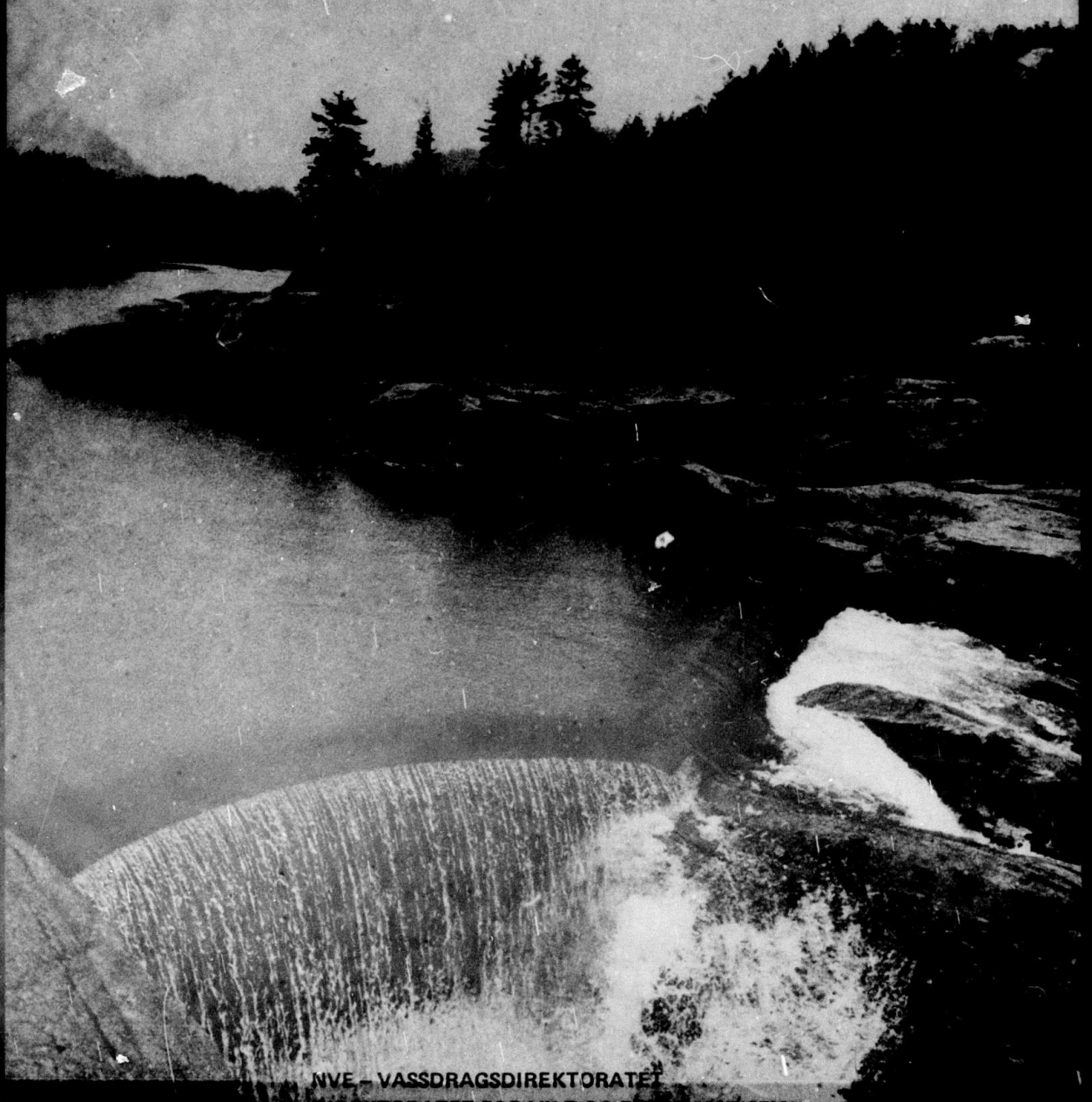
# TERSKELPROSJEKTET

## SUMMARIES FROM THE WEIR PROJECT INFORMATION BULLETINS



NVE – VASSDRAGSDIREKTORATET
DIREKTORATET FOR VILT OG FERSKVANNSFISK

# TERSKLENES INNVIRKNING PÅ BIOLOGISKE FORHOLD I REGULERTE VASSDRAG - (TERSKELPROSJEKTET)

# THE WEIR PROJECT

## PUBLIKASJONSOVERSIKT OG SAMLING AV SAMMENDRAG FRA TERSKELPROSJEKTETS INFORMASJONSSERIE

## SUMMARIES FROM THE WEIR PROJECT INFORMATION BULLETINS

PÅL MELLQUIST

NVE - VASSDRAGSDIREKTORATET

NORWEGIAN WATER RESOURCES AND ELECTRICITY BOARD

1984

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NB! DEN NORSKE SAMMENSTILLINGEN BEGYNNER BAKERST I HEFTET!

CONTENTS

PREFACE

The Weir Project, a cooperative research project on ecological changes in running water ecosystems subjected to hydropower development and building of weirs, was started in 1975.

Since then the results have regularily been published in the WEIR PROJECT INFORMATION BULLETINS. This series consists today of 24 titles, and more are planned in the near future. This amounts to more than 1000 pages, far too much to send all of those who wish to "get some information" on our doings. It was therefore decided to make a collection of the summaries from each bulletin which could more conveniently be sent through the mail.

The bulletins are written in Norwegian, but with English summaries, table- and figure captions. (Bulletins 1-3 are exceptions). The material gathered will be systematized and processed in various contexts over a long period of time. The series will therefore continue as long as there is interesting and relevant material available for publication.

In addition to the "Information Bulletins", there is material available in the form of academic theses ("hovedoppgaver"), articles in international journals and records of proceedings from symposiums, etc. References to materials relevant to the Weir Project are listed at the end of this survey.

The final report, giving a complete presentation of the results of the Weir Project, will be published by the Environmental and Landscaping Department at the NVE - Water Resources Directorate in the series POWER AND THE ENVIRONMENT.

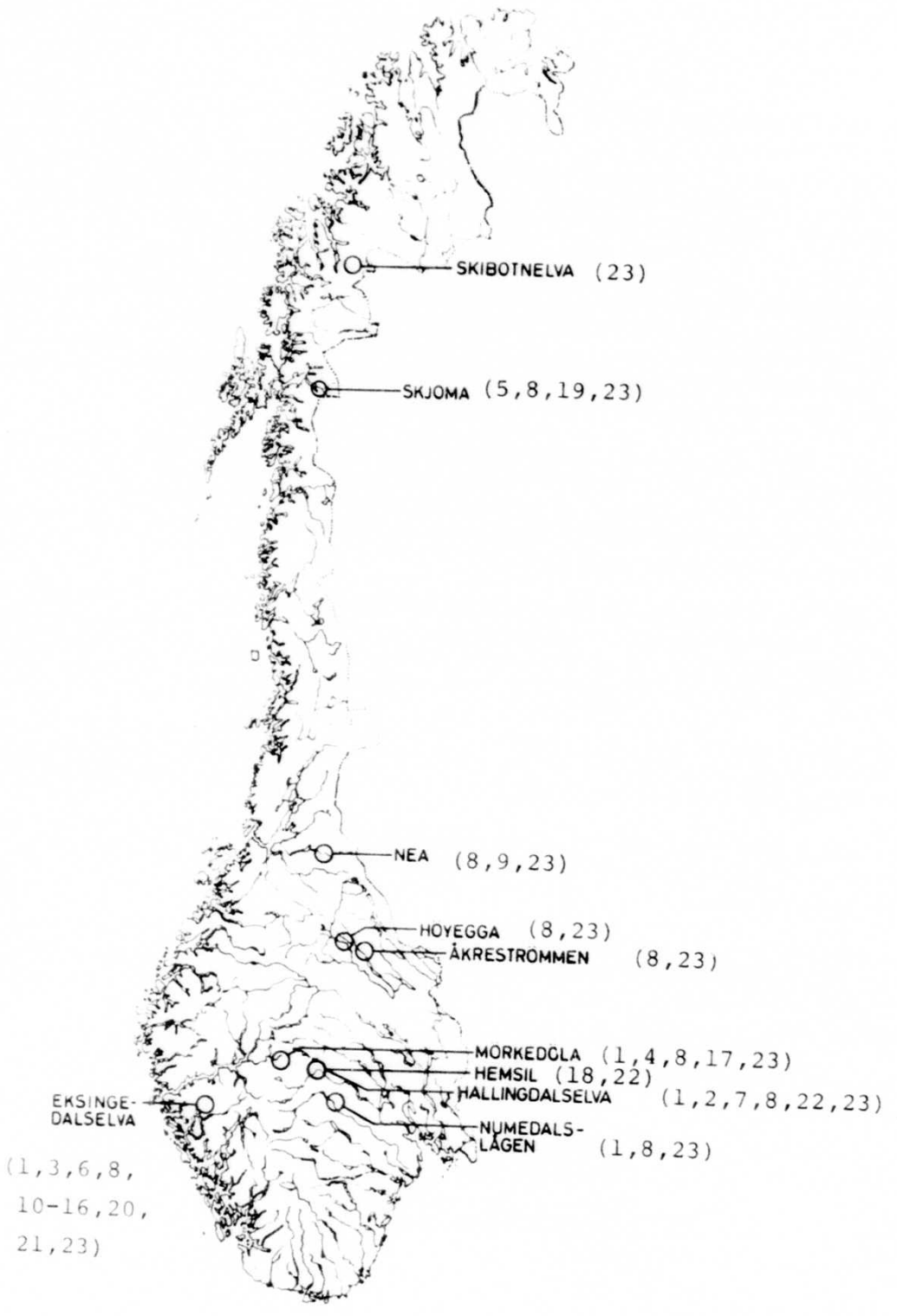
The above mentioned publications will be distributed free of charge, but there are only a limited number of each available. Some of the reports may be re-issued if necessary.

