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# Intensive whitefish exploitation: effects on population structure of whitefish *Coregonus lavaretus* L. and brown trout *Salmo trutta* L. in a mountain reservoir

SVEIN JAKOB SALTVEIT AND ÅGE BRABRAND

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During the years 1980—1986, an intensive whitefish, *Coregonus lavaretus,* exploitation programme was carried out in the mountain reservoir Goppollen, SE Norway, in an attempt to improve whitefish quality and to reduce interspecific competition between whitefish and brown trout *Salmo trutta.* For whitefish, individual mean weight increased from 99 g in 1980 to 175 g in 1986, length/weight ratio was improved and empirical growth rate increased. For brown trout, no change in the population structure was observed, indicating that not even intensive whitefish exploitation will create reduced predation pressure on zooplankton, and allow brown trout to utilize planktonic food items in such lakes.

Svein Jakob Saltveit & Åge Brabrand, Freshwater Ecology and Inland Fisheries Laboratory (LFI), University of Oslo, Sarsgt. 1, 0562 Oslo 5, Norway.

## INTRODUCTION

Brown trout *Salmo trutta* are very flexible when choosing food items. In lakes brown trout are usually bottom feeders in the littoral zone, although they may often migrate into the pelagic zone and feed on zooplankton (Klemetsen 1967, Aass 1969, Haraldstad & Jonsson 1983, Brabrand & Saltveit, ms). Feeding as a planktivore is even more pronounced in the presence of littoral competitors, such as minnows *Phoxinus phoxinus,* or in reservoirs where littoral food items are scarce. In certain reservoirs under extreme conditions brown trout may become completely pelagic (Borgstrøm et al. 1986).

Fluctuating water level in reservoirs causes erosion, drying and freezing in the draw down zone, leading to a reduction or absence of fish food items, such as *Gammarus* and snails (Grimås 1982, Aass 1969). To compensate for this scarcity of preferred food items, trout migrate into the pelagic to feed on zooplankton. The pelagic zone and its zooplankton are little effected by regulation (Elgmork 1970).

In reservoirs zooplankton is thus an important food component for maintaining brown trout production. However, a number of fish species, such as whitefish *Coregonus lavaretus* and Arctic char *Salvelinus alpinus* are more typical zooplankton consumers than brown trout (Nilsson 1965). Their presence in reservoirs can therefore reduce the possibility for trout to compensate for the reduced supply of littoral food items by increased consumption of zooplankton. It may be possible to improve brown trout quality by reducing the dominance of pelagic whitefish. In lakes and reservoirs, where reproduction is high, fish populations often show stunted growth. In such cases, intensive fishing programmes are often recommended. The aim of this study has been to follow the population structure of whitefish and brown trout during a period of such intensive whitefish exploitation.

## STUDY AREA

The studied reservoir, Goppollen (Fig. 1), 982 m a.s.l. and 1.2 km$^2$, was first regulated as early as in 1919 with a second, increased regulation in 1947. The regulation zone is 2.2 m. The northern basin of the reservoir is the

