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POPULATIONS OF PRESMOLT ATLANTIC SALMON (*SALMO SALAR* L.) AND BROWN TROUT (*SALMO TRUTTA* L.) BEFORE AND AFTER HYDROELECTRIC DEVELOPMENT AND BUILDING OF WEIRS IN THE RIVER SKJOMA, NORTH NORWAY.

TOR G. HEGGBERGET

The river Skjoma was a cold and grey river before the regulation in 1977. The river was regulated in such a way that the elevated parts of the water shed were eliminated, which caused increased water temperatures and reduced silt transportation in summer.

After the reduction of the waterflow, the density of presmolt salmonides increased from about 8 fish/100 m^2 to about 30 fish/ 100 m^2. The increase of the proportion of salmon from 40 to 60 in the period from 1976 through 1980 is likely to be a result of the methods used. The productive area of the river was reduced by about 2/3 in the same period. In the weir magazines, the trout became the dominating species, while the salmon was the dominating one at the river stations. The growth of presmolt salmon and trout increased by 1,5-2,0 cm for each year-class in the period from 1978 through 1980. The reasons for the increasing growth is mainly an effect of the increased water temperatures, which were caused both by the hot summers in 1978 and 1979 and the elimination of the elevated, cold tributaries. There were no significant differences in growth of the fish caught at the river stations and in the weir magazines. Though the production of salmon and trout did not seem to be reduced significantly, 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 caused by the low water flow after the water abstraction.

Introduction

The biological effects of hydroelectric power development in streams in Norway are relatively poorly documented. No complete studies discribing the biological situation before and after hydroelectric development have been carried out (Gunnerød & Mellquist 1979). However, several studies describing the biological situation after different kinds of hydroelectric development are carried out during the last years (Jensen 1979, Lillehammer 1979, Borgstrøm 1981, Bækken et al. 1981).

The present study started in 1976, one year before hydroelectric development and building of weirs in the Skjoma (Heggberget 1977). This study continued in the years 1977 through 1980. The aim of the study was to analyse the density and growth of presmolt salmonids during the first years after hydroelectric development and establishing of the weirs.

The study area

The river Skjoma (68° 15' N, 17° 30' E) is situated near Narvik, Northern Norway (Fig. 1). In its unregulated condition, the catchment area of the Skjoma was 850 km^2. Due to the hydroelectric development the catchment area was reduced by about 70%.

