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Artikel: Pflanzenökologische und limnologische Untersuchungen des Reussdelta-Gebietes (Kanton Uri) : Aufnahme des Ist-Zustandes von 1987/88 = Phytoecological and limnological investigations in the region on the Reuss delta (canton Uri)

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- **Makrophyten:**
  - Es konnte im Vergleich zur Vegetationsaufnahme von 1982/83 keine Verkleinerung der bewachsenen Fläche beobachtet werden. Daraus wurde der Schluss gezogen, dass keine hochwasserbedingte Verschlechterung der Standortbedingungen eingetreten war.

7. PROGNOSEN

Es darf angenommen werden, dass nach der Neugestaltung der Reussmündung, abhängig vom jahreszeitlichen Einschichtungsverhalten der Reuss, der Uferbereich stärker vom Reusswasser beeinflusst wird als bisher. Aufgrund von Erkenntnissen, die aus den vorliegenden Untersuchungen gewonnen wurden sowie aufgrund von Hinweisen aus der Literatur, wurden Prognosen für die Entwicklung der chemisch-physikalischen und biologischen Gegebenheiten im südlichen Uferbereich des Urnersees gemacht. (Fig. 9.1 und 9.2).

1. Phase: Öffnung des Reussdammes links.

Die Bereiche links des Reusskanals werden stärker, die Stellen rechts davon hingegen weniger stark durch das Reusswasser beeinflusst als vor der Öffnung des Reussdammes. Die durch die Reuss eingebrachten Schwebstoffe verschlechtern die Lichtverhältnisse und führen zu einer grösseren Sedimentation. Die Primärproduktion sowohl des Phytoplanktons als auch der Aufwuchsalgen und der Makrophyten wird vermindert, und die Untergrundbeschaffenheit verändert (kleinere Korngrössen), was Auswirkungen auf die Wasserwirbellosen zeigt. Aufgrund der im Vergleich zum Seewasser höheren Nährstoffkonzentrationen im Reusswasser machen sich Eutrophierungstendenzen bemerkbar. Dies hat Änderungen bei den Biozönosen sowohl in quantitativer (Zunahme der Biomasse) als auch in qualitativer Hinsicht (Änderung der Artenzusammensetzung) zur Folge. Die niedrigeren Temperaturen der Reuss dürften dagegen im Uferbereich zu einer Verlangsamung der Lebensvorgänge führen.

2. Phase: Öffnung des Reussdammes rechts und Deltabildung.

Aufgrund der Auftrennung der Reussmündung in zwei Arme gelangt das Reusswasser in den gesamten Uferbereich. Sein Einfluss verringert sich auf der linken Seite, nimmt dafür gegenüber der Phase 1 auf der rechten Seite zu. Als Folge der Deltabildung dehnen sich die Flachuferbereiche und die Pflanzenbestände (Makrophyten) aus. Im Mündungsbereich entstehen teilweise oder ganz abgeschlossene Kompartimente (Weiher, Tümpel), in denen sich spezielle Biozönosen entwickeln.

SUMMARY LIMNOLOGY

During the period April 1987 to April 1988, limnological investigations with regard to the biology and to chemical and physical parameters were carried out at six sampling stations in the littoral zone and two sampling stations in the pelagial zone of Lake Uri (Fig. 2.1). The aim of the investigations was to characterize the present state before the planned alteration of the mouth of the River Reuss. The results should help, in comparison with results of future investigations, to recognize and to evaluate possible changes in the lake which may occur as a consequence of the new mouth formation.

1. CHEMICAL AND PHYSICAL CONDITIONS

The chemical and physical parameters investigated are listed in chapter 3.2.2. In the littoral, a water column from the 0-4 m depth interval was taken as an average sample, and in the pelagial water samples from 0, 1, 2.5, 5 and 10 m depths were taken. Sonde measurements took place in the littoral up to 5 m and in the pelagial, up to 10 m water depth.

Variations in chemical and physical parameters in Lake Uri during the sampling period were as follows:

- Rather low values of the nutrient concentrations, the total hardness, the carbonate hardness and the conductivity during summer (stagnation period), as a consequence of the photosynthetic activity of the primary producers, especially of the phytoplankton.
- High oxygen saturation (temporary over-saturation) and high pH values in summer, also a consequence of this production.
- Reversed conditions of the described parameters during winter as a consequence of the mixing process and the low production.

The transparency of the water was reduced from May to August 1987, compared with the other time of the year, because of the high content of suspended matter in the River Reuss (Chapter 3.3.1). The flood event at the end of August 1987 and the deposition of soil in the littoral (especially at sampling Station 1, where an island for birds was being built) caused a marked decrease in transparency.