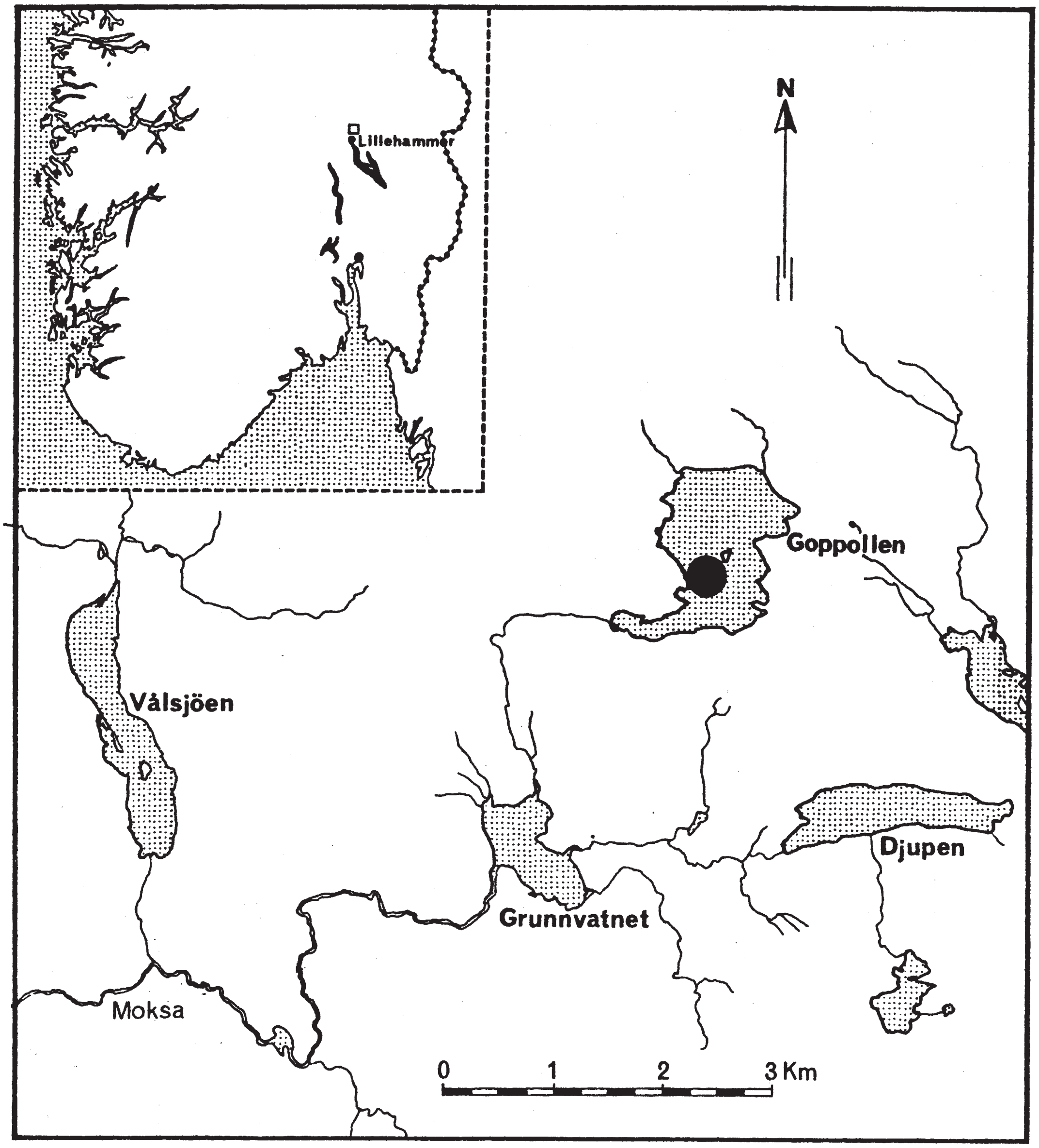


Fig 1. Map of the reservoir Goppollen with the spawning area of whitefish indicated in black.

deeper, maximum depth c. 20 m, while the southern basin is shallow, c. 2.5 m.

Three fish species are present in the reservoir: trout, whitefish and minnow. Both minnows and whitefish have been introduced, whitefish around 1930 and minnows probably more recently. During the first 10—20 years after whitefish introduction, high growth rates were reported. Individual whitefish of 1—2 kg were regularly observed. After 1950, the whitefish population has shown low annual growth, early spawning and generally poor quality. Mean individual weight was approx. 100 g, and almost no exploitation of whitefish was reported. About 5000 trout are stocked annually, as their natural spawning is very limited.

## METHODS

The whitefish were caught using gill nets, both before the intensive exploitation and every year from 1980 onwards.

As few whitefish were caught during summer, the intensive fishing was limited to the spawning season in September—October. The spawning area is shown in Fig. 1. The intensive fishing was carried out each autumn from 1981 until 1986 using 25 m x 1.5 m gill nets with mesh sizes of 24, 26 and 28.5 mm.

The highest amount of whitefish, 6.3 kg $ha^{-1}$, was caught in autumn 1981 (Table 1). The low catches in 1986 were due to early ice cover, which limited the fishing period. Very low numbers of trout were taken during this fishing.

