic level that methane-oxidizing bacteria occur in close proximity to diatoms that carry out photosynthesis. The bacteria apparently obtain their oxygen from the algae.

1996

Conversion and renovation of the "Seeheim"
The former lakeside villa is now available for exclusive use by Eawag. It is completely renovated, inside and out, and is adapted to meet the requirements for research. The multi-purpose room on the ground floor is used for courses, and the upper levels house offices and accommodation. Part of the garden is opened up to the public.

Encyonema Cymbella diatoms in a gelatinous tube, frequently found in the shore area of lakes. The gel extruded by the cells keeps the cells from drifting with the current.

Fascinated, curious, committed – the people who work here today

Working the equivalent of over 83 full-time jobs, there are currently 37 women and 60 men employed at the Eawag site in Kastanienbaum, ranging from those completing their civilian service, to members of the management committee. In the brief portraits below, nine of these people provide an insight into why water research fascinates them.

Salome Mwaiko – science is not always plain sailing

Biologist and laboratory manager. 55. Native country: Tanzania. "Sometimes the experiments work out perfectly for a week, then you do exactly the same thing and nothing goes right. I like this challenge", says Mwaiko. Her laboratory for molecular genetics investigates topics in ecology, evolution and biodiversity. Not only does she use and maintain the complex equipment herself; she also instructs students in how to use the technology. She also assists with fieldwork and is partially responsible for administrating the immense quantity of data and for the growing collection of preserved fish, which are kept for reference purposes in future research work. "When a new study is published, I am as happy as the researchers", says Mwaiko. She has also provided encouragement to disheartened researchers when something has gone wrong yet again, and reams of unusable data are churned out after hours of painstaking precision work.

Intellectual activity in Lucerne

In 1965 Eawag Director Otto Jaag outlined the project for a "central federal hydrobiological institute on Lake Lucerne, with a guest house". It was planned that the institute should be run by the ETH and the cantons of central Switzerland. The plans for a university in Lucerne were regarded by Jaag with scepticism: "It is the opinion in various circles that the need for more intellectual activity would be far better met by the creation of a hydrobiological research institute, the construction of which is far more pressing than the creation of a new university", he wrote in a memorandum.

Doris Hohmann – continuing education

Medical laboratory assistant and technician. 62. Hometown: Horw. Before Doris Hohmann came to Eawag in 1990 to work as a technician, she had been investigating skin, amongst other materials, at the Zurich University Hospital; now she deals with algae and small zoological specimens from lakes and brooks. "Actually, I was not sufficiently qualified for this work, but the team showed more and more confidence in me", she recalls. This confidence gave her the boost she needed to embark on part-time postgraduate studies in environmental sciences alongside her paid work, and she became an expert in entomology (the study of insects). Research work had already appealed to her when she worked in the hospital. But it was distressing to be the first to know that a patient had cancer. Sick bodies of water, on the other hand, can usually be restored to health, as she learnt, for example, in a major study on water protection in the Lake Lucerne catchment area. Doris Hohmann wants to continue learning after her retirement: she hopes to register at the University of Zurich as a student of German literature.

Blake Matthews – one animal less can change everything

Environmental scientist, biologist, 37. Hometown Vancouver, Canada. Since 2008 Blake Matthews has been the group leader for eco-evolutionary dynamics in Kastanienbaum. “We usually think that the environment determines organisms”, says Matthews, “but the opposite can also be true. If three families move into precisely identical flats, after a few weeks these flats will appear entirely different. That is also true in the environment. If one animal disappears, that can have consequences for the whole food chain or even the landscape.” This is what Matthews and his group are investigating – in nature, in the laboratory, with computer models and with experiments in mesocosms, such as the blue tubs in the picture. Matthew’s birth coincided with the inauguration of the new laboratory building in Kastanienbaum. “I am proud to be able to work in the country in which limnology was founded”, he says, going on to speak highly of the interdisciplinary cooperation with his colleagues.