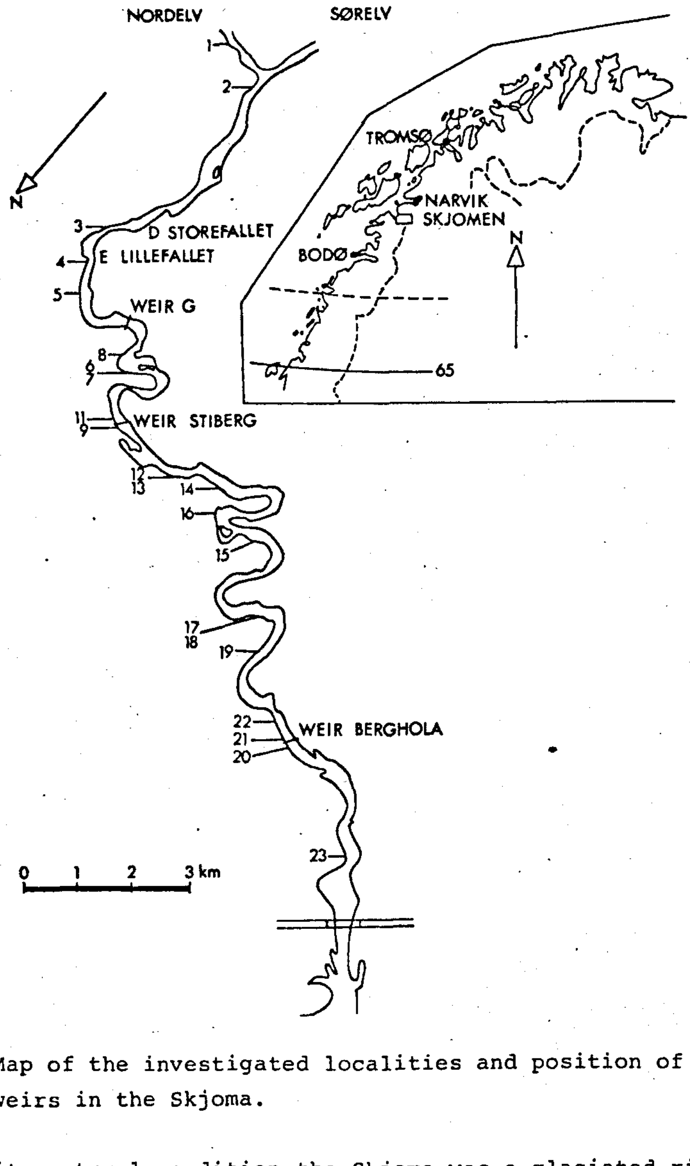

Fig. 1. Map of the investigated localities and position of the weirs in the Skjoma.

In its natural condition the Skjoma was a glaciated river with cold and turbid water in summer. After the water abstraction, the glacier parts of the drainage area was deleted, and the stream changed into warmer and less turbid condition in the summer. The mean flow was reduced from 31 m^3/sec to 8,7 m^3/sec, and the mean water temperatures increased by 1,8°C in June, 3,3°C in August and 2,7°C in September. (Norwegian Water Resources Electricity Board - hydrology departement).

The dominating fish species are Atlantic salmon (*Salmo salar* L.) and brown trout (*Salmo trutta* L.). There are small populations of arctic charr (*Salvelinus alpinus* L.), flounder (*Platichtys flesus* L.), threespined stickleback (*Gasterosteus aculeatus* L.) and eel (*Anguilla anguilla* L.).

The Skjoma is accessible for upstream migrating fish for about 13 km, but the reduced waterflow after the regulation has caused difficulties for upstreams migrating salmon. The river sport fishery for salmon has been reduced to a minimum after 1976.

In the years 1976-1979 there were established three weirs in the river. The length of the weir basins varies from 1 to 3 km. Artifical fishways are established through the weir dams.

Methods and material

The fish were sampled by electrofishing at 15 different localities, which were fished 3 periods each year in 1976, 1977, 1978 and 1980. The density of fish were computed by successive removal method (Zippin 1958) after three fishing runs. The habitat selection of the fish was described by recording distance from the river bank, water depth, water velocity and size distribution of the substratum for each fish caught.

Electrofishing was impossible in the deeper parts of the weir basins, and therefore some of the fish from these areas were sampled by using small nets.

The material consisted of a total of 13740 fish (1976: 1359, 1977: 6064, 1978: 2448 and 1980: 3869). Most of the fish were released after a superfical examination, while some of the fish were conserved for further analyses (age, growth and stomach contents).

Differences in habitat selection in salmon and trout were tested by using a chi-square test (Gutman and Wilks 1967).

Results

The density of salmon and trout increased from a mean of 8 fish/100 m^2 before, to 28 fish/100 m^2 after hydroelectric development (Fig. 2). The main reduction in waterflow was accomplished during the first half of August 1977. Therefore, the results from 1977 are divided into two groups, before and after August 10. 1977. The density of fish increased with the reduction of waterflow, indicating that the fish were forced together in a narrow watercovered area, without any signs of mortality. Both before and after the reduction of the drainage area, the density of fish was highest in the upper part of the stream. The mean density at the upper part (st. 4-12) in 1977-80 was 36 fish/100 m^2 while the corresponding numbers for the lower part (st. 12-23) was 19 fish/ 100 m^2 in the same period.