It must be pointed out that several of the reports in the series are only partial. Some were temporary and have later been replaced by newer up-dated editions. The material may be used freely as long as the copyright act and source reference rules are respected.

The reports and further information about the Weir Project are available from:

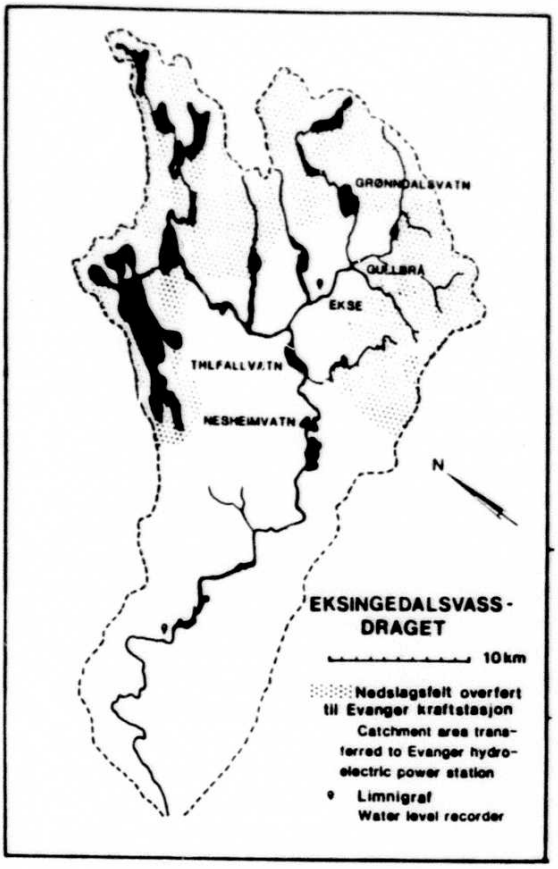
The Weir Project
The Environmental and Landscaping Department
NVE - Water Resources Directorate
Middelthunsgt. 29
OSLO 3
NORWAY tel.: 02/46 98 00

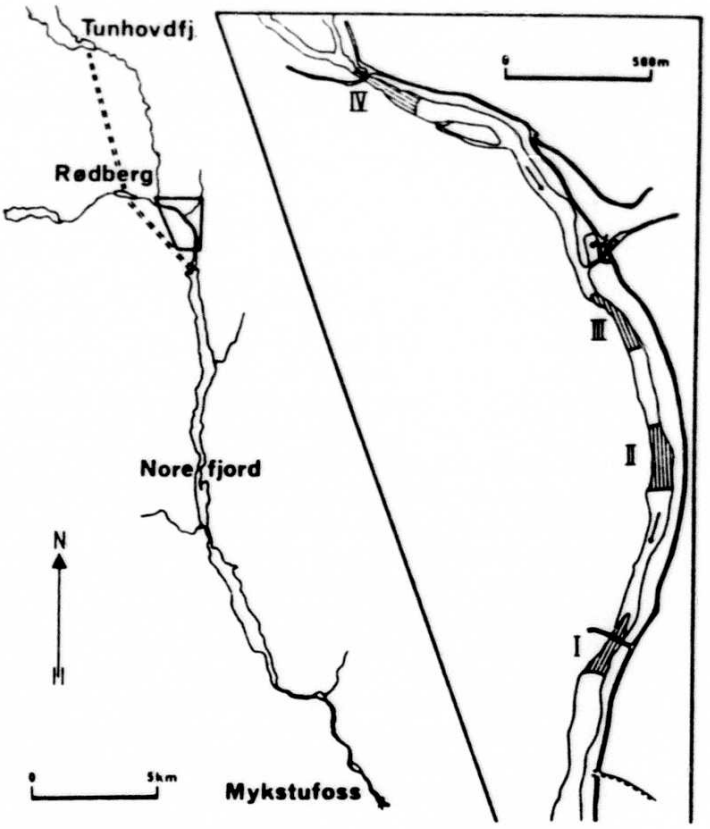
Pål Mellquist
Project leader



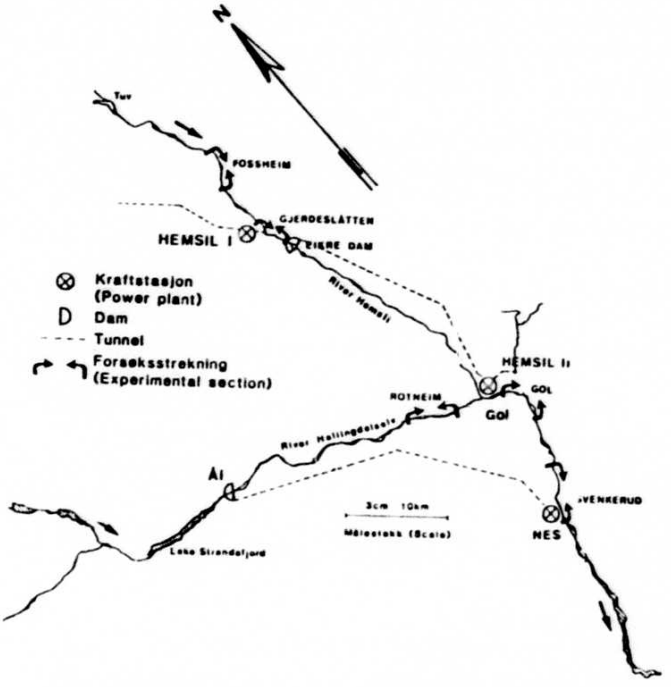

Oversikt over undersøkte lokaliteter med referanse til TP-Informasjoner fra vedkommende lokalitet.

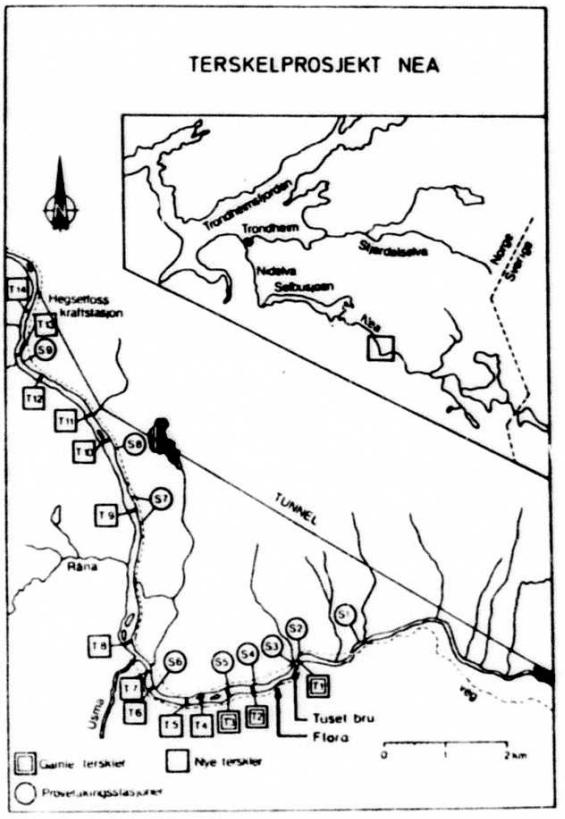
The location of the different research areas with references to Information Bulletin numbers.




NUMEDALSLÅGEN




HALLINGDALSELVA / HEMSIL

## INFORMATION ABOUT THE WEIR PROSJECT

Pål Mellquist, 1976
Information bulletin no. 1, 47 pages

This is the first report in the "Information Series" from the Weir Project. It surveys the origins of the project, its goals, structure and administration. It goes on to give a general description of the locations chosen for investigations at the start of the project in 1975. The studies did, however, expand somewhat in size and were adjusted while in progress, so this report is, for those reasons, not completely up-to-date.

Information bulletin nr. 1 also contains a technical description of what weirs are and an explanation of the technical terms used in connection with this type of constructions.

Almost every hydropower development project results in the reduction of waterflow in rivers and streams. These reductions vary greatly. The reduction may be barely noticeable, or it may result in a complete dry-up. Since the 1960s the construction of low dams across dried-up riverbeds has become quite common. By doing this, a fairly constant water level can be maintained even though the water input is minimal. These constructions are called weirs. Weirs have become an invaluable tool for landscaping in connection with modern hydropower development projects, and as of 1983, approximately 6 - 700 weirs have been built or are in the planning stages.

In the beginning of the 1970s little was known about possibilities and limitations of "biotope adjustments". The Environmental and Landscaping Department of the Water Resources Directorate (NVE) took the initiative to establish a research project called "The Weir Project". It was financed by the Concession Fees Fund, which is made up of fees paid by all hydropower developers.

The Weir Project is above all an ecosystem project where "living and non-living" processes are studied toghether. The energy flow is followed from the primary producers to top consumers. To do this it was necessary to analyse the water quality, make a survey of the aquatic and terrestrial vegetation along the river, investigate the amount and quality of the drift, calculate the growth, nutrition, condition, quality, migration, mortality and population densities of the fish and so on.

