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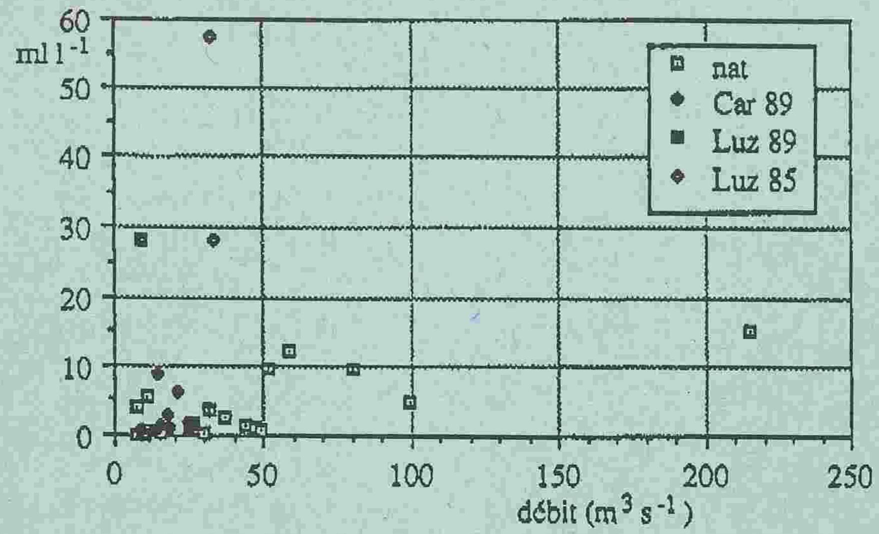

FIG. 7 Valeurs maximales de la concentration des substances sédimentables en ml par litre (moyenne journalière) en fonction des débits moyens journaliers corréspondents pow des évènements natwels (nat) et les pwges du Carassina (Car 89, ce travail), et les pwges de la retenue du Luzzone (mesures effectuées à la station S) aux années 1985 (Luz 85) et 1989 (Luz 89).

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ECOLOGICAL EFFECTS AND FISHERY PROBLEMS RELATED TO NORWEGIAN MOUNTAIN RESERVOIRS

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ABSTRACT In addition to the landscape impact, watercourse development in mountain regions has considerable ecological and biological consequences. The abiotic forces of erosion, drought and frost are active when lakes are regulated. Shore erosion destroys the soft bottoms and the vegetation. The redeposition of sediments below draw-down limit covers the organic deposits. As a result the feeding basis of the bottom fauna is permanently reduced. The extent of the damage depends on reservoir topography and species composition. Increased turbidity has a temporary but severe effect on both plankton and benthic fauna. Suspended silt may also influence down-stream lakes. Impoundments alter the bottom fauna/zooplankton ratio, favouring plankton feeding fishes and impairing bottom feeders such as brown trout. Fishery exploitation of reservoirs is made difficult by the variable water level, forest debris covering the bottom and reduced fish size. However, Arctic char gather in the currents when the reservoirs are drawn down in winter and are easily caught by ice fishing.

INTRODUCTION

Small reservoirs for timber transport, running of flour mills and sawmills were established centuries ago in Norway. The really large reservoirs established for hydroelectric purposes belong to this century. The first three: Møsvatn, Tinnsjø and Ringedalsvatn were completed in 1906, 1907 and 1908, respectively. Reservoirs mostly have been established by damming or lowering a natural lake. Only a few have been created by barraging a river valley. According to the last official statistics

(1981) there are about 800 hydroelectric reservoirs in Norway with a storage capacity of 51.1 billion m^3. The reservoirs constitute about 40% of the nations freshwater area and they have submerged 1100 km^2 of land area (Anon 1984). These figures are rising. A majority of the reservoirs are situated in mountain regions, while industrial and household water is supplied from lowland sources. The mountain reservoirs generally have a higher amplitude in water level than lowland ones, and the average height is also increasing. More than 30% of recent impoundments have an amplitude of more than 40 m, the maximum being 125 m.

