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MIGRATORY PATTERNS OF ESCAPED FARMRAISED ATLANTIC SALMON

by

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ABSTRACT

Simulated escapes of farmed salmon from netpens are done. Migratory behaviour and routes are studied by combining acoustic tagging and standard tagging - release methodology. A prototype of a recapture trap has been preliminary tested. Gillnets have also been used during recapture trials. Results indicate seasonal differences in migratory behaviour and consequently a need for adaptations of recapture strategies relative to this behaviour.

INTRODUCTION

Each year a substantial number of farmreared salmon is reported to escape from norwegian saltwater farms. Numbers in the range of several hundred thousands are recorded by insurance companies. A compilation of data on escaped farmed salmon done by the National Escape Committe concluded that the number of fish lost due to escaping from norwegian fishfarms was around 2 million specimens in 1989 (Anon. 1990).

Evidently these escapees represent a huge financial loss for the farming industry. In addition negative impacts on wild fish stocks and the natural environment are debated. Concerns regarding possible genetic influence and disease spreading have been frequently expressed (Anon. 1990) and the magnitude of the losses the last few years have made escaping farmraised salmon a major problem.

Escapes from fishfarms occur most typically either as 1) continuous leaks of singlefish after minor operational accidents (holes, ruptures, jumping) or 2) as major catastrophes caused by extreme events (storms, collisions) with resulting loss of the fishstock.

The objective of this study is to investigate general behaviour of salmon after escaping from netpens and to study migratory characteristics with relevance to recapture gear design and operation.

In order to distinguish possible differences in migratory behaviour between singlefish and groups of fish, both types of escapes have been simulated.

The project Escaped Farmed Salmon is financed by the Norwegian Council for Fishery Research (NFFR) and is a cooperation between the Institute of Fishery Technology Research (FTFI) and the Institute of Marine Research (HI).

This report presents preliminary results from the ongoing project which will continue throughout 1990.

MATERIALS AND METHODS

Fish

Farmed salmon kept in netpens at Austevoll Aquaculture Research Station were tagged and released. In table 1 length, weight and condition factors for the fish released either as singlefish with acoustic tags or in groups carrying hydrostatic external tags, are listed.

Prior to being released the fish had been reared for a minimum of one year in 12 x 12 x 5 m netpens after transfer from Matre Aquaculture Research Station where the smolts were produced according to standard hatchery procedures.

In order to simulate escapes by singlefish, 17 specimens carrying miniature radiotransmitters were released from September 1989 to May 1990.

In addition to singlefish escapes, groups of 200 salmon (5 groups) were also released from the same netpens. During some of the group releases a video camera was installed close to the release site. One of the fishes in each group carried an acoustic tag while the rest had hydrostatic Floy tags. Samples taken from the same cohort as the released fish were frequently examined by qualified fishpathologists at Sentrallaboratoriet , Bergen, in order to assure that no disease infected fish were released.

Tags and tagging procedures

The acoustic tags and the equipment consisting of a directional hydrophone and a receiver unit is described by Holand (1983). Frequencies ranging from 100 - 150 kHz were used. Prior to tagging the fish were tranquillized in 40 ppm benzocain in seawater and afterwards left in running seawater for a minimum of one hour to wake up and recover. The acoustic tags were attached to the dorsal part of the fish by using a tagging gun and 2 vinyl anchors taped to the tag. The tags were positioned parallell to the dorsal fin. Figure 1 shows how the acoustic tag is attached to the fish. The Floy tags used for identifying the fish in group releases, were attached with the same tagging gun in front of the dorsal fin.

All simulated escapes had on beforehand been advertized in local newspapers and rewards for returned tags and information regarding capture were promised.

The acoustically tagged fish were followed by a speedboat with the directional hydrophone equipment installed. The crew operating the boat were divided into four teams with 6 hours watches thus covering 24 hours of the day.

Hydrography

Hydrographic and meteorological data were collected continuously by equipment described by Bjordal (1986). In addition a current meter type SD - 200 (Sensordata) was recording current speed and direction at 3 meter depth. On a few selected places inside the release area temperature and salinity data were collected. This information is presented in table 2.

Recapture trials

In order to initiate a recapture gear development, a fishtrap was modified and tested.

The gear shown in fig. 2, was based on a commercial salmon trap (norw: kilenot) and was installed close to the release site. The length of the two herding nets were approximately 50 meters each, 2,5 and 4 m deep and with meshsizes 40 and 100 mm (stretched meshes) respectively. A low light video camera connected to a videotape recorder was used to monitor the efficiency of the trap.

Monofilament gillnets with meshsize 68 mm (stretched meshes) were used. The Figures 3 - 5 show how the trap and the gillnets were set relative to the release site in the recapture trials.

RESULTS AND DISCUSSION

Migratory patterns

Migration routes for fish no. 5, 11 and 15 are shown in figs. 6 a, b and c and the migration of these selected fishes are presented as representative for fish released in the autumn, winter and spring, respectively. Furthermore table 3a summarizes observations on migratory behaviour of all released and acoustically tagged fishes, such as swimming speed, distance from shore, stops at farms along the route and tracking time. In addition recapture data for the 17 simulated escapes are presented in the same table.

Releases of singlefish in the fall revealed a significant pattern characterized by frequent visits and stops at nearby fishfarms. Fish no. 5 for instance had stops at 4 different farms.

For later releases, it was seen (Table 2) that the fish more rarely visited other farms. During the group releases only one of the acoustically tagged fish strayed to nearby farms. Whether fish released in groups or as single specimens really behave differently in this respect or whether this is a function of the time of year is difficult to interpret from the available data. This since the group releases (12, 13, 14, 15 and 17) have all taken place in winter when the behaviour characterized by stops at fish farms has been less pronounced. It should be noted that of all the single fishes released in winter (fish 7-11), only one strayed to other farms. Another factor which can be taken into consideration, is the fact that tracking time is generally lower in the winter and spring compared to the autumn which would reduce the possibility to track the fish to nearby or more remotely located farms.

