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Restoring Endangered Fish In Stressed Habitats

ReFISH project
1988-1991

Norwegian Institute for Water Research NIVA

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Abstract:

Five brown trout strains have been stocked yearly into 13 acidic (pH 4.5-5.2, 60-180 µg Al/l and 0.2-1.0 mg Ca/L) lakes in southern Norway. The lakes have been test-fished yearly. The catches show good survival in 8 lakes, with fish growing to 25-30 cm at the age of 3+. The K-factor was high and the gonadal development normal. No single chemical factor can explain the occurrence or absence of fish in the lakes. The ability to support fish seems to be lake specific, and determined by pH, calcium and/or aluminium. The use of local "acid tolerant" strains is proposed as a supplement to other acid water mitigating techniques.

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For the Administration

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Restoring Endangered Fish In Stressed Habitats ("ReFish") Project, 1988 to 1991

Progress Report 1990-1991

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SUMMARY

The ReFISH programme (**R**estoring **E**ndangered **F**ish **I**n **S**tressed **H**abitats) started in 1988, with the stocking of 5 brown trout strains in 13 acidic lakes in Southern Norway. The fish stocking has been repeated yearly since. All lakes were highly acidic, and located in some of the regions most damaged by long-range transported pollution in Norway. The pH ranged from pH 4.5 - 5.2, aluminium (as monomeric aluminium) from 60 - 180 µg Al/L, and calcium from 0.3 - 1.0 mg Ca/L.

The lakes have been fished yearly using gillnets. The captures in 1990 and 1991 indicate that survival has been good in several (8) of the lakes. In lakes with good survival, the fish were growing fast, reaching 25-30 cm at the age of 3+. Gonadal development was normal and the K-factor was normally higher than 1.1. No adverse affects could be detected on fish in lakes with surviving fish.

No single chemical factor can explain the occurrence or absence of fish in the lakes. The ability to support fish seems to be lake specific, and determined by pH, calcium and/or aluminium.

Of the five strains used for restocking, two strains performed clearly best, contributing to more than 80% of the catches, while two strains are doing poorly and contributed to less than 10% of the catches.

In the time over which the ReFISH Project has operated, it has not been possible to gain data on reproductive success, but the first spawners (gonad stage 4 and 5) were registered in 1991. It is hoped that further funding will be forthcoming to enable an assessment of reproductive ability to be undertaken. Without this information, it will be difficult to determine restocking strategies for larger regions.

Restocking acid lakes with local "acid tolerant" strains of brown trout might prove to be a supplement to other mitigating techniques as liming.

1. INTRODUCTION

The restoration of acid lakes and watersheds by reducing long-range transported pollution is possible (Wright *et al.*1991a) but is predicted to be a slow process (Christophersen *et al.*, 1990, Wright *et al.* 1991b, Warfvinge *et al.* 1992). To ensure a self-sustaining fish population in the most acid lakes in Southern Norway, estimates shows a recovery period of 50 - 150 years even at a 100 % reduction in acid depositions. However, despite measures taken to reduce pollution emissions, a complete reduction in depositions is not realistic. This implies that a number of lakes will remain too acidic to allow fish survival and reproduction (Henriksen *et al.* 1992). Liming is currently the most commonly used method in Norway for restoration of fish populations in acidified regions (Hindar and Rosseland 1991). However, as a supplement to liming, or as a mitigation method by itself, restocking of more acid-tolerant fish has to be considered.

Differences in the sensitivity to acid water among salmonid species are well documented (Jensen and Snekvik, 1972, Grande *et al.*, 1978, Rosseland and Skogheim, 1984). Different strains within one species have shown different sensitivity to acid water in laboratory experiments e.g. brook trout, *Salvelinus fontinalis* (Robinson *et al.*, 1976) and brown trout, *Salmo trutta* L. (Gjedrem, 1976, 1980, McWilliams, 1980, 1982, Rosseland and Skogheim, 1987, Swarts *et al.*, 1978, Turnpenny *et al.*, 1987). However, long-term studies combining laboratory and field experiments under natural conditions, have been lacking. The purpose of the ReFish Project is to study brown trout strain- dependent survival in lakes representing a range of water qualities (pH 4.5 - 5.2, 60 - 180 µg Al_i/L, 0.3 - 1.0 mg Ca/L) and in laboratory experiments, to assess the feasibility of this method of mitigating the effects of acidification.

The ReFISH-project started in autumn 1987. Five Norwegian brown trout strains are being assessed. Thirteen lakes in three separate regions of southern Norway are used for stocking and testfishing, the results of which can be correlated with lake water chemistry. The lakes were first stocked with the fry of the five strains in October 1988. Descriptions of the strains and the experimental regions have been reported by Sadler and Rosseland (1988). In addition to stocking and testfishing, laboratory hatching and survival experiments using the same strains have been conducted in the UK since spring 1988. The results of stocking, testfishing and laboratory experiments conducted in 1988 and 1989 are reported by Rosseland *et al.* (1990).

This progress report summarises the results of stocking from 1988 and onward, testfishing and laboratory experiments undertaken in 1990 and 1991. For completeness, earlier field data are also reported. A fish response/water chemistry evaluation has been attempted. More detailed reporting of the laboratory experiments in the UK are given by Sadler and Lynam 1989ab and Dalziel and Lynam (1991, 1992). The main results of testfishing have already been reported by Rosseland and Kroglund (1992). In addition, experiments using the same strains at the RAIN (Reversing Acidity In Norway) Project site at Risdalsheia are described by Kroglund and Rosseland (1992). A report on survival experiments performed at NIVA is in progress (Kroglund *et al.* 1993).

In addition to funding from NIVA and the Joint Environmental Programme of PowerGen and National Power in the UK, funding was provided in 1990 and 1991 from the Norwegian Water Resources and Energy Administration (NVE).

2. STOCKING AND TESTFISHING, 1990 AND 1991

2.1. PROCEDURE

The testfishing, the overnight survival tests and the stocking followed the procedure described previously (Rosseland *et al.*, 1990).

The numbers of fish of each strain stocked into each lake in 1990 and 1991 were the same as those in the 1989 stocking (Table 1). The Bygland strain was supplied from Bygland Fish Farm in both years, while the other strains came from the Oslo Fish Administration (OFA). Unfortunately, fish of the Fossbekken strain were not available for restocking in 1990 or 1991.

TABLE 1. Numbers of fish of each strain stocked into each lake in 1990 and 1991.

		Number of fish	
Region	**Lake**	**Per strain**	**Total**
Valle/Njardarheim	Hyttetjørni	150	600
	Kringlevatn	200	800
	Rennevatn	100	400
	Skammevatn	300	1200
	Smalevatn	200	800
Lyngdal	Homsvatn	150	600
	Trollselvvatn	100	400
	Sandvatn	100	400
	Skjekelivatn	150	600
	Mjåvatn	100	400
Birkeland	Repstadvatn	100	400
	Barkevatn	100	400
	Mørkelivatn	100	400

2.2. STOCKING AND TESTFISHING IN 1990

Stocking and testfishing in 1990 was performed between August 19 and 27. Leif Lien, Bjørn Olav Rosseland, Frode Kroglund, Tom Dalziel and Arthur Bulger participated in the field work.

Data on fishing effort, results of testfishing and overnight survival tests are given in Table 2. Data on individual fish are given in Appendix 1.

2.2.1. Birkeland region

Stocking and testfishing in the Birkeland region took place over August 20 and 21. Heavy rain (102 mm in 20 h) resulted in very high water levels in the three lakes in the region.

The fish came from Oslo by air on August 20 and were brought to the region by car. Transport time from packing to stocking was 7 h. The fish were in good condition.

2.2.2. Lyngdal region

Stocking and testfishing in the Lyngdal region took place between August 21 and 23. The weather was partly cloudy with little wind and no rain.

The fish came by air on August 22 and were brought to the region by car and rucksack. Transport time was 9 h. The fish were in good condition.

2.2.3. Valle/Njardarheim region

The stocking and testfishing in the Valle/Njardarheim region took place between August 25 and 27. The weather was slightly cloudy with little wind and no rain. Fish from OFA and Bygland Fish Farms were brought by seaplane directly to the region. The condition of the fish was generally good, although the Bygland fish seemed "slack" when stocked in Skammevatn and Kringlevatn.

TABLE 2. Fishing effort and results of testfishing (brown trout/brook trout) and overnight survival tests (n=10 of each strain) in 1990. Exposure time (Exp.) is given. (d = dying)

			Captured	Exp.	Mortality (n)			
Region	**Lake**	**Gillnets**	**1990**	**(h)**	**Bygland**	**Gjedrem**	**Bustul**	**Tunhovd**
Valle	Hyttetjørni	2x3	0	20	1			
	Kringlevatn	1x8	0	20				
	Rennevatn	1x8	0	20				1d
	Skammevatn	1x8	0	20	1			
	Smalevatn	1x8	2/0	20				
Lyngdal	Homsvatn	1x8	0	20				
	Trollselvvatn	1x8	0/1	20	4	9	8	10
	Sandvatn	1x8	4/10	20			1	
	Skjekelivatn	1x8	0	20				
	Mjåvatn	2x3	19/0	20				
Birkeland	Repstadvatn	1x8	2/0	20				
	Barkevatn	1x8	2/2	20				
	Mørkelivatn	1x8	0/1	20		1	2	7+1d

2.3. STOCKING AND TESTFISHING IN 1991

Stocking and testfishing in 1991 was performed between August 26 and September 3. Leif lien, Frode Kroglund, Espen Lydersen and Tom Dalziel participated in the field work.

Data on fishing effort, results of testfishing and overnight survival tests are given in Table 3. Data on individual fish are given in Appendix 1.

2.3.1. Birkeland region

Stocking and testfishing in the Birkeland region took place over August 26 and 27.

The fish came from Oslo by air on August 26 and were brought to the region by car. Transport time was 7 h. The fish were in good condition at the time of stocking.

The weather was sunny with few clouds and little wind.

2.3.2. Lyngdal region

Stocking and testfishing in the Lyngdal region took place over August 28 and 19.

The fish came by air on August 28 and were brought into the region by car and rucksack. Transport time was 9 h. The fish were in good condition at the time of stocking.

The weather was sunny with few clouds and little wind.

2.3.3. Valle/Njardarheim region

Stocking and testfishing in the Valle/Njardarheim region took place over September 2 and 3.

Fish from OFA and Bygland Fish Farms were brought by seaplane directly to the region. The fish were in good condition at the time of stocking.

Strong winds were experienced during the stocking and testfishing, which resulted in the keepnet used for the overnight survival test at Lake Rennevatn being blown on-shore and, at Lake Hyttetjørni, not being recovered.

TABLE 3. Fishing effort and results of testfishing (brown trout/brook trout) and overnight survival tests (n=10 of each strain) in 1991. Exposure time (Exp.) is given. (d) = dying

			Captured	Exp.	Mortality (n)			
Region	Lake	Gillnets	1991	(h).	Bygland	Gjedrem	Bustul	Tunhovd
Valle	Hyttetjørni	3+3	0	24	*			
	Kringlevatn	8+3	2	24			1	5
	Rennevatn	8+3	0	24	*			
	Skammevatn	8+8	1	24		1		3
	Smalevatn	8+8	23	24				
Lyngdal	Homsvatn	8+3	0/1	20				
	Trollselvvatn	8+3	0	20				
	Sandvatn	8+8	20	20				
	Skjekelivatn	8+8	6	20				
	Mjåvatn	3+3	26	20				
Birkeland	Repstadvatn	8+8	5	18		1	1	
	Barkevatn	8+3	12	17		1		
	Mørkelivatn	8+3	0	17				

* Cage lost due to strong wind.

3. WATER CHEMISTRY, 1988 - 1991

3.1. METHODS

Water samples were collected on a regular basis by local helpers and sent immediately to NIVA for analysis. Analyses were performed according to standard methods at NIVA.

Cations were analysed by atomic absorption spectrophotometry and SO_4^{2+} and Cl^- by ion chromatography.

NO_3^- and NH_4^+ were analysed colorimetrically. Aluminium fractions were analysed by ion-exchange colometry. Inorganic monomeric aluminium (Al_i) is defined as the difference between reactive aluminium (Al_r) and organic aluminium (Al_o). TOC is determined by infrared spectroscopy after oxidation to CO_2.

ANC (acid neutralizing capacity) was calculated according to Lien *et al.* (1990). The ANC calculation is not based on sea-salt corrected values.

$$ANC = ([Ca^{2+}]+[Mg^{2+}]+[Na^+]+[K^+] - [SO_4^{2-}]+[Cl^-]+[NO_3^-])\mu eq/L$$

3.2. STATISTICS

The chemical data from 1988 to October 1991 were subjected to ANOVA testing (Statview SE + Graphics, version 1.03), to help identify significant differences in water chemistry between the lakes.

3.3. RESULTS

Water chemistry data from the start of the field work in September 1988 to November 1991 are given in Appendix 3. Given below are comparisons of water chemistry between regions and between lakes.

3.3.1. Comparisons between regions

There were significant differences ($p<0.05$) in pH, calcium, inorganic monomeric aluminium and ANC between the three regions (Figures 1 - 4).

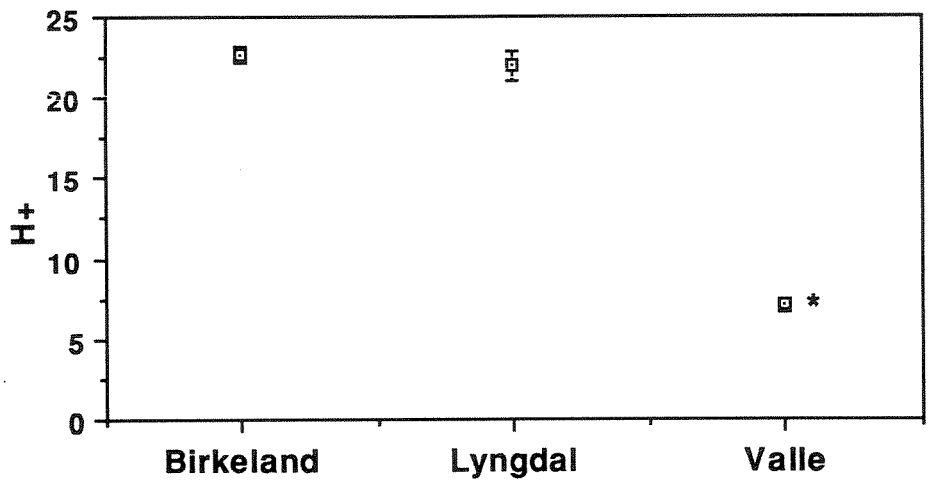

Figure 1. Mean pH (as H^+) in each of the three regions. S.E. shown. * indicates significant difference ($p<0.05$)

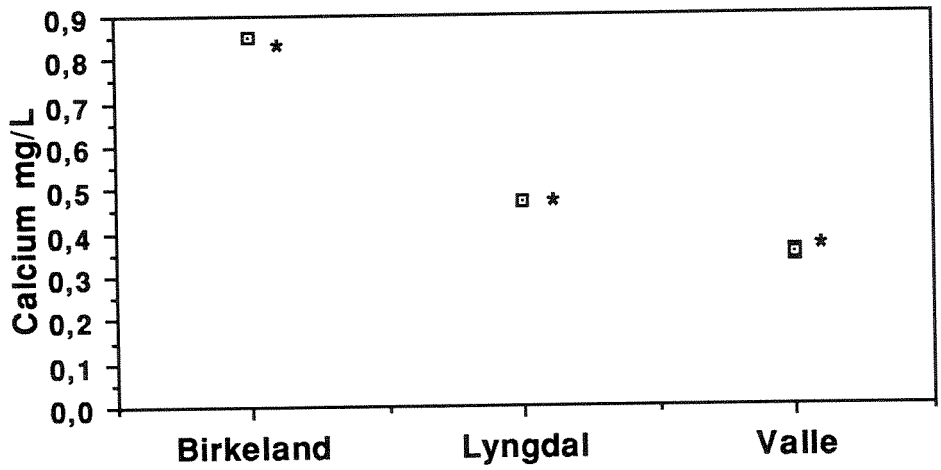

Figure 2. Mean calcium concentration (mg Ca/L) in each of the three regions. S.E. shown. * indicates significant difference ($p<0.05$)

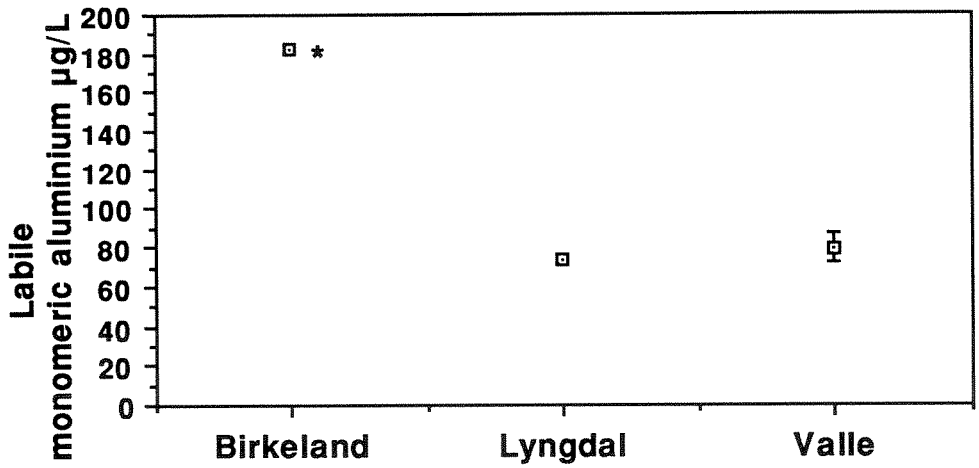

Figure 3. Mean inorganic monomeric aluminium concentration (µg/L) in each of the three regions. S.E. shown. * indicates significant difference ($p<0.05$)

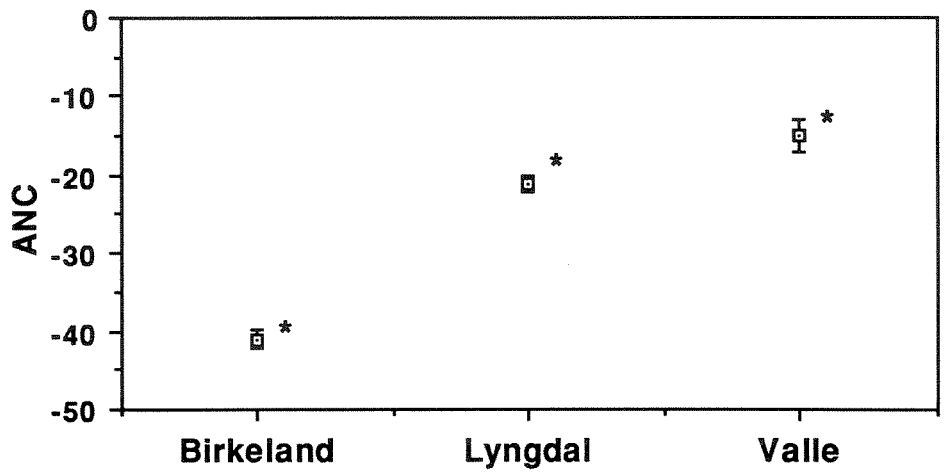

Figure 4. Mean ANC (µeq/L) in each of the three regions. S.E. shown. * indicates significant difference ($p<0.05$)

3.3.2. pH

3.3.2.1. Birkeland region

pH measured in the Birkeland region lakes is shown in Figure 5. The pH of Mørkelivatn was seldom higher than pH 4.6, a pH level only common during the winter for the other two lakes.

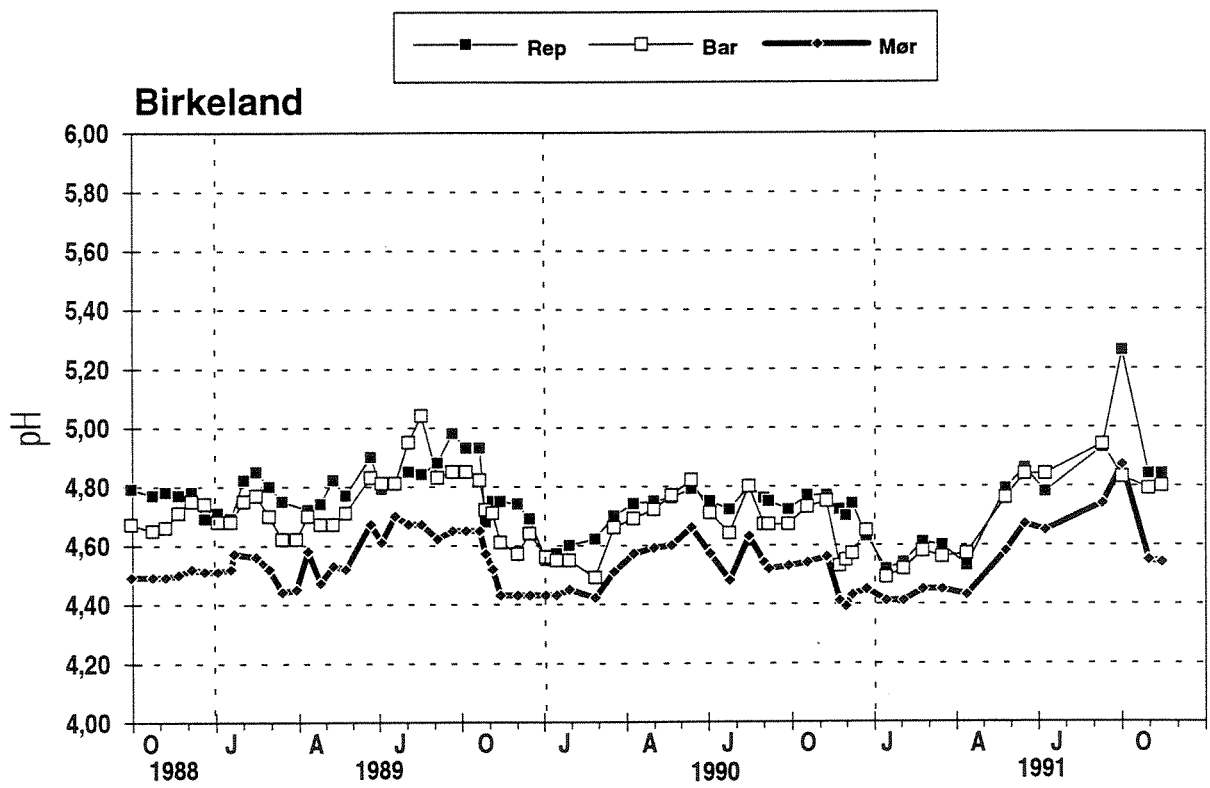

Figure 5. pH measured in Barkevatn, Repstadvatn and Mørkelivatn (Birkeland region) between October 1988 and November 1991.

3.3.2.2. Lyngdal region

pH measured in the Lyngdal region lakes is shown in Figure 6. Trollselvvatn had a significantly lower mean pH than the other lakes. Mjåvatn had higher mean pH than Sandvatn, but was not significantly different ($p>0.05$) from the other lakes. Trollselvvatn was clearly the most acidic lake but had a mean pH in 1989 not very different from the other lakes. Mjåvatn generally had the highest pH, but did experience very acidic water during autumn.

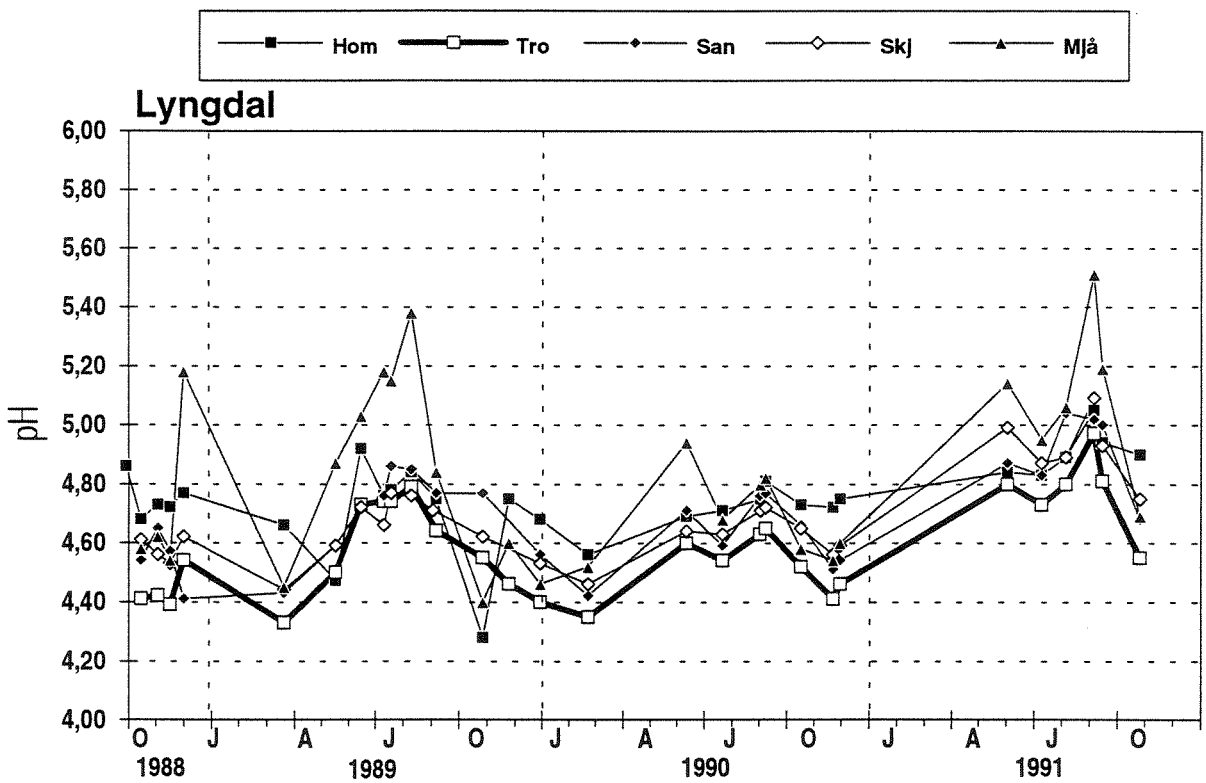

Figure 6. pH measured in Homsvatn, Mjåvatn, Skjekelivatn, Sandvatn and Trollselvvatn (Lyngdal region) between September 1988 and October 1991.

3.3.2.3. Valle/Njardarheim region

pH measured in the Valle/Njardarheim region lakes is shown in Figure 7. There is no significant difference ($p>0.05$) between the mean pH of the five lakes in the Valle/Njardarheim region, but Hyttetjørni would have been significantly more acidic than the other lakes had it not been for the high pH levels recorded in 1991. Hyttetjørni, as such, stands out as different from the other lakes. For all the lakes, summer pH values tend to be higher than spring values.