Papers dealing with the impoundment effects of Norwegian freshwater fisheries were first published in 1917 (Dahl, HuitfeldtKaas). Because of the great number of reservoirs and the economic importance of freshwater fisheries, studies of impounded lakes have been given priority by the Ministries of Agriculture and Environment local authorities and the hydroelectric industry. The major ecological effects and their short and middle-term impact on fisheries in mountain reservoirs are well documented. Data is however still coming in, and the genuine long-term effects are unknown.

ECOLOGICAL CHANGES

Erosion and turbidity

Small reservoirs close to the power station may have a daily water level cycle, while the large reservoirs have an annual or an even longer fluctuation cycle. During the long draw-down period, the eroding forces of ice, wind, waves and running water work in the exposed area between maximum and minimum water levels. The old lake bottom is rapidly transformed, while it takes longer to clear recently submerged land. However, in a stony environment erosion is completed within a few years. The finer substrate are transported down below the draw-down limit and settle in the deeper parts of the reservoir. On shallow, soft and sandy bottom the redeposition of substrate may continue for decades creating a very broad regulation zone. Dramatic changes may appear if waves erode land above maximum water level or when running water digs into river deltas as a result of a steeper gradient. The deltas may disappear completely, shortening the rivers.

Depending on the nature of the mobile substrate, the water will turn more or less turbid. Severe siltation was recorded in the reservoir, Marvatn, where Secchi disc transparency was reduced from 9.0 to 0.3 m in the summer following increased winter lowering (Borgstrom 1973). In the reservoir, Ringedalsvatn, transparency dropped from about 18 to 0.5 m (Borgstrøm et al. 1990). In both cases normal transparency was restored after two years. Moving glacial silt may remain suspended for a long time, and this may also influence downstream lakes and reservoirs. After the impoundment of Ustevann, the outlet of the lake carried a silt load of 267 mg SiO/1 and the Secchi disc transparency was less than 10 cm (Aass 1979).

With the substrate gone, the living aquatic vegetation of the regulation zone will disappear and the production of dead fine particulate organic material, detritus, is more or less terminated. Light conditions usually prevent recolonization below the minimum water level. In low mountain reservoirs, the vegetation carpets of the shallow littoral may be replaced by clusters of *Ranunculus reptans* growing on muddy substrates in sheltered bays. In deeper waters the alga *Nitella opaca* may survive. Otherwise the vegetation of the regulation zone consists of dead remnants resistant to decomposition. The stumps and branches of trees and shrubs may crowd the littoral, while moss and peat are found on former wetlands. Thus, erosion interrupts the food chain: Macrophytes-bottom fauna-fish, while the chain: phytoplankton-zooplankton-fish survives.

Draining and thermal regime

Depending on storage coefficient and the annual precipitation, the low water period may vary between reservoirs and years. Normally draining starts in October-November, the reservoir is emptied by April and refilled by June-July. Thus the upper part of the littoral may be dry for 7-8 months a year. Reservoirs with a storage capacity surpassing the annual inflow may be partly drained for years. It takes 3 years to fill the biggest Norwegian reservoir, Blåsjøen, which covers an area of 82 km^2 and holds 3.1 billion m^3.

The thermal regime of reservoirs deviates from natural lakes in two ways: the annual cycle is delayed and the temperature budget is reduced. When the reservoirs are drained in winter, ice covers the regulation zone and the bottoms freeze. In spring the reservoirs are largely filled rapidly with cold meltwater. The heating period may be protracted especially if the water volume is increased. On the other hand, it takes longer time to cool the reservoir in autumn. However, in total the temperature sum is reduced, and this is evident from faunal changes.

Currents

The establishment and management of a reservoir will inevitably change the discharge and flow pattern of the inflow and outflow streams. This will influence hydrological and biological conditions in the reservoir proper.

In addition to water level fluctuations, the changed hydrological conditions create new patterns of flow through the reservoir lakes. The main through flow shifts from summer to winter. The annual water level cycle also creates a steady contour change. The promontories and narrows which are formed, lead to a new current system.

To make full use of the storage capacity of a reservoir it may be necessary to increase the catchment area. Inter-river transfers are now a common part of hydroelectric developments and they may alter the chemical properties of the receiving reservoirs. This can be for the better or the worse, but deteroirations are always easier perceived. In Norwegian mountain developments changes in pH are those most likely to occur.

