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Exploitation pattern and migration of the anadromous Brown trout, *Salmo trutta* L., from the River Gjengedal, western Norway

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Post-spawners of anadromous Brown trout (*Salmo trutta* L.) were individually tagged and released in the River Gjengedal during the period 1981—1990. The tag returns suggested that the overall exploitation of the trout stock was relatively small. Most recaptures were reported from the sea where the majority was taken by trolling and spinning. A substantial part was also reported in the Atlantic salmon commercial fishery. In the river all recaptures were made by anglers. Although a few fish migrated far away from the river, most fish were caught in the fjord outside the river, suggesting that the migrations in the marine environment were short.

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INTRODUCTION

In Norway anadromous Brown trout, *Salmo trutta* L., is distributed from the Swedish border in the southeastern part of the country to the border with USSR in the northeast. The species is very popular among anglers and is caught in commercial salmon gear and as bycatch in marine gillnets.

Life history of Brown trout is very variable and flexible (Jonsson 1985, L'Abbée Lund et al. 1989, Jonsson et al. 1991): in Norway the fish usually have a short migration and feed in the local fjord (Jensen 1968, Hagala & Heggberget 1976, Berg & Berg 1987), as opposed to the Baltic Sea where they move over greater distances (Svärdson & Fagerström 1982).

The anadromous Brown trout stock in the river Gjengedal is of great value as a recreational fish. The river is planned used for generation of hydroelectric power, and research on the ecology of the salmonid fish species has been initiated (Heggenes & Saltveit 1990, Saltveit & Heggenes 1991). We have tagged and released post-spawners of anadromous Brown trout since 1981. The present paper describes the exploitation and migratory pattern of these fish.

STUDY AREA

The River Gjengedal (LP490375) empties into the deep Nordfjorden on the western coast of Norway. The catchment area of the river is 171 km, and the river width is about 30 m at the outlet of the river into Hyenfjord. The annual mean water discharge is about 12 m^3s^{-1}. About 9 km of the river is accessible for anadromous fish, and near the river mouth there is a large lake. Annual angling catches of salmon and sea trout in the river have varied between 614—2106 kgs during the last decade. On average sea trout have constituted 35% in weight of these catches (range 7—52%) and the annual mean weight of the sea trout in this period has varied between 1.0 and 1.9 kg.

MATERIAL AND METHODS

Brood stock of anadromous Brown trout is caught in the autumn for stock enhancement purposes, and fertilized eggs are incubated in a hatchery. Spawned fish have been individually tagged and released yearly during the period 1981—1990, except in 1988. The fish were primarily sampled by netting (trammel nets), to a lesser extent by seine and by ang-

ling. Each year all brood fish caught were tagged with numbered Lea tags anchored at the base of the dorsal fin (Dahl & Sømme 1938). Before release fish lengths were measured from the snout to the tail tips (nearest cm) and sex was determined during stripping. The fish were then released into the river the same day.

Several fish tagged from 1987 till present are still expected to be recaptured, and these experiments are not included in the analysis of the recapture rates. However, we found it appropriate to include all recaptures when analysing the distribution in different fisheries by year, and in the overall migratory pattern of the fish.

RESULTS

In total 2316 spawners were tagged, of which 51% were males. The male fraction in the samples tagged the individual years varied between 32 and 60%. Fish lengths varied between 30 and 97 cm, and females were on average larger ($\bar{x}$= 54,0 cm) than males ($\bar{x}$= 51,9 cm). Furthermore, four and 21 immature fish (23—44 cm) were tagged and released in 1982 and 1983, respectively.

Of the 2007 trout tagged and released during the period 1981—1986, 544 individuals (27.1%) were reported recaptured, 442 (22.0%) from marine fisheries and 102 (5.1%) from freshwater, respectively (Table 1). In marine fisheries the recapture rate has successively decreased from 31.4% to 11.5%, whereas the rates in the riverine sport fishery have fluctuated between 3.5 and 6.5% during the same period. In the brood stock fishery 157 fish of the groups tagged 1981—1986

Table 1. Number of anadromous Brown trout tagged and recaptured (N) in marine and freshwater fisheries.