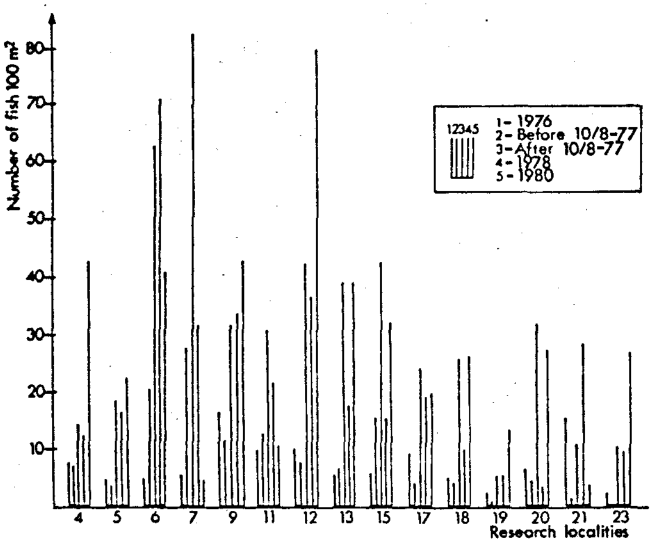

Fig. 2. Mean density of salmon and trout in the different parts of the river in the research period. Sampling was carried out from July 10. to September 10. each year.

The composition of the species varied both between and within the research localities (Table 1). The mean catch of salmon increased from about 38% in 1976 to about 62% in 1980. Within each station, there was great variation, but for most of the localities there was a clear tendency towards an increasing proportion of salmon. For st. 11 and 21, which were transformed from river to weir basins in 1977 and 1979 respectively, there was a decreasing proportion of salmon following the building of the weirs. In 1976, the mean proportion of salmon was 38%, both with and without st. 11 and st. 21. For 1980, however, the mean proportion of salmon was 62% for all the research localities, while the salmon constituted 69% if sampling localities in the weir basins (st. 11 & 21) are deleted, thus indicating a tendency of reduction of salmon in the weir basins.

Table 1. Percentage occurrence of salmon at different stations in the river Skjoma, 1976-1980.

		1976	1977	1978	1980	
Station	4	70	80	85	70	
"	5	60	60	60	80	
"	6	70	20	30	90	
"	7	40	10	35	75	
"	9	40	60	60	60	Downstreams side of the weir.
"	11	45	15	20	15	Weir basin finished 1977.
"	12	50	90	90	90	
"	13	40	80	80	70	
"	15	30	45	40	65	
"	17	5	10	10	40	
"	18	20	10	70	70	
"	19	15	45	45	70	
"	20	35	15	40	60	Downstream side of the weir.
"	21	20	15	65	15	Weir basin finished 1979.
"	23	30	45	30	60	
Mean		38	42	50	62	

In addition to the main sampling stations (4-23), a number of locations in several parts of the weir basins were fished. In all the parts of the weirs basins, except a narrow zone along the weir dam, the trout was the dominating species (Table 2).

A significant increase in growth was observed both for salmon and trout during the research period (Fig. 3 and 4). There were minor differences between fish caught in 1976 and 1977, while 2+ and 3+ salmon caught in 1980 were 1,8-2,3 cm larger than fish of corresponding age caught in 1976-77. Similar growth differences were also observed for trout.

Table 2. Percentage catch of salmon and trout and age composition from different biotope types with regard to the weirs.

	Salmon (%)				Trout (%)			
	Total	0+	1+	>1+	Total	0+	1+	>1+
Sampling stations apart from the weirs	71,6	20,2	28,2	51,6	28,4	17,4	29,1	53,5
Sampling stations in the weir basins	16,5	1,4	58,1	40,5	83,5	3,1	17,1	79,8
Sampling stations along the weir dams	69,9	3,6	41,4	55,1	30,1	0,7	29,7	69,7
Sampling stations downstreams the weirs	68,9	-	-	-	31,1	-	-	-