In addition an analysis of how people actually use the regulated rivers for recreational purposes such as sport fishing was carried out. A comparison of salmon and trout in watercourses where they occupy the same localities is also a part of the project, likewise a survey of the bird life along river-stretches with and without weirs.

Altogether 11 localities are included in the Weir Project programme. The number of research localities was kept to a minimum to insure a sufficient geographic variation and to compose a complete "before-under-after" sequence of cause and effect relationship.

The Weir Project was a cooperative project between the University of Oslo, the University of Bergen, The Directorate for Wildlife and Freshwater Fish (DVF) and NVE - Water Resources Directorate. Since its conception, the project has had the following Steering Committee:

Project leader, senior engineer Pål Mellquist, NVE - Water Resources Directorate.
Dr. Per Aass, DVF's Fish Research Division.
Senior engineer Øystein Aars, NVE-Water Resources Directorate.
Ass. professor Reidar Borgstrøm, Institute for Environmental Management, The Norwegian Agricultural College.
Dr. Tor B. Gunnerød, DVF's Hydropower Research Group.
Director Knut Ove Hillestad, NVE-Water Resources Directorate.
Ass. professor Roald Larsen, Zoological Museum, University of Bergen.
Dr. Petter Larsson, Zoological Museum, University of Bergen.
Dr. Albert Lillehammer, Zoological Museum, University of Bergen.

BIRDLIFE ALONG PARTS OF THE RIVER HALLINGDALSELVA DURING THE PERIOD FROM 1. MAY TO 1. AUGUST 1975

Jan Michaelsen and Viggo Ree, 1976
Information Bulletin no. 2, 39 pages

## SUMMARY

The weir basins in the River Hallingdalselva in Gol seem to have positive biological significance for a number of bird species. There were 15 primary species registered in the sample areas during the period from 1 May until 1 August, 1975. 4 of the species had previously inhabited the watercourse. Two of these, the mallard (Anas platyrhynchos) and the goosander (Mergus merganser), showed a definite preference for the weir basins, while the opposite was true of one of the two remaining species, the dipper (Cinclus cinclus). Dippers were observed most often in rapids and whitewater areas. The fourth species, the common sandpiper (Actitus hypoleucos), had no clear biotopic preference. The other species included in the primary group were found only in small numbers. Most of these other birds were migrants or vagrants. Of the other primary species, two birds in the duck family, the teal (Anas crecca) and the goldeneye (Bucephala clangula), were observed to prefer the weir basin for feeding and resting, while the wading birds were fairly evenly distributed throughout the various types of river biotopes. Two rather uncommon species, the kingfisher (Alcedo atthis) and the grey wagtail (Motacilla cinerea), were both observed at weir basins. As for the secondary species, three kinds of swallows (Hirundinidae): the barn swallow (Hirunda rustica), the house martin (Delichon urbica), and the sand martin (Riparia riparia), used the weir basin areas for feeding far more often than rapids and waterfall areas.

A comparison of larger areas of the river course where weir basins alternate with rapids to areas with only rapids showed that the birdlife was richer in the areas with weirs. Owing to differences in topography and vegetation, these comparisons are not particularly valid, however, as there are a number of uncertain factors involved.

A REPORT ON BIRDLIFE IN A NUMBER OF WEIR BASINS ALONG THE RIVER EKSINGEDALS-ELVA IN THE SUMMER OF 1975

Olav Råd, Bjørn Angell-Jacobsen, 1976
Information bulletin no. 3, 18 pages

This report may be viewed as a preliminary description of the birdlife around the basins under investigation. A variety of locations were studied: natural basins, river pools and a number of man-made weir basins.

Some of the bird species registered, were observed only during their migrations in the spring and fall, or as dispersal-resident birds in the late summer. The common sandpiper and the wagtail are definitely quantitatively the most important species, and are evenly distributed along the entire water-course.

The lack of studies of pre-development project birdlife in the areas involved makes it difficult to evaluate the effects of hydropower activities on birds. The material available does not provide a sufficient basis for any conclusions about the significance of the apparently modest birdlife around the man-made weir basins.

# THE TROUT POPULATION IN THE RIVER MØRKEDØLA BEFORE THE CONSTRUCTION OF WEIRS

Reidar Borgstrøm, 1976
Information Bulletin no. 4, 29 pages (See also Information no. 17)

## SUMMARY

In the River Mørkedøla, a tributary to the River Lærdalselva in Sogn, Western Norway, the water flow has been considerably reduced due to the impoundment of the Lake Eldrevatn. In the upper part of Mørkedøla (from about 1010 to 1115 m a.s.l.) the water flow may now vary from nearly zero to several $m^3/s$. To increase the river surface some weirs will be constructed, and in this connection the population of brown trout (Salmo trutta L.) has been studied, with special regard to population size. The study was carried out from August 1975 to August 1976.

The year classes 1975 and 1976 were not caught or observed during electrofishing in the upper part of the river, and probably the recruitment has failed due to the reduced water flow.

The fish survive in certain sections of the river where there is still some water even at minimum flows, and in two of these sections the population was estimated by means of multiple mark-recaptures. In section T 4 electrofishing was used for fish capture, while in section T 2A electrofishing was combined with gill netting.

The number of trout between 6 and 18 cm was estimated on four occasions in section T 4. The estimates varied from about 1.9 to 4.8 fish/100 $m^2$. In section T 2A multiple mark-recaptures were carried out twice for fish between 10 and 24 cm. The estimates gave population densities of 3.0 and 3.7 fish/100 $m^2$. As other sections of the river had even lower densities or no fish at all, the total fish population of Mørkedøla has to be considered extremely low.

With no recruitment the number of trout will probably decline rapidly due to natural mortality and fishing.

The constructed weirs may increase the productive area of the river and provide more favourable conditions for the trout, with the condition that recruitment is maintained by stocking.

# POPULATIONS OF YOUNG SALMON AND TROUT IN THE RIVER SKJOMA BEFORE BUILDING OF WEIRS

Tor G. Heggberget, 1977
Information Bulletin no. 5, 42 pages (See also Information no. 19)

## SUMMARY

The river Skjoma near Narvik in Northern Norway was in its natural condition a typical glacier-fed river. The catchment area of approximately 860 $km^2$ was reduced to 184 $km^2$ in connection with hydroelectric exploitation. The power plant was completed in 1976. Skjoma now receives only the natural run-off from the remaining of the catchment area. Since the run-off from the glaciers no longer enter the river a different discharge pattern, increased water temperature in summer and reduced turbidity are expected.

The river Skjoma has fish populations of salmon (Salmo salar L.), trout (Salmo trutta L.), char (Salvelinus alpinus L.), flounder (Platichtus flesus L.) and eel (Anguilla anguilla L.). The populations of trout and char are so far belived to be a mixture of stationary and anadromous populations. The upstream movement of the salmonides are stopped by Lillefallet waterfall approx. 13 km from the estuary and approx. 37 m a.s.l.

In order to partly compensate the damage and inconvenience caused by the reduction in water flow, 5 weirs are planned downstream Lillefallet. Two weirs were finished in 1977.

The scope of this investigation is to gather information on how the young salmon, trout and char react on the changed environmental factors generally and the building of weirs in particular.

The study so far has shown that the mean yearly increase in length is nearly 2.0 cm for salmon and trout in the first years, and with a slightly better growth in favour of the trout in the first period after hatching.

The gut content shows that the trout to a greater extent than salmon feed on surface-insects. The salmon on the other hand shows a greater tendency to feed on drifting aquatic insects (larvae).

Average catch after 3 electrofishing periods was 6 fishes pr. 100 $m^2$ (max. 21.4, min 0.6 fishes pr. 100 $m^2$). The fish population in every locality was estimated by Zippin's (1958) method. According to this 73 % of the standing crop was caught with the fishing method we used, and we end up with a calculated fish-density of 9 pr. 100 $m^2$. The density calculations also indicates somewhat higher densities in the upper parts of the salmon-containing part of the river.

The relative proportions of the fish material was 42.3 % salmon, 56.0 % trout, 1.3 % char and 0.4 % eel. As a rule, we caught a lesser proportion 0+ salmon and trout compared with older year classes. The reason for this, we believe, is due to the selective effect of the electrical equipment. The estimated efficiency on 0+ salmon and trout was 0.24 and 0.27 respectively and 0.46 and 0.43 for 1+. The difference in efficiency on salmon and trout is small and will not influence the results, while the difference in efficiency for different fish-sizes are large and hence influence the results. The estimation of fish densities are very rough and the calculations encumberated with inaccuracies. Considering these factors, the sampling methods used in Skjoma tends to underestimate the fish densities.

# MIGRATION, POPULATION SIZE, GROWTH AND NUTRIMENT OF BROWN TROUT (SALMO TRUTTA L.) IN THE RIVER EKSINGEDALSELVEN, WESTERN NORWAY, BEFORE REGULATION OF THE RIVER

Roald Larsen, 1977
Information Bulletin no. 6, 31 pages

## SUMMARY

The Eksingedalen river is located in Vaksdal, approx. 50 km NE of Bergen. The river lost the upper parts of the catchment area in 1970-73 due to hydro-electric exploitation. Before the regulation of the river took place, a thorough biological investigation was carried out in 1967-69 by the Department of Zoology, University of Bergen. The same localities are now the basis of the Weirproject (Terskelprosjektet), where the goal is to investigate the biological effects of regulation and weir-building.