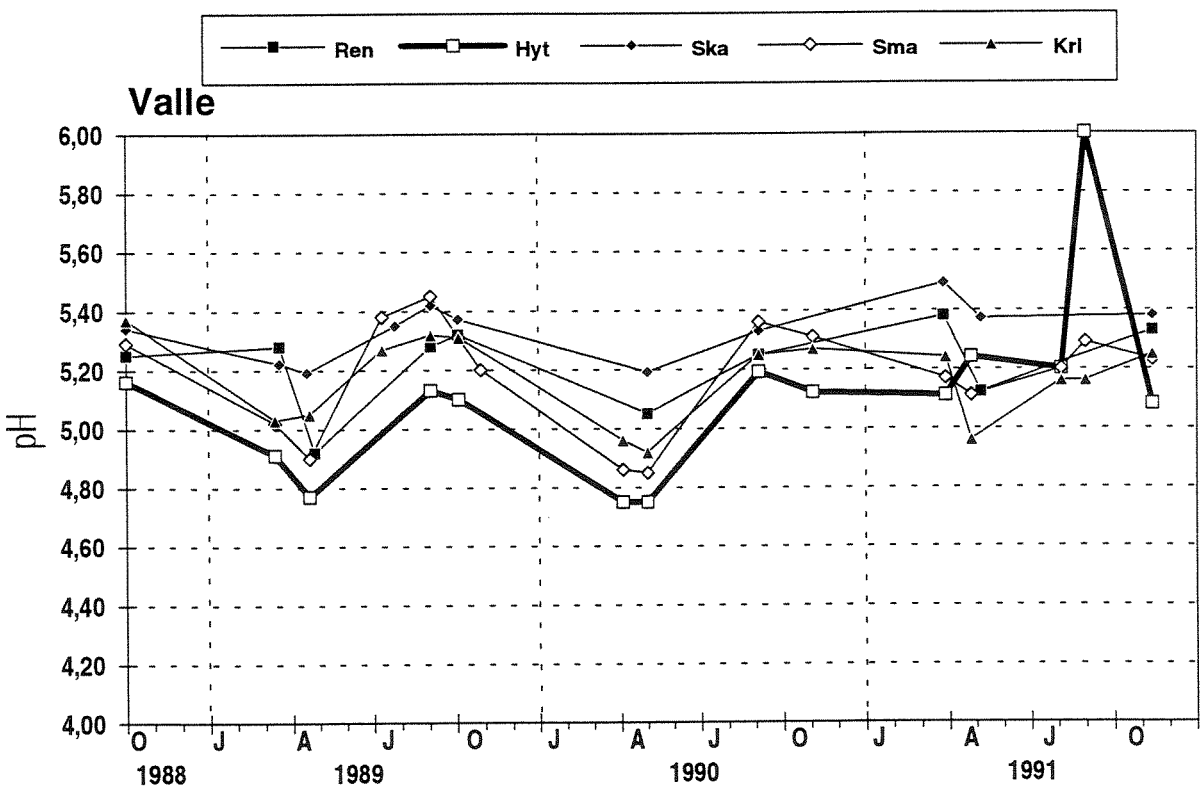

Figure 7. pH measured in Rennevatn, Hyttetjørni, Skammevatn, Smalevatn and Kringlevatn (Valle/Njardarheim region) between September 1988 and October 1991.

3.3.3. Calcium concentrations

3.3.3.1. Birkeland region

Calcium concentrations measured in the Birkeland region lakes are shown in Figure 8. Mørkelivatn had significantly ($p<0.05$) lower mean calcium concentrations than Repstadvatn and Barkevatn. Calcium concentrations tended to increase in autumn in all the lakes, while, in general, lower concentrations were recorded during summer, when the pH was highest (Figure 5-7).

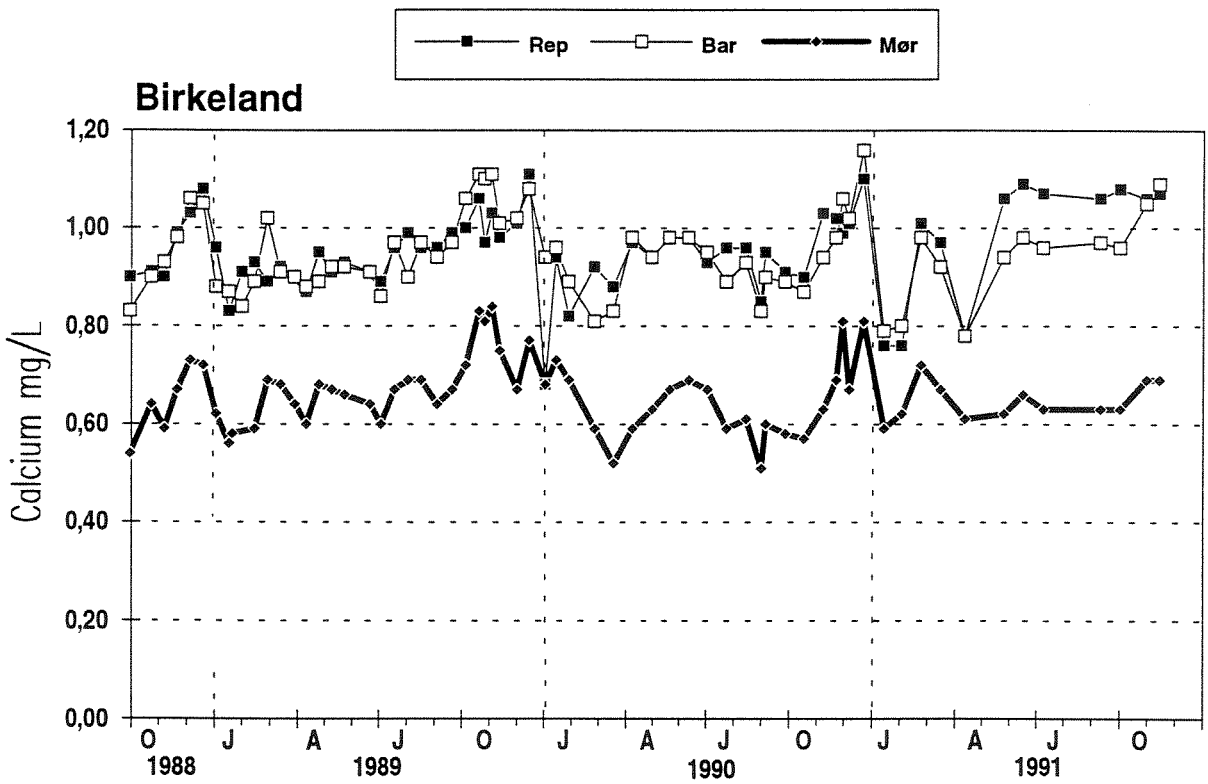

Figure 8. Calcium concentrations measured in Repstadvatn, Barkevatn and Mørkelivatn (Birkeland region) between October 1988 and November 1991.

3.3.3.2. Lyngdal region

Calcium concentrations measured in the Lyngdal region lakes are shown in Figure 9. Trollselvvatn had significantly lower ($p<0.05$) mean calcium concentrations than the other lakes. Mjåvatn and Homsvatn had similar and "high" concentrations, while Skjekelivatn and Sandvatn were similar with intermediate concentrations. There appeared not to be any clear seasonal trend in calcium concentration, although higher concentrations were recorded in 1989 than in following years.

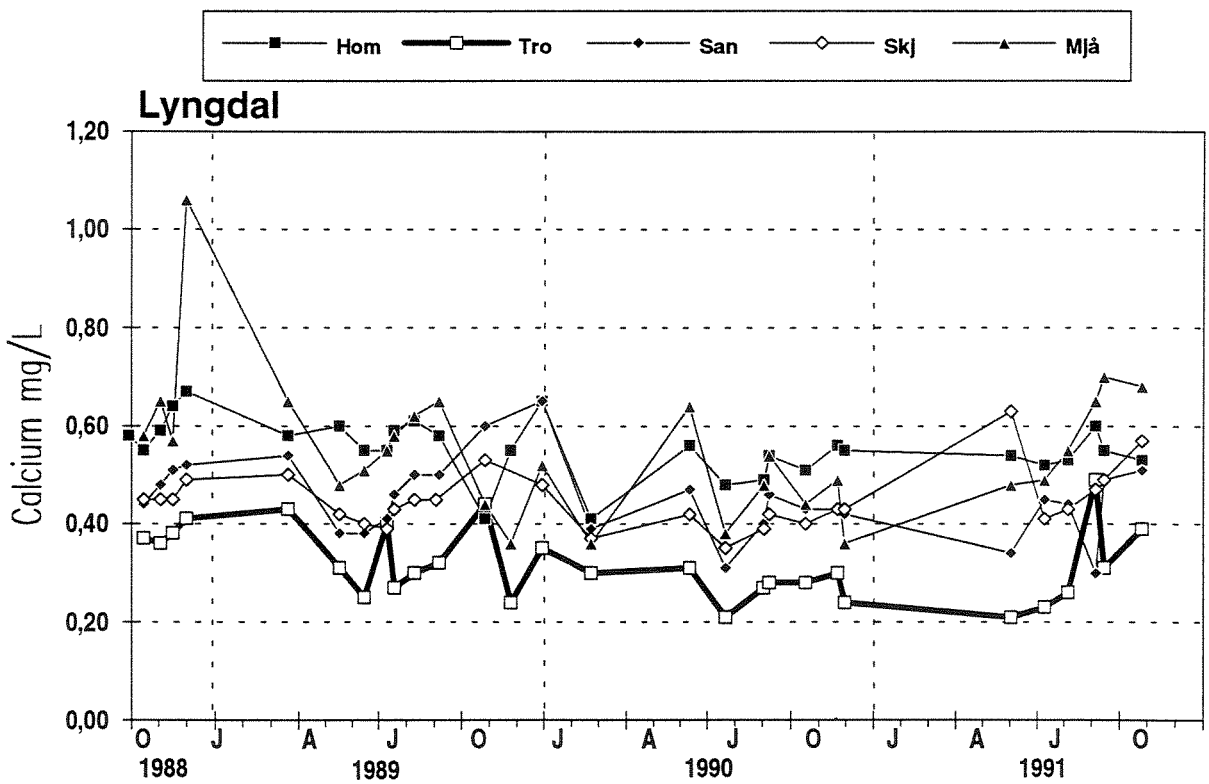

Figure 9. Calcium concentrations measured in Homsvatn, Mjåvatn, Skjekelivatn, Sandvatn and Trollselvvatn (Lyngdal region) between September 1988 and October 1991.

3.3.3.3. Valle/Njardarheim region

Calcium concentrations measured in the Valle/Njardarheim region lakes are shown in Figure 10. Rennevatn had significantly higher ($p<0.05$) mean calcium concentrations than other lakes, which all had similar concentrations. The concentrations were highest during summer and lower during winter. The spring concentrations in 1991 were slightly lower than spring concentrations recorded in previous years.

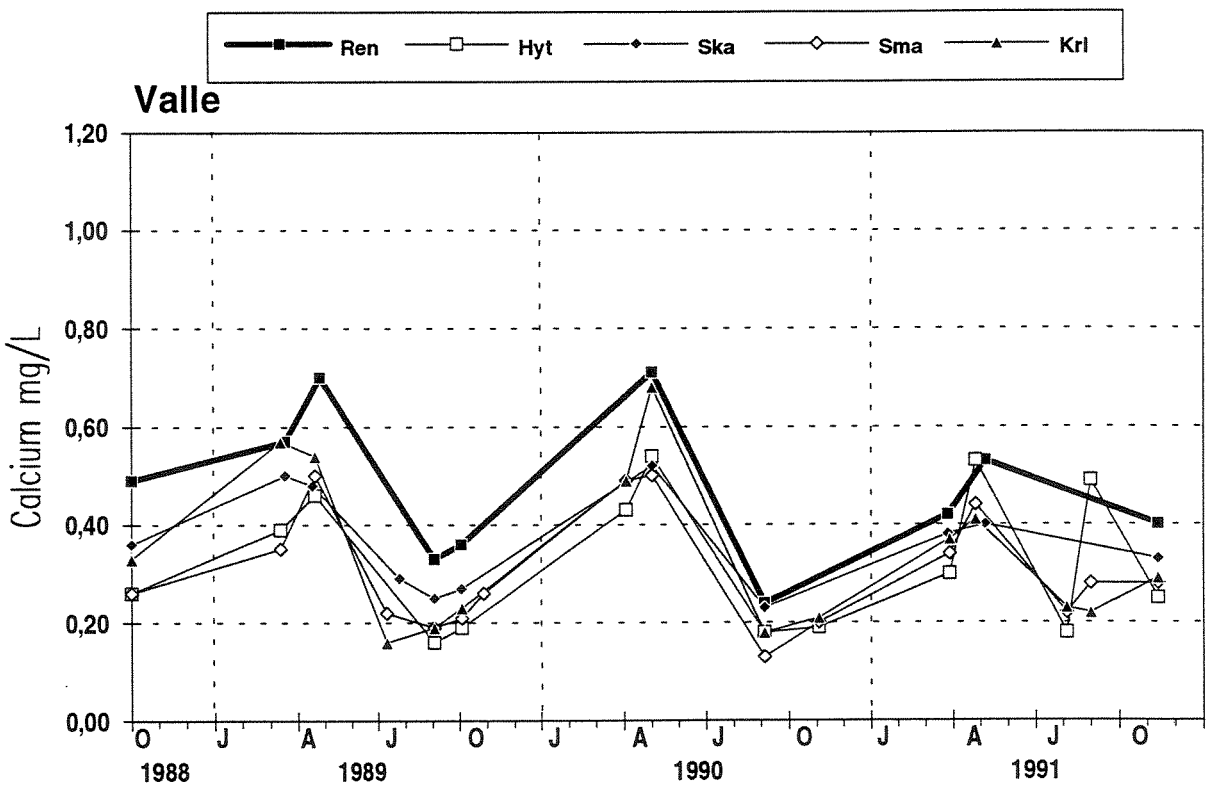

Figure 10. Calcium concentrations measured in Rennevatn, Hyttetjørni, Skammevatn, Kringlevatn and Smalevatn (Valle/Njardarheim region) between September 1988 and October 1991.

3.3.4. Inorganic monomeric aluminium

3.3.4.1. Birkeland region

Inorganic monomeric aluminium (Al_i) concentrations measured in the Birkeland region lakes are shown in Figure 11. Concentrations were similar for all three lakes. There were large seasonal variations, with lower Al_i concentrations recorded during late summer and higher concentrations during winter. Concentrations in October of 1991 were slightly lower than recorded in previous years, which may have been due to the higher pH values recorded that year than in other years.

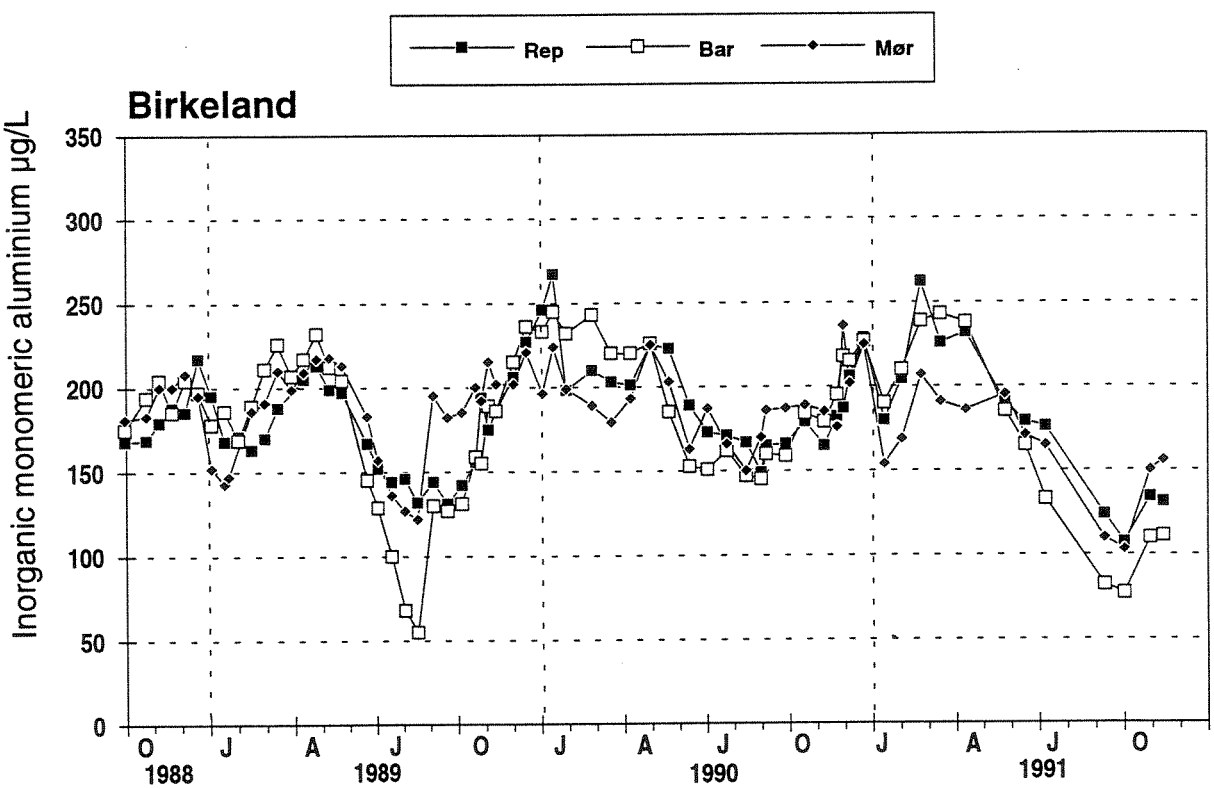

Figure 11. Al_i concentrations measured in Repstadvatn, Barkevatn and Mørkelivatn (Birkeland region) between October 1988 and November 1991.

3.3.4.2. Lyngdal region

Inorganic monomeric aluminium (Al_i) concentrations measured in the Lyngdal region lakes are shown in Figure 12. Homsvatn had significantly higher ($p<0.05$) mean Al_i concentrations than the other lakes, which all had similar concentrations. There was no clear seasonal variation in Al_i concentration.

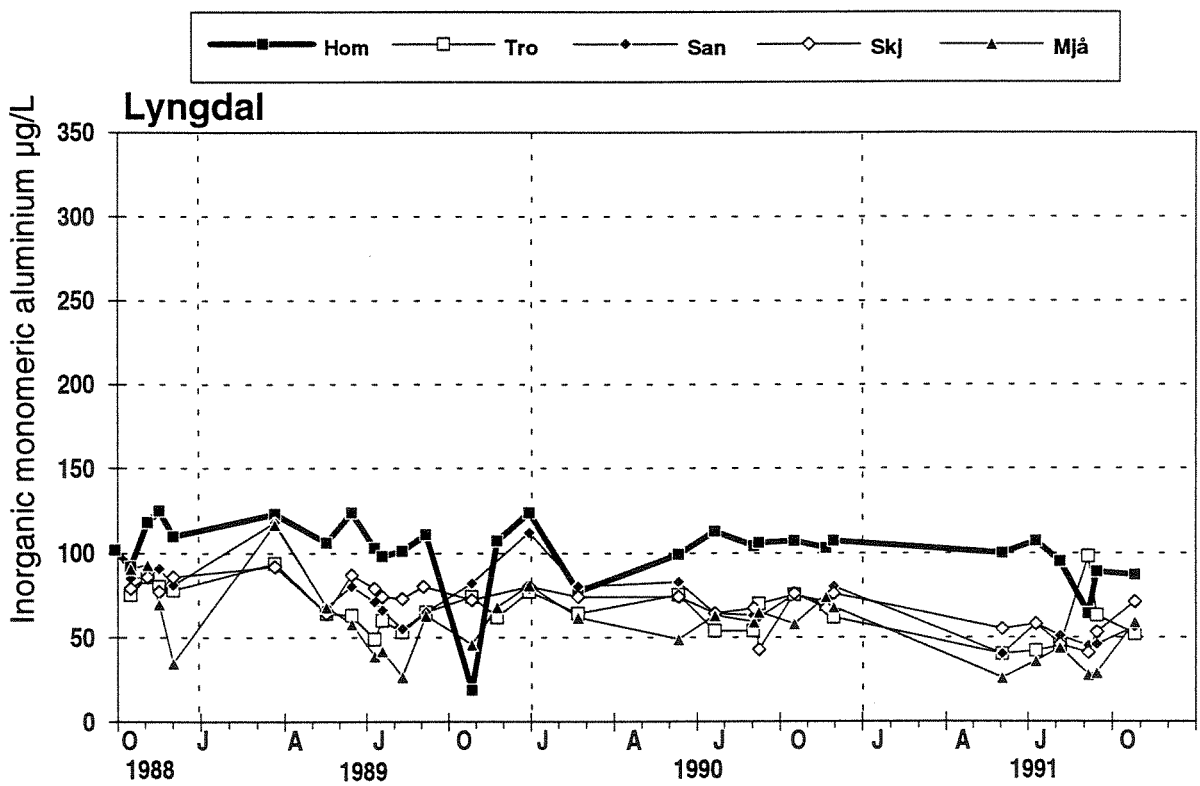

Figure 12. Al_i concentrations measured in Homsvatn, Mjåvatn, Skjekelivatn, Sandvatn and Trollselvvatn (Lyngdal region) between September 1988 and October 1991.

3.3.4.3. Valle/Njardarheim region

Inorganic monomeric aluminium (Al_i) concentrations measured in the Valle/Njardarheim lakes are shown in Figure 13. Rennevatn and Hyttetjørni had significantly higher ($p<0.05$) mean Al_i concentrations than the other lakes; concentrations recorded in Rennevatn were significantly higher ($p<0.05$) than those of Hyttetjørni. Large seasonal variations were obvious, with higher concentrations occurring in spring and lower concentrations during summer.

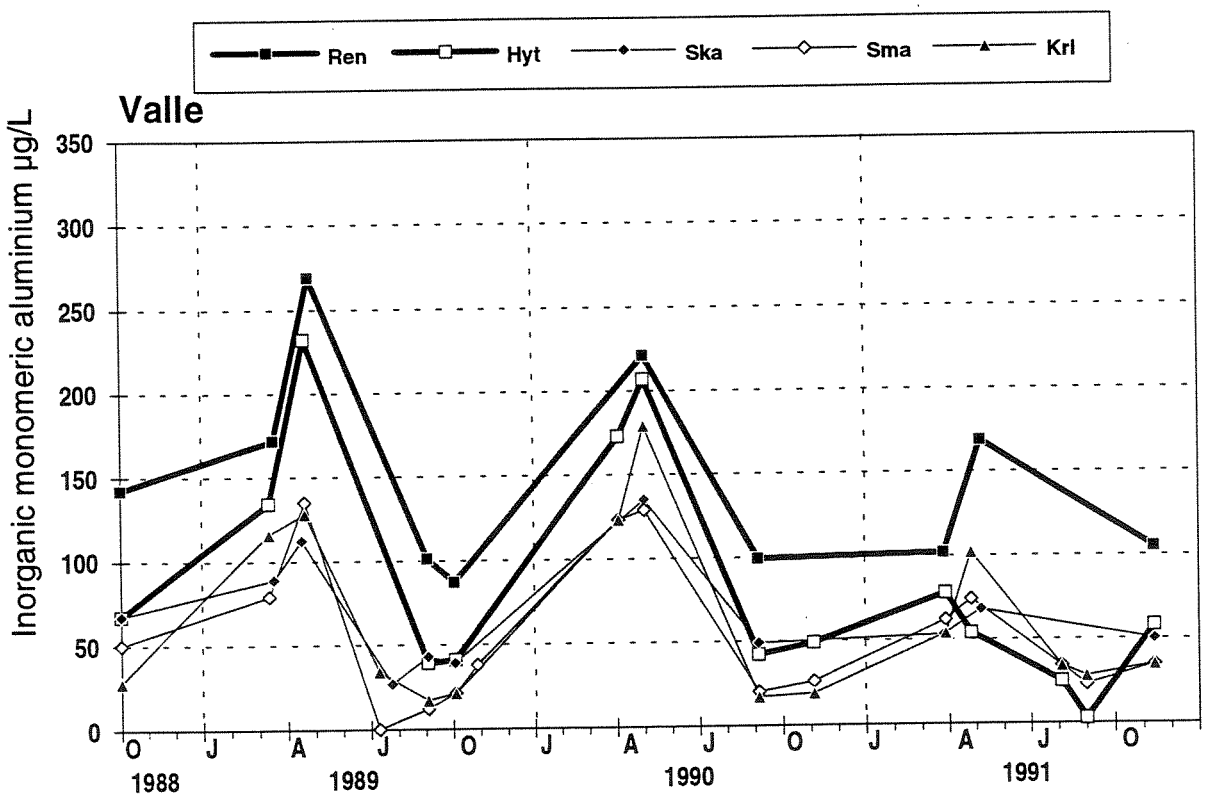

Figure 13 Al_i concentrations measured in Rennevatn, Hyttetjørni, Skammevatn, Kringlevatn and Smalevatn (Valle/Njardarheim region) between September 1988 and October 1991.

3.3.5. Acid neutralizing capacity (ANC)

3.3.5.1. Birkeland region

ANC measured in the Birkeland region lakes are given in Figure 14. Mørkelivatn had significantly lower ($p<0.05$) mean ANC than Repstadvatn and Barkevatn, which had similar values. No clear seasonal trend is obvious. Low ANC (< -50 µeq l/L) was recorded in all the lakes in winter 1989/90. ANC increased again during 1990.

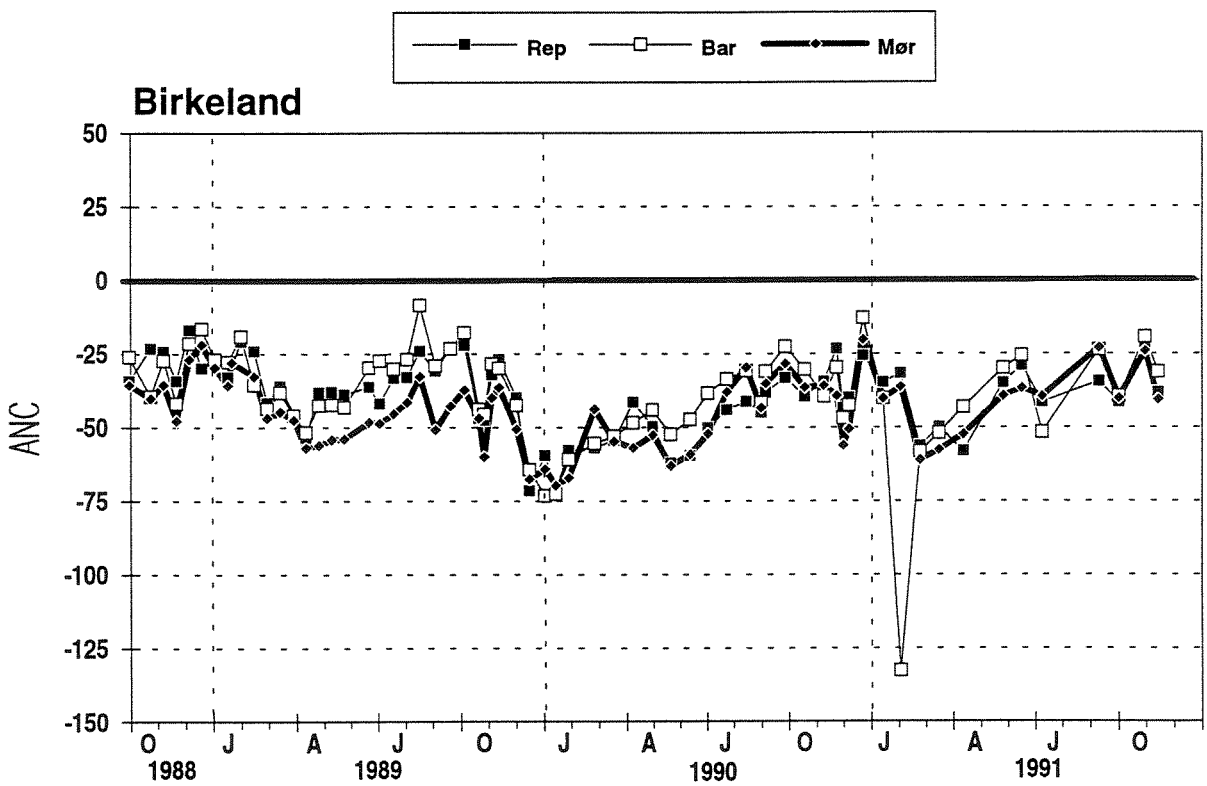

Figure 14. ANC measured in Repstadvatn, Barkevatn and Mørkelivatn (Birkeland region) between October 1988 and November 1991.

3.3.5.2. Lyngdal region

ANC measured in the Lyngdal region lakes are shown in Figure 15. Homsvatn had significantly lower ($p<0.05$) mean ANC than the other lakes. Mjåvatn had significantly higher ($p<0.05$) mean ANC than the other lakes. Intermediate ANC values were recorded in Skjekelivatn, Sandvatn and Trollselvvatn. Some seasonal variation is apparent, with lower values in winter/spring and higher values in summer.