Ages of whitefish and brown trout were determined using otoliths. The otoliths were cleared in ethanol for 24 hours before being studied under a stereo binocular in 2.4 propandiol. When the age was uncertain, whitefish otoliths were first burned and then cut transversely according to Power (1978).

Table 1. Yield of whitefish and brown trout in Goppollen during autumn in the period 1981 to 1986.

| | Whitefish | | | Brown trout | | |
|---|---|---|---|---|---|---|
| Year | Number | Kg | Kg/ha | Number | Kg | Kg/ha |
| 1981 | 7608 | 754 | 6.3 | 138 | 21 | 0.2 |
| 1982 | 3643 | 385 | 3.2 | 47 | 6 | 0.05 |
| 1983 | 2865 | 344 | 2.9 | 154 | 20 | 0.2 |
| 1984 | 2429 | 340 | 2.9 | 77 | 11 | 0.1 |
| 1985 | 2149 | 327 | 2.8 | 263 | 40 | 0.34 |
| 1986 | 538 | 95 | 0.8 | 47 | 7 | 0.06 |

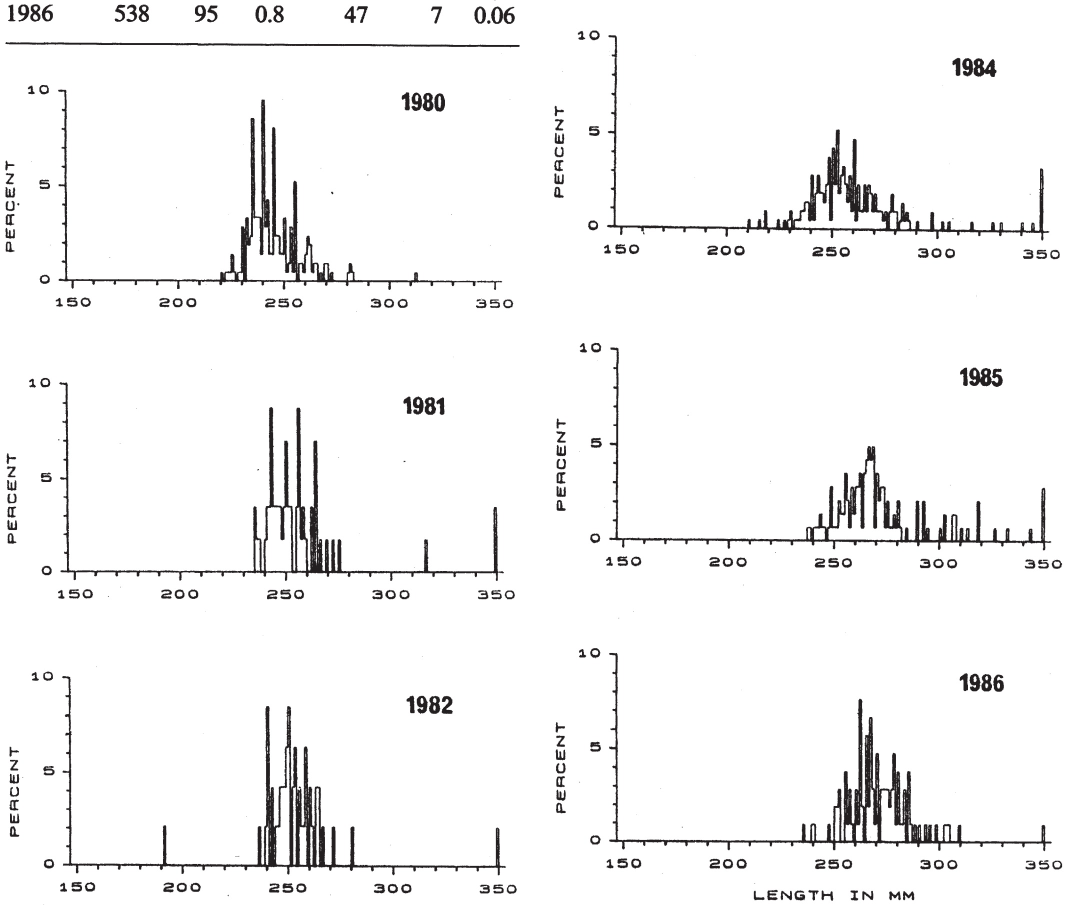


Fig. 2. Length frequency distribution of whitefish from Goppollen in autumn during the period 1980—1986.

