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KALANTUTKIMUSOSASTO

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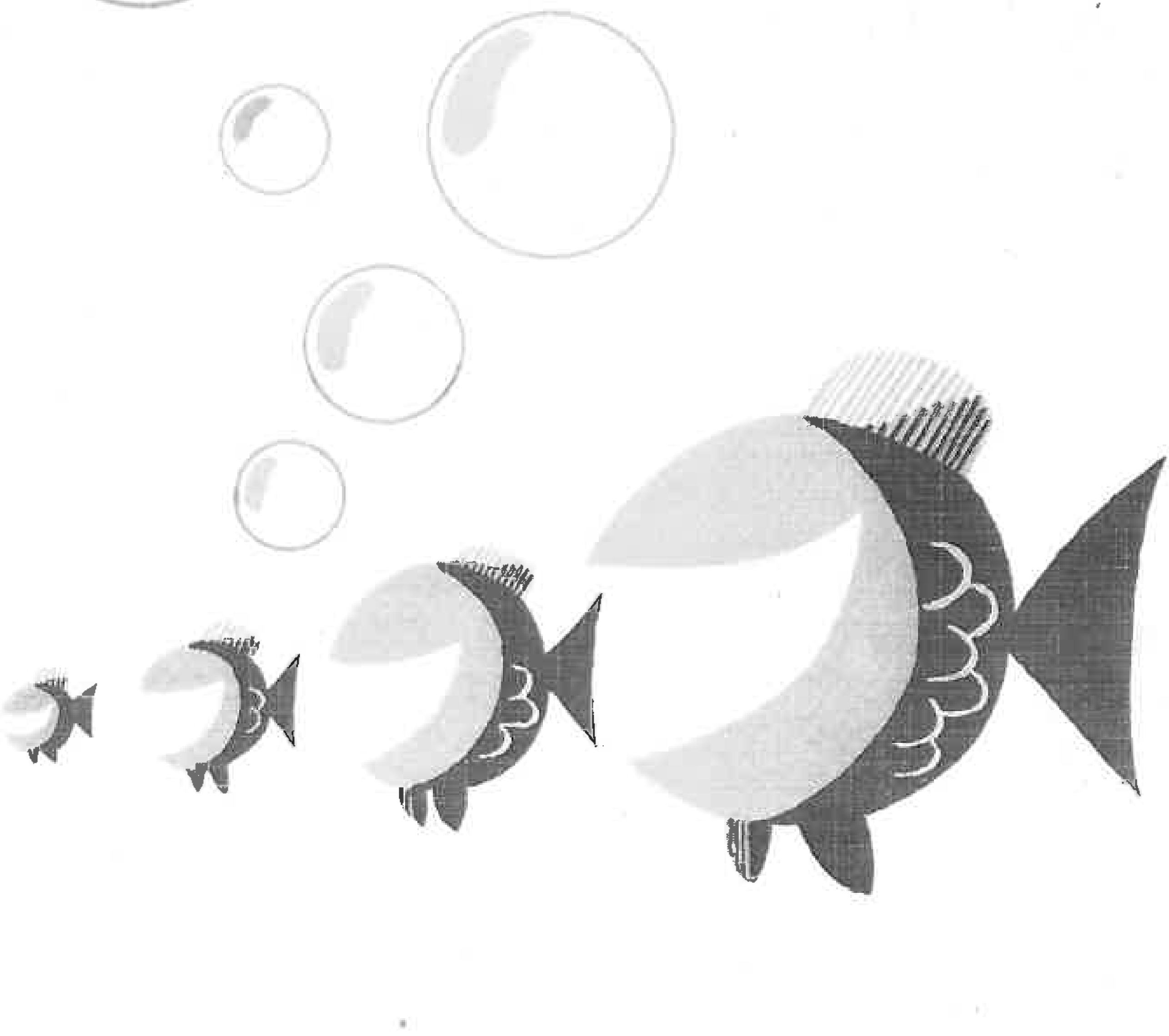

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THE BALTIC HERRING TRAPNET FISHERY OFF THE COAST OF FINLAND

by

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Abstract

The herring trapnet fishery in Finland began early in the 19th century, in the northern part of the Bothnian Bay (ICES subdivision 31). Nowadays one third of the total Finnish herring catch is taken with trapnets, and herring trapnets are used along the whole of the Finnish coast, numbering about 3 400. Of these, about 60 per cent are hoop nets (big fyke nets) and the rest are pound nets. The construction, mooring and emptying of these trapnets are described. The price of a typical herring trapnet is equal to the price of a 500 - 700-foot herring midwater trawl.

Résumé

Les pêcheries du hareng par filet-piège ont commence au début du 19ème siècle en Finlande dans la partie nord du Golfe de Bothnie (sous-division CIEM 31). Aujourd'hui, un tiers des prises totales finlandaises de hareng le sont avec des filets-pièges, au nombre de 3 400, qui sont utilisés tout le long des côtes finlandaises. Environ 60 % d'entre eux sont des trubles et le reste sont des verveux. On décrit la fabrication, l'amarrage et le vidage de ces filets-pièges. Le prix d'un filet-piège typique à hareng vaut celui d'un châlut à hareng de 500 - 700 pieds d'eaux intermédiaires.

I. Introduction

The most important species in the Finnish fishery is the Baltic herring. In 1982 the catch was 85 000 tonnes. During the last few decades the trapnet catch has been fairly stable, but its proportion of the total herring catch has diminished due to the increase in the trawl catches since the 1950's. Of the total Baltic herring yield in 1982, 59 % was caught with trawls and 34 % with trapnets (PARMANNE & SJÖBLOM 1984).

The herring trapnets used along the Finnish coast, from the eastern part of the Gulf of Finland (ICES subdivision 32) to the northern part of the Bothnian Bay (subdivision 31), amount to about 3 400. The number of trapnets is biggest off the southwestern coast of Finland, where the yearly trapnet catch is over 5 000 tonnes per ICES statistical rectangle. The average catch per net in 1982 was 8.8 tonnes. The biggest catches have been made in the Gulf of Finland, 15.8 tonnes. The smallest herring catches have been taken in the Bothnian Bay, in 1982 4.2 tonnes per trapnet (PARMANNE & SJÖBLOM 1984).

Herring trapnets are used almost entirely in spring and summer, during the spawning time of the spring spawning Baltic herring. The trapnets are set soon after the breaking up of the ice. The greater part of the herring spawns in May - June close to the coast. The spawning depth is as a rule less than 10 m. In 1982 the catch in May - June was 87 % of the total trapnet catch. The mean length of the herring in the catches in 1983 was 17-18 cm (PARMANNE & SJÖBLOM 1984). Trapnets have been used in autumn only in exceptional cases.

This report presents the history of the trapnet fishery in Finland, and deals with the construction and price of hoop nets and pound nets, and with the mooring and emptying of trapnets.

II. The history of the herring trapnet fishery

The use of hoop nets (fyke nets with large rings) (Fig. 1) in the fishing of Baltic herring started at the beginning of the 19th century in the northern part of the Bothnian Bay (NORDQVIST 1896). The first trapnets were developed primarily for fishing whitefish and salmon.

The art of constructing and using trapnets spread from the northern coast of the Bothnian Bay (subdivision 31) to the other parts of the Finnish coast, and by the end of the 19th century these nets were known on the Finnish Baltic Sea coast from the Bothnian Bay to the eastern part of the Gulf of Finland (subdivision 32) (NORDQVIST 1896, GOTTBERG 1926).

In the 19th century, the trapnets were woven from hempen and linen threads by the fishermen themselves. Towards the beginning of the 20th century manufactured cotton netting was taken into use (JÄRVI 1932).

Synthetic fibres came into use in the late 1950's, and rapidly displaced natural materials. This prolonged the service life of the trapnets and maintenance became easier, making it possible to increase the number of trapnets employed by one fisherman.

Pound nets (Fig. 2) were already in use at the end of the 19th century on the northern part of the Bothnian Bay, but chiefly for fishing whitefish and salmon (JÄRVI 1932, HALME & AALBERG 1959, TUOMI-NIKULA 1982). Pound net fishing for Baltic herring did not begin until the early 1940's, in the Archipelago Sea (ICES subdivision 29), in Kustavi. In the 1950's and 60's the number of pound nets increased rapidly in the Archipelago Sea, and by the early 1970's in this area, hoop nets had been almost totally replaced by pound nets (LUNDELL 1972). In the 1970's and 80's pound nets also became more common in the Gulf of Finland (32) and in the Bothnian Bay (31). In 1980, about 30 per cent of the trapnets in the Gulf of Finland were pound nets.

The first pound nets were made from hoop nets by replacing the rear part of the hooped bag with a rectangular box and leaving the first three hoops, with funnels (throats) inside, in front of this box (Fig. 3). Even nowadays, most pound nets used along the coast of the Gulf of Finland are still of this kind.

The chief advantage of a pound net is the spacious bag, called the crib, in which a large amount of fish can survive for a longer period than in the limited space of a hoop net. The emptying (hauling) of a pound net is also easier than that of a hoop net, because the crib of a pound net is uncovered and there is no need to lift the crib up from the water. A pound net is generally considered to be a more effective gear than a hoop net. The greatest known amount of herring hauled in Finland during one day with a pound net is nearly 40 tonnes.

The disadvantages of a pound net are the necessity of firm mooring and the risk of the big crib cracking in places where it is exposed to waves or strong currents.

III. The construction of trapnets

Information on the construction of the trapnets used for herring fishing in 1983 was collected at selected areas on the coast of Finland (Fig. 4). The data on hoop nets were collected from the Bothnian Sea (subdivision 30, Merikarvia and Korsnäs), the Bothnian Bay (31, Kalajoki) and the Gulf of Finland (32, Inkoo and Loviisa). The data on pound nets were collected from the Archipelago Sea (29, Taivassalo), the Bothnian Bay (31, Kalajoki) and the Gulf of Finland (32, Inkoo and Loviisa). The material used for this paper consisted of data on 202 hoop nets and 84 pound nets.

1. Hoop nets

1.1. Leader and wings

The leader generally tapers gradually towards the shore, depending on the depth. Because of the shallow seashore, the leaders are longer in the Gulf of Bothnia (subdivisions 30 and 31, usually 150-200 m) than in the Gulf of Finland (32, 80 m) (Table 1).

The heart-shaped chamber of a trapnet consists mainly of two wings, designed to deflect fish into the trap. The length and setting of the wings vary with the local conditions and customs. In the Bothnian Sea (30) the length of the wings is around 70-80 m, in the Bothnian Bay (31) 55 m and in the Gulf of Finland (32) around 40 m (Table 1).

The leader and wings generally extend from the surface to the bottom. In the Gulf of Bothnia (subdivisions 30 and 31) the height is about 13 m and in the Gulf of Finland (32) 10 m (Table 1).

A slotlike gate (entrance) is formed by the end of the leader and the wings. In the Bothnian Sea (30) the width of this gate is around 7 m, and in the Bothnian Bay (31) and the Gulf of Finland (32) 3 m.

1.2. Chute

The trap part of a hoop net is connected to the wings with a ramp, called a chute (climb-way). This tapering ramp guides the fish swimming inside the wings to the entrance of the trap. The length of the gently sloping chute (10 - 15 m) is a little more than the height of the wings.

1.3. Trap

The trap may be close to the surface or nearly on the bottom. The coast of the Bothnian Sea is fairly open and traps set near the water surface are more liable to damage by wave action than those set in deeper water. In the Bothnian Sea (30) the average distance from the top of the trap to the surface is 3-5 m, in the Bothnian Bay (31) 2 m and in the Gulf of Finland (32) 1-1.5 m (Table 1).

The trap of a hoop net has a conical shape. The trap must be large enough to prevent the fish from finding the way out and to keep the catch alive between hauls. The rigid skeleton is constructed of aluminium or plastic hoops (earlier of wood), over which the netting is stretched. The height of the hoops is 1.8-2.5 m (Table 1). In some cases the hoop height decreases from the first to the last hoops, so that they fit into each other for easy handling.

There may be 5-13 hoops in a hoop net (Table 1). The mean distance between the hoops is 1.9-2.7 m (Table 1), which is about the same as the height of the hoops. The volume of the trap of a hoop net is around 50 m^3.

The non-return devices, usually two funnel-shaped throats made of netting, are located inside the trap. The first funnel starts at the first hoop and usually ends slightly behind the second hoop. The outlet (diameter 0.7-1.5 m) of the narrow end of this funnel is held open by 4-6 strings tied to the third hoop. The second funnel starts at the third hoop and is longer and has a smaller outlet (diameter 0.3-0.6 m) than the first one. It is stretched open by elastic strings, which extend into the trap and are tied together at its rear end. The number of these strings is 50 - 110 (Table 1).

1.4. Netting

The various parts of the trapnet are made of netting with up to 5-6 different mesh sizes. Off the central and northern coast of the Bothnian Sea (30), the mean mesh size (bar length) of the leader is about 35-70 mm, in the Bothnian Bay (31) 90 mm and in the Gulf of Finland (32) 14 mm (Table 1). The reason for the differences may be, for instance, the lighter summer night in the north, but also the customs of the fishermen. The mean mesh size (bar length) of the wings and chute is 13-16 mm and of the trap 13 mm (Table 1). The netting of the trapnets is usually coloured black. In the Gulf of Bothnia (30 and 31) red netting is also used in the leader. The detailed construction of a typical hoop net is presented in Fig. 5.

2. Pound nets

2.1. Leader and wings

In the Archipelago Sea (subdivision 29) the mean length of the pound net leader is 65 m, in the Bothnian Bay (31) 210 m and in the Gulf of Finland (32) 85 m (Table 2). The length of the wings is around

50 m in all areas. The height of the leader and wings in the Archipelago Sea (29) is about 6.5 m, and in the Bothnian Bay (31) and the Gulf of Finland (32) 10 m. The mean width of the first gate formed by the end of the leader and the wings is around 3-4 m (Table 2).

2.2. Chute

In the Archipelago Sea (29), the chute extends into the crib, forming a funnel-shaped throat inside the crib. The chute may be partly uncovered, and there may be a special slotlike gate formed by two vertical sections of netting starting from the first part of the chute. The throat is held open by an average of 80 strings tied together in the rear wall of the crib.

In the Bothnian Bay (31) there is usually only a vertical, slotlike gate formed by the walls of the chute extending like a "throat" into the crib.

In the Gulf of Finland (32) there are usually three hoops with funnels inside between the chute and crib. The construction of this hooped part, with throats inside, looks like the construction of the corresponding part of hoop nets in this area.

2.3. Crib

Usually the crib of a pound net is a rectangular box without a cover. In the Archipelago Sea (29) the mean length of the crib is 13 m, in the Bothnian Bay (31) 6 m and in the Gulf of Finland (32) 11-12 m (Table 2). In the Archipelago Sea the length of the cribs may reach 25 m. The height of the crib varies, depending on the water depth. In all four areas investigated the mean width and height are around 6 m.

Generally, the longer side of the crib is parallel to the axis of the pound net, but especially in the Archipelago Sea (29) the crib may also be situated transversely at the corner of one wing, or there may even be two cribs set at both corners of the wings.

2.4. Netting

The mean mesh size (bar length) of the leader in the Archipelago Sea (29) and the Gulf of Finland (32) is about 13-14 mm and in the Bothnian Bay (31) 30 mm (Table 2). The mean mesh size of the wings, chute and crib is around 13 mm in all areas (Table 2).

The construction of a typical pound net is presented in Fig. 6.

3. Floats and sinkers

The headlines of a trapnet are generally fitted with plastic floats (often 12 x 8 x 4 cm) at a distance of 0.5 - 2 m from each other.

Stone sinkers (ballasts) are emloyed at the leadlines of trapnets. These sinkers (0.5 - 5 kg) are fastened at a distance of 1 - 2 m, depending on the height, thickness and mesh size of the netting, and on current velocity, etc.

4. Mooring of trapnets

There are two basic methods for mooring a trapnet; with wooden stakes (poles) driven into the bottom, and/or with floats (buoys) and anchors. Stakes can be used only in places where the depth does not exceed about 13 m and the ground is not too hard. The latter method can be used in both shallow and deep waters.

Hoop nets are generally moored with floats and anchors, as are also pound nets in open areas. Mooring with stakes alone is restricted to the sheltered parts of the Archipelago Sea (29).

The weight of the iron anchors usually varies between 10 and 30 kg (up to 70 kg). For one trapnet 10 - 40 anchors are needed. Ropes about 40 m long are fastened to the anchors and tied to the long walls and corners of the netting. The anchor ropes are usually tied only to the headlines of the gear, but in difficult conditions anchors are also used for the leadlines. Special floats are generally connected to each point of attachment of the anchor ropes. The anchors are set on both sides of the gear in case of changes in the direction of the current and waves.

The trap part of a hoop net is held straight and at the right depth by one or two special heavy anchors (up to 150 kg) and a big float attached with a rope to the rear end of the trap. Some hoops may also be fastened with anchors.

In the Archipelago Sea (29) the crib of pound nets is often moored on a rigid, floating framework made of pontoons or large floats. This framework is fastened with anchors to the bottom. In the sheltered parts of the Archipelago Sea (29, Taivassalo) the gear is usually moored with wooden stakes, sometimes with the help of some anchors. The number of stakes per pound net is about 30. The diameter of the stakes is 10 - 20 cm, depending on the water depth. The distance between the stakes is usually 5 - 15 m, but along the longer sides of the crib the distance is 4 - 5 m. The netting walls are fastened to the stakes at both the headlines and leadlines. The headline of the crib is fastened to horizontal poles stretched between the stakes about 0.5 m above the water surface. The stakes are pushed into the bottom with manpower. Pole-drivers, made by the fishermen themselves, are used for pulling the stakes out of the ground.

In addition to these principal methods of mooring, there is often a framework of ropes and wooden booms connecting and securing the different parts of the trapnet and maintaining the shape of the gear.

IV. Emptying the trapnets

The vessels used in the trapnet fishery are mainly open or partly decked boats with a total length of around 7 - 10 m. The output of the petrol engine is mainly 10 - 50 hp.

Generally, the trapnets are emptied with a small handnet operated by one person. The capacity of these nets is around 10 - 15 kg fish per haul. A hoop net is mostly emptied by lifting the trap on to the side of the boat, or partly into the boat, so that fish can be hauled out with the help of a handnet.

Interest in suction pumps for emptying pound nets awoke in the mid 1970's. Nowadays 60 - 80 suction pumps are in use along the southern and south-western coast of Finland.

The pumps are centrifugal type screw-pumps, placed either directly on the deck, or inside the forecastle of the boat. Their capacity is up to 2 000 kg mixed fish and water per minute. The fraction of fish in this mixture is 1/4 - 1/5.

The basic system consists of a pump, suction hose and fish/water separator. The length of the armoured rubber suction hose is 2-6 m and the diameter 10 cm. In operation, the boat is brought alongside the crib, the fish are forced into a corner of the crib, and the suction hose is lowered into the crib. The fish/water mixture is pumped into the separator, which guides the fish into the boat and the water into the sea. The separator is made by the fishermen themselves from plywood and wire netting, and mounted on the side of the boat.

Power for the pump can be taken either from an auxiliary engine, or hydraulically from the main engine of the boat. The maximum power needed is 4-7 kW.

Fish up to 0.5 - 1 kg can be pumped from the crib without noteworthy damage of the fish. The pump can be handled by one person. It saves manpower and makes the emptying of a pound net faster, easier and cleaner than handnet emptying.

V. The price of trapnets

The netting accounts for the greater part of the price of trapnets (Table 3).

Table 3. Materials needed for a typical hoop net (Figs. 1 and 5) and pound net (Figs. 2 and 6) with leader and wings (KYLLÖNEN 1983).

	Cost (% of the total price) Hoop net	Pound net
Netting, 100 kg	48	60
Ropes, hoop net 100 kg, pound net 20 kg	12	3
Floats, 300 in all	3	4
Aluminium tube for the hoops, 70 m	2	-
Iron anchors, 23 weighing 10-15 kg each	5	-
Wooden stakes, 30	-	3
Other material	4	3
Working hours, hoop net 250 h, pound net 200 h	25	27
Total price, USD	4 600	3 600

The cost of trapnets is equal to the price of a 500 - 700-foot herring midwater trawl. The trapnets are mainly prepared by the fishermen themselves. The life of a trapnet is around ten years, depending on the fishing place.

The mean number of trapnets used by fisherman is around 3 (Table 4). Most fishermen have 1 - 3 trapnets, but some have more than ten (Fig. 7).

Table 4. The mean number of trapnets per fisherman off the coast of Finland.

	Trapnets per fisherman
Archipelago Sea (subdivision 29)	4.1
Bothnian Sea (30)	3.5
Bothnian Bay (31)	2.1
Gulf of Finland (32)	3.3
All areas	3.3

Discussion

In the trapnet fishery the herring catches are big compared with the amount of fuel consumed. On the other hand, the price of herring is low during the herring spawning time, and the trapnet fishing season lasts only 1 - 3 months. The severe marketing problems are reduced by using the greater part of the catch as mink fodder.

There are considerable differences in the leader mesh size along the coast of Finland. Preliminary results obtained in summer 1984 show that it may be possible to increase the leader mesh size in the Archipelago Sea (ICES subdivision 29), where it is commonly smaller than in the northern areas. This change would increase the profitability of the trapnet fishing. It may also be possible to increase the mesh size of the wings.

The herring trapnet is a very selective gear. The catch consists almost entirely of herring. In addition, since the fishing is directed at spawning shoals, the amount of young herring (0 - 2 years old) in the trapnet catches is low. The trapnet exploits the herring stock less than the trawl, because young individuals are excluded.

References

GOTTBERG, G. 1926: Strömmingsfisket med storryssjor. - Fiskeritidskrift för Finland 33: 185-88.

HALME, E. & AALBERG, A. F. 1959: Parhaita kalanpyydyksiä. - WSOY Porvoo, 87 pp.

JÄRVI, T. H. 1932: Suomen merikalastus ja jokipyynti. - WSOY Porvoo, 378 pp.

KYLLÖNEN, S. 1983: Ammattimaisessa kalastuksessa käytössä olevia kalanpyydyksiä Varsinais-Suomessa. - Kalatalousteknikkotutkintoon liittyvä erikoistyö, 104 pp.

LUNDELL, S. 1972: Paunetti - avoin silakkarysä. - Suomen Kalastuslehti 79: 173-74.

NORDQVIST, O. 1896: Isorysät ja isorysäkalastus. - Suomen Kalastuslehti 5: 18-53.

PARMANNE, R. & SJÖBLOM, V. 1984: Baltic herring in the seas around Finland in 1982 and 1983. - Annls. biol. Copenh. 40 (in press).

TUOMI-NIKULA, O. 1982: Keskipohjalaisen kalastajan vuosi. - Kansantieteellinen Arkisto 32, Suomen Muinaismuistoyhdistys, Helsinki, 392 pp.

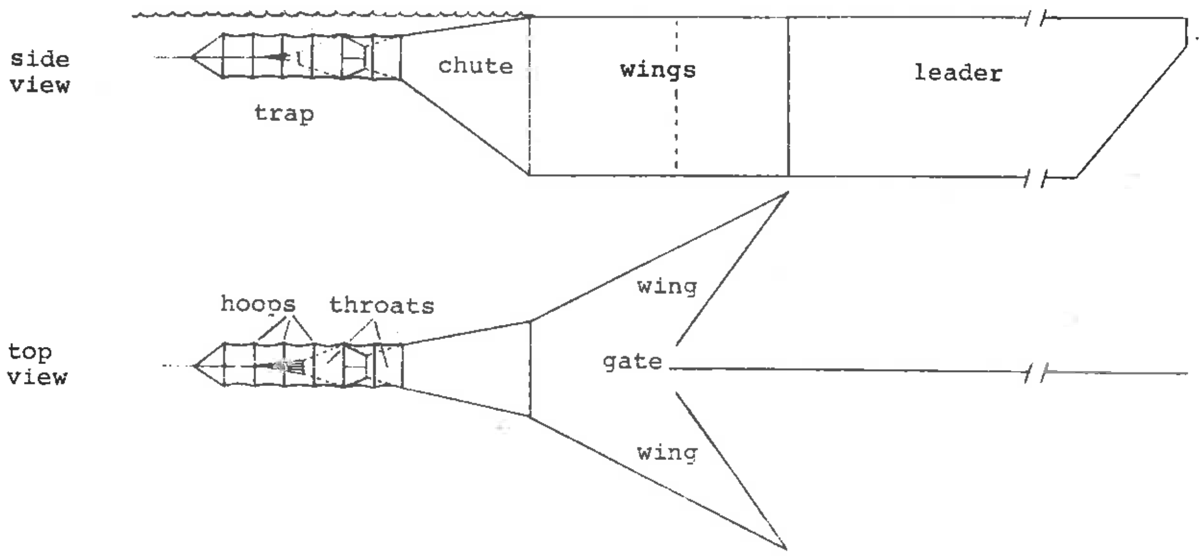

Figure 1. A typical hoop net used off the coast of Finland.

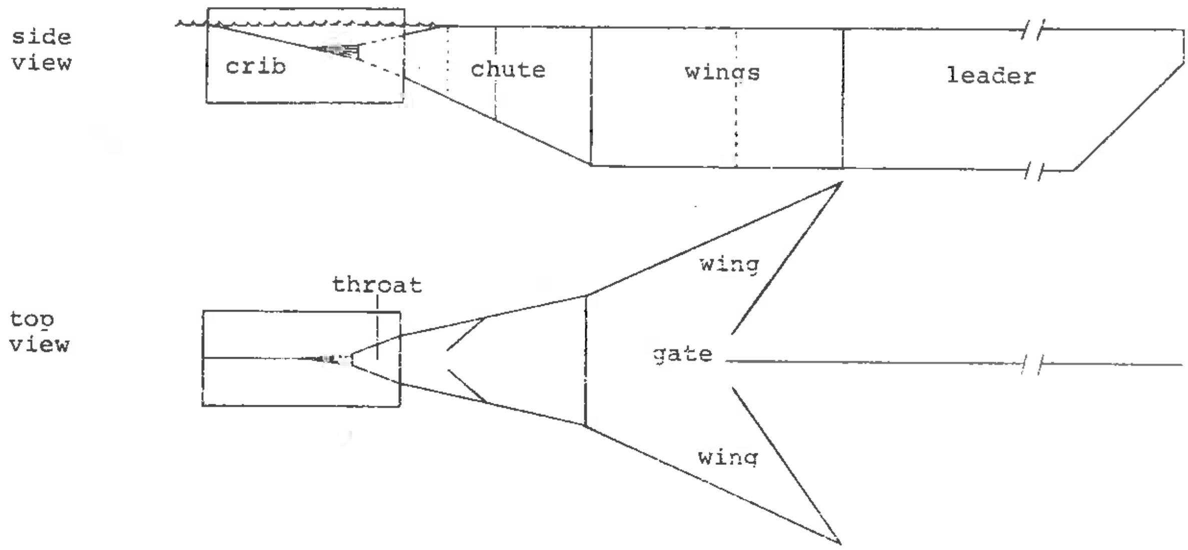

Figure 2. A typical pound net used off the coast of Finland.

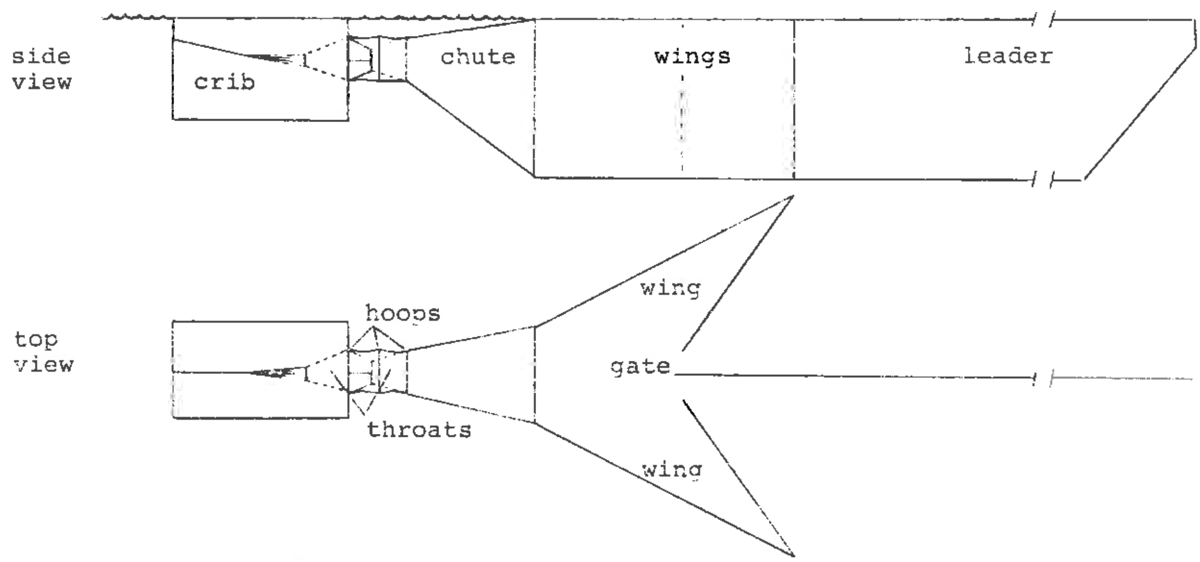

Figure 3. A pound net with hoops.

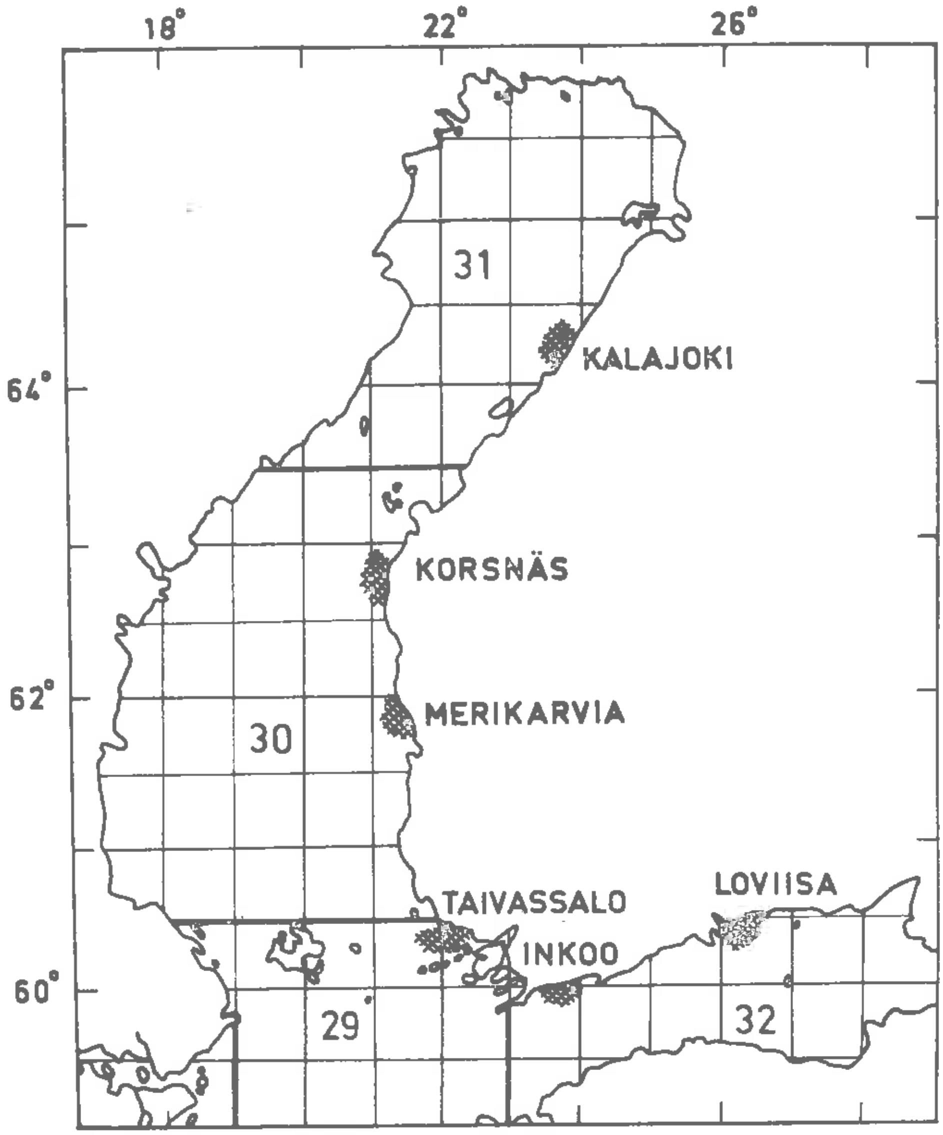

Figure 4. The areas where the information on the construction of the trapnets was collected.

