Butcher or bait?

The potential for using brown trout stocking as a biocontrol agent

Gjelland[1,2], K.Ø., P.-A. Amundsen[1], O.T. Sandlund[2]

[1]Department of Arctic and Marine Biology, University of Tromsø, 9037 Tromsø, Norway
[2]Norwegian Institute for Nature Research, Tungasletta 2, 7047 Trondheim, Norway
Corresponding author: Karl Øystein Gjelland, karl.gjelland@uit.no

Background

Invasive species represent a great management challenge. Often the only feasible management action is to use different means to control the size of the invasive population. Predator enhancement for consumption of the invader (biocontrol) provide one such mean. Vendace *Coregonus albula* invaded the Pasvik watercourse on the border between Russia and Norway in the 1990s. Effects of the invasive zooplanktivorous vendace have been reduced zooplankton diversity and abundance, reduced growth and abundance of native zooplanktivorous whitefish, reduced growth in the invader, and an important food source for stocked piscivorous brown trout *(Salmo trutta).*

Objectives:

Can the stocking program of native brown trout be used as an agent in controlling the population size of invasive vendace?

Methods

Stocking experiments were performed in two lakes of similar area (about 6 km^2). Three trophic levels (zooplankton, planktivorous fish, piscivorous fish) were sampled to look for cascading trophic effects as a result from the top-predator brown trout stocking. To achieve this, a combination of zooplankton trapping, gillnetting, echosounder surveys, and acoustic telemetry was used (Fig. 1).

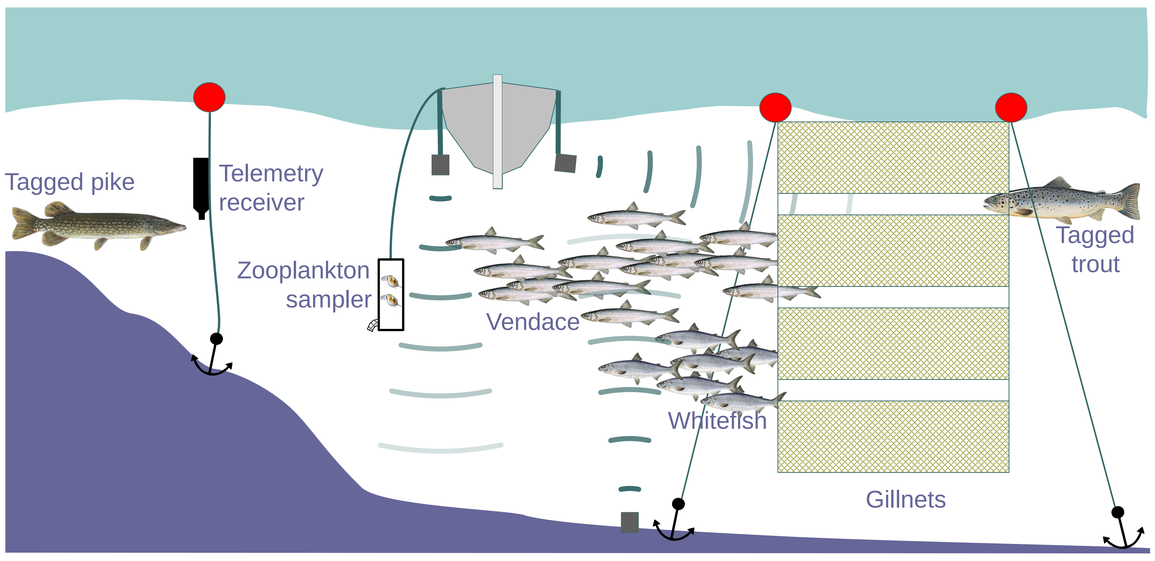

Fig. 1. Fish density and vertical distribution were sampled with gillnets deployed at different depths, and with echosounder surveys deploying the sound beam in down-looking or side-looking orientation (mobile surveys) and stationary up-looking orientation.