All the tracked fish from no. 1-12 (except no. 3) stayed at or close to the release site for a length of time ranging from 0,5 to about 6 hours before they started to migrate away from the area. The group released fish, however, with the exception of no. 17, disappeared quite rapidly from the release area. Again, this can be an effect of group release versus single fish release or merely a response to different environmental conditions related to the time of year.

In Table 3B, the different behaviour patterns are compared for 3 time periods. In period 1, covering the autumn between mid September and mid November, the stops both at the release site and at other farms were long. In period 2 (from end Jan. to end Feb.) the staying time at other farms was short, while time spent at the release site was still long. For period 3 from late March to end og May, the time the fish could be observed under netpen systems, both belonging to the research station and other companies was short.

The migration performed by the spring released fish seemed in several ways to be more directed towards a distinct goal. Fish no. 15, as showed in fig. 6c, moved relatively quickly from the release site and headed straight out the sound towards the open fjord where it dove to deeper water and disappeared.

The length of time it was possible to follow the movements of the fish also differed greatly. This is believed to be reflecting differences in behaviour for the released fish for the most part , but also technical difficulties are considered. Some were tracked for several days, while others disappeared shortly after being released. Some of the times when fish were lost, this coincided with rough sea and poor conditions for the sound receiving equipment. Most of the times, however, fishes disappeared as they appeared to dive under the surfacelayer of low density water. In these incidents refraction of the signals in the stratified surface layers was suspected to cause loosing track of the fish.

The presence of a distinct low density surfacelayer is clearly demonstrated in the temperature and salinity data presented in table 2. In order to check for this refraction possibility a test involving hanging an acoustic tag from a buoy at various depths down to 100 meters below the surface was conducted. This test revealed, however, detectable signals even from 100 meter depth under conditions with substantial horisontal stratification.

Earlier trackings of salmon (Westerberg, 1982) have concluded that the behaviour of the fish is closely related to the hydrographic structure of the watermasses. When a tagged fish met a branch of a fjord, it showed large amlitude diving activity from close to the surface and down to about 30 m (Døving et. al. 1985, Wåtevik 1980). It is apparent that when the fish perform this vertical migration in inshore, shallow waters, the acoustic signals will be disturbed by local underwater topography.

Based on the above, the causes for disappearance of fish can not be explained by one single factor, but more as a combined effect of several factors including both equipment limitations, environmental conditions and variation in fish behaviour.

Migration speed and position

Observations on swimming speed are presented in tables 3a and 3b. The highest recorded swimming speed over a distance of more than a half nautical mile was 0,75 m/s.

Tables 3 a and b shows that during the last releases (13-17) the fish had a tendency for higher swimming speed. At the same time the duration of pauses under the release site as well as other farms was negligible. For the group releases (13, 14, 15 and 17) it was observed visually that the fish swam faster and more directionally away from the farm.

Looking at the "medium swimming speed" (Table 3B), the fish swam nearly 3 times more with medium speed in period 3 compared to period 1. Also for period 2 the time with medium swimming speed was significantly higher than for period 1. When comparing the numbers for slow swimming speed, there is an opposite trend although of the same magnitude.

Also the time swimming at a distance from the shore increased in period 3. The staying time at the release site decreased to nearly zero and the fish more or less immediately swam away from the site.

Recaptures

The trap was used twice (fish no. 12 and 13) and was placed longitudinally to the farm as shown in fig. 3. During release no. 13 gillnets were also used. No released fish were caught in the trap, but some saithe, pollack and rainbow trout were trapped. The latter probably being escapees from a nearby farming operation.

The gillnet setting during release 13 caught six (6) fish of a total of 190 released. Two gillnets were set from the shore and down to about 30 m depth (Fig. 4a and b). Four fish were caught between 20 and 30 m below surface, and two at about 4 m depth near the shore.

During release 14 and 15, the trap was removed and gillnets were set on each side of the farm at different depths (Fig. 5a and b). Only the surface gillnets caught fish, 11 and 40 fish for release no. 14 and 15, respectively. Only a few minutes after the release the first were captured.

The last release (no. 17) gave no catch at all, probably because the gillnets soon after being set, were completely covered by chainbuilding phytoplankton, making the gear easily visible.

The local recapture areas are shown in Figure 7. This includes both fish with floytags and fish with acoustic tags. Catches from our own trials with trap and gillnets around the research facility is not included.

The recaptures in the vicinity of the farm could indicate that in winter and early spring the fish prefer deeper water than later in the season. This can be explained by the hydrographic conditions in the winter and early spring and the fish preferring the warmer water below the cold surface layer. Some exceptions to this general observation was seen, however, and some of the fish caught in other areas (Fig. 6), were taken in gillnet in the upper 5 m. The tendency to swim deeper in winter and early spring could be one reason for the failure of the trap since most of the fish most likely must have been escaping under the leading nets. Mork (1989) reported catches of salmon in bottom gillnets in wintertime which supports this suggestion.

SUMMARY

* The time the fish stayed at the site after the escape varied throughout the year from immediately leaving the area to a stay of approx. 6 hours.

* Straying to other farms and the time spent there were most frequently seen in autumn, but some straying also happened in winter and spring. A maximum of 4 other farms were visited. The fish could stay at a farm for several hours.

* Swimming speed seemed to increase from autumn to spring. The fish released in spring also seemed to swim further away from the shore, and the swimming pattern looked more directed towards the open fjord. There were fewer local catches of acoustically tagged fish in spring.

* During autumn and late spring the fish swam close to the surface. In winter it stayed deeper.

* The fish trap did not catch salmon, which can be related to either gear construction, fish behaviour or a combination of both.

* In March fish were mostly caught at 30 m depths while the same gillnet settings in May caught all fish in the surface.

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Table 1 : Length, weight and C-factor for fish with acoustic tags.