Beat Müller – working where the real needs are

Chemist. 59. Hometown: Greppen. “I dare not think what dangerous substances I mixed in the cellar as a boy,” says Beat Müller. Following his studies in chemistry, however, the search for the substance that holds the world together was less fascinating than Müller had hoped. Encouraged by Werner Stumm, the then director of Eawag, he came here in 1985 and wrote his dissertation on the behaviour of heavy metals in sediment.“ I felt there were tasks here that were worth doing”, he explains, and speaks of the spirit of optimism that led him in 1987 to begin the study of environmental sciences at the ETH Zurich, serving as adjunct lecturer and laboratory instructor. Expeditions to Lake Baikal and the Yangtze river belong to his most adventurous experiences. Today he sits most of the time in front of the computer: “Unfortunately,” he says, “as, experiencing an ecosystem in nature, as did the founders of the laboratory 100 years ago, is still very much a different thing from a computer model.”

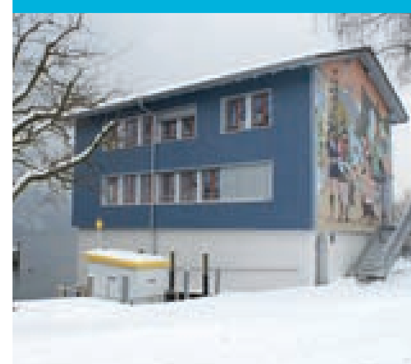
Ole Seehausen – how animal species emerge and how they die out

Evolution ecologist. 51. Hometown Hannover, Germany. He completed his doctorate at the University of Leiden (NL). In 2001 he was Assistant Professor in Hull (GB). Since 2004 he has headed up the Fish Ecology and Evolution department in Kastanienbaum and is Professor in the Institute for Ecology and Evolution at the University of Bern. A newspaper described him as “one of the truly great researchers into the natural world”. His passion is palpable, for example when the results of his research refute old beliefs: “On the one hand, the emergence of a species doesn’t always take many thousand years, and on the other, species that have been developing independently for millions of years can exchange genetic material”. His group is investigating the role of the environment in these processes, as well as the impact of evolutionary changes on the ecosystem. “The working environment in Kastanienbaum is ideal for this research”, he says, “as evolutionary biologists, ecologists and geoscientists are all working under the same roof.”

2007

Rebuilding of the boathouse

The old 1938 laboratory, now referred to as the “Boathouse”, is reconstructed and renovated. The mural of the Kastanienbaum Saga by artist Marcel Nuber is also restored (p. 35).



Brigitte Germann – when fish fly into the forest

Chemistry laboratory assistant and technician. 52. Hometown: Lucerne. When Brigitte Germann began her apprenticeship at Eawag in 1976, she never dreamed that she would spend most of her working life here. But neither the interlude in a chemical company nor the hard work as cook in a children's home was a dream job. She thus came back in 1982 to work in the limnology laboratory, measuring heavy metals and other substances as well in water. But because she prefers fresh air to being inside and could only venture out onto the lake to collect samples once a month, she left this job and applied successfully to the department of Fishery Science, which involves spending more time on field work on rivers and streams. The photo shows her demonstrating how fish are fitted with tiny transponders in order to keep track of their migrations with antennas. Sometimes these migrations even end up in the forest: "Just recently we found transponders under a heron's nest", Germann chuckles.

Carsten Schubert – half way to Italy

Geologist. 49. Hometown Pohlheim, Germany. Carsten Schubert's doctoral dissertation dealt with climate fluctuations in the inhospitable Arctic. Then he planned to do research in Italy: "The weather and the food are good there", he says. During a postdoc stay in Vancouver, however, he got to know the director of Eawag's Surface Water Research and Management department, Bernhard Wehrli. When he saw a job advertisement for a group leader in biogeochemistry in Kastanienbaum, that was it: he exchanged oceans for lakes and moved from central Germany to head south, albeit not as far as he'd originally intended. His speciality is methane and the processes by which it escapes from lakes, breaks down on the way, or remains in the depths. Take Lake Kivu in Africa, for example: "It is terrific to be able to explain something that was observed in the data 30 years ago," he says. Recently he has spent a lot of time looking at biomarkers, for example the hydrogen isotope deuterium, with the help of which the paths travelled by water can be traced back. "The past is the key to the future", he reminds us, quoting an old geological adage.