To sum up: The ecological changes lead to oligotrophication or impoverishment of the lakes involved. Their development are put back to an early stage and the annual water level fluctuation prevent restoration. The nutrient flow is restricted to the open water, the pelagical.

BIOLOGICAL CHANGES

EROSION SHORT-TERM EFFECTS

In the development of the fauna in a mountain reservoir, two main lines are discernible. One short-term and positive and one long-term and negative when it comes to fish food production. Fish may browse on drowning organisms from submerged land. In addition erosion and redeposition of sediments leads to a temporary increase in nutrients. This increase is rapidly assimilated by the plankton community and the total amount of fish food increases. Thus the immediate effect of impoundment is a rapid improvement in fish growth. After the impoundment of Palsbufjord (12.5 m regulation) the average weight of brown trout, *Salmo trutta* L., in gill net catches rose from 250 g to 1 kg within two years. Even greater changes may occur when river valleys are barraged and the small-sized trout living in running water get access to the excessive food supply. In Innerdalsvatnet the growth rate jumped from 5 to 10 cm in average the first year after impoundment and decreased only slowly during the next 4 years (Koksvik 1987). Brown trout growth rate improved even better in Nesjø. The Arctic char reacted positively to the impoundment but not to the same degree as brown trout. The decline set in after a few years time but growth has stayed faster than before impoundment (Koksvik 1974). Even if maximum growth and size of fish is reached in a few years, a positive effect may be discernible for 20-25 years. This is especially the case in shallow reservoirs with large areas of inundated bogs. The slowly decomposing peat serve as the basis for a high production of chironomids and the benthic biomass is greater than before impoundment (Jensen 1982).

Nevertheless there exist exceptions to the rule of a positive damming effect. Suspend-

Table 1. Condition factor of brown trout in the reservoir, Starsjø. No. of fish in parentheses.

Fish length cm	1972	1973	1974
34	1.06 (68)	1.02 (50)	1.06 (83)
35	1.07 (71)	0.99 (84)	1.06 (59)
36	1.11 (48)	1.01 (56)	1.07 (41)

ed silt always negatively affects the living conditions of fish, whether in virgin mountain lakes or reservoirs. Sometimes the disadvantages surpass the positive effects. Erosion in course moraine substrate may only lead to a brief deterioration in the length-weight relationship of the fish, expressed by the condition factor. An example is given in Table 1.

During episodes with heavy silting, often met with in impounded mountain lakes with glacial deposits, the fish may even be killed or driven away. In Mårvatn the catch per unit effort and total yield fell to a fraction of the presilting results. Borgstrøm (1973) suggests the reduction was partly due to increased mortality. The mean condition factor of brown trout dropped from about 1.0 to 0.75/0.80 and values down to 0.58 were recorded. At the same time the fish flesh colour changed from red to white. In Lake Ringedalsvatn the mean condition factor fell from 0.82 to 0.76 and the minimum value was estimated to be 0.46 (Borgstrøm et al. 1990).

The development of the river Ustekveikja set large quantities of sediment moving in three reservoirs, Ustevann being the lowest one. In the shallow and unimpounded Ustedalsfjord, 8 km downstream, the turbid water started a mass migration and dead fish were observed in the river below. Catch per unit effort was reduced by 90% at the most (Fig. 1). Twenty years after the incident the fish population is not fully restored, and the balance between brown trout and Arctic char, *Salvelinus alpinus* L., seems to be altered for decades at least. The protracted effect is possibly due to the reduction of bottom fauna biomass, which 10-12 years after silting still was reduced by 35%. In Strandafjord, 16 km further down the river, the same observations with regard to fish behaviour were made (Aass 1979). Directly or indirectly silting influenced the main food organisms of each lake negatively. In lake Ustedalsfjord the large bottom dwelling snails, crustaceans and insect larvae suffered. In Ringedalsvatn the small, planktonic custracean were most affected, and in the lakes Marvatn and Starsjo the larger crustaceans *Eurvcercus lamellatus* and *Lapidurus Arcticus* were severely reduced in numbers.