		Recaptured					
		Marine		Freshwater		Total	
Year	Tagged	N	%	N	%	N	%
1981	500	157	31,4	29	5,8	186	37,2
1982	490	118	24,1	32	6,5	150	30,6
1983	229	43	18,8	8	3,5	51	22,3
1984	398	68	17,1	14	3,5	82	20,6
1985	251	40	15,9	11	4,4	51	20,3
1986	139	16	11,5	8	5,8	24	17,3
1981-86	2007	442	22,0	102	5,1	544	27,1

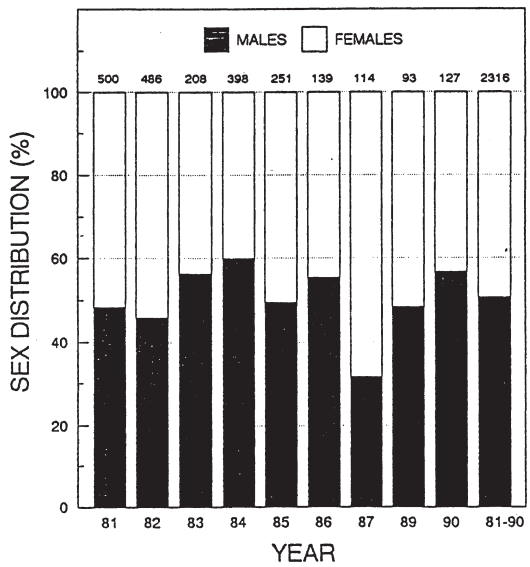

Fig. 1. Sex distribution of anadromous Brown trout tagged and released in the River Gjengedal during the period 1981—1990. The figures show the number of fish tagged the respective years.

were recaptured and released after they were stripped, which is 7.8% of the total number of fish tagged.

There was no significant difference between recapture rates of males and females either in the sea or in the river (X^2-test on pooled material, $P>0.05$) Table 2). In the sea the recaptures were predominantly recorded from trolling and spinning catches; these constituted on average 54% of the recoveries from the sea fisheries (Table 3). Bend nets were the second prevailing gear and constituted on average 32% of the recoveries, whereas minor proportions were recorded from bag nets (7%) and trammel, cod and mackerel nets (7%).

The mean lengths of fish recaptured in bag nets and bend nets were significantly larger than those reported from the marine recreational fisheries (t-test, $P<0.01$) and the fish caught by anglers in the river (t-test, $P<0.05$), whereas there was no difference in mean length of fish caught in recreational fisheries in the sea and river (t-test, $P>0.05$) (Fig. 3).

Most Brown trout recaptures were reported from Nordfjord, relatively close to the home river (Fig. 4). In total more than 90% were recovered within 40 km from the river mouth (Table 4). Six fish were recaptured in

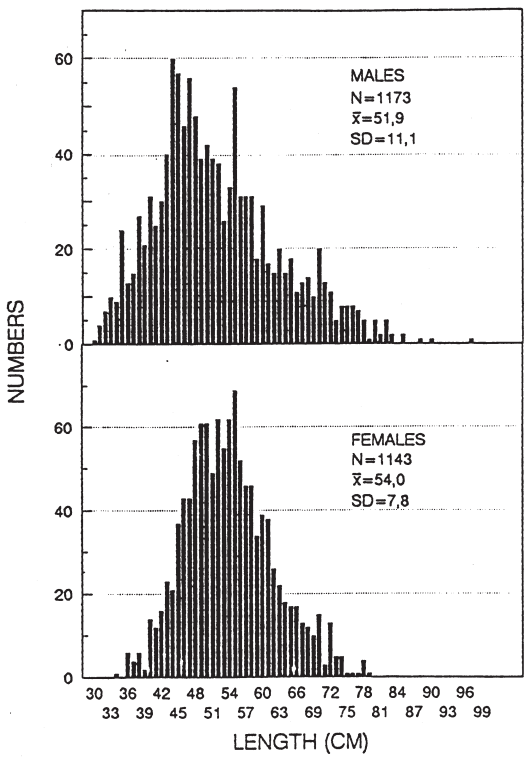

Fig. 2. Length distribution of males and females of anadromous Brown trout tagged and released during the period 1981—1990. N = number of observations; $\bar{x}$ = mean length of the fish; SD = standard deviation.

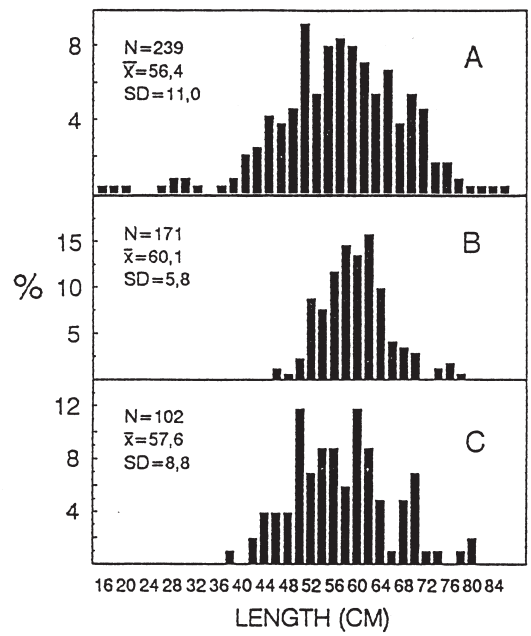

Fig. 3. Length distribution of Brown trout recaptured by (A) spinning and trolling in the sea; (B) bend nets and bag nets; (C) anglers in the river. N = the number of observations; $\bar{x}$ = mean length of the fish; SD = standard deviation.