Results

The downstream experimental lake had a high pelagic area to littoral area ratio, whereas this ratio was much smaller in the upstream lake (Fig. 2). In the downstream lake experiment, 1000 individually marked brown trout (25-30 cm) were stocked, 15 of these were internally tagged with acoustic tags containing depth sensors. Stomach analyses from 144 recaptured brown trout revealed a 100 % piscivorous diet. Vendace constituted about 90% of this (Fig. 3), although planktivorous whitefish was equally abundant as vendace in the lake. Both plantkivores performed diel vertical migrations, but they were consistently segregated by depth (“parallell migrations”). Brown trout was found between 0 and 6 m for >90% of the time, apparently limited by light dependence in foraging efficiency. The brown trout light dependence combined with a higher habitat overlap with vendace explained the brown trout preference for vendace.

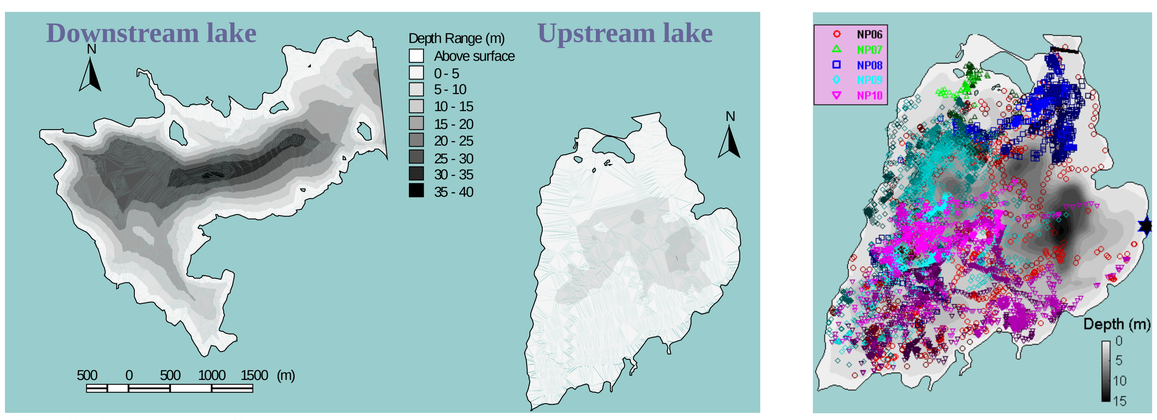

Fig. 2. Left panel: Comparison of the two experimental lakes, with areas drawn to scale and depth morphometry indicated by the same grayscale. Right panel: Positions of 5 of the 17 tagged northern pike in the upstream lake from 14 June to 13 August. Individuals have different symbol and color as indicated in the figure key, and the most recent positions have the strongest hue. As is illstrated, there were no place in the lake safe from pike encounter.

In the upstream lake experiment, 1500 brown trout (25-30 cm) individually marked were stocked, 17 of these were tagged with acoustic transmitters. Additionally, 17 northern pike were caught, tagged with acoustic transmitters, and released prior to the brown trout stocking. In the upstream lake a new positioning system (Vemco VPS) were deployed, enabling the horizontal positioning of tagged fish (Fig. 2) in addition to the depth registrations received from the depth sensors.

Fig. 3: Diet composition in wild northern pike and stocked brown trout. The whitefish found in the brown trout diet was a planktivorous whitefish morph, whereas the whitefish found in northern pike diet was a benthivorous morph. Newly stocked brown trout found in pike diet within the 5 first days after stocking are not included in the figure.

Brown trout stocked in the upstream lake got little chance to forage on the abundant vendace population. Within the five first days after stocking, 27 of 50 investigated pike were found with freshly stocked brown trout in their stomach, and three of them had even eaten two brown trout. No brown trout were caught nor found in pike stomachs (Fig. 3) during intensive gillnet sampling at later (30 days +) occasions. The telemetry data proved helpful for further investigation of the fate of the brown trout.

