Successful stocking of brown trout (*Salmo trutta*) in a formerly highly acidified Norwegian hydroelectric reservoir after termination of stocking of non-native brook trout (*Salvelinus fontinalis*)

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Summary

Acidification wiped out nearly all populations of brown trout in lakes in large areas of southern Norway. This was in many cases the only species of fish present. To replace locally extinct brown trout populations, the acid-tolerant and non-native brook trout was stocked in many lakes in these areas, starting in the 1980s. However, in 2005, new legislation made the release of this non-native species illegal in Norwegian waters. In order to sustain fish populations in these acidified watercourses, brown trout stocking had to be attempted. The motivation for these efforts was that water quality have improved in recent years. In our study lake, which was formerly highly acidified, stocked brown trout are now surviving well and we obtained higher catches on gill-nets than that of brook trout. However, the water quality of many tributary streams is still unfavorable for natural reproduction of brown trout. This will be the case for many years to come, and successful recruitment can only be achieved by means of liming.

The study lake

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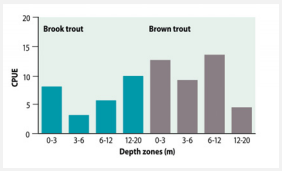
The study was carried out in Juvatn Reservoir, which is located in southernmost Norway, at an altitude of 513 m about 30 km from the coast. The reservoir was formed in 1961 by damming four smaller natural lakes. It covers an area of 8.12 km^2 at the highest water level (HWL). The water level fluctuates annually by 24.0 m, of which 23.3 m is caused by damming. Most of the basin is 5-20 m deep, with a maximum depth of 46 m (HWL). Juvatn Reservoir lost its native populations of brown trout in the 1970s, and at that time pH was measured at 4.7. It is still relatively acidified with pH of 5.06-5.27 and inorganic (toxic) aluminium of 40 µg L^{-1}. However, two tributary streams had a much less favorable water quality, with pH of 4.70-4.95 and inorganic aluminium of 67-143 µg L^{-1}.

Brown trout (three specimens to the right) and brook trout caught in a nearby lake to Juvatn Reservoir

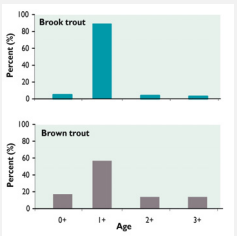
Methods

8000 juveniles (age 0+) brook trout and brown trout were stocked every year between 1985 and 2004, and between 2005 and 2008, respectively. The fish were raised in circular tanks in a local hatchery and fed artificial food until early July, when they were stocked. Both species had then attained lengths of 60-70 mm. All stocked fish were marked by removing the adipose fin. Fish were sampled with both benthic and pelagic gillnets in August 2004 and 2008. Sampling in the epibenthic habitat involved Nordic multi-mesh gill nets (30.0 x 1.5 m), 5-55 mm mesh size. A total of 30 nets were set at ten stations throughout the reservoir, at standard depths of 0-3 m, 3-6 m, 6-12 m and 12-20 m. The pelagic nets (54 m x 6 m) had mesh sizes between 10 and 45 mm. We fished overnight for about 12 h, and catch-per-unit-effort (CPUE) was expressed as numbers 100 m^{-2} net area.

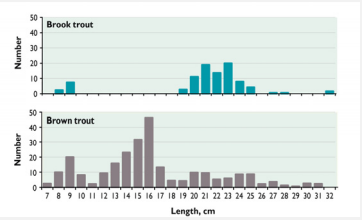


Both species were mainly restricted to the epibenthic habitat. Only a few fish were caught in the pelagic habitat (n=7). In 2004, the lake sustained a relatively sparse population of benthic brook trout with CPUE of 5.9 (n=80), while no brown trout were caught. However, in 2008 the catch of brown trout in benthic nets was significantly higher than that of brook trout in 2004, with a CPUE of 10.6 (n=143). In 2008, one brook trout was also caught. Both brown trout and brook trout largely utilized the entire epibenthic habitat, being caught at depths of 0-20 m However, their horizontal distribution was significantly different. Brown trout exhibited little difference in abundance at depth intervals of 0-3, 3-6 and 6-12 m, whereas brook trout occurred in higher numbers at 0-3 m than at 3-12 m (CPUE=4.2). However, their highest CPUE was at 12-20 m.

The electrofishing surveys in the two main tributary streams yielded no fry of either species. In 2008, however, two stocked brown trout with lengths of 17 and 18 cm were caught.



Brook trout and brown trout differed greatly in age frequency distribution. Brook trout were mainly aged 1+ (89 %), with small fractions of fish of aged 0+ (5%) and 2+/3+ (6%). In brown trout, the catches included all four cohorts that had been established by means of stocking in previous years. Brown trout of age 1+ dominated (43%), then 3+ (28%), 2 + (18%) and 0+ (11%). The unmarked brown trout (n=8) were aged 1-3 years. A shorter life-span in brook trout is probably related to (i) early maturation, which was 75% in 1+ males as opposed to 17% in brown trout, and (ii) a high rates of migration.



The length-frequency distributions of the two species differed highly . Brook trout aged 1+ ranged in lengths between 195-259 mm, while 2+ and 3+ fish were 271-327 mm in length. Brown trout aged 1+ ranged in lengths of 121-170 mm, while that of 2+ and 3+ fish was from 164 to 315 mm. Thus, few brook trout reached catchable size on gill nets with mesh sizes that are normally used (> 30 mm). Brook trout aged 1+ and 2+ were significantly larger than brown trout of the same age; with mean values in mm of 227±15 (n=71) vs 156±13 (n=63), and 307±24 (n=3) vs 214±21 (n=27).