The statistical comparisons of the sampling points (Chapter 3.3.2) showed the following results:

- Littoral and pelagial sampling stations showed strong differences (with the exception of ammonium, nitrate, and orthophosphate).
- No differences were found between the two sampling Stations Pelagial Left and Pelagial Right.
- Differences occurred between the littoral sampling points with regard to ammonium, oxygen, and transparency.

From the measured pollution indicators, only ammonium showed cause for concern. The annual mean was clearly below the critical concentration. However, the maximum ammonium concentration of 120 µg/l (Station 1) and of 200 µg/l in the pelagial (Right) seemed to be the result of pollution. This was probably caused by the insufficiently purified waste water from the sewage treatment plant of Altdorf.

The chemical conditions in the littoral may also be affected by the drainage channel reaching into the agriculture area (Chapter 3.3.1 and 3.4.1). The critical concentration for lakes of 20-30 µg/l total phosphorus during the circulation period, was not exceeded during the whole investigation period. Compared with other large Swiss lakes with regard to nitrate (concentration during circulation 0.55 mg/l), ortho-phosphate (5.1 µg/l) and total phosphorus (10 µg|l), the state of Lake Uri was the best.

With regard to the annual mean of the total phosphorus the probability was 70-75%, that the pelagial of Lake Uri could be classified as oligotrophic. That of the littoral, was 50-70%. Using the orthophosphate concentration at the end of the spring circulation as indicator of the trophy state, the pelagial was oligotrophic with 75% probability, the littoral with 60-90%.

Because of the nutrient input from the agriculture area and the great influence of the sediment, the littoral seemed to have a greater nutrient availability than the pelagial.

The chemical conditions in the River Reuss were different from those at the pelagial, and the data more dispersed (Chapter 3.3.3). In the River Reuss, the annual mean of the total hardness, the carbonate hardness, the conductivity, the nitrate concentration, and the temperature were lower, the concentration of oxygen, orthophosphate and total phosphorus were higher. The drainage area of River Reuss mainly consists of igneous rocks and therefore the conductivity and the total hardness and carbonate hardness were low. The higher mean concentration of total phosphorus in the River Reuss might be a result of erosion and leaching after strong precipitations.

2. PLANKTON

The water sampled for chemical and physical analyses was also used to investigate the plankton. During the investigation period, 117 species of phytoplankton organisms were identified (Table 4.1). Half of them, including the diatoms, belonged to the chrysophytes. With regard to the biomass, as well as to the species composition, the phytoplankton communities of the pelagial and of the littoral differed little. With regard to the relative frequency the centric diatoms (especially *Cyclotella* aff. *comensis* and *Stephanodiscus*), the pennate diatom *Tabellaria flocculosa*, the cryptophyte *Rhodomonas minuta* and the group of the "diverse flagellates" were most important. From January to May, the centric diatoms occurred in great numbers and caused the spring bloom. During the rest of the year, *Tabellaria flocculosa* was most often dominant.

The chlorophyll a content in the pelagial was in a value range typical for oligotrophic lakes. In the littoral, it indicated oligo- to mesotrophic conditions (Table 4.2). The dry weight was strongly influenced by deposition of material in the shore area. The sampling stations therefore differed with regard to this parameter. Station 1, with the highest values of dry weight, was prominent. During the summer, the inorganic compounds built the main part of the dry weight (Fig. 4.8), even when the phytoplankton biomass was increased (Fig. 4.5). In winter, the organic compounds exceeded the inorganic compounds. This may be a consequence of the influence of the River Reuss water. In summer, the discharge was high and thus a larger amount of suspended matter was transported into the lake than in the winter.

The results of the investigation of the zooplankton can be used only for orientation purposes. The highest density of individuals of zooplankton was observed from April to May 1987. The consumption of the zooplankters probably caused the strong decrease of the phytoplankton density from May to June (end of the phytoplankton bloom).

3. PERIPHYTON

The periphyton in the littoral of Lake Uri was investigated with regard to the biomass and to the species composition at six sampling stations in 2.5 m and 5 m depth. Racks of vertical glass slides acted as an artificial substrate. The development of the biomass (Chlorophyll a and ash-free dry weight) might be influenced markedly by the nutrient availability and the phytoplankton-periphyton interaction (Chapter 5.2.2).

On the glass slides for the 2.5 m depth, the biomass clearly was higher than for those at the 5 m depth (Chapter 5.3.1). This probably was the result of the lack of light at the 5 m depth. The cover density of the periphyton, expressed as a percent, whereby 100% means a monolayer cover on the slide) ranged between 13 and 590% at 2.5 m and between 7 and 219% at 5 m depth (Chapter 5.3.2). At the 2.5 m depth, it was always higher. The largest cover densities were observed in February, March and April. Station 2 showed the highest average cover density, Stations 1 and 6, the smallest.