Table 2. Total number of male and female anadromous Brown trout tagged and recaptured (N) in marine and freshwater fisheries.

		Recaptured					
		Marine		Freshwater		Total	
Sex	Tagged	N	%	N	%	N	%
♂	1020	223	21,9	58	5,7	281	27,6
♀	962	211	21,9	44	4,6	255	26,5

Table 3. Number of recaptures in the sea related to gear types in successive years. The figures in brackets give the catch proportions.

Year	Spinning and trolling	Bend nets	Bag nets	Marine gill nets*	Total
1982	41 (50)	26 (31)	10 (12)	6 (7)	83 (100)
1983	50 (58)	24 (28)	4 (5)	8 (9)	86 (100)
1984	45 (52)	34 (40)	5 (6)	2 (2)	86 (100)
1985	38 (61)	12 (19)	2 (3)	10 (17)	62 (100)
1986	25 (46)	25 (46)	3 (6)	1 (2)	54 (100)
1987	13 (48)	11 (41)	2 (7)	1 (4)	27 (100)
1988	12 (60)	7 (35)	1 (5)	0 (0)	20 (100)
1989	11 (85)	1 (8)	0 (0)	1 (8)	13 (100)
1990	3 (23)	3 (23)	4 (31)	3 (23)	15 (100)
1991	5 (83)	0 (0)	1 (17)	0 (0)	6 (100)
1982-91	243 (54)	143 (32)	32 (7)	32 (7)	450 (100)

* = trammel, cod and mackerel nets.

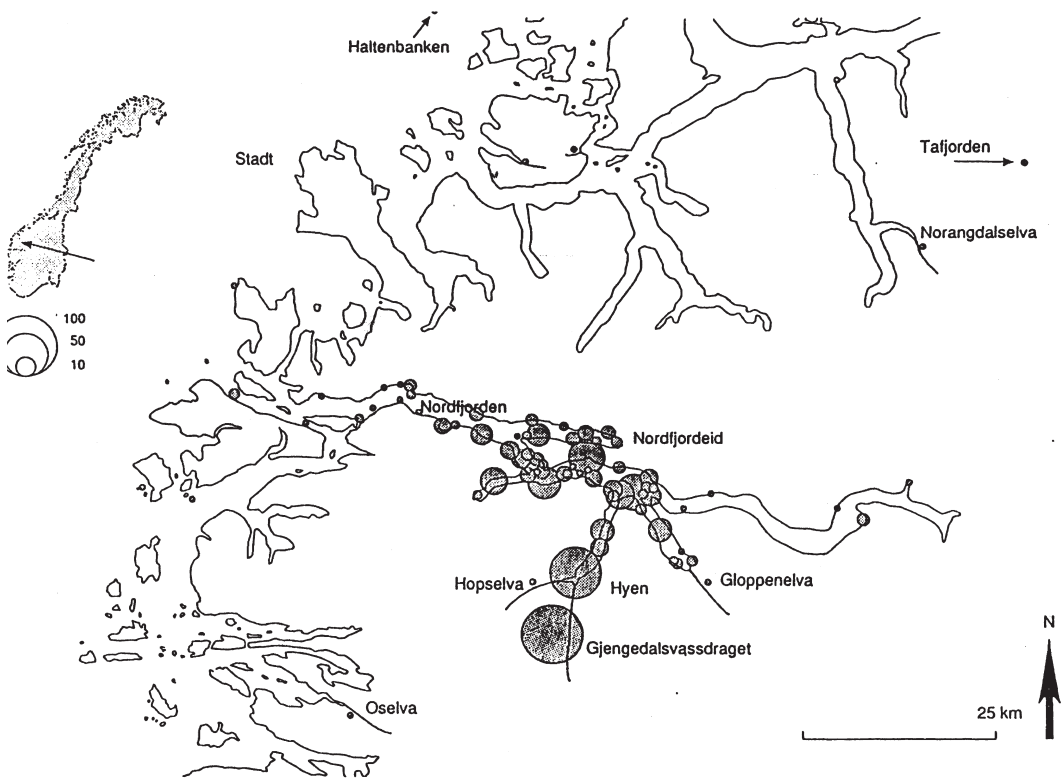

Fig. 4. Geographical distribution of Brown trout recaptured in the sea and rivers.

rivers other than River Gjengedal which is 5.9% of the total number of fish caught in freshwater.