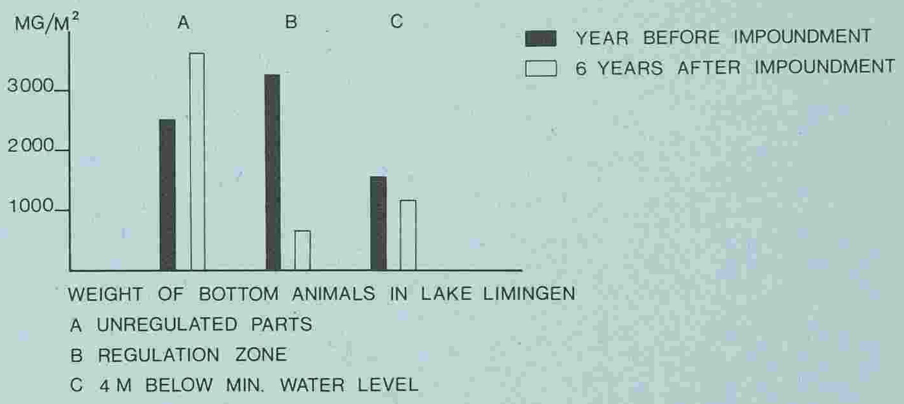

Fig. 2. Lake Limingen. Weight of soft bottom animals before and after impoundment.

EROSION LONG-TERM EFFECTS

Together with the short-term effects of siltation, the lake shore is transformed into a barren, stony zone. The material removed covers the organic bottom sediments below the minimum regulated level. In the regulation zone itself the numbers and biomass of bottom animals are drastically reduced for the forseeable future. In moderately impounded lakes, with amplitudes less than 10 m, some recolonization takes place just below the regulation zone. Further down the biomass is reduced. Fig. 2 shows the effect of a 6 m lowering of lake Limingen, Central Norway. The weight/m² of soft bottom animals was reduced by about 80%. 4 m below the draw-down limit the reduction was 25%, while one unimpounded bay showed no reduction. In the Swedish reservoir, lake Blasjon, situated about 20 km east of Limingen, Grimas (1961) found the number of bottom animals fell by 70% in the regulation zone and 25% for the rest of the lake after a 6 month's impoundment. For the whole lake, the loss in bottom animals was estimated to be 50%. Later, the impoundment height was raised to 13 m, and the total loss increased to 70% (Grimas 1962). Thus the reduction was greatest after the first, but smallest regulation. This is due to the fact that the shallow shore exhibits the greatest number of species and the highest density.

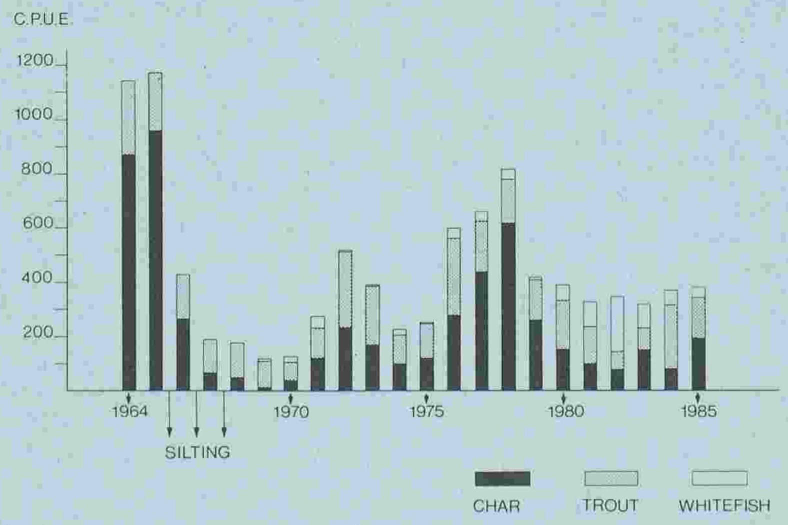

Fig. 1. Catch per unit effort (gill net mesh size 45 mm) in the lake Ustedalsfjord.

The reduction in number and weight of bottom animals is accompanied by a shift in relative abundance. The high species diversity of the natural lake is replaced by a community with few species. According to Grimas (1961, 1962), about 75% of the species disappeared in the Blasjon reservoir. Digging species loose the finegrained substrate, herbivores and detritivores are left without available food. The loosers are mainly large species, such as snails, crustaceans and insect larvae. Most are valuable food organisms for mountain fish species. The winners are mobile species adapted to a rocky shore or free swimming animals. A few cold tolerant species may belong to this group. The individual size of the surviving species is often smaller than the disappearing ones, or they are less easily available. After the peak in the first post-impoundment years the zooplankton biomass seems to return to its startingpoint. Oischarge of reservoir surface water in summer may however have a negative effect on zooplankton numbers in the main feeding season of the fish (Axelson 1961, Løtmarker 1964).