During the investigation period the periphyton were dominated by the diatoms. The estimated portion of the diatoms at the algal community almost always ranged between 95 and 100%. 204 taxa of diatoms were determined (Table 5.7). Green and blue-green algae only sporadically went over the 5% threshold. On the glass slides, apart from the diatoms, there were 64 other algal taxa: 16 cyanophytes, 5 chrysophytes, 42 chlorophytes and one dinoflagellate (Table 5.6).

Within the diatoms, 18 species could be identified which reached more than 10% relative frequency at least once (called major species). The dominant species was *Achnanthes minutissima* at 2.5 m, as well as at 5 m. In addition, *Fragilaria capucina*, *Cymbella minuta/silesiaca* and *Gomphonema angustum* were present with high relative densities (Fig. 5.9). With regard to the relative frequency, no difference in the development of the main species could be observed. In general the relative frequencies of the species during mixing period were more equable than during the stagnation stage, and at 5 m, the dominance of any species was less pronounced. Because of these results, we assume a relationship between community structure and nutrients (depending among other things on the stratification) and between community structure and light supply (depending on the exposition

depth; Chapter 4.3.4).
Of the 18 major species, the *Navicula menisculus* var. *menisculus*, *Nitzschia dissipata* and *Fragilaria capucina* seem to have a special depth preference (Chapter 5.3.5).
The determination of the water quality based on LANGE-BERTALOT's (1978/1979) principle of the diatom differential groups, yields Water Quality II at 2.5 m and 5 m depths (β-mesosaprobic, moderately polluted). This result must be interpreted as "at least Water Quality II, presumably better", because Lake Uri ranges between the oligotrophic and the β-mesosaprobic state, which is difficult to separate using the principle of diatom differential groups (Chapter 5.4).

4. MACROINVERTEBRATES

The macroinvertebrates were caught with labyrinth traps (Fig. 6.1) set in 5 m depths for one month. During the investigation period 58 taxa were identified (Table 6.2). The main species groups were flatworms, leechs, water-louses (Asellus aquaticus), mussels and snails. The species compositions showed great differences at the various sampling stations (Fig. 6.6). The main species groups at the six sampling stations were (in decreasing order):
Station 1: leechs, flatworms, water-louses (*Asellus aquaticus*)
Station 2: mussels (*Dreissena polymorpha*) and snails
Station 3: water-louses (*Asellus aquaticus*), snails and flatworms
Station 4: snails and mussels (*Dreissena polymorpha*)
Station 5: leechs, mussels (*Dreissena polymorpha*) and flatworms
Station 6: water-louses (*Asellus aquaticus*) and leechs
The mean density of individuals was smaller at the sampling stations with a low sedimentation rate (e.g. Station 2, Tables 6.1 and 6.3) compared with those with a higher sedimentation rate (e.g. Station 6). The macroinvertebrates were also influenced by the composition of the lake bottom, especially in regard to snails. At the sampling Stations 1, 5 and 6, where the bottom was more or less sandy, snails seldom occurred. However, at Stations 2 and 3 with a more stony bottom, they occurred in larger numbers. The macroinvertebrate community probably was influenced by predator-prey relations. For example, large populations of flatworms (predators) occurred together with large numbers of *Asellus aquaticus*.

5. MACROPHYTES

The cartography of the aquatic plants in the southern Lake Uri littoral zone was carried out at the end of July 1988 with the help of aerial colour photographs and field observations (Scuba diving). This was the first vegetation period after the flood event of August 1987. 18 species of macrophytes were observed (Table 7.1). With regard to the vegetation area, the most important species were *Chara contraria, Potamogeton pectinatus, P. filiformis* and *P. perfoliatus*. Other species were observed in small numbers only. For Lake Lucerne region seven of the species found in Lake Uri were rare.
To present the vegetation areas in the littoral of Lake Uri, three sectors were separated and the vegetation area, together with the degree of cover and the floristical composition are shown (Figs. 7.3, 7.5, 7.7). To determine wether the changes of the macrophytes during the last year were normal or a consequence of the flood event, a comparison was made between the current investigation and the cartography from 1982/1983 (LACHAVANNE et al. 1985; see Figs. 7.2, 7.4 and 7.6). However, the differences between the two studies may be the result of the newer relief map of Lake Uri and the more detailed investigation of 1988.
The vegetation zone of 1988 was 34,000 m^2 larger than in 1982/83. The proportion of the vegetation area to the actual shallow water area increased from 21% to 38%. In 1988 the theoretical and the actual shallow water zone were smaller than 1982/83 (Fig. 7.1). The decrease was observed especially within Sectors 1 and 2 where the gravel excavater was positioned. In Sector 3, the above mentioned areas remained more or less constant.
In both investigations the main species composition was similar. However, *Potamogeton friesii* didn't occur in 1982/83.

