This paper not to be cited without prior reference to the authors

International Council for
the Exploration of the Sea

C.M.1975/M.21
Anadromous and Catadromous
Fish Committee
Ref.: Fisheries Improvement

COMPARATIVE GROWTH STUDIES OF SALMONIDS

by

Dag Møller and Øyvind Bjerk x)

INTRODUCTION

The natural conditions for marine farming of salmonids are excellent along large stretches of the Norwegian coast. Factors worth mentioning are the coastal topography (vast areas of shallow waters), the relatively slight difference between high and low tide, the situation in regard to currents, and the favourable temperature of the sea.

When marine farming of salmonids started in the mid 60, the question raised if there is any northern temperature limit restricting feasible operations. Studies concerning this question started in 1973 in cooperation with commersial fish farmers. The objective was to investigate growth and condition in stocks of Atlantic salmon (*Salmo salar*) and rainbow trout (*Salmo gairdineri*) in environments with varying parameters found at localities along the coast.

x) Institute of Marine Research,
Directorate of Fisheries,
Bergen, Norway.

MATERIALS AND METHODS.

In 1973 salmon smolts and rainbow trout fingerlings were transported from Bergen in a well boat and placed in floating cages at three and five localities respectively (Table 1 and Figure 1). The individuals were counted and measured at stocking in May and after ½, 1 and 1½ year in the sea.

In 1974 fish of both species again were stocked in May but now in ten plants along the coast. In the case of smolts 2/3 of the individuals were of Baltic origin. The smolts of Norwegian origin were tagged by removing the adipose fin.

Smolt were transported from Långhult, Sweden in a tank truck to Bergen, where the fish gradually were adapted to sea water over a period of six weeks.

Before transportation samples of 100 fish were taken from each group of fish (rainbow trout and the two types of smolts) for length (fork length) and weight measurements (Table 1). All fish were counted by delivery. After 6 months all fish were numbered again, and samples were measured.

The fish farmers all used the same type (octagonal) and size of cages, 12 m in diameter with a water volume of about 500 m^3. The mesh size has varied from 10.5 to 15.7 mm.

Each fish farmer recorded daily temperature, salinity and feeding. Temperature (Table 2) and salinity were registered in water samples from the cages at a depth of 2 m. Common feed were fish and shrimp trash.

The records were mailed to the Institute of Marine Research monthly. The food factor (Table 4) has been calculated by dividing the amount of wet feed used with the increase of total biomass in each cage.