Table 4. Cumulative numbers of recaptures with increasing distances from the mouth of the River Gjengedal.

Distance (km)	♂ N	♂ %	♀ N	♀ %	Total N	Total %
0—10	44	18,7	45	20,4	89	19,5
10—20	124	52,8	109	49,3	233	51,1
20—30	182	77,5	172	77,8	354	77,6
30—40	216	91,9	201	91,0	417	91,5
40—50	228	97,0	214	96,8	442	96,9
50—60	231	98,3	214	96,8	445	97,6
60—70	233	99,2	215	97,3	448	98,3
70—80	234	99,6	216	97,7	450	98,7
90—100	234	99,6	216	97,7	450	98,7
>100	235	100	221	100	456	100

DISCUSSION

Although several tags may not have been reported, the total reported recapture rate of tagged anadromous Brown trout kelts (27.1%) suggested that the total exploitation of the River Gjengedal stock is relatively small. However, there was a decrease in the reported recapture rates of the groups tagged in 1981 and onwards, which may be caused by a reduced tag reporting rate, decreased exploitation or a combination of the two factors. It is not likely that a significant number of recaptures will be reported in the future from the tagging experiments considered (fish tagged in the period 1981 to 1986). Relatively low exploitations of anadromous Brown trout in Norway have also been reported from the River Istra (Jensen 1968), River Ervik (Hagala & Heggberget 1976) and River Vardnes (Berg & Berg 1987).

Most anadromous Brown trout from the River Gjengedal are harvested in the sea. Of

were reported from recreational and commercial fishermen, whereas the remaining 19% were all caught by anglers in freshwater. Among the recaptures in the sea, recreational spinning and trolling took more than half of the fish, whereas commercial salmon gear like bend nets and bag nets accounted for 39% of the catch. Bycatches in nets catching marine fish species were relatively small, accounting for 7% of the total marine catch. Although the tag reporting rate may not have been the same for all gear types involved, the present results suggest that recreational fishing are for sea trout in the fjord is important, as well as bycatches in bend nets set to catch Atlantic salmon.

The observation that there were no difference in recapture rates in the fisheries between males and females, suggest that no sex selective mortality is acting on post spawners in this river.

It is interesting to note that the recreational fishery, both in freshwater and the sea took a wider size distribution of trout than salmon gear. Furthermore, the salmon gears also took larger fish than the recreational fisheries. This could be explained by gear selection, as the minimum legal mesh size in the salmon gear is 58 mm knot to knot.

The migratory pattern of the anadromous Brown trout from the River Gjengedal is typical of those feeding in a Norwegian fjord (Jensen 1968, Hagala & Heggberget 1976, Jonsson 1985, Berg & Berg 1987); most of the fish stay very close to the home river. In the present experiment one male (0.4%) and five females (2.3%) of the total number of males and females with an exact position of recapture, were observed more than 100 km from the home river.

The relatively low straying of the fish to other rivers confirms the observations made by Jensen (1968) based on tagged trout kelts. Berg & Berg (1987), however, observed a minimum estimate of 15.5% straying of trout tagged as migrating smolts. Similarly tagged smolts and kelts released in the River North Esk, Scotland (Pratten & Shearer 1983) also suggested a high straying into nearby rivers. However, these straying rates are not necessarily real. In anadromous Brown trout immatures may ascend freshwater to overwinter (Jonsson 1985) without spawning there. Furthermore, the strayers have been caught by anglers, and the angling season closes a caught, there could be time enough for fish to return to their home river. However, it has also been suggested that straying increases with decreased river size or water discharge (Quinn 1982) which may explain the high straying in the River Vardnes (Berg & Berg 1987).

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SAMMENDRAG

Spredning og gjenfangst av sjøørret fra Gjengedalselva

Utgytt (strøket) sjøørret (*Salmo trutta* L.) ble individuelt merket og sluppet i Gjengedalselva i årene 1981 til 1990.

Gjenfangstene av merket fisk viste at beskatningen av sjøørretbestanden var relativt liten. Hovedtyngden av fisken ble gjenfanget på dorgefiske i fjorden, mens en betydelig andel også ble gjenfanget i kilenøter og krokgarn. I vassdrag kom gjenfangstene kun fra sportsfiskefangster. I sjøen ble hovedtyngden av fisken gjenfanget i kort avstand fra munningen av Gjengedalselva, mens en mindre andel av fisken ble gjenfanget på lengre avstander enn 40 km fra elvemunningen. Dette indikerer at sjøørreten fra Gjengedalselva har korte sjøvandringer.

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