Release No.	Weight (kg)	Length (cm)	C-factor ($\frac{W}{L3}$ x 100)
1	2,6	60	1.18
2	2,5	62	1.04
3	2,6	61	1.14
4	2,9	63	1.15
5	2,0	56	1.11
6	3,8	69	1.15
7	2,6	62	1.1
8	2,4	59	1.15
9	2,5	62	1.1
10	2,75	63	1.1
11	3,4	67.5	1.15
12	4,2	73	1.08
13	2	55	1.2
14	1,4	50.5	1.1
15	1,9	56.5	1.1
16	1,4	50	1.1
17	1,7	55	1.0

Table 2 Salinity and temperature from 9 localities on the west side of Bjørnefjorden, May 1990.

Post no.	Bottle no.	Temperatur (°C)	Salinity (o/oo)	Depth (m)
1	16589	10.1	24.440	2.5
	16590	8.2	31.143	10.0
	16591	6.2	33.380	50.0
	16592	-	-	100.0
2	16578	9.8	29.733	2.5
	21470	8.2	31.065	10.0
	14634	7.4	33.592	50.0
	16579	-	-	100.0
3	16551	10.2	29.194	2.5
	16594	8.2	30.947	10.0
	14617	7.3	33.993	50.0
	14627	8.0	39.856	100.0
4	21476	9.9	29.483	2.5
	16572	8.2	31.104	10.0
	21495	7.4	33.691	50.0
	14631	8.1	34.371	100.0
5	14618	10.2	29.247	2.5
	14610	8.2	31.103	10.0
	14649	7.3	33.927	50.0
	16558	8.0	34.829	100.0
6	19182	9.8	29.559	2.5
	14609	8.0	29.613	10.0
	16586	7.2	33.927	50.0
	16576	8.0	34.764	100.0
7	16569	9.8	29.570	2.5
	16588	8.0	31.576	10.0
	19181	7.4	34.019	50.0
	16575	8.0	34.860	100.0
8	14640	10.4	29.270	2.5
	21747	8.1	31.142	10.0
	14613	7.4	33.961	50.0
	16593	7.7	34.939	100.0
9	16571	8.0	29.297	2.5
	16587	8.0	31.176	10.0
	340	7.4	33.944	50.0
	14625	8.1	34.835	100.0

Table 3b : Swimming speed and place from table 3a grouped into 3 periods.

Period	Date	Release number	Swimming speed (%) Not moving	Slow	Medium	Fast	Location (%) Near shore	Away from shore	At other farms	At release site	Tracking time (hours)
1	18-SEP-89 08-NOV-89	1-6	27.0	58.0	14.4	0.6	49.0	22.8	12.0	19.0	30.6
2	30-JAN-90 28-FEB-90	7-12	23.9	47.2	28.0	0.8	34.9	31.9	2.3	31.0	11.3
3	21-MAR-90 29-MAY-90	13-17	19.4	41.2	37.0	2.5	49.7	47.5	2.0	0.7	10.6

Table 3a : Behaviour and recapture data for simulated escapes of farmed salmon. Swimming speed in 4 cathegories given as percentages of total tracking time. Swimming direction relative to current when fish leave release site. Recapture data divided into own catch and commer cial catch.

Release number	Date	Time	Swimming speed (%) Not moving	Slow	Medium	Fast	Location (%) Near shore	Away from shore	At other farms	At release site	Tracking time (hours)	Swimming direction	Last observ-ation	Number released	Own catch Gear	Number	Comm. catch Gear	Number
1	18-SEP-89	15:00:00	13.8	72.4	10.3	3.5	65.5	13.8	10.3	10.3	4.0	-		1				
2	10-OCT-89	15:00:00	35.0	47.0	18.0	0.0	18.0	18.0	9.0	65.0	7.0	with		1				
3	18-OCT-89	13:50:00	33.0	67.0	0.0	0.0	71.0	29.0	0.0	0.0	6.0	against		1			gillnet	1
4	19-OCT-89	12:45:00	17.5	58.0	24.5	0.0	50.5	23.0	13.0	13.5	30.0	with		1				
5	30-OCT-89	11:00:00	29.0	63.0	10.0	0.0	42.0	22.0	29.0	8.0	90.0	with		1			gillnet	1
6	08-NOV-89	11:00:00	33.0	42.0	25.0	0.0	46.0	31.0	8.0	15.0	6.0	-		1				
7	30-JAN-90	10:15:00	22.2	33.3	44.4	0.0	0.0	57.1	0.0	42.9	6.5	-		1				
8	31-JAN-90	16:30:00	20.0	60.0	20.0	0.0	25.0	25.0	0.0	50.0	4.0	with		1				
9	08-FEB-90	15:00:00	11.0	50.0	34.0	5.0	54.0	31.0	0.0	15.0	10.0	against	Bjorne-fjorden	1				
10	14-FEB-90	14:00:00	47.0	40.0	13.0	0.0	20.0	10.0	0.0	70.0	5.0	against		1			gillnet	1
11	14-FEB-90	22:20:00	33.3	45.1	21.6	0.0	57.7	32.7	7.7	1.9	31.0	with		1			gillnet	1
12	28-FEB-90	14:15:00	10.0	55.0	35.0	0.0	52.9	35.3	5.9	5.9	11.0	with		200	trap	0	gillnet	5
13	21-MAR-90	15:00:00	0.0	100.0	0.0	0.0	66.6	33.3	0.0	0.0	2.0	with		200	trap/ gillnet	6	gillnet	2
14	02-MAY-90	15:00:00	0.0	12.5	75.0	12.5	37.4	62.5	0.0	0.0	12.0	with	Bjorne-fjorden	200	gillnet	12	gillnet	2
15	03-MAY-90	23:00:00	0.0	0.0	100.0	0.0	10.0	90.0	0.0	0.0	1.0	-	Bjorne-fjorden	200	gillnet	40		
16	15-MAY-90	05:15:00	20.0	70.0	10.0	0.0	45.0	45.0	10.0	0.0	11.0	with	Bjorne-fjorden	1		0		
17	29-MAY-90	15:00:00	76.7	23.3	10.0	0.0	89.7	6.9	0.0	3.4	27.0	-		200	gillnet	0		
AVERAGE			20.7	49.3	25.9	1.2	44.2	33.3	5.5	17.7	15.0							