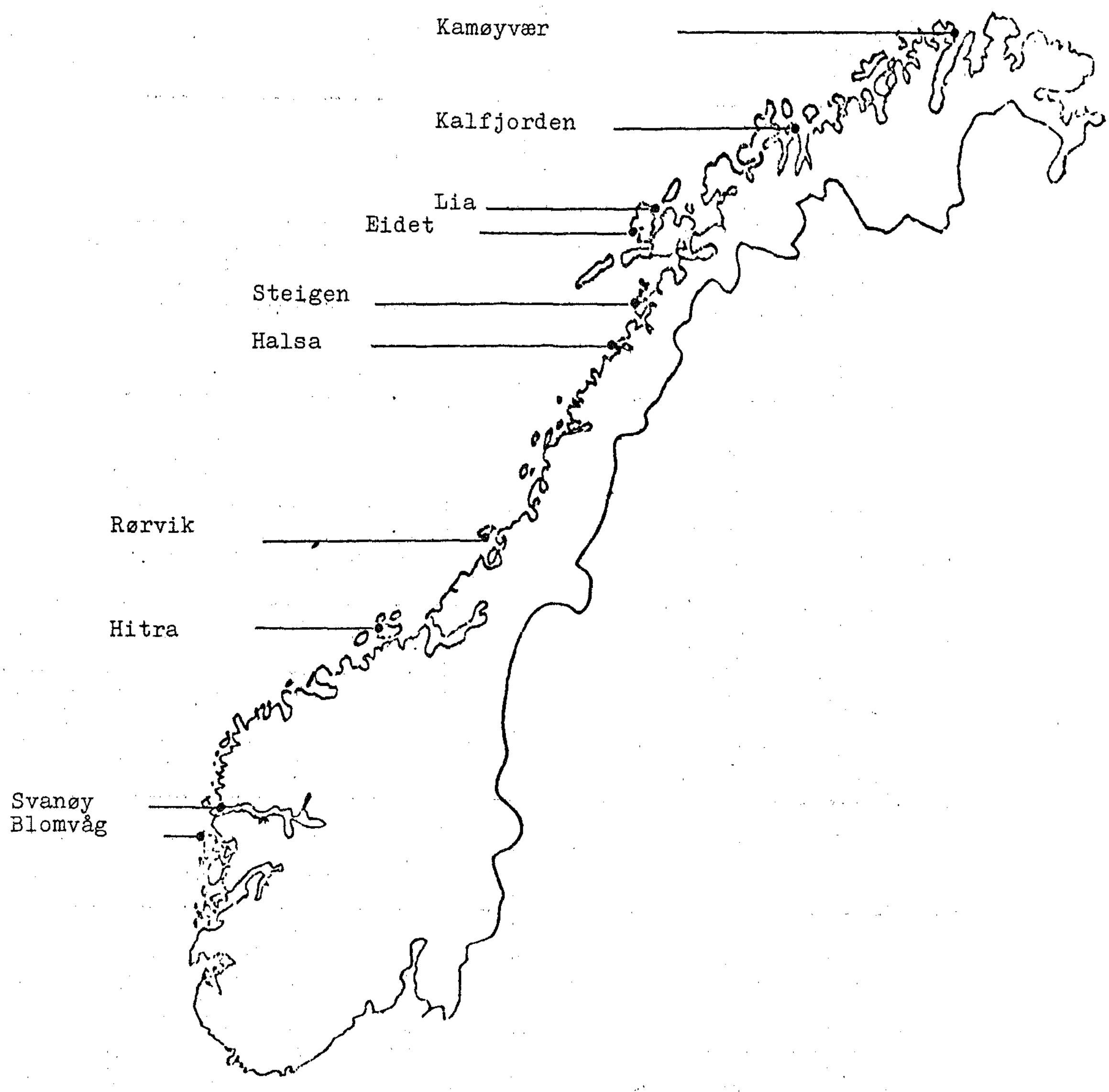

Figure 1. Locality of fish farms.

Table 1. Data of growth and number of stocked salmonids.

Locality	SALMON STOCKED 1973: By start 26-30 May -73, Number	By start 26-30 May -73, 1,cm	Length, cm, ½ year	Length, cm, 1 year	Length, cm, 1½ year	Weigth by start	Weigth, g, ½ year	Weigth, g, 1 year	Weigth, g, 1½ year	Number by 1½ year	RAINBOW TROUT STOCKED 1973: By start 26-30 May. 73, Number	By start 26-30 May. 73, 1, cm	Length, cm, ½ year	Length, cm, 1 year	Length, cm, 1½ year	Weigth by start,g	Weigth, g, ½ year	Weigth, g, 1 year	Weigth, g, 1½ year	Number by 1½ year
Blomvåg											2000	20.1	36.9	50.0	57.7	ca. 100	880	2170	3270	1480
Hitra	1660	15.5	35.4	45.4	57.6	ca.35	530	970	2500	ca.500	2010	20.9	37.8	43.9	-	"	980	1510	-	ca 8-10
Steigen	1700	15.8	33.6	47.9	59.2	"	450	1140	2260	ca.350	2060	20.7	34.3	41.4	52.0	"	740	1280	2440	1350
Eidet	1450	16.6	34.8	45.9	58.0	"	490	960	2050	500	2700	21.6	34.6	40.1	49.8	"	670	1060	2000	1810
Lia											4050	20.7	33.6	40.3	44.8	"	700	1090	1390	?