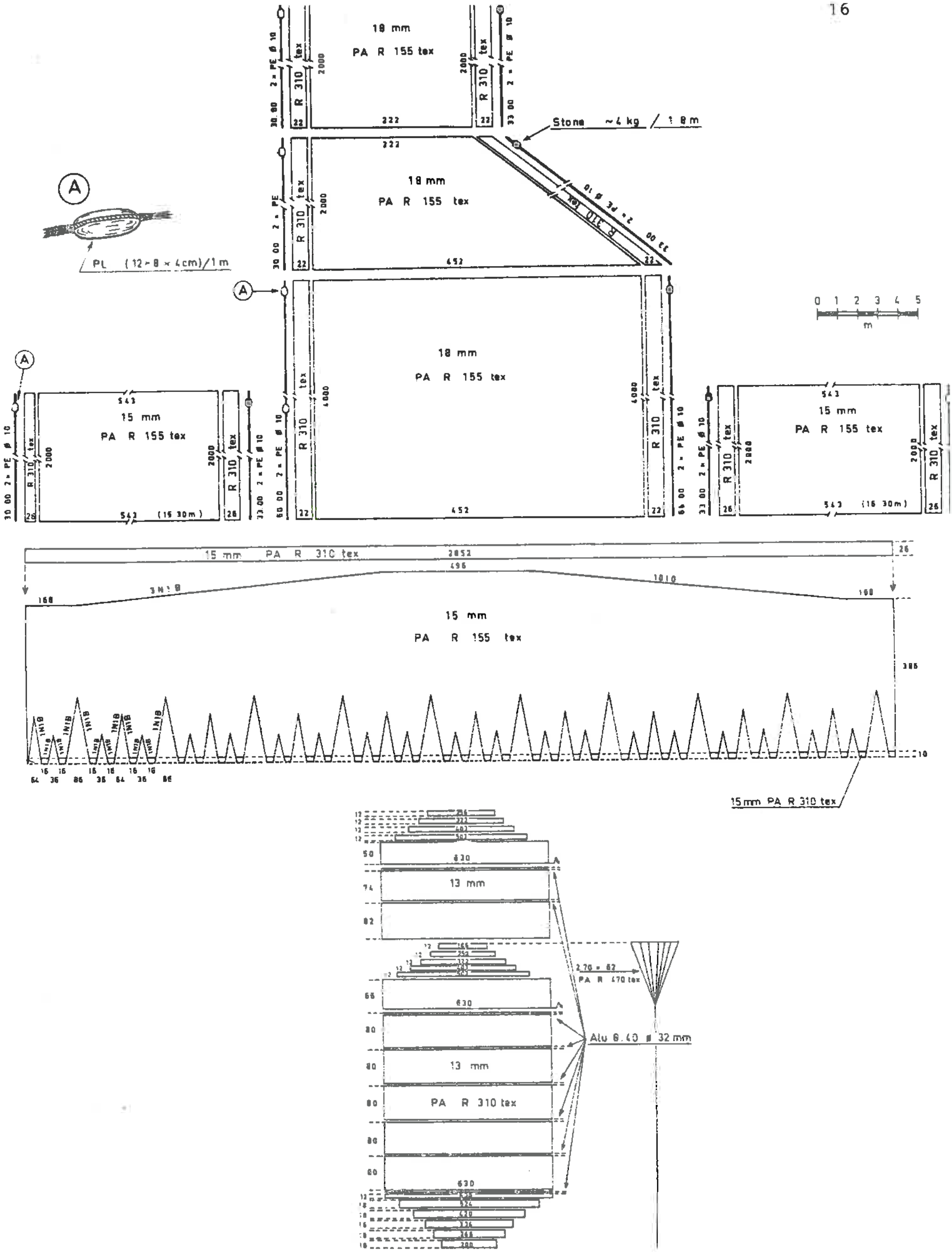

Figure 5. The construction of a herring hoop net from the southern Bothnian Sea (30).

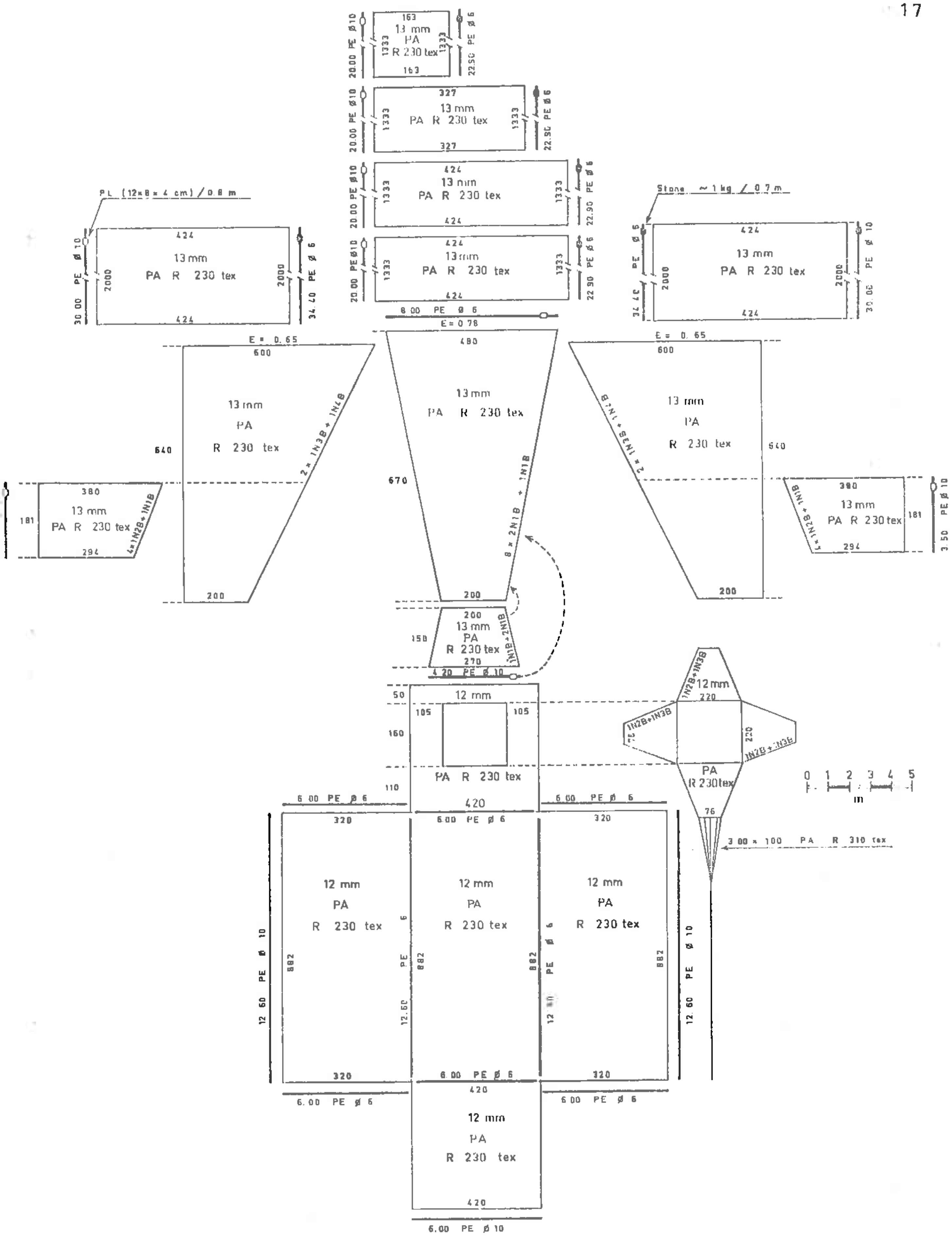

Figure 6. The construction of a herring pound net from the Archipelago Sea (29).

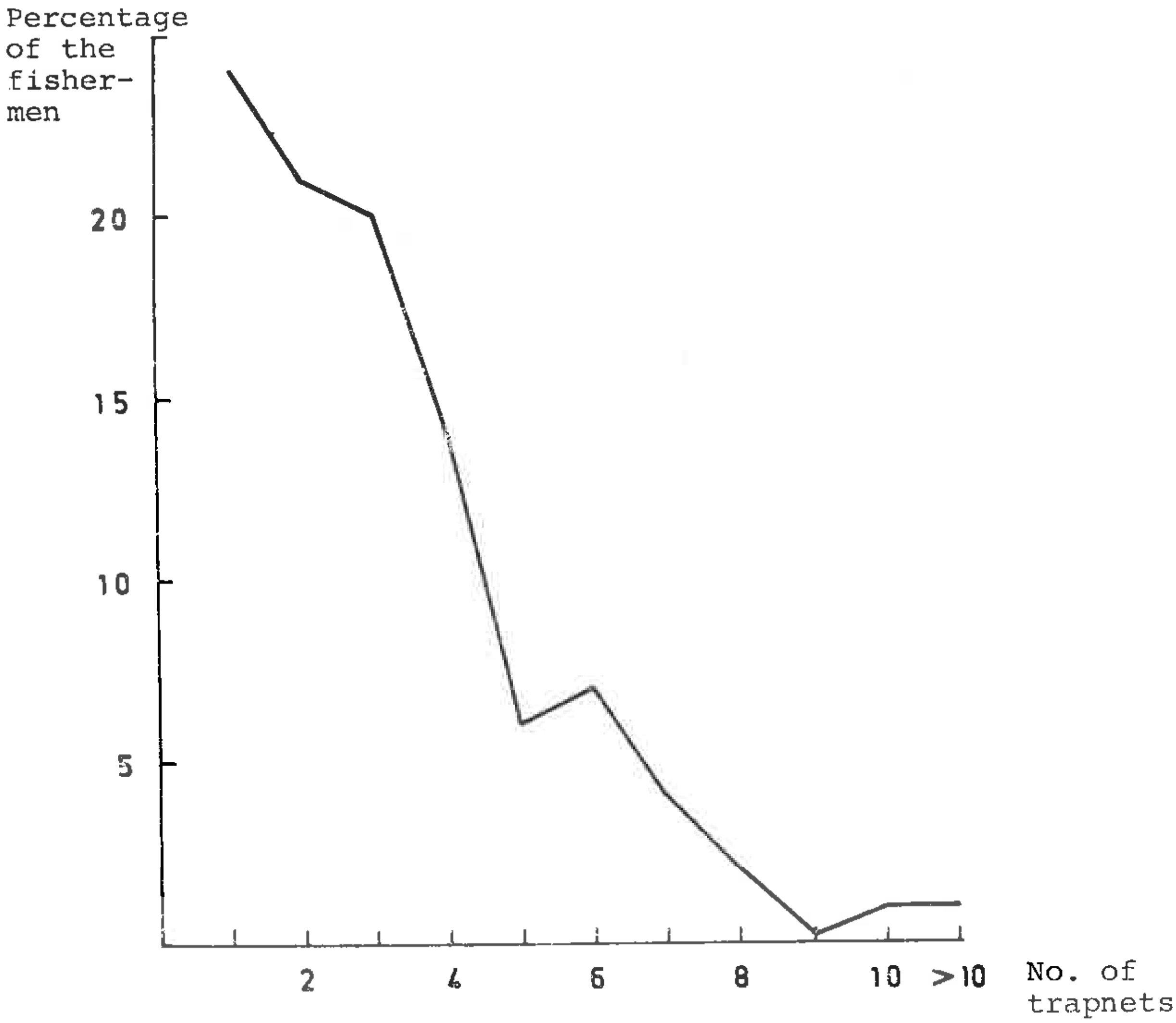

Figure 7. The numbers of trapnets per fisherman.

Table 1. The means and ranges of the main dimensions of the hoop nets used off the coast of Finland, n=202.

	Bothnian Sea (30)		Bothnian Bay (31)	Gulf of Finland (32)	
	Meri-karvia	Kors-näs	Kalajoki	Inkoo	Loviisa
length of leader (m)	170	140	200	75	90
range	95-310	100-180	140-250	25-160	65-130
total length of wings (m)	80	68	55	32	46
range	60-130	60-90	52-60	24-50	30-70
maximum height of net (m)	14	11	13	11	8.5
range	7-23	8-14	8-16	6-18	4-12
width of first gate (m)	6	8	2.7	2.6	3.7
range	3-10	3-20	2-3.5	2-4	2-6
depth of trap (bag) (m)	3	5	2	1.5	1
range	0-8	3-6	0-4	1-3	0-2
number of hoops (rings)	6	6	6	9	9
range	5-6	5-7	-	8-11	8-13
distance between hoops (m)	2.1	2.7	1.9	2.5	1.9
range	1.8-3.2	2.1-4.0	1.8-2.4	1.5-4.0	1.8-2.2
number of strings stretching second funnel	66	102	53	50	110
range	30-100	75-150	46-64	30-65	80-140
mesh size (bar) of leader (mm)	33	70	90	13.9	14.2
range	15-100	37-200	14-400	13-15	12-15
mesh size of wings and chute	15.5	13.8	15.7	13.5	13.5
range	14-20	13-16	13-30	13-15	11-17
mesh size of trap (bag)	13.0	12.7	13.2	13	12.9
range	12-16	12-14	13-14	-	11-14

Table 2. The means and ranges of the main dimensions of the pound nets used off the coast of Finland, n=84.

	Archipelago Sea (29)	Bothnian Bay (31)	Gulf of Finland (32)	
	Taivassalo	Kalajoki	Inkoo	Loviisa
length of leader (m)	65	210	85	85
range	20-110	200-216	50-150	60-130
length of wings (m)	52	54	46	50
range	24-68	-	30-50	30-70
maximum height of net (m)	6.5	9.5	11	9.5
range	3-9	8-11	8-13	8-15
width of first gate (m)	2.9	4.2	3.4	3.5
range	2-4	4-5.5	3-5	2-4
length of crib (m)	13	6	11	12
range	8-25	-	?	7-16
mesh size (bar) of leader (mm)	13.2	31.2	13.7	13.5
range	12-16	14-35	12-15	12-15
mesh size of wings and chute	13.0	13.4	12.9	13.3
range	12-15	13-14	12-14	12-17
mesh size of crib	12.5	12.2	12.6	12.9
range	12-14	12-13	12-14	12-14

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ABUNDANCE OF SPRAT EGGS AND LARVAE IN THE NORTHERN BALTIC SEA IN 1982 and 1983

by

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Abstract

In July and August 1982 and 1983, samples were taken with the modified Gulf V sampler in the northern Baltic Sea proper and the Åland Sea (ICES subdivision 29), in the Bothnian Sea (30) and in the Gulf of Finland (32). The decline in the number of sprat eggs suggests that the sprat stock has decreased in the northern Baltic Sea. According to the larval survey, the sprat year classes 1982 and 1983 are weak, and there are no signs of recovery of the northern sprat stock.

Résumé

Des échantillonnages furent effectués en juillet et août 1982 et 1983 dans la partie nord de la Baltique Proprement Dite et dans la Mer d'Åland (sous-division CIEM 29), dans la Mer de Bothnie (30) et le Golfe de Finlande (32) à l'aide de l'échantillonneur Gulf V modifié. Le déclin du nombre d'oeufs de sprat suggère que le stock de sprat a diminué dans la Baltique septentrionale. D'après le relevé larvaire, les classes annuelles 1982 et 1983 de sprat sont faibles et il n'y a pas de signes de redressement du stock de sprat septentrional.

Introduction

The abundance of sprat eggs and larvae in the seas around Finland has been followed annually since 1975 (SJÖBLOM & PARMANNE 1976, 1977, 1978, 1979; PARMANNE & SJÖBLOM 1980, 1981, 1982). Sampling was continued at the same sites in 1982 and 1983. The results are presented in this report.

Material and methods

From 15 to 24 July and from 29 July to 5 August 1982, altogether 63 samples were taken from the northern Baltic Sea proper and the Åland Sea (ICES subdivision 29), the Bothnian Sea (30) and the Gulf of Finland (32). In 1983, the sampling periods were from 21 July to 2 August and from 8 to 12 August. The samples were taken with the modified Gulf V sampler (SCHNACK 1974). The mesh size of the larval net was 300 µm. Double oblique hauls were made at a towing speed of 5 knots from the surface to 5-10 m above the bottom. At depths of more than 100 m, the sampler was lowered to 90 m only. The maximum towing time was 30 min. The sampling technique is described in an earlier report (SJÖBLOM & PARMANNE 1976). Altogether 3 300 eggs and 443 larvae were caught in 1982, and 1 200 eggs and 131 larvae in 1983.

Results

The number of sprat eggs and larvae was lower in 1983 than in 1982 (Tables 1 and 2, Figs. 1 - 4). As usual, the highest densities were recorded in the northern part of the Baltic Sea proper (subdivision 29). The year 1983 was the only time since observation started in this subdivision, in 1978, that no sprat eggs were found in the Bothnian Sea (30).

Counting of sprat eggs was initiated in 1977. In 1983, the numbers of eggs in subdivisions 29 and 32 were only 21 % and 25 %, respectively, of the amounts observed in 1977 (Table 3).

The number of sprat larvae ≥ 15 mm in length was at the same low level in 1982 and 1983 as it has been since 1975 (Table 3).

Table 1. Number of sprat eggs in 1982 and 1983.

Area	No. of eggs/m^2 15-25 July 1982	21 July-2 August 1983
Northern Baltic Sea proper	83.4	35.8
Åland Sea	36.3	10.1
Bothnian Sea	13.7	0
Gulf of Finland	42.3	24.8
	29 July-5 August 1982	8-12 August 1983
Northern Baltic Sea proper	11.4	0
Åland Sea	20.6	0
Bothnian Sea	2.6	0
Gulf of Finland	1.3	0

Table 2. Number of sprat larvae in 1982 and 1983.

	No. of larvae/m^2 15-25 July 1982	21 July-2 August 1983
Northern Baltic Sea proper	3.8	3.1
Åland Sea	0.3	0
Bothnian Sea	0	0
Gulf of Finland	0	0
	29 July-5 August 1982	8-12 August 1983
Northern Baltic Sea proper	13.2	1.8
Åland Sea	0.4	0
Bothnian Sea	0	0
Gulf of Finland	0.2	0.3

Discussion

The amount of pelagic fish eggs can be used to estimate the spawning biomass of pelagic fishes (cf. SMITH & RICHARDSON 1977). The decline in the number of sprat eggs suggests that the sprat stock has decreased in the northern Baltic, as was also noted in the VPA (Anon. 1984).

The abundance of sprat larvae ≥ 15 mm in length was great in 1975, when the latest strong year class developed in the northern sprat stock (Anon. 1984). Since 1975 all the sprat year classes have been weak, and the number of larvae ≥ 15 mm has been low. The larval surveys in 1982 and 1983 provide no signs of recovery of the northern sprat stock.

The number of sprat eggs and larvae in the northern Baltic Sea was at the same level as in the ICES subdivisions 22 and 24, but much smaller than in subdivision 25 (Anon. 1984).

References

Anon. 1984: Report of the working group on assessment of pelagic stocks in the Baltic, Copenhagen, 2-13 April 1984. - ICES C.M. 1984/Assess:14 (mimeo).

PARMANNE, R. & SJÖBLOM, V. 1980: Abundance of sprat eggs and larvae in the northern Baltic in 1979. - ICES C.M. 1980/J:10 (mimeo).

PARMANNE, R. & SJÖBLOM, V. 1981: Abundance of sprat larvae in the northern Baltic in 1980. - ICES C.M. 1981/J:24 (mimeo).

PARMANNE, R. & SJÖBLOM, V. 1982: Abundance of sprat eggs and larvae in the northern Baltic in 1981. - ICES C.M. 1982/J:22 (mimeo).

SCHNACK, D. 1974: On the biology of herring larvae in Schlei Fjord, western Baltic. - Rapp. P.v. Réun. Cons. Int. Explor. Mer 166: 114-123.

SJÖBLOM, V. & PARMANNE, R. 1976: Abundance of sprat larvae in the northern Baltic in 1975. - ICES C.M. 1976/P:13 (mimeo).

SJÖBLOM, V. & PARMANNE, R. 1977: Abundance of sprat larvae in the northern Baltic in 1976. - ICES C.M. 1977/P:10 (mimeo).

SJÖBLOM, V. & PARMANNE, R. 1978: Abundance of sprat eggs and larvae in the northern Baltic in 1977. - ICES C.M. 1978/J:18 (mimeo).

SJÖBLOM, V & PARMANNE, R. 1979: Abundance of sprat eggs and larvae in the northern Baltic in 1978. - ICES C.M. 1979/J:20 (mimeo).

SMITH, P. & RICHARDSON, S. 1977: Standard techniques for pelagic fish egg and larva surveys. - FAO Fisheries Technical Paper 175: 1-100.

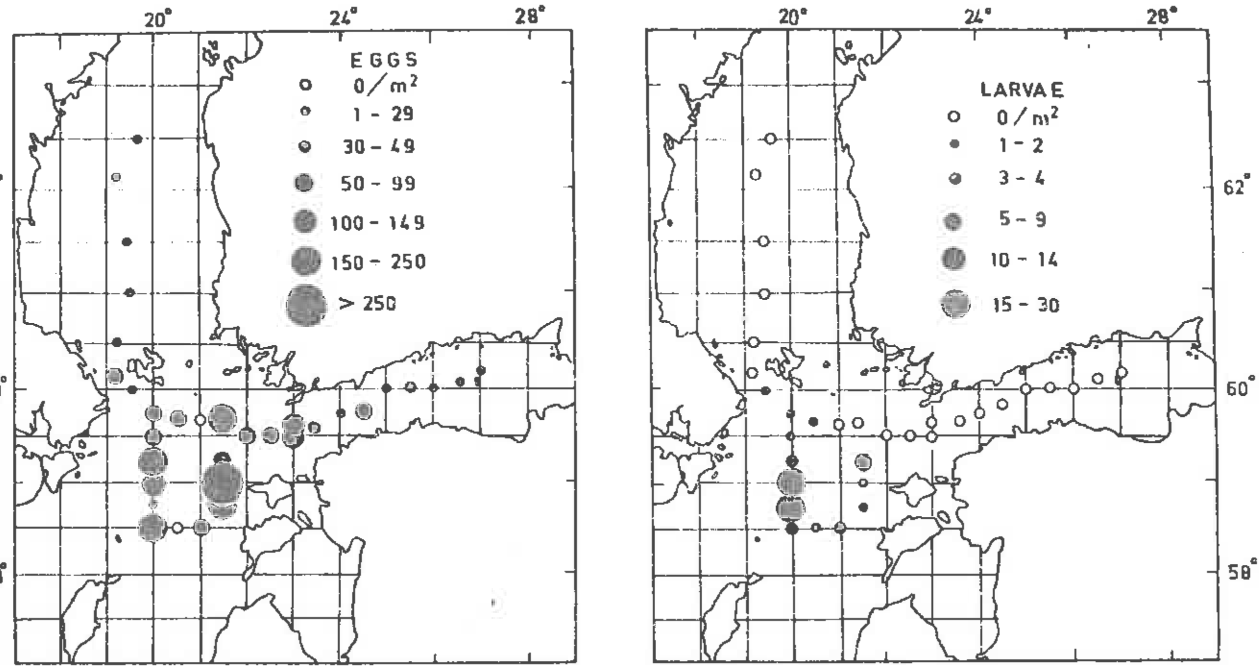

Figure 1. Distribution of sprat eggs and larvae in the northern Baltic Sea, 15 - 25 July 1982.

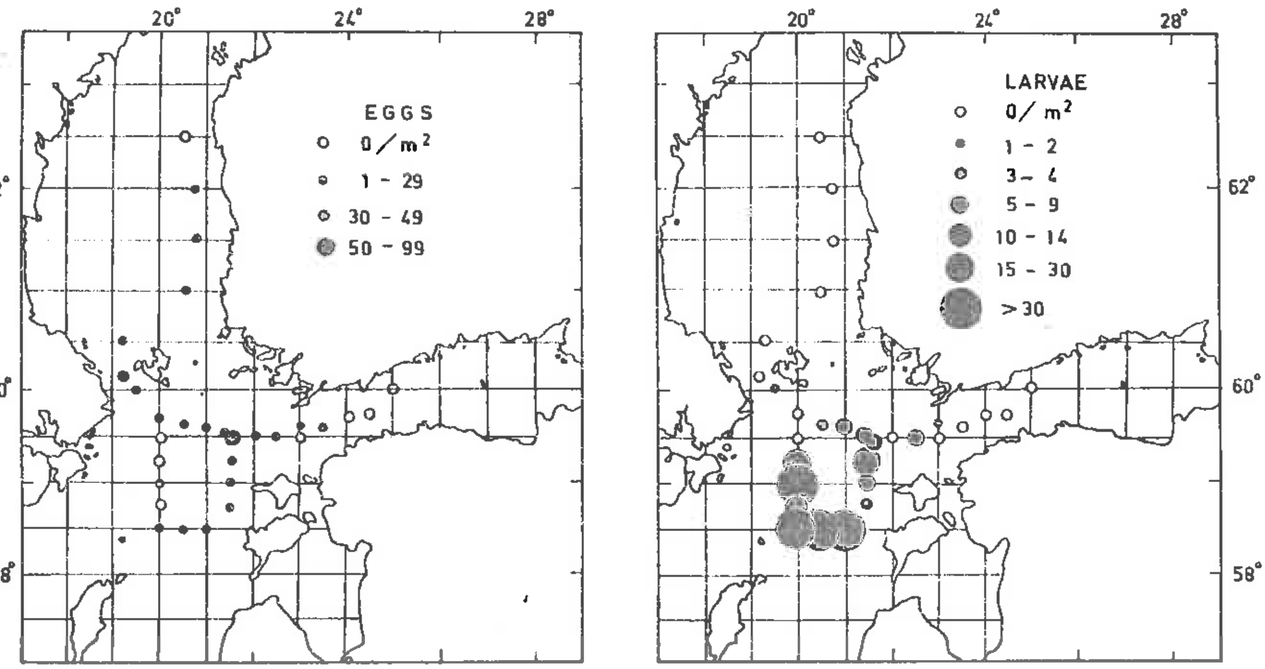

Figure 2. Distribution of sprat eggs and larvae in the northern Baltic Sea, 29 July - 5 August 1982.

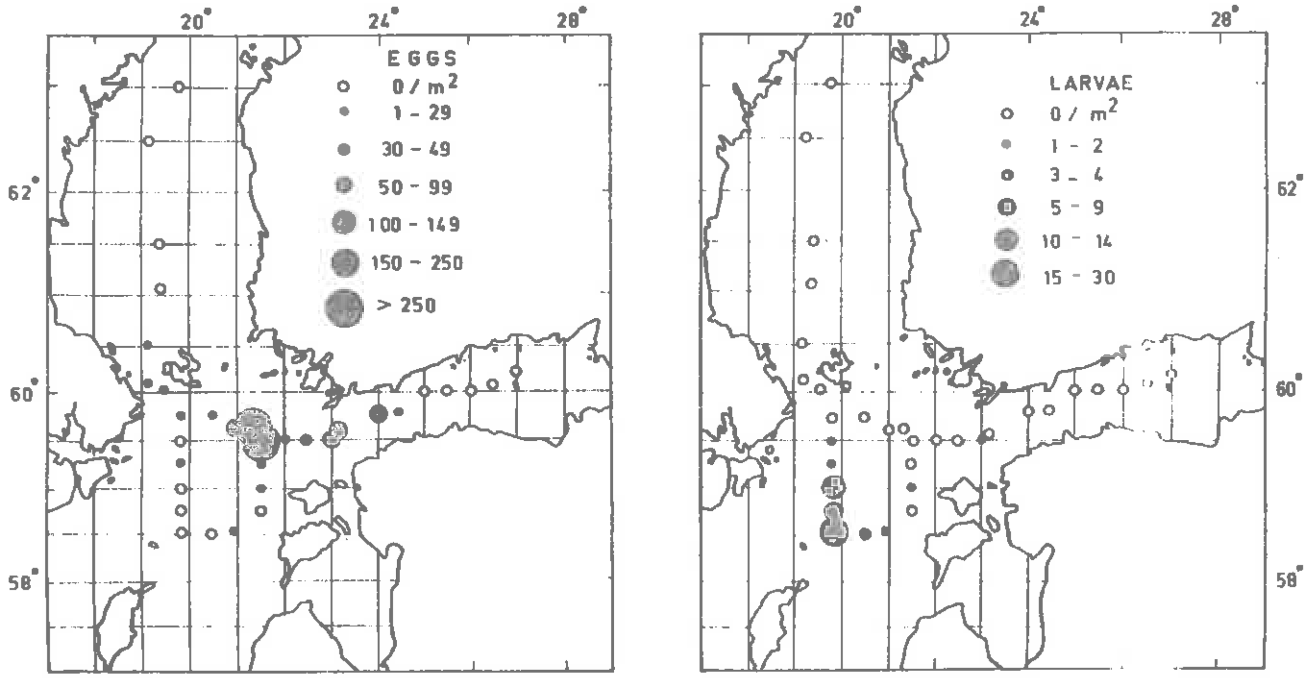

Figure 3. Distribution of sprat eggs and larvae in the northern Baltic Sea, 21 July - 2 August 1983.

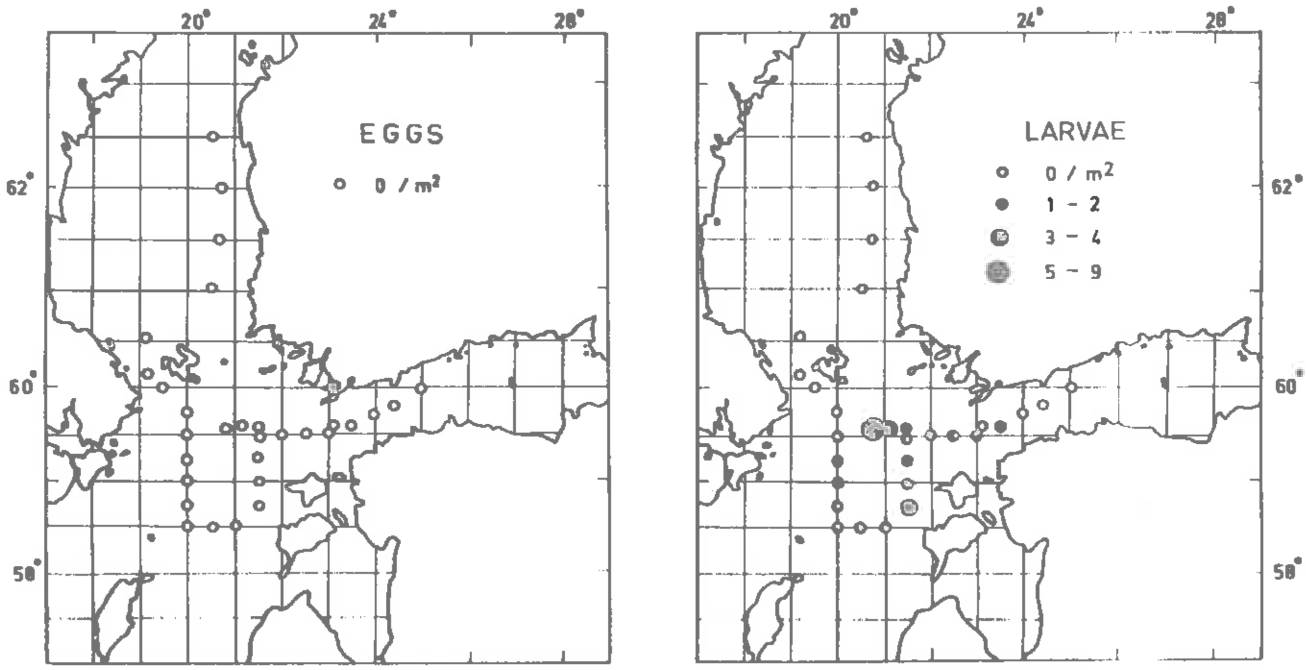

Figure 4. Distribution of sprat eggs and larvae in the northern Baltic Sea, 8 - 12 August 1983.

Table 3. Number of sprat eggs and larvae below 1 m^2 and length distribution (%) of larvae in the northern Baltic Sea.