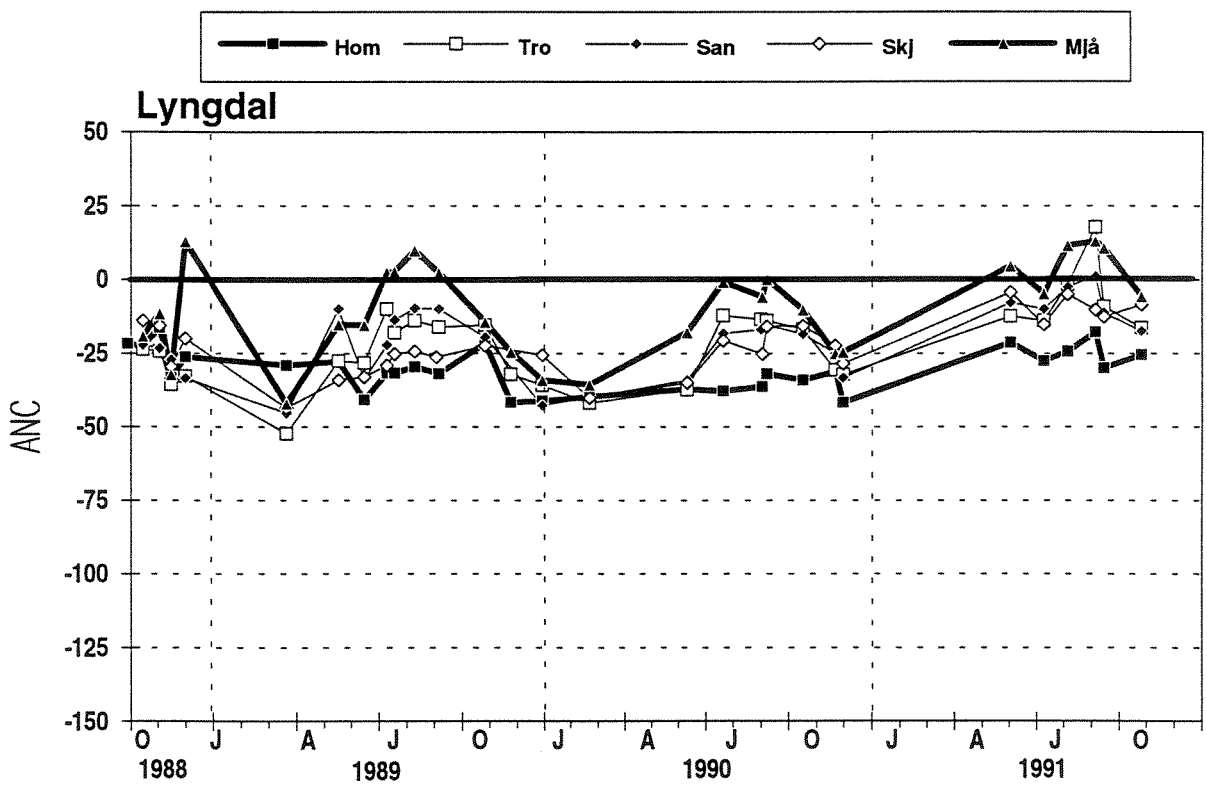

Figure 15. ANC measured in Homsvatn, Mjåvatn, Skjekelivatn, Sandvatn and Trollselvvatn (Lyngdal region) between September 1988 and October 1991.

3.3.5.3. Valle/Njarhardeim region

ANC measured in the Valle/Njarhardheim region lakes are shown in Table 16. There were no significant differences ($p<0.05$) in mean ANC between the lakes. Some seasonal variation was obvious, with higher values in late summer and lower values in spring. There seems to be a general trend towards higher ANC levels in 1991 than recorded the previous years.

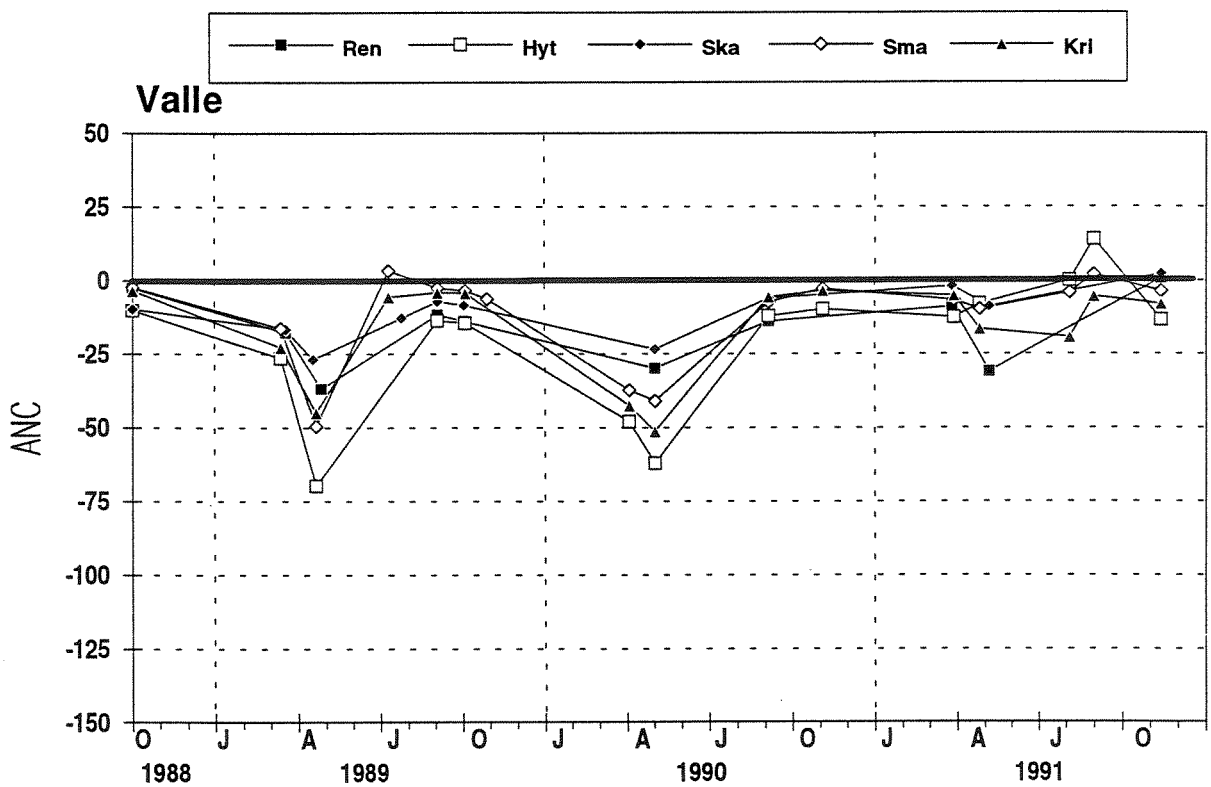

Figure 16. ANC measured in Rennevatn, Hyttetjørni, Skammevatn, Kringlevatn and Smalevatn (Valle/Njardarheim region)between September 1988 and October 1991.

3.3.6. Comparisons between lakes

Comparisons of water chemistry of all lakes in each of the regions are presented in Tables 4, 5 and 6. Significant differences ($p<0.05$) between lakes are shaded.

3.3.6.1. pH

pH comparisons are shown in Table 4. The mean pHs of both Repstadvatn and Barkevatn were not significantly different ($p<0.05$) from Mjåvatn and Homsvatn. Barkevatn did not differ from Sandvatn and Skjekelivatn, and Mørkelivatn did not differ from Trollselvvatn. Apart from these instances, there were significant differences in mean pHs ($p<0.05$) between lakes. pHs were most similar between lakes in the Lyngdal and Birkeland regions.

3.3.6.2. Calcium

Calcium concentration comparisons are shown in Table 4. The low calcium concentrations in Trollselvvatn were not significantly different ($p>0.05$) from those of Hyttetjørni, Skammevatn, Kringlevatn or Smalevatn. Mean calcium concentrations in Sandvatn and Skjekelivatn were similar to Rennevatn. There were significant differences ($p<0.05$) in the mean calcium concentrations for other combinations of lakes. There was some similarity in the mean calcium concentrations of lakes in the Lyngdal and Valle/Njardarheim regions.

3.3.6.3. Inorganic monomeric aluminium

Comparisons of inorganic monomeric aluminium concentrations are shown in Table 5. Mjåvatn, Skammevatn, Kringlevatn and Smalevatn all had similar low Al_i concentrations. Trollselvvatn, Sandvatn and Skjekelivatn were not significantly different ($p>0.05$) from Hyttetjørni, Skammevatn, Kringlevatn and Smalevatn. Homsvatn was similar to Hyttetjørni. Mean Al_i concentrations in lakes in the Lyngdal and Valle/Njardarheim regions were similar.

3.3.6.4. TOC

Comparisons of TOC concentrations are shown in Table 5. The TOC of Repstadvatn was similar to that of Homsvatn, and Sandvatn and Skjekelivatn were similar to Barkevatn and Mørkelivatn. TOC concentrations varied to a large extent between lakes.

3.3.6.5. ANC

Comparisons of lake ANC are shown in Table 6. Trollselvvatn, Sandvatn and Skjekelivatn had similar mean ANCs to Rennevatn, Hyttetjørni and Kringlevatn. The high mean ANC in Mjåvatn was similar to that of Rennevatn, Skammevatn, Kringlevatn and Smalevatn. ANC varied greatly within both the Lyngdal and Valle regions and was low in the Birkeland region.

TABLE 4 Comparisons of mean lake water pH and calcium concentrations. Significant differences ($p<0.05$) are shaded.

MEAN DIFFERENCE **1988-1991** **pH**

CALCIUM	Mjåvatn	Homsvatn	Trollselvvatn	Sandvatn	Skjekellvatn	Repstadvatn	Barkellvatn	Mørkllvatn	Rennevatn	Hyttetjørni	Skammevatn	Kringlevatn	Smalevatn
Mjåvatn		0.06	0.23	0.12	0.11	0.13	0.18	0.33	-0.37	-0.31	-0.49	-0.28	-0.30
Homsvatn	0.00		0.17	0.06	0.05	0.07	0.12	0.27	-0.43	-0.37	-0.55	-0.34	-0.36
Trollselvvatn	0.24	0.24		-0.11	-0.12	-0.10	-0.05	0.10	-0.60	-0.53	-0.72	-0.50	-0.53
Sandvatn	-0.10	0.10	-0.13		-0.01	0.01	0.07	0.20	-0.49	-0.42	-0.60	-0.39	-0.42
Skjekellvatn	-0.11	0.11	-0.13	0.00		0.02	0.07	0.22	-0.48	-0.42	-0.60	-0.39	-0.41
Repstadvatn	-0.40	-0.40	-0.64	-0.50	-0.51		0.06	0.20	-0.48	-0.63	-0.59	-0.62	-0.65
Barkellvatn	-0.40	-0.39	-0.63	-0.50	-0.50	0.01		0.14	-0.47	-0.62	-0.58	-0.61	-0.64
Mørkllvatn	-0.11	-0.10	-0.34	-0.21	-0.21	0.30	0.29		-0.18	-0.33	-0.29	-0.32	-0.62
Rennevatn	0.08	0.08	-0.16	-0.02	-0.03	0.51	0.48	0.19		0.07	-0.12	0.09	0.07
Hyttetjørni	0.23	0.23	-0.08	0.13	0.12	0.62	0.60	0.31	0.15		-0.18	0.03	0.01
Skammevatn	0.19	0.19	-0.05	0.09	0.08	0.58	0.55	0.26	0.11	-0.04		0.21	0.19
Kringlevatn	0.21	0.21	-0.02	0.11	0.11	0.62	0.60	0.31	0.14	-0.02	0.03		-0.04
Smalevatn	0.25	0.25	-0.10	0.15	0.14	0.64	0.62	0.33	0.17	0.02	0.06	-0.02	

Shaded = significant at 95% level, Fisher LSD

Shaded + border = significant at 95% level, Fisher LSD and Scheffe F-test

TABLE 5. Comparisons of mean lake water inorganic monomeric aluminium and TOC concentrations. Significant differences ($p<0.05$) are shaded.

1988-1991

MEAN DIFFERENCE — **Labile monomeric aluminium**

TOC	Mjåvatn	Homsvatn	Trollselvvatn	Sandvatn	Skjekellvatn	Repstadvatn	Barkellvatn	Mørkllvatn	Rennevatn	Hyttetjørni	Skammevatn	Kringlevatn	Smalevatn
Mjåvatn		43	7	14	12	-125	-122	-126	-89	-28	-8	-4	4
Homsvatn	-2.6		36	29	31	-82	-78	-83	-46	15	34	34	47
Trollselvvatn	-0.1	-2.5		-6	-4	-117	-114	-118	-81	-20	0	3	11
Sandvatn	-0.9	-1.8	0.7		2	-111	-108	-112	-75	-14	5	10	18
Skjekellvatn	3.1	-1.6	0.9	0.2		-112	-110	-114	-77	-16	3	8	16
Repstadvatn	2.3	-0.3	2.2	1.4	1.3		3	-1	-36	-97	-116	-121	-129
Barkellvatn	1.2	-1.4	1.1	0.4	0.2	-1.0		-4	-32	-93	-113	-117	-126
Mørkllvatn	0.8	-1.8	0.6	-0.1	-0.3	-1.5	-0.5		-37	-98	-117	-121	-121
Rennevatn	4.1	1.5	4.0	3.2	3.1	-1.8	-2.8	-3.4		61	80	84	93
Hyttetjørni	4.1	1.5	4.0	3.3	3.1	1.5	-2.9	-3.4	0.0		19	23	32
Skammevatn	3.5	0.9	3.4	2.7	2.5	-1.2	-2.3	-2.8	-0.6	-0.6		4	13
Kringlevatn	4.2	1.6	4.1	3.3	3.2	-1.9	-2.9	-3.4	0.1	0.1	0.6		-9
Smalevatn	3.8	1.2	3.7	2.9	2.8	-1.5	-2.6	-3.0	-0.3	-0.3	0.3	0.4	

Shaded = significant at 95% level, Fisher LSD

Shaded + border = significant at 95% level, Fisher LSD and Scheffe F-test

1988-1991

ANC

MEAN DIFFERENCE

	Mjåvatn	Homsvatn	Trollselvvatn	Sandvatn	Skjekellvatn	Repstadvatn	Barkellvatn	Mørklivatn	Rennevatn	Hyttetjørnl	Skammevatn	Kringlevatn	Smalevatn
Mjåvatn		-21	-11	-11	-12	30	29	35	7	11	1	6	2
Homsvatn			-9	-9	-8	9	9	14	-14	-10	-19	-14	-19
Trollselvvatn				0	1	18	18	21	-5	-1	-10	-5	-10
Sandvatn					1	18	18	23	-4	-1	-10	-4	-9
Skjekellvatn						17	17	22	-5	-2	-11	-6	-10
Repstadvatn							0	5	26	19	28	23	28
Barkellvatn								5	22	19	28	23	27
Mørklivatn									28	24	33	28	33
Rennevatn										4	-6	0	-5
Hyttetjørnl											-10	-4	-9
Skarr												5	1
Kr'													4

TABLE 6 Comparisons of mean lake water ANC concentrations. Significant differences ($p<0.05$) are shaded.

4. FISH CATCHES, 1988-1991

Fish catches from the lakes in each region between 1988 to 1991 are shown in Figures 17, 18 and 19.

4.1. BIRKELAND REGION

Catches in the three lakes in the Birkeland region are shown in Figure 17. Until 1990, no fish were caught. No brown trout have been caught in Mørkelivatn. Of the few fish which have been caught in this region, most have been of the Bygland strain.

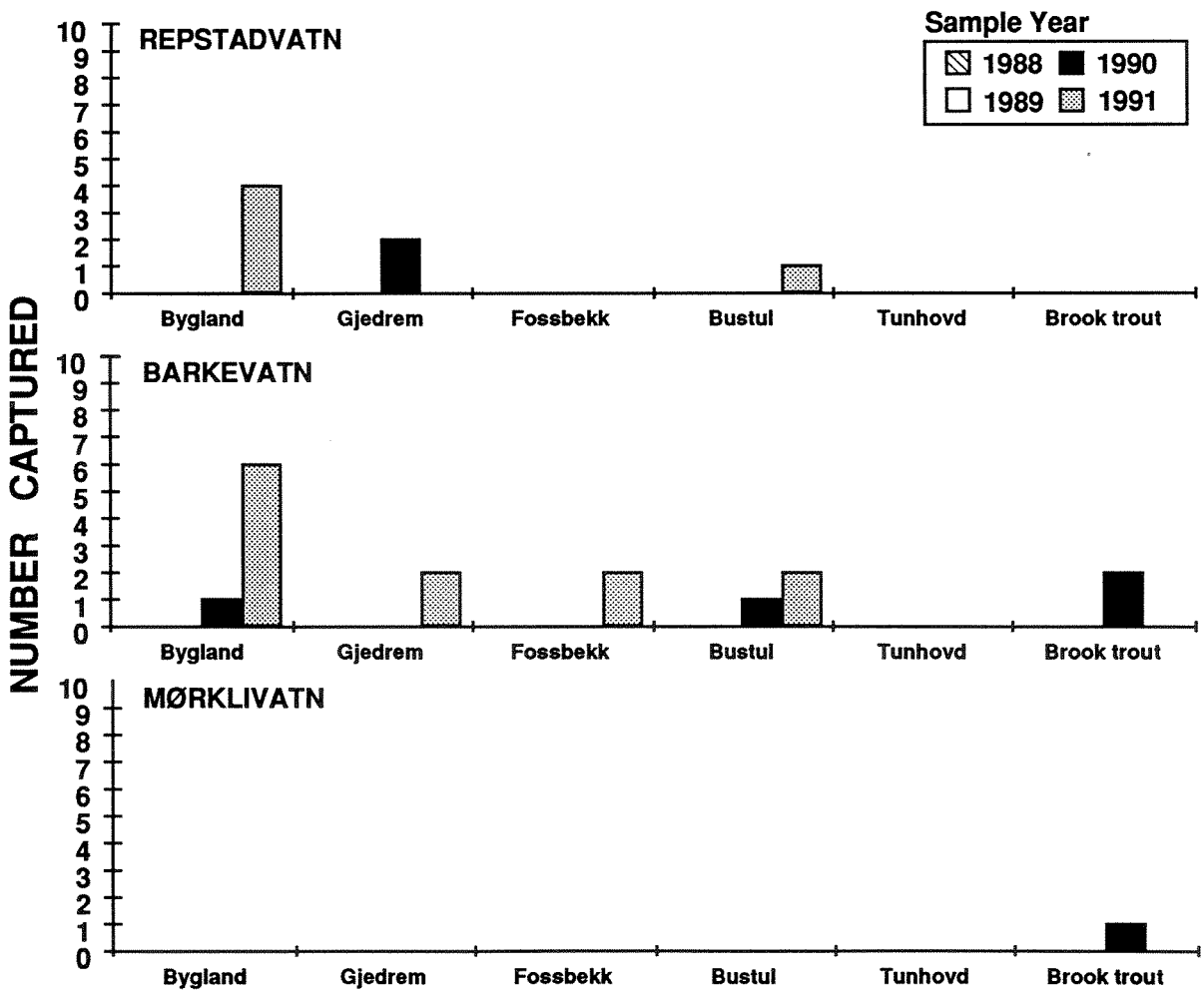

Figure 17. Brook trout and stocked brown trout caught in lakes in the Birkeland region between 1988 and 1991.

4.2. LYNGDAL REGION

Catches in the five lakes in the Lyngdal region are shown in Figure 18. No brown trout have been caught in Trollselvvatn.

Brook trout were stocked in Lake Homsvatn in 1987, a year before the start of the ReFish project. Since then, as apparent from the results of testfishing, the brook trout have migrated downstream and have been caught subsequently in the other lakes in the region.

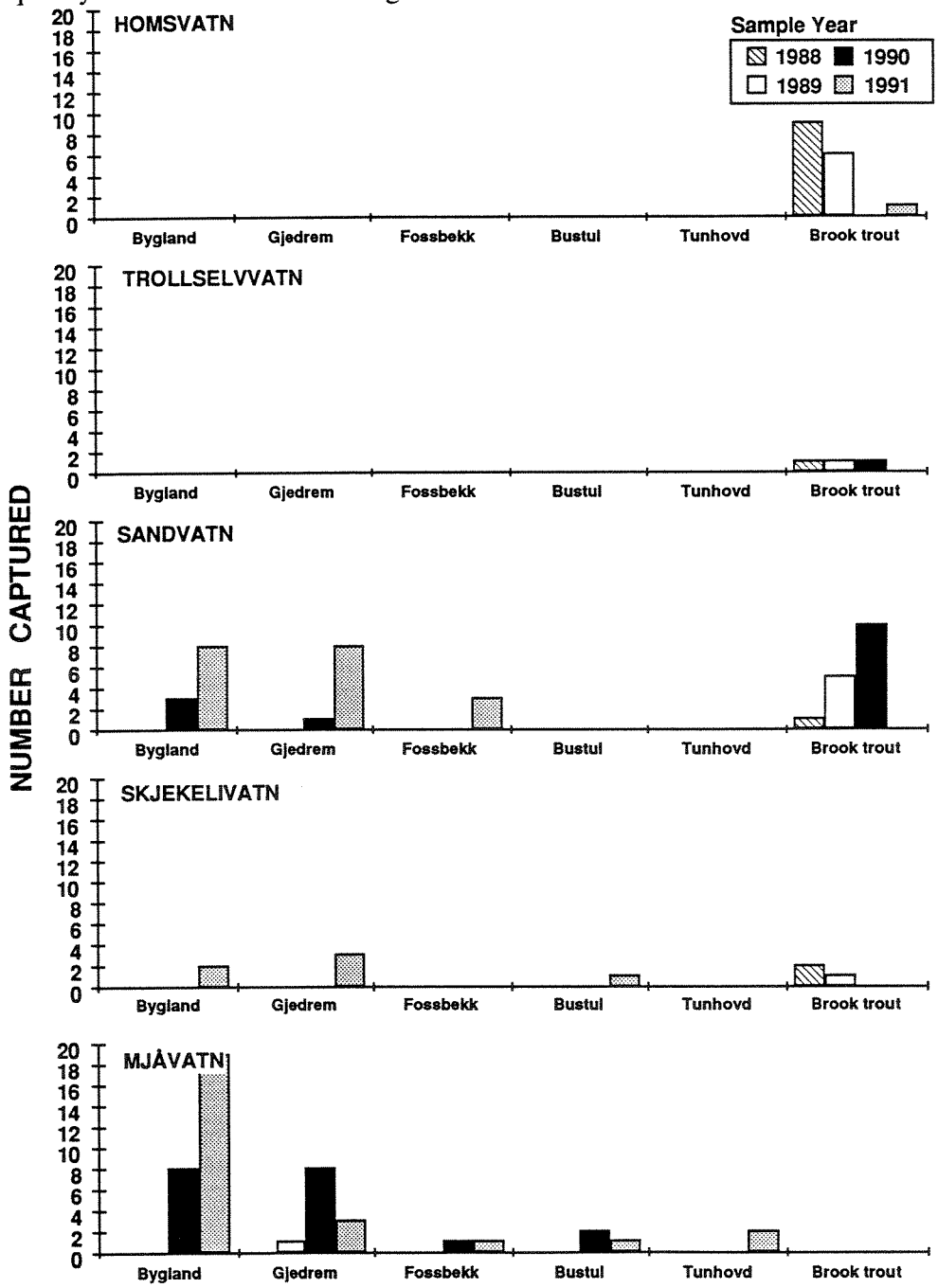

Figure 18. Brook trout and stocked brown trout caught in lakes in the Lyngdal region between 1988 and 1991

4.3. VALLE/NJARDARHEIM REGION

Catches in the five lakes in the Valle/Njardarheim region are shown in Figure 19. Stocked brown trout have been caught in only three of the lakes in this region. In Skammevatn only Bygland strain fish have been caught. One Bygland and one Gjedrem strain fish were caught in 1991 from Kringlevatn. In Smalevatn fish from all strains except Bustul have been caught.

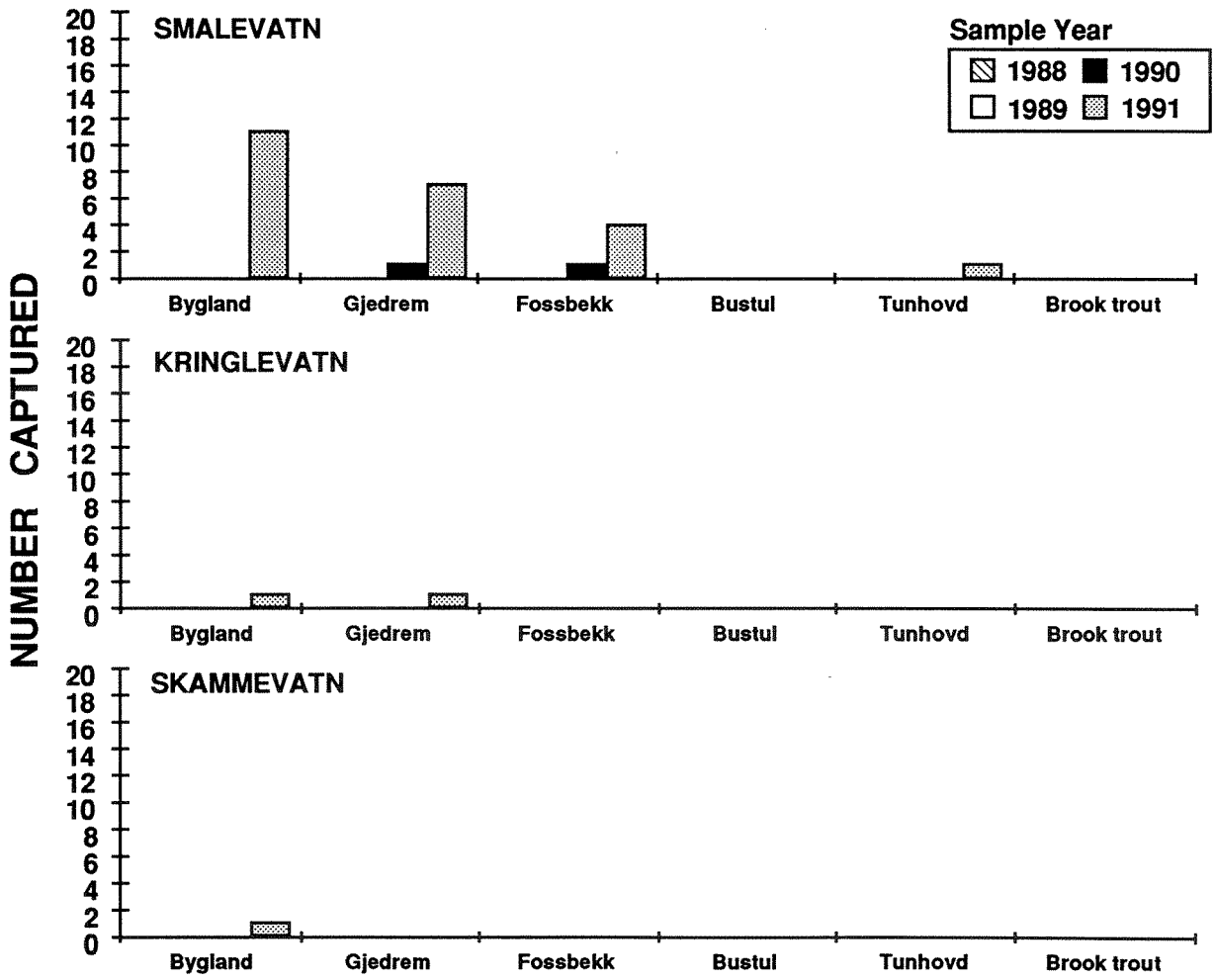

Figure 19. Brook trout and stocked brown trout caught in lakes in the Valle/Njardarheim region between 1988 and 1991

4.4. STRAIN-DEPENDENT CATCHES

The percentage contributions of the five strains to the total number of fish caught are shown in Figure 20. The Bygland strain dominated, contributing 51% of fish caught. Gjedrem fish made up 30% of the catches and Fossbekken, Bustul and Tunhovd strains each contributed 10% or less. The Figure has not been corrected for uneaven number of fish stocked from each strain in the different lakes.