In Sector 1 (Allmeini, Schützenrüti), the species composition and the vegetation density was influenced by the inflow of the insufficiently purified waste water from the sewage treatment plant of Altdorf and by the deposition of material for the bird island. Because of the screening effect of the island, the waste water couldn't get into the western part to the right of the River Reuss (called Rechten). As a consequence, the *Characeae*, which are sensitive to higher nutrient concentrations, settled this region. Here the *Characeae* were absent during the investigation of 1982/83. In 1988, the main species in this sector were *Potamogeton pectinatus* and *P. filiformis*. Of the actual shallow water area, only 20.9% was covered with aquatic plants.
In Sector 2 (Flüelerschachen, Schanz), in contrast to the investigation of 1982/83, a larger vegetation area occurred in the western part of the region (called Schanz). The vegetation area in front of the Flüelerschachen was more or less stable and stayed within the range of the annual fluctuations. In this sector the main species were *Chara contraria*, *Potamogeton pectinatus*, *P. filiformis* and *P. perfoliatus*. Of the actual shallow water area in 1988, 22.9% were covered with plants.
In Sector 3 (Schwäb, Seedorferbucht), the same enlarged vegetation zone in front of the Seehof (western part of the bay of Seedorf) existed in 1982/83 and in 1988. *Chara contraria*, *Potamogeton pectinatus* and *P. perfoliatus* were the main species. The relatively well developed macrophyte vegetation in front of the Schwäb wasn't observed during the investigation of 1982/83. Of the actual shallow water zone in 1988 62.7% were covered with aquatic plants.
Because of the occurrence of *Chara* in wide-spread parts of the southern littoral of Lake Uri, this region may be classified as oligotrophic to mesotrophic (Chapter 7.3.3).
Because of the morphology of Lake Uri, the southern littoral zone is more or less the only place where macrophytes can exist in enlarged numbers. For the fishery especially, this region has a very high value with regard to spawn locations and maturation places.

6. EFFECTS OF THE FLOOD EVENT

After the flood event of August 1987, the southern part of Lake Uri's shore was affected mainly by deposition of fine-material and by the high turbidity of the water. The following changes occurred after the flood event:

- **Chemical and physical properties**
  - Increase in sedimentation
  - Increase in the attenuation coefficient and thus a decrease in the secchi-depth
  - Increase in the phosphorus concentration
- **Phytoplankton**
  - Increase in the total density of individuals
  - Increase in the chlorophyll a concentration
  - Decrease in the individual density and the relative frequency of *Tabellaria flocculosa* as a consequence of coprecipitation and fast sedimentation
  - Increase in the individual density and the relative frequency of *Rhodomonas minuta* and the "diverse flagellates" because of the high growth rate which increased as a result of the nutrient input conditioned by the flood
- **Periphyton**
  - Decrease in the diatom's species richness
  - Increase in the relative frequency of *Achnanthes minutissima*
  - Decrease in the diversity H' (SHANNON and WEAVER 1949) of the diatom community
  - No change observed With regard to the determination of water quality using the principle of diatom differential groups
- **Macroinvertebrates**
  - Decrease in the total density of individuals
  - Decrease in the population size of *Asellus aquaticus*, snails, leechs and flatworms

- **Macrophytes**
  - Compared with the investigation of 1982/83, no decrease in the vegetation area was noticed. Therefore, we conclude that no adversed changes to the macrophytes' living conditions occurred as a consequence of the flood event.

7. PROGNOSES

We may assume that after the new formation of the River Reuss mouth, depending on the seasonal intrusion level of the River Reuss, the littoral will be influenced by water of the River Reuss more than before. With the results of the present investigation and references from literature, prognoses were worked out for the chemical, physical and biological development of the southern part of Lake Uri's littoral (Figs. 9.1 and 9.1).

Phase 1: Opening of the left dam of River Reuss

The region on the right of the River Reuss channel will be more heavily influenced by the River Reuss water than before the opening of the dam. The imported suspended matter deteriorates the light conditions and increases the sedimentation rate. The primary production of the phytoplankton, the periphyton and the macrophytes will decrease. Further, the lower temperature of the River Reuss may slow down life processes. In contrast, because of the higher nutrient concentration of the River Reuss water as compared with the water in Lake Uri, there will be a tendency to eutrophication in the littoral. This causes changes in the biocoenosis with regard to quantitative properties (e.g. changes in biomass) and qualitative properties (e.g. changes in species composition). Because of the increased sedimentation rate, the lake bottom will change to a smaller grain size, which will affect the macroinvertebrates.

Phase 2: Opening of the right dam of River Reuss and delta formation

The mouth of River Reuss will be separated into two arms. Therefore, water from the River Reuss will reach the entire littoral zone. Compared with Phase 1, its influence will decrease left to the River Reuss but will increase on the right. As a result of the delta formation, shallow water and vegetation areas with aquatic plants will increase. In the region of River Reuss mouth partially or totally separated compartments (ponds and pools) will develop, where specific biocoenosis will grow.