FISH FEEDING HABITS IN MOUNTAIN RESERVOIRS

The true mountain fish species, i.e. brown trout and Arctic char prefer bottom organisms to other food items. Returning to the situation pictured in Fig. 2, the trout and char living in the unimpounded parts of lake Limingen still feed mainly on bottom organisms. Their growth and quality have remained excellent. The fish populations living in Limingen proper managed partly to compensate for the loss of bottom animals by increasing the consumption of terrestrial insects and zooplankton. However, such a shift always leads to a reduction in individual size (Fig. 3). In some cases, the char population may be dwarfed.

In most mountain reservoirs with only trout, zooplankton become the staple food in late summer and autumn (Aass 1969). However, trout coexisting with char do not change their feeding habits as easily. Char exploit zooplankton more effectively and dominate the open waters, the pelagic. Their presence renders it difficult for the trout to leave the shore. The trout usually must rely on terrestrial insects and the remnants of the littoral fauna. Thus food segregation leads to a habitat segregation, but in some reservoirs this partly fails, even where the diets of the species is totally different.

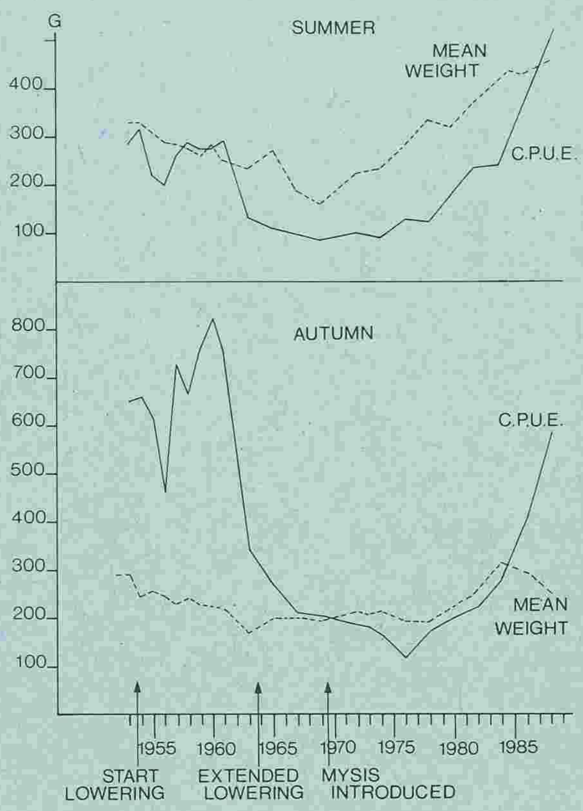

Fig. 3. Lake Limingen. Catch pr. unit effort and mean weight of char in test fishing.

This is the case when adult trout invade the pelagic, not in search of plankton, but to predate on the small-sized char. The development in the Tunhovdfjord reservoir is most illustrative. After 20 years of coexistence char had become the most important food of the medium sized and large trout. The change in diet takes place when the trout are about 25 cm long and is accompanied by a change in growth rate. The largest trout caught weighed 16 kg compared to a maximum of 3 kg before impoundment.

TEMPERATURE EFFECTS

In many high altitude subArctic lakes the large crustacean *Lepidurus Arcticus* is the dominant food of trout. *Lepidurus* is never known to have disappeared as a consequence of water fluctuations, and a radical change in trout diet does not take place when these lakes are turned into reservoirs. On the contrary, the species establishes itself in lower reservoirs, where it did not occur before impoundment (Aass 1969, Brabrand & Saltveit 1980). In other lakes where *Lepidurus* was known to exist, its numbers have increased after impoundment. The reduced temperatures of the impounded lakes are assumed to be of importance for the dispersal of the species. However, when impoundments lead to silting of the water, the populations may decline severely. This was the case in lake Marvann (Borgstrøm 1973) and lake Starsjø. Borgstrøm also drew attention to the fact that the winter eggs of *Lepidurus* are deposited in shallow water, and that hatching success is dependent on rapid and complete filling of the reservoirs.