Sampling time	Sub-div.	No. of eggs/m^2	No. of larvae/m^2	Length distribution (%) of larvae (mm)				Larvae ≥15 mm/m^2 in subdiv. 29
				<10	10-15	15-20	>20	
1975 5-14 Aug	29 32	- -	4.6 1.0	-	13.6	21.8	64.6	4.0
1976 27 Jul-4 Aug	29 32	... -	4.2 0.1	12.1	52.5	25.5	9.9	1.5
1977 20 Jul-10 Aug	29 32	75.3 49.0	2.8 1.1	66.5	20.8	9.1	3.6	0.4
1978 20 Jul-11 Aug	29 32	48.4 33.5	1.5 0.5	2.2	33.2	31.2	33.3	1.0
1979 15 Jul-12 Aug	29 32	16.1 20.9	1.9 0.4	25.2	40.1	18.9	15.3	0.7
1980 16 Jul-9 Aug	29 30	46.4 24.4	2.6 0.4	30.7	21.6	22.2	25.5	1.2
1981 17 Jul-9 Aug	29 30	36.3 16.6	7.8 1.4	35.1	47.5	11.3	6.1	1.4
1982 15 Jul-5 Aug	29 32	47.7 26.9	8.5 0.1	48.5	39.1	11.1	1.4	1.1
1983 21 Jul-12 Aug	29 30	16.0 12.4	2.1 0.2	6.8	47.8	28.0	17.4	0.9

International Council for the
Exploration of the Sea

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ABUNDANCE OF AUTUMN-SPAWNING HERRING LARVAE OFF THE COAST OF FINLAND IN 1981 - 83

by

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Abstract

In August-November 1981-83 samples were taken every other week with the modified Gulf V sampler in the Åland Sea (ICES Sub-division 29) and in the Bothnian Sea (30). The highest density recorded off Reposaari (30) was 9 larvae per 10 m^2. In the Åland Islands at most 3 larvae of autumn-spawning herring were caught per 10 m^2. According to low abundance of larvae there are no signs of recovery of the northern autumn-spawning stock.

Résumé

Des échantillons de larves de hareng baltique ont été pris toutes les deux semaines à l'aide de l'echantillonneur "Gulf V" modifié, au large de la mer d'Åland (sousdivision CIEM 29) et dans la mer de Bothnie (30) pendant la période août-novembre 1981-83. Les échantillons donnent la plus grande densité au large de Reposaari (30): 9 larves par 10 m^2. Aux Iles d'Åland on obtint au moins 3 larves du frai d'automne par 10 m^2. Vu la petite quantité de larves il n'y a pas de signes de rétablissement de l'espèce, c'est à dire du frai d'automne dans le Nord.

Introduction

The southwest coast of Finland is a part of the frontier for autumn-spawning herring populations in the Baltic. The low abundance, which has lasted since the 1940's, is explained as a result of severe winters (SJÖBLOM 1978). Since then the economic importance of autumn spawners has been very low.

Sampling of autumn-spawning Baltic herring larvae has been performed in two field stations, In the Åland Islands since 1977 (Fig.1) and in the Bothnian Sea since 1980 (Fig.2) (HALLING 1978, HALLING & SALMI 1981). Sampling was continued at the same sites in 1981-1983 and the results are presented in the report.

Material and methods

From 31 August to 1 December samples were taken generally every other week with the modified Gulf V sampler (SCHNACK 1974). The mesh size of the larval net was 300 µm and that of the plankton net 60 µm. The towing speed was 4 knots. Single oblique hauls were made from the surface to the bottom. The sampling technique was the same as described by SJÖBLOM & PARMANNE (1975).

Results

In the Åland Islands annually 0-2, altogether 3 autumn-spawning herring larvae were obtained (Table 1). Off Reposaari altogether 32 larvae occurred in the samples. According to both size and occurring time of larvae 25 larvae were determined offspring of autumn spawners (Fig.3). The first larvae were caught on 31 August. Highest densities recorded off Reposaari were 5-9 larvae per 10 m^2 annually. In 1981 densities were highest on 30 October, in 1982 and 1983 as early as in the end of September (Table 2).

The temperature of the sea during the sampling time is shown in Figures 4 and 5. The abundance of copepods in the same time is presented in Figures 5 and 6 .

Discussion

The catch of autumn-spawning Baltic herring is negligible. The abundance of autumn-spawning Baltic herring larvae is only a few percentage units of the amount of spring-spawning larvae (SJÖBLOM & PARMANNE 1975,1976,1977,1978,1979, PARMANNE & SJÖBLOM 1980,1981,1982,1983). In the Åland Sea larvae occurred in 1977 in exeptionally high densities, highest 24 larvae per 10 m^2 (HALLING 1978). Since then the number has been below 1 per sample. Off Reposaari the highest densities vary between 5 and 9 per 10 m^2.

Statistically significant correlation between copepod nauplii and 0-year-old spring spawning herring has been shown by PARMANNE & SJÖBLOM 1982 . In this material such a relationship does not exist between copepods and autumn-spawning larvae.

The abundance of copepods is however very low. LISIVNENKO 1961 counts on an abundance of at least 10,000 individuals per m^3 for normal feeding of the larvae. At several sampling times the numbers of copepods are lower than this. Low abundance of food animals may contribute to the low abundance of larvae and the continuing low abundance of autumn spawning stock. No signs of recovery is seen in the abundance of the stock.

References

HALLING, F. 1978. Autumn-spawning herring larvae and the abundance of copepods off the Åland Islands in September-November 1977. Copenhagen, ICES Baltic Fish Committee. C.M. 1978 /J:20. 9 p. (Mimeogr.)

HALLING, F. & SALMI, J. 1981. Abundance, growth and mortality of autumn-spawning Baltic herring larvae off the coast of Finland. Copenhagen, ICES Baltic Fish Committee. C.M. 1981 /J:22. 15 p. (Mimeogr.)

LISIVNENKO, L. N. 1961. Plankton and the food of larval Baltic herring in the Gulf of Riga. Trudy nauch. Inst. ryb. Khoz. 3, p. 105-138. Translation: Fish. Res. Bd. Canada Translation Series 444. 1963.

PARMANNE, R. & SJÖBLOM, V. 1981. Baltic herring in the seas around Finland in 1978 and 1979. Ann. Biol. Copenh. 36, p. 159-162.

PARMANNE, R. & SJÖBLOM, V. 1982. The abundance of spring spawning Baltic herring larvae in the seas around Finland in 1981 and the effect of zooplankton abundance on the herring year class strength. Copenhagen. ICES Baltic Fish Committee. C.M. 1982/J:17. 14 p. (Mimeogr.)

PARMANNE, R. & SJÖBLOM, V. 1983. Baltic herring in the seas around Finland in 1979 and 1980. Ann. Biol. Copenh. 37, p. 183-186.

PARMANNE. R. & SJÖBLOM, V. 1984. Baltic herring in the seas around Finland in 1980 and 1981. Ann. Biol. Copenh. (in press)

SCHNACK, D, 1974. On the biology of herring larvae in Schlei Fjord, western Baltic. Rapp. P. -v. Réun., Cons. int. Explor. Mer 166, p. 114-123.

SJÖBLOM, V. 1978. The effect of climatic variations on fishing and fish populations. Fennia 150, p. 33-37.

SJÖBLOM, V. & PARMANNE, R. 1975. Abundance of Baltic herring larvae in the seas around Finland in 1974. Copenhagen, ICES Baltic Fish Committee. C.M. 1975/P:3. 7 p. (Mimeogr.)

SJÖBLOM, V. & PARMANNE, R. 1976. Abundance of Baltic herring larvae in the seas around Finland in 1975. Copenhagen, ICES Baltic Fish Committee. C.M. 1976/P:12. 12 p. (Mimeogr.)

SJÖBLOM, V. & PARMANNE, R. 1977. Abundance of Baltic herring larvae in the seas around Finland in 1976. Copenhagen, ICES Baltic Fish Committee. C.M. 1977/P:9. 5 p. (Mimeogr.)

SJÖBLOM, V. & PARMANNE, R. 1978. Abundance of Baltic herring larvae in the seas around Finland in 1977. Copenhagen, ICES Baltic Fish Committee. C.M. 1978/J:6. 6 p. (Mimeogr.)

SJÖBLOM, V. & PARMANNE, R. 1979. The year class strength of spring spawning Baltic herring estimated from abundance of larvae in the seas around Finland in 1974-79. Copenhagen, ICES Baltic Fish Committee. C.M. 1979/J:19. (Mimeogr.)

SJÖBLOM, V. & PARMANNE, R. 1980. Baltic herring in the seas around Finland in 1977 and 1978. Ann. Biol. Copenh. 35, p. 194-198.

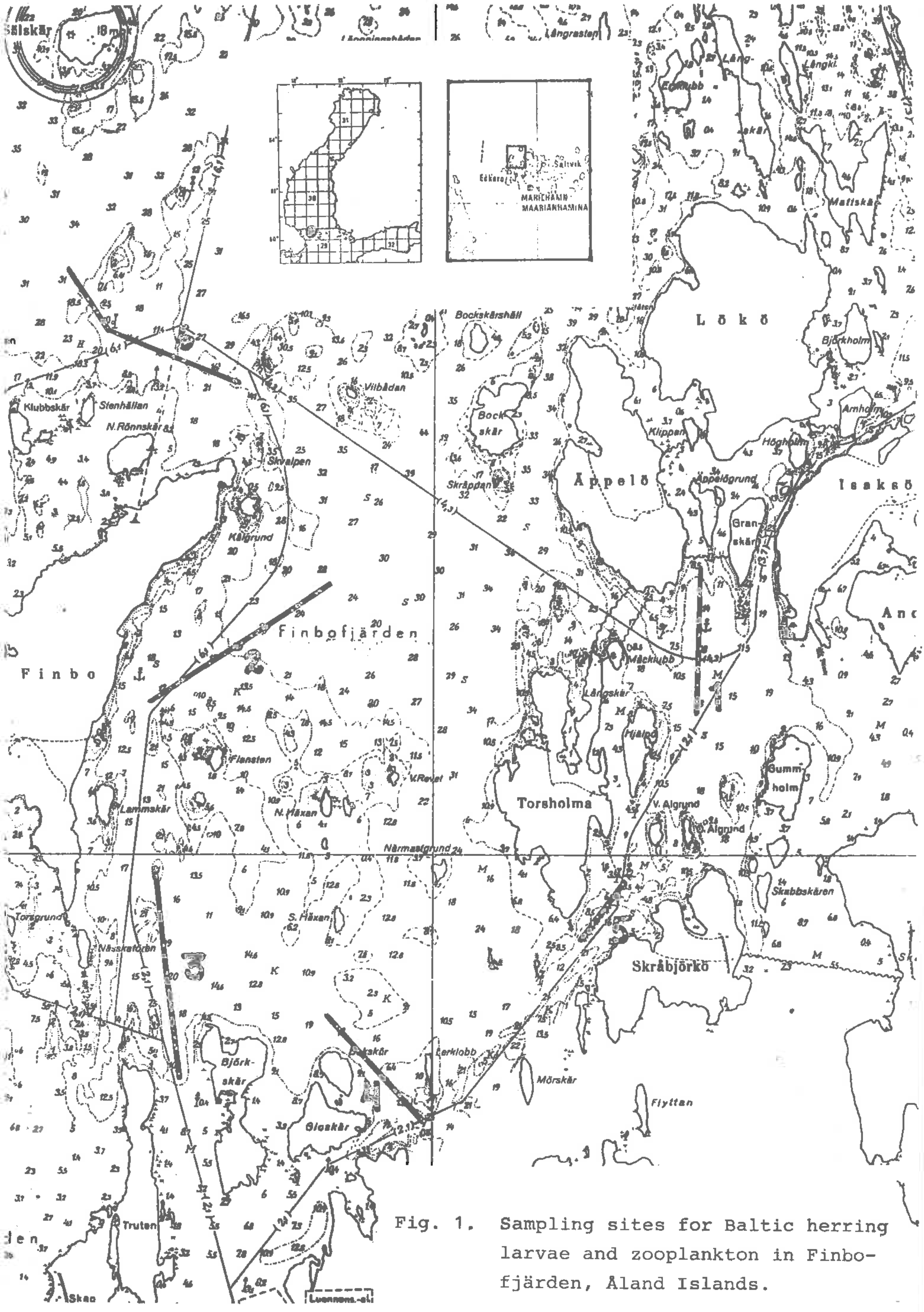

Fig. 1. Sampling sites for Baltic herring larvae and zooplankton in Finbofjärden, Åland Islands.

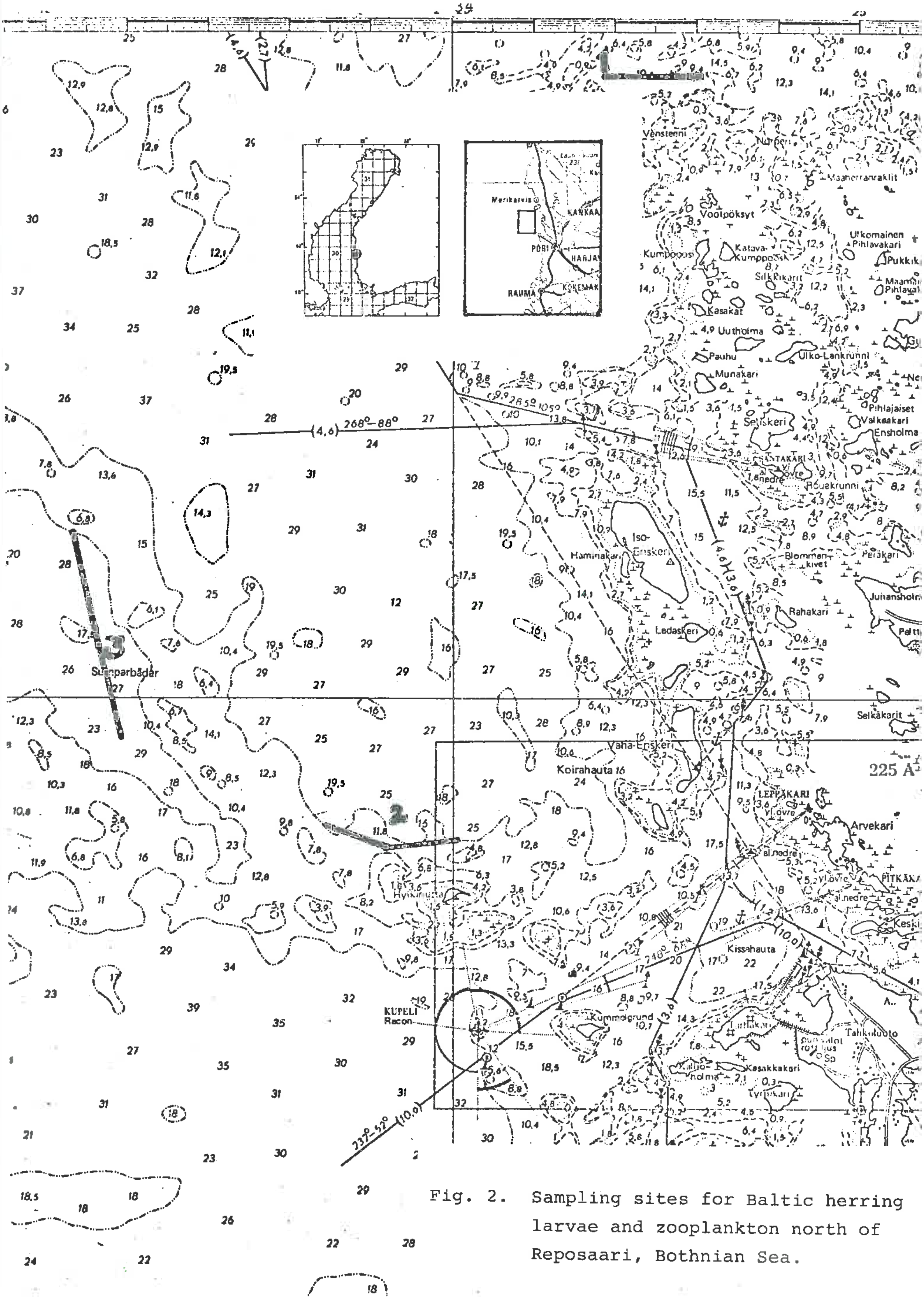

Fig. 2. Sampling sites for Baltic herring larvae and zooplankton north of Reposaari, Bothnian Sea.

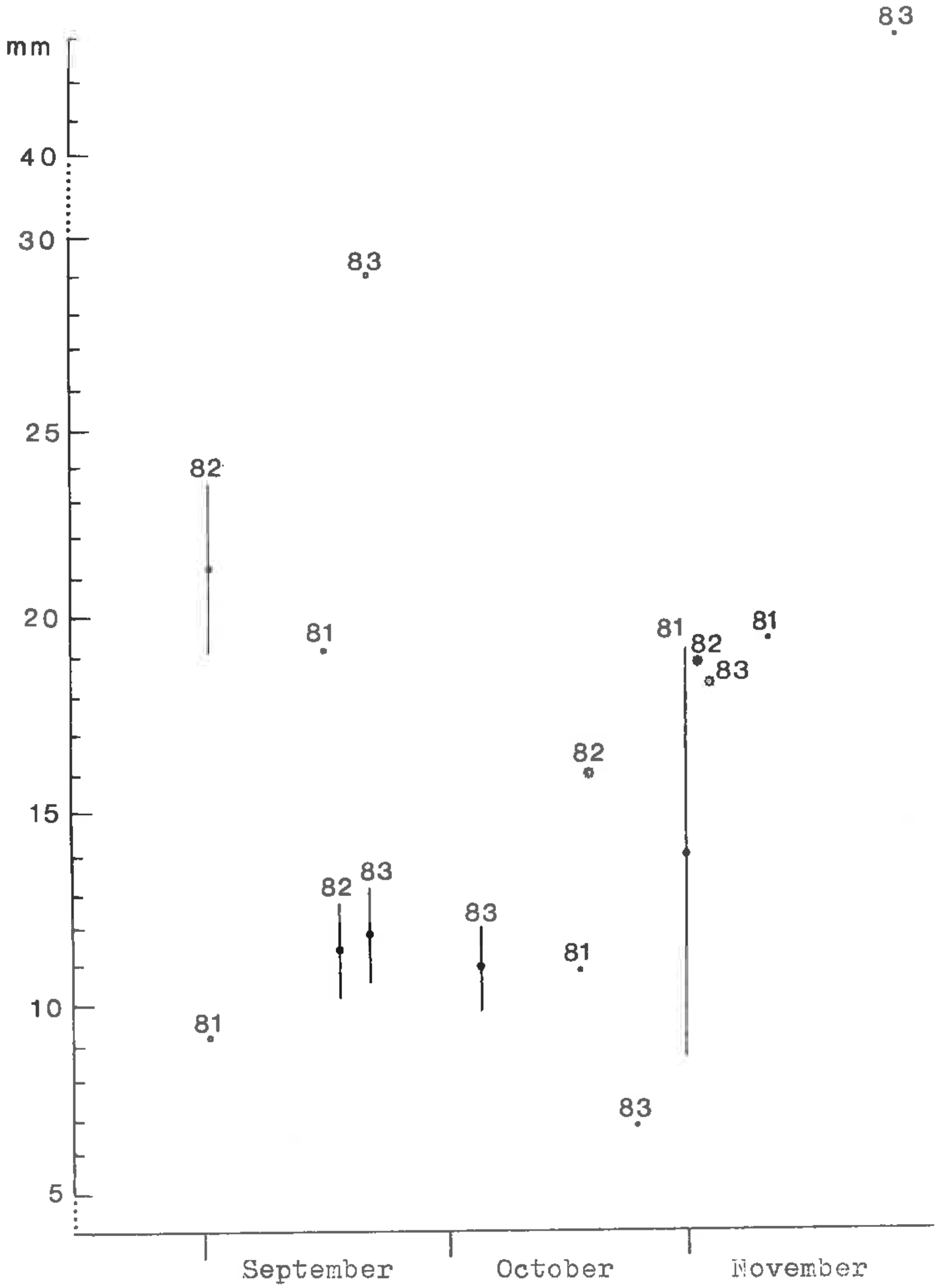

Fig. 3. Mean length and standard deviation of larvae caught off Reposaari and in Finbofjärden in 1981-83. The asterisks represent the larvae taken in Finbofjärden.

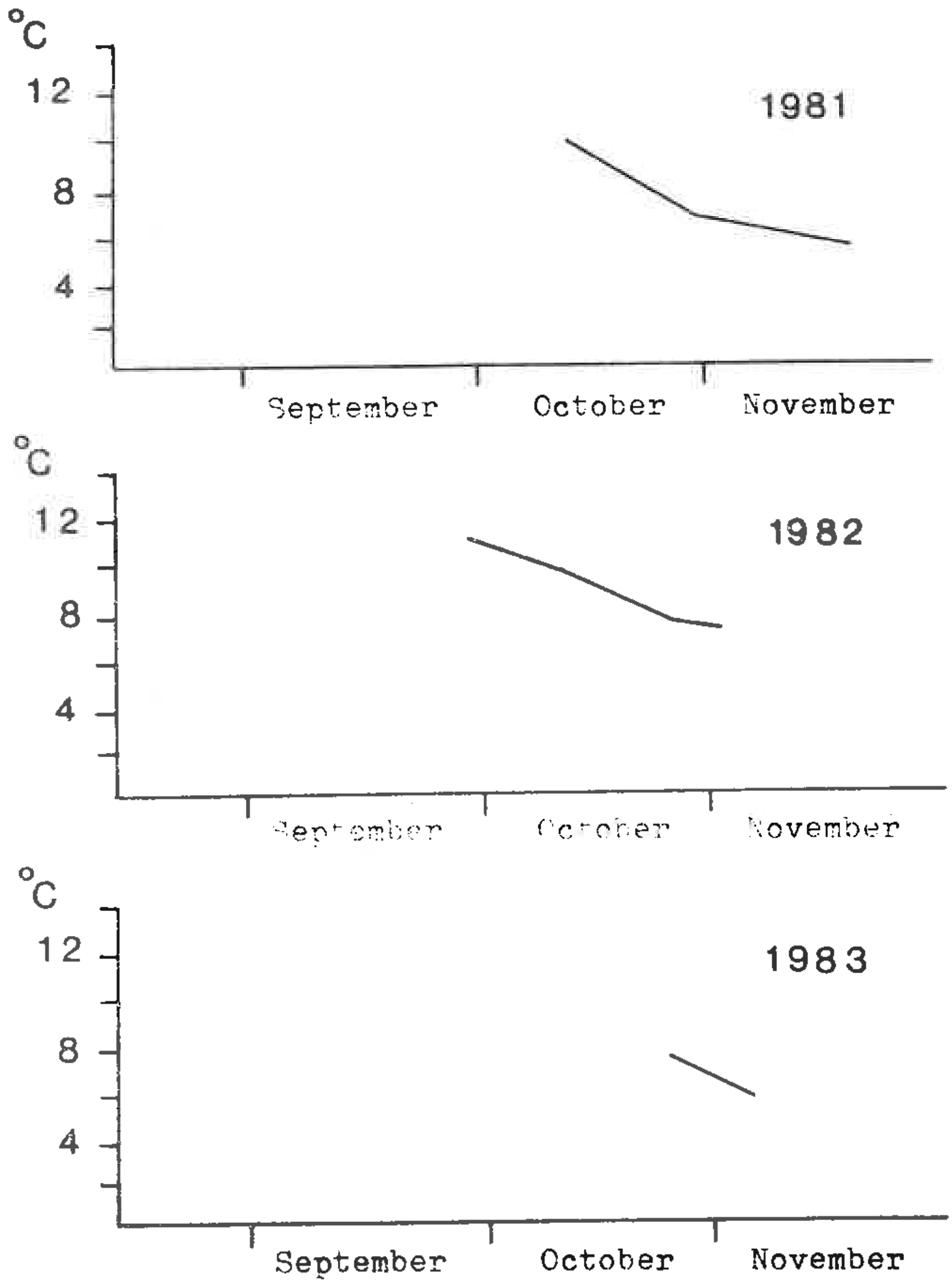

Fig. 4. Water temperature (°C) at a depth of 10 m in Finbofjärden, Åland Islands.

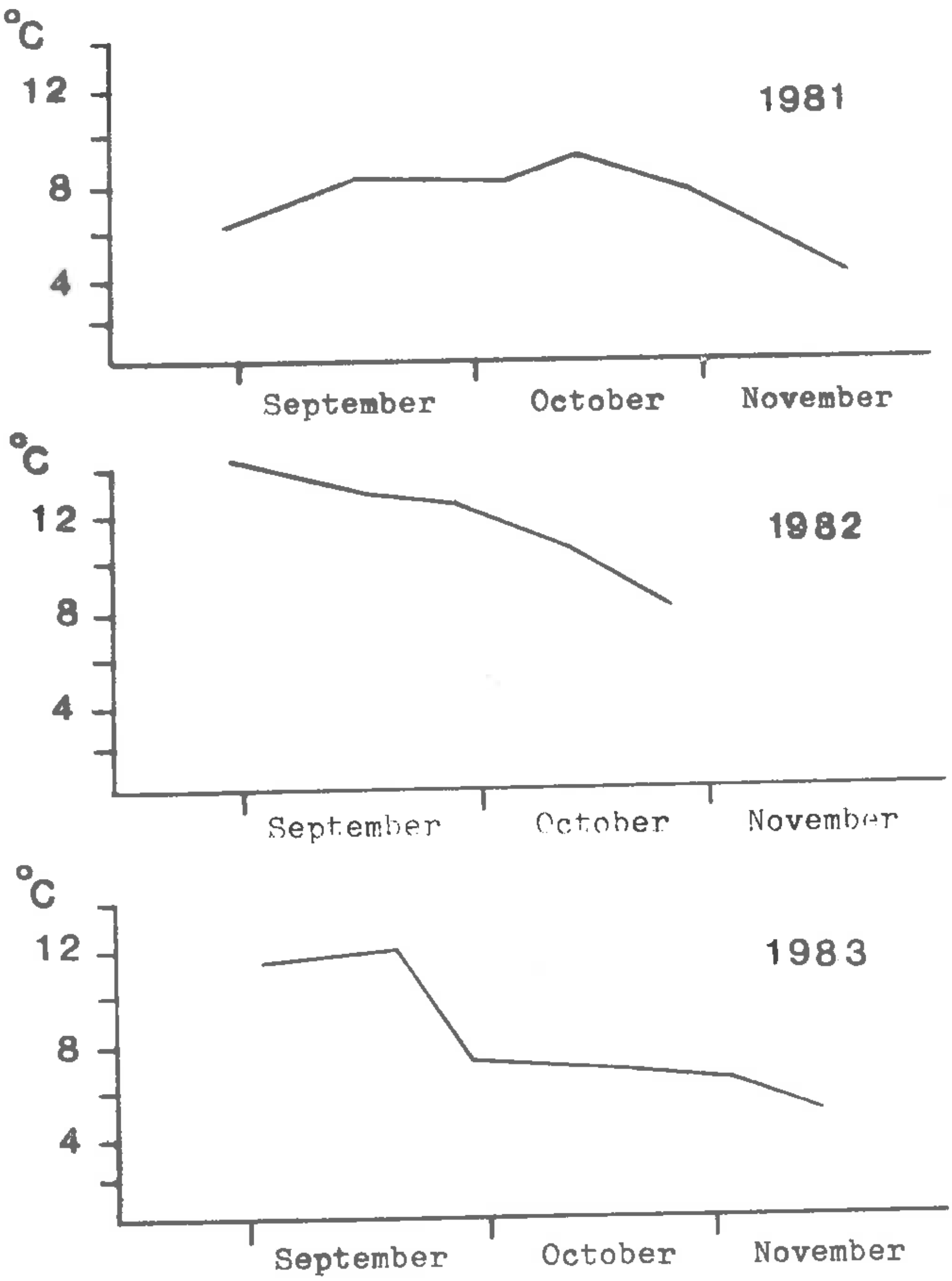

Fig. 5. Water temperature (°C) at a depth of 10 m off Reposaari, Bothnian Sea.

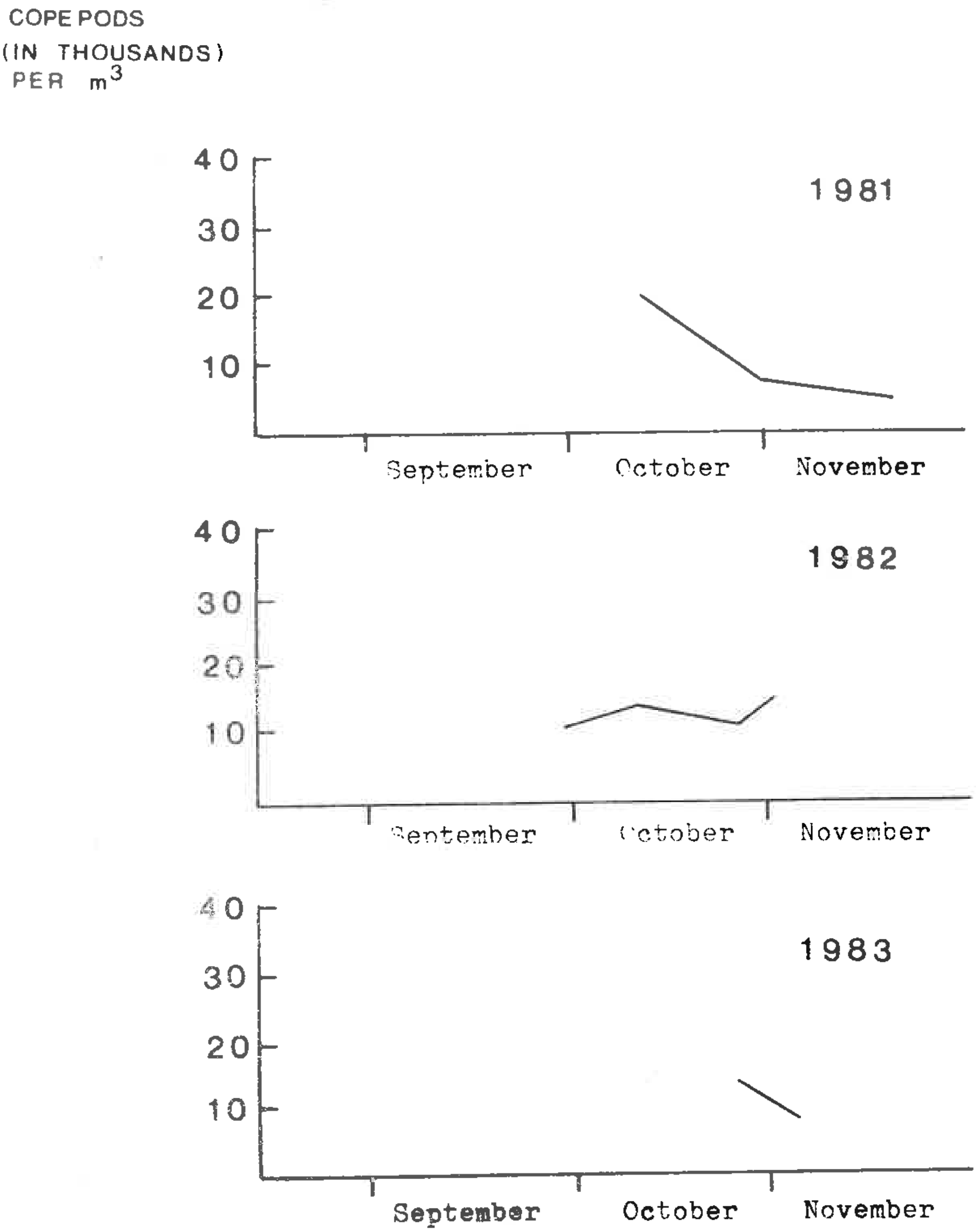

Fig. 6. Abundance of copepods in Finbofjärden, Åland Islands.