Locality	SALMON STOCKED 1974: By start 22-31 May-74, Number	By start 22-31 May-74, 1,cm	Length, cm after ½ year, S*	Length, cm after ½ year, N *	Length, cm after ½ year, mixed	Weigth by start g	Weigth, cm after ½ year, S	Weigth, cm after ½ year, N	Weigth, cm after ½ year, mixed	Number by ½ year	RAINBOW TROUT STOCKED 1974: By start 1-7 May 74, Number	By start 1-7 May 74, 1, cm	Length, cm, ½ year	Length, cm, -	Length, cm, -	Weigth by start g	Weigth, g, ½ year	Weigth, g, - .-	Number by ½ year
Blomvåg	3000	Norwegian smolt: 17,3 cm Swedish smolt: 15,5 cm	27,8	35.0	29.4	Norwegian smolt: ca. 50 g Swedish smolt: ca. 30 g	278	537	330	2450	3000	13.6	29.5			33.0	413		2435
Svanøy	3000		28.3	32.8	31.4		254	378	339	1960	3000	"	31.7			"	498		2695
Hitra	3000		-	-	30.1		-	-	288	2640	2900	"	31.3			"	479		1840
Rørvik	3000		33.7	38.7	36.4		501	694	603	ca 1600	2900	"	36.0			"	845		1600
Halsa	3000		36.5	36.3	36.4		634	551	610	2940	2900	"	37.1			"	916		2140
Steigen	3000		26.8	30.5	28.1		218	309	247	1450	2900	"	31.2			"	513		750
Eidet	3000		26.2	28.6	27.1		186	237	210	2100	3200	"	31.4			"	430		1590
Lia	3000		27.0	30.1	28.4		227	289	253	ca 2000	2900	"	31.6			"	486		950
Kalfjorden	750		-	-	35.1		-	-	536	ca 540	2900	"	32.2			"	554		?
Kamøyvær	2000		28.4	-	-		235	-	-	1850	3000	"	26.7			"	272		?

* S - Swedish
N-- Norwegian

Table 2. Average temperatures at fish farms May 1973 to October 1974.

Locality	Blomvåg	Hitra	Steigen	Eidet	1) Lia
1973					
May	10,5	-	8,5	-	6,5
June	11,0	-	9,7	-	9,5
"	14,1	-	9,7	-	12,5
July	15,0	10,4	13,0	-	13,0
"	14,7	10,1	15,2	-	13,0
August	14,0	-	13,1	12,3	14,0
"	13,9	-	13,1	10,5	13,0
September	12,8	-	9,3	9,8	12,5
"	12,8	-	9,3	8,9	9,5
October	10,8	-	-	7,4	7,5
"	9,5	-	6,3	-	6,5
November	8,7	-	5,5	-	6,5
"	6,3	-	3,0	-	-
December	6,2	5,0	- *	6,5	-
"	5,5	4,4	- *	6,5	-
1974					
January	6,1	4,8	3,5	6,0	-
"	5,5	4,6	3,0	5,5	-
February	5,0	4,0	2,2	4,5	-
"	4,7	5,0	2,8	-	-
March	5,1	4,3	3,0	-	3,2
"	5,9	4,6	3,3	4,0	2,7
April	6,6	4,7	3,7	-	3,9
"	7,6	5,2	4,1	-	4,5
May	9,6	7,7	5,1	-	-
"	11,5	-	-	-	-
June	12,5	10,8	10,0	8,9	-
"	12,5	12,2	11,2	11,4	-
July	12,7	13,0	12,3	11,6	11,0
"	12,7	12,6	13,4	13,3	11,5
August	14,3	12,7	15,3	13,8	12,0
"	14,5	14,1	13,6	11,8	13,5
September	14,9	14,1	11,8	11,3	13,5
"	13,7	13,6	9,2	10,7	11,0
October	11,8	11,3	7,0	9,7	9,0
"	10,6	9,5	7,0	9,0	8,0

1) Periodical measurements

* Lack of observation due to bad weather conditions

RESULTS

Table 2 shows average temperatures observed through the testing period. Lowest value (2,2^{O}C) is recorded in Steigen in the first part of February 74. Steigen has also the highest temperature, 15,3 ^{O}C, in the first part of August 74. The temperature values during the winter time at Blomvåg and Hitra, however, is clearly higher than the values from Steigen and probably also in Lia.
The salinity values were very stable. Monthly average were from 27 to 31 ^{O}/oo for all five plants through the testing period.