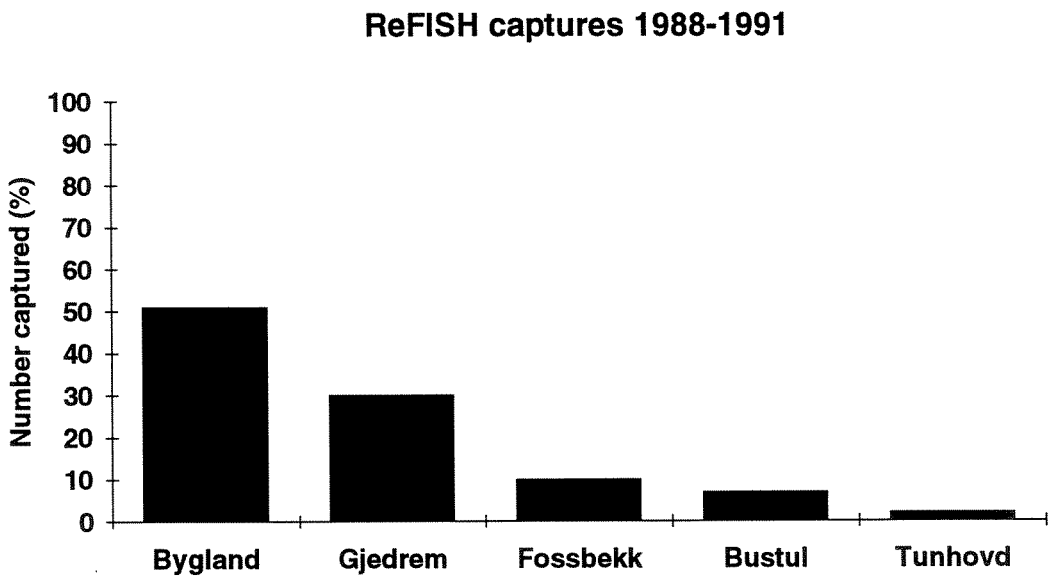

Figure 20. Percentage contribution of the five strains to the total number of fish caught between 1988 and 1991. (N.B. No Fossbekken strain fish were stocked in 1990, and a reduced number in 1988.)

5. FISH GROWTH

Estimates of absolute fish growth can be made from the mean length measurements of different age classes of caught fish. Length data from caught fish are given in Table 7. Fish ages were determined from scale and otolith samples. Since numbers of caught fish were small, mean lengths have been calculated for all fish of the same age class, irrespective of year of restocking or catch. Estimates of growth have been made for fish of the Fossbekken, Gjedrem and Bygland strains captured from each of the three regions.

TABLE 7 Mean lengths (and S.D.) of captured fish of Fossbekken, Gjedrem and Bygland strains from each of the three regions. Data for fish of the same age group (1+, 2+ and 3+) are irrespective of year of stocking or catch.

Region	Strain	Age	Length cm	S.D.	No. fish
Birkeland	**Fossbekk**	1+	-		
		2+	22,3	3,5	2
		3+	-		
	Gjedrem	1+	13,5		1
		2+	19,7	2,2	2
		3+	27,8		1
	Bygland	1+	13,2	2,2	5
		2+	17,9	1,6	4
		3+	22,8	0,8	2
Lyngdal	**Fossbekk**	1+	-		
		2+	21,6	3,7	4
		3+	29,5		1
	Gjedrem	1+	13,5	1,3	3
		2+	21,5	3	11
		3+	27,8	4,6	9
	Bygland	1+	13,5	1,9	13
		2+	20,6	2,9	18
		3+	24,4	2,3	9
Valle	**Fossbekk**	1+	8,9		1
		2+	17,2	2,7	4
		3+	-		
	Gjedrem	1+	-		
		2+	15,9	2,3	5
		3+	22,9	2,5	3
	Bygland	1+	9,9	1,3	8
		2+	15,9	2,5	5
		3+	-		

The differences in growth of fish of the Bygland and Gjedrem strains in Mjåvatn in the Lyngdal region, and Smalevatn in the Valle/Njardarheim region, are shown in Figure 21. There are no significant differences ($p<0.05$) in growth of fish of either strain within each region, but growth of both strains in Smalevatn (Valle/Njardarheim) is significantly less ($p<0.05$) than in Mjåvatn (Lyngdal). This may explain the greater number of captured fish in the Lyngdal region in 1990; fish become a catchable size earlier than in the Valle/Njardarheim region.

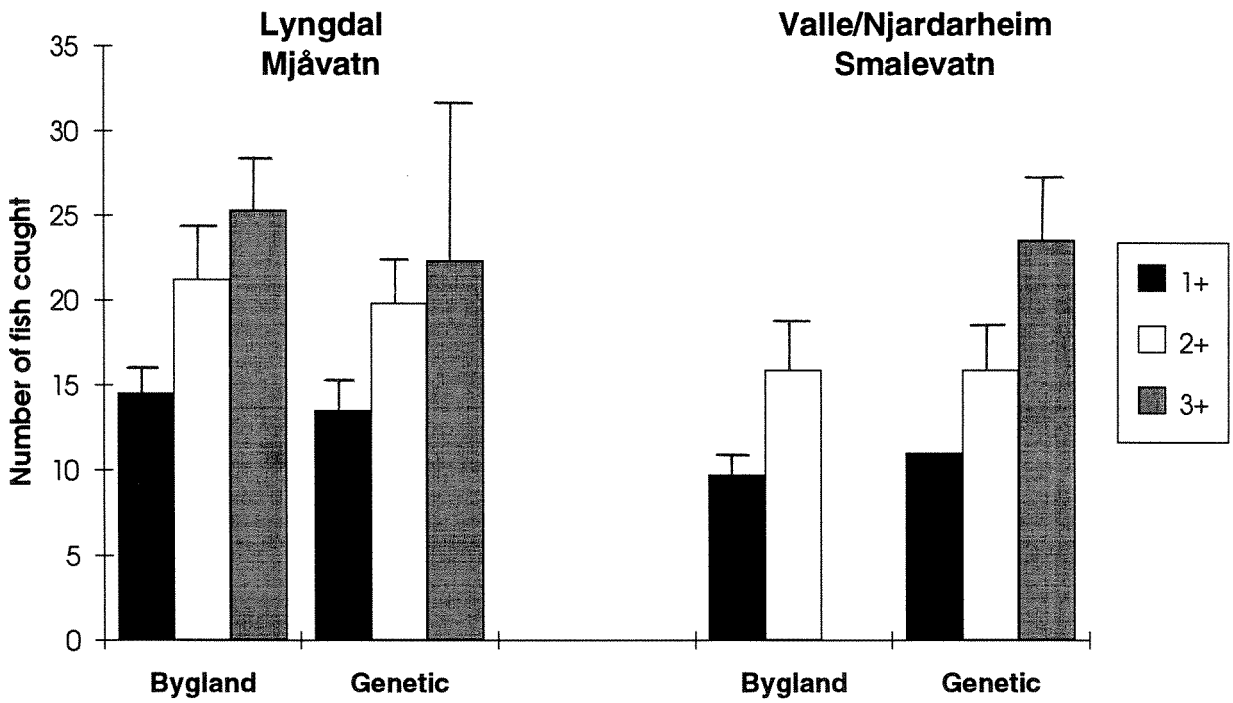

Figure 21. Comparison of growth of fish of the Bygland and Gjedrem strains caught in Mjåvatn (Lyngdal region) and Smalevatn (Valle/Njardarheim region). 1 S.D. shown.

6. FISH STOMACH CONTENTS

The stomach contents of all caught fish were analysed to assess diet composition. The data are shown in Figures 22, 23 and 24. The y-axis shows the percentage number of fish having eaten organisms of a taxonomic group and the x-axis shows the taxonomic group's contribution to the stomach content. The relative contribution from each taxon is volume corrected, increasing the importance of large food items and reducing the influence from zooplankton. All data are presented in Appendix 2.

6.1. BROOK TROUT

Brook trout were caught in Sandvatn, Trollselvvatn, Homsvatn, Mørkelivatn and Barkevatn. Corixids were common in the brook trout diets in all lakes. (Figure 22).

6.2. BROWN TROUT

In 1989 only one brown trout was caught (in Mjåvatn) and had zero stomach content. Therefore, data shown are from 1990 and 1991. The fish are not divided into strain or age as there was too little material to permit a detailed interpretation of the data. The results are presented for each region.

6.2.1. Birkeland region

Fish were caught in Barkevatn and Repstadvatn; four in 1990 and 17 in 1991. In Barkevatn Chaoborus was an important prey item in both years. Corixids were eaten only in 1990. In Repstadvatn Chaoborus was present only in 1990, together with Chironomids and Corixids (Figure 23). In 1991 Trichoptera were the dominant prey, together with Corixids (Figure 24).

The number of Chaoborus present in fish caught in the Birkeland region may indicate that the fish were feeding in the pelagic zone during nighttime, alternating with the profundal zone during the day, in response to the diurnal migration pattern recorded for Chaoborus species in the region. Feeding habits may explain the "low" catches of fish in this region in 1990, as littoral insects were plentiful only in 1991. The data may also indicate that fish density was higher in 1991 than in 1990, causing the fish to utilize a larger number of taxonomic groups.

6.2.2. Lyngdal region

23 fish were caught in Mjåvatn and Sandvatn in 1990 and in 52 Mjåvatn, Sandvatn and Skjekelivatn in 1991.

In Mjåvatn approximately 50% of the fish had zero stomach content in both 1990 (Figure 23) and 1991 (Figure 24). Six to eight taxonomic groups were represented, with Odonats and Corixids being the dominant food organisms in 1990, and Odonats and Megaloptera in 1991. The fish had also been eating zooplankton in 1991.

In Skjekelivatn, fish were caught only in 1991 (Figure 23). Corixids dominated as food item, together with a small proportion of Dytiscids and Trichoptera.

In Sandvatn only 80% of the fish had eaten in 1990, while all fish had eaten in 1991 (Figure 23). Corixids dominated as food item both years, together with a small amount of other littoral prey items.

The general impression is that fish were feeding in the littoral zone, both in 1990 and 1991. All taxa common in acidic lakes in the region were present in the fish stomachs. Corixids dominated as the prey item, but Odonarts, Dytiscids and Megaloptera were commonly present. The largest number of taxa was utilized in Mjåvatn, the lake also showing best fish survival. The high number of taxa fed upon in this lake could indicate increased competition for food, indicating a higher fish density than in the other 2 lakes sampled from this region. It is worth pointing out that fish from Mjåvatn were predating on zooplankton in 1991.

6.2.3. Valle/Njardarheim region

In 1990 two fish were caught in Smalevatn. In 1991 26 fish were captured in Smalevatn, Kringlevatn and Skammevatn. The stomach content of the one fish captured in Skammevatn was zero.

In Smalevatn, Odonata, Corixids and Dytescids were preyed upon in 1990 (Figure 23). In 1991 a large number of taxa were present in the stomachs, but only in 40% of the fish (Figure 24). Zooplankton and Megaloptera were the dominant prey items in 1991, together with a large number of Corixids, Dytescids, Trichoptera and terrestrial insects.

In Kringlevatn only two taxa were commonly preyed upon, with zooplankton being the dominant prey item (Figure 24). Trichoptera were present in low numbers.

The large number of zooplankton present in the stomachs of fish from the Valle/Njardarheim region indicates a different feeding strategy in the fish there compared with those from the Lyngdal and Birkeland regions.

Brook trout - 1990/91

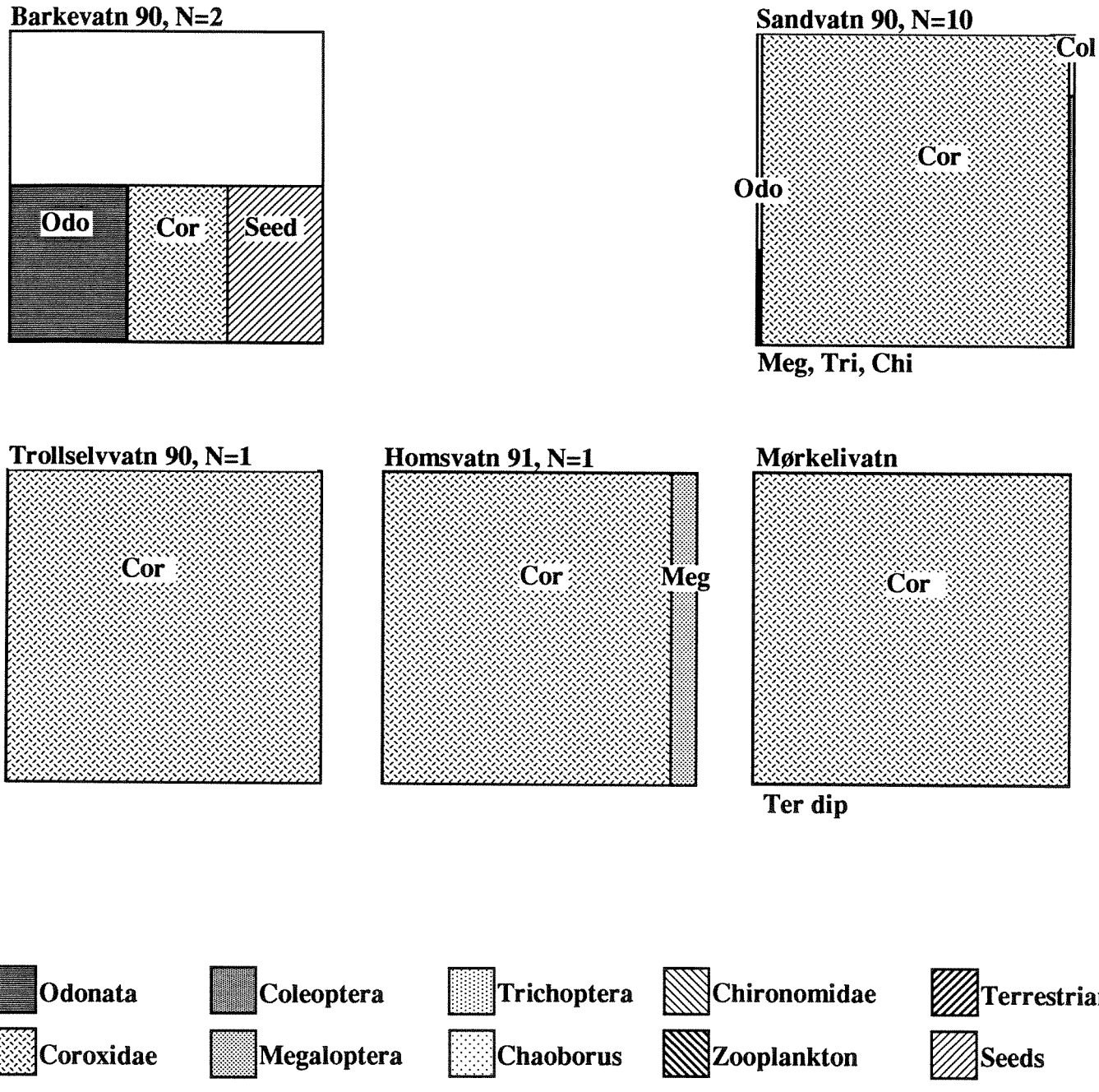

Figure 22 Diet composition of brook trout 1990-1991. The percentage of food item making up the total diet is presented on the x-axis and the percentage number of fish having eaten a food item is shown on the y-axis.

Brown trout - 1990

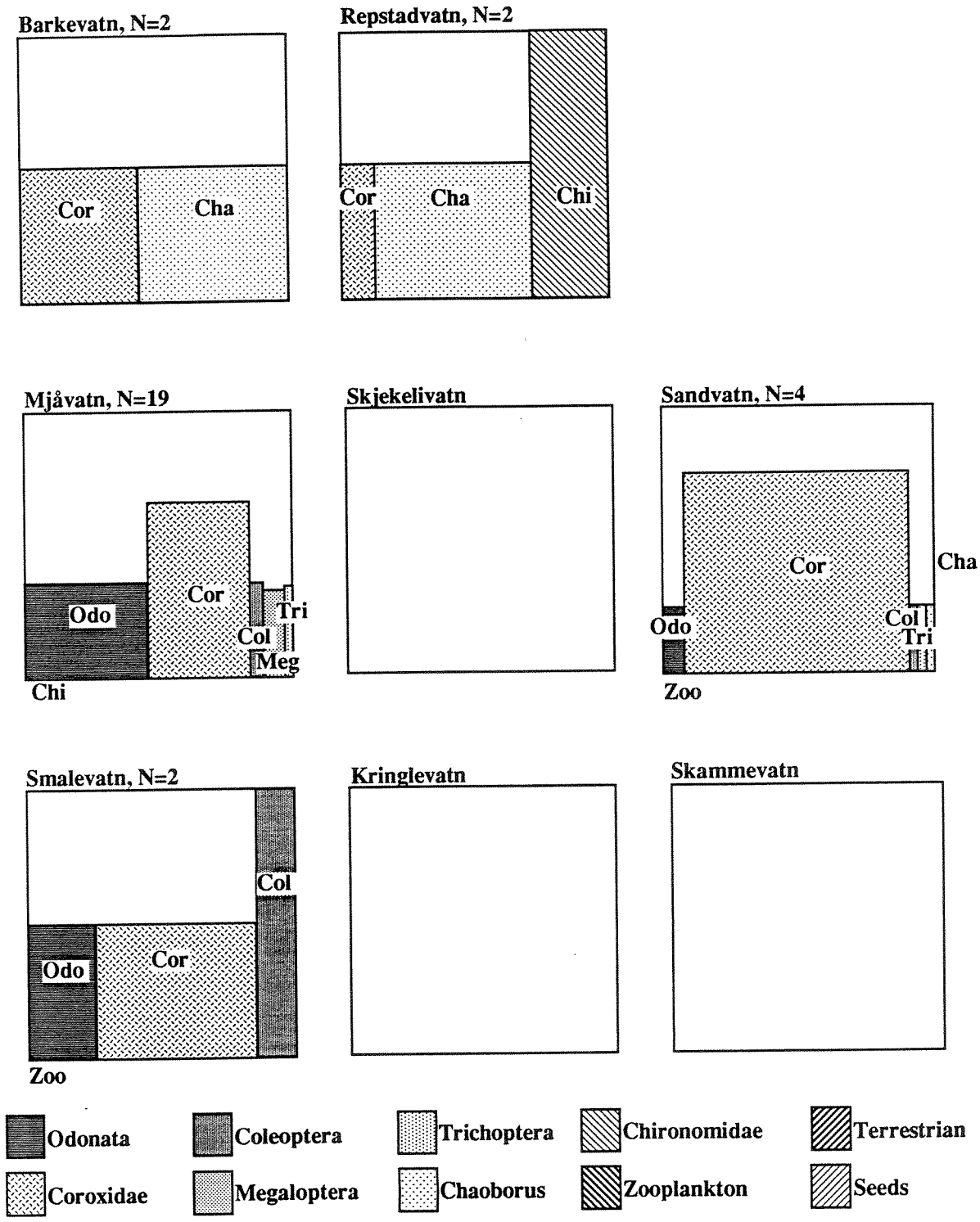

Figure 23. Diet composition of brown trout caught in 1990. The percentage of food item making up the total diet is presented on the x-axis and the percentage number of fish having eaten a food item is shown on the y-axis.

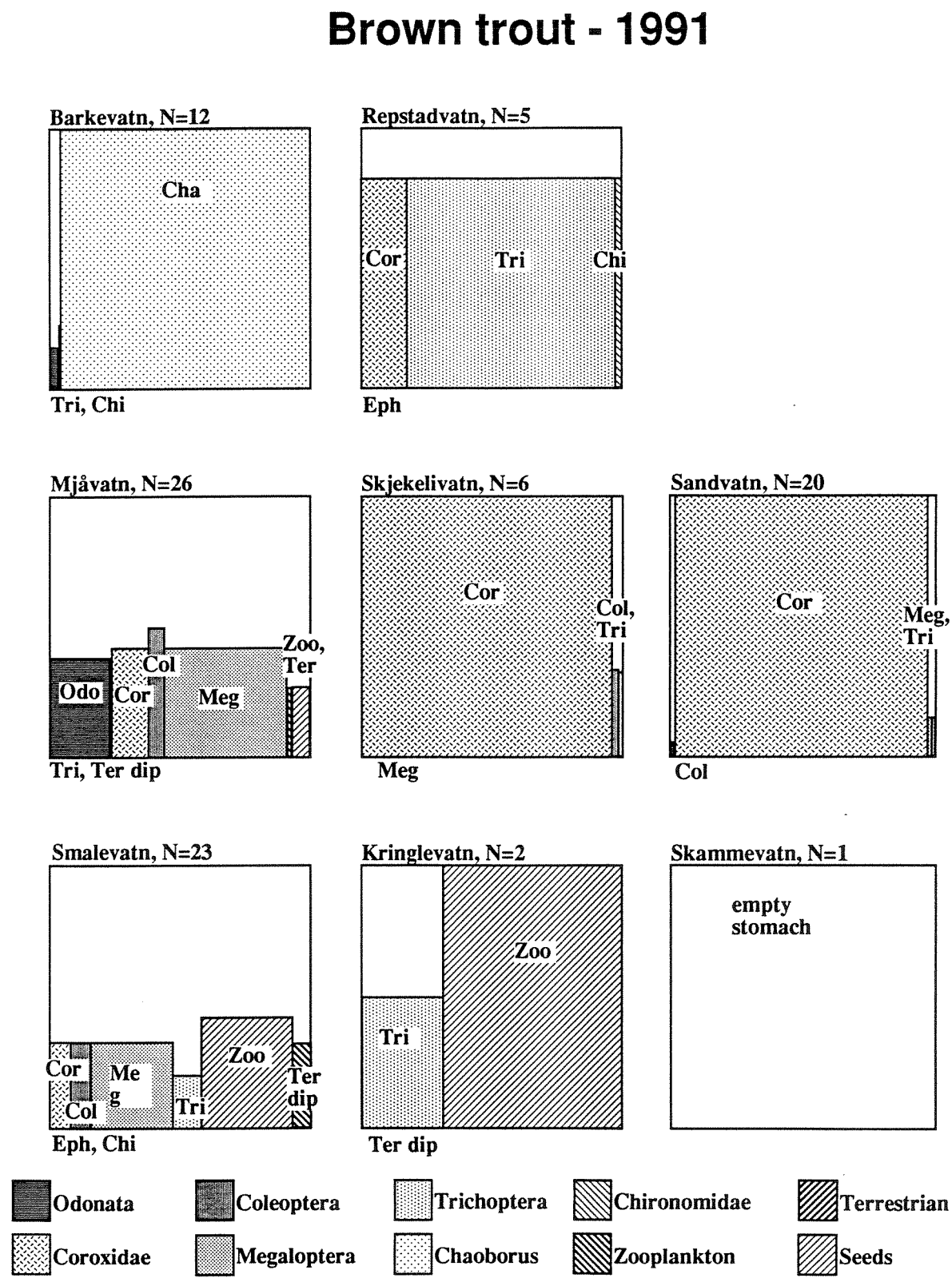

Figure 24. Diet composition of brown trout caught in 1991. The percentage of food item making up the total diet is presented on the x-axis and the percentage number of fish having eaten a food item is shown on the y-axis.

7. LABORATORY EXPERIMENTS

Eyed eggs of all the strains except Fossbekken were imported into the U.K. in 1990 and 1991 under quarantine conditions stipulated by the Ministry of Agriculture, Fisheries and Food (U.K.). The eggs were used in experiments simulating typical southern Norwegian water qualities to investigate survival through hatching to the swim-up stage, and growth and development. In place of the Fossbekken strain, which was unavailable, a strain of trout from Scotland was also used.

The experimental apparatus at PowerGen's Power Technology Centre near Nottingham is described by Dalziel and Lynam (1990). In brief, eggs and fry are subjected to carefully controlled water qualities simultaneously in a flow-through system under conditions of constant temperature and controlled light/dark regime

In 1990 the eggs were hatched and the fry reared for up to 10 weeks following hatching at 8^{o}C in a range of pH from 4.5 to 6.0 in the absence of aluminium. The calcium concentration was 0.5 mg/L. Low pH affected whole body ion concentrations and skeletal development of all the strains. Survival of all the strains with the exception of Bygland was impaired at the lowest pH tested. Skeletal development of the Bygland strain was slower than the other strains at all pHs. Full details and results of the experiment are given by Dalziel and Lynam (1991).

In 1991 the eggs were hatched and the fry reared for up to 10 weeks following hatching at 8^{o}C in a range of total aluminium concentrations from zero to 80 µg/L at either pH 4.7 or pH 5.3. The calcium concentration was once again 0.5 mg/L. The aluminium concentrations used had only marginal effects on survival but adversely affected whole body mineral concentrations and skeletal development in all strains at both pHs. Overall, the effects due to aluminium were not as severe as effects due to pH. Few inter-strain differences were determined, although impairment of skeletal calcification was less in the Tunhovd strain. Full details and results of the experiment are given by Dalziel and Lynam (1992).

8. DISCUSSION

All the lakes used for stocking and testfishing can be described as acidic (pH 4.5 - 5.2), aluminium-rich (50 - 180 µg/L as Al_i) and low in calcium (0.3 - 1.0 mg Ca/L). The lakes are typical and representative of lakes in three of the most acidified regions of Norway (Henriksen *et al.*, 1987). Based on common criteria for identifying acidic lakes it is reasonable to assume that the previously resident fish populations have been lost from the lakes because of acidification. The lakes in Birkeland supported a minor brown trout and perch populations up to the beginning of the 1980`s, but both Repstadvatn and Barkevatn had become barren by 1984 (Rosseland *et al.*, 1980. SFT 1985).

ANC can be used to classify lakes into water qualities having lethal, sub-lethal or no effect on fish (Lien *et al.*, 1992, Hesthagen *et al.*, 1992). According to ANC data, Mjåvatn, Skammevatn and Smalevatn (mean ANC levels > -12 µeq l/L) could, with the present water chemistry, at least support a damaged fish population, while Rennevatn, Hyttetjørni, Kringlevatn, Skjekelivatn, Sandvatn and Trollselvvatn (mean ANC > -22 < -16 µeq l/L) only have a 50% chance of having, at best, a damaged fish population. All fish should be extinct from Homsvatn, Repstadvatn, Barkevatn and Mørkelivatn (mean ANC < -31 µeq l/L). All lakes in the ReFISH programme were barren prior to the fish stocking in 1988.

Mean water quality values (1988-1991) for pH, calcium, Al_i, and ANC, combined with the fish results, are presented in Table 8.

TABLE 8 Comparisons of mean values of pH, calcium (Ca), inorganic monomeric aluminium (Al_i) and ANC with fish catches over 1989 - 1991. Significant differences ($p<0.05$) between lakes within an region are marked by shading (different from all lakes), or borders (different from lakes outside the border).

Locality	pH	Ca	Ali	ANC	Bygland	Gjedrem	Fossbekk	Bustul	Tunhovd
Rennevatn	5.20	0.48	147	-17					
Hyttetjørni	5,03	0.33	86	-21					
Skammevatn	5.32	0.37	67	-11	x				
Kringlevatn	5.14	0.34	62	-16	x	x	x		
Smalevatn	5.14	0.30	54	-12	x	x	x		x
Homsvatn	4.73	0.56	101	-31					
Mjåvatn	4,74	0.55	58	-10	x	x	x	x	x
Skjekelivatn	4.66	0.45	70	-22	x	x			
Sandvatn	4,66	0.45	72	-21	x	x	x		
Trollselvvatn	4.56	0.32	66	-21					
Repstadvatn	4.74	0.96	183	-39	x	x		x	
Barkevatn	4.69	0.95	180	-39	x	x	x	x	
Mørklivatn	4.53	0.66	184	-44					

Mean pH calculated as H+

There appears to be systematic differences between lakes from which fish were caught and lakes with no catches. Rennevatn was significantly different ($p<0.05$) from the other four lakes in the Valle/Njardarheim region for mean calcium and Al_i concentrations. Hyttetjørni was significantly different ($p<0.05$) from the remaining lakes for Al_i and had very low pH values, although not significantly different ($p<0.05$) from the other lakes. In the Lyngdal region, Homsvatn was significantly different ($p<0.05$) from the other four lakes for Al_i, while Trollselvvatn was significantly different ($p<0.05$) for pH and calcium concentration. In the Birkeland region, Mørkelivatn was significantly different ($p<0.05$) from the other two lakes for pH and calcium. From these data, no single variable can explain the occurrence or absence of fish in the lakes. The ability to support fish seems to be lake-specific, and determined by pH, calcium and/or the Al_i concentrations. ReFISH can so far, only evaluate survival and not reproduction, the life stage most critical in nature. The captures in Repstadvatn and Barkevatn, both having ANC<-39, do indicate that additional factors than the bare ANC-level are of importance, e.g. these lakes have the highest calcium concentration of the 13 lakes. On a lake by lake basis, ANC seems, on its own, an insufficient measure of whether a fishery can be supported.

