



## Seven new species of whitefish described in Central Switzerland

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**Biologists at Eawag have identified ten species of whitefish in the lakes of the Reuss river system. Of these, seven have been described as distinct species for the first time – although in two cases this required inspection of specimens from historical collections, since eutrophication of lakes in the 20th century also led to the extinction of fish species in Central Switzerland.**

The “Edelfisch” (*Coregonus nobilis*) was, after the smaller “Albelli”, the second most commonly caught species of whitefish in Lake Lucerne until, in the second half of the 20th century, phosphate from domestic wastewater and nutrient-rich run-off from farmland led to a massive increase in algal blooms. Compared to the lakes of the Central Plateau, nutrient levels in Lake Lucerne were moderate, and eutrophication was short-lived; even so, due to algal decomposition, oxygen was depleted in the deeper layers of the lake. The “Edelfisch”, which reproduces in the late summer at a spawning depth of 80 metres or more, suffered as a result. Shortly before nutrient inputs decreased following the ban on phosphates in detergents and the expansion of wastewater treatment plants, stocks of this species collapsed and it was considered to be extinct in 1980. Only from the late 1990s were individual specimens caught once again, unequivocally identified as *C. nobilis* in 2000 by the whitefish specialist and Eawag researcher Rudolf Müller.



**Ruedi Müller with the then Lucerne fisheries and hunting administrator, Josef Muggli, catching whitefish (Photo: Robert Muggli, Archive)**

### **Five whitefish species in Lake Lucerne**

As the “Edelfisch” is now a protected species, Lake Lucerne has not lost any of its historically recorded whitefish species. Indeed, in addition to the familiar “Edelfisch”, “Albeli” and “Bodenbalchen”, Eawag scientists have identified two new species – two large whitefish, differing from the previously known species in their habits, morphological characteristics and genetic composition. The pelagic “Schwebbalchen” (*Coregonus suspensus*) probably lives permanently in the open water, not only for foraging but also for reproduction – a spawning behaviour only previously observed in the “Blaufelchen” (*C. wartmanni*) of Lake Constance. Occupying a position intermediate to the pelagic “Schwebbalchen” (*C. suspensus*) and the “Bodenbalchen” (*C. littoralis*) is the littoral “Schwebbalchen” (*C. intermundia*).

### **Lake Sarnen puzzles**

In the 20th century, the question whether Lake Sarnen naturally harboured whitefish or whether these fish derived from artificial stocking measures documented at the end of the 19th century was a matter of controversy among zoologists. With forensic precision, Eawag scientists have now examined sediment cores retrieved from Lake Sarnen – and found whitefish scales in deposits dating back to the period preceding stocking measures. In addition, analyses of present-day Lake Sarnen whitefish showed clear genetic differences from all other Swiss whitefish species. Based on this supplementary information, the Lake Sarnen whitefish was described as a distinct species, *C. sarnensis*. It has not yet been established whether the “Balchen” (*C. littoralis*) which occurs along with *C. sarnensis* was introduced via stocking or colonised Lake Sarnen via the formerly existing connection with Lake Lucerne, so further forensic efforts will be required to solve this puzzle.

### **Lake Zug survivor**

Particularly affected by eutrophication in the mid-20th century were whitefish in Lake Zug, which – like other Central Plateau lakes – was exposed to higher nutrient levels, for a longer period, than waterbodies further upstream. As only the uppermost water layers of this 200-metre-deep lake maintained oxygen levels sufficient to support fish, two whitefish species

spawning in the depths of the lake died out – the (Lake Zug) “Albeli” (*C. zugensis*) and “Albock” (*C. obliterus*). Indeed, the Lake Zug “Albock” would have been completely forgotten if specimens had not been found by Eawag scientists Oliver Selz and Ole Seehausen in the historical Steinmann-Eawag Collection. Its morphology and historical accounts indicate that the Lake Zug “Albock” was a deep-water specialist – a specialisation only otherwise observed to the same degree in the (likewise extinct) Lake Constance Kilch (*C. gutturosus*) and the (still extant) Lake Thun Kropfer (*C. profundus*).