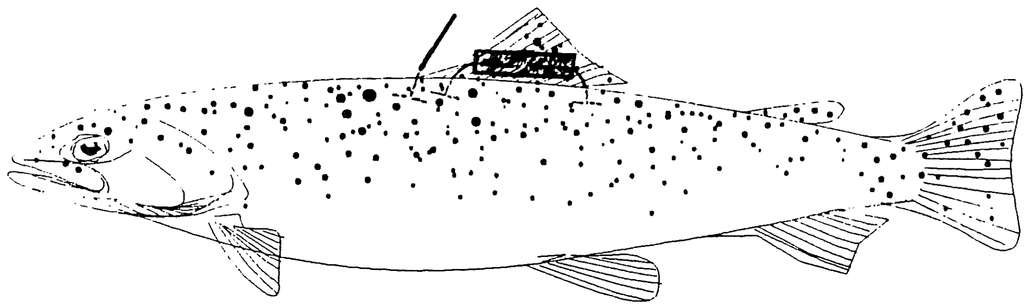

Figure 1 : Attachment of acoustic tag and Floy tag on salmon.
Not drawn to scale.

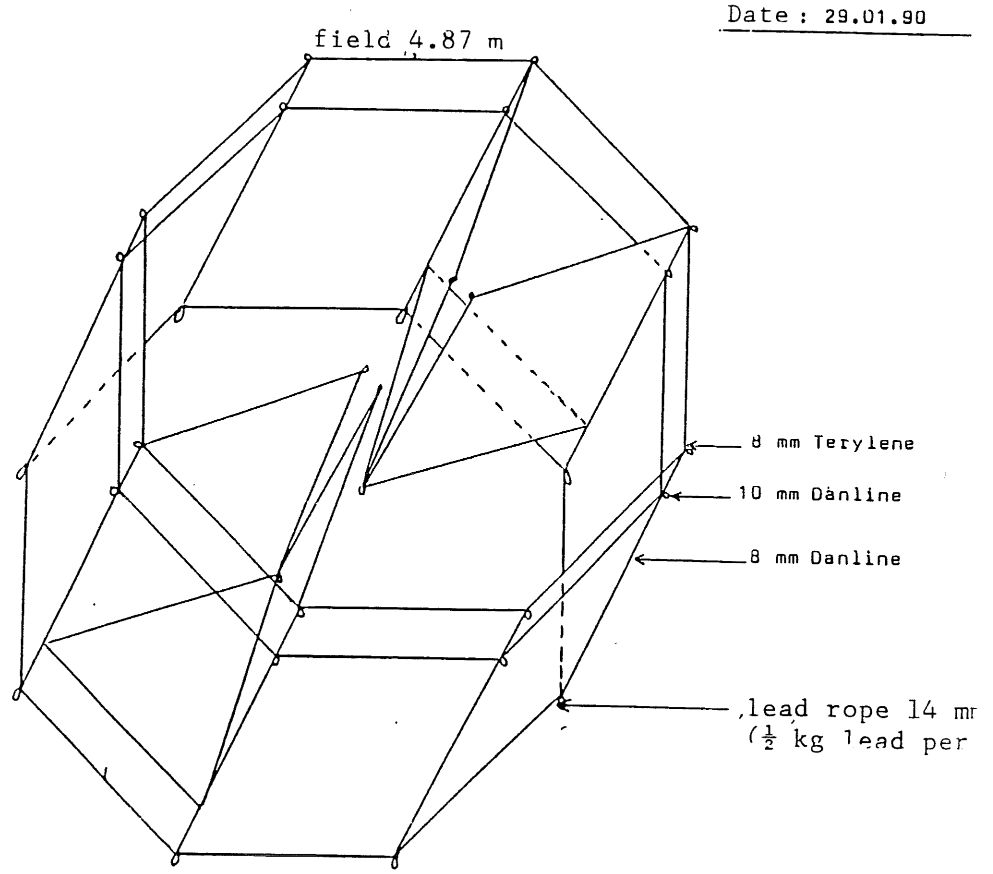

Figure 2. Trap. Herding net not drawn. Entrances are skewed relative to each other.