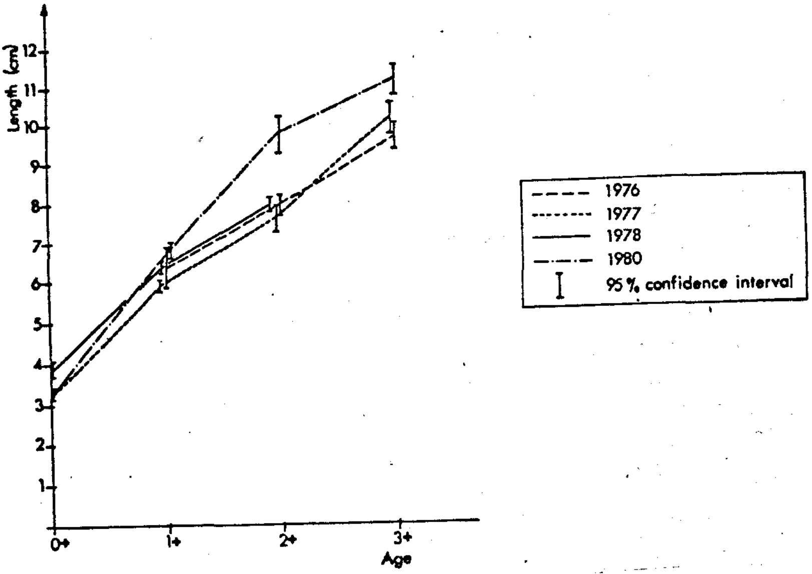

Fig.3. The growth of trout in the years 1976, 1977, 1978 and 1980.

Analyses of scales and otholits indicate that the growth increase started in the period 1978-1980. The oldest fish (3+, 4+) caught in 1980 had a longer distance between the two last winter zones than between the previous ones.

The growth increase indicates reduced smoltification age for salmon and trout in the river Skjoma. The frequency of 4+ and older salmon caught in 1976 was 17,7%, while the frequency of 4+ and

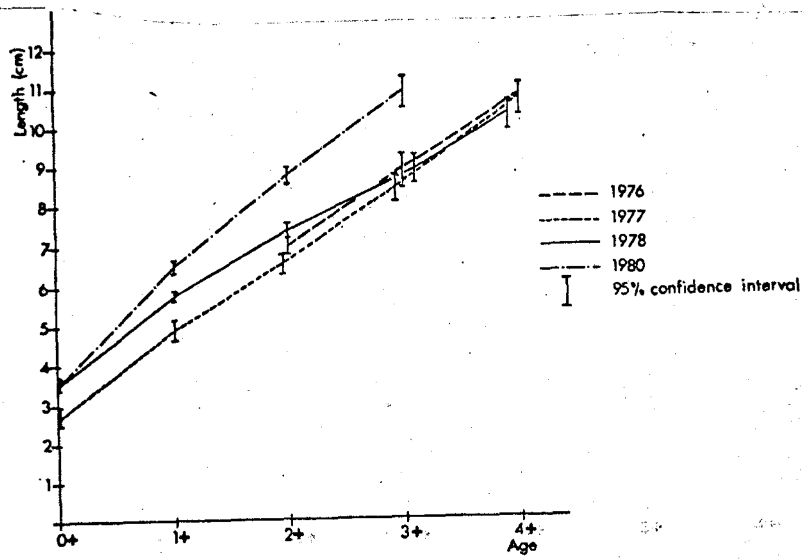

Fig.4. The growth of salmon in the years 1976, 1977, 1978 and 1980.

older salmon in the 1980-catches was 7,4%. The corresponding numbers for trout were 3,6% in 1976 and 0,9% in 1980.

There were no systematic differences in growth between the different parts of the stream, neither in the weir basins nor in the parts of the river between the weirs when electrofished samples were compared. The fish caught by nets in the weir basins showed a better growth than fish sampled by electrofishing in the weir basins. This is due to nonrandom sampling of the stock, and indicates that growth of fish caught by nets and electric fishing gear should not be compared.

Both the results from 1976 and 1980 showed significantly different habitat selection in salmon and trout. The salmon was caught further from the river banks, at deeper water and at higher water velocities than the trout. The described segregation of these species when ocurring sympatrically, is a result of competition (Karlstrøm 1977, Heggberget 1977, 1982). At the sampling localities between the weirs, there was a tendency towards more distinct segregation in 1980 than in 1976. This might be the result of the increased density of fish and hence increased interspecific competition. In the weir basins (not including the area near the weir dam), however, significantly different segregation to the same degree between the two species was not observed. There was a tendency that most of the salmon was observed further from the banks than the trout, while the majority of trout was caught in deeper

Table 3. Distribution of salmon and trout compared to distance from the banks, water depth, water velocity and substratum tested by chi-square test.
p)0.01=** p(0.05=* S = Salmon T = Trout