The growth of salmon stocked in 1973 were very uniform in the three localities. (Table 1, Figure 2 and 4). After half a year the difference between the plants was about the same. After one year the salmon in Steigen had the best growth. After 1½ year this salmon was 1,6 cm longer on the average than the salmon at Hitra. The weigth variation was more significant. The fish at Hitra was on the average 240 g heavier than the fish in Steigen and 450 g heavier than the Eidet one.

Growth of rainbow trout (Table 1, Figure 3 and 5) seems best in the southern part of Norway. The difference became significant after one sea-year. The size of the fish can almost be ranked after the fish farms locality along the coast, from 50 cm at Blomvåg in the south to 40,1 and 40,3 cm respectively at Eidet and Lia in the north. The established difference after 12 month at sea did not increase further.

The results after half a sea year for fish stocked in 1974 are also listed in Table 1. In regard to salmon the results are grouped in Norwegian-, Swedish-, and mixed smolt. The total average values for mixed smolts were 31,4 cm and 380 g, lowest values at Eidet with 27,1 cm and 237 g and highest at Halsa with 36,4 and 610 g.

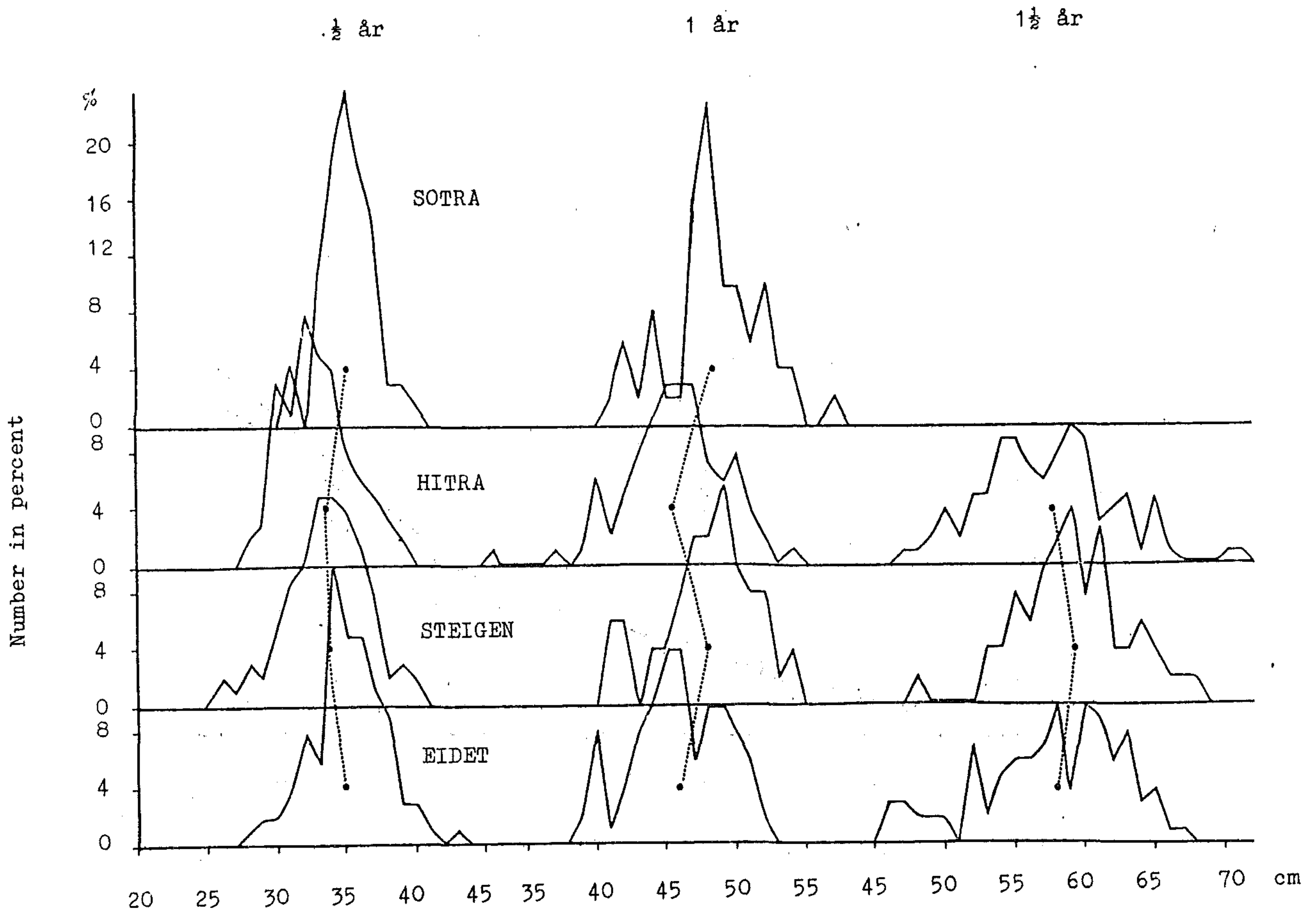

Fig. 2. Length distributions of salmon stocked 1973.