Christian Dinkel – sampling crane on a rubber dinghy

Chemistry laboratory assistant and technician. 46. Hometown: Kastanienbaum. At the age of seven, "Chregu" Dinkel was already around in 1977 as Eawag celebrated their newly built laboratories and offices on the hillside. He knew he wanted to work here, too, one day. He mounted a sampling crane on his little rubber dinghy and analysed his lake water samples in his "laboratory" at home. At the age of 14 he telephoned to inquire which apprenticeship he should do in order to achieve his goal, and at the end of his chemistry laboratory assistant apprenticeship he took up his first temporary position. He studied part-time at technical college and became a professional technician for electronics, metrology and control technology. "There is very little that can be classed as routine at Eawag. It's a continual learning experience," says Dinkel as he works a motorised winch that has seen service on Lake Tanganyika in Africa. Chregu's commute to work is not routine, either. When he was still living in Hergiswil he used to come to work across the lake in a kayak - summer and winter.

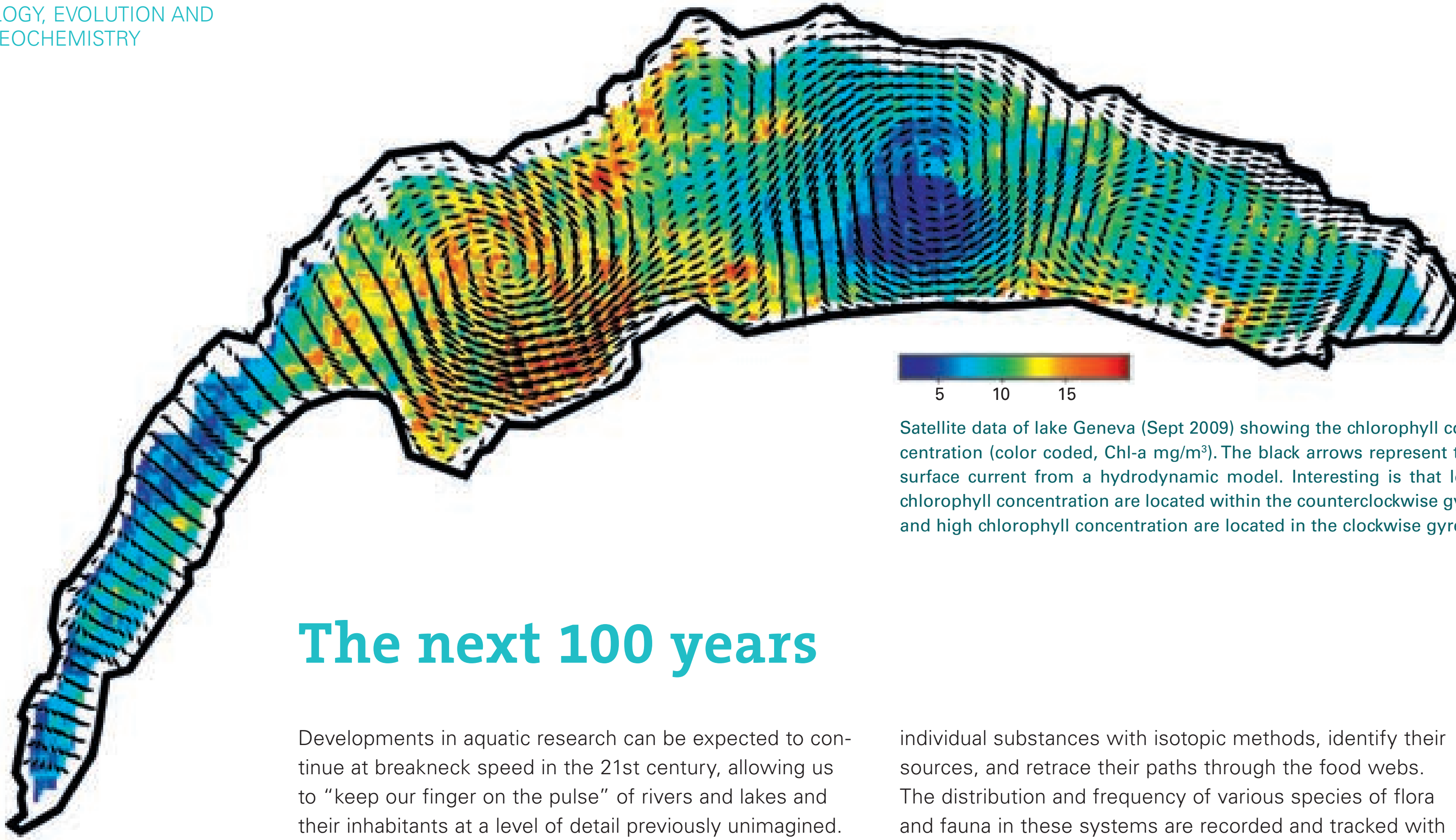
Philine Feulner – from deer to fish to sheep to fish