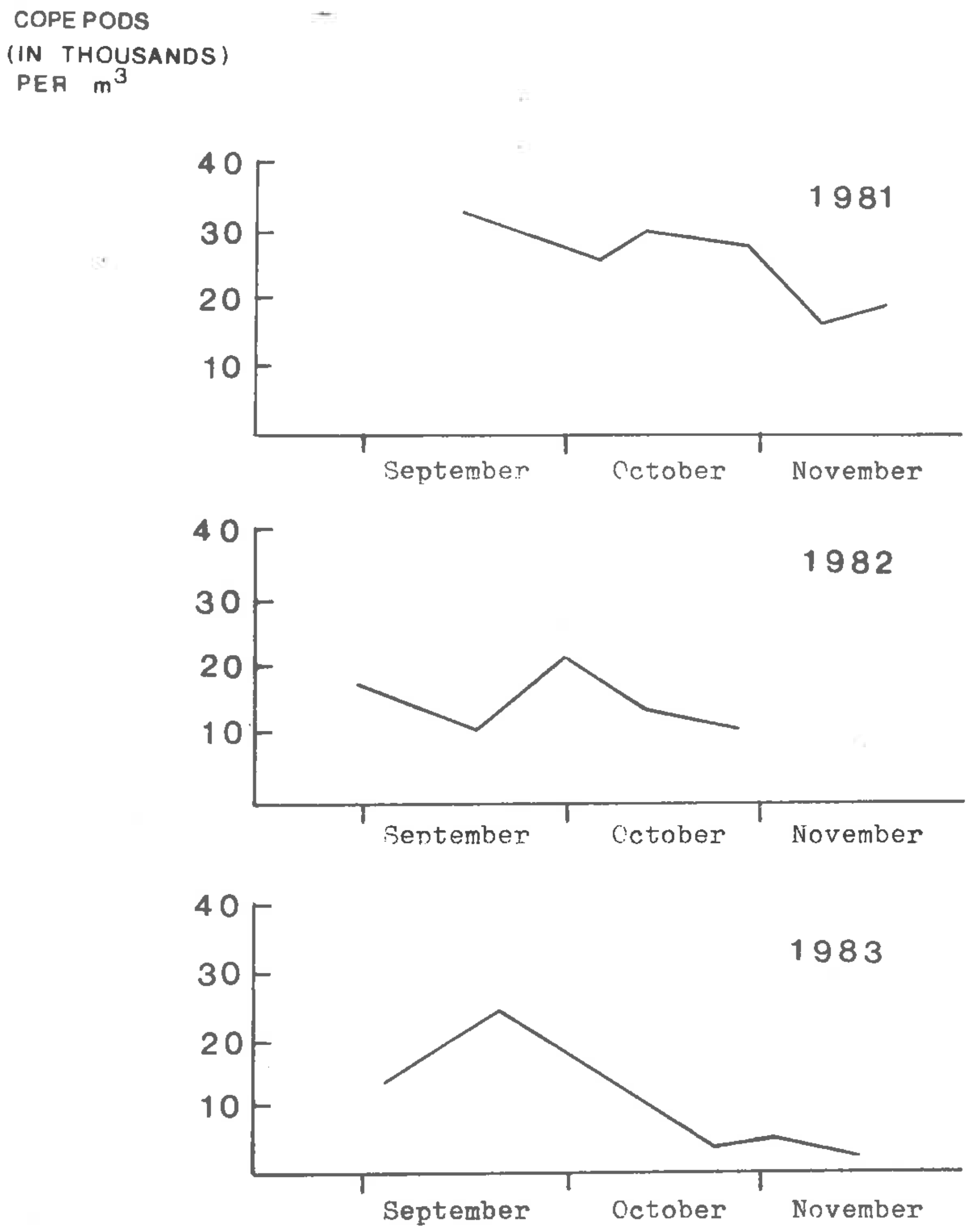

Fig. 7. Abundance of copepods off Reposaari, Bothnian Sea

Table 1. Number of Baltic herring larvae per 10 m^2 in Finbofjärden, Åland Islands (Fig. 1), 1981-83.

1981 Site	Depth (m)	Oct 13	Oct 29	Nov 11
1	10	0	0	0
2	15	0	0	0
3	15	0	0	0
4	10	0	0	0
5	5	0	0	0
6	15	0	0	0
1-6		0	0	0

1982 Site	Depth (m)	Sep 28	Oct 11	Oct 25	Nov 1
1	10	0	0	2	0
2	15	0	0	0	0
3	15	0	0	0	0
4	10	0	0	0	0
5	5	0	0	0	0
6	15	0	0	0	3
1-6		0	0	1	1

1983 Site	Depth (m)	Oct 24	Nov 4
1	10	0	0
2	15	0	0
3	15	0	2
4	10	0	0
5	5	0	0
6	15	0	0
1-6		0	1

Table 2. Number of Baltic herring larvae per 10 m^2 off Reposaari, Bothnian Sea in 1981–1983

1981 Site	Depth (m)	Aug 31	Sep 15	Oct 2	Oct 13	Oct 30	Nov 9	Dec 1
1	6	2	0	0	0	2	0	0
2	8	0	3	0	0	0	0	0
3	15	0	0	0	5	9	2	0
1–3		1	1	0	2	4	1	0

1982 Site	Depth (m)	Sep 1	Sep 17	Sep 30	Oct 13	Oct 25
1	6	8	3	0	0	0
2	8	2	5	0	0	0
3	15	-	5	0	0	0
1–3		5	4	0	0	0

1983 Site	Depth (m)	Sep 6	Sep 22	Oct 3	Oct 23	Nov 8	Nov 22
1	6	0	2	6	0	0	0
2	8	0	4	2	0	0	2
3	15	0	7	2	3	-	0
1–3		0	4	3	1	0	1

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International Council for the Exploration of the Sea

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Anadromous and Catadromous Fish Committee

Migration of salmon in the Baltic Sea, based on Finnish tagging experiments

by

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Abstract

Wild salmon stocks Tornionjoki River and Simojoki River stocks still exist in Finland in the northern part of the Gulf of Bothnia (ICES 31). The Iijoki River stock from the same area has been kept alive in the hatchery, while the Oulujoki River stock is a mixture of Finnish and Swedish stocks. All of these stocks make a feeding migration to the Baltic Sea. The main feeding areas are in sub-divisions 24-29. The spawning migration route follows the Finnish coast of the Gulf of Bothnia. In sub-division 31, part of fish also seem to migrate along the Swedish coast of the upper part of the Gulf.

In sub-divisions 30 and 32, the original Finnish salmon stocks have been destroyed by damming the rivers.

For stocking purposes Iijoki River stock and Neva River stock (imported from the USSR) have been used. Iijoki River stock released in the southern part of the Gulf of Bothnia or in the Gulf of Finland also appears to migrate to the southern part of the Baltic Sea. However, the migration pattern of the Neva River stock differs greatly from that of the Iijoki River stock. In the southern part of the Gulf of Bothnia (ICES 30), 93 % of the Neva River stock tag recoveries were obtained in the same sub-division. In the Gulf of Finland, 86 % of Neva recoveries were obtained from the Gulf. The feeding migration of Neva stock is much shorter than that of more northern stocks.

Résumé

Des souches de saumons naturelles (des rivières Tornionjoki et Simojoki) fréquentent encore les eaux finlandaises de la baie de Botnie (ICES 31). La souche de l'Iijoki apparaissant dans la même zone a été maintenue en vie en vivier et celle de l'Oulujoki est un croisement de souches finlandaises et suédoises. Toutes ces souches effectuent leur migration alimentaire jusque dans la Baltique majeure. Les principales zones alimentaires sont situées dans les sections 24 à 29. Le trajet de la migration de frai suit le littoral finlandais de la mer de Botnie. Une partie des poissons fréquentant la section 31 semble également passer le long de la côte suédoise de la baie de Botnie.

Les souches de saumons finlandais originels des sections 30 et 32 ont disparu à la suite de la construction de barrages sur les rivières.

Des expériences d'étiquetage ont été conduites sur la soche de l'Iijoki et celle de la Neva (importée d'U.R.S.S.) La souche de l'Iijoki implantée dans la mer de Botnie ou dans le golfe de Finlande semble migrer vers les régions sud de la Baltique. Le mode migratoire de la souche de la Neva diffère fortement de celui de la souche de l'Iijoki. Dans la mer de Botnie (ICES 30), 93 % des retours de poissons marqués de la souche de la Neva viennent de la même section. Dans le golfe de Finlande, le taux de retours en provenance du même golfe s'élève à 86 %. La migration alimentaire de cette souche est beaucoup plus courte que celle des souches plus septentrionales.

1. Introduction

Salmon migration has lately received a great deal of attention. Migration routes and marine feeding areas have been of great interest because of salmon fishing in the sea. In the Baltic Sea, salmon migrations, biology, and population dynamics have been studied by Alm (1934), Järvi (1935, 1938, 1948), Carlin (1965, 1969a, 1969b), Lindroth (1965), Thurow (1966, 1968), Toivonen (1973), Christensen and Larsson (1979), Larsson (1980, 1983), and Ikonen (1983).

The aim of this paper is to descripe the migration patterns of salmon released in different river mouths on the Finnish coast of the Baltic Sea. The migration behaviour of salmon originating from separate rivers but imprinted in the same place is also considered. For management purposes, both the feeding and spawning migration of salmon have been studied on the basis of data on tags recovered by different fishing methods.

2. Material and methods

The data considered in this paper consists of salmon tag recoveries in 1969-1984 from tagging experiments made in 1969-1982. Numbers of tagged smolts in different river mouths are presented in the table number 1.

The division of years into categories before 1978 and 1978-82 was chosen because the extended economical zones were established in the Baltic Sea in 1978. The effect of this establishment was a very radical change in fishing possibilities. Before 1978 most of the Baltic Sea was open to fishermen from all countries.

For the description of migration patterns tagging data until 1982 have been used; but in the evaluation of the results (recapture rate, catch/1 000 released smolts) only the years 1978-1980 have been utilized because the more recent tagging experiments are not completed yet.

Wild salmon stocks (Tornionjoki and Simojoki stocks) still exist in Finland in the northern part of the Gulf of Bothnia (ICES 31). The Iijoki River stock from the same area has been kept alive in the hatchery. The Oulujoki River stock is a mixture of Finnish and Swedish stocks. In stocking in the Kemijoki River, hatchery stocks from Iijoki and Tornionjoki have been used. Hatchery reared smolts released in the mouth of the Simojoki River originate from the Oulujoki stock.

In sub-divisions 30 and 32, the original Finnish salmon stocks have been destroyed by the damming of the rivers. In stocking in the Kokemäenjoki River, Swedish stocks originating from sub-division 30 (Dalälven and Ångermanälven) were used in 1975-76, but since 1978 stocks have come from the Iijoki River and the Neva River (sub-division 32).

Finnish Salmon rearing is mainly based on the egg production of hatchery reared brood stocks. The eggs and milt for these brood stocks have been stripped from spawners migrating to the river mouths. The natural smolt production of the Simojoki River is estimated to vary between 10 000-60 000 smolts annually (Toivonen and Jutila 1982). Smolts for tagging have been caught by smolt-trap-nets during smolt migration in late May-early June.

All taggings were done with Carlin tags (Carlin 1965). Smolts were anesthetisized before tagging with Ms-222^{TM}. Until 1980 smolts were tagged a few days before releasing. In the 1980s part of the smolts were tagged 5-8 months before releasing.

The separation of the post-smolt, feeding, and spawning migrations was made as follows for stockings in the Gulf of Bothnia:

- Recoveries made between the time of release and March of the following year were classified as post-smolt
- Tag returns (excluding post-smolt) from sub-divisions 22-30 caught by gill nets, long lines, were classified as feeding migrators
- Tag returns caught with trap nets, and tag-returns in sub-division 31 caught by gill nets and hoop nets were classified as spawning migrators.

3. Results

3.1. Salmon migration

3.1.1. Northern stocks (sub-division 31)

<u>Post-smolt migration</u>

Salmon stocking in the northern river mouths usually takes place between late May-early June. During these months the bulk (75 %) of post-smolt tag recoveries are taken: these tag returns come from the area near the rivermouths (Fig. 1).

In the northern part of the Gulf of Bothnia (sub-division 31), post-smolts mainly follow the Finnish coast up to the Quarc area.

During July-August they move to the Swedish side of the Gulf (sub-division 30). In September-October the majority of recoveries come from the southernmost part of the Gulf, and the first post-smolt have entered the Baltic Main Basin (sub-divisions 27-29). At the end of the year they have reached the Southern Baltic Sea (sub-divisions 25-26).

Feeding migration

The Baltic Main Basin (sub-divisions 24-29) is the main feeding area for northern stocks. Feeding salmon are also caught in the Gulf of Bothnia (sub-division 30).

The most important feeding grounds for these northern stock salmon are around the islands of Gotland (sub-divisions 27-28) and Bornholm (sub-divisions 24-25) (Fig. 2-7). The feeding salmon are almost exclusively caught with drift nets and long lines.

Spawning migration

It is possible to observe the spawning migration of grilse in the Gulf of Bothnia beginning in May when the ice cover disappears from the Gulf, and trap-net fishing begins. Tag recoveries in May have been reported only in sub-division 31 on the Finnish coast (Fig. 8). In June, 23 % of tag recoveries occur in sub-division 30 and the rest in sub-division 31. Grilse seem to follow the Finnish coast of the Gulf of Bothnia. In the Quarc area, June recoveries also occur in the rectangle on the Swedish side of the Gulf. In July, 84 % of grilse tag recoveries occur in sub-division 31, while 46 % of the grilse were caught in the rectangles where they were released as smolts (H4 60, H5 60, H5 59) (Fig. 8). In August-September, 70 % of the tag recoveries occured in the release rectangles.

The first spawners from the older group of salmon reach the Gulf of Bothnia in May, at which time the tags recovered were from fish caught by trap nets in sub-division 30 on the Finnish coast (Fig. 9). In June, 54 % of tag recoveries from older fish occur in sub-division 31; and in July 84 % of such recoveries occur in the rectangles where the fish have been released (H4 60, H5 60, H5 59, H5 58). By August-September most of the fish have reached the area where they were imprinted.

3.1.2. Gulf of Bothnia stocks (sub-division 30)

Post-smolt migration

For the four stocks used in stockings in sub-division 30, the post-smolt recovery areas do not differ from each other: 94 % of all tag recoveries from post-smolt migrating fish occur in sub-division 30 (Fig. 1).

Feeding migration

During feeding migration, about 85 % of the tag recoveries from the Iijoki stock occur in the Main Baltic (Fig. 10). Swedish stocks (Ångermanälven and Dalälven) behave similarly, with 75 % of recoveries coming from the Main Baltic (Fig. 11). The most important feeding grounds for these stocks are around the islands of Gotland (sub-divisions 27-28) and Bornholm (sub-division 24-25).

The Neva River stock, originating from the easternmost part of the Gulf of Finland, behaves quite differently when released in sub-division 30. Only 7 % of tag recoveries are reported in the Main Baltic (Fig. 12). The feeding grounds seem to be near the Finnish coast in sub-division 30.

Spawning migration

During spawning migration, tag returns for all stocks studied are concentrated along the Finnish coast of sub-division 30 (Fig. 10-12).

3.1.3. Gulf of Finland stock (sub-division 32)

Post-smolt migration

During post-smolt migration, all tag recoveries from stockings in the mouth of the Kymijoki River, have occured in the Gulf of Finland (sub-division 32) (Fig. 1).

Feeding migration

The Gulf of Finland is the main feeding area for the Neva stock released in the mouth of the Kymijoki River; of the Neva tag returns, 66 % come from the Gulf. In the Main Baltic, the Neva returns are dispersed quite evenly, with only a few returns coming from sub-division 30 (Fig. 13).

Spawning migration

Because the feeding ground of the Neva stock lies near the releasing site, spawning migration along the coast is difficult to observe. Neva tag returns are concentrated in the rectangle of the Kymijoki River mouth where the stock was released (H7 49) (Fig. 13).

3.2. Distribution of tag recoveries according to different fishing methods

Salmon post-smolts are caught as a by-catch in Baltic herring trap net fishery, trawl fishery, and small mesh-sized (27-40 mm) gill nets. Salmon long line fishery in the Gulf of Finland also takes post-smolts. The percentage of post-smolt returns of all returns depends on the area (Table 2.), and there is great annual variation.

Off-shore fishery for salmon (drift nets, long lines) takes 83 % of the A.1+ and older salmon caught. The rest are caught in trap nets and set nets on the coasts during the spawning migration (Table 2.). Only a few recoveries have been obtained from rivers.

The percentage of grilse among spawners was about 35 % in stockings in 1969-77. In later years (1978-82), the percentage estimate is unverified because the latest tagging experiments are not completed yet (Table 2.).

3.3. Distribution of tag between feeding and spawning migrations

In the tagging experiments made before 1978, about 70 % of A.1+ and older salmon tag recoveries came from the Main Baltic during the feeding migration. In the later taggings, the corresponding figure was less than 60 % (Table 3.). This slight decrease is mainly caused by the increasing number of spawners caught in the Gulf of Bothnia, which might reflect a change in the fishing effort in the Main Baltic Sea.

Tagging experiments made in sub-division 30 reveal that Swedish stocks and the Iijoki stock give a high percentage of tag recoveries in the Main Baltic; but the Neva stock does not seem to migrate to the Main Baltic, as only 5 % of Neva returns come from sub-divisions 22-29. This salmon stock is mainly caught by off-shore fishery in sub-division 30 (Table 3.).

The Neva stock in the Gulf of Finland (sub-division 32) has yielded only 14 % of tag returns in the Main Baltic. The majority of tag returns come from spawning migrators (Table 3.).

3.4. Catch and growth rate of different stocks, based on release data

The comparison of the northern released stocks with stocks released in the sub-divisions 30 and 32 shows that legal size (60 cm) is achieved during the early autumn at age A.1+ (Fig. 14). The Neva stock salmon released in either sub-division 30 or 32, where they more-or-less remain during the feeding migration, have a growth rate as good as those stocks which migrate to the Main Baltic.

The recapture rate of the northern stocks was c. 10 %, before 1978 (Table 4.). In 1978-1980 this figure decreased to the level of 6.5 %. Similarly the catch/1 000 released smolts of the northern stocks decreased. No comparable observations are available from sub-divisions 30 and 32 before 1978.

In 1978-1980 tagging experiments showed that northern stock (Iijoki stock) released in sub-division 30 gave similar results as those of other northern stocks released in sub-division 31. Neva River stock released in sub-divsions 30 and 32 gave slightly better results compared to the northern stocks with the exception of Simojoki River wild stock. In spite of their smaller feeding area, the Gulf of Finland and the southern part of the Gulf of Bothnia seem to provide satisfactory feeding grounds for Neva salmon stock released in these areas.

4. Discussion

In the Baltic Sea, currents caused by the Coriolis effect follow the eastern coast of the Main Basin of the north. In the Gulf of Finland, currents follow the southern coast to the east and the northern coast to the west. In the Gulf of Bothnia, the currents follow the Finnish coast to the north and the Swedish coast to the south. Christensen and Larsson (1979) have stated that post-smolt migration seems to follow the main current in the Gulf of Bothnia.

According to Finnish tagging data, part of the post-smolt salmon seem to follow the current in sub-division 31, but the greater number appear to migrate against the current to the Quarc area.

Smolts released in the northernmost part of the Gulf (mouth of the Tornionjoki River) and southernmost releasing area (mouth of the Oulujoki River) seem to migrate primarily along the Finnish coast. Tornionjoki River post-smolt recoveries have mostly been obtained from the Swedish coast. On the basis of these observations, it would appear that post-smolt migration does not strictly follow the current in the northern part of the Gulf of Bothnia. It is possible that post-smolt migration to the south takes place quite evenly throughout the Gulf, but because there is no fishing in the centre of the Gulf, recoveries have not been obtained from that area. However, sea trout tagging experiments in the mouth of the Oulujoki River have revealed that the majority of sea trout have migrated with the current to the north and then along the Swedish coast to the south (Toivonen & Tuhkunen 1975, Toivonen & Ikonen 1979).

In the Quarc area, post-smolts seem to move to the Swedish coast and then follow the current to the south. Along the Finnish coast there are very few recoveries in sub-division 30. ALM (1934) has proposed that Swedish northern stocks migrate along the Swedish coast to the south, and the majority of Finnish northern stock follow the Finnish coast to the Archipelage Sea and then over the mouth of the Gulf of Finland to the eastern coast of the Main Baltic. According to new data on Finnish stocks, this has not been observed.

At the end of the year post-smolts have reached the Main Baltic and the beginning of the following year post-smolts have reached the southern Baltic Sea. ALM (1934) reported that Tornionjoki River post-smolts were caught in the southern Baltic Sea.

Post-smolts are practically always caught as a by-catch while fishing for other species than salmon. During this phase post-smolts are also undersized (<60 cm). For these reason, the distribution of tag recoveries is highly dependent on fisheries in the different parts of the Baltic Sea. In the Gulf of Finland, as well as in sub-division 30, some post-smolts are caught with long lines.

The feeding grounds for northern salmon stocks are in the Main Baltic Sea. Areas around the islands of Gotland and Bornholm seem to be the most important feeding grounds for Finnish northern salmon stocks.

Tag recovery aggregations in the same areas can also be seen in the maps presented by Carlin (1959) and Halme (1961 and 1964) concerning Swedish and Finnish salmon migrations. Alm (1934) thought that the large catches taken in the early part of the year from around Gotland Island indicate a spawning migration from the southern Baltic to the north rather than salmon feeding in this area. According to the Swedish data (Carlin 1959) and present Finnish data, this has not been observed to be the case.

Spawning migration is first observed in the Gulf of Bothnia in May in trap net fishery. Along the western coast of Åland Island trap net fishery for salmon was begun a few years ago. On the basis of catch samples collected from this fishery in 1983, the first spawning migrators were obtained in the second half of May (Ikonen, unpubl. data 1984). The salmon caught during May were almost all of wild origin; during the first half of June 70 % of the salmon were classified as being of wild origin on the basis of the scale structure (Antere & Ikonen 1983). This same phenomen on that salmon of wild origin first enter the trap nets has also been observed in the Quarc area (sub-division 30) and in the Gulf of Finland (ibid.). The reason for this is unknown. However, in artificial salmon smolt production, spawners which have been caught late in the autumn just before spawning have earlier been used for breeding purposes. The reason for catching spawners as late as possible has been to avoid storing spawners during the summer when mortality is high due to the physiological state of the fish. Heavy coastal fishery and river mouth fishery in summer have resulted in only a few early migrating spawners being left in the river mouths near the spawning time.

The spawning migration route seems to follow the Finnish coast of the Gulf of Bothnia, but in the Quarc area and northwards, recoveries have also been obtained from the Swedish side of the Gulf. According to tag recoveries, those fish which follow the Finnish coast seem to swim beside the river mouth to its north shore and then turn back to the south to migrate up-river. The reason for this might be the current which carries the water of the home river to the north. Spawners usually find this water after they have passed the river mouth. This means that in the northernmost part of the Gulf of Bothnia there is a mixed population of spawners originating from different rivers trying to find the smell or taste of their home river in order to locate it. As a result, it is impossible to extend trap net fishery for certain stocks e.g. hatchery reared stocks, to save wild stock for fishery. Coastal fishery aimed at a certain stock seems to be possible only in the vicinity of the river mouth from which this stock originates.

Post-smolt migration routes of salmon released in sub-division 30 have been impossible to find. Most of recoveries have been obtained in this sub-division.

In a comparison of two Swedish salmon stocks (Dalälven, Ångermanälven) originating from sub-division 30, Finnish northern stock (Iijoki stock), and Russian stock (Neva stock) originating from the Neva River in the Gulf of Finland, the Swedish stocks and the Iijoki stock migrate to the Main Baltic Sea. Neva stock differs greatly from these two stocks. During feeding migration, only 7 % have been caught in the Main Baltic compared to the 86 % of Iijoki stock caught in the same area.

Neva stock tag recoveries from the tagging experiment carried out in the Gulf of Finland also reveal a short feeding migration. Post-smolts have been caught in the Gulf, mainly in the eastern part in the eastern corner of the Finnish fishing zone. The majority of feeding fish have also been caught in the same area.

Northern stocks released in the Gulf of Finland have been shown on the basis of tagging experiments with Oulujoki River stock (Toivonen 1973), Iijoki River stock (Ikonen & Auvinen unpubl. 1984) to migrate to the Main Baltic during feeding migration. Järvi (1935) observed that hooks used off Bornholm and in the southern Baltic Sea were fairly often found in salmon caught in sub-division 31, but they were rare in fish caught in the Gulf of Finland in Kymi River salmon fishery. Other migratory species behave similarly. The feeding migration of river spawning migratory whitefish (Coregonus lavaretus s. (L.) str. is short in the Gulf of Finland. The main feeding ground of the Kymi River whitefish is in the same area as that of Neva salmon released in the Kymi River. The migratory whitefish stock in the northern part of the Gulf of Bothnia migrate to the southern part of the Gulf (Ikonen 1982).

According to these observations, the Gulf of Finland migratory fish stocks seem to be of a short migrating type, and Gulf of Bothnia stocks long migrating. Food availability in the Gulf of Finland seems to be better than in sub-division 30, because the growth rate of Neva stock released in sub-divisions 30 and 32 is better in the Gulf of Finland. The recapture rate of Neva salmon is higher in sub-division 30, but the catches (kg/1 000 released smolts) do not differ in these areas. If this comparison is made between northern stocks and Neva stock, the growth rate of Neva stock is not worse in spite of the fact that its feeding areas are in the less productive areas in the Gulf of Bothnia and the Gulf of Finland compared to the southern

Baltic Sea. In the comparison between these stocks, the catch/1 000 released smolts of Neva stock was best in 1978-1980, excluding Simojoki River wild stock which has given a slightly better result.

On the basis of these tagging experiments, the extent of feeding migration appears to be genetically determined. Alm (1934) has proposed that the Main Baltic Salmon stocks and Gulf of Finland stocks do not migrate over such a wide area as do northern Swedish and Finnish stocks. According to Alm's thesis, the reason for this difference might be the gradient in salinity and water temperature between the river mouth and the nearby sea. In the Gulf of Finland and in the Baltic main basin salinity is between 5-8 %, compared to the Gulf of Bothnia where salinity is 3-3.5 %.

At present Baltic salmon fishery is concentrated in the Baltic Main Basin area. Off-shore fishery in sub-division 30 took about 12 % of feeding salmon originating from Finnish northern stocks, according to the tagging experiments carried out in 1978-1982. The increased number of Neva salmon released in sub-division 30 will increase catches in off-shore fishery. Increased catch per unit of effort will encourage fishermen to increase their fishing efforts in this sub-division. This might be harmful to northern wild stocks which migrate through this area. However, during post-smolt migration, salmon is practically not caught at all in this sub-division. In November-January, post-smolts are taken in the southern part of this sub-division, where they are caught by long lines; but according to tag recoveries the numbers taken are small. Perhaps part of the northern stock salmon remain longer in this sub-division and are then caught at legal size.

Trap net fishery on the coastal area of sub-division 30 is taking spawning migrators as well as spawners originating from wild stocks. At present the best way to utilize Neva stock salmon in sub-division 30 is to catch fish in the rivermouth area or in offshore fishery using drift nets. Long lines take post-smolts or undersized salmon, which is not desirable.

REFERENCES

Alm, G. 1934: Salmon in the Baltic precints. - Rapports et Procés-Verbaux des Réunions, Conseil International pour l'Exploration de la Mer, 92:17-18.

Antere, I. & Ikonen, E. 1983: A method of distinguishing wild salmon from those originating from fish farms on the basis of scale structure. - ICES C.M. 1983/M:26 (mimeo).

Carlin, B. 1959: Results of salmon smolt tagging in the Baltic area. - Rapp. P.-v. Réun Cons. int. Explor. Mer 147, 89-96.

Carlin, B. 1965: Redogörelse för laxmärkningar. In: Årsberättelse för år 1964. Laxforskningsinst. Medd., 1.

Carlin, B. 1969a: The Migration of Salmon. Swedish Salmon Research Institute. - Report, Laxforskningsinst. Medd., 2.

Carlin, B. 1969b: Salmon tagging experiments. - In: Årsberättelse för år 1968. - Laxforskningsinst. Medd., 3.

Christensen, O. and Larsson, P.-O. (ed.) 1979: Review of Baltic Salmon Research. A synopsis compiled by the Baltic Salmon Working Group. - ICES Coop. Res. Rep. 89. 124 pp.

Halme, E. 1961: Report on salmon tagged in Finland. - ICES, Doc. C.M. 1961/No. 17 (mimeo).

Halme, E. 1964: Report on salmon tagged in Finland 1959-1964:-ICES, Doc. C.M. 1964/No. 61 (mimeo).

Ikonen, E. 1982: Migration of river-spawning whitefish in the Gulf of Finland. - Finnish Fisheries Research 4: 40-45.

Ikonen, E. 1983: The salmon in its sea phase. - Salmo salar symposium, Luleå 1983 (in print).

Järvi, T.H. 1935: Om laxens färdvägar i Östersjön. - Finl. Jakt- och Fiskeritidskr. 30, 53-63.

Järvi, T.H. 1938: Fluctuations in the Baltic stock of salmon. - Repp. P.-v. Réun. Cons. int. Explor. Mer, 106: 1-114.

Järvi, T.H. 1948: On the periodicity of salmon reproduction in the northern Baltic area and its causes. - Rapp. P.-v. Réun. Cons. int. Explor. Mer, 119: 1-131.

Larsson, P.-O. 1980: Smolt Rearing and the Baltic Salmon Fishery. - In: Salmon Ranching, (ed. J. Thorpe), pp. 157-186. London 1980.

Larsson, P.-O. 1983: Some characteristics of the Baltic Salmon (Salmo salar L.), population. - Thesis, Zoologiska Institutionen, Stockholm. 80 pp.

Lindroth, A. 1965: The Baltic Salmon Stock. - Mitt. int. Verein. theor. angew. Limnol. 13, 163-192.

Thurow, F. 1966: Beiträge zur Biologie und Bestandkunde die Atlantischen Lachses (Salmo salar L.) in der Ostsee. - Ber. dt. wiss. Komm.Meeresforsch. XVIII (3/4), 223-379.

Thurow, F. 1968: On food, behaviour and population mechanism of Baltic salmon. Laxforskningsinst. Medd. 4.

Toivonen, J. 1973: The stock of salmon in the Gulf of Finland. - ICES, Doc. C.M. 1973/M:17 (mimeo).

Toivonen, J. and Ikonen, E. 1979: Meritaimen Suomessa. - Suomen kalastuslehti 1/1980:4-10.

Toivonen, J. and Jutila, E. 1982: Report on parr population densities, tagging experiments, and river catches of the salmon stock of the Simojoki River in 1972-1980. - ICES C.M. 1982/M:40 (mimeo).

Toivonen, J. and Tuhkunen, A. 1975: Migration of sea trout along the coastal waters of Finland on the basis of tagging experiments. - ICES C.M. 1975/M:3 (mimeo).

Table 1. Numbers of tagged smolts in different river mouths

Sub-div.	River	Years	No. of tagged fish	No. of tags recaptured	Recapture rate (%)
31	Tornionjoki (hatchery reared)	-1977	19970	368	1.84
	"	1978-1982	1977	41	2.07
	Kemijoki	-1977	9293	318	3.42
	"	1978-1982	18062	710	3.93
	Simojoki (wild)	-1977	5872	564	9.60
	" "	1978-1982	3900	362	9.31
	Simojoki (hatchery reared)	-1977	8082	929	11.49
	"	1978-1982	4932	273	5.53
	Iijoki	-1977	6491	831	12.80
	"	1978-1982	19588	800	4.08
	Oulujoki	-1977	41470	4552	10.98
	"	1978-1982	23528	955	4.06
30	Kokemäenjoki (Dalälven , Ångermanälven stocks)	-1977	5820	716	12.30
	(Iijoki stock)	1978-1982	9337	288	3.08
	(Neva stock)	1978-1982	7288	271	3.72
32	Kymijoki (Neva stock)	1978-1982	19153	1751	9.14

Table 2. Distribution of tag returns according to different migration phases.

Place of release			Tag returns		A.1+ and older			Spawning migrators		
Sub-div.	River and stock	Years	Total number	Post-smolt %	Number	Feeding fish %	Spawning migrators %	Number	Grilse %	Multisea-winter fish %
31	Tornionjoki	-1977	150	27.3	109	91.4	8.6	13	30.8	69.2
	"	1978-1982	30	30.0	21	100.0	-	14	100.0	-
31	Kemijoki	-1977	167	9.0	152	76.2	23.8	40	12.5	87.5
		1978-1982	366	10.4	328	66.7	33.3	160	47.5	52.5
31	Simojoki wild stock									
		-1977	345	13.9	297	87.4	12.6	48	25.0	75.0
		1978-1982	177	11.9	156	83.4	16.6	30	16.7	83.3
31	Simojoki hatchery stock									
		-1977	600	6.5	561	81.9	18.1	166	47.6	52.4
		1978-1982	144	13.9	124	81.6	18.4	31	32.2	67.8
31	Iijoki	-1977	472	3.8	454	94.0	6.0	77	68.8	31.2
		1978-1982	444	36.3	283	70.3	29.7	129	49.6	50.4
31	Oulujoki	-1977	2701	20.3	2153	83.7	16.9	633	53.4	46.6
		1978-1982	464	17.0	385	82.4	17.6	90	30.0	70.0
30	Kokemäenjoki									
	Swedish stocks	-1977	384	6.2	360	95.0	5.0	21	14.3	85.7
	Iijoki stock	1978-1982	129	20.9	102	77.0	23.0	25	8.0	92.0
	Neva stock	1978-1982	157	28.7	112	79.2	20.8	28	21.4	78.6
32	Kymijoki (Neva stock)	1978-1982	733	13.9	631	45.2	54.8	346	66.5	33.5

Table 3. Distribution of tag recoveries between feeding and spawning migration in separate sub-divisions in percent. Post-smolts excluded.

