Fish population responses to food web manipulation in eutrophicated Lake Tuusulanjärvi, southern Finland

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Background

• Eutrophication: the main environmental problem of Finnish lakes
• Diffuse nutrient load from agriculture the main reason of eutrophication
• Pollution from point sources reduced during the four last decades
• 2100 eutrophicated lakes out of 29500 lakes larger than 4 ha according to the Finnish Fish Status Survey 1996 (Tammi et al. 1999)
• Ecological status often moderate or poor
• Food web manipulation a common method in lake restoration
• A number of outstanding research projects: L. Vesijärvi (Horppila et al. 1988, Ruuhijärvi et al. 2005), Pyhäjärvi (Sarvala et al. 2000, Ventelä et al. 2007), Tuusulanjärvi (Sammalkorpi 2000, Rask et al. 2005)
Tuusulanjärvi

Lake and catchment
- Lake area 5.95 km$^2$
- Max. depth 10 m, mean depth 3.2 m
- Retention time 250 days
- $P_{\text{tot}}$ 80-130 µg/l
- Secchi depth 0.3-1 m
- Drainage area 92 km$^2$
  - Forest 40 %
  - Arable land 35 %
  - Settlements 20 %
- Soil: 65 % clay, 15 % till, 10 % gravel-sand
- Long eutrophication history: waste waters of Järvenpää City until diversion in 1979

Restoration project since late 1990s
- Removal of cyprinid fish 1997 ‡
- Oxygenation of hypolimnion 1998 ‡
- Water protection wetlands in 2000s
- Poor ecological status in WFD classification

- Location: 30 km north from Helsinki
Aim of this study

To characterize the responses of fish populations to management fishing of planktivorous cyprinids in L. Tuusulanjärvi

Main hypotheses:

- Management fishing mainly by autumnal seining
- Gillnet test fishing with NORDIC survey nets (CEN 14757/2005)
- Echosounding and trawling (Simrad EY 500 + 2x5 m trawl with cod end mesh size of 3 mm)
- VPA analyses for dominating cyprinid species of the removal catches

Food web manipulation

- Effective management fishing should decrease the fish biomass and result in smaller unit catches of gillnet test fishing and in lower hydroacoustic fish biomass estimates
- Targeting of management fishing to cyprinid species should increase the proportion of percid and the predatory species
Food web manipulation by management fishing

- Mass removal of planktivorous (cyprinid) fish was started in 1997
- Target catch to ca. 150 kg/ha/year (Sammalkorpi 2000)
- Autumnal seining as the main method
- Total catch during 1997-2015 was 808000 kg and 1430 kg/ha
- Proportion of cyprinid fishes 47-88 % of the total catch: bream 440 kg/ha, roach 350 and white bream 150 kg/ha
- Perch 115 kg/ha, ruffe and smelt both 85 kg/ha
Changes in population structure: roach, perch

- Effective management fishing in 1998-2000 resulted in successful reproduction and dominance of small/young fish in (examples for roach and perch from gillnet catches)
Different responses in the growth of fish

- Bream: clear increase in growth
- Pikeperch: growth remained unchanged
- Roach, perch: no or slight increase in growth after high seining catches of early years
No decrease in gill net catches during the years of management fishing

- Mean BPUE increased in 1996-2003 from 3 to 6 kg
- From 2004 onwards mean unit catches of NORDIC nets around 4 kg
- No decrease in the catches of cyprinid fishes, proportion 67-82 %
- Bream and smelt apparently underestimated in the catches: behaviour and shape of bream, small size of smelt, mesh size composition of NORDIC net
- Percids 16-31 % of the catches
- No or slight increase in the proportion of predatory fishes
No or slight increase in the gillnet catches of predatory fish species
A summary of echosounding based fish biomass estimates in pelagial waters of Tuusulanjärvi during 1997-2016

- Wide variation in biomass estimates of larger cyprinids in early years – occasional occurrence in echosounding lines?
Hydroacoustic biomass estimates of dominating fish species

- The biomass of smelt is low but density is one of the highest
- Pikeperch mainly 0+ fish
- Small bream and white bream abundant in warm summers – and also small perch, mainly 0+
Bream

- Most abundant species in the catches of management fishing
- Effective removal in early years resulted in decreased gillnet catches
- Lower catches in autumn 2005-2006 increased total biomass according to VPA calculations
- Increased growth supported the higher production
Roach

- High removal catches up to 50 kg/ha in the early years of management fishing
- Gillnet catches of roach still increased to 2003
- No major changes in growth
- Total biomass 10000-30000 kg during 2005-2011 (VPA analyses)
White Bream

- The proportion in the seining catches 5-20 %
- In gill net catches most abundant together with roach
- Gillnet catches increased in 1996-2002 to a level of 1 kg/net
- Low catches from management fishing these years
Smelt

- Key species in the pelagial fish community of lake Tuusulanjärvi
- A steep collapse of the smelt stock in 2002
- Associated to the artificial mixing of hypolimnnetic water and subsequent loss of calm water for smelt
- Effect of Glugea hertwigi infection...?
- Still essential as a major food source for sander
Pikeperch

- Main target species for recreational fishing
- Management fishing was first thought to be a threat
- No changes in gillnet catches, growth, or length weight relation: Pikeperch is doing well!
- Successful reproduction: high pelagial densities of 0+ fish from year to year
Concluding remarks

• The increase of gillnet BPUE in the early years of food web management was surprising – effective reproduction, increased growth and overall fish production. Changes in size distribution of fish? Gillnet saturation...?

• Hydroacoustic surveys indicated reasonable efficiency during the early years of management fishing

• Generally, the management fishing has been too ineffective to decrease the proportion of cyprinids in the fish community

• Pikeperch population has remained productive – benefitted from the increased abundance of small prey fish

• Bream with its high production potential is a key species for management fishing

• Smelt is still important as a food source for pikeperch

• In Tuusulanjärvi, applying of several monitoring methods was essential
Thanks for your attention!
VPA – Virtual Population Analysis

• VPA (or cohort analysis) is based on the total catch in numbers and on the age-distribution of the catch (requires very many age determinations!)
• It requires educated guesses for natural mortality and for the fishing mortality of the last year
• The size of a year-class at the beginning of the each previous year is computed backwards
• The stable solution for analysis is sought iteratively