Evolutionary biologist. 39. Hometown: Würzburg, Germany. Philine Feulner wrote her thesis at the University of Kiel on red deer in the Carpathian Mountains. Then she worked with the genome of elephant-nose fish in the Congo, sheep in England and stickleback at the University of Münster and the Max Planck Institute in Plön. She has now been living in Lucerne for a year and a half, and works as group leader for fish genomics in Kastanienbaum. Her workplace is chiefly the office; once in a while she greets her whitefish in the aquarium room. But when the opportunity arises, she takes to the lake with colleagues who know every fish and not "only" their genetic structure. "I have the good fortune to work at a place where there is no rift between theory and practice", she says. She is delighted that today's technological advances mean that earlier investigations can now be expanded on, and hypotheses tested.

2008

Summer schools instead of project weeks

With the number of employees now at around 70, as well as academic guests to accommodate, space on the lake again grows tight. The management decides to dispense with multiple-day specialized biology weeks for middle schools. Instead, the focus is on summer schools for students, and individual PEAK courses (practice-oriented Eawag courses) are relocated to the Kastanienbaum site. Regular public tours are also advertised.



Satellite data of lake Geneva (Sept 2009) showing the chlorophyll concentration (color coded, Chl-a mg/m³). The black arrows represent the surface current from a hydrodynamic model. Interesting is that low chlorophyll concentration are located within the counterclockwise gyre and high chlorophyll concentration are located in the clockwise gyre.

The next 100 years

Developments in aquatic research can be expected to continue at breakneck speed in the 21st century, allowing us to "keep our finger on the pulse" of rivers and lakes and their inhabitants at a level of detail previously unimagined. In place of the old monthly sampling routines, today's sensor systems test water quality and movements in real time and provide data round the clock. Thanks to remote sensing with satellites, we will soon have access to maps that are updated on a daily basis to show algae growth for all the sizeable bodies of water on this blue planet of ours. The same goes for surface temperature, turbidity and even dissolved substances. Such information is recorded using an increasingly fine grid resolution, providing us with insights into the moment-by-moment distribution of aquatic characteristics, as well as the dynamics of their developments.

Making the most of the wealth of data

Modern technology allows us to assess the mass balance in ecosystems to a high degree of accuracy: we can date individual substances with isotopic methods, identify their sources, and retrace their paths through the food webs. The distribution and frequency of various species of flora and fauna in these systems are recorded and tracked with constantly advancing methods. The task of making the most intelligent use of this wealth of data will require new computer models. The researchers will be able to use these models along with the monitoring data and other information to make comparisons and arrive at valuable insights which draw on an extensive range of specialist areas.

New methods – more precise answers

In recent years, a scientific revolution has set ecological research on a new footing. Thanks to molecular genetic analysis and evolutionary biology models, we can now reconstruct the evolution of species and species diversity in water bodies over the course of thousands of years. At the same time, we can track the rapid changes in today's ecosystems as they take place. Researchers can establish the relationship between the development of environmental influences such as nutrient load, loss and fragmentation of habitats or changes in climate on the one hand, and developments in the genome on the other. This will provide us with a clearer idea of the specific conditions which promote biodiversity and the emergence of new species, and the circumstances under which species lose their adaptations or even die out.

Ambitious goals

The Swiss population has set ambitious goals for water protection in their country over the coming decades. These include re-oxygenating even the deepest parts of lakes and preserving their biodiversity, revitalising many stretches of flowing water. Barriers to fish migration in rivers will be removed and hydropower must adhere to strict ecological constraints. The Centre for Ecology, Evolution and Biogeochemistry in Kastanienbaum will continue to provide scientific support for these efforts, and the Centre's research findings will play an important role in debates over water resource usage conflicts. The research centre has set itself the ambitious goal of bringing together the population sciences – evolutionary biology and classical ecology – with the environmental systems sciences – biogeochemistry and physical limnology, in order to gain a better understanding of how ecosystems work, and, ultimately to better protect the ecosystems and their biodiversity in the future. Even decades ago, Eawag was undertaking pioneering work in Kastanienbaum in the area of interdisciplinary aquatic research. We are not about to take our eye off the ball.