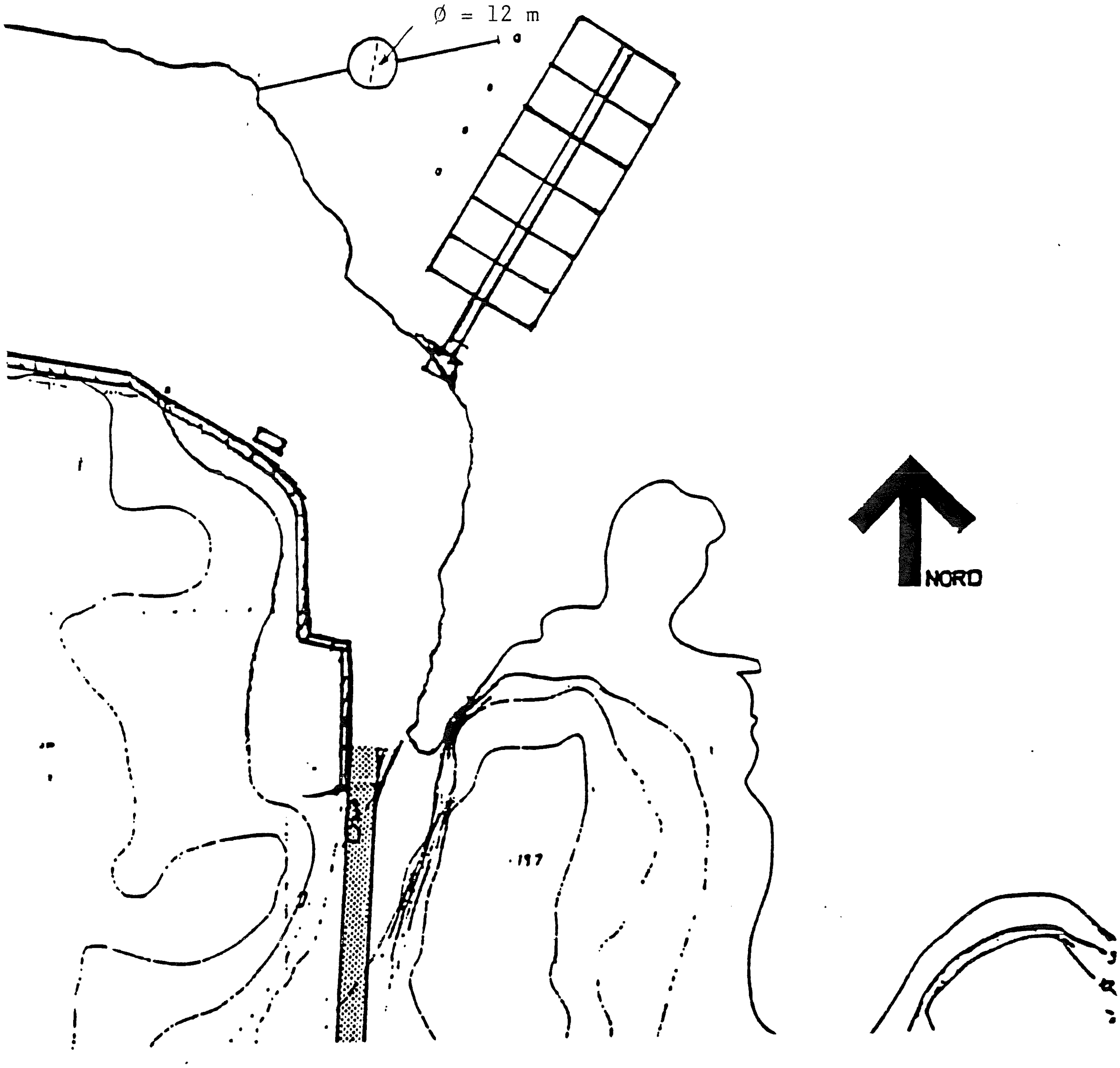

Figure 3. Position of the trap with herding nets

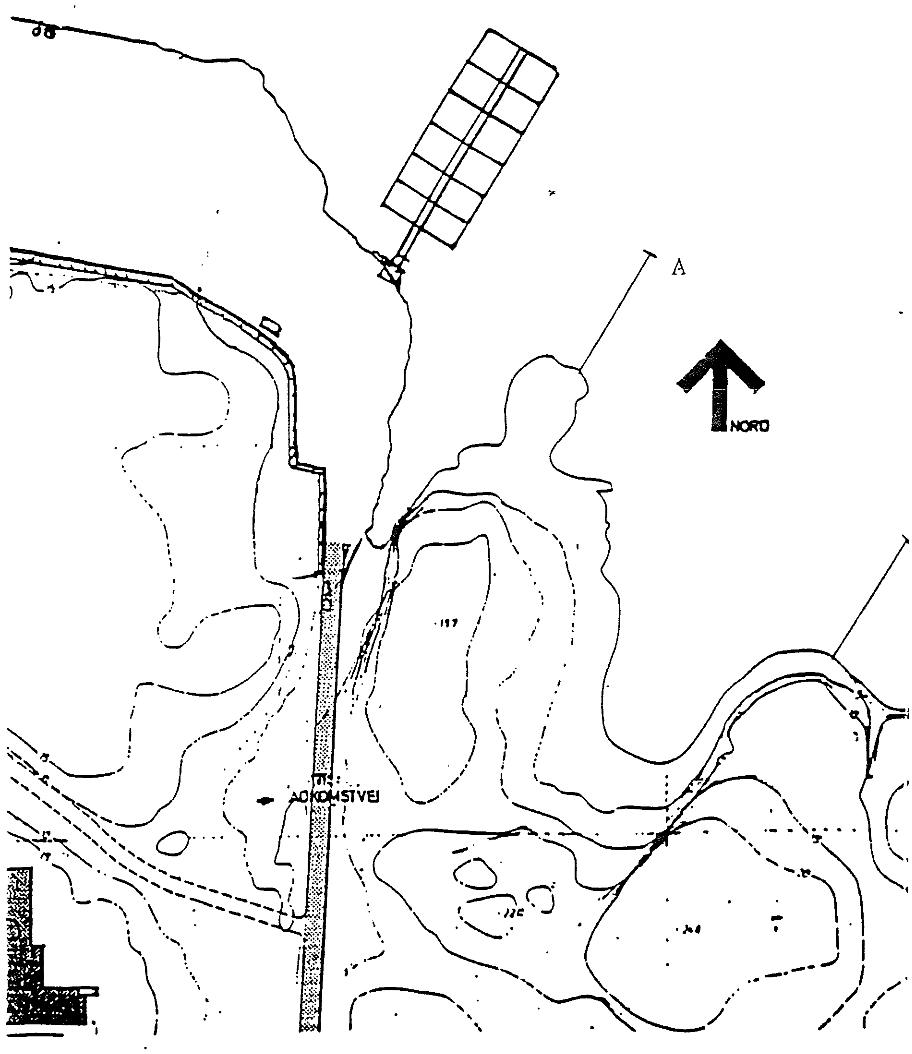

Figure 4a. Position of gillnets during release no. 13.