Station	Distribution compared to		x^2	p	Numbers of fish
	Distance from the banks	1 m	46.24	**	
		2 m	18.89	**	
4		10 cm	23.32	**	S = 169
	Water depth	20 cm	41.53	**	T = 91
		30 cm	13.83	**	
		0.1 m/s	60.53	**	
	Water velocity	0.2 m/s	71.75	**	
		0.3 m/s	20.22	**	
	Substratum	30 cm	2.38		
	Distance from the banks	1 m	62.24	**	
		2 m	39.33	**	
5		10 cm	34.00	**	S = 174
	Water depth	20 cm	36.03	**	T = 73
		30 cm	26.92	**	
		0.1 m/s	30.33	**	
	Water velocity	0.2 m/s	66.91	**	
		0.3 m/s	15.76	**	
	Substratum	30 cm	2.12		
	Distance from the banks	1 m	0.11		
		2 m	0.36		
7		10 cm	0.79		S = 31
	Water depth	20 cm	0.28		T = 11
		30 cm	0.62		
		0.1 m/s	0		
	Water velocity	0.2 m/s	0		
		0.3 m/s	0		
	Substratum	30 cm	7.45		
	Distance from the banks	1 m	65.86	**	
		2 m	24.27	**	
9		10 cm	28.10	**	S = 190
	Water depth	20 cm	42.48	**	T = 128
		30 cm	46.50	**	
		0.1 m/s	86.92	**	
	Water velocity	0.2 m/s	42.48	**	
		0.3 m/s	14.38	**	
	Substratum	30 cm	7.44	**	
	Distance from the banks	1 m	3.87	*	
		2 m	13.06	**	
Weir-		10 cm	0		S = 20
basin	Water depth	20 cm	1.06		T = 39
C - A		30 cm	0.23		
		0.1 m/s	0		
	Water velocity	0.2 m/s	0		
		0.3 m/s	0		
	Substratum	30 cm	0.72		

Table 3, continued.

Station	Distribution compared to		2	p	Numbers of fish
	Distance from the banks	1 m	0.95		
		2 m	0.13		
Weir		10 cm	0.13		S = 71
G - B	Water depth	20 cm	0.32		T = 12
		30 cm	0.17		
		0.1 m/s	0.42		
	Water velocity	0.2 m/s	0.52		
		0.3 m/s	0.09		
	Substratum	30 cm	5.99	*	
	Distance from the banks	1 m	2.65		
		2 m	0		
Weir-		10 cm	0.40		S = 5
basin	Water depth	20 cm	0.93		T = 40
11 - A		30 cm	0.21		
		0.1 m/s	3.20		
	Water velocity	0.2 m/s	0		
		0.3 m/s	0		
	Substratum	30 cm	2.18		
	Distance from the banks	1 m	13.24	**	
		2 m	3.22		
Weir		10 cm	21.77	**	S = 155
11 - B	Water depth	20 cm	16.50	**	T = 56
		30 cm	1.31		
		0.1 m/s	28.83	**	
	Water velocity	0.2 m/s	35.74	**	
		0.3 m/s	21.79	**	
	Substratum	30 cm	1.90		
	Distance from the banks	1 m	34.09	**	
		2 m	25.93	**	
12		10 cm	11.65	**	S = 418
	Water depth	20 cm	5.85	*	T = 44
		30 cm	2.74		
		0.1 m/s	17.10	**	
	Water velocity	0.2 m/s	30.30	**	
		0.3 m/s	18.44	**	
	Substratum	30 cm	10.12	**	
	Distance from the banks	1 m	35.74	**	
		2 m	19.29	**	
13		10 cm	12.60	**	S = 165
	Water depth	20 cm	9.77	**	T = 73
		30 cm	8.66	**	
		0.1 m/s	37.36	**	
	Water velocity	0.2 m/s	14.04	**	
		0.3 m/s	0.44		
	Substratum	30 cm	2.27		
	Distance from the banks	1 m	96.02	**	
		2 m	16.36	**	
15		10 cm	3.74		S = 136
	Water depth	20 cm	0.21		T = 107
		30 cm	3.75		
		0.1 m/s	24.52	**	
	Water velocity	0.2 m/s	32.31	**	
		0.3 m/s	19.84	**	
	Substratum	30 cm	0.01		

Table 3, continue.