Place of release			Feeding migration			Spawning migration			Number of fish
Sub-div.	River and stock	Years	Sub-divisions 22-29	30-31	32	Sub-divisions 22-29	30-31	32	
31	Tornionjoki	-1977	84.4	3.7			11.9		109
	"	1978-1982	9.5	23.8			66.7		21
31	Kemijoki	-1977	63.8	9.9			26.3		152
		1978-1982	40.8	9.8	0.6		48.2	0.6	328
31	Simojoki wild stock								
		-1977	75.4	8.1			16.2	0.3	297
		1978-1982	79.5	1.3		0.6	18.6		156
31	Simojoki hatchery stock								
		-1977	65.1	5.3		0.2	29.2	0.2	561
		1978-1982	56.4	18.5			25.0		124
31	Iijoki	-1977	78.0	5.1			17.0		454
		1978-1982	39.2	14.5	0.7	0.3	45.2		283
31	Oulujoki	-1977	60.4	10.1	0.1		29.4		2153
		1978-1982	68.1	8.6		0.3	23.1		385
30	Kokemäenjoki								
	Swedish stocks	-1977	71.1	23.0			5.8		360
	Iijoki stock	1978-1982	63.7	7.8	3.9	2.0	22.5		102
	Neva stock	1978-1982	5.4	69.6			25.0		112
32	Kymijoki (Neva stock)								
		1978-1982	13.9	0.9	30.3		0.6	54.2	631

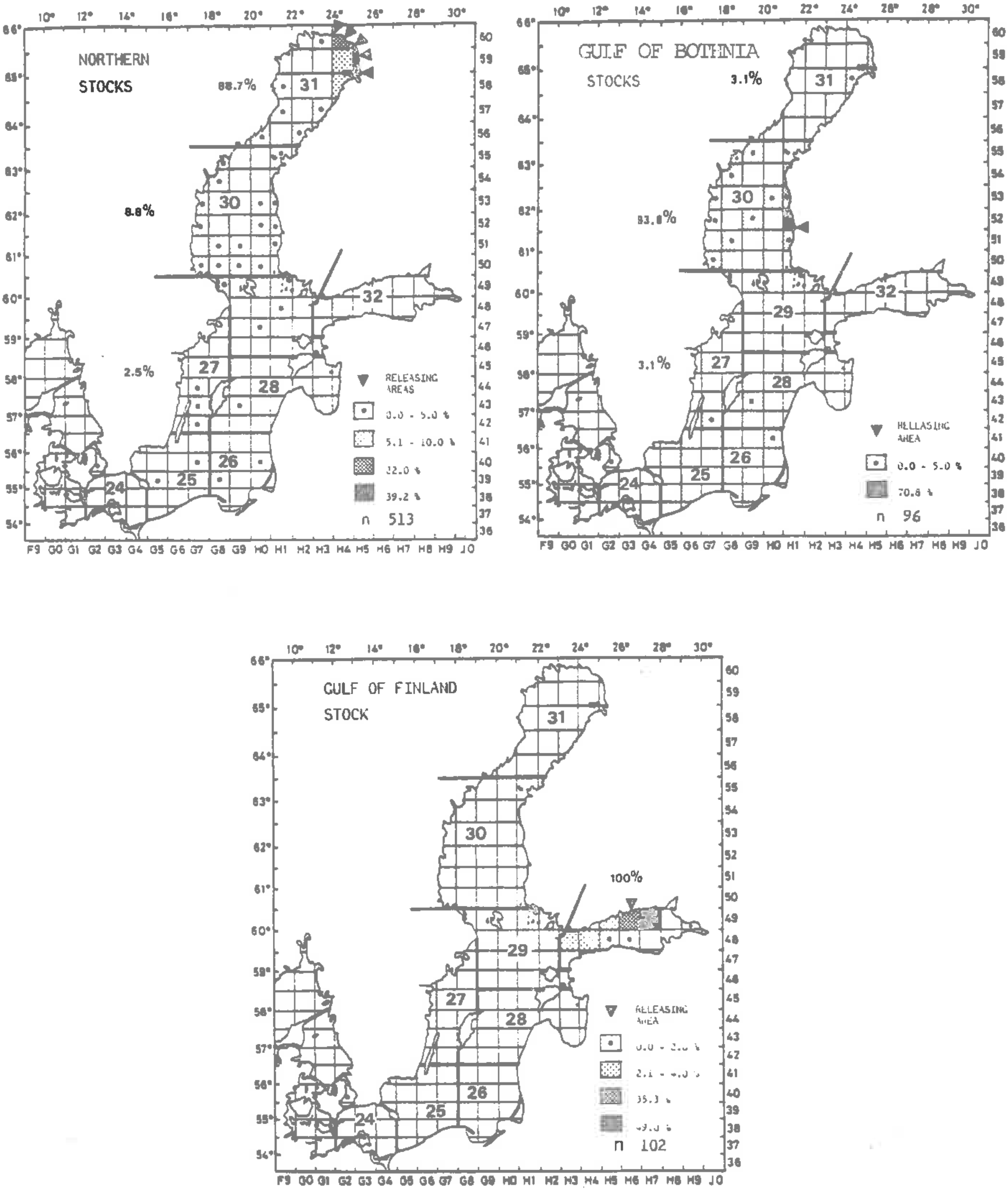

Figure 1. Distribution of post-smolt tag recoveries in percentages by sub-divisions (24-32 heavy black lines) and rectangles (lighter lines)

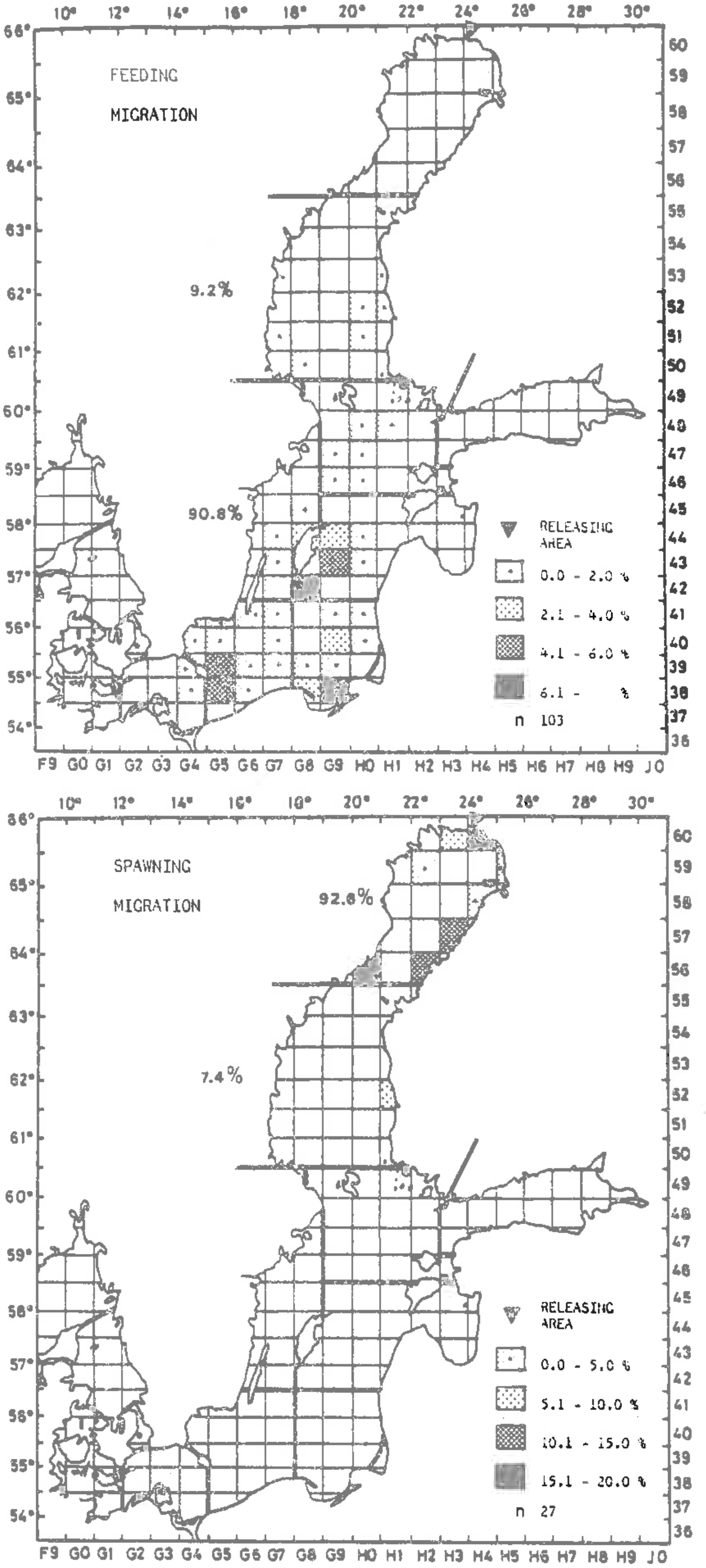

Figure 2. Distribution of tag recoveries of salmon released in the Tornionjoki River by sub-divisions and rectangles during feeding migration and spawning migration

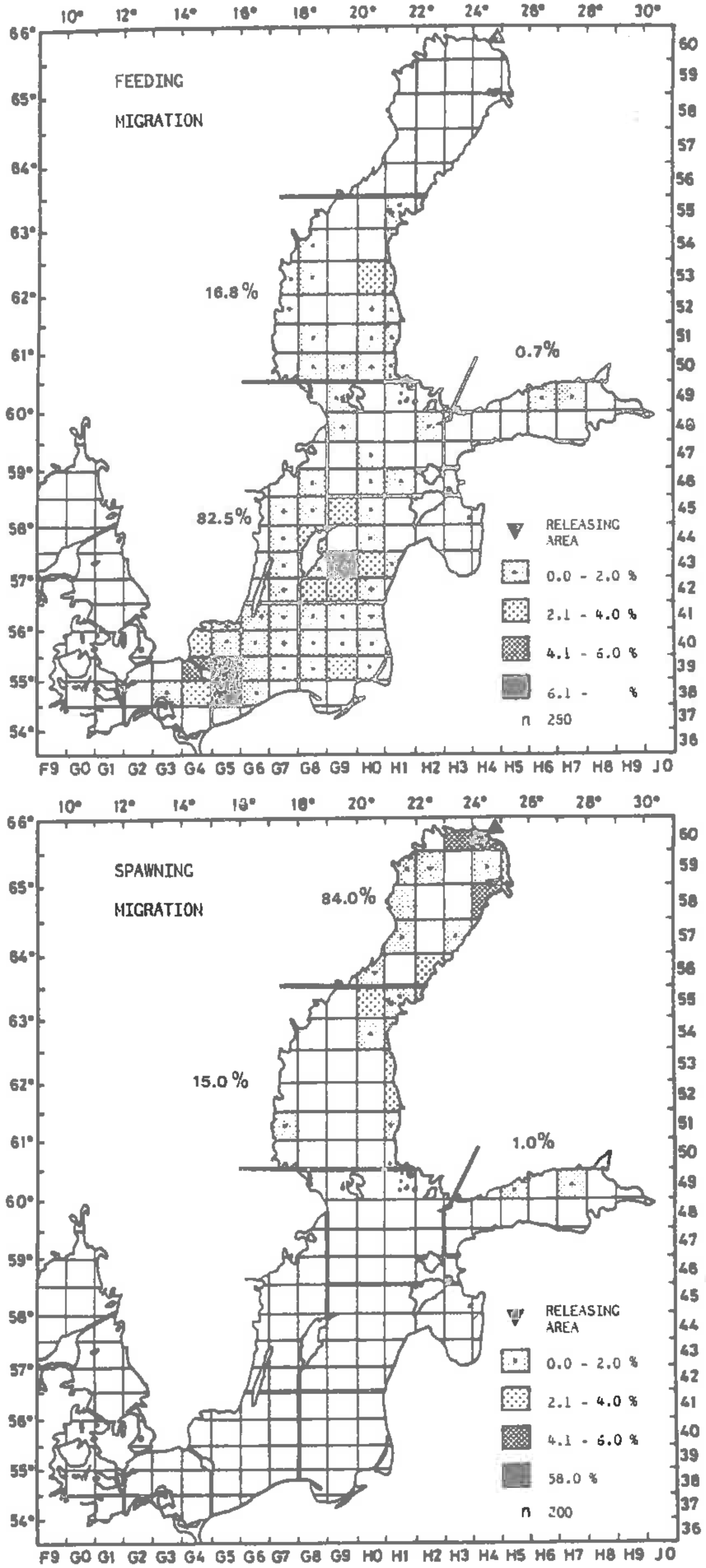

Figure 3. Distribution of tag recoveries of salmon released in the Kemijoki River mouth in percentages by sub-divisions and rectangles during feeding and spawning migrations

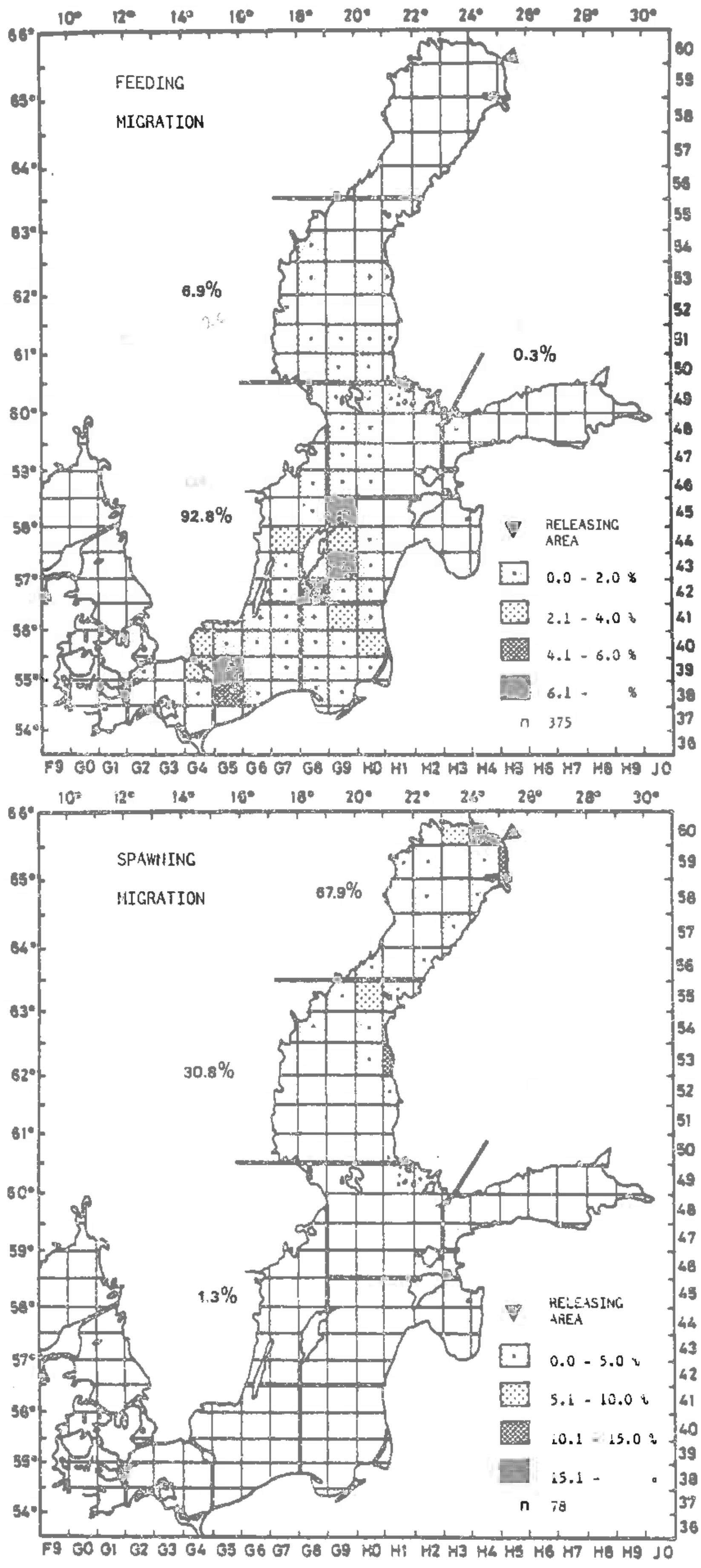

Figure 4. Distribution of tag recoveries of salmon (wild stock) released in the Simojoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

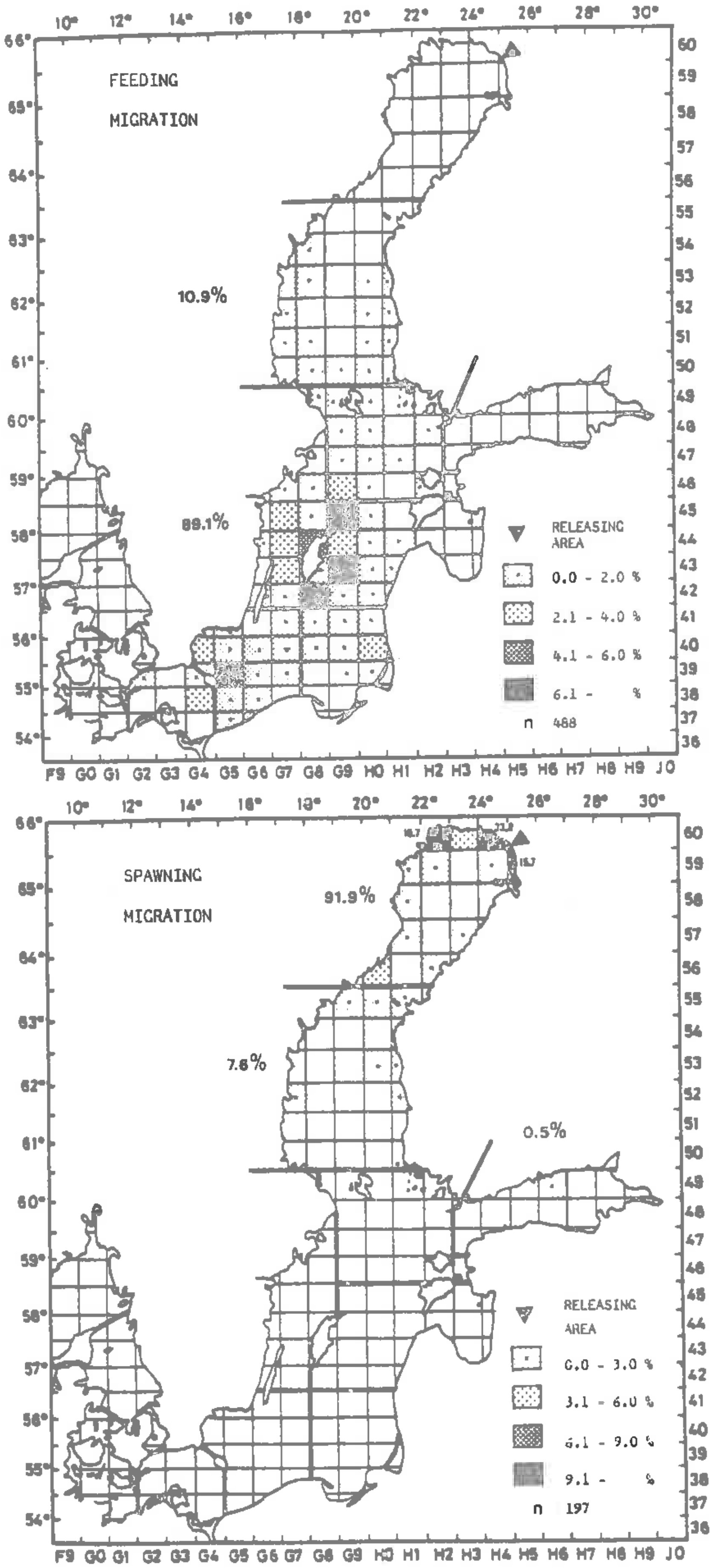

Figure 5. Distribution of tag recoveries of salmon (hatchery stock) released in the mouth of the Simojoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

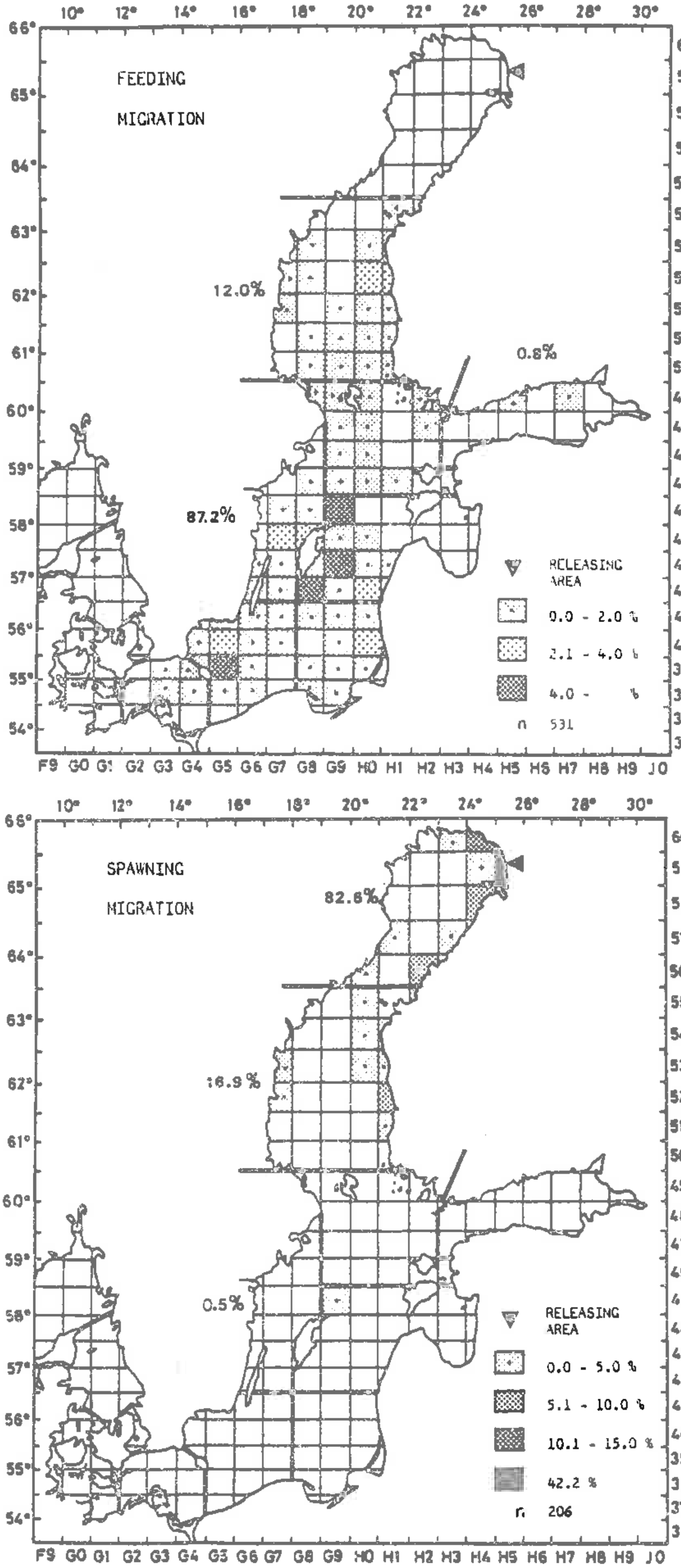

Figure 6. Distribution of tag recoveries of salmon released in the mouth of the Iijoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

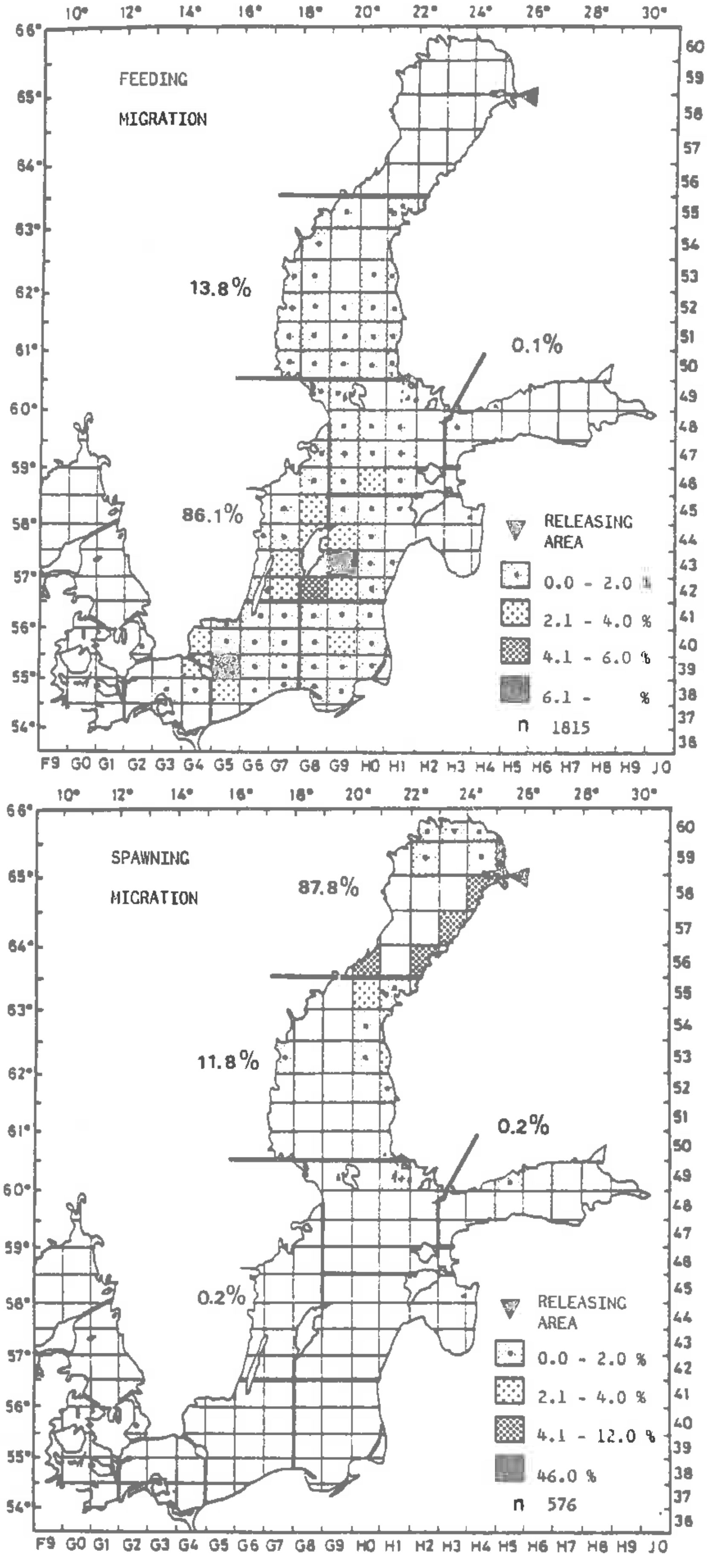

Figure 7. Distribution of tag recoveries of salmon released in the mouth of the Oulujoki River in percentages by sub-divisions and rectangles during feeding and spawning migration

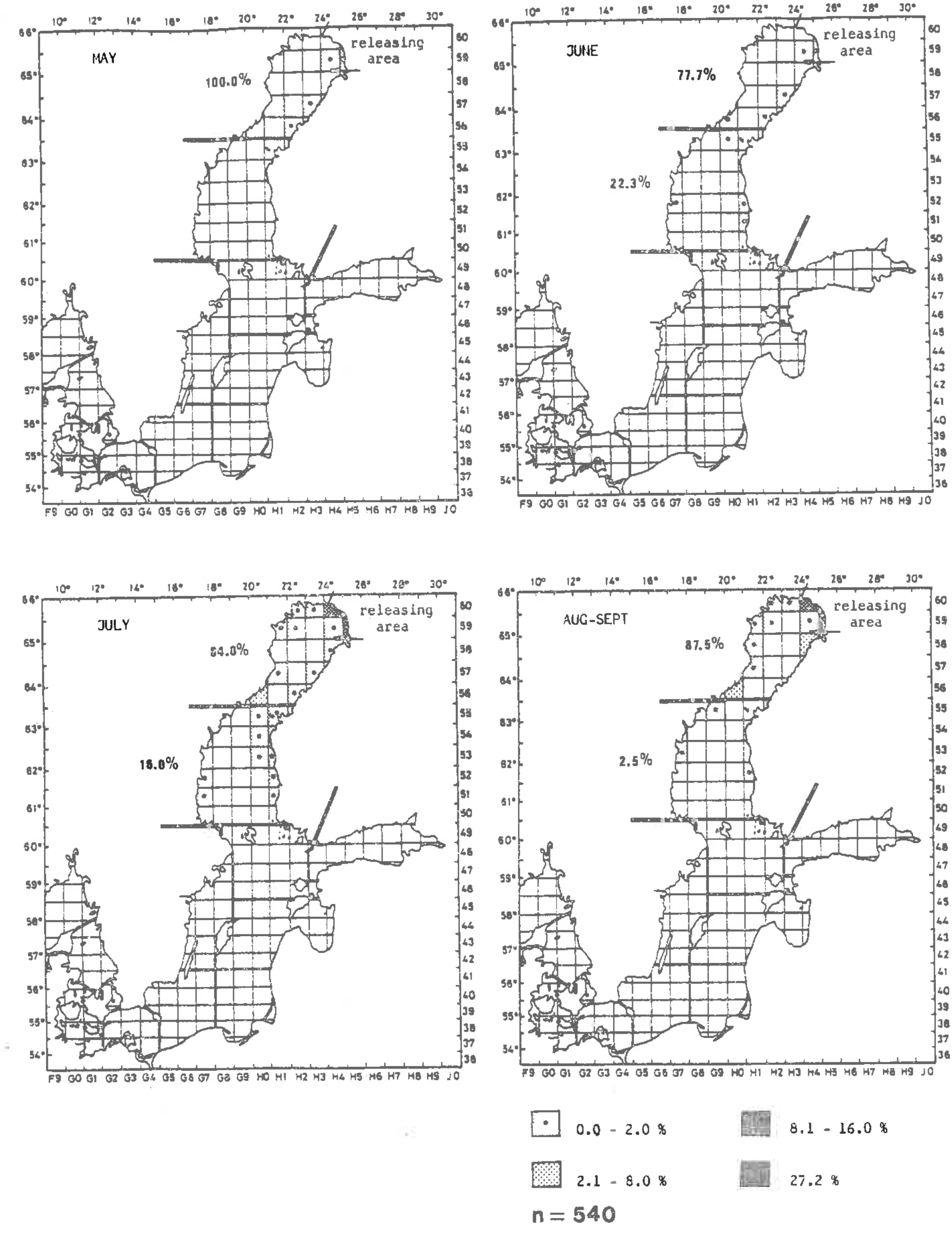

Figure 8. Distribution of tag recoveries of grilse released in sub-division 31 in percentages by sub-divisions, rectangles, and months