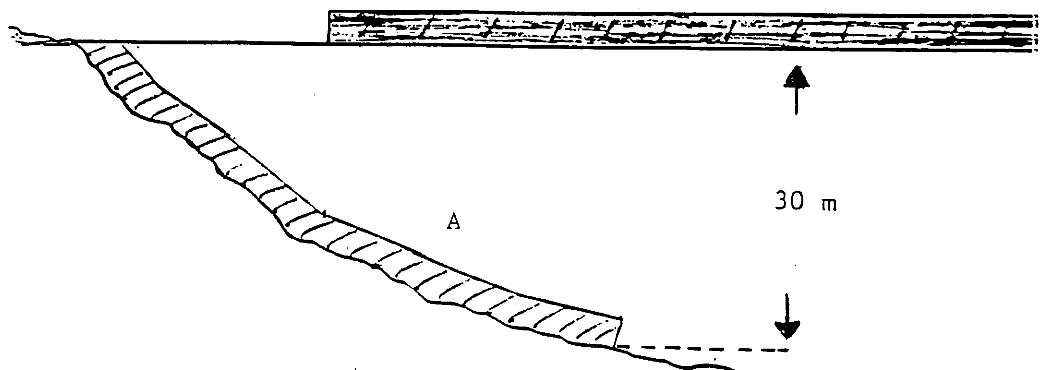

Figure 4b. Position of gillnets during release no. 13.

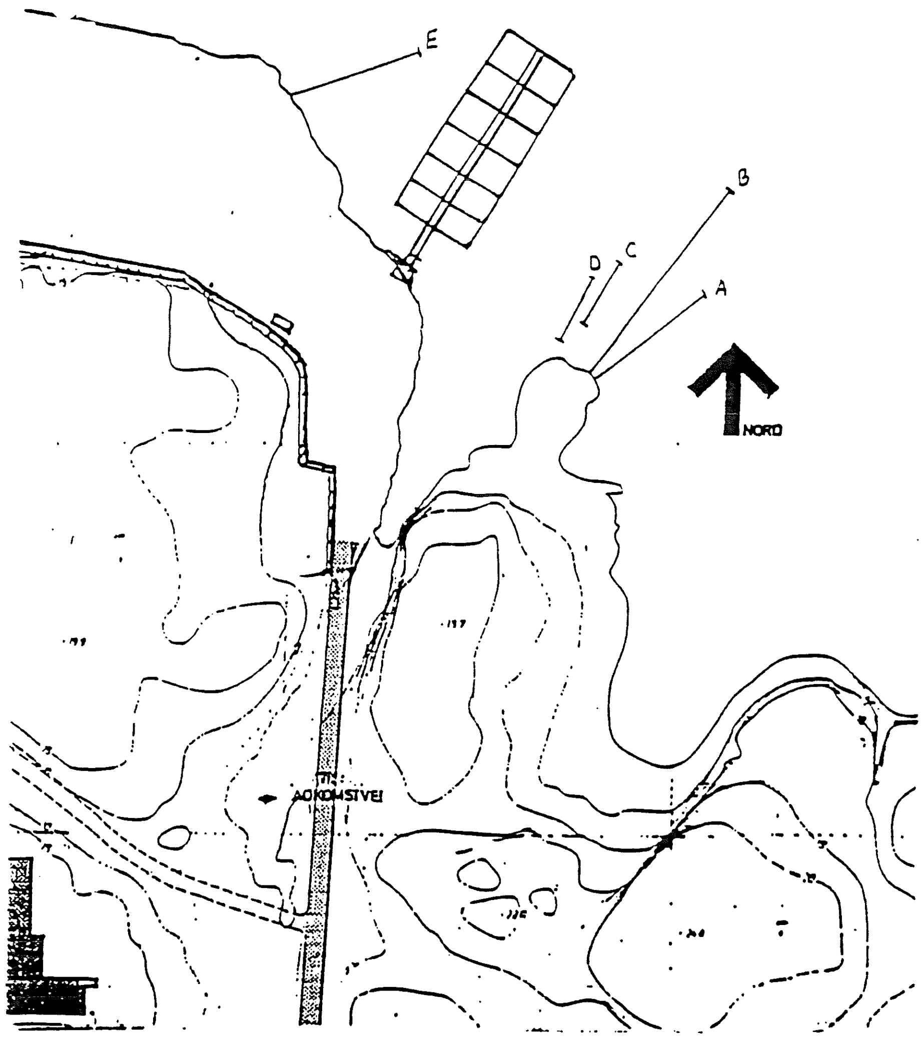

Figure 5a. Position of gillnets during release no. 14 and 15.

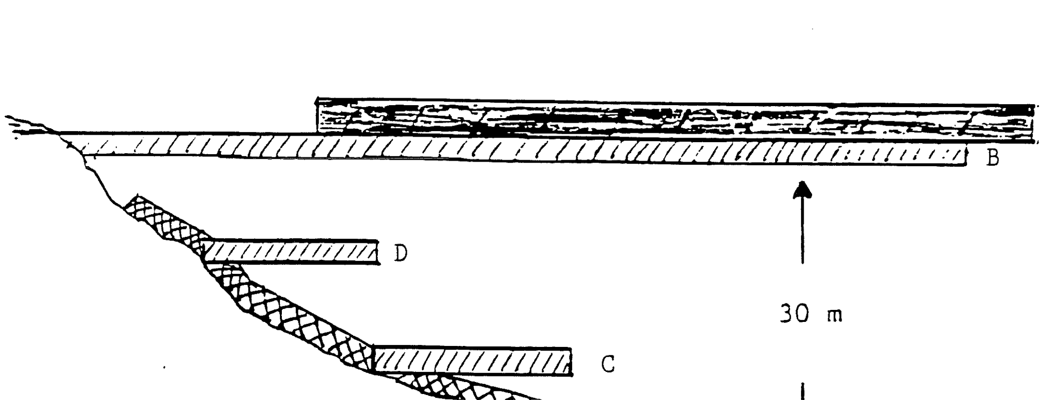

Figure 5b. Position of gillnets during release no. 14 and 15.