Station	Distribution compared to		2	p	Numbers of fish
	Distance from the banks	1 m	29.54	**	
		2 m	32.90	**	
17		10 cm	0.76		S = 49
	Water depth	20 cm	0.01		T = 78
		30 cm	0.35		
		0.1 m/s	55.46	**	
	Water velocity	0.2 m/s	68.93	**	
		0.3 m/s	48.75	**	
	Substratum	30 cm	0.76		
	Distance from the banks	1 m	9.20	**	
		2 m	11.68	**	
Weir-		10 cm	6.51	*	S = 15
basin	Water depth	20 cm	0.73		T = 28
11 - C		30 cm	3.10		
		0.1 m/s	0.07		
	Water velocity	0.2 m/s	1.91		
		0.3 m/s	0		
	Substratum	30 cm	0.21		
	Distance from the banks	1 m	0.02		
		2 m	0.01		
Weir-		10 cm	0.46		S = 26
basin	Water depth	20 cm	0.07		T = 27
21 - A		30 cm	0.03		
		0.1 m/s	0.12		
	Water velocity	0.2 m/s	0.002		
		0.3 m/s	0.98		
	Substratum	30 cm	1.05		
	Distance from the banks	1 m	1.35		
		2 m	4.47	*	
Weir		10 cm	6.06	*	S = 142
21 - B	Water depth	20 cm	0.46		T = 129
		30 cm	0.12		
		0.1 m/s	1.82		
	Water velocity	0.2 m/s	0.59		
		0.3 m/s	0.22		
	Substratum	30 cm	0.78		
	Distance from the banks	1 m	0.07		
		2 m	0.07		
Weir-		10 cm	0.03		S = 8
basin	Water depth	20 cm	1.09		T = 227
21 - C		30 cm	1.54		
		0.1 m/s	0		
	Water velocity	0.2 m/s	0		
		0.3 m/s	0		
	Substratum	30 cm	0.09		
	Distance from the banks	1 m	122.10	**	
		2 m	107.45	**	
18		10 cm	94.35	**	S = 211
	Water depth	20 cm	14.44	**	T = 99
		30 cm	0		
		0.1 m/s	44.63	**	
	Water velocity	0.2 m/s	115.60	**	
		0.3 m/s	81.30	**	
	Substratum	30 cm	0.09		

Table 3, continued.

Station	Distribution compared to		2	p	Numbers of fish
	Distance from the banks	1 m	5.57	*	
		2 m	8.66	**	
19		10 cm	8.00	**	S = 131
	Water depth	20 cm	10.98	**	T = 80
		30 cm	8.93	**	
		0.1 m/s	11.66	**	
	Water velocity	0.2 m/s	23.78	**	
		0.3 m/s	28.22	**	
	Substratum	30 cm	0.02		
	Distance from the banks	1 m	3.12		
		2 m	12.95	**	
20		10 cm	12.96	**	S = 93
	Water depth	20 cm	23.08	**	T = 63
		30 cm	18.25	**	
		0.1 m/s	30.23	**	
	Water velocity	0.2 m/s	22.83	**	
		0.3 m/s	14.47	**	
	Substratum	30 cm	0		
	Distance from the banks	1 m	28.00	**	
		2 m	39.67	**	
23		10 cm	31.33	**	S = 227
	Water depth	20 cm	50.80	**	T = 162
		30 cm	17.17	**	
		0.1 m/s	122.27	**	
	Water velocity	0.2 m/s	95.77	**	
		0.3 m/s	74.53	**	
	Substratum	30 cm	0.94		

water than the salmon (Table 3). Also along the weir dams there were minor differences in habitat selection for salmon and trout, though there was a tendency towards more frequent observations of salmon at higher water velocities than for trout (Table 3).

Discussion

The reduced water flow and reduced turbidity of the Skjoma have increased the catch effeciency in general and especially the catchability for salmon. As a result of the increased visibility in the water, the smaller fish (0+, 1+) were easier to observe after than before the reduction of the river catchment area. Due to the reduced water level the midstream dwelling fish became more catchable by electrofishing after the hydroelectric development. Because of the susceptibility for salmon to be located further from the river banks than trout (Karlstrøm 1977, Heggberget 1977), an increased electrofishing effeciency for salmon would be expected. The results are to some extent affected by the methods used, but is mainly a consequence of a real increase of fish density.