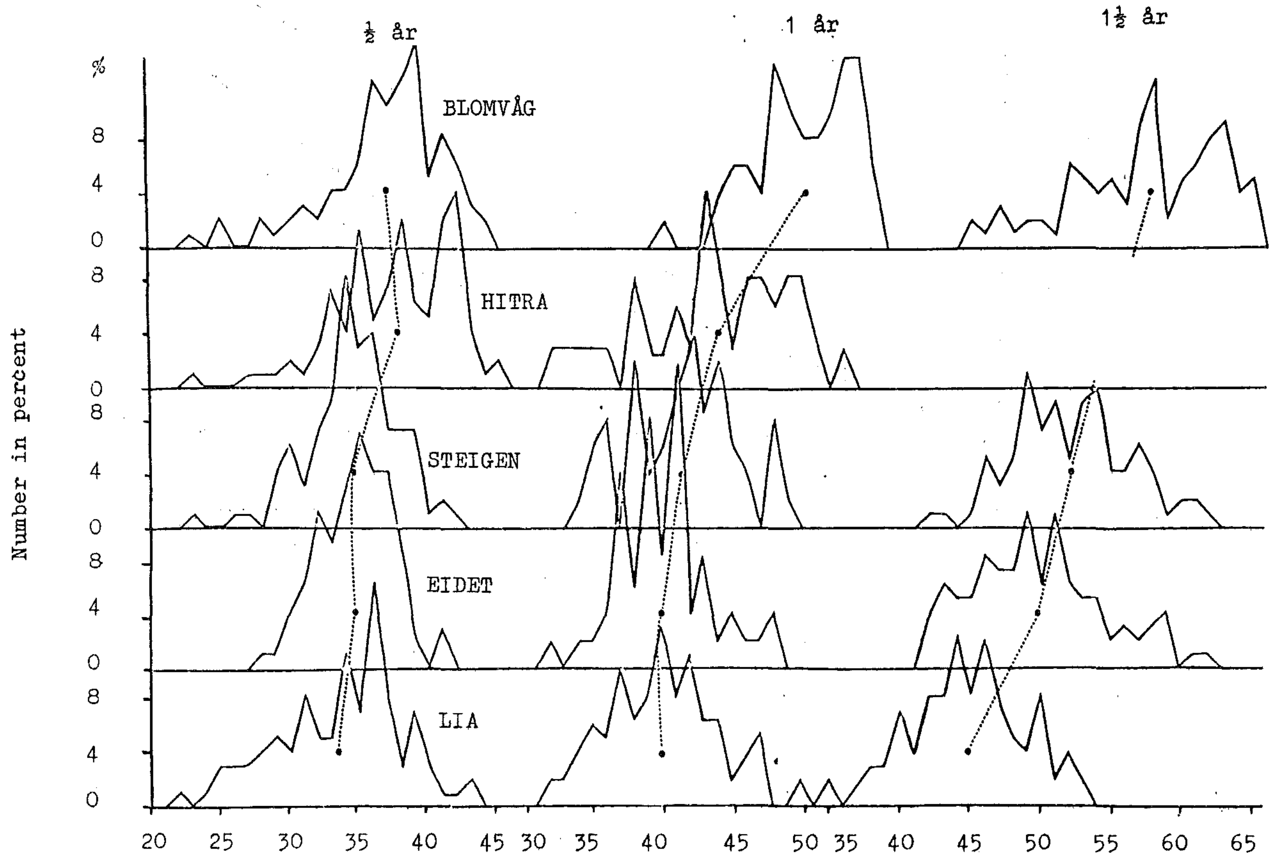

Fig. 3. Length distribution of rainbow trout stocked 1973