This paper presents fish data from 1967-69 i.e. before the regulation.

In the Trefall area 4 spawning populations based on the recapture of previous tagged fish can be recognized. One of these are migratory, the 3 others stationary. In the Ekse area there are 2 main spawning-populations, one concentrating its spawning in the upper reaches of the river, the other spawning in the lower parts of the Ekse area.

The sexual immature part of the population is as stationary as the corresponding spawning population.

The recruitment appears to be excellent in the Trefall area with a population between 30 000 and 60 000 fish. In the Ekse area the recruitment appears to be poor with a population of hardly more than 2000 fish in 1968.

Terrestrial insects constitute about 50 % of the fish nutriment. The other half is mainly made up of stoneflies and midges. At Trefall the terrestrial insects constitute only about 32 % with as much as 45 % chironomids. The crustacea here appear to contribute about 5 % of the food. At Nesheim the terrestrial insects make up nearly 41 %, while the crustaceans and the chironomids each constitutes about 20 %. Mayflies and caddiesflies are nowhere a dominant part of the fish diet and generally constitute 5-7 % of the food.

In total about 40 % of the nutriment is of terrestrial origin, while 60 % is produced in the water. Taken into consideration that perhaps 50 % of the nutriment for the latter is of terrestrial origin, about 70 % of the fish nutriment was in 1967-69 indirectly a terrestrial product.

AGE, GROWTH, STOCKING AND YIELD OF BROWN TROUT IN RIVER HALLINGDALSELV AT GOL, EAST NORWAY

Per Aass, 1978
Information Bulletin no. 7, 42 pages

SUMMARY

The yield of brown trout was estimated in two sections of the heavy regulated River Hallingdalselv. Their acreages were identical, but they differed in length, topography and hydrology. The upper section was steep and shallow with minimum water flows in winter and summer of 2.5 and 10 $m^3$/sec respectively. The lower one was calm and deep with a much greater waterflow. The total yield in 1977 was estimated to 7-8 kg/ha for the upper and to 14-16 kg/ha for the lower section. The numbers caught on each were very much the same, but the mean weight of trout caught in the upper section was only about one half of that in the lower. Rod was the dominant gear, only a negligible fraction of the catch was made by nets. Rod fishermen paid about 1400 day visits to each section and the average catch per fishing day was one trout. The individual catches varied, however, greatly.

The year's plantings of legal-sized trout have given returns of 40-50 %. A positive correlation between the length of stocked fish and rate of recapture exists. Most of the recaptures were made within few weeks, but the time lag was correlated with the time of stocking. Planting in early summer gave a more even distribution of returns. The winter mortality of the remaining planted fish exceeds that of the local trout by 3-4 times. The migrations of the stocked trout were in general very short.

The wild trout caught in the upper section were on the average younger than trout from the lower one, possibly due to the hardships of overwintering. Fishing reduces a year class from its third summer on, and the catches consists mainly of fish 3-5 years old. The age of 784 trout were determined and no one was older than 11 years.

The growth was rapid. The yearly length increment of the immature fish was on the average 5 and 6 centimeters on the upper and lower section respectively. The average condition factors were close to 1.0, but highest on the lower section where also a greater fraction of the trout longer than 25 centimeter was red-fleshed.

Differences in fish growth and quality must be due to the food situation. Larvae and adult mayflies and caddis flies totally dominated the stomach contents of the trout caught on the lower section. The quantity eaten was also greatest on this part of the river.

INVESTIGATIONS OF THE BOTTOM FAUNA OF REGULATED RIVERS, WITH SPECIAL EMPHASIS ON BLACK-FLIES, (DIPTERA, SIMULIIDAE)

Jan E. Raastad, 1979
Information Bulletin no. 8, 62 pages. (See also Information no 23).

SUMMARY

Terskelprosjektet's investigations in 1975-79 are intended to answer some of the questions which arise in connection with the building of weirs in heavily-regulated rivers to maintain the previous water level. The main part of the research is being carried out in Eksingedalen north-east of Bergen, and is organised by the Zoological Museum, University of Bergen. Research on bottom fauna at the Zoological Museum in Oslo acts as a supplement to the investigations in Bergen.

The aims of the benthos studies are to find out whether there are differences in the benthic communities above and below weirs, and whether the building of weirs gives similar effects in rivers in different areas. Most of this work is being carried out in the River Numedalslågen north of Kongsberg (Buskerud). This preliminary report also includes results from investigations in the rivers Hallingdalselva (Buskerud), Mørkedøla (Sogn og Fjordane), Glomma (Hedmark), Renaelva (Hedmark), Nea (Sør-Trøndelag) and Skjoma (Nordland). Samples of black-flies from Eksingedalselva (Hordaland) are also included.

The main emphasis in the benthos studies is on black-flies (Simuliidae) because techniques for sampling this group are simple, and because we already have observations which indicate a connection between the building of dams and an accumulation of blood-sucking black-fly species. Samples have been taken by collecting stones and brushing them to remove all the animals. This method is selective, and estimates of benthos will be best for Simuliidae, important groups of Chironomidae, and certain Ephemeroptera. So far, the material received from Bergen only includes drift samples and bottom samples taken with a sampler for soft substrate.

In all, 18 black-fly species have been identified in the areas investigated, and 14 of these have been found in Numedalslågen. Investigations here are mainly limited to the area between Rødberg and Norefjord, where four weirs of river material and blasted rock have been built. Samples have also been taken at 10 stations over a distance of 30 km from Rødberg to well below Norefjord. The life-cycles of 8 black-fly species have been investigated by measuring the body lengths of larvae collected during 1976.

The life-cycle studies show that it is convenient to distinguish two types of black-fly species in Numedalslågen: some species overwinter as eggs, and others as larvae. Four of the six species which overwinter as eggs have only one generation a year: Prosimulium ferrugineum, Cnephia fuscipes, Eusimulium curvans and Simulium rostratum. Simulium reptans and S. tuberosum have two generations a year. The lifecycle studies include two species which overwinter

as larvae in Numedalslågen: Eusimulium vernum and Simulium ornatum. It appears that S. ornatum develops three generations a year, while E. vernum seems to have one generation, the larvae of which develop very slowly. The adults of most species emerge in June-July, but imagines of S.reptans, S. tuberosum and S. ornatum also fly in September.

A much higher benthos density was found in Numedalslågen in 1977 than in 1976. In June-July 1977 up to 750 000 animals/$m^2$ were found, while the highest recorded density in 1976 was 70 000 animals/$m^2$ in May-June. Black-flies dominated, and made up as much as 99 % of the material in May-July: the species Simulium reptans and S. tuberosum were most numerous. On average 75-85 % of the remaining benthos was Chironomidae, while Ephemeroptera at times constituted up to 50 %. The densities of these benthos groups were also found to be higher in 1977 than in 1976. Spot checks of the material from 1978 suggest that the density of black-flies in June-July was even lower than in the same period in 1976, while other groups of benthos seem to have about the same density in 1978 as in 1977.

Samples from 10 stations in Numedalslågen in July 1977 show that the density of the bottom fauna is strongly influenced by the weirs. This was most obvious for black-flies, which dominated at outlet stations. At these, there were average densities of up to 160 000 animals/$m^2$, and 80-90 % of the material was black-flies. Below the weir area the density of black-flies decreased sharply, and at the same time the density of Chironomidae increased greatly: this was now the dominant group, constituting up to 85 % of the material. The effects of weirs on the other benthos groups are not as obvious, as they were relatively poorly represented.

Most of the material from Eksingedalselva so far is from winter samples collected at Ekse in 1975-76. Material from the other localities was collected in September 1975 and/or July 1976 (Hallingdalselva, Mørkedøla, Glomma and Renaelva), and in June 1977 (Nea) and August 1977 (Skjoma).

The drift samples from Eksingedalselva show that 30 % of the black-fly material was taken at the outlet stations. It is difficult to draw any conclusions from the bottom samples, but black-flies do not seem to be very abundant in this river. The same applies to Hallingdalselva and Mørkedøla. In the September samples from Hallingdalselva 7 000 - 20 000 animals/$m^2$ were registered, with an average of 12 000 animals/$m^2$. Nearly 80 % of the material was Ephemeroptera. In July the density varied from 15 000 - 240 000 animals/$m^2$, with an average of 100 000 animals/$m^2$, of which 70 % were Chironomidae. In Mørkedøla the September samples showed a density of 220 - 1 700 animals/$m^2$, and an average of 850 animals/$m^2$. The material included 50 % planktonic Crustacea and 40 % Ephemeroptera. In the July samples there were 4 500 - 22 000 animals/$m^2$, and an average of 12 000 animals/$m^2$, of which 80 % were Chironomidae.

Fairly high numbers of black-flies were found in Glomma, Renaelva and Nea. At Høyegga in Glomma 14 000 animals/$m^2$ were found in July, and 50 % of the material was black-flies. In Renaelva (Åkrestrømmen), 88 000 animals/$m^2$ were registered, nearly 50 % of which were black-flies. In the June samples from Nea 340 - 15 000 animals/$m^2$ were found, and 70-90 % of these were black-flies. There were also large numbers of Chironomidae in Glomma (23 %) and in Renaelva (40 %).

In Skjoma 3 600 - 9 700 animals/$m^2$ were found in August, with an average of 6 200 animals/$m^2$. Chironomidae dominated, making up 65 % of the material, and were followed by black-flies and Ephemeroptera, which made up 15 % each. The black-fly material consists mainly of exuviae, which shows that the samples were taken too late in the year to be representative.