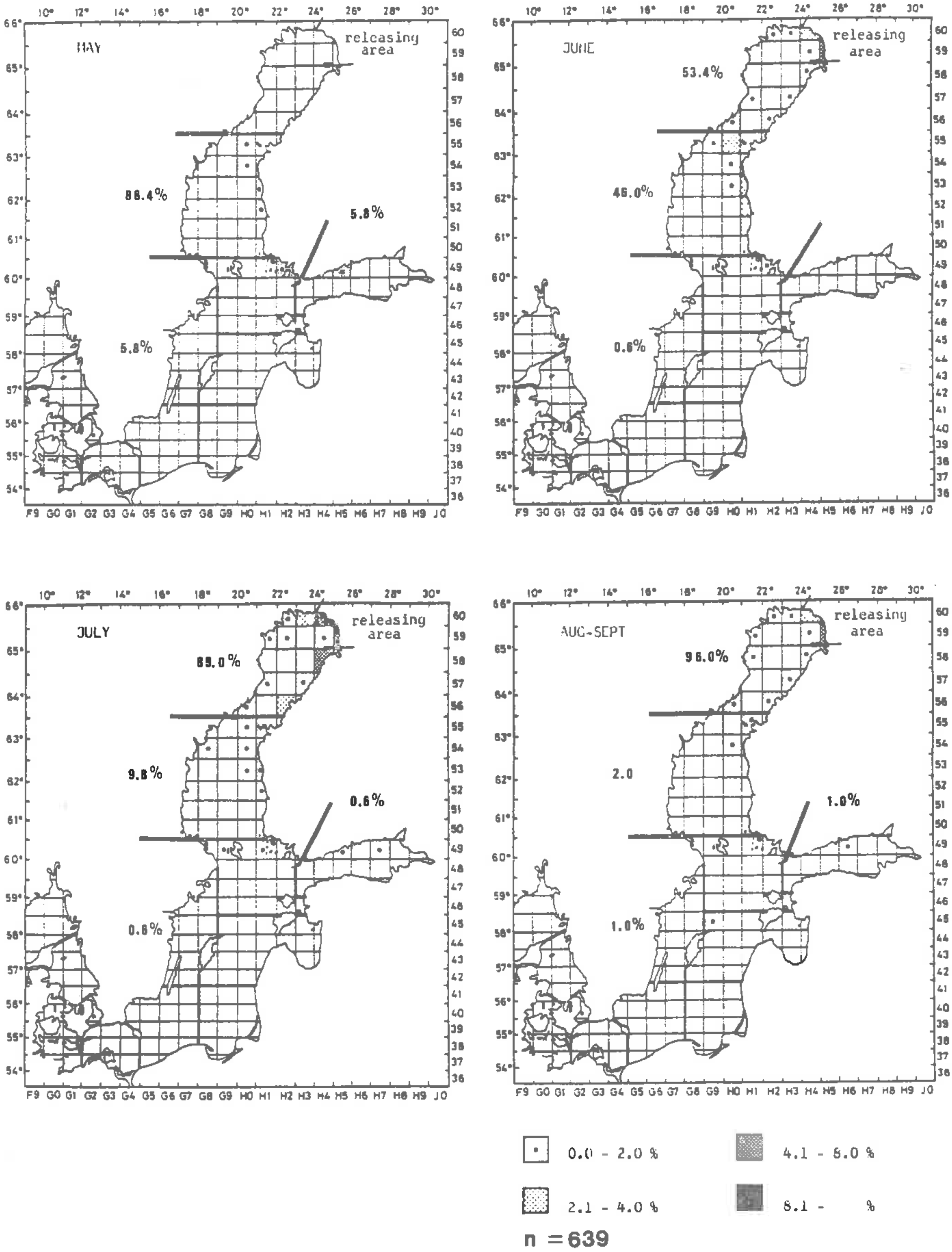

Figure 9. Distribution of tag recoveries of older than A.1+ spawners released in sub-division 31 in percentages by sub-divisions, rectangles, and months

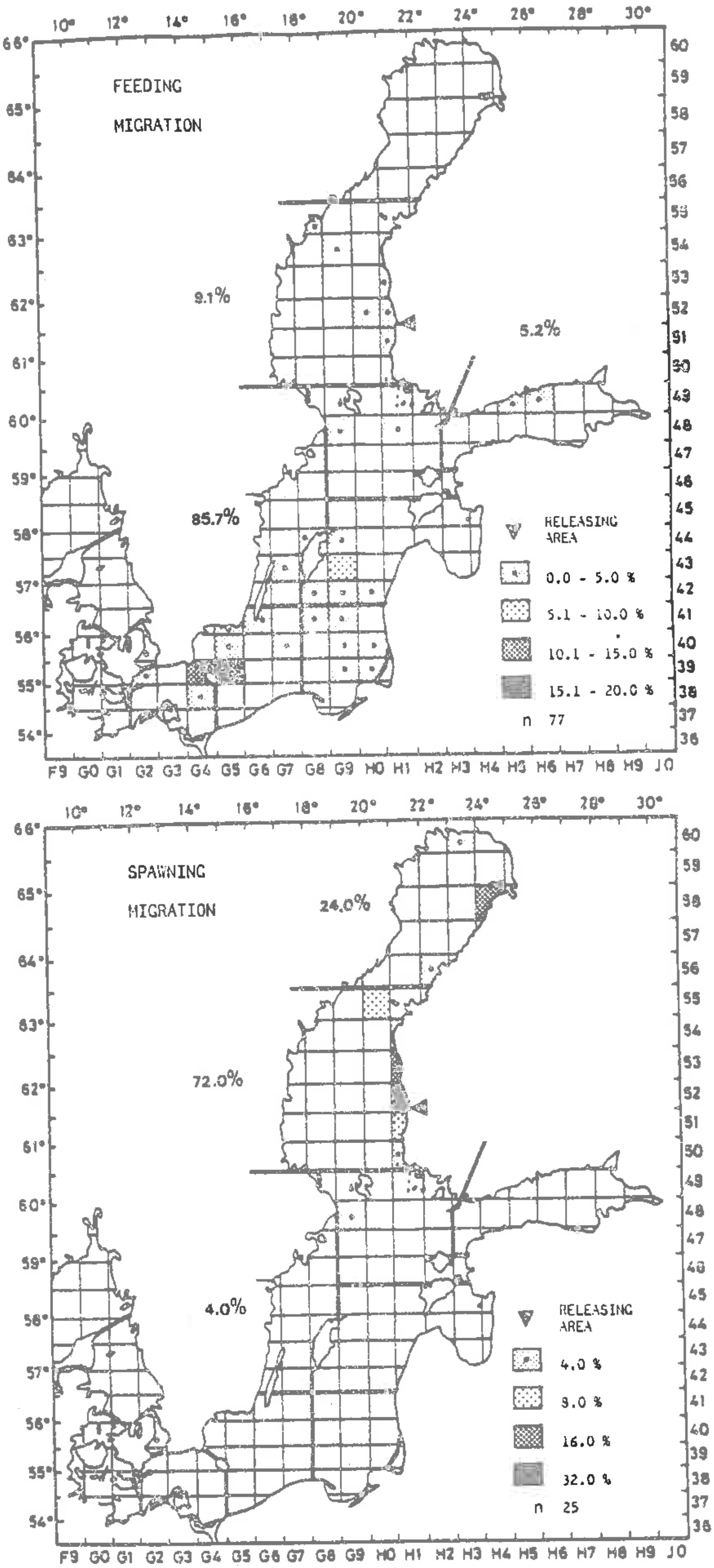

Figure 10. Distribution of tag recoveries of Iijoki River stock salmon released in the mouth of the Kokemäenjoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

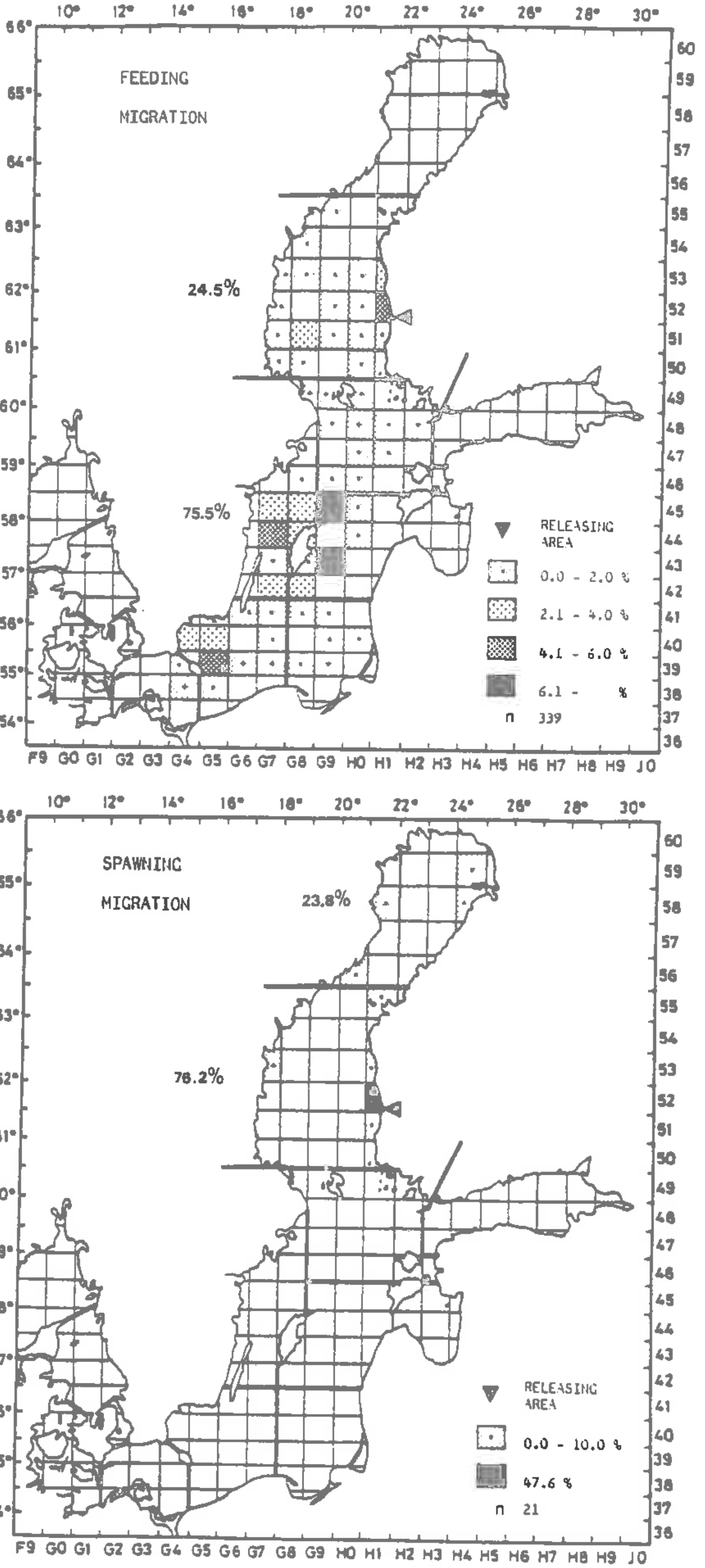

Figure 11. Distribution of tag recoveries of Dalälven and Ångermanälven stock salmon released in the mouth of the Kokemäenjoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

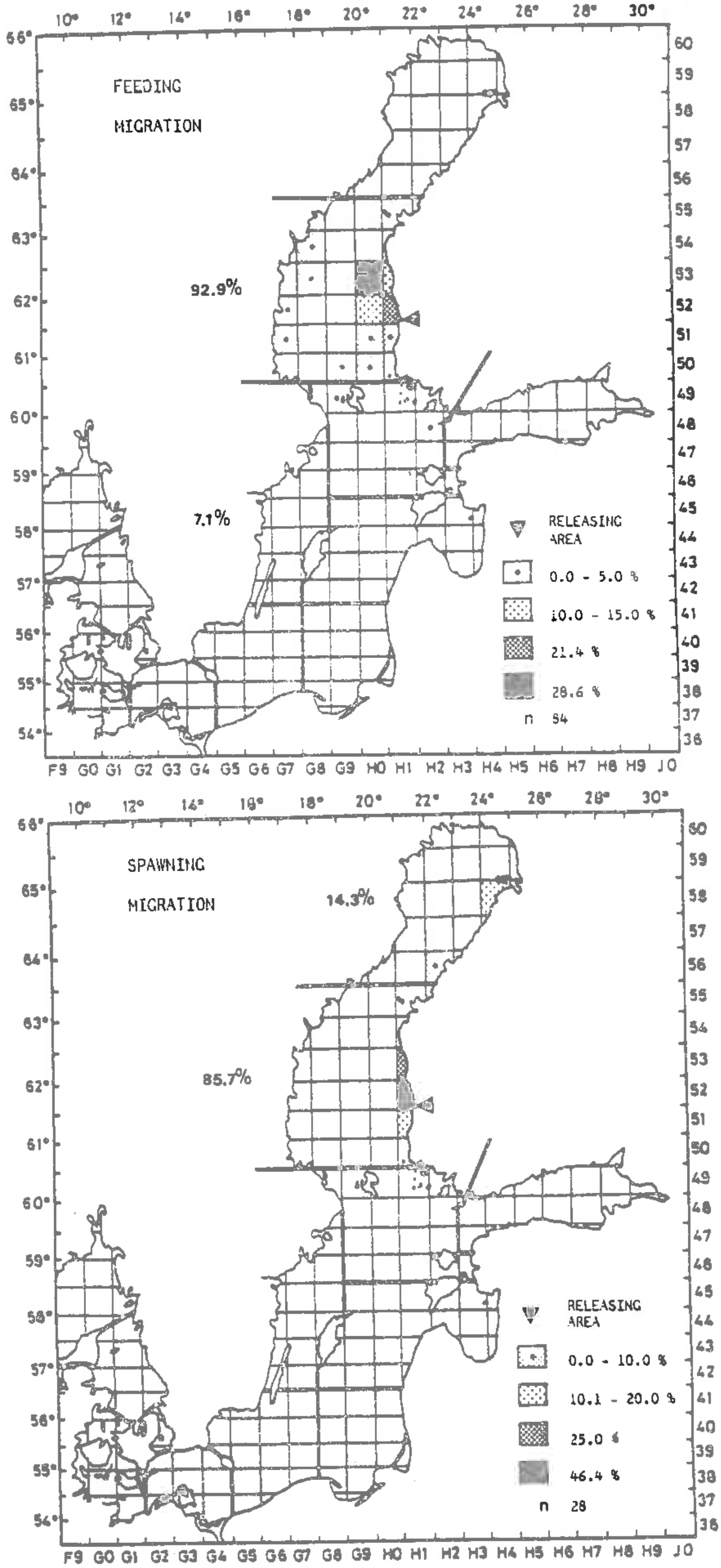

Figure 12. Distribution of tag recoveries of Neva River stock salmon released in the mouth of the Kokemäenjoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

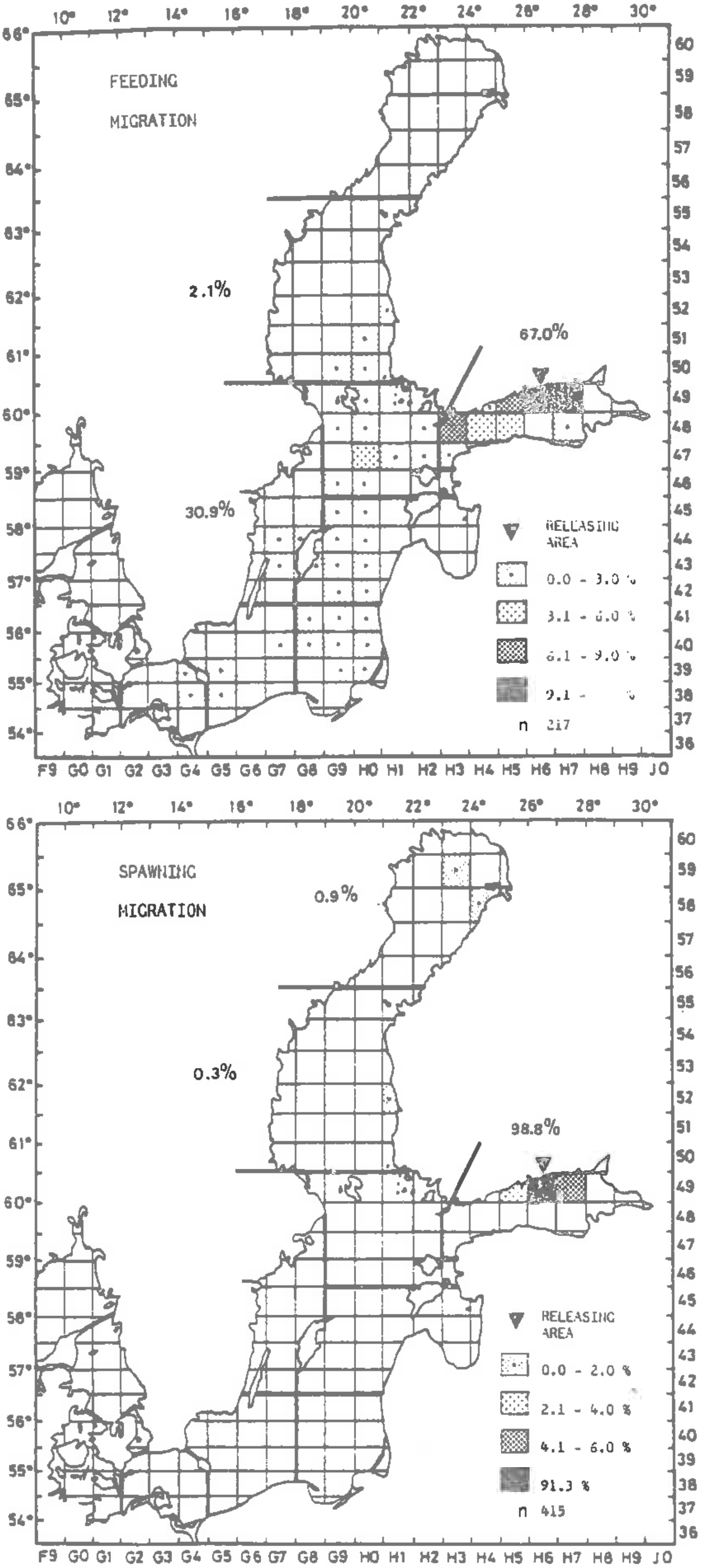

Figure 13. Distribution of tag recoveries of Neva River stock salmon released in the mouth of the Kymijoki River in percentages by sub-divisions and rectangles during feeding and spawning migrations

International Council for the Exploration of the Sea

C.M. 1984/M:5
Anadromous and Catadromous Fish Committee

Migration of sea trout stocks in the Baltic Sea on the basis of Finnish tagging experiments

by

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Abstract

About 800 000 sea trout smolts have been released annually in Finnish coastal waters. Most of the fish were released straight into the sea, often at some distance from the nearest rivers. The migration of sea trout has been studied with the aid of Carlin tags. Marked differences have not been noted in migration behaviour between separate stocks. All the stocks were of the stationary type; there are no widely migrating sea trout stocks in Finland. In the Gulf of Bothnia sea trout feeding migration seems to follow the coast northwards with the main current. In the Gulf of Finland the direction of migration is not so obvious. During spawning migration fish return to the release area. It has been observed that fish return to the release site even though there is no source of freshwater in the vicinity. Some of the fish seem to drift to the river nearest to the release site.

Resumé

Environ 800 000 jeunes truites de mer ont été lachées annuellement sur les côtes de Finlande. La plupart des lâchages l'ont été directement dans la mer, souvent très loin de la rivière la plus proche. On a étudié la migration des truites de mer à l'aide de marqueur Carlin. Aucune différence nette entre les stocks différents n'a pu être observée dans le comportement migratoire. Tous ces stocks ont été appelé stationaires. Il n'existe pas de stocks de truite de mer de large migration en Finlande. La migration d'alimentation de la truite de mer dans le Golfe de Bothnie semble suivre la côte vers le nord le long du courant principal. Ceci n'est pas si évident dans le Golfe de Finlande. Durant la migration de frai les poissons retournent vers la région de lâchage. On a observé que les poissons reviennent à leur lieu de lâchage bien qu'il n'y ait pas de source d'eau douce dans le voisinage. Une partie des poissons semble dériver vers la rivière la plus proche du lieu de lâchage.

1. Introduction

The natural smolt production of sea trout in Finland has almost ceased because of man-made changes to rivers. At present only five rivers are known to support sea trout stocks (Toivonen and Ikonen 1978). In the 1980, about 800 000 hatchery-reared sea trout smolts were released yearly into coastal waters and at river mouths (Anon. 1984). In 1982 the Finnish sea trout catch was about 250 tonnes, of which the non-commercial catch was about 70 %.

The aim of this paper is to contribute to sea trout management in terms of migration, growth, fishing and utilization of stocking. Earlier papers on these topics include those by Segerstråle (1937), Järvi (1940), Toivonen and Tuhkunen (1975), Toivonen and Ikonen (1978), Kummu (1975), Bartel (1977), Larsson et al. (1979), Svärdson and Fagerström (1982), Christensen and Johansson (1975) and Ikonen and Auvinen (1982).

2. Material and methods

The data considered in this paper are for sea trout tagging recoveries in 1972-84 from tagging experiments conducted in 1972-82. The number of tagged smolts, the number of tag recoveries and the recapture rate in different areas are presented in the table below.

Area Sub-div.	River	Number of tagged smolts	Number of tag recoveries	Recapture rate %
31	River Tornionjoki	2495	328	13.1
31	River Kemijoki	7737	832	10.7
31	River Iijoki	5882	811	13.8
31	River Oulujoki	20950	3026	14.4
30	River Kokemäenjoki	7469	882	11.8
32	River Kymijoki	4476	481	10.7

The sea trout stocks used were from those in the rivers Tornionjoki, Kemijoki, Iijoki, River Oulujoki and Lestijoki in sub-division 31 from the River Isojoki stock in sub-division 30, and from the stocks of the rivers Isojoki and Dalälven (Sweden) in sub-division 32.

These stocks are based on hatchery-reared brood stocks originating from spawners caught in the river mouths.

3. Results

3.1. Migration

Sea trout stocking usually takes place in May-June; previously even autumn releases were used. During the year of release sea trout post-smolts released in sub-divisions 31 and 30 seemed to migrate north and northwestwards (Figs. 1-5), although the great majority of the tag returns derived from the immediate vicinity of the release site.In the Gulf of Finland (sub-division 32) post-smolt tag returns were from a more limited area (fig. 6).

In the following year tag returns were still concentrated around the vicinity of the release site. However, some of the fish released in sub-division 31 migrated southwards along the Swedish coast and in smaller numbers along the Finnish coast. Some tag returns even derived from the Baltic proper (Figs. 1-4). Fish released in sub-division 30 showed a clear tendency to migrate northwards. Some of the fish appeared to cross the Quark in the Gulf of Bothnia and to continue southwards along the Swedish coast (Fig. 5). The returns from releases in sub-divisions 32 were still concentrated around the release area.

In the third year in the sea the distribution of tag recoveries was equal to that in the previous year, with the exception of stocks in the River Iijoki (sub-division 31) in which a prominent percentage of tags were reported in sub-division 30 (Figs. 1-6).

In later years in the sea tag returns outside the sub-division of release become rare, more being concentrated on the rectangle of release (Figs. 1-6).

3.2. Growth and utilization of stocked sea trout

In sea trout releases in sub-division 31,75 % of the returns were caught during the year of release and the following year. In sub-division 30, the corresponding figure was 65 % and in sub-division 32, 53 % (Table 1). The growth rate of the northern stocks was poorer than that of the southern stocks (Table 2-3). The legal size (40 cm) is barely reached during the year after release in sub-division 31. In the southern stocks the legal size is nearly reached by the end of the year of release. As a consequence, the catch per 1000 released smolts in sub-division 31 is poorer than in the southern releases (Table 4).

4. Discussion

Sea trout stocks in the Baltic Sea can be divided into two groups by migration behaviour: the widely migrating type and the stationary type. The former , which has a tendency to migrate in the open sea, includes the stocks of the rivers Vistula (SKROCHOWSKA 1969) and Verke (SVÄRDSON & FAGERSTRÖM 1982). All Finnish stocks and most Swedish sea trout stocks are of the stationary type (SVÄRDSON & FAGERSTRÖM 1982, TOIVONEN & TUHKUNEN 1975), which means that their migration follows the coastlines.

The migration of Finnish sea trout stocks in the Gulf of Bothnia (ICES sub-division 30-31) is directed northwards along the Finnish coast and southwards along the Swedish coast. The surface current, caused by the Coriolis effect, in the Gulf of Bothnia is in the same direction (WESSEL 1971 ref SVÄRDSON & FAGERSTRÖM 1975) and thus the sea trout appear to follow the current. The Swedish Dalälven-stock, however, migrates against the current northwards along the Swedish coast (SVÄRDSON & FAGERSTRÖM 1982). TOIVONEN & TUHKUNEN (1975) have suggested that the direction of sea-trout migration, after the smolts have entered the sea, is towards less saline water. This hypothesis seems to fit the situation on the Finnish coast and also on the Swedish coast, as many rivers flow into the sea north of the mouth of the River Dalälven.

The wide migrating Vistula stock seems to migrate northeastwards (SKROCHOWSKA 1969). Even this migration seems to be directed towards less saline water, as water from the Vistula flows in this direction, and there are other large rivers on the eastern coast of the Baltic. The migration of Verke sea trout (SVÄRDSON & FAGERSTRÖM 1982) could also be explained by the salinity hypothesis. The migration follows the Öland-Gotland-Gulf of Finland route. The isohaline of 7 per mille lies on the same route. In the Gulf of Finland the migration of sea trout is directed towards both sides of the river mouth. No preference for a less saline water can be observed. This does not however contradict the salinity hypothesis, because the surface current due to the coriolis effect is weaker and the isohalines change rapidly because of winds.

In the Gulf of Bothnia (ICES sub-division 31) the bulk of the sea trout are caught undersized (below 40 cm), mainly during gill-net fishing for whitefish (50 %). Trap-netting (15 %) and trawling (5 %) for Baltic herring (Clupea harengus) and vendace (Coregonus albula) also take undersized sea trout. These three types of fishing account for about 70 % of the tagreturns during the year of release and the following year. The poor stocking result (catch per 1000 stocked smolts) in the Gulf of Bothnia is due to the methods used by the fishing industry and the slow growth rate. Whitefish fishing is important in that area and strong limitations on gill-net fishery are out of the question. Detailed research into the proportions of whitefish and sea trout catches in different seasons and areas should provide a more reliable basis for management.

The growth of sea trout is better and the percentage of undersized fish is lower along the southern coast of Finland (ICES subdivisions 30 and 32). This is partly due to the methods used by the fishing industry. The importance of sea trout sport fishing (sea angling) is marked in the Gulf of Finland, where there are several big cities along the coast situated. Sport fishing for sea trout could be increased by stocking rivers and river mouths instead of releasing the smolts into the sea. This would provide opportunities for sport fishing in the rivers, too. Suitable rivers flow into both in the Gulf of Finland and the Gulf of Bothnia.

Sea trout are also caught by the gill-nets of non-professional fishermen operating near the coast, and trap-net fishery for salmon takes in sea trout, too. In the Gulf of Finland the proportion of sea trout is in fact greater than that of salmon. Off-shore fishing for salmon also accounts for some sea trout. In southern areas, sea trout are thus a necessary catch for many professional fishermen. The feeding grounds for salmon and sea trout in the Gulf of Finland and the Bothnian Sea (sub-division 32, 30) are utilized by the sea trout that stay near the coast and by Neva stock salmon, which feed off-shore but mainly stay in the Gulf during their sea migration (Ikonen & Auvinen 1984).

REFERENCES

BARTEL, R. 1977: Variability of sea trout returns from many years tagging experiments with hatchery-reared parr and smolts. - ICES C.M. 1977/M:9, Mimeo.

CHRISTENSEN, O. & JOHANSSON, N. (ed.) 1975: Reference report on Baltic salmon with additional information on Baltic sea trout compiled by the Working Group on Baltic Salmon. Laxforsknings-institutets Meddelande 2/1975.

IKONEN, E. & AUVINEN, H. 1982: Results of Finnish stocking with sea trout (Salmo trutta m. trutta) in the Baltic sea in 1971-80. - ICES C.M. 1982/M:39, Mimeo.

- 1984: Migration of salmon in the Baltic Sea, based on Finnish tagging experiments. - ICES C.M. 1984/M:4, Mimeo.

JÄRVI, T.H. 1940: Sea trout in the Bothnian Bay (Salmo trutta). - Acta Zool.Fennica 29: 1-27.

KUMMU, P. 1975: Meritaimenmerkintöjen tuloksia. - Suomen Kalastus-lehti 82: 140-143.

LARSSON, P.-O, STEFFNER, N.G., LARSSON, H.O. & ERIKSSON, C. 1979: Review of Swedish sea trout (Salmo trutta L.) stocks based on results of tagging experiments. - Salm. Res. Inst. Rep. (2) 31 pp. (in Swedish).

SEGERSTRÅLE, C. 1937: Studier rörande havsforellen (Salmo trutta L.) i södra Finland, speciellt på Karelska näset och i Nyland. - Acta Soc. pro Fauna et Flora Fennica 60: 696-750.

SKROCHOWSKA, S. 1969: Migrations of the sea trout (Salmo trutta m. Fario L.) and their crosses. Part III. Migrations to, in and from the sea. - Pol. Arch. Hydrobiol. 16 (29): 149-180.

SVÄRDSON, G. & FAGERSTRÖM, Å. 1982: Adaptive differences in the long-distance migration of some trout (Salmo trutta L.) stocks. - Rep. Inst. Freshw. Res. Drottningholm 60: 51-80.

TOIVONEN, J. & IKONEN, E. 1978: Havsöringen i Finland. - Fiskeri-tidskrift för Finland 5: 104-109.

TOIVONEN, J. & TUHKUNEN, A. 1975: Migration of sea trout along the coastal waters of Finland on the basis of tagging exper-iments. - ICES C.M. 1975/M:3.

WESSEL, L. 1971: Havströmmar. Instruktion för stridtjänster vid flottan, Ubåtsjakt, Hydrografi. Bil. 4: 7-9.

Table 1. Distribution of tag returns in different years.

Sub-div.	River	Tag recoveries												Total
		Year of release		2nd year		3rd year		4th year		5th year		6th year		
		n	%	n	%	n	%	n	%	n	%	n	%	n
31	Tornionjoki	177	52.6	108	33.0	37	11.3	9	2.6	1	0.3	-	-	327
31	Kemijoki	207	25.4	288	35.9	199	24.4	108	13.2	12	1.5	2	0.3	816
31	Iijoki	333	41.2	265	33.0	138	17.2	52	6.5	14	1.7	2	0.3	804
31	Oulujoki	1300	46.0	922	32.7	387	13.7	150	5.3	44	1.6	21	0.7	2824
30	Kokemäenjoki	177	20.6	384	44.6	248	28.8	48	5.6	2	0.2	2	0.2	861
32	Kymijoki	98	21.4	145	31.7	136	29.8	65	14.2	12	2.6	1	0.2	457

Table 2. Mean length of tagged sea trout at recapture.

Sub-div.	River	Mean length (mm) Year of release	2nd year	3rd year	4th year	5th year	6th year
31	Tornionjoki	250	398	503	593	-	-
31	Kemijoki	290	410	503	617	652	-
31	Iijoki	294	405	522	625	633	-
31	Oulujoki	291	386	486	602	636	680
30	Kokemäenjoki	315	426	563	651	735	-
32	Kymijoki	365	434	509	647	739	-

Table 3. Mean weight of tagged sea trout at recapture.

Sub-div.	River	Mean weight (kg) Year of release	2nd year	3rd year	4th year	5th year	6th year
31	Tornionjoki	0.260	0.790	1.500	2.650	-	-
31	Kemijoki	0.350	0.800	1.500	2.690	3.040	5.000
31	Iijoki	0.310	0.750	1.620	2.850	3.250	4.000
31	Oulujoki	0.320	0.680	1.450	2.710	3.350	5.480
30	Kokemäenjoki	0.450	0.930	2.410	3.780	4.410	-
32	Kymijoki	0.380	1.040	1.720	3.290	5.020	-

Table 4. Catch in kg/1000 of tagged, released sea-trout smolts in different years.

