Lake Constance in a state of change

November 19, 2021 | Annette Ryser
Topics: Biodiversity | Ecosystems | Society

Rising temperatures, invasive species and other factors have changed the composition of species in Lake Constance over the last century. Researchers are trying to understand how this could have happened and what it means for the lake.

Lake Constance on the border between Germany, Austria and Switzerland is one of the largest lakes on the edge of the Alps and is an essential drinking water reservoir and ecosystem, important for tourism, recreation, fishing, nature conservation and thermal utilisation. Over the past century, Lake Constance has undergone far-reaching changes. Biologist Piet Spaak, head of the research group at the Aquatic Research Institute Eawag, is leading the interdisciplinary project “SeeWandel” (=Lake Changes). Researchers from all three neighbouring countries are investigating the significance of nutrient decline, climate change, alien species and other stress factors for the lake. One important aspect being investigated is biodiversity.

Biologist Piet Spaak, head of the research group at the Aquatic Research Institute Eawag, is leading the interdisciplinary project “SeeWandel”.
(Photo: Eawag, Raoul Schaffner)

Piet Spaak, how has biodiversity changed in Lake Constance?

There have been major changes in the last hundred years. This is because the lake was heavily polluted with nutrients from agriculture and domestic effluent (eutrophication) in the period from 1950 to 1980. This resulted in higher productivity of the lake, i.e. more algae, more zooplankton, more fish. But there were also shifts in the species composition: cyanobacteria appeared more frequently and the water flea *Daphnia galeata* has ousted the species Daphnia *longispina* to some extent. We were able to prove the latter by examining sediment layers in which the permanent states of these species can be detected – even 100 years later.

It was also possible to reconstruct microbial diversity over the last 100 years with the help of environmental DNA (eDNA). These analyses show that the microbial diversity steadily declined form 1930 onwards, reached its lowest level at the peak of pollution, and then increased again after the lake began to be restored to a more nutrient-deficient state (oligothrophication).

The water flea Daphnia galeata (pictured) has ousted the species Daphnia longispina to some extent.
(Photo: Eawag)

What is the situation with the fish?

Because there were enough nutrients in the lake, there was also a very large supply of plankton during the pollution. This benefited the fish, which were able to grow faster. This has been best studied in the case of the European whitefish: as a result, some of the fish were only two years old before they were able to be fished, although the average age is normally over three years. This has been reversed with the oligothrophication: now 7-8 year-old fish are being caught in Lake Constance again.

The composition of the fish species has also changed, as we can show on the basis of historical catches as well as in two large fishing campaigns (Project Lac 2014, and

SeeWandel 2019). It turned out that the stickleback is now much more common. 70 to 90 percent of the fish in the open water are sticklebacks. In contrast to the typical native sticklebacks, which are quite small and live on the shore area and in rivers where they feed on bed-dwelling invertebrates, these Lake Constance sticklebacks are very large and have adapted to life in open water. We have been able to prove with genetic studies that they exhibit characteristics of marine sticklebacks from the Baltic States, which were probably introduced into Lake Constance and mixed with native species. These sticklebacks are also a threat to the whitefish species in Lake Constance, because they both eat the same type of zooplankton. And they also eat whitefish larvae.

The appearance of sticklebacks in Lake Constance varies widely: these are both adult females – from the open water of the lake (top) and from a small tributary (bottom). (Photo: Eawag, Cameron Hudson)

What role do invasive species play?

37 alien species have been introduced by humans into Lake Constance since 1880. These include plants, diatoms, small invertebrates and fish species. Some have spread very widely and to a certain extent have pushed out native species. I have already mentioned the stickleback, but invasive mussels also cause problems. In the 1960s, for example, the Zebra mussel (*Dreissena polymorpha*) spread in Lake Constance and other Swiss waters; it is found everywhere on hard surfaces: typically on stones, but also on boats and pipes. A related species, the quagga mussel (*Dreissena rostriformis bugensis*), has been found in Switzerland since 2015 and in Lake Constance since 2016. Because these mussels filter the water so efficiently and bind many nutrients, less algae and nutrients are available for other lake inhabitants. This is a problem.

In the 1960s the Zebra mussel (Dreissena polymorpha) spread in Lake Constance and other Swiss waters. (Photo: Bj.schoenmakers/Wikimedia)

What do these changes mean for the utilisation of Lake Constance?

These changes have both positive and negative consequences for Lake Constance. One positive aspect is certainly that the water quality of the lake is not endangered by invasive species. The water has even become clearer, it is suitable for swimming and diving and the quality of the drinking water is excellent.

However, the negative consequences outweigh the positive ones: quagga mussels grow on everything, including the intake pipes of water extraction plants, which can become clogged. This forces water suppliers to build new plants that contain an automatic quagga cleaning system. These investments will cost hundreds of millions of euros.

I am also afraid that fish catches in Lake Constance will continue to decline. The quagga mussel generally reduces the productivity of the lake by filtering out the algae from the water. And the stickleback also contributes to the fact that the already scarce plankton that is still available as fish food is not available for the fish that are interesting for fishing, for example the whitefish. Unfortunately, quagga mussels and sticklebacks are hardly eaten by fish in Lake Constance.

Are there any efforts being made to reduce the dominance of quagga mussels and sticklebacks?

That is difficult. Diving ducks love the *Dreissena* mussels, but unfortunately they cannot keep the quagga mussel population in check. Therefore, at the moment we cannot do much more than closely examine and document the situation. We have just started a two-year monitoring campaign to track the quagga mussel at all depths of the lake. In this way, we want to find out whether it spreads as quickly as it does in North American lakes. This way we can at least prepare ourselves for what to expect.

How is biodiversity being promoted in Lake Constance?

Despite the points mentioned, there are also many positive things to say about Lake Constance. It is an important aquatic habitat for numerous species. To date, 330 bird species

have been observed in the Rhine delta and the lake is an important resting place for water birds. Around the lake there are also various nature reserves and repeated efforts to renaturalise built-up shores in order to create more habitats for shore animals and plants.

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International research project SeeWandel

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Contact

Piet Spaak

Tel. +41 58 765 5617

piet.spaak@eawag.ch

Annette Ryser

Science editor

Tel. +41 58 765 6711

annette.ryser@eawag.ch

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