The benthos fauna in Numedalslågen is adapted to the conditions found in heavily regulated rivers, such as great variations in water level and periodic drying-out of the river bed, and can be described as a "catastrophe community". Black-flies are well adapted to such conditions because of their short life-cycle, and the greatest concentration of larvae is found at the outlet from weir pools, where there is a good nutrient supply in the form of drift.

Some aspects of the composition of benthos in rivers with weirs can probably be explained by succession; the short-term effect is dominance of black-flies, as for the relatively new weirs in Numedalslågen. At older weirs, where there is much more growth of moss and algae, black-flies do not compete as effectively and Chironomidae and Ephemeroptera are more likely to dominate the fauna, as in Hallingdalselva.

The great variations in the density of benthos in Numedalslågen show that the community is not very stable. Observations suggest that succession is occurring as the black-fly species Simulium rostratum is increasing greatly at the expense of S. reptans and S. tuberosum. In Renaelva, where Eusimulium pusillum was dominant, there were also large numbers of S. tuberosum. This species was also numerous at Høyegga, and dominated in Hallingdalselva, Mørkedøla, Nea and Skjoma, making up 40-90 % of the black-fly material.

Eusimulium pusillum, Simulium reptans and S. rostratum are among the species which are most troublesome for humans and domestic animals in Norway, but it is not known whether S. tuberosum, which seems to be the most typical species in weir areas, is of any importance in this connection. The so-called "Tuneflua" (Simulium truncatum) known as the main pest species in some districts, was almost entirely missing from weir areas, and there is little to suggest that the situation near weir pools gives rise to any special black-fly problem.

TROUT, BURBOT AND BOTTOM INVERTEBRATES IN THE RIVER NEA, CENTRAL NORWAY, BEFORE BUILDING OF WEIRS

Arnfinn Langeland, Trond Haukebø, 1979
Information Bulletin no. 9, 56 pages

SUMMARY

In 1962 the river Nea, in Central Norway, lost the upper parts of its catchment area due to hydroelectric exploitation. This has caused a great reduction in water flow in the river. In order to compensate for damage caused by the waterflow reductions, 3 weirs were built when the river was regulated. Several new weirs were completed in 1978.

This paper presents data from the preliminary investigations of fish and benthos in 1977 and 1978, before the new weirs were built.

Investigations of the benthos showed that a wide variety of animal groups was represented, and the total density of benthic animals in the samples was relatively high. Selected samples of Ephemeroptera, Plecoptera and Trichoptera have been identified to species; only a small number of common species was recorded within each group.

In the investigated area of the river Nea there are fish populations of trout (Salmo trutta) and burbot (Lota lota), and the former species is dominant.

Yield from nets used in weir basins varied from 404 to 672 g per net-night. The fish leech (Acanthobdella peledina) was a common parasite on trout.

Fish collected by electrofishing was used to calculate population densities for trout using the methods described by Zippin (1958). The mean values calculated for one- to three-year old trout varied from 5.7 to 83.5 trout per $m^2$. Highest densities were found just downstream of the old weirs.

The total gain in length for young trout was calculated to 4.7 cm, 9.3 cm, and 14.5 cm after growth was finished in the first, second, and third year, respectively.

Nymphs of mayflies (Ephemeroptera) seem to be the most important food item for trout. Airborne insects were also important, especially in August, and larvae of Simuliidae may contribute substantially to the diet of trout in June.

**INPUT AND OUTPUT OF ORGANIC MATERIALS TO THE WEIR BASIN AT EKSE, EKSINGEDALEN**

Torleif Bækken, Arne Fjellheim, Roald Larsen, Christian Otto, 1976
Information Bulletin no. 10, 38 pages

SUMMARY

1. About 25 % of the energy input to the weir basin at Ekse is accounted for by primary production within the weir basin (moss and algae), and about 75 % by energy from external sources (allochtonous material).

2. Dissolved organic material, DOM, constitutes 94 % of the energy flow through the basin, but there is no accumulation in the system.

3. Coarse particulate organic matter, CPOM, makes up 25 % of the particulated input (POM), and 58 % of CPOM is accumulated or transformed in the system. CPOM is therefore a very important energy source for the heterotrophs in the weir basin.

4. The CPOM fraction enters the basin mainly as surface drift in autumn and as drift in the water masses in spring and summer.

5. Leaves, twigs, grass etc. dominate in the CPOM drift into the weir basin (monthly mean 43,1 %): moss made up 21,4 % algae 3,7 % and 31,8 % was unidentified material.

6. Fine particulate organic material, FPOM, constitutes as much as 48 % of input and 50 % of output of particulate organic matter, POM. There is thus a net output of FPOM, due to transformation of coarse particles to finer by organisms in the weir basin. There is a large net accumulation of FPOM in the basin in autumn, at the same time as the leaf-fall, and CPOM is mainly transformed to FPOM at this time of year.

7. Fish and benthos also contribute to the net import of particulate matter to the weir basin. This only constitutes a small part of the total input of POM, 0,8 o/oo for fish and 15 o/oo for benthos. The transport of benthos is nutritionally important for the fish.

8. The flow of organic material into and out of the weir basin fits well with the model developed by Fisher and Likens in 1973. The equation $(I+P)/(R+E) \approx 1$, and the system can be regarded as stable with regard to import and export of organic matter.

9. There is relatively as much accumulation of CPOM at high as at low discharges. The waterflow is not an important factor for the accumulation because the weir basin prevents too much washing away of organic matter.

# A SURVEY OF VEGETATION IN THE UPPER CATCHMENT AREA OF THE RIVER EKSINGEDALS-ELVEN, WESTERN NORWAY

Karen Skauge Fredriksen, 1980
Information Bulletin no. 11, 28 pages

## SUMMARY

This report describes higher terrestrial and aquatic vegetation in the upper part of Eksingedalen and Grøndalen, from Ekse to lake Grøndalsvatn, and also higher vegetation in lake Trefallsvatn and lake Nesheimvatn.

In order to understand the origin of plant material in the drift and simplify its identification, the vegetation bordering the river was closely studied.

The terrestrial vegetation is mainly composed of birchwood, but cultivated land, heathland, and bogs also cover large areas. Other types of woods are of lesser importance, but stands of grey alder (Alnus incana), Norway spruce (Picea abies) and other species occur. The most important dwarf shrubs are heather (Calluna vulgaris), crawberry (Empetrum hermaphroditum), blueberry (Vaccinium myrtillus), "bilberry", and bog wortleberry (Vaccinium uliginosum). In addition to these, dwarf conel (Cornus suecica) and various fern species are important. The vegetation of the bogs is dominated by graminids and mosses.

The areas along the river are commonly characterised by a thick scrub dominated by grey willows (Salix glauca, S. lapponum).Both these thickets and the commonest types of riverbank vegetation, i.e. cultivated land dominated by grass species, nitrophilous tallherbmeadows and birch woods contribute great amounts of plant debris to the water.

The higher water vegetation is rather poorly developed, but some species seem to have increased their areas during the last few years.

The regulated lake Grøndalsvatn seems to be without any form of living, higher vegetation. In lake Trefallvatn and lake Nesheimvatn floating bur-reed (Sparganium angustifolium), bottle sedge (Carex rostrata) and water horsetail (Equisetum fluviatile) are quantitatively the most important, especially Fontinalis dalecarlica and Dichelyma falcata. In the river itself, the mosses constitute the greatest part of the flora. Especially important is Dichelyma falcata and species of the general Fontinalis Hygrohypnum and Rhacomitrium. On the rivershores scattered species normally considered as spring- or weed-species grow. Yet Ranunculus reptans is found in continuous mats, and it seems to be well adapted to the variations in water level.

**MIGRATION OF BROWN TROUT (SALMO TRUTTA L.) IN THE UPPER PART OF THE RIVER EKSINGEDALSELVA**

Tor Henning Evensen, 1981
Information Bulletin no. 12, 37 pages

## SUMMARY

Migrations of brown trout were investigated around a weir basin in the regulated river Eksingedalselva north-west of Bergen. The stretch of river studied was divided into 9 zones: the weir basin is located in the lowest part of this area, with stretches of rapids above an below.

The trout in the research area are small streamtrout, generally under 150 g. and 25 cm. The material is divided into age groups 3, 4 and $\geq$ 5 (fish in their 4th, 5th and $\geq$ 6th growth season). Younger fish are not included in the investigation.

The year of research, May 1976 to May 1977 is divided into 5 periods. Migration is recorded as recapture from the last place caught in one time period to the first place caught in the next time period.

About 10 % of the fish were recaptured outside the area where they were marked. Few fish moved more than 1 km. during the investigation.

There are at least three more or less separate trout populations within the area investigated, despite the fact that there are no physical barriers between them.

A more detailed study was made of movements in the immediate area of the weir basin. Male trout here become sexually mature in age groups 3 and 4, but female trout not until age group 5. Approximately 50 % of the sexually mature trout in this area, mostly non-spawners that year, remained more or less stationary in the weir basin during the year. The rest of the sexually mature fish migrated out of the weir basin early in summer and during spawning (in october). Sexually immature fish in age groups 3 and 4 remained mostly in the rapids upstreams and downstreams of the weir basin. Before or during the spawning period these fish migrated into the basin, but it is not certain whether they overwintered there.