Sub-div.	River	Catch kg/1000 released Year of release	2nd year	3rd year	4th year	5th year	6th year	Total
31	Tornionjoki	18	34	22	10	1	-	85
31	Kemijoki	9	30	39	38	5	1	122
31	Iijoki	18	34	38	25	8	0	123
31	Oulujoki	20	30	27	19	7	6	109
30	Kokemäenjoki	11	48	80	24	1	1	165
32	Kymijoki	8	34	52	48	13	1	156

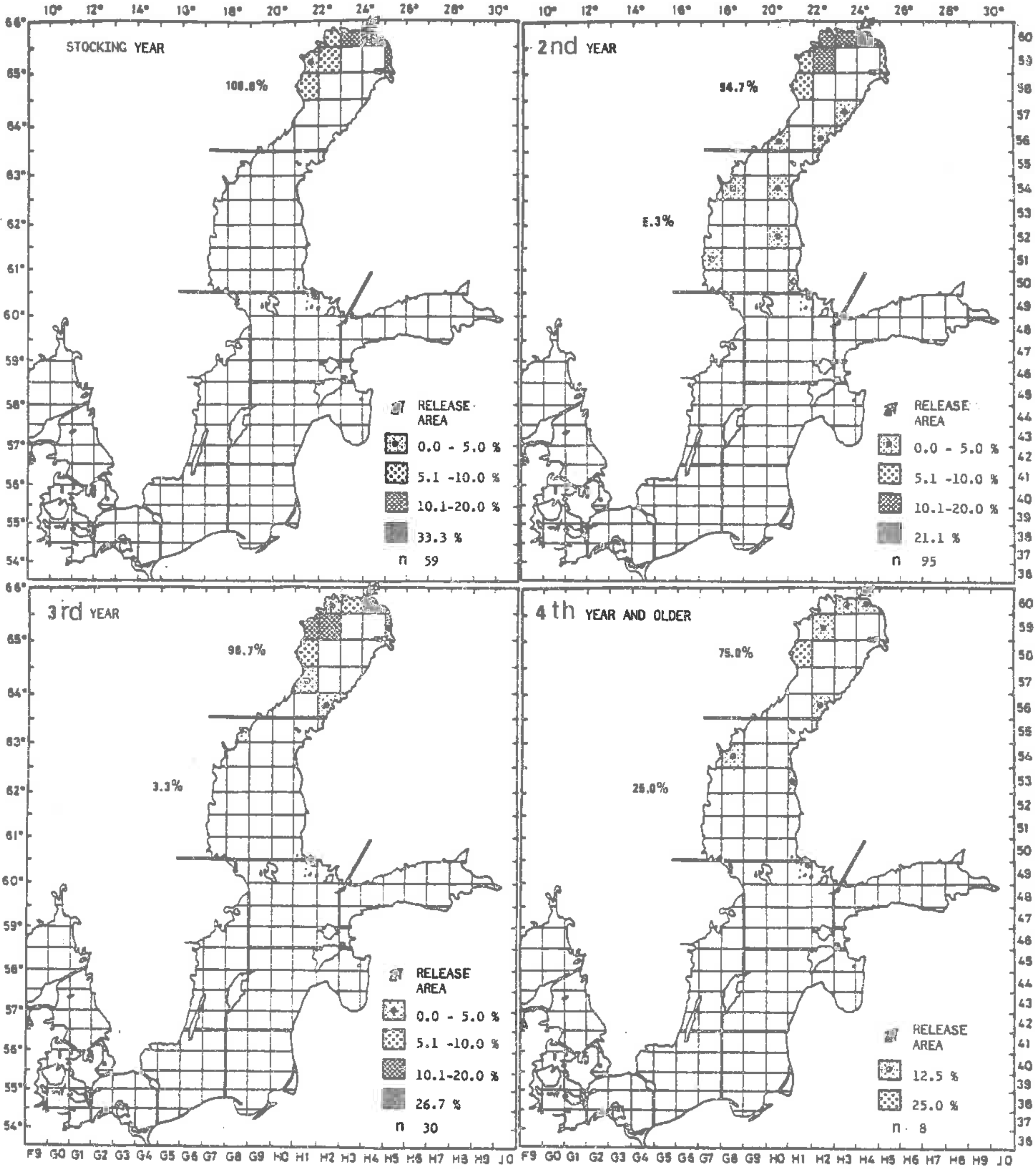

Figure 1. Tag recoveries of sea trout released in the mouth of the River Tornionjoki; rectangles show percentages recoveries.

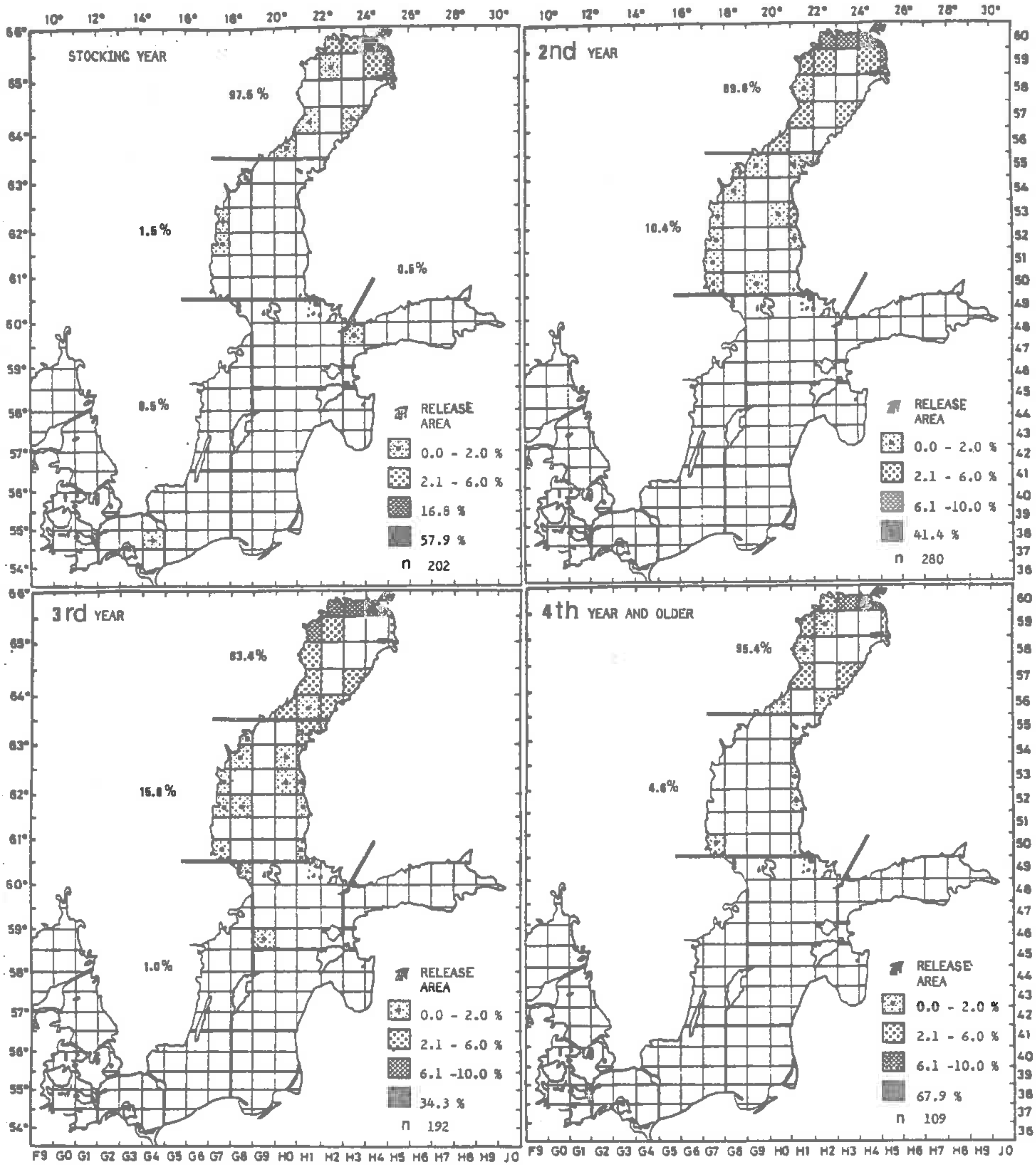

Figure 2. Tag recoveries of sea trout released in the mouth of the River Kemijoki; rectangles show percentages recoveries.

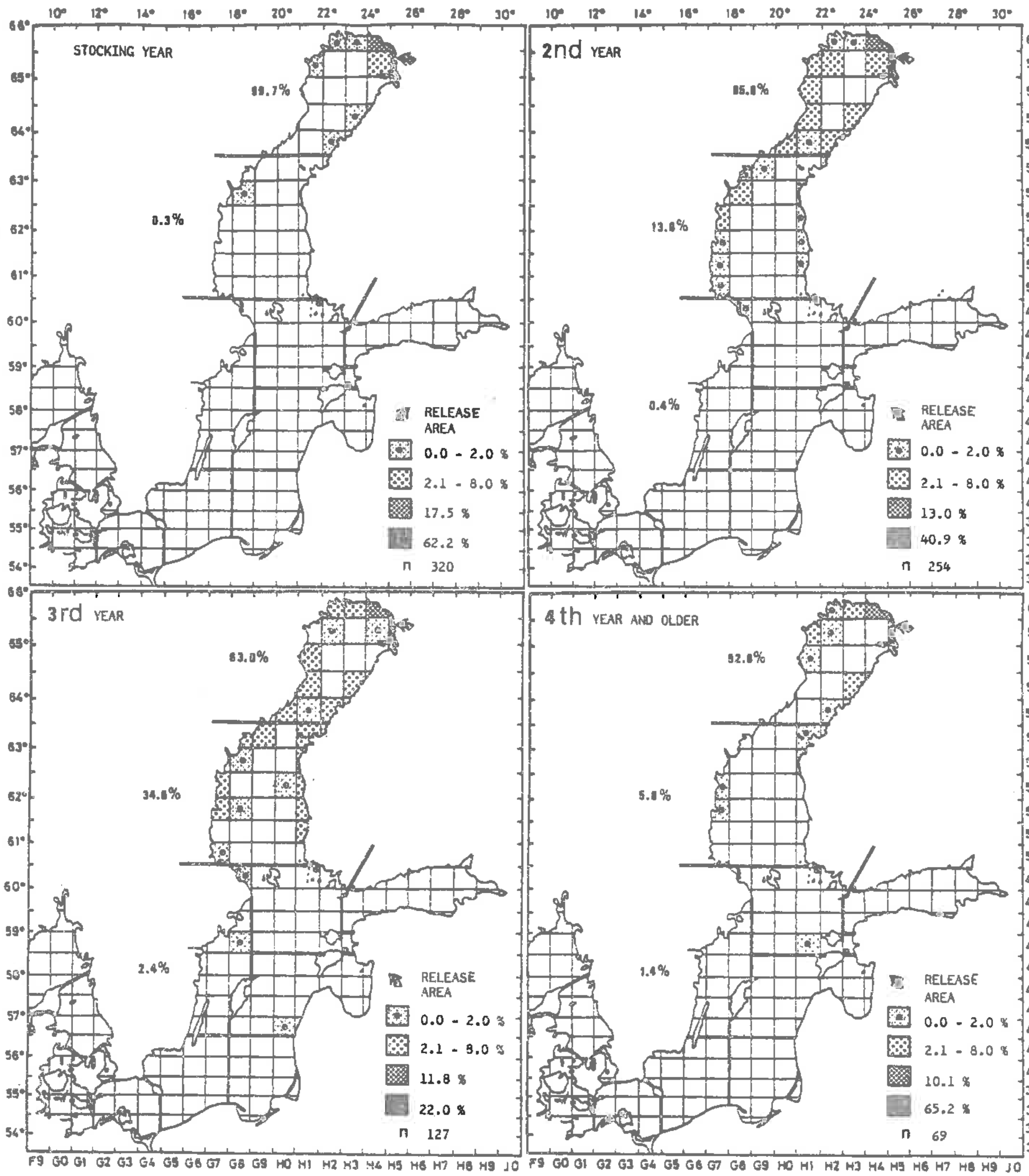

Figure 3. Tag recoveries of sea trout released in the mouth of the River Iijoki; rectangles show percentages recoveries.

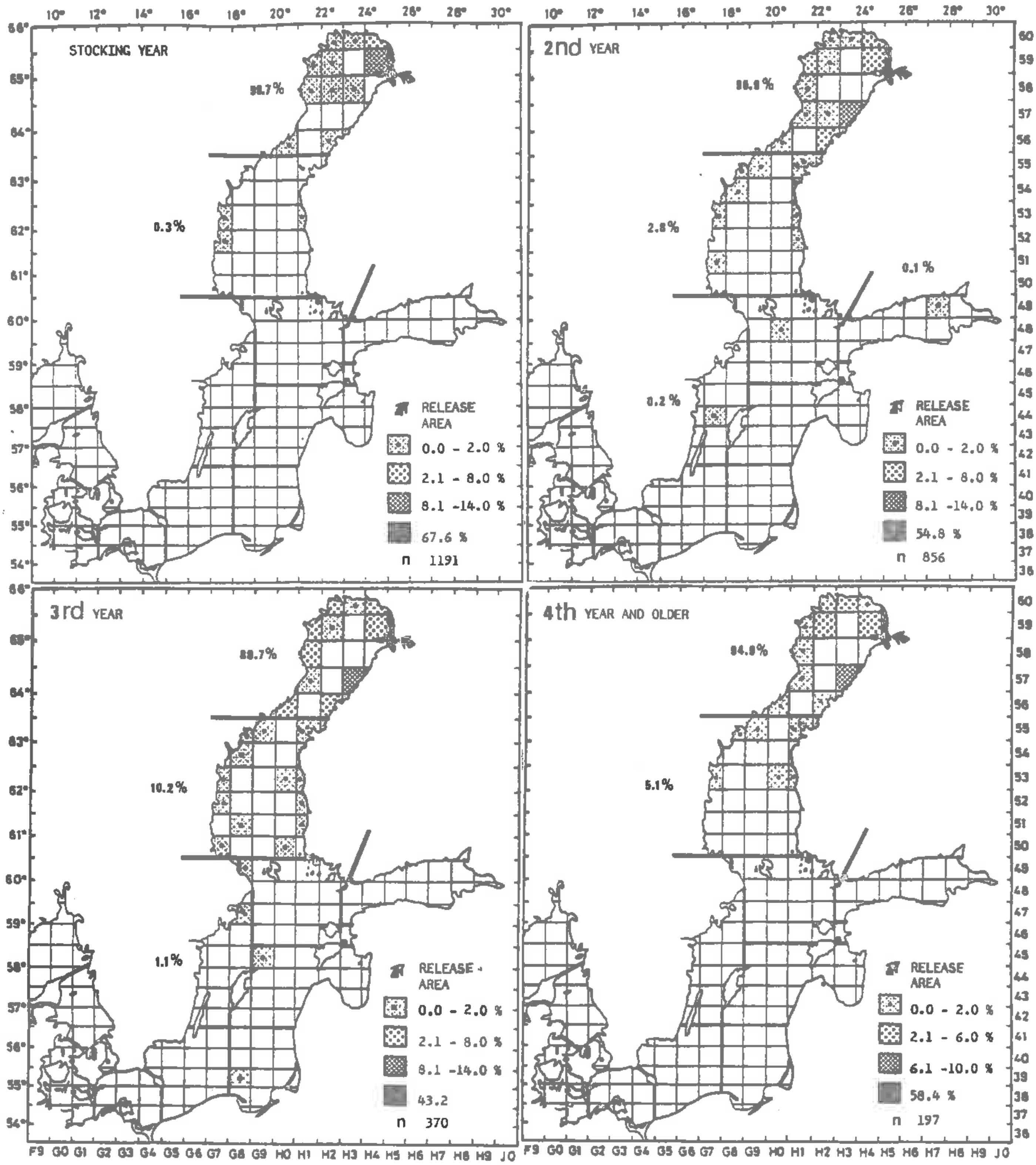

Figure 4. Tag recoveries of sea trout released in the mouth of the River Oulujoki; rectangles show percentages recoveries.

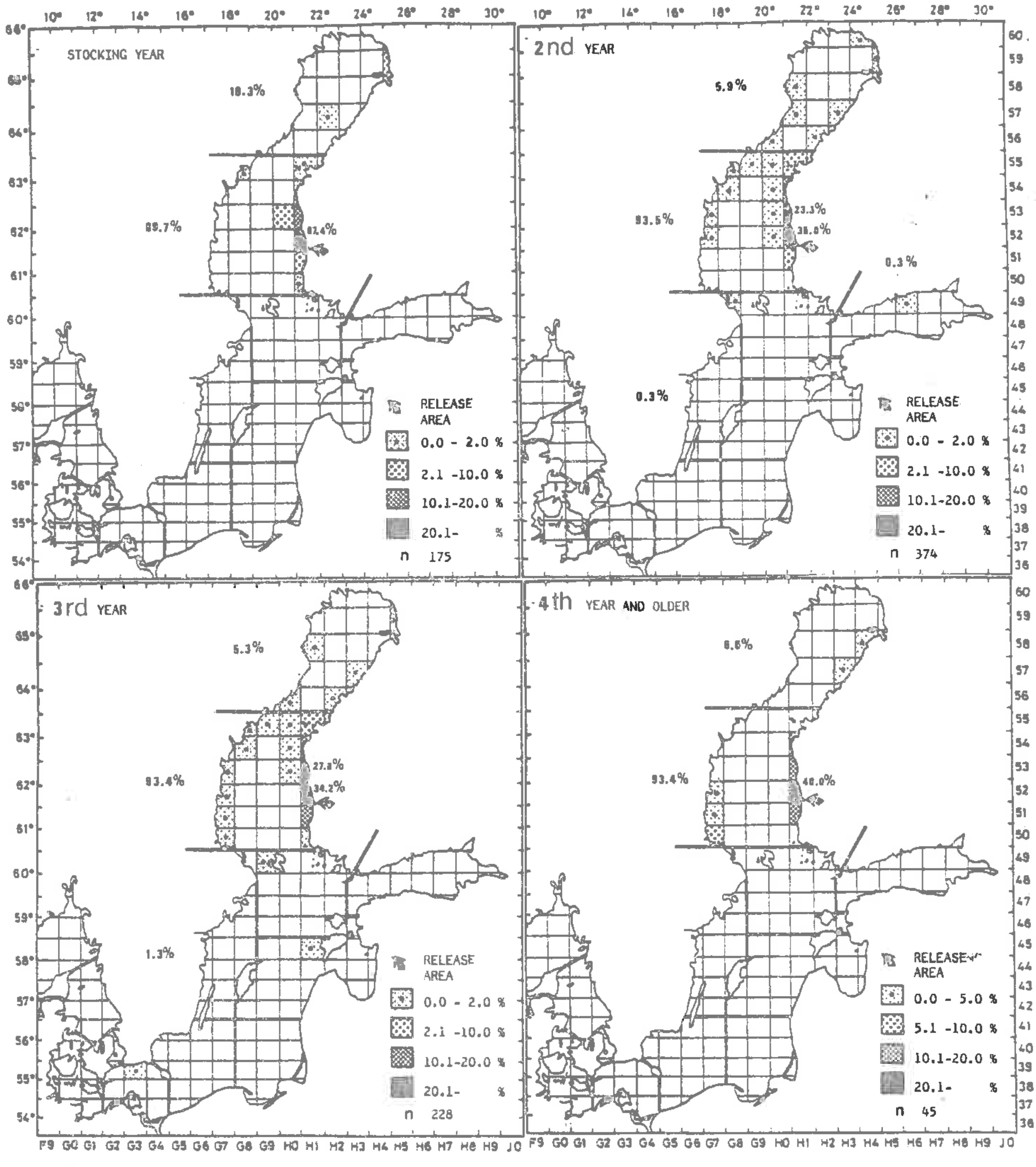

Figure 5. Tag recoveries of sea trout released in the mouth of the River Kokemäenjoki; rectangles show percentages recoveries.

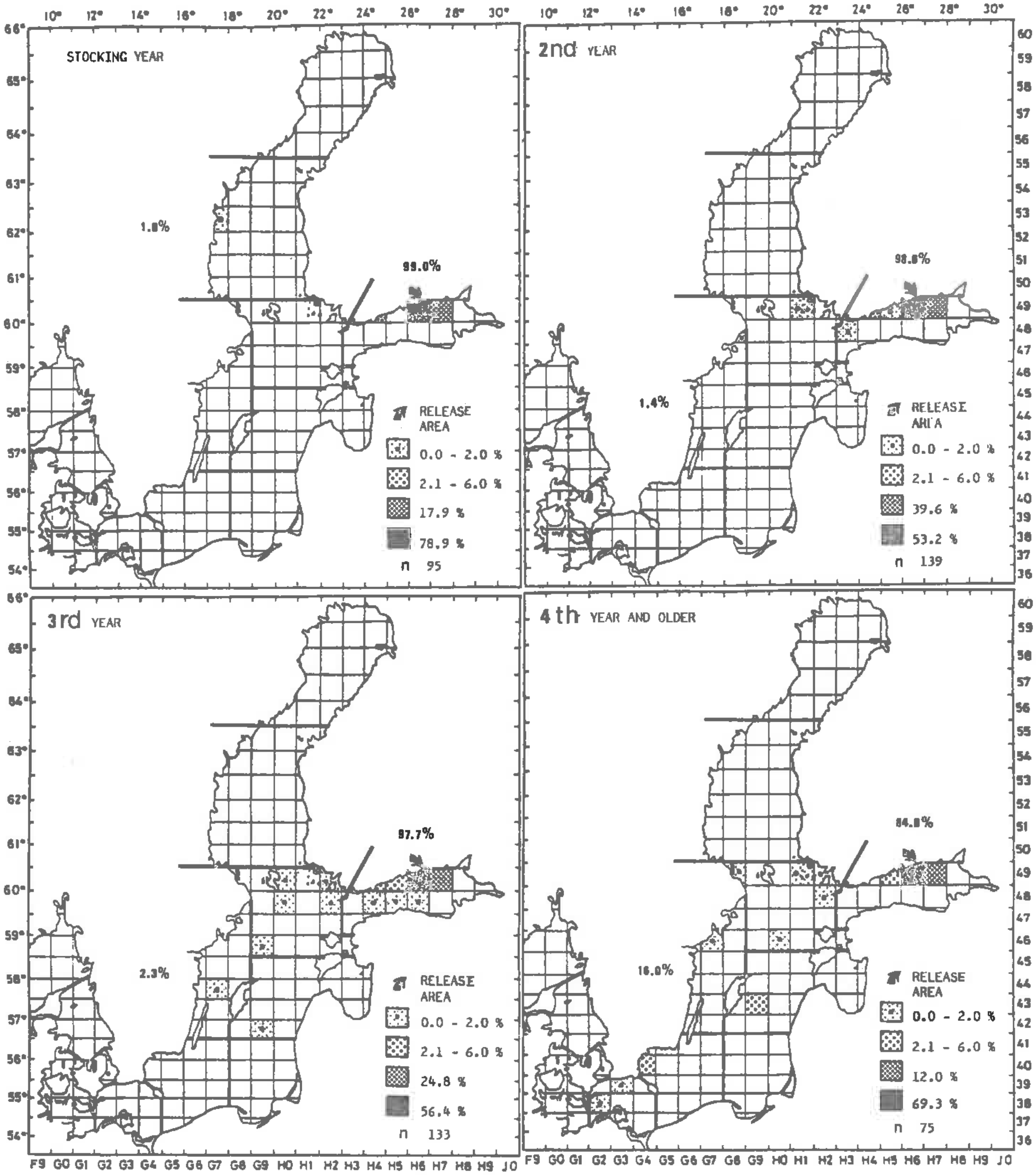

Figure 6. Tag recoveries of sea trout released in the mouth of the River Kymijoki; rectangles show percentages recoveries.

International Council for the Exploration of the Sea

C.M. 1985/J:28

ABUNDANCE AND DISTRIBUTION OF SMELT (OSMERUS EPERLANUS (L.)) YOLK SAC LARVAE IN THE NORTHERN QUARK, GULF OF BOTHNIA

by

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Abstract

In May-June 1978-1984 about 280 samples were taken at permanent stations in the Northern Quark with modified Gulf high speed samplers. In 1982-1984 about 500 extra samples were taken at four subareas in order to check the horizontal and vertical distributions of yolk sac smelt larvae. Yolk sac larvae occured only in estuarine areas, with daily mean densities between 0 and 9.8 ind./m^3. Highest densities occured near spawning sites. Great local variations in almost uniform mean vertical distribution still require sampling at several depth strata. Extra samples also revealed that sampling at the outer border of the main larval area should be intensified. Sampling interval should be a week or less.

Résumé

Environ 280 échantillons furent relevés, avec des échantillonneurs Gulf modifiés à grande vitesse, en Mai-Juin 1978-1984 aux stations permanentes du Quark septentrional. En 1982-1984, environ 500 échantillons supplémentaires furent relevés dans quatre sous-régions afin de contrôler la distribution horizontale et verticale d'éperlans. Les larves à membrane vitelline se trouvaient dans les estuaires seulement, avec une densitējournalière moyenne entre 0 et 9.8 ind./m^3. Des densités supérieures se rencontrent près des lieux de frai. La présence de grandes variations locales dans la distribution verticale aseez uniforme pourtant en moyenne, impose encore la prise d'échantillons á plusieurs profondeurs.Les échantillons supplémentaires révélèrent aussi que l'échantillonnage devrait être intensifié à la limite externe de la zone larvaire principale. Les périodes d'échantillonnage devraient être d'une semaine ou moins.

Introduction

The study of the population dynamics of the smelt (Osmerus eperlanus (L.)) in the Northern Quark started in 1978. The program consists of monitoring the catches, the cpue:s, the recruited stock (Hudd 1985a), fecundities (Hudd 1985b) and monitoring the larval abundances. The present paper is the first presentation of the larval abundance.

Material and methods

The study area consisted of four separate estuarine areas in the Northern Quark (Fig. 1); the areas of Maxmo (I), Köklot (II), Vaasa (III), and Malax (IV). Sampling took place at permanent sampling stations, five to ten per estuarine area, at the end of May and in June (1978-1984).

The sampling was performed with Gulf V high speed sampler (Schnack 1974) in single oblique hauls (1-2 min/m depth) or on more shallow areas only at one depth. The Gulf V sampler turned out to be inadequate, since large areas are very rocky and shallow and in addition the inner parts get their vegetation already in June. For this reason the Gulf-olympia was developed (Hudd et al. 1984). Gulf V and Gulf-olympia samplers have the same basic construction (fig. 2), but Gulf V is towed behind a boat and the Gulf-olympia is fixed in front of a boat.
In order to check the reliability of the chosen sampling depth strata the vertical distribution of larvae was studied more accurately in 1983 and 1984. At one station, in a bay without major currents, a 14-hour sampling was conducted. To confirm the outer border of the horizontal distribution the samples from herring larval surveys (Sjöblom & Parmanne 1976, Axell 1984) were also checked. Our collections in the 7-year period included about 850 samples.

The difficulties met in sampling larger and more active larvae led us to concentrate here only on the results of yolk sac larvae (YSL), defined here as length $\leq$ 7 mm. $YSL_7\%$ was used to indicate the closeness of hatching.

$$YSL_7\% = \frac{\text{number of larvae} \leq 7 \text{ mm}}{\text{number of all larvae in sample}} \times 100$$

Results

1. Hatching cohorts

Yolk sac larvae of smelt occured from the last weeks of May until the end of June. The hatching peak occured during the first weeks of June. In the years 1983 and 1984 there appeared to be several hatching cohorts at least in Maxmo (I) and in Vaasa (III), which is seen as an occasionally rising YSL_7% (fig. 3, table 1). Hatching occurred later in the inner areas of the River Kyrönjoki estuary (also in the inner areas of Vaasa) and the outspreading of larvae possibly mixes the cohorts. During the study period hatching was latest and most protracted in 1981 in all areas. In Malax (IV) hatching happened earliest in every year of study.

2. Horizontal distribution and the abundance of larvae

Smelt yolk sac larvae were found only in estuarine areas (fig. 1). They have never been found in the outer archipelago. The highest densities appeared in shallow areas (1-3 m) close to the river mouths and in the vicinity of spawning sites (fig. 4-7). In years such as 1984 when the inner parts of spawning areas are very acid, spawning also takes place in the outer parts of the Maxmo (I) archipelago leading to greater catches there too. The Köklotfjärden (II) did not produce smelt larvae to any noteworthy degree in 1980 (table 1).

The mean densities of yolk sac larvae at the permanent stations has usually varied between 0 and 1.5 ind./m^3 (table 1). The very highest daily mean densities were found in Maxmo (I) off the River Kyrönjoki in 1982 and 1984 (9.8 ind./m^3, resp. 4.4). In Malax (IV) sampling occured late every year compared to the hatching peak, and most larvae were consequently over 7 mm in nearly all samples. The highest densities of all larvae were up to 8.6 ind./m^3 in Malax (IV) (table 1).

3. Vertical distributions

During the 14-hour sampling period on 4 June 1984 the mean density of yolk sac larvae varied between 2.1 and 3.7 ind./m^3 (fig. 8).

Mean length of smelt larvae decreased from 7.7 to 7.2 mm and YSL_7% rose from 28.0 to 40.8 %. Clear changes in vertical distribution occurred diurnally, but the mean of the distribution appears almost even (fig. 8). Midday maximum was distinct at the surface. Variation between different depth strata reached from one to nine individuals per m^3. Daily mean densities through other areas also express almost even depth distribution for yolk sac smelt larvae (fig. 9A, 8B). In the second week of June in 1984 densities increased from surface to 2 meters depth strata (Fig. 9C).

Discussion

As a rule the smelt ascend rivers to spawn. In the Northern Quark spawning sites are usually situated in estuaries. Probably spawning sites in rivers have been lost because of acid outflow due to water clearances and excavations in sulfuric clays (Hildén et al. 1982, Hudd et al. 1984, Hudd 1985a).

Yolk sac larvae of smelt were found in all salinities inside the study area (0-4 %) and the densities were not directly proportional to salinities. According to Lillelund (1961) salinities below 10 % have no developing eggs and larvae. Thus the lack of smelt yolk sac larvae from the outer archipelago is not due to high salinity. The preference of estuarine areas is due to their better circumstances to act as a nursery area (Urho et al. 1985). Estuary currents spread out larvae into these favourable areas and the archipelago acts as a barrier producing "safe sites". Eventually larval retention is a consequence of the change in their behaviour (Urho & Hildén 1985).

Comparing Gulf V and Gulf-olympia hauls in Vaasa (III) gave identical results (table 2). This also refers to uniform vertical distribution.The same conclusion can be drawn from the daily means of different strata over large areas (fig. 9A). Tin & Jude (1983) did not find any particular pattern of vertical or diurnal distribution of rainbow smelt larvae during May in eastern Lake Michigan, but in Lake Ontario Dunstall (1984) found more yolk sac larvae in 0,5 m strata than in 6 or 12 m strata. This supports for the use of Gulf-olympia in horizontal distribution studies. On the other hand some results indicate that vertical distribution may also vary between different stations and especially at the end of the yolk sac period it may resemble the vertical distribution of larvae over 7 mm (fig. 9C). It means that the bottom near part of the more advantage larvae may not be reached with normal sampling program (Urho & Hilden 1985).

The 14-hour sampling, in a bay without currents, indicates that the density of yolk sac larvae stayed at the same level but the variation in extremes of values was twofold (fig. 8). Changes in vertical or horizontal distribution are thought to be the reasons for these density variations. Short time sampling experiments in a tide-influenced estuary have shown that vertical distribution may change extensively within a day (Portier & Leggett 1982, 1983). As vertical distribution is not unambiguous the smelt larvae program continues sampling at several strata, and in addition when possible, in single oblique hauls with Gulf V.

Giving a hatching size of 5 mm and a growth rate of 0,3 mm/day, the theoretical catchability time of yolk sac larvae is 6-7 days. Thus sampling should take place at least once a week in order to overhaul each cohort. This was not accomplished during the years of pilot studies (1978-79). After that weekly sampling has as far as possible been carried out, at least in Maxmo (I) and in Vaasa (III).

The adequancy of sampling stations depends largely on the distribution pattern of the larvae. For this reason our sampling program should been larged. Especially in the most important area in Maxmo off the River Kyrönjoki, the network of sampling stations should be expanded to cover the whole distribution area. This is necessary to reveal year-to-year variations in the total area of larval production, which seems to be of major importance for the understanding of the variations in year class strengths (Hudd unpubl.).

References

AXELL, M., NYMAN, S. and KYRÖLÄINEN, H. 1984: Fiskeri-, bottendjurs- och bottensedimentutredning i havsområdet utanför Vasa 1983. Vasa 54 pp. (mimeo).

DUNSTALL, T.G. 1984: Distribution of rainbow smelt and alewife larvae alone the north shore of Lake Ontario. - J. Great Lakes Research 10 (3): 273-279.

FORTIER, L. & LEGGETT, W.C. 1984: Small-scale covariability in the abundance of fish larvae and their prey. - Can.J.Fish. Aquatic Sc. (41 (3): 502-512.

HILDÉN, M., HUDD, R. and LEHTONEN, H. 1982: The effects of environmental changes on the fisheries and fishstocks in the Archipelago Sea and the Finnish part of the Gulf of Bothnia. - Aqua Fennica 12: 47-58.

HUDD, R. 1985a: Assessment of the smelt (Osmerus eperlanus (L.)) stock in the Northern Quark, Gulf of Bothnia. - Finnish Fish. Res. 5: 55-68.

HUDD, R. 1985b: The mean fecundity of smelt (Osmerus eperlanus (L.)) in the Northern Quark, Gulf of Bothnia, in 1981-84. - ICES C.M. 1985/J:27.

HUDD, R. et. al. 1984: Fishery investigations (in 1980-1982) of the Kyrönjoki River estuary and its influence area in the northern Quark of the Baltic Sea. - National Board of Waters, Finland. 242B: 1-249. (English summary).

LILLELUND, K. 1961: Untersuchungen über die Biologie und Populationsdynamik des Stintes Osmerus eperlanus eperlanus (LINNAEUS 1798), der Elbe. - Arch. Fischereiwiss. XII: 1-128.

SCHNACK, D. 1974: On the biology of herring larvae in Schlei Fjord, Western Baltic. - Rapp. P.-v. Réun. Cons. int. Explor. Mer. 166: 114-123.

SJÖBLOM, V. and PARMANNE, R. 1976: Abundance of Baltic herring larvae in the seas around Finland in 1975. ICES C.M. 1976/P:12

SJÖBLOM, V. & PARMANNE, R. 1976: Abundance of Baltic herring larvae in the seas around Finland in 1975.