No fish were captured in lakes with pHs lower than pH 4.56, but were caught at higher pHs if the Al_i concentration was sufficiently low. There appears to be an upper limit to acceptable Al_i concentrations of about 60 µg/L, given the low calcium concentrations (Figure 25), in accordance with observations by Skogheim and Rosseland 1986. The fish had higher tolerance to Al_i when calcium concentrations were higher than 0.95 mg Ca l/L (Barkevatn and Repstadvatn, Birkeland region).

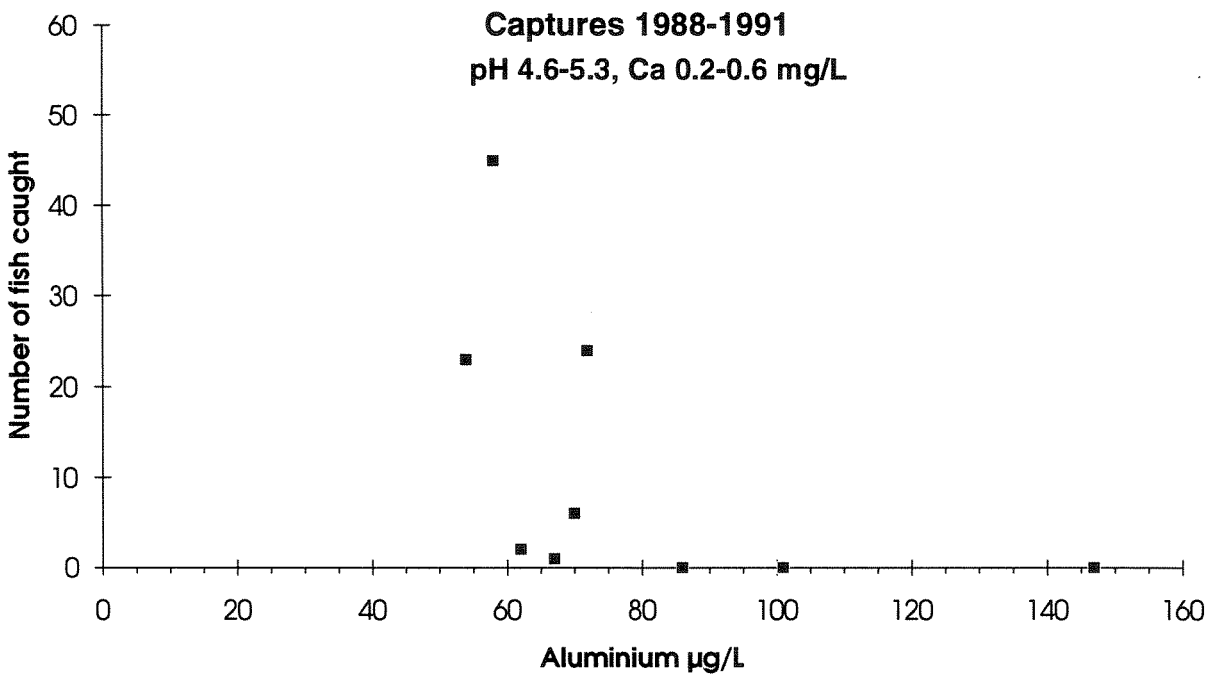

Figure 25. Numbers of fish captured in lakes with pH ranging from 4.6 - 5.2 and calcium concentrations between 0.2 and 0.5 mg Ca l/L.

Stocking of 0+ brown trout in October 1988 would not normally result in any capture by gill net in the following year. Even a gill net of 10 or 12.5 mm mesh size normally catches fish only from the age of 2+, unless the growth of the fish is exceptionally good. This has obviously been the case in Lake Mjåvatn, where the trout from the Gjedrem strain which were stocked at a size of ca. 1 g had grown up to the size of 42 g in less than one year. Growth was good in all regions, highest in Birkeland and lowest in Valle/Njardarheim. Growth differences are most likely due to temperature differences between the three regions, and are not necessarily chemically determined. There does not appear to be any sign of food shortage in any region. Good condition factors ($K \geq 1$) and gonadal development of caught fish (Appendix 1) indicate that energy is being expended by the fish in growth and sexual maturation rather than in survival alone. Results of test fishing in 1992 and 1993 should make it possible to both evaluate variation in growth within lakes and between lakes within a region, as well as document whether successful reproduction has taken place in some regions.

Certain life-cycle stages use other habitats than the lake body and thus may expose themselves to waters possibly more toxic than the lake water. For example, fish returning to brooks to spawn might be more susceptible to being affected by poor water quality, while lake-living fish can seek areas with temporarily better water quality. Brood fish and fry are especially vulnerable during their stay in the brooks. In the time over which the ReFish Project has operated, it has not been possible to gain data on reproductive success, but the first spawners (gonad stage 4 and 5) were registered in the Lyngdal region in 1991. The survival and growth results achieved so far, however, and the consistency obtained with the Bygland strain in laboratory experiments and in the field, are very encouraging. It is hoped that further funding will be forthcoming now to enable an assessment of reproductive ability to be undertaken. Without this information, it will be difficult to determine restocking strategies for larger regions.

9. REFERENCES

Christophersen, N., N. Colin and J. Mulder (1990). Reversal of stream acidification at the Birkenes catchment, Souuthern Norway: Predictions based on potentional ANC changes. Journal of Hydrology, 116, 77-84.

Dalziel, T.R.K. and Lynam, S. (1990). A toxicity testing apparatus for assessing simultaneously the tolerance of fish eggs and fry to different levels of pH and aluminium under controlled water quality conditions. PowerGen Technology and Research Memorandum No. TR/90/23005

Dalziel, T.R.K. and Lynam, S. (1991). Survival and development of four strains of Norwegian trout and one strain of Scottish trout (*Salmo trutta*) exposed to different pH levels in the absence of aluminium. PowerGen Report No. TR/91/23052/R.

Dalziel, T.R.K. and Lynam, S. (1992). Survival and development of four strains of Norwegian trout and one strain of Scottish trout (*Salmo trutta*) exposed to different concentrations of aluminium at two pH levels. PowerGen Report No. PT/92/330007/R.

Grande, M., I.P. Munitz and S. Andersen (1978). Relative tolerance of some salmonids to acid water. Verh. Int. Verein. Limnol 20, 2076-2084.

Gjedrem, T. (1976). Genetic variation in tolerance of brown trout to acid water. SNSF-project, FR5/76, 11p.

Gjedrem, T. (1980). Genetic variation in acid tolerance in brown trout. In: Drablos, T. and Tollan, A. (Eds.) "Ecological Impact of Acidification", Proceedings of an International Conference, Sandefjord, Norway, 1980. SNSF Project Report No. 1432 As-NLH, Oslo ISBN 82-90376-07-3, p.308.

Hesthagen, T., B.M. Larsen, A.K. Schartau and H.M. Berger (1992). Tålegrense for aure i ferskvann i forhold til forsuring. In: Vassdragskalking, strategi og effekter. R&D seminar, Finse, 1992. Directorate for Nature management no 5, 31-37.

Henriksen, A., L. Lien, T. Traan and I. Sevalrud. (1987). 1000-lake survey 1986, Norway. The Norwegian State Pollution Control Authority report 283/87, 33p.

Henriksen, A., J. Kamari, M. Posch and A. Wilander (1992). Critical loads of acidity: Nordic surface waters. Ambio, 21, 356-363.

Hindar, A. and B.O. Rosseland (1991). Liming strategies for Norwegian lakes. In:International lake and watershed liming practices; edited by: H. Olem, R.K. Schreiber, R.W. Brocksen and D.B. Porcella. ISBN 1-880686-00-7. p 173-192.

Jensen, K.W., and E. Snekvik (1972). Low pH levels wipe out salmon and trout populatyions in southern Norway. Ambio 1, 223-22.

Kroglund, F. and Rosseland, B.O. (1992). Reversibility of acidification: fish responses in experiments at Risdalsheia. NIVA Report No. 27/1992. ISBN 82-577-2058-5

Kroglund, F., B.O. Rosseland, A. Bulger, E. Lydersen (1993). Survival studies on four brown trout strains (*Salmo trutta* L.), performed at different concentrations of calcium and aluminium in acidic water. NIVA-report in prep.

Lien, L., Raddum, G.G. and Fjellheim, A. (1992). Critical loads of acidity to freshwater fish and invertebrates. NIVA Report No. 0-89185

McWillians P.G. (1980). Acclimation to an acid medium in the brown trout, *Salmo trutta*. J. Exp. Biol 88:269-280.

McWilliams, P.G. (1982). A comparison of physiological characteristics in normal and acid exposed populations of the brown trout, *Salmo trutta*. Comp. Biochem. Physiol. 72a:515-522.

Robinson, G.D., Dunson, W.A., Wright, J.E. and Mamolito, G.E. (1976). Differences in low pH tolerance among strains of brook trout, *Salvelinus fontinalis*. J. Fish Biol. 32, 607-624.

Rosseland, B.O., I.H. Sevalrud, D. Svalastog and I.P. Munitz (1980). Studies of freshwater fish populations - effects of acidification on reproduction, population structure, growth and food selection. In: Drabløs and Tollan (eds): Ecological impacts of acid precipitation, p 336-337, SNSF-project.

Rosseland, B.O. and Skogheim, O.K. (1984). A comparative study on salmonid fish species in acid aluminium-rich water. II. Physiological stress and mortality of one and two year old fish. Rep. Inst. Freshw. Res. Drottningholm 61, 186-194.

Rosseland, B.O. and Skogheim, O.K. (1987). Differences in sensitivity to acidic soft water among strains of brown trout (*Salmo trutta* L.). Annls. Soc. r. zool. Belg. Vol. 117, suppl. 1, 255-264.

Rosseland, B.O., Lien, L., Kroglund, F., Sadler, K. and Dalziel, T.R.K. (1990). Strains of brown trout (*Salmo trutta* L.). stocking and testfishing 1988 and 1989. Field and laboratory experiments. NIVA Report No. 2380.

Rosseland, B.O. and A. Henriksen (1990). Acidification in Norway - loss of fish populations and the 1000-lake survey 1986. The Science of the total Environment, 96, 45-56.

Rosseland, B.O. and F. Kroglund (1992). Variasjon i toleranse overfor surt vann hos ørret. In: Vassdragskalking, strategi og effekter. R&D seminar, Finse, 1992. Directorate for Nature management no 5, 23-31.

Sadler, K. and Lynam, S. (1989a). Survival and development of four Norwegian strains of brown trout, *Salmo trutta*, when exposed to low pH and elevated aluminium concentrations. Central Electricity Research Laboratory (CEGB) Report No. RD/L/3446/R88.

Sadler, K. and Lynam, S. (1989b). Results of a second year's experiments concerning survival and development of some Norwegian strains of brown trout, *Salmo trutta*, when exposed to low pH and elevated aluminium concentrations. National Power Technology and environmental Centre Report No. ESTD/L/0053/R89.

Sadler, K. and Rosseland, S. (1988). Progress report on the CEGB/NIVA joint project to mitigate acidification by stocking of fish, January to August 1988. Central Electricity Generating Board Memorandum No. RD/L/LSC/0002/M88.

SFT 1985. Overvåking av langtransportert forurenset luft og nedbør. Statlig program for forurensningsovervåking. Report 201/85. 190p.

Skogheim, O.K., and B.O. Rosseland (1986). Mortality of Atlantic salmon *Salmo salar* L., at low levels of aluminium in acidic softwater. Bill. Environ. Contam. Toxicol. 37, 258-265.

Swarts, F.A., Dunson, W.A. and Wright, J.E. (1978). Genetic and environmental factors involved in increasing resistance of brook trout to sulphuric acid solutions and mine acid polluted waters. Trans. Am. Fish. Soc. 107, 651-677.

Turnpenny, A.W.H., C.H. Dempsey, M.H. Davis and J.M. Fleming (1987). Factors limiting fish populations in the Loch Fleet system, an acidic drainage system in south west Scotland, CERL Report No. TPRD/L/312887.

Warfvinge, M. Holmberg, M. Posch and R.F. Wright (1992). The use of dynamic models to set target loads. Ambio in press.

Wright R.F. and M. Haus. 1991. Reversibility of acidification: soils and surface waters. Proceedings from the Royal Society of Edinburgh, 97B, 169-191.

Wright R.F., B.J. Cosby and G.M. Hornberger (1991b). A regional model of lake acidification in Southmost Norway. Ambio. Vol 20, 222-225.

APPENDIX 1. FISH DATA

DATA 1988-1991 Brook trout

Species	Lake	Region	Field code	Year	Strain identity	Strain identity	Strain	Year Stock	Age scale	Length cm	Weight g	K-factor	Sex	Gonad stage	Flesh color	St cont
Brook trout	Homsvatn	Lyngdal	12	88	Brook	Brook	Brook			18.0	73	1.25	M	5	R	-
Brook trout	Homsvatn	Lyngdal	13	88	Brook	Brook	Brook			19.0	72	1.05	M	5	R	-
Brook trout	Homsvatn	Lyngdal	8	88	Brook	Brook	Brook			20.5	100	1.16	F	2	R	-
Brook trout	Homsvatn	Lyngdal	5	88	Brook	Brook	Brook			21.0	150	1.62	F	2	R	-
Brook trout	Homsvatn	Lyngdal	9	88	Brook	Brook	Brook			21.0	135	1.46	M	5	R	-
Brook trout	Homsvatn	Lyngdal	11	88	Brook	Brook	Brook			21.0	110	1.19	F	2	R	-
Brook trout	Homsvatn	Lyngdal	7	88	Brook	Brook	Brook			21.5	140	1.41	F	2	R	-
Brook trout	Skjekelivatn	Lyngdal	2	88	Brook	Brook	Brook			22.0	160	1.50	F	2	LR	-
Brook trout	Homsvatn	Lyngdal	10	88	Brook	Brook	Brook			22.5	160	1.40	F	2	LR	-
Brook trout	Sandvatn	Lyngdal	1	88	Brook	Brook	Brook			23.0	170	1.40	F	2	R	-
Brook trout	Skjekelivatn	Lyngdal	3	88	Brook	Brook	Brook			23.5	190	1.46	M	5	R	-
Brook trout	Trollselvvatn	Lyngdal	4	88	Brook	Brook	Brook			28.0	330	1.50	F	5	R	-
Brook trout	Homsvatn	Lyngdal	6	88	Brook	Brook	Brook			32.5	410	1.19	F	5	W	-
Brook trout	Skjekelivatn	Lyngdal	7	89	Brook	Brook	Brook			15.7	52	1.34	M	4	LR	4.0
Brook trout	Sandvatn	Lyngdal	14	89	Brook	Brook	Brook			22.0	144	1.35	M	4	R	0.0
Brook trout	Homsvatn	Lyngdal	2	89	Brook	Brook	Brook			23.5	154	1.19	M	4	LR	4.5
Brook trout	Sandvatn	Lyngdal	13	89	Brook	Brook	Brook			24.5	154	1.05	M	2	LR	5.0
Brook trout	Homsvatn	Lyngdal	1	89	Brook	Brook	Brook			25.0	210	1.34	M	4	R	3.0
Brook trout	Homsvatn	Lyngdal	4	89	Brook	Brook	Brook			25.5	232	1.40	M	4	R	5.0
Brook trout	Homsvatn	Lyngdal	5	89	Brook	Brook	Brook			26.0	240	1.37	F	4	R	4.0
Brook trout	Homsvatn	Lyngdal	6	89	Brook	Brook	Brook			26.0	220	1.25	M	4	R	4.0
Brook trout	Homsvatn	Lyngdal	3	89	Brook	Brook	Brook			27.5	298	1.43	M	4	R	5.0
Brook trout	Sandvatn	Lyngdal	12	89	Brook	Brook	Brook			30.0	426	1.58	F	4	R	4.0
Brook trout	Sandvatn	Lyngdal	11	89	Brook	Brook	Brook			31.5	452	1.45	F	4	R	4.0
Brook trout	Trollselvvatn	Lyngdal	9	89	Brook	Brook	Brook			34.0	502	1.28	M	4	R	2.0
Brook trout	Sandvatn	Lyngdal	10	89	Brook	Brook	Brook			35.5	676	1.51	M	3	R	3.0
Brook trout	Sandvatn	Lyngdal	40	90	Brook	Brook	Brook		2	23.2	158	1.27	M	2	R	-
Brook trout	Sandvatn	Lyngdal	35	90	Brook	Brook	Brook		2(3)	24.5	182	1.24	F	4	R	-
Brook trout	Sandvatn	Lyngdal	37	90	Brook	Brook	Brook		2	25.5	234	1.41	F	5	R	-
Brook trout	Trollselvvatn	Lyngdal	8	90	Brook	Brook	Brook		2	25.6	306	1.82	M	'4-5	R	-
Brook trout	Sandvatn	Lyngdal	32	90	Brook	Brook	Brook		2	25.8	224	1.30	F	5	R	-
Brook trout	Sandvatn	Lyngdal	33	90	Brook	Brook	Brook		2(3)	26.0	240	1.37	F	5	R	-
Brook trout	Sandvatn	Lyngdal	36	90	Brook	Brook	Brook		1	26.0	270	1.54	M	5	R	-
Brook trout	Sandvatn	Lyngdal	34	90	Brook	Brook	Brook		2(3)	27.0	248	1.26	F	5	R	-
Brook trout	Sandvatn	Lyngdal	38	90	Brook	Brook	Brook		2	28.5	310	1.34	M	5	R	-
Brook trout	Sandvatn	Lyngdal	39	90	Brook	Brook	Brook		2	28.5	262	1.13	M	5	R	-
Brook trout	Mørkelivatn	Birkeland	5	90	Brook	Brook	Brook		2	30.3	518	1.86	M	4	R	4.0
Brook trout	Sandvatn	Lyngdal	41	90	Brook	Brook	Brook		2	33.0	604	1.68	F	4	LR	-
Brook trout	Barkevatn	Birkeland	7	90	Brook	Brook	Brook		2	35.4	788	1.78	F	2	R	1.0
Brook trout	Barkevatn	Birkeland	6	90	Brook	Brook	Brook		2	39.1	952	1.59	M	5	R	0.0
Brook trout	Homsvatn	Lyngdal	18	91	Brook	Brook	Brook		3	30.7	494	1.71	F	5	R	2.0

DATA 1988-1991 Brook trout

Species	Lake	Region	Field code	Year	Strain identity	Strain identity	Strain	Year Stock	Age scale	Length cm	Weight g	K-factor	Sex	Gonad stage	Flesh color	St cont
Brown trout	Barkevatn	Birkeland	4	90	A	FF	Bygland	89	1	9.9	10	1.03	F	1	W	2.0
Brown trout	Barkevatn	Birkeland	3	90	LP	VB	Bustul	89	1	11.1	11	0.80	*	0	W	0.0
Brown trout	Barkevatn	Birkeland	3	91	A	FF	Bygland	90	1	12.2	19	1.05	M	1	W	2.0
Brown trout	Barkevatn	Birkeland	9	91	A-LP	FFVB	Gjedrem	90	1	13.5	26	1.06	M	1	W	1.0
Brown trout	Barkevatn	Birkeland	1	91	A	FF	Bygland	90	1	14.5	29	0.95	M	1	W	1.0
Brown trout	Barkevatn	Birkeland	7	91	A	FF	Bygland	90	1	14.8	33	1.02	M	1	W	2.0
Brown trout	Barkevatn	Birkeland	8	91	A	FF	Bygland	90	1	14.8	32	0.99	F	1	W	1.0
Brown trout	Barkevatn	Birkeland	2	91	A-RP	FFHB	Fossbekk	89	2	19.8	89	1.15	M	1	W	2.0
Brown trout	Barkevatn	Birkeland	10	91	A-RP	FFHB	Fossbekk	89	2	24.7	169	1.12	F	1	W	3.0
Brown trout	Barkevatn	Birkeland	11	91	LP	VB	Bustul	89	2	25.2	190	1.19	F	4	W	4.0
Brown trout	Barkevatn	Birkeland	4	91	A	FF	Bygland	88	3	26.2	198	1.10	M	4	W	1.0
Brown trout	Barkevatn	Birkeland	12	91	A	FF	Bygland	88	3	27.3	224	1.10	F	1	R	2.0
Brown trout	Barkevatn	Birkeland	5	91	A-LP	FFVB	Gjedrem	88	3	27.8	258	1.20	F	2	LR	4.0
Brown trout	Barkevatn	Birkeland	6	91	LP	VB	Bustul	88	3	32.0	365	1.11	M	4	R	4.0
Brown trout	Repstadvatn	Birkeland	1	90	A-LP	FFVB	Gjedrem	88	2	18.1	55	0.93	F	1	W	2.0
Brown trout	Repstadvatn	Birkeland	2	90	A-LP	FFVB	Gjedrem	88	2	21.2	92	0.97	M	2	W	2.0
Brown trout	Repstadvatn	Birkeland	13	91	A	FF	Bygland	89	2	16.1	43	1.03	M	2	W	2.0
Brown trout	Repstadvatn	Birkeland	14	91	A	FF	Bygland	89	2	17.0	48	0.98	M	2	W	3.0
Brown trout	Repstadvatn	Birkeland	16	91	LP	VB	Bustul	89	2	17.5	58	1.08	F	1	W	1.0
Brown trout	Repstadvatn	Birkeland	17	91	A	FF	Bygland	89	2	19.0	72	1.05	F	1	W	4.0
Brown trout	Repstadvatn	Birkeland	15	91	A	FF	Bygland	89	2	19.6	82	1.09	M	2	W	2.0
Brown trout	Mjåvatn	Lyngdal	8	89			Gjedrem			16.0	42	1.03	F	1	W	0.0
Brown trout	Mjåvatn	Lyngdal	24	90	LP	VB	Bustul	89	1	11.1	14	1.02	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	17	90	FVB	FVB	Gjedrem	89	1	12.2	19	1.05	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	21	90	FVB	FVB	Gjedrem	89	1	13.5	25	1.02	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	15	90	VB?	VB?	Bustul?	89	1	13.9	27	1.01	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	20	90	A	FF	Bygland	89	1	14.0	28	1.02	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	18	90	A	FF	Bygland	89	1	14.7	35	1.10	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	22	90	FVB	FVB	Gjedrem	89	1	14.7	32	1.01	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	19	90	A	FF	Bygland	89	1	15.0	34	1.01	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	23	90	A	FF	Bygland	89	1	15.4	36	0.99	?	1	W	-
Brown trout	Mjåvatn	Lyngdal	11	90	A	FF	Bygland	89	1	15.5	45	1.21	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	16	90	A	FF	Bygland	89	1	15.8	41	1.04	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	10	90	A	FF	Bygland	88	2	17.2	66	1.30	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	9	90	A-RP	FFHB	Fossbekk	88	2	17.5	59	1.10	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	13	90	FVB	FVB	Gjedrem	88	2	17.9	70	1.22	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	14	90	FVB	FVB	Gjedrem	88	2	18.0	70	1.20	F	1	W	-
Brown trout	Mjåvatn	Lyngdal	12	90	FVB	FVB	Gjedrem	88	2	18.5	82	1.30	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	26	90	FVB	FVB	Gjedrem	88	2	18.5	70	1.11	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	25	90	FVB	FVB	Gjedrem	88	2	20.5	96	1.11	M	1	W	-
Brown trout	Mjåvatn	Lyngdal	27	90	A	FF	Bygland	88	2	27.0	244	1.24	F	2	W	-

DATA 1988-1991 Brook trout

Species	Lake	Region	Field code	Year	Strain Identity	Strain Identity	Strain	Year Stock	Age scale	Length cm	Weight g	K-factor	Sex	Gonad stage	Flesh color	St cont
Brown trout	Mjåvatn	Lyngdal	42	91	A	FF	Bygland	90	1	12.8	20	0.95	F	1	W	2.0
Brown trout	Mjåvatn	Lyngdal	25	91	A	FF	Bygland	90	1	13.4	23	0.96	M	1	W	1.0
Brown trout	Mjåvatn	Lyngdal	44	91	A	FF	Bygland	90	1	14.1	32	1.14	M	1	W	2.0
Brown trout	Mjåvatn	Lyngdal	48	91	A	FF	Bygland	89	2	17.2	62	1.22	M	5	W	1.0
Brown trout	Mjåvatn	Lyngdal	50	91	A	FF	Bygland	89	2	19.8	90	1.16	F	1	W	2.0
Brown trout	Mjåvatn	Lyngdal	37	91	A	FF	Bygland	89	2	20.0	88	1.10	M	2	W	2.5
Brown trout	Mjåvatn	Lyngdal	49	91	A	FF	Bygland	89	2	20.0	90	1.13	M	5	W	1.0
Brown trout	Mjåvatn	Lyngdal	41	91	A	FF	Bygland	89	2	20.2	96	1.16	F	1	LR	2.5
Brown trout	Mjåvatn	Lyngdal	26	91	A	FF	Bygland	89	2	20.3	82	0.98	M	1	LR	1.5
Brown trout	Mjåvatn	Lyngdal	32	91	LP	VB	Bustul	88	3	20.9	98	1.07	M	2	W	1.5
Brown trout	Mjåvatn	Lyngdal	33	91	A	FF	Bygland	89	2	21.6	114	1.13	M	2	LR	1.0
Brown trout	Mjåvatn	Lyngdal	31	91	A	FF	Bygland	88	3	21.7	116	1.14	F	1	LR	1.5
Brown trout	Mjåvatn	Lyngdal	35	91	A	FF	Bygland	89	2	21.9	122	1.16	F	1	LR	2.0
Brown trout	Mjåvatn	Lyngdal	47	91	A	FF	Bygland	89	2	22.5	124	1.09	F	1	LR	2.0
Brown trout	Mjåvatn	Lyngdal	36	91	A-LP	FFVB	Gjedrem	89	2	22.5	132	1.16	F	1	W	3.0
Brown trout	Mjåvatn	Lyngdal	43	91	A-LP	FFVB	Gjedrem	89	2	22.9	128	1.07	F	1	LR	3.0
Brown trout	Mjåvatn	Lyngdal	40	91	A	FF	Bygland	88	3	23.1	134	1.09	M	4	LR	1.0
Brown trout	Mjåvatn	Lyngdal	39	91	RP	HB	Tunhovd	88	3	23.1	140	1.14	M	2	W	2.0
Brown trout	Mjåvatn	Lyngdal	27	91	A	FF	Bygland	89	2	23.3	142	1.12	M	1	LR	2.0
Brown trout	Mjåvatn	Lyngdal	29	91	A	FF	Bygland	89	2	24.1	152	1.09	M	2	LR	1.0
Brown trout	Mjåvatn	Lyngdal	28	91	RP	HB	Tunhovd	88	3	24.8	180	1.18	F	1	LR	3.5
Brown trout	Mjåvatn	Lyngdal	38	91	A	FF	Bygland	88	3	25.6	172	1.03	F	1	R	2.5
Brown trout	Mjåvatn	Lyngdal	45	91	A	FF	Bygland	88	3	25.6	210	1.25	M	4	R	0.0
Brown trout	Mjåvatn	Lyngdal	30	91	A-LP	FFVB	Gjedrem	88	3	28.5	258	1.11	F	1	LR	1.5
Brown trout	Mjåvatn	Lyngdal	34	91	A	FF	Bygland	88	3	28.9	252	1.04	M	2	R	1.5
Brown trout	Mjåvatn	Lyngdal	46	91	A-RP	FFHB	Fossbekk	88	3	29.5	260	1.01	M	2	R	2.5
Brown trout	Sandvatn	Lyngdal	29	90	A	FF	Bygland	89	1	10.5	13	1.12	M	1	W	-
Brown trout	Sandvatn	Lyngdal	30	90	A	FF	Bygland	89	1	10.5	12	1.04	M	1	W	-
Brown trout	Sandvatn	Lyngdal	28	90	A	FF	Bygland	89	1	12.5	21	1.08	F	1	W	-
Brown trout	Sandvatn	Lyngdal	31	90	FVB	FVB	Gjedrem	88	2	25.0	200	1.28	F	2	W	-
Brown trout	Sandvatn	Lyngdal	63	91	A	FF	Bygland	89	2	14.6	32	1.03	F	1	W	2.5
Brown trout	Sandvatn	Lyngdal	58	91	A	FF	Bygland	89	2	17.2	56	1.10	F	1	W	2.0
Brown trout	Sandvatn	Lyngdal	69	91	A-RP	FFHB	Fossbekk	89	2	20.1	92	1.13	F	1	W	1.0
Brown trout	Sandvatn	Lyngdal	68	91	A	FF	Bygland	89	2	21.2	100	1.05	F	1	W	1.0
Brown trout	Sandvatn	Lyngdal	70	91	A	FF	Bygland	89	2	21.2	102	1.07	F	1	W	2.0
Brown trout	Sandvatn	Lyngdal	60	91	A	FF	Bygland	88	3	21.5	132	1.33	M	1	W	1.0
Brown trout	Sandvatn	Lyngdal	67	91	A-LP	FFVB	Gjedrem	88	3	21.8	124	1.20	M	"1/2	W	2.0
Brown trout	Sandvatn	Lyngdal	65	91	A	FF	Bygland	89	2	22.2	152	1.39	F	1	W	1.0
Brown trout	Sandvatn	Lyngdal	59	91	A-RP	FFHB	Fossbekk	89	2	22.7	98	0.84	F	2	W	3.0
Brown trout	Sandvatn	Lyngdal	62	91	A-LP	FFVB	Gjedrem	89	2	22.8	142	1.20	F	1	W	3.0
Brown trout	Sandvatn	Lyngdal	66	91	A-LP	FFVB	Gjedrem	88	3	24.1	156	1.11	M	2	W	3.0
Brown trout	Sandvatn	Lyngdal	55	91	A	FF	Bygland	88	3	24.9	174	1.13	F	2	W	2.0
Brown trout	Sandvatn	Lyngdal	61	91	A-LP	FFVB	Gjedrem	88	3	25.1	196	1.24	M	1	W	2.0
Brown trout	Sandvatn	Lyngdal	64	91	A	FF	Bygland	88	3	25.2	214	1.34	M	2	LR	1.5
Brown trout	Sandvatn	Lyngdal	56	91	A-RP	FFHB	Fossbekk	89	2	26.2	236	1.31	F	1	LR	3.0