The density of presmolt salmonides after hydroelectric development has increased by about twice to three times in the Skjoma. At the same time, the permanent watercovered area of the stream has been reduced to about one third.

The total production of presmolt salmonides is therefore not supposed to have been negatively affected by the flow reduction in the river. A positive effect is the growth increase in salmon and trout.

The increase of water temperatures in the summers after the hydroelectric development in the Skjoma is due both to the reduction of the glacier fed areas and the hot summers in Northern Norway 1978-80 compared to 1975-76. The mean air temperatures in June, July and August 1977-1980 were 1,9 - 3,3°C higher than the mean temperatures for the same period in 1975-1976 (Norwegian Meteorological Institute). Growth analyses of presmolt salmonids in another glacier fed North Norwegian stream which was not regulated, showed a growth increase of 0,5-1 cm in the period 1978-1980 compared to that of the period 1975-1977 (Jensen & Johnsen 1982).

The simultaneous increase of the fishes' growth and density is in contrast to the results from several other studies. Horton (1961), Le Cren (1965), (1973) and Mortensen (1975) showed that growth rates in presmolt salmon and trout were negatively correlated to fish density. Those studies were made in rivers which were not changed during the research period. Welch (1952) claims that high turbidity modifies productivity in general and Hynes (1970) states that high turbidity has a negativ photosyntetic effect. This indicates that there has been an increase in the general productivity in the Skjoma during the research period. The stomach contents of the fish were not changed qualitatively during the research period (Heggberget 1982). Quantitative bottom or drift fauna studies have not been made in the Skjoma, but other studies in North Norwegian streams indicate increasing densities of bottom invertebrates with decreasing water flow (Koksvik 1977).

A proportionally greater part of the drainage area consists of woodland (birch) after the hydroelectric development. Allochtonous material from leaf woods affects the fish production in streams positively (Egglishaw 1964, 1967, Lillehammer 1975). An effect of the establishment of the weir basins might be an increased deposition and a decreased outwashing of organic material and food organisms (Bækken et al. 1981). It was observed an increased production of algae during the research period. Huntsman (1948) observed that increased growth og algae lead to increased density of presmolt streamdvelling salmon.

The changes in the species composition between salmon and trout in the weir basins, are likely to be due to the different competetiveness under varying physical conditions. Several studies (Lindroth 1955, Kalleberg 1958, Karlstrøm 1977, Heggberget 1981) have shown that the trout is the more competetive at slow flow, while salmon is dominating at localities with higher water velocities. Also in the Skjoma there was observed a dominance of salmon midstream and in the fast-flowing parts of the river (Heggberget 1977). When establishing weir basins, the most striking physical change is the reduction of water velocity. The decline of salmon in the weir basins is therefore explained by the fitness for slow-flowing water in trout.

Other studies (Lindroth 1965, Heggberget 1974, 1981), indicate that in areas where the one of these species are absent, or occurs only in small numbers, the dominating species tends to occupy and utilize microhabitats otherwise occupied by the other one. On this background it is possible that the trout will become even more dominating in the weir basins in the future, especially if stationary populations of brown trout is developing in the weir basins after some time.

Though the smolt production in the Skjoma in general did not seem to be negatively affected by the hydroelectric development, the reduced water flow has reduced the ascent of spawners of salmon and trout. The upstream migration of spawners seem to be sufficient to maintain the reproduction, but it is not sufficient to maintain the formerly excellent sport fishery for atlantic salmon and sea trout in the Skjoma. The weir basins seem however to be important resting places for the few large salmon and trout still entering the river.

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References

Borgstrøm, R. 1981: Ørretbestanden i Mørkedøla etter bygging av terskler. Terskelprosjektet, nr. 17. NVE-Vassdragsdirektoratet 1981.

Bækken, T., Fjellheim, A. og Larsen, R. 1981: Driv av bunndyr inn og ut av terskelbassenget ved Ekse. Terskelprosjektet, nr. 14. NVE-Vassdragsdirektoratet 1981.

Egglishaw, H.J. 1964: The distributional relationship between the bottom fauna and plant detritus in streams. J. Anim. Ecol. 33 463-476.