Authors of this perspective
Bernhard Wehrli: Professor for Aquatic Chemistry at the ETH Zürich. Group leader for aquatic chemistry and member of the directorate (2005–2015) at Eawag. **Ole Seehausen:** Professor for Aquatic Ecology at the University of Bern. Head of the Department of Fish Ecology and Evolution as well as leader of the evolutionary biodiversity research group at Eawag. **Carsten Schubert:** Geologist, Head of the Department of Surface Waters as well as group leader for biogeochemistry at Eawag. **Alfred Wüest:** Professor for Environmental Physics, Director of the Limnology Centre and leader of the Physics of Aquatic Systems Laboratory at the EPFL. Group leader for aquatic physics and member of the Eawag Directorate.

High-level politics

Thanks to the international academic contacts of the directors Otto Jaag and Werner Stumm, important guests were always visiting Eawag. Sometimes, however, world politics put restrictions on close contact. In 1968, for instance, the international congress for water and wastewater research, for which 500 attendees had registered, had to be cancelled, as the hotel where the congress was to take place in St. Moritz refused to accept representatives from countries whose armies had taken part one month earlier in the invasion of Czechoslovakia. Demonstrations were also feared. In 1992 Stumm cancelled a visit from a Chinese delegation: "Our director is not prepared to greet an official representative of the present Chinese government. I regret that scientific communication has been disrupted by the political situation", wrote the directorate member in question. One visit which did work out, however, was that of Nikolay Vorontsov, the Russian minister for the environment, who came to Kastanienbaum in 1989. At the conclusion of the visit Vorontsov and federal councillor Flavio Cotti signed an agreement of cooperation in the area of environmental protection. Present-day Eawag projects on Lake Baikal are the result of this agreement.

Mesocosms in operation
Tests and simulations in the laboratory are not 100% transferrable to actual lake conditions, while experiments in the lake are difficult to control and replicate. Ecosystem-related questions are therefore investigated with the help of mesocosms. The blue and black "tubs" above the laboratory continue a tradition of experiments in streams and aquariums. To preserve the beauty of the landscape, the plastic containers are removed when no experiments are being conducted.

Nauplius stage of a copepod (possibly cyclops). Following the germination of the eggs, the copepods go through 6 nauplius stages and then 5 copepod stages until they are sexually mature.

2012

Organization

Directorate

- Eawag/EPFL Ecotox Centre
- Standing Committees

Research departments

- Surface Waters Research and Management SURF
- Aquatic Ecology ECO
- Fish Ecology and Evolution FISHEC
- Environmental Chemistry UCHEM
- Environmental Microbiology UMIK
- Environmental Toxicology UTOX
- Water Resources and Drinking Water W+T
- Process Engineering ENG
- Urban Water Management SWW
- Sanitation, Water & Solid Waste for Development
- Systems Analysis, Integrated Assessment and Modelling SIAM
- Environmental Social Sciences ESS

completely or partially at the Kastanienbaum site (SURF, ECO, FISHEC)

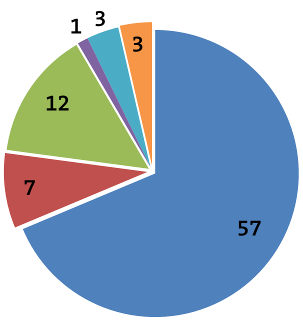
Support departments

- Corporate Services
- Communication
- IT Services
- HR and Finance
- Technical Services
- Vocational Training

Cooperation within the ETH Domain

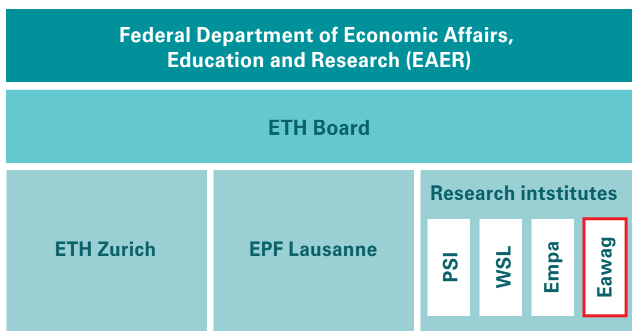
- Technology Transfer
- Childcare centre
- Library Lib4RI