DATA 1988-1991 Brook trout

Species	Lake	Region	Field code	Year	Strain identity	Strain identity	Strain	Year Stock	Age scale	Length cm	Weight g	K-factor	Sex	Gonad stage	Flesh color	St cont
Brown trout	Sandvatn	Lyngdal	57	91	A-LP	FFVB	Gjedrem	89	2	26.7	220	1.16	F	1	W	2.5
Brown trout	Sandvatn	Lyngdal	54	91	A-LP	FFVB	Gjedrem	88	3	32.1	414	1.25	F	2	LR	2.0
Brown trout	Sandvatn	Lyngdal	53	91	A-LP	FFVB	Gjedrem	88	3	33.1	448	1.24	M	2	LR	1.0
Brown trout	Sandvatn	Lyngdal	52	91	A-LP	FFVB	Gjedrem	88	3	34.7	516	1.23	F	2	LR	1.0
Brown trout	Sandvatn	Lyngdal	51	91	UM	UM	Unmarked	84	7	47.6	1250	1.16	M	"7/5	R	1.0
Brown trout	Skjekelivatn	Lyngdal	20	91	A	FF	Bygland	90	1	10.9	15	1.16	M	1	W	1.0
Brown trout	Skjekelivatn	Lyngdal	22	91	A-LP	FFVB	Gjedrem	89	2	23.0	142	1.17	M	2	W	2.0
Brown trout	Skjekelivatn	Lyngdal	19	91	A	FF	Bygland	88	3	23.5	148	1.14	F	1	W	3.0
Brown trout	Skjekelivatn	Lyngdal	21	91	A-LP	FFVB	Gjedrem	88	3	24.3	166	1.16	F	1	W	2.5
Brown trout	Skjekelivatn	Lyngdal	24	91	LP	VB	Bustul	88	3	26.4	210	1.14	F	1	W	1.0
Brown trout	Skjekelivatn	Lyngdal	23	91	A-LP	FFVB	Gjedrem	88	3	26.4	256	1.39	M	2	W	2.0
Brown trout	Kringlevatn	Valle	72	91	A	FF	Bygland	90	1	12.5	21	1.08	F	1	W	2.0
Brown trout	Kringlevatn	Valle	73	91	A-LP	FFVB	Gjedrem	88	3	21.9	106	1.01	F	1	LR	3.0
Brown trout	Skammevatn	Valle	71	91	A	FF	Bygland	90	1	8.9	7	0.99	M	1	W	0.0
Brown trout	Smalevatn	Valle	51	90	FF?HB	FF?HB	Fossbekk	89	1	8.9	7	0.99	F	1	W	3.0
Brown trout	Smalevatn	Valle	52	90	FVB	FVB	Gjedrem	88	2	12.9	22	1.02	F	1	W	2.0
Brown trout	Smalevatn	Valle	78	91	A	FF	Bygland	90	1	8.8	7	1.03	M	1	W	0.0
Brown trout	Smalevatn	Valle	79	91	A	FF	Bygland	90	1	9.0	7	0.96	M	1	W	0.0
Brown trout	Smalevatn	Valle	96	91	A	FF	Bygland	90	1	9.1	7	0.93	F	1	W	2.0
Brown trout	Smalevatn	Valle	94	91	A	FF	Bygland	90	1	9.6	9	1.02	M	1	W	2.0
Brown trout	Smalevatn	Valle	95	91	A	FF	Bygland	90	1	10.2	10	0.94	F	1	W	2.0
Brown trout	Smalevatn	Valle	80	91	A-LP	FFVB	Gjedrem	90	1	11.0	13	0.98	F	1	W	2.0
Brown trout	Smalevatn	Valle	86	91	A	FF	Bygland	90	1	11.2	14	1.00	M	1	W	1.0
Brown trout	Smalevatn	Valle	93	91	A	FF	Bygland	89	2	13.5	22	0.89	F	1	W	1.0
Brown trout	Smalevatn	Valle	83	91	A-RP	FFHB	Fossbekk	89	2	13.6	23	0.91	F	1	W	2.0
Brown trout	Smalevatn	Valle	88	91	A	FF	Bygland	89	2	13.8	25	0.95	F	1	W	0.0
Brown trout	Smalevatn	Valle	92	91	A-LP	FFVB	Gjedrem	89	2	14.7	33	1.04	F	1	W	3.0
Brown trout	Smalevatn	Valle	75	91	RP	HB	Tunhovd	89	2	14.7	35	1.10	F	1	W	3.0
Brown trout	Smalevatn	Valle	85	91	A	FF	Bygland	89	2	15.7	42	1.09	F	1	W	1.0
Brown trout	Smalevatn	Valle	76	91	A-LP	FFVB	Gjedrem	89	2	16.2	42	0.99	M	1	W	3.0
Brown trout	Smalevatn	Valle	91	91	A-RP	FFHB	Fossbekk	89	2	16.5	45	1.00	M	1	W	3.0
Brown trout	Smalevatn	Valle	77	91	A-LP	FFVB	Gjedrem	89	2	16.5	43	0.96	M	1	W	4.0
Brown trout	Smalevatn	Valle	84	91	A	FF	Bygland	89	2	17.0	48	0.98	F	1	W	1.0
Brown trout	Smalevatn	Valle	87	91	A-LP	FFVB	Gjedrem	89	2	19.0	66	0.96	M	1	W	2.0
Brown trout	Smalevatn	Valle	89	91	A-RP	FFHB	Fossbekk	89	2	19.1	66	0.95	F	1	LR	2.5
Brown trout	Smalevatn	Valle	81	91	A-RP	FFHB	Fossbekk	89	2	19.4	70	0.96	F	1	W	1.0
Brown trout	Smalevatn	Valle	82	91	A	FF	Bygland	89	2	19.7	80	1.05	M	2	W	1.0
Brown trout	Smalevatn	Valle	90	91	A-LP	FFVB	Gjedrem	88	3	21.1	100	1.06	F	1	W	3.0
Brown trout	Smalevatn	Valle	74	91	A-LP	FFVB	Gjedrem	88	3	25.8	200	1.16	M	5	R	1.0

APPENDIX 2. STOMACH CONTENT

DATA 1988-1991 Brook trout

					MACROINVERTEBRATES														ZOOPLANCTON						TERR.INV.				
Species	Lake	Region	Field code	Year	Eph	Ple	Ash	Lib	Zyg	Odo Sum	Cor	Col	Meg	Tri F	Tri C	Tri Sum	Cha	Chi	Inv. Sum	Eur	Hol	Bos	Byt	Zoopl. Sum	Dip	Other	Terr Sum	Seed	Total Sum
Brook trout	Homsvatn	Lyngdal	12	88							15							1	16	50				50					66
Brook trout	Homsvatn	Lyngdal	13	88							5	1		3		3			9					n					9
Brook trout	Homsvatn	Lyngdal	8	88							4			6		6	8		18	50				50					68
Brook trout	Homsvatn	Lyngdal	5	88							17	2							19	50				50					69
Brook trout	Homsvatn	Lyngdal	9	88			2			2	5	66	2	2		2			77	10				10					87
Brook trout	Homsvatn	Lyngdal	11	88							5	1		2		2			8					n					8
Brook trout	Homsvatn	Lyngdal	7	88										1		1	9		10	150				150					160
Brook trout	Skjekelivatn	Lyngdal	2	88							7	3		3		3			13					n		1	1		14
Brook trout	Homsvatn	Lyngdal	10	88							29			1		1			30					n					30
Brook trout	Sandvatn	Lyngdal	1	88							25	2		1		1			28					n			n		28
Brook trout	Skjekelivatn	Lyngdal	3	88							2	3							5					n					5
Brook trout	Trollselvvatn	Lyngdal	4	88			1			1	15		1	1		1			18					n					18
Brook trout	Homsvatn	Lyngdal	6	88															n					n					0
Brook trout	Skjekelivatn	Lyngdal	7	89							12								12					n					12
Brook trout	Sandvatn	Lyngdal	14	89															n					n					0
Brook trout	Homsvatn	Lyngdal	2	89			1			1	81	2		2		2			86					n					86
Brook trout	Sandvatn	Lyngdal	13	89							150								150					n					150
Brook trout	Homsvatn	Lyngdal	1	89							12								12					n					12
Brook trout	Homsvatn	Lyngdal	4	89							74			2		2	1		77					n					77
Brook trout	Homsvatn	Lyngdal	5	89							15	1					112		128					n					128
Brook trout	Homsvatn	Lyngdal	6	89							18	1							19					n					19
Brook trout	Homsvatn	Lyngdal	3	89							110	7							117					n					117
Brook trout	Sandvatn	Lyngdal	12	89							85								85					n					85
Brook trout	Sandvatn	Lyngdal	11	89							86	1							87					n					87
Brook trout	Trollselvvatn	Lyngdal	9	89							5								5					n					5
Brook trout	Sandvatn	Lyngdal	10	89							34	1							35					n					35
Brook trout	Sandvatn	Lyngdal	40	90							22	1							23					n					23
Brook trout	Sandvatn	Lyngdal	35	90			1			1	288	5	6	2		2			302					n					302
Brook trout	Sandvatn	Lyngdal	37	90							175	1	1	1		1			178					n					178
Brook trout	Trollselvvatn	Lyngdal	8	90							32								32					n					32
Brook trout	Sandvatn	Lyngdal	32	90							213	7		1		1			221					n					221
Brook trout	Sandvatn	Lyngdal	33	90							520								520					n					520
Brook trout	Sandvatn	Lyngdal	36	90							591	1		1		1			593					n					593
Brook trout	Sandvatn	Lyngdal	34	90			1	1		2	256	1						1	260					n					260
Brook trout	Sandvatn	Lyngdal	38	90							158							7	165					n					165
Brook trout	Sandvatn	Lyngdal	39	90							204	2							206					n					206
Brook trout	Mørkelivatn	Birkeland	5	90							126								126					n		2	2		128
Brook trout	Sandvatn	Lyngdal	41	90			1			1	115	1							117					n					117
Brook trout	Barkevatn	Birkeland	7	90			2	2		4	25								29					n				45	74
Brook trout	Barkevatn	Birkeland	6	90															n					n					0
Brook trout	Homsvatn	Lyngdal	18	91							68		4						72					n					72

DATA 1988-1991 Brook trout

					MACROINVERTEBRATES														ZOOPLANCTON					TERR.INV.				
Species	Lake	Region	Field code	Year	Eph	Ple	Ash	Lib	Zyg	Odo Sum	Cor	Col	Meg	Tri F	Tri C	Tri Sum	Cha	Chi	Inv. Sum	Eur	Hol	Bos	Byt	Zoopl. Sum	Dip	Other	Terr Sum	Seed	Total Sum
Brown trout	Barkevatn	Birkeland	4	90							1						10		11					n					11
Brown trout	Barkevatn	Birkeland	3	90															n					n					0
Brown trout	Barkevatn	Birkeland	3	91										1		1	30		31					n					31
Brown trout	Barkevatn	Birkeland	9	91													8		8					n					8
Brown trout	Barkevatn	Birkeland	1	91							1						5		6					n					6
Brown trout	Barkevatn	Birkeland	7	91													100		100					n					100
Brown trout	Barkevatn	Birkeland	8	91				1		1	1						10		12					n					12
Brown trout	Barkevatn	Birkeland	2	91													130	1	131					n					131
Brown trout	Barkevatn	Birkeland	10	91													800		800					n					800
Brown trout	Barkevatn	Birkeland	11	91													1750	5	1755					n					1755
Brown trout	Barkevatn	Birkeland	4	91													90	1	91					n					91
Brown trout	Barkevatn	Birkeland	12	91													250	1	251					n					251
Brown trout	Barkevatn	Birkeland	5	91													2500	1	2501					n					2501
Brown trout	Barkevatn	Birkeland	6	91				2		2							140		142					n					142
Brown trout	Repstadvatn	Birkeland	1	90														33	33					n					33
Brown trout	Repstadvatn	Birkeland	2	90							2						73	1	76					n					76
Brown trout	Repstadvatn	Birkeland	13	91										4		4		9	13					n					13
Brown trout	Repstadvatn	Birkeland	14	91							12			1		1		15	28					n					28
Brown trout	Repstadvatn	Birkeland	16	91	1						4								5					n					5
Brown trout	Repstadvatn	Birkeland	17	91							2			160		160		5	167					n					167
Brown trout	Repstadvatn	Birkeland	15	91							19			2		2		1	22					n					22
Brown trout	Mjåvatn	Lyngdal	8	89															n					n					0
Brown trout	Mjåvatn	Lyngdal	24	90							2	1		2		2			5					n					5
Brown trout	Mjåvatn	Lyngdal	17	90					1	1	1		7						9					n					9
Brown trout	Mjåvatn	Lyngdal	21	90					4	4		16							20					n					20
Brown trout	Mjåvatn	Lyngdal	15	90									2						2					n					2
Brown trout	Mjåvatn	Lyngdal	20	90					8	8									8					n					8
Brown trout	Mjåvatn	Lyngdal	18	90					1	1					3	3			4					n					4
Brown trout	Mjåvatn	Lyngdal	22	90															n					n					0
Brown trout	Mjåvatn	Lyngdal	19	90							6	3	8	2		2			19					n					19
Brown trout	Mjåvatn	Lyngdal	23	90							11								11					n					11
Brown trout	Mjåvatn	Lyngdal	11	90							4		1	1		1			6					n					6
Brown trout	Mjåvatn	Lyngdal	16	90					1	1	16	1							18					n					18
Brown trout	Mjåvatn	Lyngdal	10	90							45			1		1			46					n					46
Brown trout	Mjåvatn	Lyngdal	9	90							53								53					n					53
Brown trout	Mjåvatn	Lyngdal	13	90				1		1	5		2						8					n					8
Brown trout	Mjåvatn	Lyngdal	14	90								1		1		1		1	3					n					3
Brown trout	Mjåvatn	Lyngdal	12	90							33	2							35					n					35
Brown trout	Mjåvatn	Lyngdal	26	90					15	15	4			1		1			20					n					20
Brown trout	Mjåvatn	Lyngdal	25	90															n					n					0
Brown trout	Mjåvatn	Lyngdal	27	90							18	1	7						26					n					26

DATA 1988-1991 Brook trout

					MACROINVERTEBRATES															ZOOPLANCTON						TERR.INV.				
Species	Lake	Region	Fleld code	Year	Eph	Ple	Ash	Lib	Zyg	Odo Sum	Cor	Col	Meg	Tri F	Tri C	Tri Sum	Cha	Chi	Inv. Sum	Eur	Hol	Bos	Byt	Zoopl. Sum	Dip	Other	Terr Sum	Seed	Total Sum
Brown trout	Mjåvatn	Lyngdal	42	91							8	1							9					n					9
Brown trout	Mjåvatn	Lyngdal	25	91								3							3					n					3
Brown trout	Mjåvatn	Lyngdal	44	91					1	1			2		1	1			4					n					4
Brown trout	Mjåvatn	Lyngdal	48	91					2	2								17	19					n					19
Brown trout	Mjåvatn	Lyngdal	50	91							1	9	1	1		1			12					n					12
Brown trout	Mjåvatn	Lyngdal	37	91				1		1									1					n		6	6		7
Brown trout	Mjåvatn	Lyngdal	49	91								1							1	1				1		1	1		3
Brown trout	Mjåvatn	Lyngdal	41	91					1	1		6	17						24					n					24
Brown trout	Mjåvatn	Lyngdal	26	91							4	1			1	1			6					n					6
Brown trout	Mjåvatn	Lyngdal	32	91							6	3		1	1	2			11	15				15	1		1		27
Brown trout	Mjåvatn	Lyngdal	33	91														12	12	4				4					16
Brown trout	Mjåvatn	Lyngdal	31	91				1		1		2	5						8					n					8
Brown trout	Mjåvatn	Lyngdal	35	91				1	4	5	3	6	1					1	16	140				140		1	1		157
Brown trout	Mjåvatn	Lyngdal	47	91							12	1							13					n		2	2		15
Brown trout	Mjåvatn	Lyngdal	36	91								1	53						54					n					54
Brown trout	Mjåvatn	Lyngdal	43	91									29						29	1				1					30
Brown trout	Mjåvatn	Lyngdal	40	91							4								4					n					4
Brown trout	Mjåvatn	Lyngdal	39	91				2		2			1	2		2			5					n		1	1		6
Brown trout	Mjåvatn	Lyngdal	27	91					4	4	19								23					n					23
Brown trout	Mjåvatn	Lyngdal	29	91							7	1							8	150				150					158
Brown trout	Mjåvatn	Lyngdal	28	91									68						68					n					68
Brown trout	Mjåvatn	Lyngdal	38	91								1	15						16	1				1					17
Brown trout	Mjåvatn	Lyngdal	45	91															n					n					0
Brown trout	Mjåvatn	Lyngdal	30	91				1		1									1					n					1
Brown trout	Mjåvatn	Lyngdal	34	91							20								20					n		20	20		40
Brown trout	Mjåvatn	Lyngdal	46	91			1			1	2		1						4					n		48	48		52
Brown trout	Sandvatn	Lyngdal	29	90							1								1					n					1
Brown trout	Sandvatn	Lyngdal	30	90													15		15	1				1					16
Brown trout	Sandvatn	Lyngdal	28	90					1	1	11	3		3		3			18					n					18
Brown trout	Sandvatn	Lyngdal	31	90							63								63					n					63
Brown trout	Sandvatn	Lyngdal	63	91							23		1						24					n					24
Brown trout	Sandvatn	Lyngdal	58	91							17				4	4			21					n					21
Brown trout	Sandvatn	Lyngdal	69	91							9								9					n					9
Brown trout	Sandvatn	Lyngdal	68	91							1								1					n					1
Brown trout	Sandvatn	Lyngdal	70	91							10			6		6			16					n					16
Brown trout	Sandvatn	Lyngdal	60	91							4								4					n					4
Brown trout	Sandvatn	Lyngdal	67	91							33								33					n					33
Brown trout	Sandvatn	Lyngdal	65	91							6								6					n					6
Brown trout	Sandvatn	Lyngdal	59	91							25								25					n					25
Brown trout	Sandvatn	Lyngdal	62	91							46								46					n					46
Brown trout	Sandvatn	Lyngdal	66	91							48								48					n					48
Brown trout	Sandvatn	Lyngdal	55	91							46		1						47					n					47
Brown trout	Sandvatn	Lyngdal	61	91							9		2	2		2			13					n					13
Brown trout	Sandvatn	Lyngdal	64	91							8	1							9					n					9
Brown trout	Sandvatn	Lyngdal	56	91							170								170					n					170

DATA 1988-1991 Brook trout

					MACROINVERTEBRATES														ZOOPLANCTON					TERR.INV.				
Species	Lake	Region	Field code	Year	Eph	Ple	Ash	Llb	Zyg	Odo Sum	Cor	Col	Meg	Tri F	Tri C	Tri Sum	Cha	Chi	Inv. Sum	Eur	Hol	Bos	Byt	Zoopl. Sum	Dip	Other	Terr Sum	Seed	Total Sum
Brown trout	Sandvatn	Lyngdal	57	91							80								80					n					80
Brown trout	Sandvatn	Lyngdal	54	91							31								31					n					31
Brown trout	Sandvatn	Lyngdal	53	91							35								35					n					35
Brown trout	Sandvatn	Lyngdal	52	91							14								14					n					14
Brown trout	Sandvatn	Lyngdal	51	91					1	1	19	1							21					n					21
Brown trout	Skjekelivatn	Lyngdal	20	91							1								1					n					1
Brown trout	Skjekelivatn	Lyngdal	22	91							56	2		1		1			59					n					59
Brown trout	Skjekelivatn	Lyngdal	19	91							38								38					n					38
Brown trout	Skjekelivatn	Lyngdal	21	91							43	2	1		1	1			47					n					47
Brown trout	Skjekelivatn	Lyngdal	24	91							4								4					n					4
Brown trout	Skjekelivatn	Lyngdal	23	91							71								71					n					71
Brown trout	Kringlevatn	Valle	72	91															n				150	150					150
Brown trout	Kringlevatn	Valle	73	91										19		19			19				400	400	1		1		420
Brown trout	Skammevatn	Valle	71	91															n					n					0
Brown trout	Smalevatn	Valle	51	90								1							1	1				1					2
Brown trout	Smalevatn	Valle	52	90			1	1	1	3	53	12							68					n					68
Brown trout	Smalevatn	Valle	78	91															n					n					0
Brown trout	Smalevatn	Valle	79	91															n					n					0
Brown trout	Smalevatn	Valle	96	91								1							1					n					1
Brown trout	Smalevatn	Valle	94	91							1	1							2				10	10	4		4		16
Brown trout	Smalevatn	Valle	95	91	2								4					1	7					n					7
Brown trout	Smalevatn	Valle	80	91															n					n	20		20		20
Brown trout	Smalevatn	Valle	86	91															n				15	15	1		1		16
Brown trout	Smalevatn	Valle	93	91									1		1	1		1	3					n	1		1		4
Brown trout	Smalevatn	Valle	83	91											1	1			1				10	10					11
Brown trout	Smalevatn	Valle	88	91															n					n					0
Brown trout	Smalevatn	Valle	92	91								1	1		5	5			7				750	750					757
Brown trout	Smalevatn	Valle	75	91									15						15				50	50					65
Brown trout	Smalevatn	Valle	85	91															n					n	2		2		2
Brown trout	Smalevatn	Valle	76	91								1							1				150	150	2		2		153
Brown trout	Smalevatn	Valle	91	91									20						20					n					20
Brown trout	Smalevatn	Valle	77	91	2						6	15	6	1		1			30					n					30
Brown trout	Smalevatn	Valle	84	91							1								1					n	1		1		2
Brown trout	Smalevatn	Valle	87	91									15						15				50	50					65
Brown trout	Smalevatn	Valle	89	91							12	2							14					n					14
Brown trout	Smalevatn	Valle	81	91							5								5					n	1		1		6
Brown trout	Smalevatn	Valle	82	91							1								1				10	10					11
Brown trout	Smalevatn	Valle	90	91								1			24	24			25				75	75					100
Brown trout	Smalevatn	Valle	74	91							1								1				250	250					251

APPENDIX 3. WATER CHEMISTRY

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Lyngdal	28-09-88	Homsvatn	4.86	14	2.26	0.58	0.21	1.16	0.17	1.9	2.4	26	275	2.06		121	19	102
Lyngdal	15-10-88	Homsvatn	4.68	21	2.42	0.55	0.22	1.25	0.13	2.0	2.4	49	280	2.52		116	24	92
Lyngdal	02-11-88	Homsvatn	4.73	19	2.23	0.59	0.22	1.19	0.11	1.8	2.3	35	285	2.08		130	12	118
Lyngdal	15-11-88	Homsvatn	4.72	19	2.50	0.64	0.22	1.14	0.12	2.1	2.5	53	355	1.98		146	21	125
Lyngdal	30-11-88	Homsvatn	4.77	17	2.67	0.67	0.22	1.30	0.10	2.0	2.8	94	320	2.33		128	18	110
Lyngdal	19-03-89	Homsvatn	4.66	22	2.87	0.58	0.27	1.83	0.25	3.3	2.5	44	305	1.44		136	13	123
Lyngdal	15-05-89	Homsvatn	4.47	34	2.61	0.60	0.26	1.57	0.20	2.8	2.4	39	340	2.05		123	17	106
Lyngdal	12-06-89	Homsvatn	4.92	12	2.68	0.55	0.25	1.74	0.23	3.3	2.4	31	395	1.89	0.013	135	11	124
Lyngdal	07-07-89	Homsvatn	4.76	17	2.50	0.55	0.27	1.56	0.16	2.8	2.4	42	350	1.74		114	11	103
Lyngdal	15-07-89	Homsvatn	4.78	17	2.54	0.59	0.24	1.70	0.21	2.9	2.6	17	350	1.58		109	11	98
Lyngdal	06-08-89	Homsvatn	4.84	14	2.56	0.61	0.24	1.73	0.24	3.0	2.5	13	350	1.22		111	10	101
Lyngdal	01-09-89	Homsvatn	4.75	18	2.59	0.58	0.26	1.64	0.18	2.8	2.7	18	330	1.68		122	11	111
Lyngdal	21-10-89	Homsvatn	4.28	52	3.71	0.41	0.25	1.38	0.15	2.1	2.7	31	158	10.00		56	37	19
Lyngdal	18-11-89	Homsvatn	4.75	18	2.65	0.55	0.24	1.54	0.25	2.8	3.0	48	300	1.70		118	11	107
Lyngdal	23-12-89	Homsvatn	4.68	21	3.07	0.65	0.30	1.86	0.17	3.4	3.1	47	335	1.39		134	10	124
Lyngdal	14-02-90	Homsvatn	4.56	28	3.28	0.41	0.26	2.24	0.18	4.1	2.4	67	260	1.71		88	11	77
Lyngdal	03-06-90	Homsvatn	4.69	20	2.97	0.56	0.27	1.80	0.18	3.4	2.7	26	260	2.40		122	23	99
Lyngdal	12-07-90	Homsvatn	4.71	19	2.76	0.48	0.23	1.77	0.18	3.1	2.7	29	270	1.71		124	11	113
Lyngdal	23-08-90	Homsvatn	4.75	18	2.72	0.49	0.22	1.70	0.17	3.0	2.6	14	265	1.39		115	11	104
Lyngdal	28-08-90	Homsvatn	4.81	15	2.67	0.54	0.21	1.73	0.17	3.0	2.5	34	275	1.38		116	10	106
Lyngdal	06-10-90	Homsvatn	4.73	19	2.57	0.51	0.25	1.58	0.14	2.8	2.7	25	250	1.50		118	11	107
Lyngdal	10-11-90	Homsvatn	4.72	19	2.59	0.56	0.24	1.60	0.16	2.8	2.7	38	250	1.72		117	14	103
Lyngdal	18-11-90	Homsvatn	4.75	18	2.65	0.55	0.24	1.54	0.25	2.8	3.0	48	300	1.70		118	11	107
Lyngdal	19-05-91	Homsvatn	4.84	14	2.42	0.54	0.24	1.58	0.24	2.7	2.4	36	240	1.91		119	19	100
Lyngdal	25-06-91	Homsvatn	4.83	15	2.35	0.52	0.22	1.46	0.13	2.6	2.4	20	220	1.70		121	14	107
Lyngdal	21-07-91	Homsvatn	4.89	13	2.28	0.53	0.23	1.62	0.19	2.9	2.3	29	220	1.64		112	17	95
Lyngdal	20-08-91	Homsvatn	5.05	9	2.40	0.60	0.23	1.54	0.17	2.7	2.3	19	200	1.83		84	20	64
Lyngdal	29-08-91	Homsvatn	4.94	11	2.19	0.55	0.22	1.49	0.11	2.7	2.5	19	215	1.24		99	10	89
Lyngdal	09-10-91	Homsvatn	4.90	13	2.35	0.53	0.23	1.59	0.18	2.7	2.5	42	235	1.26		97	10	87
Lyngdal	28-09-88	Trollselvvatn	4.50	32	2.55	0.29	0.17	0.98	0.06	1.6	2.0	11	85	8.12		123	63	60
Lyngdal	15-10-88	Trollselvvatn	4.41	39	2.89	0.37	0.22	1.22	0.08	2.0	2.4	36	132	5.88		125	50	75
Lyngdal	02-11-88	Trollselvvatn	4.42	38	2.76	0.36	0.23	1.19	0.07	2.0	2.4	23	123	5.61		130	44	86
Lyngdal	15-11-88	Trollselvvatn	4.39	41	3.06	0.38	0.23	1.10	0.05	2.1	2.6	20	136	6.29		128	48	80
Lyngdal	30-11-88	Trollselvvatn	4.54	29	2.76	0.41	0.24	1.40	0.13	2.5	2.7	36	152	5.89		128	50	78
Lyngdal	19-03-89	Trollselvvatn	4.33	47	4.35	0.43	0.35	2.71	0.26	5.4	2.8	52	240	2.41		120	26	94
Lyngdal	15-05-89	Trollselvvatn	4.50	32	2.55	0.31	0.18	1.30	0.15	2.2	2.1	49	179	3.34		89	25	64
Lyngdal	12-06-89	Trollselvvatn	4.73	19	2.35	0.25	0.17	1.61	0.26	2.9	2.0	21	117	2.82	0.006	74	11	63
Lyngdal	07-07-89	Trollselvvatn	4.74	18	2.23	0.40	0.24	1.58	0.16	2.6	2.1	55	79	4.28		79	30	49
Lyngdal	15-07-89	Trollselvvatn	4.74	18	2.16	0.27	0.17	1.48	0.17	2.4	2.2	13	12	3.20		79	19	60
Lyngdal	06-08-89	Trollselvvatn	4.79	16	2.19	0.30	0.18	1.54	0.22	2.5	2.2	15	1	3.30		69	16	53