Egglishaw, H.J. 1967: The food, growth and population structure of salmon and trout in two streams in the Scottish Higlands Freshw. Salm. Fish. Res. 38 1-32.

Gunnerød, T.B. & Mellquist, P. (red.) 1979: Vassdragreguleringers biologiske virkninger i magasiner og lakseelver, NVE, DVF 294 s.

Gutman, F. & Wilks, S.S. 1967: Introductory enginering statictics. John Wiley & Sons Inc. New York, London, Sydney 340 s.

Heggberget, T.G. 1974: Habitatvalg hos yngel av laks, salmo salar L. og Ørret, Salmo trutta L. K. Norske Vidensk. Selsk. Mus. Rapp. Zool. serie 1974-12 76 s.

Heggberget, T.G. 1977: Bestanden av ungfisk i den lakseførende del av Skjoma før bygging av terskler. Terskelprosjektet, nr. 5. NVE-Vassdragsdirektoratet 1977.

Heggberget, T.G. 1981: Habitat selection and segreation of parr of arctic charr, Salvelinus alpinus L., brown trout, Salmo salar L. and Atlantic salmon, Salmo salar L. in two streams in North Norway. Proceedings, Symposium on Arctic charr, Winnipeg, Canada 1981 (in press).

Heggberget, T.G. 1982: Presmolt Atlantic salmon and brown trout after hydroelectric development and building of weirs in the river Skjoma, North Norway. Informasjon fra Terskelprosjektet nr. 19. 58 pp. (In Norwegian with English summary).

Horton, P.A. 1961: The bionomics of brown trout in a Dartmoor stream. J. Anim. Ecol. 30 311-338.

Huntsman, A.G. 1948: Fertility and fertilization of streams. J. Fish Res. Bd. Can. 7 248-253.

Hynes, H.B.N. 1970: The Ecology of Running Waters. Liverpool University Press. 555 pp.

Jensen, A. og Johnsen, B.O. 1982: River growth and smolt age of Atlantic salmon (Salmo salar L.) in the glacier river Beiarelva, Northern Norway (in manus).

Jensen, K.W. 1979: Lakseundersøkelser i Eira. In Gunnerød, T.B og Mellquist, P. (ed). Vassdragsreguleringers biologiske virkninger i magasiner og lakseelver. NVE, DVF 1979.

Kalleberg, H. 1958: Observations in a stream tank of territoriality and competition in juvenile salmon and trout (Salmo salar L. and Salmo trutta L.). Rep. Inst. Freshw. Res. Drottningholm 39 55-59.

Karlstrøm, Ø. 1977: Habitat selection and population densities of salmon and trout parr in Swedish rivers. Inform Inst. Freshw. Res. Drottningholm 6, 72 p. (Mimeographed in Swedish with English summary).

Koksvik, J.I. 1977: Ferskvannsbiologiske og hydrografiske undersøkelser i Saltfjell - Svartisområdet. Del II. Saltdalsvassdraget. K. Norske Videns. Selsk. Mus. Rapport Zool. ser. 1977-16 62 s.

Le Cren, E.D. 1965: Some factors regulating the size of populations of freshwater fish. Mitt. int. Verein. theor. angew. Limnol. 13 88-105.

Le Cren, E.D. 1973. The population dynamics of young trout (Salmo trutta) in relation to density and territorial behaviour. Rapp. P.-V. Reun. Const. int. Explor. Mar. 164 241-246.

Lillehammer, A. 1975: Viktige sider ved laksens oppvekstmiljø i elvene. Fauna 28 8-15.

Lillehammer, A. 1979: En sammenligning av oppvekstmulighetene for laks i Suldalslågen før og etter vassdragsreguleringer. In Gunnerød, T.B. og Mellquist,P. (ed). Vassdragsreguleringers biologiske virkninger i magasiner og lakseelver NVE, DVF 1979.

Lindroth, A. 1955: Distribution, territorial behavour and movements of sea trout fry in the river Indalselen. Rep. Inst. Freshwater Res. Drottningholm 36: 104-119.

Mortensen, E. 1975: The population dynamics of young trout (Salmo trutta L.) in a Danish Brook. J. Fish. Biol. 10 23-33.

Welch, S. 1952: Limnology. 2. ed. McGraw-Hill Book company Inc., London 538 p.