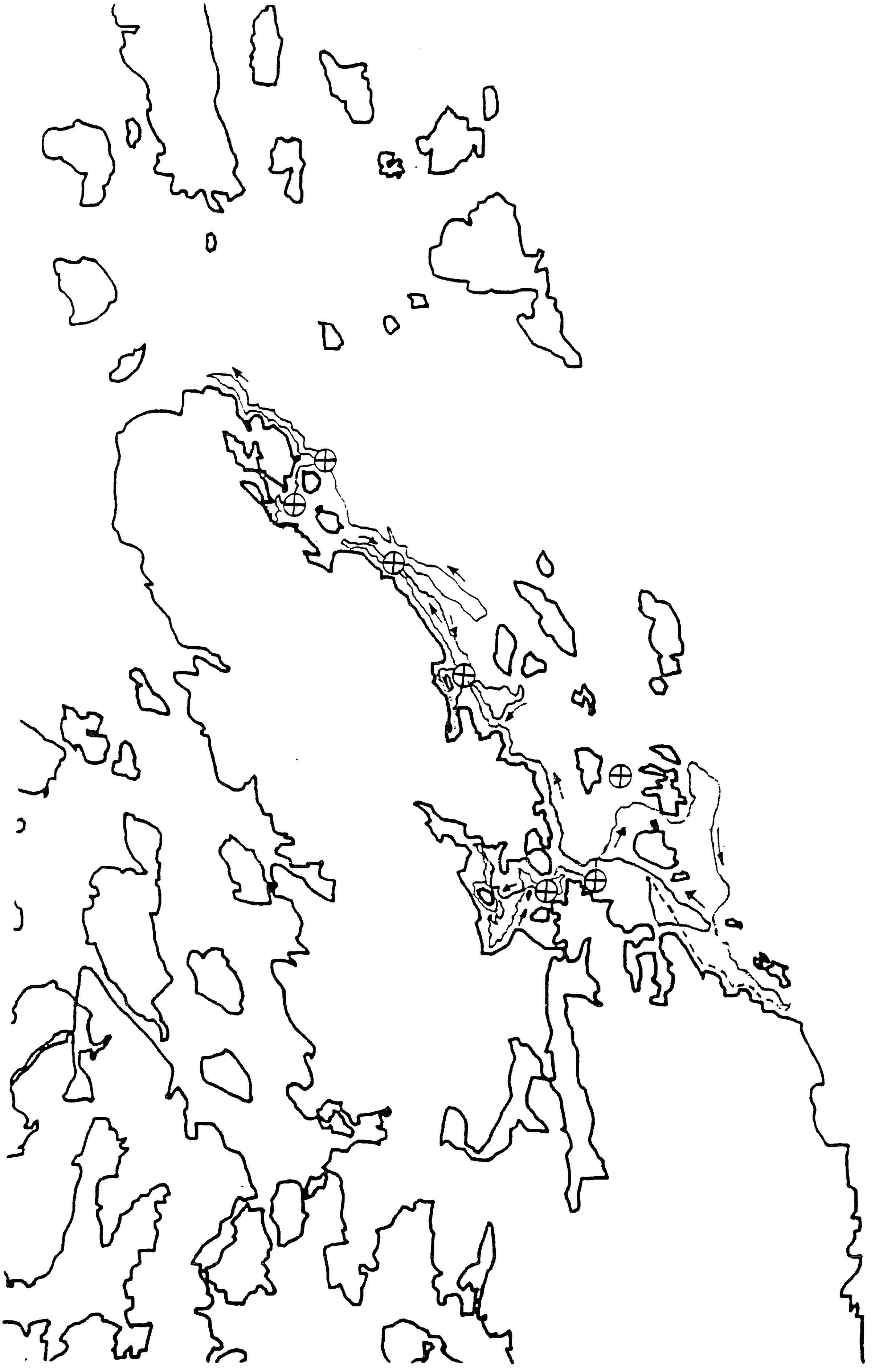

Figure 6a : Migration route for fish no. 5.