The only whitefish species still found in Lake Zug today, spawning near the shore, is the “Balchen”. Testifying to its survival is its new scientific name – *Coregonus supersum* (“I have survived”).

### **Species endemic to each lake**

Also new are the scientific names of the Lake Lucerne “Bodenbalchen” (*C. litoralis*) and “Albeli” (*C. muelleri*). For the morphological and genetic studies carried out by Oliver Selz and Ole Seehausen in order to revise the taxonomy of whitefish showed that almost every lake in Central Switzerland has its own species of “Albeli” and “Bodenbalchen”.

Previously, the “Albeli” of Lakes Zug and Lucerne had been classified as members of the same species (*C. zugensis*), while the “Balchen” spawning near the shore of the various Central Swiss lakes were known as *C. suidteri*. These collective species names have now been inherited by the extinct Lake Zug “Albeli” (*C. zugensis*) and the Lake Sempach “Balchen” (*C. suidteri*).

The Lake Lucerne “Albeli” received the new name *C. muelleri* in honour of the fisheries biologist and whitefish specialist Dr Rudolf Müller (1944–2023).

### **A reflection of Switzerland**

The lakes of the Reuss river system are a reflection of Switzerland as a whole. Since the last ice age, at least 35 whitefish species evolved in the pre-alpine lakes, usually two or more in each lake. Switzerland lost a third of these species during the period of lake eutrophication around the middle of the 20th century. Many of the lost species are known to researchers only thanks to historical collections, such as that created before the eutrophication period by the naturalist Paul Steinmann and currently curated by the Natural History Museum of Bern.

Rudolf Müller – the scientist honoured by the species name *C.muelleri*



**Ruedi Müller, deceased on 9 January 2023**  
 (Photo: Eawag, Andri Bryner, 2006)

As part of the revision of the taxonomy of endemic whitefish, the most common whitefish species of Lake Lucerne, the “Albeli”, was named *Coregonus muelleri*, after the whitefish specialist Dr Rudolf Müller, who died earlier this year. Müller was head of Eawag’s Fisheries Sciences department at Kastanienbaum, which was integrated into the Limnology department in the 1990s and into the new Fish Ecology & Evolution department in 2004. After his retirement in 2008, he continued to make his extensive expertise available as an independent consultant, establishing an office (Limnos Fischuntersuchungen) in Horw. From 2000 to 2006, the influential fish and fisheries biologist served as Chair of the European Inland Fisheries Advisory Commission (EIFAC) of the Food and Agriculture Organization. With his research on whitefish reproduction in Swiss lakes, he played a key role in the discovery of the mechanisms that led to the rapid loss of whitefish species during the eutrophication period. Müller also made a vital contribution to the rediscovery of the Lake Lucerne whitefish species previously believed to be extinct: in the summer of 2000, using scientific methods, he unequivocally identified a specimen provided by fishermen as *C. nobilis*; and in 2004, in collaboration with professional fisherman Gottfried Hofe, he definitively demonstrated the existence of a breeding population of *C. nobilis*.

## Names

### Lake Sempach

*C.suidteri* = Sempacherfelchen, Sempacherbalchen

### Lake Zug

*C.zugensis* = Zugerabeli (verschwunden)

*C.oblitterus* = Zugerabock (verschwunden)

*C.supersum* = Zugerbalchen

### Lake Lucerne VWS

*C.muelleri* = Albeli

*C.nobilis* = Edelfisch

*C.litoralis* = Balchen, Bodenbalchen

*C.intermundia* = benthischer Schwebbalchen

*C.suspensus* = pelagischer Schwebbalchen

Lake Sarnen

*C.sarnensis* = Sarnerfelchen, Sarneralbeli

*C.litoralis* = siehe VWS: Balchen, Bodenbalchen

Cover picture: These seven whitefish were described as separate species for the first time, including the "Albeli" from Lake Lucerne, which now bears the name *Coregonus muelleri* in memory of the whitefish expert Rudolf Müller. (Photos: Eawag)

### Original publication

Selz OM, Seehausen O (2023) A taxonomic revision of ten whitefish species from the lakes Lucerne, Sarnen, Sempach and Zug, Switzerland, with descriptions of seven new species (Teleostei, Coregonidae). ZooKeys 1144: 95–169.

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