Other groups may also obtain a more Arctic character on account of the lowered temperatures in the bottoms. Grimås (1962) takes his examples from the Chironomids. Cold tolerant species belonging to the two main groups Tanytarsini and Orthocladiinae increased both in absolute numbers and in their relative share of the chironomid fauna.

RESERVOIR YIELD

Dependent on local conditions, Norwegian mountain lakes stocked exclusively with brown trout may give an annual yield between 0.5 and 5 kg ha^{-1}. The reduced bottom feeding potential of the impounded lakes will inevitably affect the trout production. Extensive investigations have been made on feeding habits, growth rates, size distribution etc. in reservoirs, yet few have aimed at measuring the decline of brown trout production and yield in relation to bottom area fluctuations and depth conditions. However, it is common experience that the yield drops to a fraction of the original.

If a reservoir is established by combining two or more lakes, the one with the lowest amplitude may serve as a refuge to both fish and fish food organisms. This is the case in the SOnstevann reservoir, where amplitudes varies between 8, 20 and 31 m for the upper, middle and lower parts respectively. Accordingly, the reservoir still yields about 1 kg/ha/yr, which is high compared to other reservoirs. Bottom feeding populations of Arctic char and whitefish *Coregonus lavaretus* L., may undergo the same development as the brown trout. Figure 3 (left half) shows the decline of the char catch of lake Limingen.

The presence of fish species more adaptable than brown trout to the post impoundment food situation, may further reduce the brown trout production through an increase in food competition. Jensen (1979 a) states that fish species feeding on reservoir plankton may give a yield 3-5 times higher than brown trout. In the Nesjøen reservoir however, the proportion of Arctic char to brown trout in catches was 9:1 (Jensen 1979 b). The present annual trout yield of about 0.3 kg/ha in Tunhovdfjord is estimated to be a tenth of the preimpoundment catch. On the other hand, exploitatiün of the expanding char population give an estimated average yield of 2.7 kg ha/yr (Aass 1984) based on the area of maximum water level.

CHAR MIGRATIONS

The heavy exploitation of Arctic char in many mountain reservoirs is not possible without their migrations. As a result of the winter draining, a large share of the char population move from the littoral to the pelagic in search of food. Attracted by the flow, the char move down to the narrows which are formed when the water is lowered or to the outlet. Here they gather and stay as long as the current is perceptible. The migration is obviously controlled by hydrological factors. The char gather when the reservoir has dropped to a certain level, particular to each place, and no dependence on time exists. With rising water level the currents weaken and the shoals disband (Aass 1970). Ice fishing with worms and spoon close to the currents is responsible for a large proportion of the total char catch in many reservoirs. During the period 1961-80, the estimated total number of char caught in lake Tunhovdfjord varied between 47 100 and 158 250. On average, 65% of the catch was taken in the current flows, Fig. 4.

Char may also leave reservoirs in large numbers (Dahl 1933, Aass 1970). This usually occurs in the spring when the quest of food is most active, but this emigration is also totally dependent on water level, release depth and flow regime. For a seven year period, betwen 11 and 33% of the mature population was assumed to leave lake Pålsbufjord and enter lake Tunhovdfjord. After entering the river below the dams, the char pause before descending further and this gives rise to extensive fishing. Impoundments thus favour the char populations and the management of the reservoirs may ease the harvesting of the growing populations.

RECRUITMENT

Impoundments may prevent the access to spawning areas for fish spawning in running-water. Dams may close the outlets or inflowing streams may be transferred to other watercourses. In addition, the new instream flow regime will in many cases reduce the spawning and nursery capacity of the rivers. This especially affects trout, and also the Arctic char in the north. Whitefish and grayling, *Thymallus thymallus* L., have shorter spawning migrations and are not so vulnerable. The reduced recruitment possibilities will further restrict trout populations, but it is often difficult to distinguish between the effects on feeding and on recruitment. However, attempts at trout stocking often reveal that natural recruitment is more successful than expected.