The results of this investigation are compared with those of Larsen from a similar investigation in 1968, before the river was regulated and weirs built. In 1976, the trout in the immediate area of the weir seem to have become separate from the populations further upstreams in the study area. The area above the weir basin has become a new important spawning area since 1968. The weir is not a direct barrier for trout movements in the Ekse area.

**BENTHIC ANIMAL STUDIES IN THE EKSINGEDALEN RIVER AT EKSE AFTER REGULATION AND WEIR-BUILDING**

Torleif Bækken, Arne Fjellheim, Roald Larsen, 1981
Information Bulletin no. 13, 47 pages

SUMMARY

A study of benthic animals has been carried out at Eke in Vaksdal municipality north-east of Bergen, as part of the Weir Project's (Terskelprosjektet) investigations in the river Eksingedalselva.

The material discussed in this report was collected in 1976 with a suction apparatus specially developed for the project. Benthos was collected from 3 localities in the weir basin and 2 localities in the river outside the weir basin.

Oligochaeta was the dominant group by weight at all localities, and constituted more than 50 % of the total average biomass. Chironomidae was the largest group of insect larvae, both by weight and by number. For Ephemeroptera and Plecoptera, biomass per unit area was lower in the weir basin than at the localities outside it. A diversity analysis showed that there was a significantly higher species diversity of Plecoptera nymphs at the locality upstream of the weir basin than in the other areas.

The localities outside the weir basin had the highest total average biomasses, 706.3 and 770.9 mg dry weight $m^{-2}$, while the corresponding figures for the localities in the weir basin were 438.2, 589.7 and 434.1 mg dry weight $m^{-2}$ respectively.

There was a higher proportion of benthic animals adapted to slowflowing water in the weir basin than in the river upstream and downstream of it. A reduction of current speed has physiological effects on some animal species, and has also resulted in a much finer substrate in the weir basin than outside it. A fine substrate is more unstable and has fewer microhabitats than a coarser substrate in areas with stronger currents, such as those outside the weir basin.

# DRIFT OF BENTHIC ANIMALS INTO AND OUT OF THE WEIR BASIN AT EKSE

Torleif Bækken, Arne Fjellheim, Roald Larsen, 1981
Information Bulletin no. 14, 37 pages

## SUMMARY

1) In 1976 an investigation of drift of animals into and out of the weir basin at Ekse was carried out.

2) Drift samples were taken approximately every 14 days using 7 drift samplers at the inlet and 7 at the outlet of the weir basin. The drift samplers were allowed to operate for 24 hours before they were emptied.

3) During the year 24280.9 x $10^5$ animals were drifting at the inlet and 21792.8 x $10^5$ at the outlet.

4) For the whole year, the figures for each group at the inlet to the weir basin were as follows (percentage of total in brackets): Plecoptera nymphs 74.5 x $10^5$ (0.3 %). Ephemeroptera nymphs 271.4 x $10^5$ (1,1 %), Simuliidae larvae 41.0 x $10^5$, Chironomidae larvae 1136.2 x $10^5$ (4,7 %), Diptera pupae 201.6 x $10^5$ (0,8 %), Diptera imago 187.4 x $10^5$ (0,8 %), Oligochaeta 51.2 x $10^5$ (0,2 %), Crustacea 21988.4 x $10^5$ (90,6 %), others 329.2 x $10^5$ (1,4 %).

5) Taking the year as a whole, only Simuliidae larvae were found in greater numbers at the outlet than at the inlet of the weir basin.

6) Nearly 100 % of the Ephemeroptera nymphs in the drift belonged to the species Baetis rhodani. From June onwards a greater number of large B. rhodani nymphs drifted into the basin than out of it.

7) Crustaceans dominated the drift from July to November. Most were planktonic forms, mainly from the genus Bosmina. They originated from the reservoir from which large amounts of water were released in connection with repair work.

8) Oligochaeta were rarely found in the drift material, although they were an important part of the zoobenthos. The reverse was true for Crustacea, Diptera pupae and imago and Simuliidae larvae, and at certain times also for nymphs of Ephemeroptera and Plecoptera. These groups were more common in the drift than one would expect from their frequency in the benthos.

BENTHIC ANIMAL PRODUCTION IN THE EKSINGEDALEN RIVER AT EKSE AFTER REGULATION AND WEIR-BUILDING

Torleif Bækken, Arne Fjellheim, Roald Larsen, 1981
Information Bulletin no. 15, 32 pages

SUMMARY

As part of the Weir project's (Terskelprosjektet) investigations in the river Eksingedalselva, measurements of benthic animal production have been carried out at 3 transects in the weir basin at Ekse and 2 transects outside the weir basin.

The material collected was divided into groups which were analysed by different methods. Production of the ephemeropteran Beatis rhodani and the Plecopteran Capnia pygmaea was measured by the method of Winberg et al (1971), while for Oligochaeta production/biomass (P/B) ratios from the literature were used. The rest of the benthos was divided into groups and production for each was calculated using the method developed by Hynes and Coleman (1968) and Hamilton (1969).

The ratio between dry weight and length varied from group to group, being highest for Baetis rhodani and lowest for Diptera larvae. The same was true for the ratio between energy content and length.

Production was highest in the rapids upstream and downstream of the weir basin, 3,8 and 3,4 g dry weight $m^{-2}$ $year^{-1}$ or 90,1 and 78,1 kJ $m^{-2}$ $year^{-1}$ respectively. In the weir basin the values for the transects were 2,0, 2,8 and 2,2 g dry weight $m^{-2}$ $year^{-1}$ or 44,9, 61,3 and 48,6 kJ $m^{-2}$ $year^{-1}$.

The most important group was Oligochaeta, which accounted for approximately 50 % of the total zoobenthos production in the area. The most important insect group, Chironomidae, had a high production rate else within the weir basin. For Ephemeroptera, Plecoptera and Simuliidae, production rates were considerably higher outside the weir basin.

The highest P/B ratios (7.9 - 8.5) were found for Baetis rhodani, which in this area has 2 generations a year.

Benthic animal production was lower in the weir basin than in the river outside it because of changes due to the lowered current speed: altered physiological conditions, and a more homogeneous and less stable substrate.

**PYSICAL AND CHEMICAL PARAMETERS AT THE INLET AND OUTLET OF THE WEIR BASIN AT EKSE, EKSINGEDALEN**

Torleif Bækken, Arne Fjellheim, Roald Larsen, 1981
Information Bulletin no. 16, 33 pages

## SUMMARY


1) Physical and chemical conditions were investigated in the river Eksingedalselva at Ekse before it was regulated (1967, 68 and 69), and at the inlet and outlet of the weir basin at Ekse after regulation.
2) The mean water discharge for 1976, 77 and 78 was 3.04, 1.26 and 1.05 $m^3 s^{-1}$ respectively. Water discharge was high in summer and low in winter.
3) The river was ice-covered from about November to May. Before regulation (1967 and 68), the water reached about 10°C in summer. After regulation (in 1977), water temperatures as high as 24°C were recorded. The temperature was lower in 1967 than in 77.
4) Before regulation the water was super-saturated with oxygen, while after regulation it was usually slightly less than saturated.
5) The water was slightly acid (pH 5.7 - 6.8). No change in pH was found after regulation.
6) No significant change was found in conductivity. Before regulation values for conductivity ($K_{20}$) varied from 7 to 48 $\mu Scm^{-1}$, with the highest values in autumn, and after regulation from 10 to 49 $\mu Scm^{-1}$, with the highest values in winter.
7) The concentrations of $Ca^{2+}$, $Cl^-$, $NO_3^-$- N and $PO_4^{3-}$ P were measured before regulation. No clear pattern of variation emerged. The concentration of $Ca^{2+}$ varied from 0.9 - 4.2 $mgl^{-1}$, that of $Cl^-$ from 0.7 - 6.4 $mgl^{-1}$, and that of $NO_3^-$- N from 30 to 170 $\mu gl^{-1}$. The concentration of $PO_4^{3-}$ P was always less than 2 $\mu gl^{-1}$. After regulation (1976, 77 and 78), the concentrations of the different ions were highest in winter and lowest in summer. The concentration of $Ca^{2+}$ varied from 0.4 to 5.6 $mgl^{-1}$, that of $Mg^{2+}$ from 0.14 to 1.10 $mgl^{-1}$, that of $SO_4^{2-}$ from 0.9 to 9.6 $mgl^{-1}$, that of $Cl^-$ from 0.4 to 6.4 $mgl^{-1}$ and that of $NO_3$- N from 10 - 250 $\mu gl^{-1}$. The concentration of $NH_4$+ - N was normally below 10 $\mu$gl-1, and that of $PO_4^{3-}$-N normally below 2 $\mu$gl-1.
8) The transport of ions through the weir basin was greatest in autumn, with up to 60 000 kg $month^{-1}$ $SO_4^{2-}$ .The maximum values for other ions were lower.
9) The highest values for net input and net output respectively for the different ions were as follows: $Ca^{2+}$ 590 and 19 130 kg $month^{-1}$, $Mg^{2+}$ 130 and 2 210 kg $month^{-1}$, $SO_4^{2-}$ 2700 and 2410 kg $month^{-1}$, $Cl^-$ 1510 and 600 kg $month^{-1}$ and $NO_3^-$-N - 217 and 59 kg $month^{-1}$.
10) The effect of water discharge on ion concentrations was measured separately in summer and winter. Conductivity and $SO_4^{2-}$ concentration showed no correlation with water discharge either in summer or winter. The concentrations of $Ca^{2+}$ in summer and winter, and of $Mg^{2+}$ and $NO_3$- in winter, were lower when water discharge was high. The concentrations of $Mg^{2+}$ and $NO_3^-$ showed no correlation with water discharge in summer. The concentration of $Cl^-$ increased with increasing water discharge in both summer and winter.

