Loss of fish species caused by lake eutrophication

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Within a relatively short period, eutrophication has led to a reduction of almost 40% in the number of endemic whitefish species in Swiss lakes. Only in deep perialpine lakes least exposed to high nutrient inputs – such as Lakes Thun, Brienz and Lucerne – has the original diversity of endemic species been able to survive. But even these species have become less genetically distinctive. These findings are reported in a study by Eawag and Bern University researchers, published in Nature today.

The decline in the diversity of whitefish species is not merely due to a loss of habitats. Rather, the disappearance of species has been largely caused by the hybridization of formerly distinct species. According to a study by scientists from Eawag and Bern University, this in turn can be explained by the eutrophication of Swiss lakes between 1950 and 1980: as the bottom and deep waters of many lakes were severely oxygen-depleted during this period, deep-feeding or deep-spawning species were deprived of their ecological niche. These specialists, which had evolved since the last ice age, had to move to shallower waters. Here, they interbred with related species, thus losing their genetic and functional distinctiveness within a few generations, in a process known as speciation reversal.

Redefining conservation

As the paper published today in Nature[i] demonstrates, eutrophication levels not only account for the loss of species but are also responsible for the loss of differentiation among the surviving species. In the 17 pre-alpine lakes studied, the higher the maximum phosphorus concentrations recorded, the greater the loss of genetic diversity and specialization to particular water depths, spawning times or types of feeding among the remaining whitefish species. Evolutionary biologist Ole Seehausen, the lead author of the study, comments: "Speciation reversal appears to be more widespread than has previously been supposed; this process involves the rapid disappearance of species which evolved over thousands of years by adaptation to specific ecological conditions." This means that the protection of biodiversity requires not only the conservation of existing species, but the protection of ecological and evolutionary processes which assure the maintenance of specialists and promote the generation of new species.

Whitefish – suitable objects of investigation

What makes whitefish special is the fact that there are at least 25 perialpine lakes which harbour between one and six endemic species – i.e. species found exclusively in the lake in question. In addition, good historical records and tissue samples exist for these species. This is not only because whitefish is a popular commercial fish, but in particular because whitefish from 17 of these lakes were scientifically studied and classified in a detailed study carried out 60 years ago. The same lakes have now been investigated once again by Seehausen's PhD student Pascal Vonlanthen (Eawag and Bern University): on average, the number of whitefish species has declined by 38%. In seven lakes, the original whitefish populations are now extinct and have been replaced by hatchery stocks (Lakes Geneva, Murten, Sempach, Baldegg, Hallwil, Greifen and Pfäffiker). The only study lakes not suffering any species loss were Lakes Thun, Brienz and Lucerne – deep perialpine waterbodies less seriously affected by eutrophication. In both Lake Walen and Lake Zurich, two of three historical whitefish species have survived, and four of five historical species are still found in Lake Constance. But among the extant species, there has been a strong decline of genetic and ecological distinctiveness and also of phenotypic variation.

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Whitefish are regarded as a model organism by the scientists involved in the study. Seehausen, who is affiliated with both Bern University and Eawag, says: "We must assume that lake eutrophication has caused similar losses of diversity among other fish, and perhaps also among their invertebrate prey species." He also interprets this study as a warning to those in the fishing community who have recently called for the restriction of phosphorus elimination measures at wastewater treatment plants in the hope that fishing yields would be increased as a result of nutrient enrichment: "Even a slight rise in nutrient levels over the natural trophic state of a lake has an impact on species diversity. And if endemic species are lost as a result of eutrophication, this process cannot be reversed." Accordingly, in Seehausen's view, oligotrophic lakes in particular deserve special protection as unique reservoirs of biodiversity, where new species can evolve.

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