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Lyngdal	01-09-89	Trollselvvatn	4.64	23	2.29	0.32	0.21	1.47	0.12	2.2	2.6	18	4	5.03		97	32	65
Lyngdal	21-10-89	Trollselvvatn	4.55	28	2.77	0.44	0.25	1.47	0.18	2.4	2.6	50	70	5.52		117	43	74
Lyngdal	18-11-89	Trollselvvatn	4.46	35	2.58	0.24	0.17	1.26	0.09	2.1	2.3	38	118	1.40		101	39	62
Lyngdal	23-12-89	Trollselvvatn	4.40	40	3.62	0.35	0.26	1.92	0.12	3.5	2.5	35	152	4.08		114	37	77
Lyngdal	14-02-90	Trollselvvatn	4.35	45	3.57	0.30	0.25	2.30	0.14	4.4	2.1	45	191	2.08		80	16	64
Lyngdal	03-06-90	Trollselvvatn	4.60	25	2.77	0.31	0.20	1.60	0.18	3.0	2.2	24	188	2.30		86	11	75
Lyngdal	12-07-90	Trollselvvatn	4.54	29	2.38	0.21	0.15	1.22	0.09	1.6	2.0	21	54	6.20		106	52	54
Lyngdal	22-08-90	Trollselvvatn	4.63	23	2.27	0.27	0.16	1.24	0.07	1.7	2.2	18	30	6.15		109	55	54
Lyngdal	28-08-90	Trollselvvatn	4.65	22	2.23	0.28	0.15	1.25	0.07	1.8	2.1	32	28	5.85		118	48	70
Lyngdal	06-10-90	Trollselvvatn	4.52	30	2.56	0.28	0.20	1.27	0.05	2.0	2.1	23	51	6.79		137	62	75
Lyngdal	10-11-90	Trollselvvatn	4.41	39	2.97	0.30	0.20	1.30	0.07	2.1	2.6	38	102	5.33		115	46	69
Lyngdal	18-11-90	Trollselvvatn	4.46	35	2.58	0.24	0.17	1.26	0.09	2.1	2.3	38	118	1.40		101	39	62
Lyngdal	19-05-91	Trollselvvatn	4.80	16	1.85	0.21	0.13	1.09	0.17	1.8	1.4	42	80	3.50		84	44	40
Lyngdal	25-06-91	Trollselvvatn	4.73	19	1.84	0.23	0.13	1.05	0.07	1.8	1.4	20	53	4.00		84	42	42
Lyngdal	21-07-91	Trollselvvatn	4.80	16	1.73	0.26	0.15	1.15	0.09	1.7	1.5	23	3	5.24		134	89	45
Lyngdal	20-08-91	Trollselvvatn	4.97	11	1.71	0.49	0.15	1.19	1.14	2.1	1.9	32	19	3.57		160	62	98
Lyngdal	29-08-91	Trollselvvatn	4.81	15	1.74	0.31	0.16	1.14	0.05	1.7	1.9	17	19	4.64		91	28	63
Lyngdal	09-10-91	Trollselvvatn	4.55	28	2.87	0.39	0.24	1.60	0.19	3.0	2.0	48	55	6.46		129	77	52
Lyngdal	28-09-88	Sandvatn	4.48	33	2.77	0.43	0.21	1.18	0.13	2.1	2.4	17	141	6.59		132	52	80
Lyngdal	15-10-88	Sandvatn	4.54	29	2.60	0.44	0.23	1.21	0.08	1.9	2.5	43	174	4.86		129	44	85
Lyngdal	02-11-88	Sandvatn	4.65	22	2.43	0.48	0.23	1.22	0.08	1.9	2.7	21	167	4.50		122	36	86
Lyngdal	15-11-88	Sandvatn	4.57	27	2.56	0.51	0.23	1.09	0.08	2.1	2.4	23	171	4.57		135	44	91
Lyngdal	30-11-88	Sandvatn	4.41	39	3.05	0.52	0.23	1.34	0.08	2.2	2.9	27	235	4.56		122	41	81
Lyngdal	19-03-89	Sandvatn	4.43	37	3.74	0.54	0.34	2.32	0.20	4.6	2.8	52	265	2.06		142	24	118
Lyngdal	15-05-89	Sandvatn	4.59	26	2.45	0.38	0.20	1.37	0.17	2.4	1.2	41	240	2.73		91	23	68
Lyngdal	12-06-89	Sandvatn	4.72	19	2.39	0.38	0.20	1.44	0.21	2.7	2.2	14	220	2.22	0.01	91	11	80
Lyngdal	07-07-89	Sandvatn	4.76	17	2.17	0.41	0.23	1.48	0.15	2.5	2.3	36	163	2.38		88	17	71
Lyngdal	15-07-89	Sandvatn	4.86	14	2.24	0.46	0.21	1.65	0.19	2.6	2.4	17	105	2.48		83	17	66
Lyngdal	06-08-89	Sandvatn	4.85	14	2.27	0.50	0.22	1.70	0.17	2.7	2.3	5	104	2.73		71	16	55
Lyngdal	01-09-89	Sandvatn	4.77	17	2.30	0.50	0.24	1.63	0.16	2.5	2.5	26	104	4.07		95	30	65
Lyngdal	21-10-89	Sandvatn	4.77	17	2.55	0.60	0.28	1.59	0.23	2.6	3.1	56	140	4.46		119	37	82
Lyngdal	23-12-89	Sandvatn	4.56	28	3.58	0.65	0.33	2.16	0.18	3.9	3.4	48	290	3.01		142	30	112
Lyngdal	14-02-90	Sandvatn	4.42	38	3.43	0.39	0.27	2.34	0.16	4.5	2.2	54	215	1.86		94	14	80
Lyngdal	03-06-90	Sandvatn	4.71	19	2.85	0.47	0.24	1.79	0.22	3.4	2.4	26	215	2.05		94	11	83
Lyngdal	12-07-90	Sandvatn	4.59	26	2.43	0.31	0.17	1.37	0.10	2.0	2.2	23	110	4.82		108	44	64
Lyngdal	22-08-90	Sandvatn	4.76	17	2.32	0.40	0.20	1.42	0.16	2.3	2.2	42	124	4.06		109	46	63
Lyngdal	28-08-90	Sandvatn	4.77	17	2.32	0.46	0.19	1.43	0.15	2.3	2.3	55	106	4.84		110	48	62
Lyngdal	06-10-90	Sandvatn	4.66	22	2.45	0.43	0.23	1.41	0.10	2.4	2.3	27	103	5.33		125	50	75
Lyngdal	10-11-90	Sandvatn	4.51	31	2.76	0.43	0.22	1.39	0.12	2.2	2.7	40	143	4.12		107	36	71
Lyngdal	18-11-90	Sandvatn	4.54	29	2.89	0.42	0.23	1.38	0.14	2.5	2.3	35	265	3.29		113	33	80

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Lyngdal	19-05-91	Sandvatn	4.87	13	1.80	0.34	0.15	1.11	0.15	1.8	1.5	59	105	2.99		82	42	40
Lyngdal	25-06-91	Sandvatn	4.83	15	2.03	0.45	0.18	1.21	0.18	2.1	1.7	36	144	3.39		91	33	58
Lyngdal	21-07-91	Sandvatn	5.04	9	1.77	0.44	0.19	1.23	0.12	2.1	1.6	21	61	4.21		126	75	51
Lyngdal	20-08-91	Sandvatn	5.02	10	1.82	0.30	0.19	1.28	0.11	1.7	1.7	46	69	4.57		124	79	45
Lyngdal	29-08-91	Sandvatn	5.00	10	1.82	0.49	0.19	1.30	0.11	2.2	2.1	28	72	3.67		81	35	46
Lyngdal	09-10-91	Sandvatn	4.68	21	2.68	0.51	0.26	1.62	0.16	3.1	2.1	36	110	5.12		118	62	56
Lyngdal	28-09-88	Skjekelivatn	4.67	21	2.19	0.43	0.18	1.00	0.09	1.6	2.1	28	129	5.49		108	42	66
Lyngdal	15-10-88	Skjekelivatn	4.61	25	2.92	0.45	0.21	1.27	0.16	2.0	2.2	55	156	5.08		123	44	79
Lyngdal	02-11-88	Skjekelivatn	4.56	28	2.33	0.45	0.21	1.14	0.08	1.7	2.3	37	162	5.17		122	36	86
Lyngdal	15-11-88	Skjekelivatn	4.53	30	2.62	0.45	0.21	1.02	0.06	1.8	2.5	48	177	5.13		118	41	77
Lyngdal	30-11-88	Skjekelivatn	4.62	24	2.55	0.49	0.22	1.29	0.09	2.0	2.5	42	182	4.82		130	44	86
Lyngdal	19-03-89	Skjekelivatn	4.44	36	3.61	0.50	0.32	2.25	0.20	4.5	2.6	54	245	2.14		113	21	92
Lyngdal	15-05-89	Skjekelivatn	4.59	26	2.67	0.42	0.23	1.55	0.22	2.8	2.4	51	260	2.96		87	23	64
Lyngdal	12-06-89	Skjekelivatn	4.72	19	2.67	0.40	0.22	1.71	0.34	3.2	2.2	35	260	2.39	0.01	98	11	87
Lyngdal	07-07-89	Skjekelivatn	4.66	22	2.37	0.39	0.23	1.53	0.15	2.6	2.3	59	240	2.15		96	17	79
Lyngdal	15-07-89	Skjekelivatn	4.77	17	2.52	0.43	0.21	1.80	0.31	2.9	2.5	11	235	3.11		87	13	74
Lyngdal	06-08-89	Skjekelivatn	4.76	17	2.61	0.45	0.21	1.85	0.37	3.1	2.4	28	240	1.99		86	13	73
Lyngdal	29-08-89	Skjekelivatn	4.71	19	2.37	0.45	0.23	1.64	0.19	2.7	2.6	22	195	2.66		97	17	80
Lyngdal	21-10-89	Skjekelivatn	4.62	24	2.83	0.53	0.26	1.63	0.22	2.7	2.9	43	149	3.92		102	30	72
Lyngdal	23-12-89	Skjekelivatn	4.53	30	3.06	0.48	0.24	1.59	0.13	2.7	2.5	43	196	3.51		112	32	80
Lyngdal	14-02-90	Skjekelivatn	4.46	35	3.56	0.37	0.27	2.36	0.16	4.5	2.2	47	215	1.92		88	14	74
Lyngdal	03-06-90	Skjekelivatn	4.64	23	2.94	0.42	0.24	1.76	0.21	3.4	2.3	42	200	2.31		92	18	74
Lyngdal	12-07-90	Skjekelivatn	4.63	23	2.52	0.35	0.19	1.44	0.12	2.3	2.2	27	127	4.20		104	40	64
Lyngdal	23-08-90	Skjekelivatn	4.71	19	2.36	0.39	0.19	1.45	0.12	2.4	2.4	22	127	3.80		103	36	67
Lyngdal	28-08-90	Skjekelivatn	4.72	19	2.39	0.42	0.18	1.48	0.13	2.3	2.2	38	126	3.74		101	58	43
Lyngdal	06-10-90	Skjekelivatn	4.65	22	2.43	0.40	0.22	1.41	0.10	2.3	2.2	39	101	4.89		118	42	76
Lyngdal	10-11-90	Skjekelivatn	4.56	28	2.66	0.43	0.22	1.40	0.10	2.2	2.6	42	133	4.57		109	42	67
Lyngdal	18-11-90	Skjekelivatn	4.59	26	2.62	0.43	0.21	1.42	0.15	2.4	2.6	35	158	3.75		109	33	76
Lyngdal	19-05-91	Skjekelivatn	4.99	10	2.32	0.63	0.25	1.65	0.30	2.6	2.2	40	240	3.39		97	42	55
Lyngdal	25-06-91	Skjekelivatn	4.87	13	1.97	0.41	0.17	1.23	0.19	2.2	1.8	60	122	3.49		91	33	58
Lyngdal	21-07-91	Skjekelivatn	4.89	13	1.88	0.43	0.18	1.29	0.18	2.1	1.7	21	107	3.53		110	64	46
Lyngdal	20-08-91	Skjekelivatn	5.09	8	1.99	0.47	0.18	1.37	0.26	2.4	1.9	33	109	3.16		76	35	41
Lyngdal	29-08-91	Skjekelivatn	4.93	12	1.86	0.49	0.18	1.24	0.11	2.1	2.0	19	112	3.05		81	28	53
Lyngdal	09-10-91	Skjekelivatn	4.75	18	2.53	0.57	0.24	1.70	0.21	3.0	2.2	38	82	4.92		116	45	71
Lyngdal	28-09-88	Mjåvatn	4.62	24	2.34	0.55	0.21	1.05	0.14	1.8	2.3	20	104	6.58		115	47	68
Lyngdal	15-10-88	Mjåvatn	4.58	26	2.74	0.58	0.26	1.33	0.17	2.3	2.7	45	152	4.92		133	42	91
Lyngdal	02-11-88	Mjåvatn	4.62	24	2.50	0.65	0.26	1.31	0.13	2.2	2.6	27	138	4.66		124	31	93
Lyngdal	15-11-88	Mjåvatn	4.54	29	2.77	0.57	0.24	1.08	0.07	2.2	2.7	50	157	4.77		103	33	70
Lyngdal	30-11-88	Mjåvatn	5.18	7	2.28	1.06	0.26	1.72	0.06	2.8	2.4	27	127	4.77		70	35	35
Lyngdal	19-03-89	Mjåvatn	4.45	35	3.91	0.65	0.38	2.62	0.26	5.2	2.8	50	310	2.03		138	21	117

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Lyngdal	15-05-89	Mjåvatn	4.87	13	2.08	0.48	0.20	1.36	0.23	2.3	2.1	25	174	3.42		99	31	68
Lyngdal	12-06-89	Mjåvatn	5.03	9	2.28	0.51	0.20	1.74	0.40	3.0	2.2	21	185	2.77	0.024	69	11	58
Lyngdal	07-07-89	Mjåvatn	5.18	7	2.14	0.55	0.23	1.60	0.35	2.5	2.1	91	120	3.58		63	24	39
Lyngdal	15-07-89	Mjåvatn	5.15	7	2.05	0.58	0.20	1.73	0.37	2.7	2.2	11	80	3.04		61	19	42
Lyngdal	06-08-89	Mjåvatn	5.38	4	2.00	0.62	0.20	1.75	0.31	2.6	2.2	15	39	3.11	0.037	46	19	27
Lyngdal	01-09-89	Mjåvatn	4.84	14	2.13	0.65	0.24	1.51	0.10	2.2	2.6	13	32	6.01		107	44	63
Lyngdal	21-10-89	Mjåvatn	4.40	40	3.16	0.44	0.23	1.35	0.17	1.9	3.0	22	33	8.02		108	62	46
Lyngdal	18-11-89	Mjåvatn	4.60	25	2.39	0.36	0.18	1.21	0.08	1.8	2.6	35	104	3.77		103	35	68
Lyngdal	23-12-89	Mjåvatn	4.46	35	3.62	0.52	0.30	1.99	0.09	3.8	2.7	38	149	3.45		108	27	81
Lyngdal	14-02-90	Mjåvatn	4.52	30	3.08	0.36	0.24	2.13	0.16	3.9	2.3	36	178	2.39		84	22	62
Lyngdal	03-06-90	Mjåvatn	4.94	11	2.60	0.64	0.25	1.83	0.31	3.3	2.5	33	185	3.03		67	18	49
Lyngdal	12-07-90	Mjåvatn	4.68	21	2.10	0.38	0.15	1.14	0.06	1.4	1.9	10	61	6.05		110	47	63
Lyngdal	23-08-90	Mjåvatn	4.80	16	2.11	0.48	0.18	1.26	0.05	1.8	2.3	10	30	5.64		105	46	59
Lyngdal	28-08-90	Mjåvatn	4.82	15	2.09	0.54	0.17	1.32	0.08	1.8	2.3	22	27	5.73		108	43	65
Lyngdal	06-10-90	Mjåvatn	4.58	26	2.51	0.44	0.21	1.36	0.09	2.3	2.1	23	35	6.80		108	50	58
Lyngdal	10-11-90	Mjåvatn	4.54	29	2.78	0.49	0.23	1.47	0.09	2.4	2.9	30	96	4.78		113	39	74
Lyngdal	18-11-90	Mjåvatn	4.60	25	2.39	0.36	0.18	1.21	0.08	1.8	2.6	35	104	3.77		103	35	68
Lyngdal	19-05-91	Mjåvatn	5.14	7	1.62	0.48	0.15	1.20	0.16	1.9	1.5	36	48	4.06		70	44	26
Lyngdal	25-06-91	Mjåvatn	4.95	11	1.75	0.49	0.16	1.19	0.14	2.2	1.6	24	36	5.18		86	50	36
Lyngdal	21-07-91	Mjåvatn	5.06	9	1.60	0.55	0.18	1.17	0.06	1.7	1.6	14	27	5.72		140	96	44
Lyngdal	20-08-91	Mjåvatn	5.51	3	4.34	0.65	0.19	1.23	0.06	1.7	1.9	17	37	5.07	0.032	76	48	28
Lyngdal	29-08-91	Mjåvatn	5.19	6	1.67	0.70	0.19	1.25	0.07	1.9	1.9	28	44	5.27		81	52	29
Lyngdal	09-10-91	Mjåvatn	4.69	20	2.76	0.68	0.27	1.71	0.16	3.3	2.1	28	50	5.93		124	65	59
Valle	01-10-88	Rennevatn	5.25	6	0.99	0.49	0.10	0.51	0.11	0.5	1.8	12	127	0.74	0.027	152	10	142
Valle	16-03-89	Rennevatn	5.28	5	1.53	0.57	0.17	0.90	0.12	1.8	1.8	19	205	0.17		182	10	172
Valle	24-04-89	Rennevatn	4.92	12	2.03	0.70	0.23	1.17	0.16	2.1	2.6	89	465	0.36		279	10	269
Valle	29-08-89	Rennevatn	5.28	5	1.02	0.33	0.10	0.63	0.10	0.9	1.5	11	142	0.31		111	10	101
Valle	27-09-89	Rennevatn	5.32	5	1.09	0.36	0.10	0.62	0.08	0.9	1.6	17	149	0.29	0.028	97	10	87
Valle	24-04-90	Rennevatn	5.05	9	2.41	0.71	0.22	1.34	0.20	2.5	2.6	47	320	1.25		245	24	221
Valle	25-08-90	Rennevatn	5.25	6	0.96	0.24	0.07	0.46	0.06	0.6	1.4	10	103	0.27		109	10	99
Valle	13-03-91	Rennevatn	5.38	4	1.15	0.42	0.11	0.68	0.10	0.9	1.7	32	148	0.43	0.025	112	10	102
Valle	23-04-91	Rennevatn	5.12	8	1.56	0.53	0.15	0.80	0.09	1.1	2.6	63	315	0.52		179	10	169
Valle	26-10-91	Rennevatn	5.33	5	1.05	0.40	0.10	0.55	0.06	0.3	1.6	10	160	0.78	0.03	115	10	105
Valle	01-10-88	Hyttetjørni	5.16	7	0.88	0.26	0.09	0.48	0.07	0.7	1.4	8	63	0.82		77	10	67
Valle	11-03-89	Hyttetjørni	4.91	12	2.22	0.39	0.24	1.75	0.10	3.4	1.7	21	189	0.30		144	10	134
Valle	18-04-89	Hyttetjørni	4.77	17	2.68	0.46	0.32	2.15	0.13	4.6	2.9	91	370	0.39		242	10	232
Valle	29-08-89	Hyttetjørni	5.13	7	0.88	0.16	0.08	0.55	0.06	0.9	1.1	9	78	0.51		49	10	39
Valle	28-09-89	Hyttetjørni	5.10	8	0.99	0.19	0.09	0.58	0.06	0.9	1.3	-99	83	0.71		51	10	41
Valle	27-03-90	Hyttetjørni	4.75	18	3.81	0.43	0.43	3.27	0.19	6.3	2.5	42	320	0.52		183	10	173
Valle	24-04-90	Hyttetjørni	4.75	18	4.18	0.54	0.47	3.33	0.21	7.0	2.7	89	350	0.63		217	10	207

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Valle	25-08-90	Hyttetjørni	5.19	6	0.97	0.18	0.07	0.55	0.05	0.9	1.0	12	85	0.40		52	10	42
Valle	23-10-90	Hyttetjørni	5.12	8	1.09	0.19	0.11	0.70	0.04	1.1	1.1	15	84	0.40		59	10	49
Valle	15-03-91	Hyttetjørni	5.11	8	1.34	0.30	0.14	0.85	0.09	1.4	1.3	30	170	0.37		88	10	78
Valle	12-04-91	Hyttetjørni	5.24	6	1.37	0.53	0.15	0.85	0.10	1.5	1.4	18	215	0.36		64	10	54
Valle	20-07-91	Hyttetjørni	5.20	6	0.73	0.18	0.07	0.39	0.05	0.4	0.8	8	72	0.45		35	10	25
Valle	15-08-91	Hyttetjørni	6.00	1	0.75	0.49	0.12	0.46	0.05	0.6	1.0	13	59	0.56	0.04	13	10	3
Valle	26-10-91	Hyttetjørni	5.08	8	1.12	0.25	0.10	0.64	0.04	1.1	1.2	10	102	0.50		69	11	58
Valle	01-10-88	Skammevatn	5.34	5	0.83	0.36	0.08	0.43	0.06	0.6	1.6	10	64	0.65	0.028	77	10	67
Valle	16-03-89	Skammevatn	5.22	6	1.65	0.50	0.16	1.13	0.09	2.3	1.6	17	117	0.26		99	10	89
Valle	15-04-89	Skammevatn	5.19	6	1.34	0.48	0.15	1.00	0.07	2.0	2.0	30	152	0.23		122	10	112
Valle	21-07-89	Skammevatn	5.35	4	1.28	0.29	0.08	0.69	0.09	1.2	1.3	7	78	8.24	0.03	37	10	27
Valle	29-08-89	Skammevatn	5.42	4	0.85	0.25	0.08	0.58	0.06	0.9	1.1	18	69	0.38	0.028	53	10	43
Valle	27-09-89	Skammevatn	5.37	4	0.90	0.27	0.08	0.57	0.05	0.8	1.3	12	73	0.40	0.028	49	10	39
Valle	24-04-90	Skammevatn	5.19	6	2.20	0.52	0.23	1.66	0.13	3.3	1.8	26	192	0.52		145	10	135
Valle	25-08-90	Skammevatn	5.33	5	0.90	0.23	0.07	0.54	0.04	0.8	1.0	10	66	0.34	0.021	59	10	49
Valle	13-03-91	Skammevatn	5.49	3	1.03	0.38	0.10	0.68	0.06	1.0	1.2	16	104	0.39	0.023	63	10	53
Valle	23-04-91	Skammevatn	5.37	4	1.07	0.40	0.11	0.70	0.05	1.1	1.4	36	138	0.42	0.034	78	10	68
Valle	26-10-91	Skammevatn	5.38	4	1.01	0.33	0.08	0.61	0.13	0.7	1.2	16	87	0.40	0.03	60	10	50
Valle	01-10-88	Smalevatn	5.29	5	0.79	0.26	0.09	0.48	0.05	0.7	1.1	10	34	1.08		61	11	50
Valle	11-03-89	Smalevatn	5.02	10	2.01	0.35	0.23	1.77	0.09	3.5	1.3	16	91	0.40		89	10	79
Valle	18-04-89	Smalevatn	4.90	13	2.32	0.50	0.29	2.00	0.13	4.4	2.3	57	240	0.60		145	10	135
Valle	07-07-89	Smalevatn	5.38	4	0.85	0.22	0.10	0.62	0.07	0.9	0.8	7	38	1.35	0.031	10	10	0
Valle	29-08-89	Smalevatn	5.45	4	0.73	0.19	0.08	0.54	0.06	0.8	0.9	8	35	0.72	0.027	22	10	12
Valle	28-09-89	Smalevatn	5.31	5	0.81	0.21	0.08	0.55	0.05	0.8	1.0	-99	35	0.79	0.025	31	10	21
Valle	22-10-89	Smalevatn	5.20	6	1.02	0.26	0.11	0.61	0.07	1.1	1.1	12	39	0.95		48	10	38
Valle	27-03-90	Smalevatn	4.86	14	3.58	0.49	0.42	3.16	0.23	6.2	2.3	58	245	0.78		133	10	123
Valle	24-04-90	Smalevatn	4.85	14	3.36	0.50	0.39	2.84	0.20	5.9	2.2	43	210	0.76		139	10	129
Valle	25-08-90	Smalevatn	5.36	4	0.81	0.13	0.06	0.48	0.06	0.7	0.9	14	42	0.45		30	10	20
Valle	23-10-90	Smalevatn	5.31	5	0.87	0.20	0.09	0.59	0.05	0.9	0.9	17	44	0.63	0.018	36	10	26
Valle	15-03-91	Smalevatn	5.17	7	1.23	0.34	0.13	0.81	0.06	1.4	1.2	36	96	0.60		72	10	62
Valle	12-04-91	Smalevatn	5.11	8	1.44	0.44	0.17	0.92	0.10	1.7	1.5	31	131	0.86		84	10	74
Valle	20-07-91	Smalevatn	5.20	6	0.84	0.22	0.08	0.50	0.06	0.9	0.7	8	72	0.49		44	10	34
Valle	15-08-91	Smalevatn	5.29	5	0.87	0.28	0.09	0.52	0.07	0.8	0.8	7	67	1.90		33	10	23
Valle	26-10-91	Smalevatn	5.23	6	1.01	0.28	0.10	0.64	0.05	1.0	1.1	12	58	0.69		45	10	35
Valle	01-10-88	Kringlevatn	5.37	4	0.80	0.33	0.09	0.45	0.07	0.7	1.2	7	59	0.76	0.028	38	10	28
Valle	11-03-89	Kringlevatn	5.03	9	2.46	0.57	0.29	2.09	0.12	4.2	1.8	17	190	0.25		126	10	116
Valle	18-04-89	Kringlevatn	5.05	9	2.13	0.54	0.28	1.85	0.12	4.0	2.3	49	255	0.24		138	10	128
Valle	07-07-89	Kringlevatn	5.27	5	1.00	0.16	0.09	0.74	0.12	1.1	0.9	15	94	0.87		44	10	34
Valle	29-08-89	Kringlevatn	5.32	5	0.74	0.19	0.07	0.49	0.08	0.7	0.9	16	62	0.53	0.026	27	10	17
Valle	28-09-89	Kringlevatn	5.31	5	0.80	0.23	0.08	0.51	0.06	0.8	0.9	-99	70	0.43	0.026	31	10	21