# THE POPULATION OF BROWN TROUT (SALMO TRUTTA L.) IN THE RIVER MØRKEDØLA AFTER CONSTRUCTION OF WEIRS

Reidar Borgstrøm, 1981
Information Bulletin no. 17, 25 pages

## SUMMARY

The brown trout population of the upper part of River Mørkedøla, a tributary to the River Lærdalselvi, has been investigated after construction of weirs and stocking with brown trout fingerlings in the weir basin. Brown trout is the only fish species in the river.

Due to heavily reduced water flow the recruitment to the trout population is ceased or strongly reduced. In shorter stretches of the river some natural recruitment occurs, at least in some years, but without stockings in the upper basins the population would however probably have been extinct.

In august 1980 50 % of the controlled fish in the weir basins consisted of stocked fish, while in the runs practically no stocked fish was found. The fish population in the runs is extremely small or there is no fish at all due to lack of water. In several weir basins however the population are at such level as to form a basis for a sport fishery. In one of the weir basins there is even some gillnetting.

The trout of the weir basins has a faster growth rate compared to the situation prior to the construction of weirs, without any marked change in fish density. This indicates better growth conditions, and the streches of the river where basins are found would probably produce more trout with increased recruitment.

# THE BROWN TROUT FISHERY OF RIVER HEMSIL, EAST NORWAY, 1979

Per Aass, 1981
Information Bulletin no. 18, 50 pages

## SUMMARY

The yield of brown trout was estimated on two sections of the regulated River Hemsil, situated about 600 m a.s.l. The sections differed in size, topography and hydrology. The upper was steep and narrow with bed and banks of boulders. The lower one was calm, wide and shallow with stony and sandy bottom. This section also included the 11 m deep intake dam of the power station Hemsil II. The catchment area above the dam is 772 $km^2$. The water flow may vary between 150 and 5 $m^3/s$ in the fishing season 1. June - 15. September. Except for a local minnow population in the dam, brown trout is the only native fish species present. Rainbow trout may occassionally be stocked for put and take fishing. Rod fishing only is permitted.

The lower section is 3.3 km and the area 41.8 ha of which the dam constitutes 16.1 ha. The number of day visits was estimated to 4200 and the yield to 21.6 kg/ha. Most of the fish was caught in the dam, where the catch was approximately 40 kg/ha as compared to 10 kg/ha in the river part. A large share of the total catch was taken in June, in spite of most anglers arriving in July. The mean daily catch, however, varied with the water flow, the fishing being at its best 2-4 days after the culmination of a spate.

19 % of the total number of fish caught were below the legal size of 25 cm. About one fifth of the trout weighed more than 400 g and the biggest one 4.815 kg. While the trout caught on the upper section had a mean age of 3.8 years and a yearly length increment of 5 cm, the trout of the lower section averaged 4.7 years and had a yearly growth of 5.5 cm. Most possibly the differences are due to the hydraulic conditions, the gentle current favoring survival and growth and consequently the production. Trout from the rapids had eaten more surface insects than the trout from the calm part, but in both sections bottom organisms dominated the stomach contents. In the dam, the snails and large insect larvae of the river were replaced by chironomid larvae.

The use of baits differed somewhat in the two sections, but in all one half of the anglers were using worm. Only 15 % of the anglers were fly fishers, mostly using dry flies. One per cent of the anglers were residents in the valley. The Norwegian anglers were mostly living in the central, eastern part of the country, belonging to 103 different urban and rural districts. The average distance between home and river was 221 km. One fifth of the anglers were foreigners, mostly Swedes and Danes.

One third of the anglers were satisfied with the fishing and one third not. In order to increase the catches, the river has been stocked with trout of different sizes. So far, two-summer old brown trout have been no success. Brown trout of catchable size released late in autumn have next season given a return of 20 %, rainbow trout 10 %, where as spring stocked brown trout has given a return of 50 - 60 %.

PRESMOLT ATLANTIC SALMON (SALMO SALAR L.) AND BROWN TROUT (SALMO TRUTTA L.) AFTER HYDRO-ELECTRIC DEVELOPMENT AND BUILDING OF WEIRS IN THE RIVER SKJOMA, NORTH NORWAY.

Tor G. Heggberget, 1982
Information Bulletin no. 19, 70 pages

SUMMARY

The River Skjoma near Narvik was originally a glacier-fed river. Due to hydro-electric power development in 1977 the river changed from a summercold river with turbid water to a summerwarm stream with clear water.

The present study started in 1976, and continued until 1980. The fish was sampled by electrofishing and the total material consists of 13 740 young atlantic salmon and brown trout.

The aim of the study was to gather information on how young salmon and trout reacted on the changed environmental factors generally and the establishing of weirs in particular.

During the research period there was observed an increase of fish density from about 6 fish/100 $m^2$ in 1976 to about 28 fish/100 $m^2$ in 1980. Salmon constituted 40 % of the total catch before HEP, while it constituted about 60 % in 1980. The share of 0+ salmon and trout was not changed during the research period. The density of fish was lower in the weir basins than at the sampling localities between the weir areas. In the weir basins trout dominated, and most of the fish were caught at locations with coarse substratum.

The growth of the presmolt salmon and trout increased 0.5-0.6 cm/year during the research period. The reasons are thought to be the general increased productivity due to reduced waterflow, reduced turbidity and increased water temperature in summer. The increase in summer temperatures is both a result of the hot summers in North Norway 1978-80 and the elimination of the glacier-fed parts of the watershed.

In spite of the increased growth and density, the production of salmon and trout has not been increased to the same degree. This is due to the fact that the permanent watercovered area of the stream has been reduced by at least 1/3 of that before HEP. The increasing share of salmon in the catches is mainly a result of a larger degree of midstream sampling after HEP than before. The increase of trout in the weir basins is a result of the fact that trout is more competitive than salmon at still or slowflowing water. The behaviour of salmon and trout seemed to change in the weir basins. Between the weirs, the water is fast flowing and the young salmon and trout are occupying territories where they are feeding on drift organisms. In contrast to the situation at the research localities between the weirs, tendencies of schooling was observed in the weir basins.

The sport fishery for salmon and sea trout have been reduced to a minimum during the research period, mainly because of the obstructions for upstream migrators created by the low water level after HEP.

EGG PRODUCTION, DENSITY, MORTALITY AND GROWTH OF BROWN TROUT YOUNGER THAN 3 YEARS (SALMO TRUTTA L.) AT EKSE, EKSINGEDALEN RIVER

Yngvar Hagala, 1983
Information Bulletin no. 20, 47 pages

## SUMMARY

Population density, mortality and growth of trout (younger than three years old) including the total egg-production have been investigated in a regulated river where weirs have been built.

The study area (560 m above sea level) was divided into 3 zones. The weir basin (zone 5) is situated between two stretches of rapids (breeding areas).

Large variations was found in density from zone to zone. The zone above the weir basin (zone 4B) had the greatest density with 68,6 fish per 100 $m^2$ and the weir basin had the lowest density with 3,1 fish per 100 $m^2$. The density variations must be regarded in the light of the river's varying substratum and current conditions.

Egg-production in 1977 - 566 eggs per 100 $m^2$ (in the rapids) more than twice that of the previous year (263 eggs per 100 $m^2$). Abnormal water flow is supposed to be the main cause of the low egg-production in 1976.

Egg-mortality was found to be very high - 67 %. Unsuitable ice conditions would seem to be the main cause of this high egg-mortality.

Egg and fry mortality from spawning to two-month old fry was 93 %, but mortality amongst younger fish in age group 0-1 and age group 1-2 (July to July) was also very high, 87 % and 61 % respectively.

It is thought that density-dependent mortality together with climatic induced factors were the most important mortality factors for young fish.

The annual average growth for the first three years was 3,6 cm (4,6 g).

# DENSITY AND MORTALITY OF BROWN TROUT (SALMO TRUTTA L.) OLDER THAN 2 YEARS AT EKSE, EKSINGEDALEN RIVER

Torfinn F. Andersen, 1983
Information Bulletin no. 21, 56 pages

## SUMMARY

This study is a part of the "Weir Project".

Population density and mortality of brown trout were investigated in the regulated river Eksingedalselva north-west of Bergen. The stretch of river studied was divided into 9 zones. The weir basin lies in the lower part of this area, with streches of rapids above and below. There are two bigger pools in the middle of the area.

The trout in the research area are small brown trout, generally under 150 g. and 25 cm. The material is divided into age groups 3, 4 and $\geq$ 5 in 1976 (fish in their 4th, 5th and $\geq$ 6th growth season) and the groups 4, 5 and $\geq$ 6 in 1977 (the groups of 1976 after one year). Younger fish are not included in the investigation, but are discussed in connection with population fluctuations in older fish.

Compared with the situation in the area before regulation and weir-building, the population of older fish was three times larger. In zone 5, rapids in 1968 and weir basin in 1976, the population density was 5 to 6 times larger. The weir basin alone hosted about 50 % of the population in the weir area (zone 4B-6B) in summer and early autumn 1976.