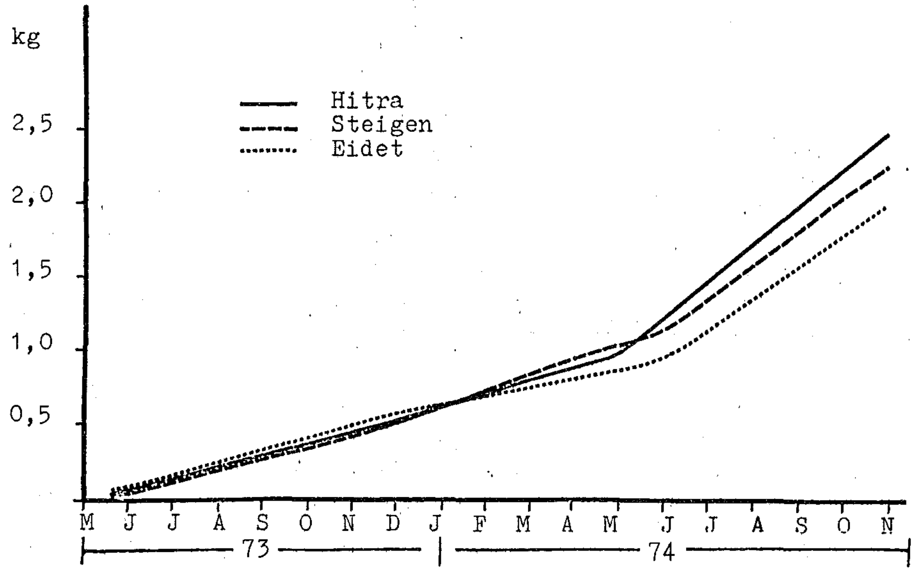

Fig. 4. Growth of salmon stocked 1973.