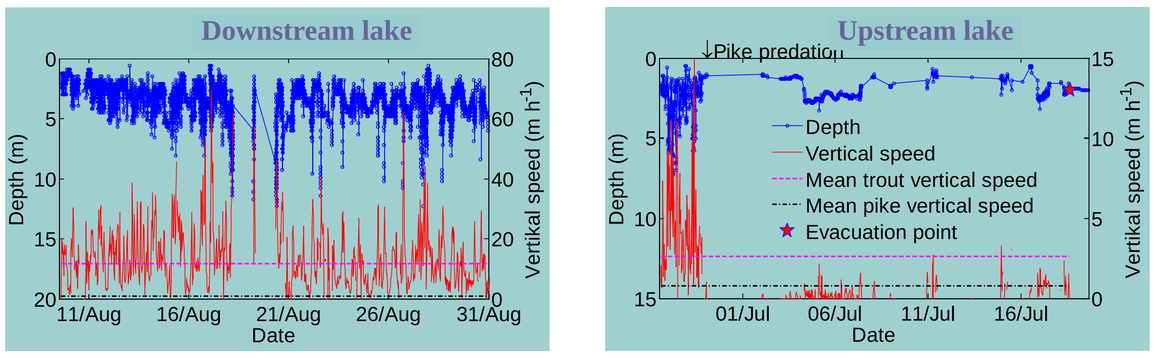

Fig. 4: Depth data from brown trout depth sensors (blue, left axis) proved very useful to identify the time of pike predation. The time where vertical swimming speed (red, right axis) dropped markedly from levels typical for brown trout to levels typical for pike. After about two weeks in the pike, the tag was evacuated and became stationary (indicated by red star).

Analysis of vertical movement patterns in brown trout and northern pike revealed very different swimming behaviour (mean vertical hand horizontal swimming speed), and this difference could be used to identify the time of predation of the tagged trout. The resulting mortality times for the tagged trout could then be used in survival analyses (Fig. 5).

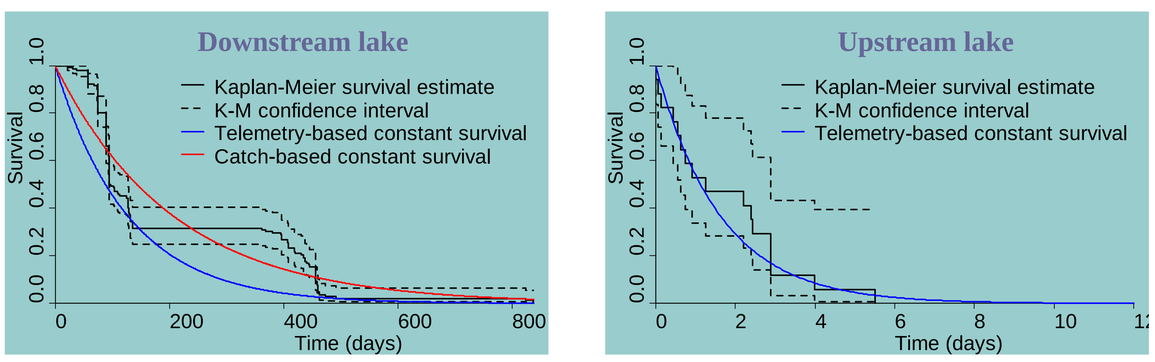

Fig. 5: Stocked brown trout survival analyses. In the downstream lake, Kaplan-Meier survival estimates were based on catch data. Only 20 % of the acoustically tagged fish were observed dead (fishing + pike predation) within the tag operation time in the downstream lake, the blue line extrapolates the survival based on this mortality rate. The red line gives survival estimate based on the assumption of constant fishery mortality. On the right-hand side, Kaplan-Meier survival (black curves) are estimated based on telemetry data. All tagged fish were predated in the upstream lake. Note the very different scale on the x-axis between the two studies.

Conclusion

Stocked brown trout >25 cm length turns directly to piscivory, and use a pelagic habitat with low diet and habitat overlap with northern pike where lake morphometry allows this. In such cases, it may be a selective and powerful biocontrol agent. However, with substantial littoral areas, pike abundance and encounters may be large enough to quickly consume the stocked trout. A stocking size of 25-30 cm is no defence; they are eaten by pike as small as 1 kg. Managers should consider this in the stocking practice of naïve brown trout.