Less competition between big and small fish and better possibilities of overwintering after the weir was built, is truly the main factors of the great increase in the population of older fish in the lower part of the research area.

Great differences in fish density were found from zone to zone, with about 31 fish/100 $m^2$ in one of the pools and 4-5 fish/100 $m^2$ in the rapids. The population of older fish was dominated by the age group 4.

Summer mortality was extremely low, about 5 %.

In despite of 6-7 months winter season with very severe ice situation in the river, winter mortality was low, about 20-25 % for fish older than age group 2.

Lowest winter mortality was found within group $\geq$ 5 fish, with about 6 % in the lower part of the weir basin and about 15 % in zone 3B-4A. In the latter area two bigger pools have functioned as very good overwintering place for older fish.

The highest winter mortality (40 %) was found in group 3 fish within zone 3B-4A. Less dominant fish, example group 3, overwinter in less good places in the river, most truly peripherial in pools/basin or in the rapids. Here the ice situation is extremely difficult in winter, and the winter mortality is consequently greater.

The winter mortality for spawners in zone 4B-6B in group 4 was 36 %, twice the mortality rate for the age group 4 generally. It must be very hard for a fish in group 4 to spawn. But spawners in the group $\geq$ 5 had a mortality rate of the same size as the group generally.

Catastrophe mortality in winter due to long winter season and very severe winter conditions is probably the main mortality factor for brown trout at Ekse, especially for smaller fish.

THE BROWN TROUT OF THE RIVERS HALLINGDALSELVA AND HEMSIL, EASTERN NORWAY, AGE GROWTH, FOOD AND MIGRATION

Per Aass, 1983
Information Bulletin no. 22, 48 pages

SUMMARY

River angling for brown trout is the most popular form of recreational fishing in Norway. Yet very little is known about the life of the river trout and the effects of regulations and water velocity on life conditions. For this reason the angling catches of different sections in the regulated Rivers Hallingdalselv and Hemsil were examined in the years 1973-82. The streams run trough wooded valleys in Eastern Norway at altitudes of 200 and 600 meters respectively. Both fast and slowrunning sections were included in the experiment. In River Hallingdalselv several low weirs have been constructed and in River Hemsil a dam has been erected across the river bed. Brown trout and minnow are the only resident fish species. Migrating whitefish may occasionally be caught.

Angling exploits the trout from its third year of life and three to five year old fish constitute the bulk of the catches. The oldest fish in the samples was 13 years. In both rivers and through all years the mean age of the trout caught was lowest in the fastrunning sections, the difference being about half a year. During the years the average age of capture increased, possibly as a result of frequent checks. Thus the proportion of undersized trout in the catches decreased, but still the angling of small trout represents a major management problem.

By Norwegian standards, the rate of growth is fast in all sections in both rivers, the average annual length increment being 5-6 cm for the first six years of life. The length to weight relationship is also most favourable in calm water, the mean K-values being below and above 1,0 on the steep and gentle sections respectively. Differences in age at capture, rate of growth and condition factor lead to well-defined differences in size distribution in the various sections.

Trout caught in the fastrunning sections averaged only half the weight of the fish from the calm sections. The difference in size between trout from weir dams and runs within the same section is negligible. The biggest trout ever caught in the experimental sections weighed 5 and 11 kgs in Hemsil and Hallingdalselv respectively.

Roughly, the food of the trout is very much the same in all sections of River Hallingdalselv. Different stages of mayflies and caddis-flies constitute the bulk of the food. There is a tendency of greater species variation in the weir dams, and in the calm parts freshwater shrimps may substitute for snails. However, the weight of food found in fish caught in a fastflowing section is

only half the amount eaten in a slow-running one. The food situation in the flowing parts of River Hemsil resembles very much the conditions of River Hallingdalselv. But in the Eikre Dam the importance of the big insect larvae is greatly reduced, and stages of midges dominate both bottom and surface foods. In both rivers minnows are of little importance as trout food.

The growth and food analyses and tagging results imply that the migrations of the river trout are short. The quality differences between the section stocks are thus not due to fish movements but to physical differences between the sections.

In River Hallingdalselv a calm section is situated between two fastrunning sections. The trout stock in the slowrunning water shows little resemblance to the populations in the rapids, although it has the same flow as on of the fastrunning sections. On the other hand, the trout populations in the two swift sections show a high degree of conformity in spite of very different discharges. The indications are that the stream gradient is the factor responsible for the quality variation between the local stocks. The results from River Hemsil support the conclusion. The higher water velocity is supposed to reduce trout longevity, growth and condition in the faster section. In stemming the current weirs may have a beneficial effect, but they don't eliminate the disadvantages of a steep gradient. A dam may, however, totally change the living conditions of the resident trout stock. This happened in River Hemsil where the quality of the trout increased after the impoundment of rapids. The dam also serve as wintering place for the river trout. The investigation shows that regulated streams may sustain viable stocks of brown trout if sensible minimum flows and physical improvements are carried through.

# THE EFFECT OF WEIRS ON MACROBENTHOS IN REGULATED RIVERS, WITH SPECIAL EMPHASIS ON BLACK-FLIES (DIPTERA, SIMULIIDAE)

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## SUMMARY

The main part of the Terskelprosjektet was carried out in the Eksingedalen north-east of Bergen. This research on the bottom fauna acts as a supplement to the investigations in Bergen.

The aims of the benthos studies was to find out whether there are differences in the benthic communitites above and below weirs, and whether the building of weirs gives similar effects in rivers in different areas.

The material was collected in 1975-79. Most of this work was carried out in the River Numedalslågen north of Kongsberg (Buskerud). Investigations were mainly limited to the area between Rødberg and Norefjord, where four weirs of river material and blasted rock have been built. Samples have also been taken at 10 stations over a distance of 30 km from Rødberg to well below Norefjord.

This report also includes results from investigations in the rivers Eksingedalselva (Hordaland), Hallingdalselva (Buskerud), Mørkedøla (Sogn og Fjordane), Åkrestrømmen in Rena (Hedmark), Høyegga in Glomma (Hedmark), Nea (Sør-Trøndelag), Skjoma (Nordland) and Skibotnelva (Troms).

Samples have been taken by collecting stones and brushing them to remove all the animals. The main emphasis in the benthos studies has been on black-flies (Simuliidae). The material from Eksingedalselva, consisting only of black-flies, also includes samples and bottom samples taken with a surber sampler ard with a sampler for soft substrate.

Results from the stony bottom in Numedalslågen show higher effidiency for the stone-picking method than for the kicking method. Stonepicking was best for black-flies and mayflies, but also good for stoneflies, caddisflies and chironomids.

21 black-fly species of Prosimulium, Cnephia, Eusimulium and Simulium have been recorded in the investigated areas. Detailed description of growth and life-cycles are estimated by observation of larvae and pupae.

Most of the black-fly species owerwinter as eggs and have one generation annually: Prosimulium ferrugineum, P. macropygum, Cnephia fuscipes, C. tredecimata, C. lapponica, Eusimulium corniferum, E. curvans, E. aureum, E. pusillum, Simulium noelleri, S. truncatum, S. sublacustre, S. paramorsitans and S. morsitans.

Among those which overwinter as eggs there are two species which seems to be able to change between one and two generations annually: Simulium rostratum and S. reptans. One species, S. tuberosum, has two generations in Numedalslågen, while it seems to be only univoltine in the other localities.

Four species overwinter as larvae. Prosimulium hirtipes has one generation, while Simulium ornatum has two generations annually. Eusimulium vernum has two generations in Numedalslågen and in Eksingedalselva, while it has only one generation in the other localities. Simulium monticola may have two generations in Eksingedalselva, but is uninvoltine in the other localities.

Results from Numedalslågen show that the density of the bottom fauna is strongly influenced by the weirs. This was most obvious for black-flies, which dominated at outlet stations with 80-90 % of the material. At these stations there were average densities of up to 160 000 animals/$m^2$. In a spot sample 750 000 animals/$m^2$ were found. Below the weir area the density of black-flies decreased sharply, at the same time as the density of chironomids increased greatly.

The benthos fauna in Numedalslågen is adapted to the conditions found in heavily regulated rivers, such as great variations in water level and periodic drying out of the river bed, and can be described as a "catastrophic community". Black-flies are well adapted to such conditions because of their short life-cycle. In Nea, Åkrestrømmen and in Glomma, where such conditions are present, large concentrations of black-fly larvae are also found. Black-flies seem to be less important in Eksingedalselva, Hallingdalselva, Skjoma and in Skibotnelva.

Some aspects of the composition of benthos in rivers with weirs can probably be explained by succession. The short term effect is a dominance of black-flies, as with the relatively new weirs in Numedalslågen. At older weirs, where there is much more growth of moss and algae, black-flies do not compete as effectirely and chironomids and mayflies are more likely to dominate the fauna, as in Hallingdalselva.

Results from Numedalslågen indicate that the short term effect may favour typical outlet species as Simulium reptans, which is known as a severe blood-sucking species. The succession in Numedalslågen appears to affect competition between S.reptans, S. rostratum and S. tuberosum.

The result is a strong reduction in density of S. reptans and some reductions of S. rostratum, while the density of S.tuberosum appears to be stable or slowly increasing. Simulium tuberosum seems to be a typical species in weir localities. It appears that the long term effect in Numedalslågen, and possibly in the other localities, is approaching a more typical riverine species composition with reduced influence of outlet species. This implies a black-fly fauna where known species seems to be less important.

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