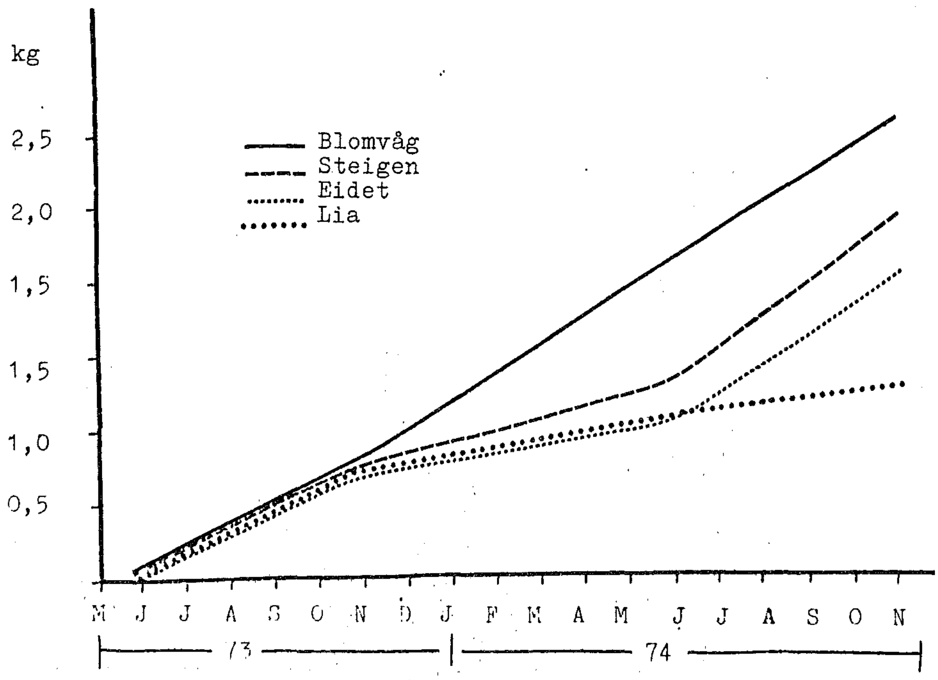

Fig. 5. Growth of rainbow trout stocked 1973.

Rainbow trout stocked in 1974 showes the average values of 31,9 cm and 540 g after half a seayear. Lowest were Kamøyvær with 26,7 cm and 272 g, and highest again Halsa with 37,1 cm and 916 g.

The condition factor after 1½ seayear (Table 3) have been calculated from the formulae $C=100 \times W/L^3$, where W equals weight in grammes and L equals length in centimetres.
No calculation have been made upon the conditionfactor for the yearclass 1974 as the results show normal accordance with length and weight.

Table 3. Condition factors of fish stocked in 1973.

	Salmon	Rainbow trout
Blomvåg	-	1,70
Hitra	1,31	-
Steigen	1,09	1,73
Eidet	1,05	1,62
Lia	-	1,54

The loss percentage after 1½ year of salmon stocked 1973 varies from 65 to 78 %. The corresponding figures for the rainbow trout are 25 to 37 %.
The loss of fish stocked in 1974 varies for salmon from 2% to 55 %, and for rainbow trout from 10% to 75%.

The 1973 fish have been attacked by vibriosis especially in Lia, but also in Blomvåg and Steigen. The fish stocked in 1974 were given profylactic terramycin treatment before shipment from Bergen, and no vibriosis have yet been reported. Periodically there have also been attacks of salmon lice, (Repeoptheirus salmonis).

Table 4. Food convertion factors.

Fish stocked 1973	0 - 6 months	6 - 12 months	12 - 18 months	0 - 18 months
Blomvåg (rainbow trout)	5,4	5,9	9,4	7,5
Fish stocked 1974	**Rainbow trout 0 - 6 months**		**Salmon 0 - 6 months**	
Hitra	8,6		10,0	
Rørvik	7,2		8,3	
Steigen	10,0		9,3	
Eidet	12,6		16,4	
Kalfjorden	5,9		7,9	
Kamøyvær	8,5		7,2	
Average	8,8		9,8	

Table 4 shows that the food convertion factor of rainbow trout stocked in Blomvåg increases with the age of the fish. This factor increases on behalf of growth, which reflect the maturing of the fish (75% the second year in sea).

DISCUSSION

In the sort of experiments described, there are always variable factors extremely difficult to control, i.e. local conditions, capability of the farmer, surveillance, and not least feed quality.

Fish stocked 1973

After 1½ year the condition factor on salmon stocked 1973, varies much in value between the fish farms (Table 3). The salmon at Hitra had steady been the shortest (Table 1), in contrast to the fish farms on Steigen and Eidet. The salmon at Hitra, however, was already heavier after 1½ year than the brothers and sisters far north: Hitra 2.500 g; Steigen 2.260 g and Eidet 2.060 g. As a matter of course this result will have great influence at the condition factor.

The high condition factor at Hitra may be due to more intensive feeding or better food conversion. However, it is difficult to explain why better feeding or feeding conversion does not also influence length. A more reasonable explanation to the diverging weight and length at the different plants could be the content of the feed.