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Valle	27-03-90	Kringlevatn	4.96	11	2.79	0.49	0.32	2.26	0.16	4.5	2.2	27	330	0.44		133	10	123
Valle	24-04-90	Kringlevatn	4.92	12	3.64	0.68	0.42	2.82	0.21	6.1	2.4	96	370	0.52		189	10	179
Valle	25-08-90	Kringlevatn	5.25	6	0.85	0.18	0.06	0.47	0.05	0.7	0.8	6	72	0.34		27	10	17
Valle	23-10-90	Kringlevatn	5.27	5	0.91	0.21	0.09	0.62	0.07	1.0	0.8	15	75	0.20		29	10	19
Valle	15-03-91	Kringlevatn	5.24	6	1.15	0.37	0.12	0.73	0.08	1.2	1.1	14	152	0.31		64	10	54
Valle	12-04-91	Kringlevatn	4.96	11	1.71	0.41	0.18	1.02	0.11	1.6	1.8	38	235	0.56		112	10	102
Valle	20-07-91	Kringlevatn	5.16	7	0.90	0.23	0.08	0.49	0.07	1.2	0.9	12	114	0.35		44	10	34
Valle	15-08-91	Kringlevatn	5.16	7	0.85	0.22	0.07	0.44	0.05	0.6	0.9	7	99	0.55		38	10	28
Valle	26-10-91	Kringlevatn	5.25	6	0.96	0.29	0.09	0.58	0.05	0.9	1.2	12	88	0.30		45	10	35
Birkeland	30-09-88	Repstadvatn	4.79	16	3.12	0.90	0.38	1.88	0.26	3.6	4.3	38	115	2.86		195	27	168
Birkeland	23-10-88	Repstadvatn	4.77	17	3.21	0.91	0.39	1.91	0.21	3.5	3.9	59	135	2.80		193	24	169
Birkeland	06-11-88	Repstadvatn	4.78	17	3.14	0.90	0.40	1.94	0.21	3.6	3.9	46	135	2.49		198	19	179
Birkeland	20-11-88	Repstadvatn	4.77	17	3.39	0.99	0.41	2.12	0.21	4.0	4.4	65	155	2.52		216	28	188
Birkeland	04-12-88	Repstadvatn	4.78	17	3.62	1.03	0.43	2.36	0.30	4.0	4.3	72	170	3.08		225	40	185
Birkeland	18-12-88	Repstadvatn	4.69	20	3.76	1.08	0.45	2.45	0.32	4.4	4.7	84	200	2.88		236	19	217
Birkeland	01-01-89	Repstadvatn	4.71	19	3.40	0.96	0.43	2.26	0.27	4.1	4.3	51	179	3.48		235	40	195
Birkeland	15-01-89	Repstadvatn	4.69	20	3.29	0.83	0.41	2.09	0.21	3.8	4.2	45	143	3.76		229	61	168
Birkeland	29-01-89	Repstadvatn	4.82	15	3.13	0.91	0.41	2.01	0.23	3.6	3.9	46	154	2.87		202	31	171
Birkeland	12-02-89	Repstadvatn	4.85	14	3.08	0.93	0.43	2.07	0.26	3.7	4.2	59	158	2.03		187	24	163
Birkeland	26-02-89	Repstadvatn	4.80	16	3.25	0.89	0.42	2.14	0.26	4.0	4.6	55	171	2.20		195	25	170
Birkeland	12-03-89	Repstadvatn	4.75	18	3.09	0.92	0.43	2.16	0.26	4.2	4.2	56	175	1.89		209	21	188
Birkeland	09-04-89	Repstadvatn	4.72	19	3.43	0.87	0.44	2.05	0.26	4.3	4.4	63	230	2.25		236	31	205
Birkeland	23-04-89	Repstadvatn	4.74	18	3.15	0.95	0.44	2.06	0.28	4.1	4.3	57	195	1.86		232	19	213
Birkeland	07-05-89	Repstadvatn	4.82	15	3.34	0.91	0.44	2.06	0.30	4.1	4.2	45	200	1.66		215	16	199
Birkeland	21-05-89	Repstadvatn	4.77	17	3.25	0.93	0.45	2.06	0.29	4.2	4.2	35	195	2.31		207	10	197
Birkeland	18-06-89	Repstadvatn	4.90	13	3.40	0.91	0.44	2.16	0.29	4.2	4.2	19	194	1.81		177	10	167
Birkeland	30-06-89	Repstadvatn	4.79	16	3.38	0.89	0.46	2.16	0.26	4.2	4.5	26	185	1.85		163	11	152
Birkeland	15-07-89	Repstadvatn	4.81	15	3.44	0.96	0.44	2.38	0.31	4.3	4.6	13	172	1.62		154	10	144
Birkeland	30-07-89	Repstadvatn	4.85	14	3.36	0.99	0.44	2.35	0.28	4.3	4.6	20	161	1.64		156	10	146
Birkeland	13-08-89	Repstadvatn	4.84	14	3.22	0.96	0.43	2.35	0.30	4.3	4.1	27	156	2.87		142	10	132
Birkeland	30-08-89	Repstadvatn	4.88	13	3.35	0.96	0.46	2.30	0.31	4.4	4.3	29	160	1.87		154	10	144
Birkeland	15-09-89	Repstadvatn	4.98	10	3.28	0.99	0.48	2.33	0.31	4.2	4.4	43	163	1.49		141	10	131
Birkeland	30-09-89	Repstadvatn	4.93	12	3.46	1.00	0.47	2.31	0.31	4.1	4.4	38	172	1.49		152	10	142
Birkeland	15-10-89	Repstadvatn	4.93	12	3.55	1.06	0.49	2.29	0.31	4.6	5.1	37	172	1.50		166	10	156
Birkeland	21-10-89	Repstadvatn	4.68	21	3.88	0.97	0.51	2.39	0.33	4.4	5.4	63	200	2.85		227	33	194
Birkeland	29-10-89	Repstadvatn	4.75	18	3.73	1.03	0.51	2.37	0.29	4.5	4.6	43	195	2.24		186	11	175
Birkeland	06-11-89	Repstadvatn	4.75	18	3.75	0.98	0.48	2.33	0.32	4.4	4.2	51	193	1.87		196	10	186
Birkeland	25-11-89	Repstadvatn	4.74	18	3.91	1.01	0.50	2.52	0.35	4.8	4.8	62	215	2.27		225	19	206
Birkeland	09-12-89	Repstadvatn	4.69	20	4.34	1.11	0.56	2.73	0.35	5.3	6.5	65	230	2.31		246	19	227
Birkeland	26-12-89	Repstadvatn	4.55	28	4.48	0.68	0.54	2.86	0.21	5.6	4.7	55	174	3.64		312	66	246

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Birkeland	07-01-90	Repstadvatn	4.57	27	4.55	0.94	0.52	2.88	0.32	5.5	5.8	67	275	2.70		297	30	267
Birkeland	21-01-90	Repstadvatn	4.60	25	4.08	0.82	0.47	2.56	0.27	5.4	4.3	47	200	2.63		243	45	198
Birkeland	18-02-90	Repstadvatn	4.62	24	3.66	0.92	0.45	2.60	0.30	4.9	5.2	51	205	2.14		226	16	210
Birkeland	11-03-90	Repstadvatn	4.70	20	3.83	0.88	0.41	2.41	0.32	5.0	4.5	38	150	2.33		227	24	203
Birkeland	01-04-90	Repstadvatn	4.74	18	3.79	0.97	0.45	2.38	0.33	4.9	4.2	34	191	2.22		215	14	201
Birkeland	23-04-90	Repstadvatn	4.75	18	3.85	0.94	0.45	2.30	0.31	4.9	4.4	41	174	1.96		238	13	225
Birkeland	13-05-90	Repstadvatn	4.76	17	3.78	0.98	0.47	2.38	0.31	5.2	4.9	22	183	1.49		233	10	223
Birkeland	04-06-90	Repstadvatn	4.79	16	3.77	0.98	0.47	2.33	0.32	5.1	4.8	44	186	1.67		203	14	189
Birkeland	24-06-90	Repstadvatn	4.75	18	3.60	0.93	0.46	2.33	0.29	4.9	4.5	59	165	1.69		190	17	173
Birkeland	15-07-90	Repstadvatn	4.72	19	3.80	0.96	0.43	2.59	0.28	5.0	4.6	27	151	2.38		193	22	171
Birkeland	05-08-90	Repstadvatn	4.80	16	3.65	0.96	0.44	2.49	0.28	4.9	4.5	23	130	1.91		177	10	167
Birkeland	21-08-90	Repstadvatn	4.76	17	3.68	0.85	0.41	2.45	0.27	4.7	4.5	18	124	1.89		173	24	149
Birkeland	26-08-90	Repstadvatn	4.75	18	3.75	0.95	0.40	2.45	0.27	4.8	4.3	12	105	2.23		175	10	165
Birkeland	16-09-90	Repstadvatn	4.72	19	3.65	0.91	0.39	2.35	0.27	4.6	4.0	22	101	2.24		180	14	166
Birkeland	07-10-90	Repstadvatn	4.77	17	3.59	0.90	0.45	2.34	0.25	4.6	4.4	27	123	2.33		196	17	179
Birkeland	28-10-90	Repstadvatn	4.77	17	3.74	1.03	0.46	2.52	0.26	4.9	4.4	49	150	2.80		182	17	165
Birkeland	11-11-90	Repstadvatn	4.72	19	4.05	1.02	0.51	2.67	0.33	4.9	4.4	50	158	2.42		215	33	182
Birkeland	18-11-90	Repstadvatn	4.70	20	4.03	0.99	0.48	2.72	0.31	5.3	4.7	49	163	2.56		207	20	187
Birkeland	25-11-90	Repstadvatn	4.74	18	3.91	1.01	0.50	2.52	0.35	4.8	4.8	62	215	2.27		225	19	206
Birkeland	10-12-90	Repstadvatn	4.63	23	4.56	1.10	0.54	3.14	0.35	5.8	4.5	57	192	2.95		262	33	229
Birkeland	01-01-91	Repstadvatn	4.52	30	4.44	0.76	0.45	2.92	0.24	5.2	4.1	72	159	3.63		239	59	180
Birkeland	20-01-91	Repstadvatn	4.54	29	4.31	0.76	0.45	3.16	0.21	6.0	3.5	36	107	2.78		258	54	204
Birkeland	10-02-91	Repstadvatn	4.61	25	4.70	1.01	0.54	3.37	0.27	6.9	4.8	48	146	2.60		312	50	262
Birkeland	03-03-91	Repstadvatn	4.60	25	4.48	0.97	0.52	3.03	0.31	5.7	4.4	102	410	2.84		278	52	226
Birkeland	30-03-91	Repstadvatn	4.53	30	4.27	0.78	0.40	2.48	0.25	4.1	4.9	188	380	2.74		274	42	232
Birkeland	12-05-91	Repstadvatn	4.79	16	3.84	1.06	0.47	2.68	0.32	5.1	4.6	32	169	2.38		209	19	190
Birkeland	02-06-91	Repstadvatn	4.86	14	3.82	1.09	0.48	2.70	0.33	5.1	4.5	22	164	1.69		190	11	179
Birkeland	24-06-91	Repstadvatn	4.78	17	3.82	1.07	0.45	2.54	0.28	5.2	4.5	13	135	2.15		190	14	176
Birkeland	25-08-91	Repstadvatn	4.93	12	3.60	1.06	0.46	2.64	0.29	5.3	4.4	32	97	2.47		142	18	124
Birkeland	15-09-91	Repstadvatn	5.26	5	3.57	1.08	0.40	2.63	0.31	5.3	4.5	30	109	1.84		122	15	107
Birkeland	13-10-91	Repstadvatn	4.84	14	3.70	1.06	0.46	2.75	0.32	5.1	4.3	30	123	2.35		158	24	134
Birkeland	27-10-91	Repstadvatn	4.84	14	3.77	1.07	0.46	2.76	0.30	5.4	4.6	38	135	2.29		168	37	131
Birkeland	30-09-88	Barkevatn	4.67	21	3.14	0.83	0.33	1.78	0.28	3.3	3.8	38	104	4.88		222	47	175
Birkeland	23-10-88	Barkevatn	4.65	22	3.51	0.90	0.38	2.06	0.26	3.7	4.8	38	114	4.37		238	44	194
Birkeland	06-11-88	Barkevatn	4.66	22	3.38	0.93	0.40	2.04	0.24	4.0	3.9	37	109	4.18		240	36	204
Birkeland	20-11-88	Barkevatn	4.71	19	3.52	0.98	0.41	2.13	0.22	4.3	4.4	67	144	3.47		223	38	185
Birkeland	04-12-88	Barkevatn	4.75	18	3.74	1.06	0.44	2.37	0.31	4.2	4.4	76	167	4.41		239	35	204
Birkeland	18-12-88	Barkevatn	4.74	18	3.56	1.05	0.43	2.29	0.30	4.1	4.1	65	153	4.47		236	39	197
Birkeland	01-01-89	Barkevatn	4.68	21	3.03	0.88	0.39	2.16	0.28	3.9	4.0	55	156	4.71		252	74	178
Birkeland	15-01-89	Barkevatn	4.68	21	3.30	0.87	0.40	2.13	0.26	3.8	4.1	36	160	4.15		258	72	186

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Birkeland	29-01-89	Barkevatn	4.75	18	3.12	0.84	0.38	1.93	0.21	3.4	3.6	28	156	3.39		213	44	169
Birkeland	12-02-89	Barkevatn	4.77	17	3.21	0.89	0.42	2.11	0.29	4.0	4.4	53	138	3.51		231	42	189
Birkeland	26-02-89	Barkevatn	4.70	20	3.92	1.02	0.48	2.60	0.37	5.3	4.6	57	167	3.33		262	51	211
Birkeland	12-03-89	Barkevatn	4.62	24	3.57	0.91	0.44	2.33	0.29	4.7	4.0	52	184	2.85		259	33	226
Birkeland	27-03-89	Barkevatn	4.62	24	3.12	0.90	0.44	2.31	0.31	4.7	4.3	36	195	2.95		241	34	207
Birkeland	09-04-89	Barkevatn	4.70	20	3.52	0.88	0.43	2.16	0.30	4.6	4.3	38	195	2.54		253	36	217
Birkeland	23-04-89	Barkevatn	4.67	21	3.12	0.89	0.43	2.17	0.34	4.1	4.5	57	235	2.54		258	26	232
Birkeland	07-05-89	Barkevatn	4.67	21	3.43	0.92	0.44	2.16	0.36	4.2	4.5	18	225	2.44		234	22	212
Birkeland	21-05-89	Barkevatn	4.71	19	3.37	0.92	0.45	2.15	0.34	4.2	4.6	21	205	2.62		215	11	204
Birkeland	18-06-89	Barkevatn	4.83	15	3.57	0.91	0.44	2.24	0.32	4.2	4.4	12	103	2.17		155	10	145
Birkeland	30-06-89	Barkevatn	4.81	15	3.44	0.86	0.46	2.21	0.28	4.0	4.4	34	104	2.14		143	14	129
Birkeland	15-07-89	Barkevatn	4.81	15	3.67	0.97	0.45	2.63	0.35	4.6	5.0	82	78	2.35		117	17	100
Birkeland	30-07-89	Barkevatn	4.95	11	3.52	0.90	0.45	2.65	0.37	4.8	4.3	225	127	4.08		111	43	68
Birkeland	13-08-89	Barkevatn	5.04	9	3.07	0.97	0.46	2.52	0.35	4.3	4.0	177	128	3.89		89	34	55
Birkeland	30-08-89	Barkevatn	4.83	15	3.50	0.94	0.48	2.44	0.34	4.4	4.8	24	94	1.84		140	10	130
Birkeland	15-09-89	Barkevatn	4.85	14	3.59	0.97	0.49	2.52	0.36	4.4	4.8	35	100	1.73		137	10	127
Birkeland	30-09-89	Barkevatn	4.85	14	3.69	1.06	0.50	2.54	0.36	4.2	5.1	46	101	2.09		141	10	131
Birkeland	15-10-89	Barkevatn	4.82	15	3.87	1.11	0.53	2.53	0.39	4.7	5.9	35	110	2.37		170	11	159
Birkeland	21-10-89	Barkevatn	4.72	19	3.94	1.10	0.53	2.44	0.37	4.4	6.1	35	127	2.69		175	20	155
Birkeland	29-10-89	Barkevatn	4.71	19	3.99	1.11	0.55	2.54	0.36	4.6	5.2	43	158	3.26		210	21	189
Birkeland	06-11-89	Barkevatn	4.61	25	4.14	1.01	0.49	2.42	0.35	4.5	4.6	51	179	3.37		221	35	186
Birkeland	25-11-89	Barkevatn	4.57	27	4.38	1.02	0.49	2.59	0.38	4.9	5.0	62	200	3.96		257	42	215
Birkeland	09-12-89	Barkevatn	4.64	23	4.36	1.08	0.53	2.73	0.36	5.1	6.3	55	215	3.27		270	34	236
Birkeland	26-12-89	Barkevatn	4.56	28	4.61	0.94	0.50	2.78	0.36	5.4	6.0	82	205	4.15		283	50	233
Birkeland	07-01-90	Barkevatn	4.55	28	4.58	0.96	0.51	2.93	0.33	5.6	6.0	69	225	3.43		288	43	245
Birkeland	21-01-90	Barkevatn	4.55	28	4.44	0.89	0.49	2.71	0.33	5.7	4.7	54	194	3.77		296	64	232
Birkeland	18-02-90	Barkevatn	4.49	32	3.96	0.81	0.40	2.69	0.36	5.2	4.6	38	183	3.38		282	39	243
Birkeland	11-03-90	Barkevatn	4.66	22	3.88	0.83	0.38	2.45	0.37	5.0	4.4	31	133	3.30		260	40	220
Birkeland	01-04-90	Barkevatn	4.69	20	3.89	0.98	0.43	2.43	0.37	5.0	4.6	22	163	2.79		243	23	220
Birkeland	23-04-90	Barkevatn	4.72	19	3.92	0.94	0.44	2.41	0.35	4.9	4.4	17	163	2.68		243	17	226
Birkeland	13-05-90	Barkevatn	4.77	17	3.79	0.98	0.46	2.52	0.34	5.4	4.7	14	107	2.18		196	11	185
Birkeland	04-06-90	Barkevatn	4.82	15	3.70	0.98	0.46	2.43	0.34	5.1	4.8	19	71	2.06		167	14	153
Birkeland	24-06-90	Barkevatn	4.71	19	3.67	0.95	0.48	2.40	0.31	4.9	4.5	27	86	2.72		175	24	151
Birkeland	15-07-90	Barkevatn	4.64	23	3.58	0.89	0.37	2.48	0.26	4.4	4.6	17	48	4.78		208	46	162
Birkeland	05-08-90	Barkevatn	4.80	16	3.52	0.93	0.39	2.50	0.29	4.5	4.7	25	14	3.46		171	24	147
Birkeland	21-08-90	Barkevatn	4.67	21	3.72	0.83	0.38	2.39	0.27	4.4	4.6	24	79	3.25		181	36	145
Birkeland	26-08-90	Barkevatn	4.67	21	3.74	0.90	0.36	2.37	0.26	4.3	4.4	12	39	4.02		190	30	160
Birkeland	16-09-90	Barkevatn	4.67	21	3.55	0.89	0.34	2.26	0.28	4.1	4.0	17	26	4.61		199	40	159
Birkeland	07-10-90	Barkevatn	4.73	19	3.47	0.87	0.41	2.28	0.25	4.3	4.2	15	65	4.45		226	42	184
Birkeland	28-10-90	Barkevatn	4.75	18	3.56	0.94	0.41	2.43	0.28	4.6	4.7	42	82	4.27		218	39	179

Region	Date	Locality	pH	H+	K25	Ca	Mg	Na	K	Cl	SO4	NH4	NO3	TOC	Alk	Alr	Alo	Ali
Birkeland	30-09-89	Mørkelivatn	4.65	22	3.62	0.72	0.41	2.32	0.26	3.6	4.8	40	190	1.47		195	10	185
Birkeland	15-10-89	Mørkelivatn	4.65	22	3.84	0.83	0.46	2.34	0.27	4.1	5.2	47	160	2.31		211	11	200
Birkeland	21-10-89	Mørkelivatn	4.57	27	4.01	0.81	0.46	2.34	0.27	4.0	5.9	67	166	2.72		212	20	192
Birkeland	29-10-89	Mørkelivatn	4.52	30	4.05	0.84	0.48	2.46	0.26	4.1	5.2	73	164	4.50		243	28	215
Birkeland	06-11-89	Mørkelivatn	4.43	37	4.32	0.75	0.43	2.35	0.24	3.9	4.6	49	173	5.33		257	55	202
Birkeland	25-11-89	Mørkelivatn	4.43	37	4.27	0.67	0.40	2.34	0.22	4.0	4.7	67	200	4.95		257	55	202
Birkeland	09-12-89	Mørkelivatn	4.43	37	4.48	0.77	0.46	2.61	0.23	4.5	5.8	74	225	5.24		279	58	221
Birkeland	26-12-89	Mørkelivatn	4.43	37	4.52	0.68	0.43	2.50	0.21	4.5	5.1	77	210	4.60		251	55	196
Birkeland	07-01-90	Mørkelivatn	4.43	37	4.66	0.73	0.44	2.72	0.19	5.1	5.0	109	255	4.19		275	51	224
Birkeland	21-01-90	Mørkelivatn	4.45	35	4.39	0.69	0.43	2.55	0.19	5.2	4.4	71	210	4.07		256	57	199
Birkeland	18-02-90	Mørkelivatn	4.42	38	3.91	0.59	0.34	2.40	0.24	4.5	3.4	54	205	3.42		233	44	189
Birkeland	11-03-90	Mørkelivatn	4.51	31	3.74	0.52	0.29	2.19	0.25	4.3	3.6	38	144	3.47		219	40	179
Birkeland	01-04-90	Mørkelivatn	4.57	27	3.67	0.59	0.34	2.18	0.26	4.2	4.1	39	174	2.95		219	26	193
Birkeland	23-04-90	Mørkelivatn	4.59	26	3.72	0.63	0.36	2.20	0.24	4.4	3.8	39	179	2.94		247	22	225
Birkeland	13-05-90	Mørkelivatn	4.60	25	3.76	0.67	0.38	2.34	0.24	4.9	4.2	20	146	2.37		214	11	203
Birkeland	04-06-90	Mørkelivatn	4.66	22	3.63	0.69	0.38	2.29	0.24	4.7	4.4	28	93	1.98		173	10	163
Birkeland	24-06-90	Mørkelivatn	4.57	27	3.82	0.67	0.38	2.31	0.21	4.5	4.2	34	123	2.80		209	22	187
Birkeland	15-07-90	Mørkelivatn	4.48	33	3.49	0.59	0.29	2.06	0.09	3.4	4.0	31	62	5.43		217	51	166
Birkeland	05-08-90	Mørkelivatn	4.63	23	3.21	0.61	0.29	2.18	0.12	3.5	4.0	21	3	4.25		171	21	150
Birkeland	21-08-90	Mørkelivatn	4.54	29	3.49	0.51	0.28	2.01	0.13	3.5	3.9	32	43	5.04		222	52	170
Birkeland	26-08-90	Mørkelivatn	4.52	30	3.59	0.60	0.27	1.99	0.13	3.4	3.8	24	33	5.60		231	45	186
Birkeland	16-09-90	Mørkelivatn	4.53	30	3.42	0.58	0.26	1.99	0.14	3.5	3.3	17	24	5.96		232	45	187
Birkeland	07-10-90	Mørkelivatn	4.54	29	3.39	0.57	0.32	2.03	0.15	3.8	3.5	33	50	5.89		239	50	189
Birkeland	28-10-90	Mørkelivatn	4.56	28	3.60	0.63	0.32	2.21	0.17	4.0	3.6	83	94	5.45		235	50	185
Birkeland	11-11-90	Mørkelivatn	4.41	39	4.28	0.69	0.40	2.34	0.22	3.8	4.5	72	193	5.37		240	64	176
Birkeland	18-11-90	Mørkelivatn	4.39	41	5.07	0.81	0.47	3.01	0.29	5.9	4.6	68	166	5.43		286	50	236
Birkeland	25-11-90	Mørkelivatn	4.43	37	4.27	0.67	0.40	2.34	0.22	4.0	4.7	67	200	4.95		257	55	202
Birkeland	10-12-90	Mørkelivatn	4.45	35	4.66	0.81	0.45	3.05	0.19	5.0	4.0	68	159	5.42		299	74	225
Birkeland	01-01-91	Mørkelivatn	4.41	39	4.38	0.59	0.37	2.62	0.14	4.4	3.9	55	178	4.63		228	74	154
Birkeland	20-01-91	Mørkelivatn	4.41	39	4.47	0.62	0.39	2.99	0.11	5.5	3.3	36	121	3.62		233	64	169
Birkeland	10-02-91	Mørkelivatn	4.45	35	4.56	0.72	0.42	3.01	0.13	5.9	4.3	53	145	3.72		274	67	207
Birkeland	03-03-91	Mørkelivatn	4.45	35	4.45	0.67	0.41	2.76	0.19	4.8	4.0	114	445	4.11		259	68	191
Birkeland	30-03-91	Mørkelivatn	4.43	37	4.28	0.61	0.36	2.35	0.21	3.3	4.7	150	420	3.89		247	61	186
Birkeland	12-05-91	Mørkelivatn	4.58	26	3.59	0.62	0.34	2.26	0.23	3.7	4.1	42	185	3.54		234	39	195
Birkeland	02-06-91	Mørkelivatn	4.67	21	3.42	0.66	0.35	2.32	0.24	3.8	4.4	20	100	2.43		188	17	171
Birkeland	24-06-91	Mørkelivatn	4.65	22	3.30	0.63	0.32	2.12	0.17	3.6	4.1	15	102	3.45		190	25	165
Birkeland	25-08-91	Mørkelivatn	4.74	18	3.03	0.63	0.32	2.20	0.11	3.6	3.7	11	14	3.35		142	32	110
Birkeland	15-09-91	Mørkelivatn	4.87	13	3.01	0.63	0.27	2.17	0.15	3.9	3.9	24	15	2.67		122	19	103
Birkeland	13-10-91	Mørkelivatn	4.55	28	3.72	0.69	0.35	2.36	0.32	4.1	3.7	52	81	6.08		234	84	150
Birkeland	27-10-91	Mørkelivatn	4.54	29	3.74	0.69	0.35	2.37	0.25	4.3	4.1	57	98	5.86		248	92	156

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