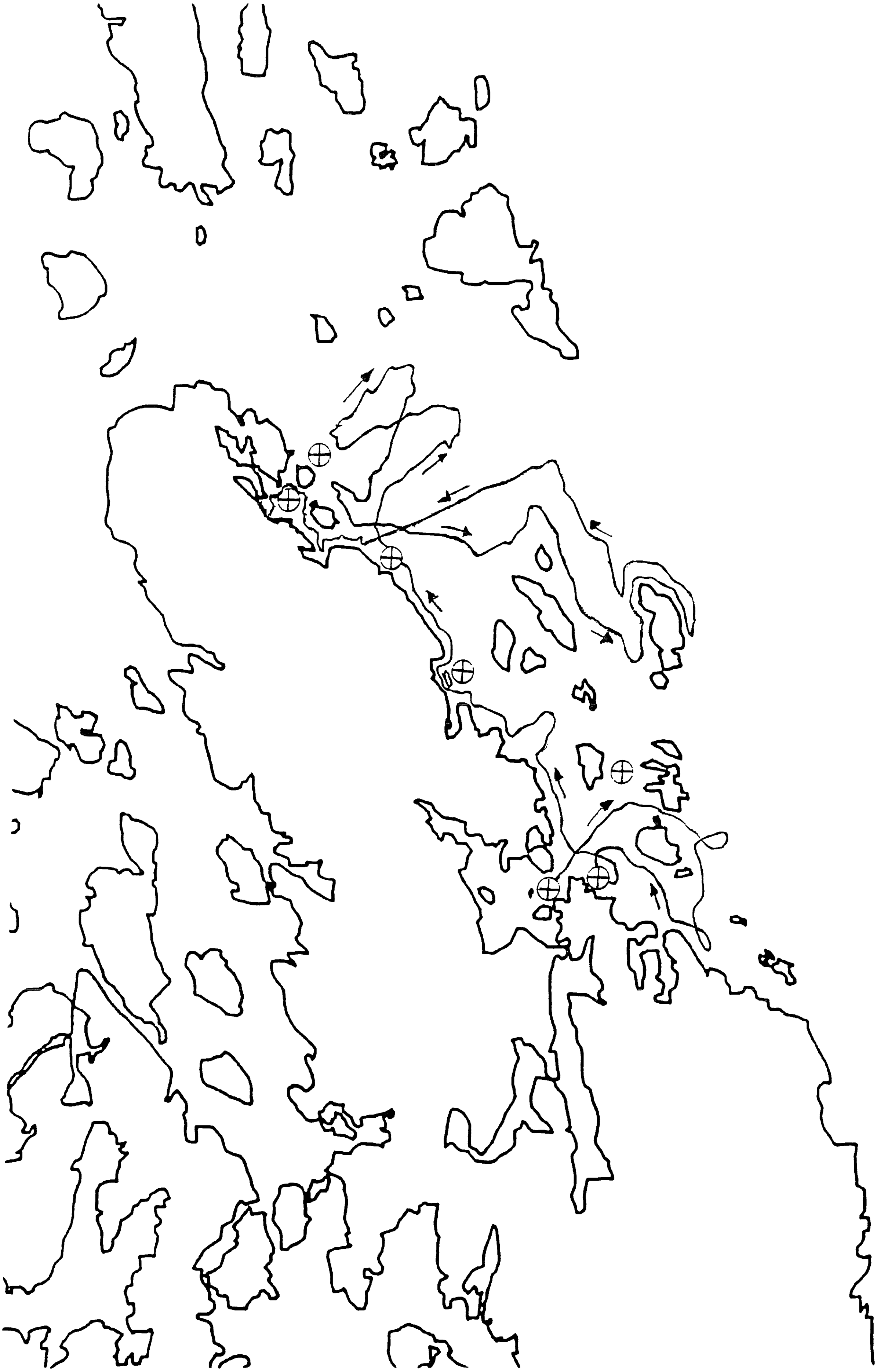

Figure 6b : Migration route for fish no.11.

Figure 6c : Migration route for fish no. 15.

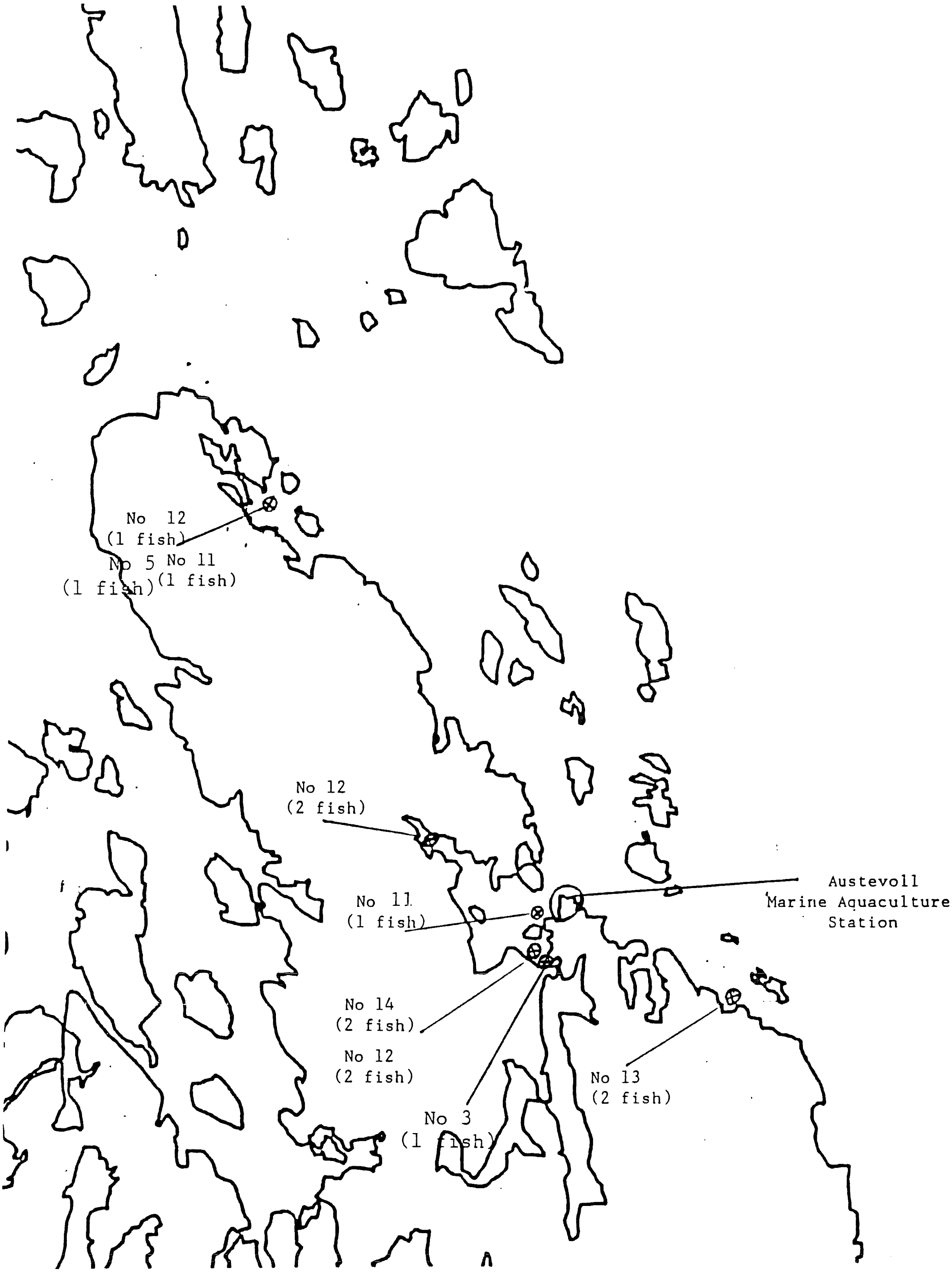

Figure 7 : Recaptures by local fishermen. Numbers refer to release numbers. Gillnets.