The growth of the rainbow trout show marked variation in length and weight at the different fish farms (Table 1, Figure 3 and 5). At the Lia farm the rainbow trout in summer 1974, had two attacks of vibriosis. Fish under antibiotic treatment mostly is uncomfortable some time after treatment. The growth-season was thus destroyed and the result is not comparable to the rest of the fish farms. The conditionfactors is also reflecting the disease attacks, as Lia has the very lowest values.

None of the fish farmers have noticed increasing mortality by low temperature. Nor does there seem to be any relation between slow growth and high mortality. The cause of the high loss percentage is partly due to disease and partly to initiatory difficulties and insufficient surveillance.

<u>Fish stocked 1974</u>

For the 1974 stocked salmon, large growth variations seem indicated (Table 1). At stocking the Norwegian smolts were larger than the Swedish ones, at the ½-year measuring this is still the case with exception of one farm. It is worth mentioning the good adjustment of the Swedish parr the first ½ year in seawater. The environment along the Norwegian coast is essentially different to the Balthic.

The surveillance of farms can be grouped as follows:

1. All day
2. Periodically
3. Only when feeding.

The grouping is compared to mortality for fish stocked in 1974 at the 9 farms where all fish were counted after a ½ year.

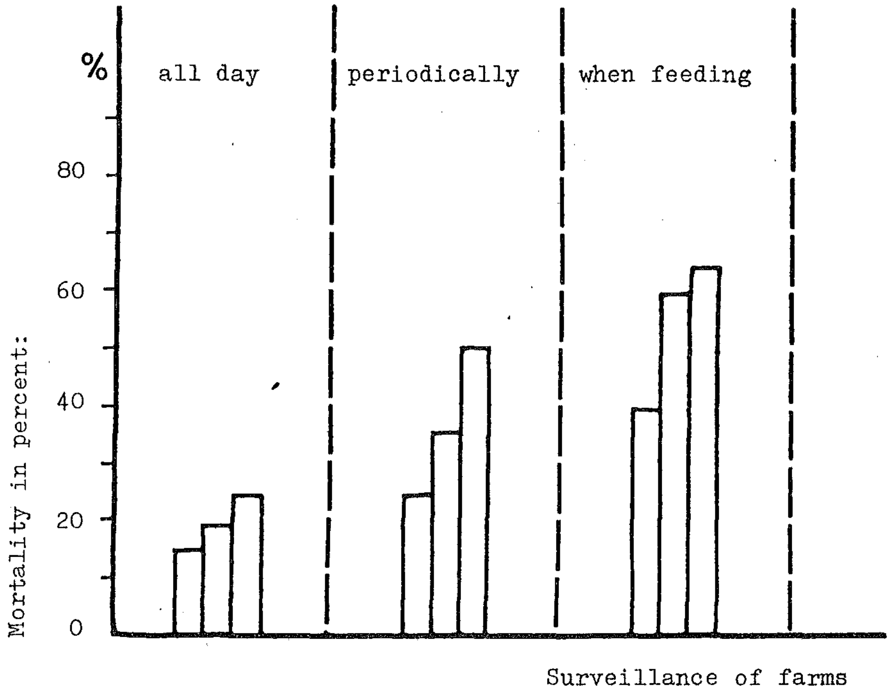

Figure 6. Mortality of fish stocked 1974 and surveillance of farms in summer 1974.

Figure 6 indicates a clear connection between surveillance and total loss in summer 1974. Principal predators are birds (heron, cormorant, gull).

Generally at the 1974 stocking the food convertion factor seems high, especially at Eidet. The increase was low (Table 1). This may be due to few feedings a day and too much food given at one time. The food convertion factor all round is lower for the rainbow trout than the salmon.

CONCLUSION

1. Salmon of same species and origin differ in the values of length and weight. The smallest fish has the highest condition factor.

2. At the farms northwards the rainbow trout had lower growth rate during the winter compared to the farms further south.

3. Salmon does not show similar difference in growth.

4. Mortality and loss is most probably related to superveillance at the farm.

5. The Swedish salmon has adjusted well to the Norwegian conditions after the first half year in sea.