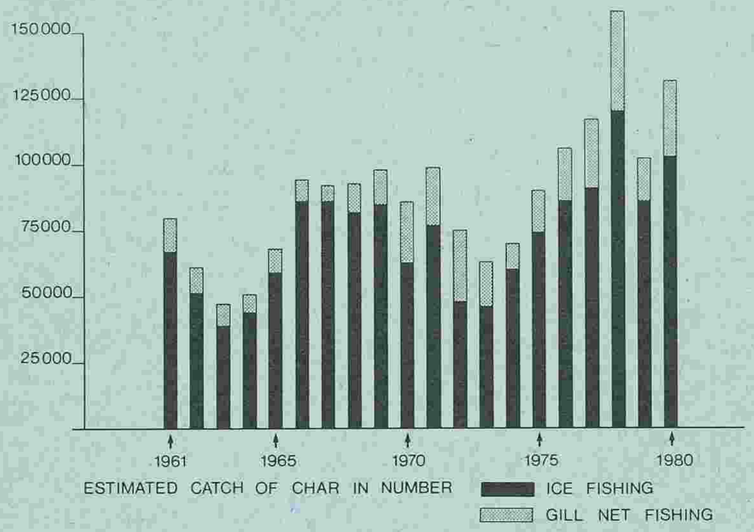

Fig. 4. Estimated number of char caught in lake Tunhovdfjord 1961-80. Catch separated into ice fishing and gill net fishing in summer.

The char populations of reservoirs may switch to a more extensive use of planktonic food. Char also have the benefit of an improved spawning situation. The stony littoral, a result of impoundment erosion, offers the species a multitude of spawning places above the draw-down limit and many are used. In char reservoirs with high amplitudes, such as Tunhovdfjord and Palsbufjord with amplitudes of 18 and 24.5 m, respectively, hatching success varies with the speed and extent of the winter draining. During the period 1948-70 lake Pålsbufjord was only drained by between 3 and 13.8 m in three winters and by 17.6-17.9 m twice. Each time a year class greater than average arose (Aass 1973). On the other hand, a rapid and complete draining will kill large number of eggs and fry which are drained along the shore. In lake Tunhovdfjord the annual catch of char varied between 1.74 and 4.61 kg/ha in the years 1961-80. The variation was partly due to the handling of the reservoir and partly to fluctuations in year class strenght (Aass 1984 a).

REMEDIAL ACTION

More than 25% of Norwegians fish in freshwater every year, and interest in outdoor life is increasing. At the same time the yield of the large lakes, 70% of all bigger than 10 km² have been turned into reservoirs, is declining. The wish for remedial action is supported both by the general public and by the authorities. For a long time compensation measures mainly involved stocking with trout. Char obviously give a higher yield in reservoirs, but the superiority of trout for sport and consumption was decisive. Underyearlings of 5-6 cm constitute the bulk of stocked fish, but elder fish are now used to an increasing extent. The two-year old smolt (15-20 cm) are released into reservoirs with a surplus of prey fish, such as minnows, *Phoxinus phoxinus* L., small char and whitefish. The results are closely related to the food situation, that is the ratio of natural recruitment to food production. In some places stocked fish may contribute only marginally to the catch, but in some reservoirs up to 75-80%. In a majority of reservoirs stocked trout constitute 20-40% of the fish caught. The return of a single stocking may vary between zero and 50%. In most cases 5% of fish stocked as fingerlings are recaught (Aass 1984 b). The return generally rises with increasing release size, but at a price. Stocking is an expensive way of improving fish populations, and more attempts are being made to improve the local spawning possibilities. That means securing a fixed instream minimum flow, constructing weirs and ladders, improving the bottom substrate etc. Inlet impoundments or dams, maintaining the natural water level have proved to be a success (Grimås 1965, Aass et al. 1972).

Reservoir fishing can also be improved by introducing large-sized food organisms. In this respect *Lepidurus Arcticus* is a natural choice. The species has extended its range after hydroelectric development of mountain watercourses. *Lepidurus* has been successfully introduced into a reservoir with trout only. Dense populations of char or other fish species will keep its numbers low, as will acidification.