Growth is shown as empirical growth. The quality of fish is indicated by it's K-value, calculated from the formula K = V x 100 $L^{-3}$.

## RESULTS

In the first two-three years the material of whitefish consisted mainly of fish between 23 and 27 cm (Fig. 2), while in the two last years, 1985 and 1986, most whitefish were above 25 cm in length. A few fish above 30 cm also appeared in the material during the last two years. A consistent increase in individual mean weight in whitefish was observed through the whole period (Fig. 3) from 99 g in 1980 to 175 g in 1986.

After a relatively fast growth during the first 4—5 years of life, the growth rate of whitefish in Goppollen stagnated (Fig. 4). However, before the intensive fishing, growth stagnated at c. 23—24 cm, while in 1985/86 it was at 26—27 cm. The growth curves for all year classes in 1985 and 1986 are at a higher level than the same year classes in 1980 and 1981, indicating that also fish hatched before the fishing period increased in size.

During the period from 1980 to 1986 the length/weight ratio of whitefish improved (Fig. 5), although there were some irregular years. Compared to 1980—1981, the relationship increased in 1982 and further in 1983, demonstrating a relatively larger increase in weight in relation to length.

The intensive fishing of whitefish was initiated in order to reduce the competition between trout and whitefish on zooplankton in the reservoir, and thereby increase the quality of trout. However, from 1980 to 1986, no changes in trout population parameteres, as expressed in growth or fish quality were observed. The K-values for brown trout are given in Fig. 6, indicating quality below the standard value of 1.0. In the same period the K-value of whitefish increased from 0.68 in 1980 to 0.83 in 1986.

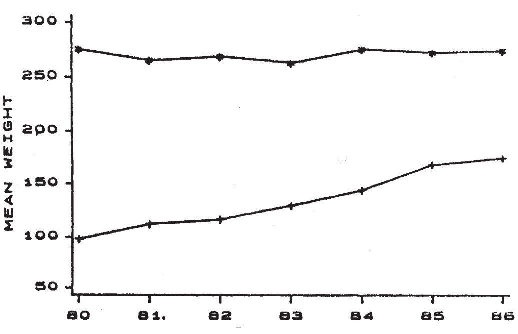

Fig. 3. Mean weight increase in whitefish from Goppollen in the autumn during the period 1980—1986 (lower curve). Mean weight of whitefish from lake Randsfjorden is unchanged during the same period (upper curve).

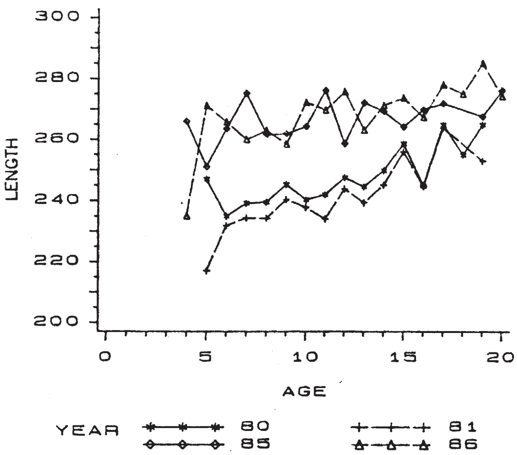

Fig. 4. Empirical growth in whitefish from Goppollen in the autumn of 1980, 1981, 1985 and 1986.

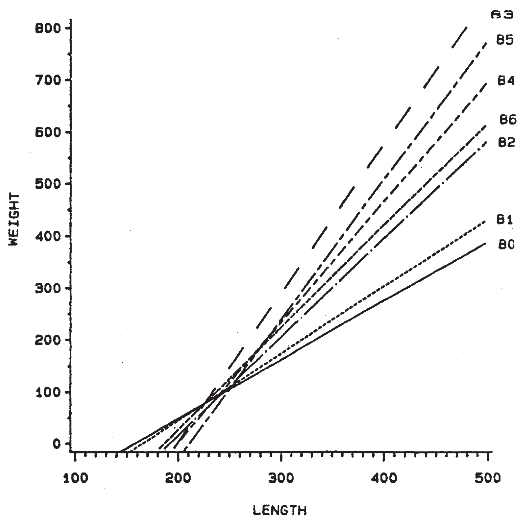

Fig. 5. Length/weight regression relationships in whitefish from Goppollen during the period 1980—1986.