Staff at Kastanienbaum



A total of 83, thereof 20 visiting researchers and 2 interns

How Eawag fits into the ETH domain



Total renovation of the terrace building

The laboratory built in 1977 is fully renovated. A completely new ventilation system is installed, along with a cooling system using lake water, resulting in vastly reduced energy consumption. In addition, a simple wooden extension replaces the pavilion, nicknamed the "Castagnettas", which had originally been designed as a temporary measure.

Publisher
Eawag: Swiss Federal Institute
of Aquatic Science and Technology

Concept, texts, editing
Andri Bryner
Andres Jordi (S. 30, 36)

Translation
Zieltext
Übersetzungen & Kommunikation
8702 Zollikon

Layout
Sandra Schwab, s-at.ch
3011 Bern

Print
Medienhaus Mattenbach
8411 Winterthur

Picture credits

Eawag — Archiv: 4, 6, 7, 7r, 10, 11r, 13r, 15, 16, 18, 19r, 20, 21, 23, 25r, 26, 29r, 30, 33r, 35r, 37r, 39r, 41r, 45r, 47r / Peter Bossard: 32 / Andri Bryner: 5, 25, 29, 35, 44o, 46o, 47 / Philipp Dubs: 36 / Rudolf Müller: 8, 9 / Peter Penicka: 46u / Armin Peter: 27or / Raoul Schaffner: 39, 45u / Aldo Todaro: 3, 43, 44u, 45o / Ole Seehausen: 24 (o=above, u=below)

Jenny Held (Eawag), Alexander Smirnow (ETH/UZH): 12, 51
Perdo Galliker, microscope pictures: 1, 14

Georg Gerster: 17o / Bundesarchiv: 17r / Andreas Hartl: 31 / NGL: 2 / Max Planck Institut, Bremen, Jana Milucka: 41 / SNF: 19, 37 / Tiefbauamt Graubünden: 27ol / Umwelt und Energie, Kanton Luzern: 33 / VAW/Eawag: 28

Selected sources

- Jahrbücher der NGL und Jahresberichte der Eawag
- Die Geschichte des Hydrobiologischen Laboratoriums in Kastanienbaum, Heinrich Wolff, Luzern. Schweizerische Zeitschrift für Hydrologie, Vol. 28. 1966
- Ein zentrales schweizerisches limnologisches Institut am Vierwaldstättersee; Memorandum von Otto Jaag, 1965
- Pressedokumentation zur Projektierung (1973) und Einweihung des Neubaus (1977)
- Ein Blick zurück; das Eawag-Forschungszentrum für Limnologie (FLZ) in Kastanienbaum. Ruedi Müller. 1997
- Beitrag zur Geschichte der Gewässerforschung in der Schweiz, Peter Perret (letzter Präsident der Hydrobiologischen Kommission der SANW). 2001

Footers

[1] Beschreibung des berühmbten Lucerner oder 4. Waldstaetten Sees und dessen fürtrefflichen Qualiteten und sonderbaaren Eygenschafften (Johann Leopold Cysat, Luzern; David Hautt; 1661)
[2] Le Léman (Genf, 1882–1904; 3 Bände)
[3] Beiträge zur Toxikologie der Fische; P. Steinmann, G. Surbeck, Zeitschrift für Hydrologie, 1920
[4] H. Wolff, «Prof. Dr. Hans Bachmann (1866–1940)», in Verh. SNG, 1940, 404–412, (mit Porträt und Schriftenverz.)
[5] Organisation für wirtschaftliche Zusammenarbeit und Entwicklung
[6] Edited from H.R. Bürgi: «Abschied von Heinz Ambühl» in den Mitteilungen der Schweizerischen Gesellschaft für Hydrologie und Limnologie/SGHL (Dez. 1970)
[7] VAW: Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie an der ETH Zürich
[8] LCH: Laboratoire de constructions hydrauliques an der EPF Lausanne

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