The so-called glacial relict *Mysis relicta* has been established in some mountain reservoirs, but the wisdom of this has been widely disputed. The results have been divergent. In uncomplicated mountain ecosystems introduction may have a positive effect on the fish populations. Fig. 3 (right half) shows the rise in catch per unit effort and average weight in lake Limingen after the char started feeding on Mysis (Aass 1986). However, *Mysis* consume zooplankton to such a degree that the species may compete with char and whitefish for food. *Mysis* may also constitute food for undesirable fish species such as burbot, *Lota lota*, which in turn predate on young char. *Mysis* has then a negative impact on char number and size (Garnås 1986). Attempts to increase zooplankton production by fertilizing has been made (Koksvik pers. com.). However, such action conflicts with the wish for pristine and uncontaminated waters.

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INNOVATIVE PRESERVATION OF A NEW ENGLAND WETLAND

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ABSTRACT Gunstock Ski Area in Gilford, NH, USA planned a major snowmaking expansion for 1986-1987. Sources of water were carefully examined, and the ponding of a 10.1 hectares wetland was determined to be the only reasonable source of an adequately large body of water. This paper is a case history of this completed project with discussions on the institutional considerations for planning such an impoundment, but with special emphasis on the innovative methods used to mitigate impacts to the diverse wetland. The key to the project's implementation was the development of a Wetland, Fish and Wildlife hitigation Plan which reduced the impacts. The centerfold of the plan was a design which allowed the seasonal flooding of the impoundment. Growing season finds the impoundment gone while winter brings a full pond forwater extraction for snowmaking. Haybail subimpoundments were built to provide winter cover for hibernating animals. Data from two of the three years of post-construction monitoring are explored. Rather than create another steep-sided pond this project attempts to allow man the use of a wetland during a part of the year and in a manner that will not compromise the wetland's overall value. The application of this project and its special mitigation to other developments that do not require year-round water supply is discussed.

INTRODUCTION

This paper is a case history of a solution to a dilemma at Gunstock Ski Area in Gilford, New Hampshire. Gunstock planned to expand their snowmaking capacity from 6800 to 15,140 liters per minute, and therefore needed a large additional water source. Review of several alternatives such as 1) pumping water from Lake Winnipesaukee (a large nearby lake) uphill for 2.5 miles; 2) establishing a well field in, or near, the 10.1 hectare on-site wetland; and 3) impounding the 10.1 hectare wetland, then extracting water from the reservoir as needed, made it apparent that the only practical alternative was number 3, impounding the waters of Poor Farm Brook at the downstream edge of the 10.1 hectare wetland.

This wetland, a 10.1 hectare wet meadow/red maple (*Acer rubrum*) swamp/beaver pond complex, had previously been designated a "prime wetland" by the Gilford Conservation Commission and therefore enjoyed an additional measure of statutory protection beyond that normally afforded wetlands. Impoundment of Poor Farm Brook at the proposed location would flood the bulk of this prime wetland with as much as 4.9 meters of water. Furthermore, as originally proposed, water would be pumped out of this impoundment as needed for snowmaking purposes, which could result in great fluctuations in the winter-time impoundment water levels.

Permanent flooding of this valuable wetland and the inherent large water level fluctuations would significantly impact the ecology of this valuable wetland. Our challenge was therefore to design the impoundment system, and to adapt the water regime, so that impacts to the stream, wetland, and wildlife would be minimal, and to mitigate for unavoidable environmental damage.

The potential and unacceptable impacts of simple, permanent, and unmitigated impoundment of this stream and wetland would be:

- Permanently (year-round) impounded stream water would warm and hold less oxygen thereby converting the impounded area and the tailwater stretch of the stream from a cold-water to a warm-water fishery.
- Decomposition of organic matter in the recently impounded reservoir could increase B.O.D. and decrease summer dissolved oxygen content of the reservoir and stream.
- "Prime wetland" would be flooded, forming a 4.9 meter deep reservoir and converting 10.1 hectares of sedge/grass wet meadow marsh and swamp to a pond.
- Declining wintertime water levels with water extraction for snowmaking would congregate fish in a small area thereby increasing competition for space, food, and oxygen, increasing predation, and stranding or freezing others.
- Insects and burrowing animals that normally live in the mud of pond bottoms, and animals that overwinter in the substrates of ponds and streams, such as hibernating amphibians and reptiles, would be exposed to freezing tempera-