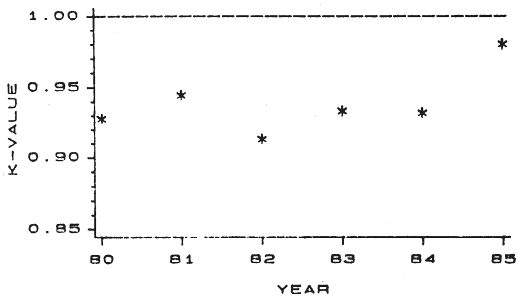


Fig. 6. K-values (condition factor) of brown trout from Goppollen during the period from 1980 to 1985.

## DISCUSSION

Whitefish populations which are not limited by spawning areas or water quality, often show stunted population structure unless heavily exploited. Having a planktivorous behaviour in the pelagic zone, whitefish avoid the more traditional fisheries after brown trout in the littoral zone with benthic gill nets. When such lakes are regulated the situation becomes even more extreme, as seen in the reservoirs Vinstervatn, Øyangen, Ustevann and Strandevatn. In all these reservoirs whitefish quality deteriorated some years after their introduction (Borgstrøm 1972, Hålimoen 1980, Aass 1986). In unregulated lakes, stunted populations of whitefish are also often observed, as seen in Mjogsjøen and Synnfjorden with individual mean weights in 1980 of 110 g and 105 g respectively (Saltveit & Brabrand 1980). On the other hand, heavily exploited whitefish populations show high individual mean weight even in reservoirs, such as Trevatn (245 g) (Hellner & Saltveit 1981) and Randsfjorden (275 g) (Brabrand et al. 1989). Individual size of whitefish is therefore obviously larger in heavy exploited whitefish populations.

Habitat shifts in fishes and changes in availability of food items may be caused by changes in intra- or interspecific competition. This has been shown experimentally for several fish species (Werner & Mittelbach 1983). Competition for food in reservoirs containing whitefish and brown trout often seems to create poor conditions for brown trout. Since whitefish usually occupy the planktivorous food niche, which is more or less undisturbed by regulation (Svärdson 1976), conditions for brown trout in the littoral zone will be greatly changed after regulation. The results from Goppollen clearly illustrated that a heavy reduction in whitefish did not influence conditions for brown trout. This is important, since the hypothesis was that a human induced whitefish reduction would create reduced predation pressure on zooplankton, allowing brown trout to turn partly planktivorous.

Since this did not occur, and only the population structure of the whitefish was changed, we conclude that even a lowered whitefish population still maintained their pelagic dominance. The reduced predation pressure on zooplankton was never lowered sufficient to permit dominance of zooplankton forms available for brown trout. Raddum (unpubl.) showed that zooplankton size distribution in Goppollen is different than in neighbouring lakes without whitefish. A number of food studies on brown trout have clearly shown high preference for large-sized zooplankton species, such as *Bythotrephes longimanus* (Fitzmaurice 1979) and *Daphnia longispina* (Kennedy & Fitzmaurice 1971), while small-sized species as *Bosmina longirostris* are rarely observed in stomach contents of brown trout.

In addition to the conditions in the pelagic zone, brown trout in Goppollen compete for food with minnows in the littoral zone. Where both whitefish and minnows are present in reservoirs, brown trout production is usually extremely low (Brabrand & Saltveit, ms).

Management strategies in reservoirs like Goppellen must be suggested with caution. In this case increased exploitation of whitefish obviously influenced whitefish quality. Such a change may also be achieved by using fish eating strains of brown trout. In fact, after 1986 a piscivorous brown trout strain has been stocked in the reservoir, which started immediately at a size of 25—30 cm to feed on preadult whitefish. Stocking of benthivorous brown trout in reservoirs with planktivorous whitefish or Arctic char and minnows is therefore not recommended.

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