TIN, H.T. & JUDE, D.J. 1983: Distribution and growth of larval rainbow smelt in eastern Lake Michigan, 1978-1981. - Trans. Am. Fish. Soc. 112: 517-524.

URHO, L. and HILDÉN, M. 1985: Catch-variability of smelt larvae in a shallow estvarine area of the Baltic Sea. - (Unpubl.)

URHO, L.; HILDÉN, M. & HUDD, R. 1985: The Kyrönjoki estuary as a nursery area for fish and the effects of environmental changes. - (unpubl.).

Table 1. Mean densities of smelt larvae at permanent sampling stations (in 1978-84).

		1978	1979	1980			1981			1982			1983			1984			
		1	1	1	2	3	1	2	3	1	2	3	1	2	3	0	1	2	3
Maxmo (I)	n	–	–	7	8	8	8	8	–	9	1	–	7	6	3	6	–	8	–
	x	–	–	0.82	0.74	0.11	0.99	0.19	–	9.76	2.17	–	0.58	0.13	0.84	1.00	–	4.38	–
	S.E.	–	–	0.38	0.24	0.07	0.61	0.08	–	9.62	–	–	0.22	0.06	0.74	0.38	–	2.08	–
	X_a	–	–	1.28	1.04	0.31	1.05	0.22	–	12.76	2.56	–	0.77	0.51	1.43	1.15	–	5.48	–
	S.E.	–	–	0.40	0.35	0.16	0.63	0.08	–	12.62	–	–	0.35	0.26	1.03	0.48	–	2.17	–
Köklot(II)	n	–	3	10	8	–	10	–	–	–	10	–	3	3	–	5	6	–	–
	x	–	0.73	0.02	0.00	–	0.48	–	–	–	0.45	–	0.49	0.00	–	0.71	0.12	–	–
	S.E.	–	0.43	0.01	–	–	0.24	–	–	–	0.24	–	0.26	–	–	0.41	0.06	–	–
	X_a	–	0.75	0.03	0.00	–	0.51	–	–	–	1.01	–	0.90	0.00	–	0.83	0.21	–	–
	S.E.	–	0.43	0.02	–	–	0.24	–	–	–	0.63	–	0.58	–	–	0.49	0.13	–	–
Vaasa(III)	n	8	6	7	7	–	7	5	–	4	7	–	7	6	–	10	6	6	6
	x	2.30	1.06	0.39	0.36	–	0.21	0.47	–	0.09	0.93	–	0.26	0.69	–	0.73			
	S.E.	0.92	0.42	0.17	0.12	–	0.08	0.26	–	0.07	0.33	–	0.08	0.37	–	0.24			
	X_a	2.65	2.21	0.45	0.58	–	0.21	0.53	–	0.11	1.41	–	0.34	0.95	–	0.74	0.40	0.15	0.15
	S.E.	1.01	0.92	0.19	0.28	–	0.08	0.25	–	0.07	0.47	–	0.11	0.44	–	0.24	0.27	0.06	0.09
Malax(IV)	n	–	–	4	4	–	–	5	5	–	5	4	5	4	–	5	–	5	5
	x	–	–	1.27	0.47	–	–	0.20	0.05	–	0.56	0.04	0.24	0.03	–				–
	S.E.	–	–	0.36	0.10	–	–	0.13	0.03	–	0.19	0.02	0.14	0.03	–				
	X_a	–	–	2.88	2.02	–	–	0.30	0.11	–	8.56	0.40	2.32	0.20	–	5.32	–	0.14	0.00
	S.E.	–	–	0.77	0.42	–	–	0.15	0.04	–	2.87	0.10	0.83	0.15	–	2.32	–	0.08	–

n = number of samples
x = mean density of yolk-sac smelt larvae (ind./m^3)
x_a = mean density of all smelt larvae
S.E.= standard error of the mean

0= last week of May
1= first week of the June
2= second week of june
3= later half of June

Table 2. Comparison between Gulf V and Gulf-olympia in Vasa (III) (7 June 1983).

Station	Density of smelt yolk-sac larvae (ind./m^3) Gulf V	Gulf-olympia
1	0,11	0,17
2	0,65	0,46
3	0,20	0,14
4	0,35	0,36
5	0,05	0,00
6	0,03	0,07
Mean	0,23	0,20

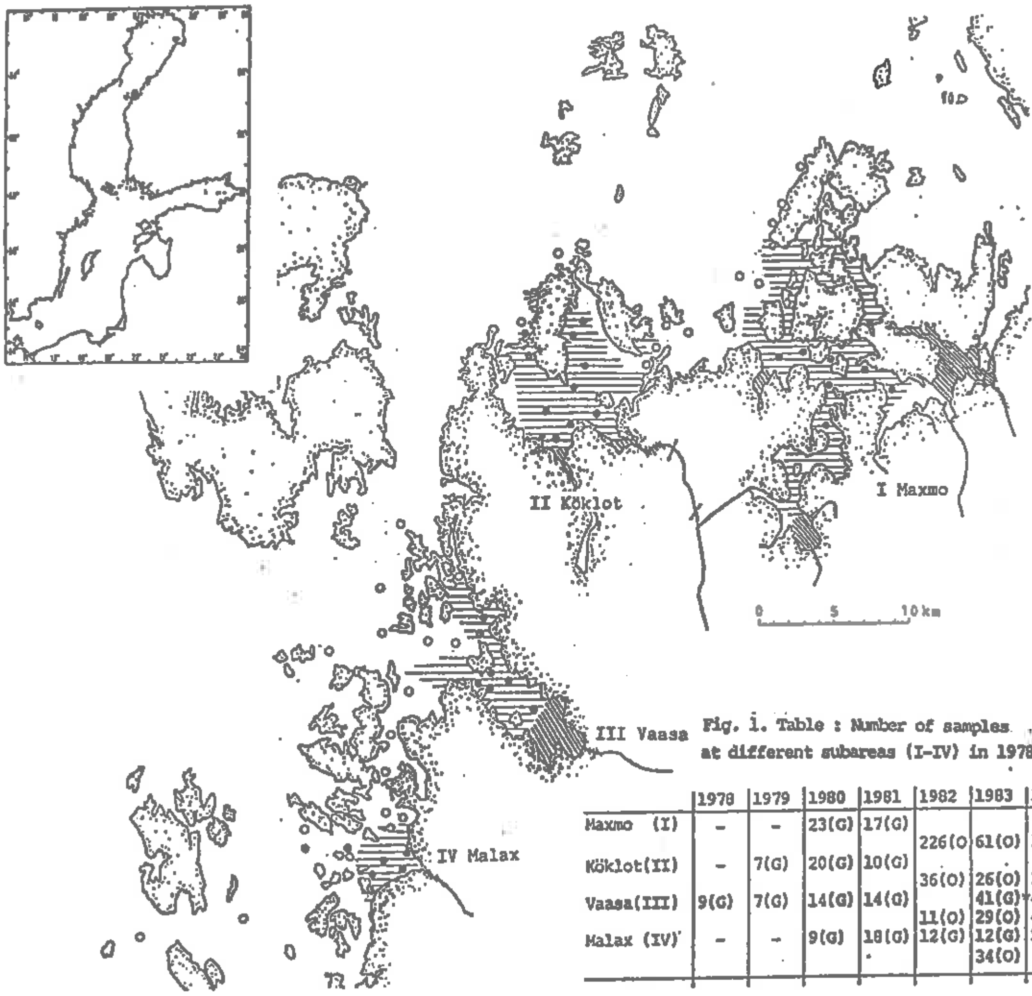

Fig. 1. Table : Number of samples at different subareas (I-IV) in 1978-84.

	1978	1979	1980	1981	1982	1983	1984
Maxmo (I)	-	-	23(G)	17(G)	226(O)	61(O)	155(O)
Köklot(II)	-	7(G)	20(G)	10(G)	36(O)	26(O)	34(O)
Vaasa(III)	9(G)	7(G)	14(G)	14(G)	11(O)	41(G)* 29(O)	42(G)* 49(O)
Malax (IV)	-	-	9(G)	18(G)	12(G)	12(G) 34(O)	21(G)

(O)= Gulf-olympia sampler
(G)= Gulf V sampler
* = samples taken by Axell (Axell 1984)

Fig. 1. Study area and the occurence of yolk sac smelt larvae

- Permanent sampling stations
- Sampling station where yolk sac smelt not found
- Occurence area of smelt yolk sac larvae in 1983-1984
- Water pH almost permanently below 5

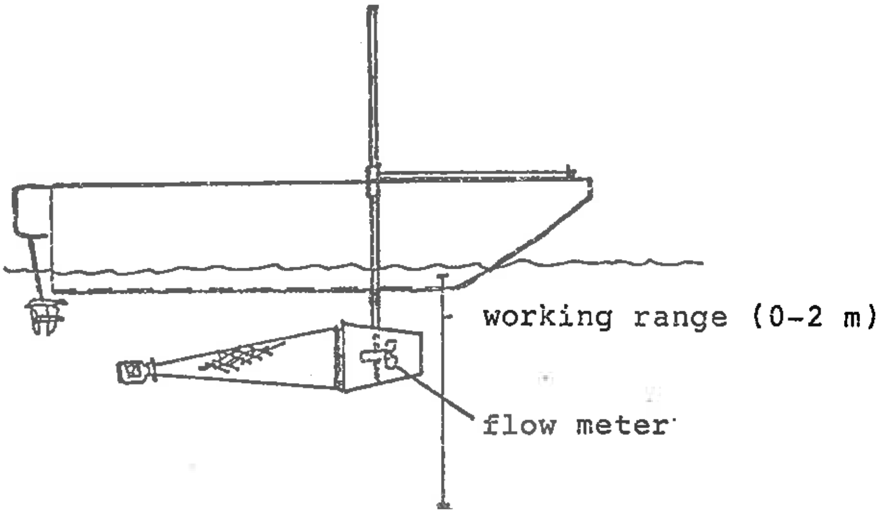

Fig. 2. The principle of the Gulf-olympia sampler

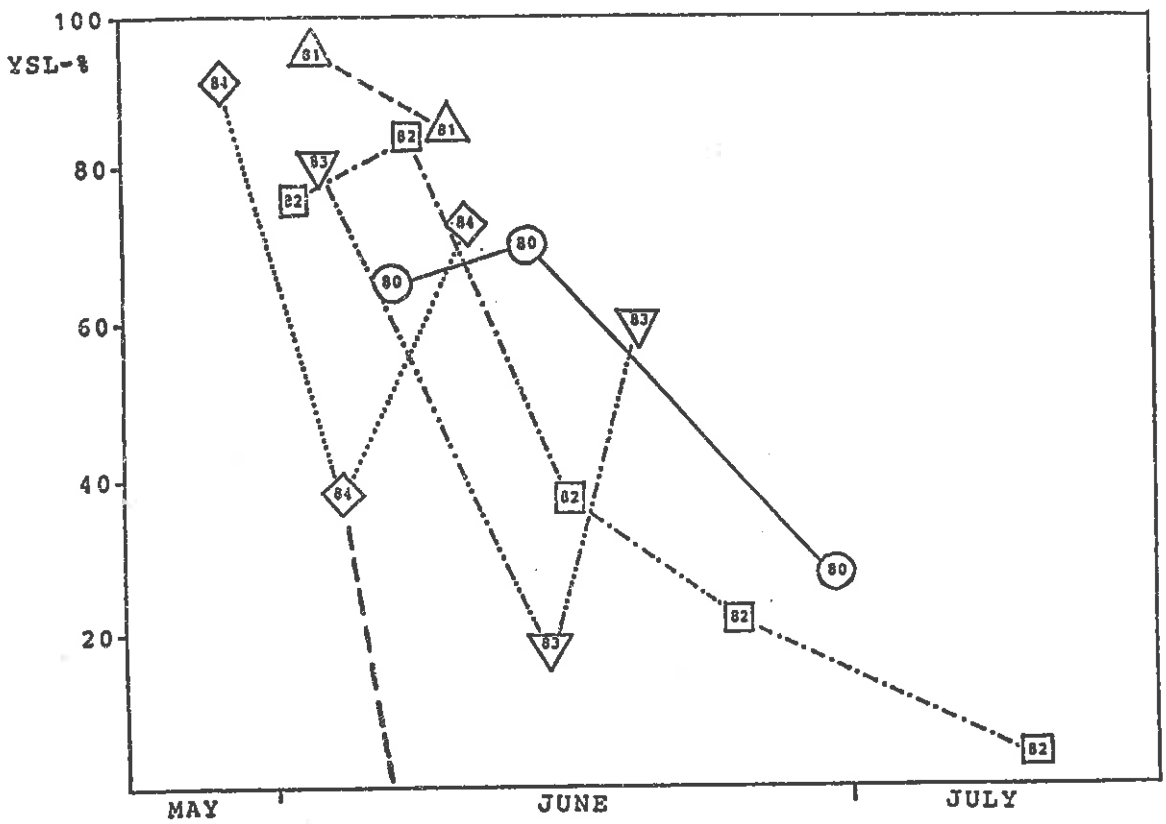

Fig. 3. Share of yolk sac smelt larvae in Maxmo (I) samples in 1980-84

* Sampling elsewhere than at permanent stations

— — —Theorethical curve, with hatching size 5 mm and growth rate 0.3 mm/d

Fig. 4. Densities of smelt larvae in Maxmo (I) in 1980

a 7 June
b 14 June
c 30 June

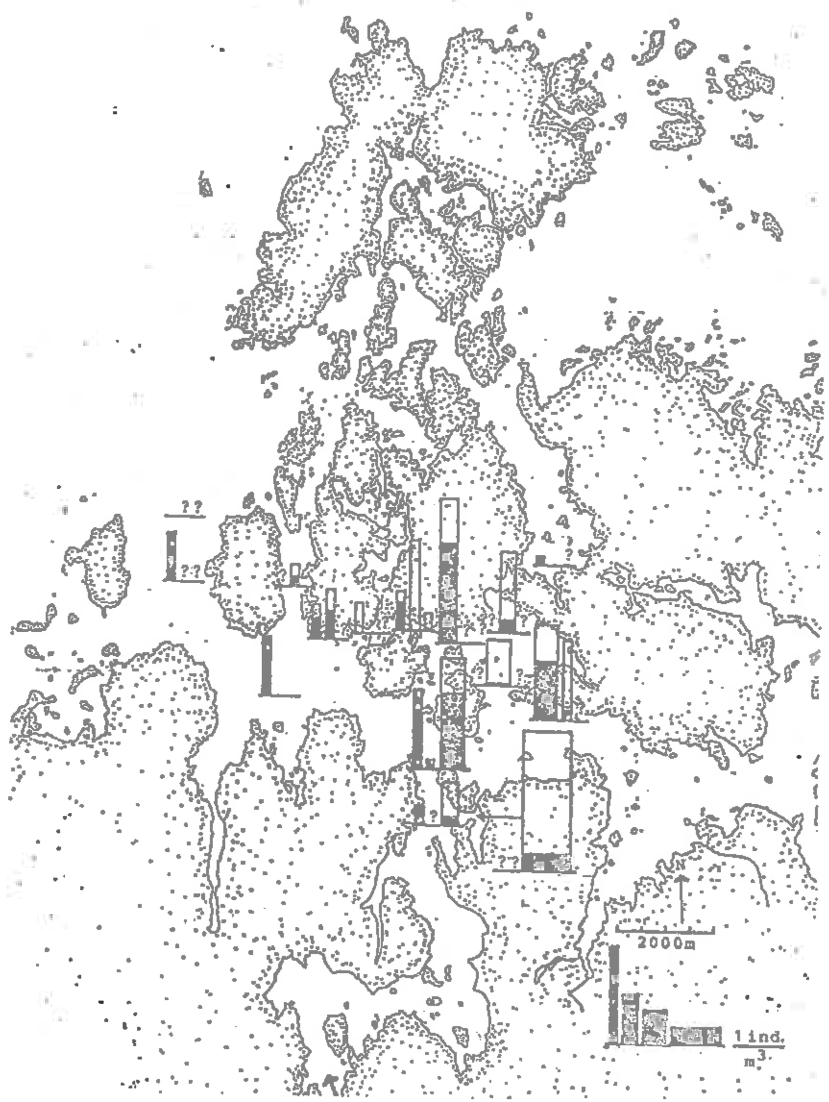

Fig. 5. Densities of smelt in Maxmo (I) in 1983

a 3 June
b 15 June
c 20 June

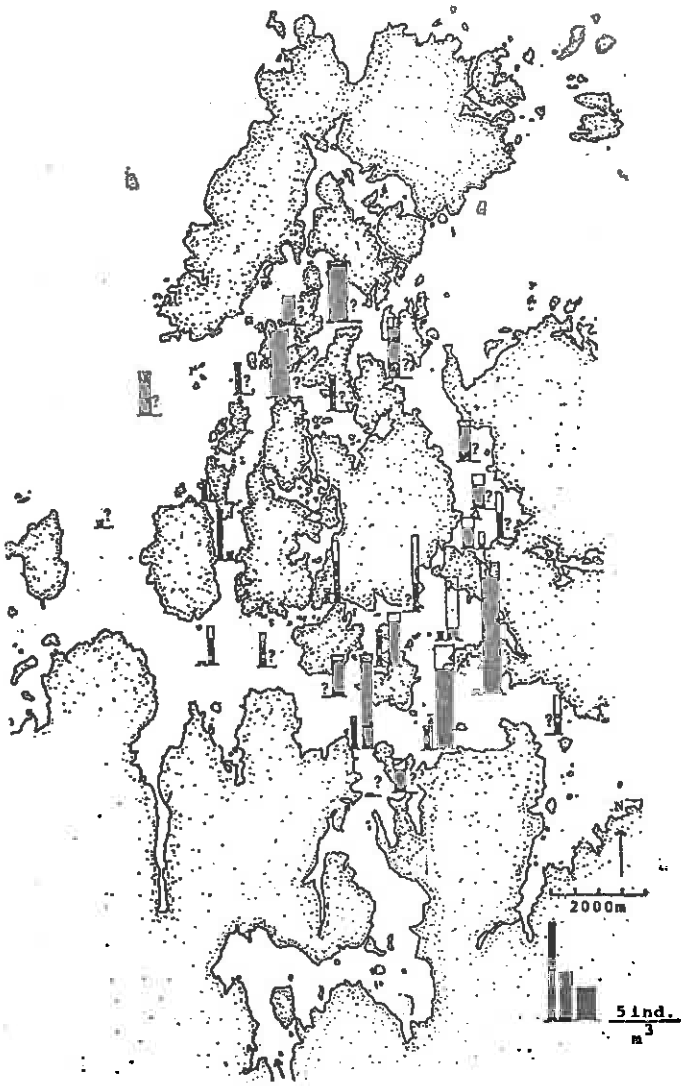

Fig. 6. Densities of smelt larvae in Maxmo (I) 1984

a 28 May
b 11 June

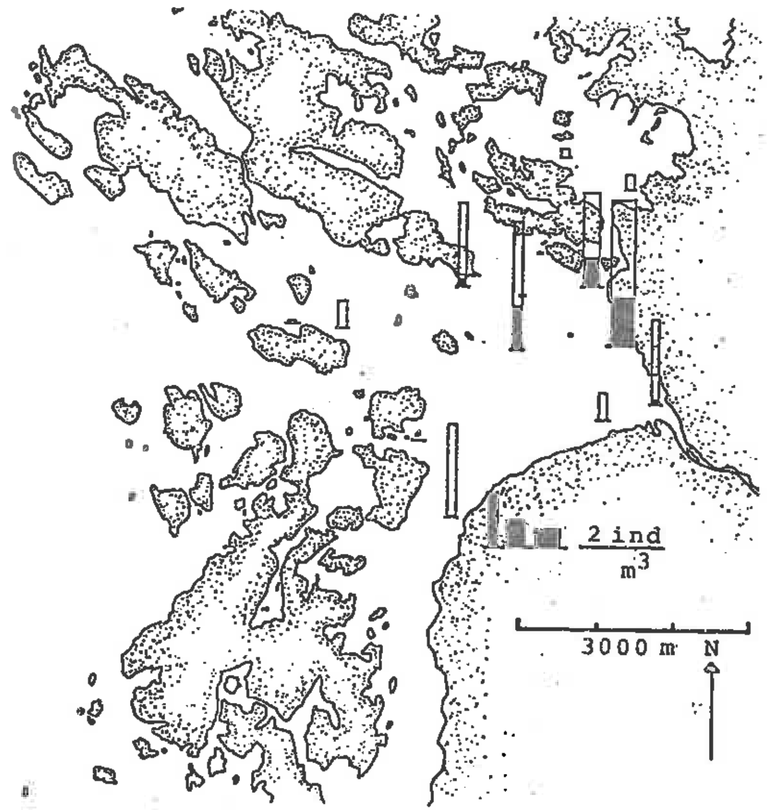

Fig. 7. Densities of smelt larvae in Malax (IV)
7 June 1982

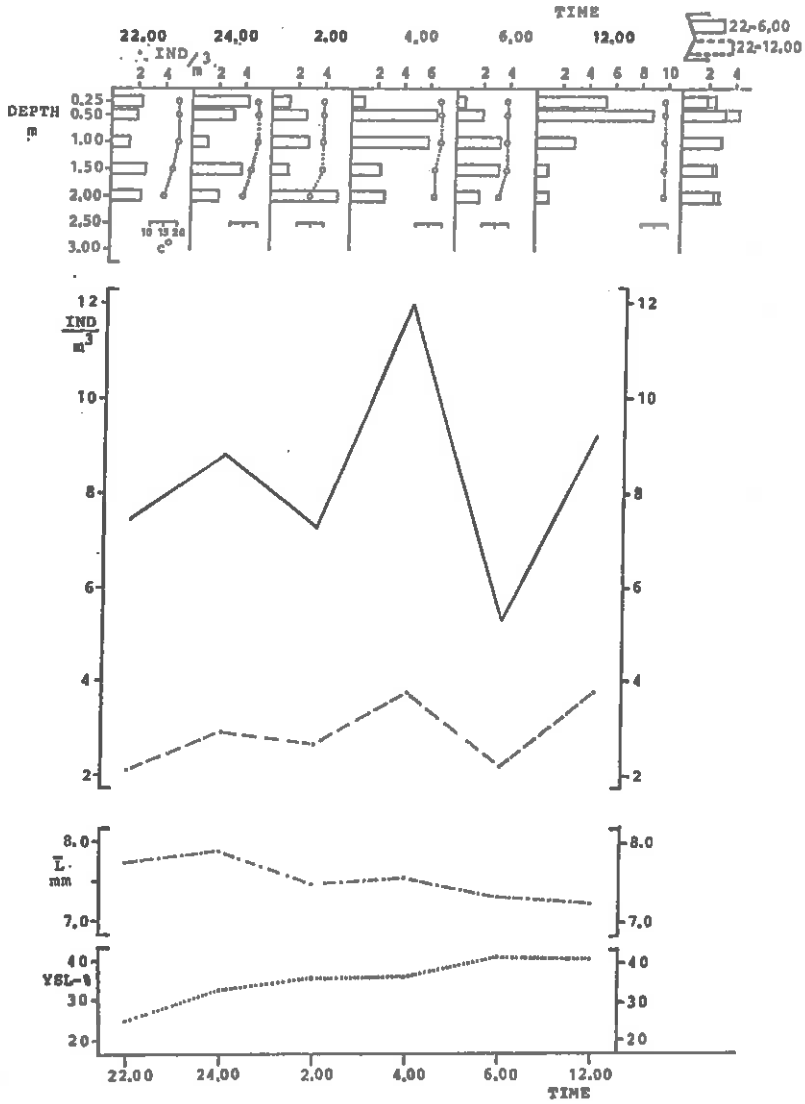

Fig. 8. Vertical distribution of yolk sac smelt larvae and mean densities during 14-hour sampling (4.-5.6. 1984) in Maxmo subarea (I).

——— density of all smelt larvae
— — — density of yolk sac smelt
·—·—·— mean total length
·········· % of larvae 7 mm (YSL %)
··o···o·· temperature

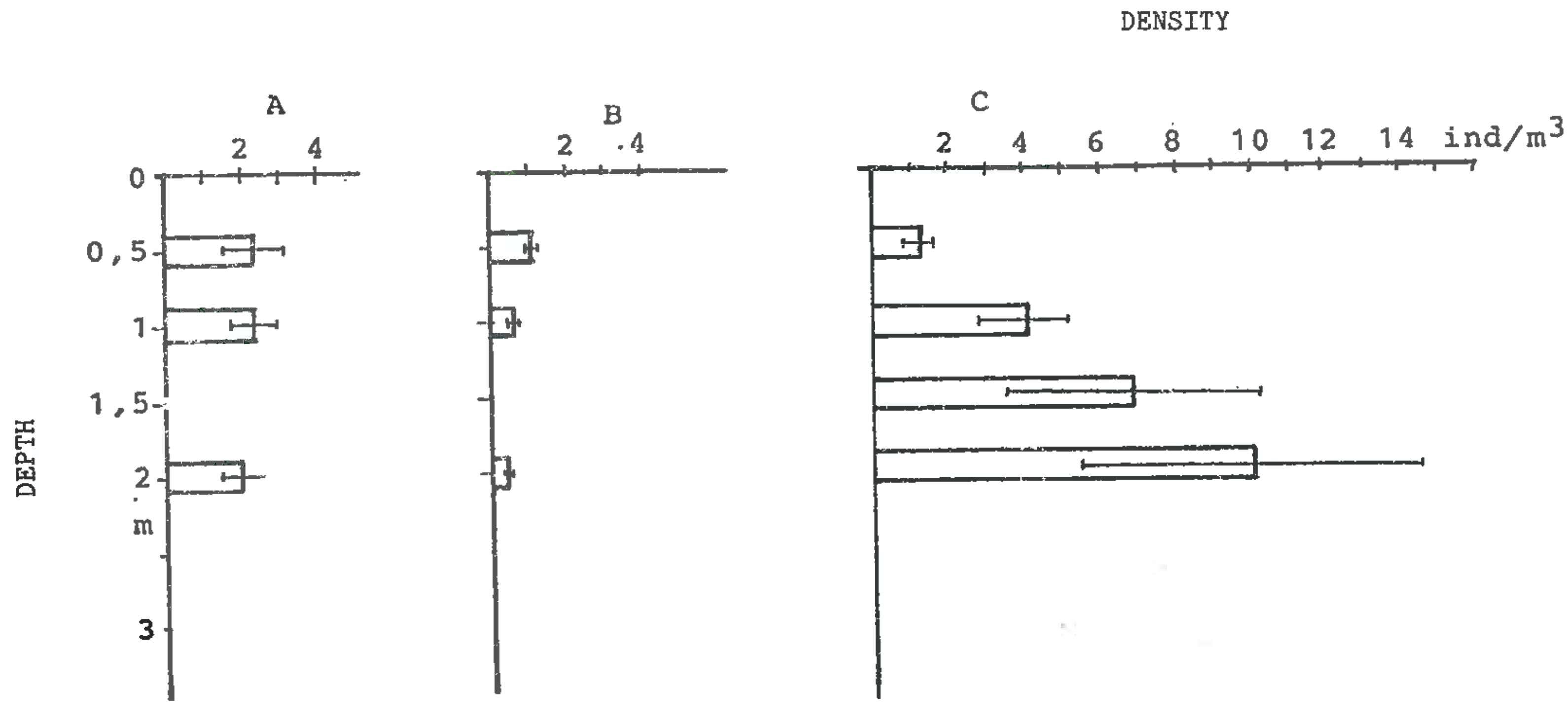

Fig. 9. Mean densities of yolk sac smelt larvae at different depth strata density ind./m^3 ± S.E.

A. 28.-29.5.-84	Maxmo, Köklot, Vasa	n=72	28-29 May
B. 30.5.-1.6.-84	Vasa	n=22	30 May-1 June
C. 11.6.-84	Maxmo	n=36	11 June

n= number of sample

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Fish Committee

MIGRATION OF SALMON POST-SMOLTS (Salmo salar L) IN THE BALTIC SEA

by

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Abstract

The migration of salmon post-smolts has been studied by tagging experiments using Carlin-tags. The paper describes the post-smolt migration of hatchery reared smolts released in the Rivers Kemijoki, Simojoki, Oulujoki and Kokemäenjoki in the Gulf of Bothnia, and in the River Kymijoki in the Gulf of Finland. The northern Gulf of Bothnia stocks migrate during the summer to the southern Gulf and towards the end of the year to the Main Basin. The Neva stock released in the southern Gulf of Bothnia and Gulf of Finland tend to stay near the releasing area. The northern stock post-smolts are mainly caught by gill-nets and trap-nets soon after their release. The Neva stock post-smolts in the southern Gulf of Bothnia are caught by gill-nets. In the Gulf of Finland post-smolts enter the long-line fishery in late autumn.

Résumé

La migration des saumoneaux a été étudiée par des expériences de marquage de saumoneaux Carlin. L'étude décrit la migration du saumoneau de pisciculture lâchés dans les rivières Kemijoki, Simojoki, Oulujoki et Kokemäenjoki qui se jetent dans le Golfe de Bothnie, et dans la Kymijoki qui débouche sur le Golfe de Finlande. Les sujets de la partie septentrionale du Golfe de Bothnie migrent durant l'été vers sa partie méridionale puis vers la Baltique proprement dite vers la fin de l'année. Les sujets de la Neva lâchés dans le sud du Golfe de Bothnie et le Golfe de Finlande tendent à rester au voisinage des régions où ils ont été lâchés. Les saumoneaux du nord sont pris essentiellement au filet et à la nasse, peu après leur mise en liberté. Les saumoneaux du sud du Golfe de Bothnie le sont à l'araignée. Dans le Golfe de Finlande, ils sont pêchés à la traîne à la fin de l'automne.

1. Introduction

Salmon post-smolt biology has become an important field of research since a major proportion of the mortality of released salmon smolts occurs during a few months after release. Knowing the factors affecting the mortality might enable excessive mortality to be avoided and make stocking more profitable. In the Baltic sea area the information on post-smolt biology has mostly been obtained through tagging programmes (Larsson et al. 1979, Lindroth et al. 1982, Jutila and Alapassi 1982). In 1980-83 a special programme for post-smolt studies (migration, feeding, predators) between several European countries was realized (Anon. 1984).

This paper aims at describing the migration routes of salmon smolts stocked in the Finnish rivers situated in the Gulf of Bothnia and the Gulf of Finland. The types of gear with which post-smolts have been caught are also discussed.

2. Material and methods

The material includes tag recoveries of post-smolts during the 12 months after their descent to the sea. Information on the recoveries has been obtained from the tag recovery data bank of the Finnish Game and Fisheries Research Institute. Tag findings from bird colonies and fish stomachs have been excluded. The material is described in the table below.

	Releasing area (river)				
	Kemijoki	Simojoki	Oulujoki	Kokemäenjoki	Kymijoki
ICES sub-division	31	31	31	30	32
Stock	Iijoki	Simojoki, wild	Montta	Neva	Neva
Number of tagged individuals	45 124	11 269	73 083	16 369	40 446
Number of post-smolt recoveries	87	94	826	102	309

3. Results and discussion

3.1 Northern Gulf of Bothnia stocks

On the basis of tag recoveries the migration route of post-smolts appears to follow the Finnish coast to the Quarken area. Only a very small fraction of the post-smolts are caught on the Swedish coast. After the Quarken post-smolts mainly follow the Swedish coast to the Main Baltic and only a few recoveries come from the Finnish coast south of the Quarken (Fig. 1).

The surface current caused by the Coriolis effect follows the Finnish coast of the Gulf of Bothnia in a northerly direction and along the Swedish coast in a southerly direction. At the Quarken area current also flows across the Gulf from the Finnish side to the Swedish side. The post-smolt migration route in the Bothnian Bay is against the current and in the Quarken and the Bothnian Sea with the current. The same phenomenon has been observed by Jutila and Alapassi (1982) and by Ikonen and Auvinen (1984a). Lindroth et al. (1982) and Larsson and Ateshkar (1979) have postulated that post-smolt migration of smolts originating from Sweden always follows the current. Thus the current does not appear to be necessarily the main factor affecting the direction of migration.

In early June when smolts are descending to the sea the surface temperature in the Gulf of Bothnia varies much. Surface temperature is highest near the shores. Isoterms of 7 and 8 centigrades follow the Finnish coast of the Bothnian Bay and the coasts of the Bothnian Sea. In the Quarken isoterms cross the Gulf of Bothnia (Fig. 2, Palosuo 1976). If the post-smolts tend to keep contact with these isoterms or search for warmer water they should migrate as presented by the tag recoveries shown in Fig. 1. In the Quarken the temperature layer which they follow leads the post-smolts near to the Swedish coast. In the Gulf of St. Lawrence in Canada the post-smolt migration has been observed to be affected by the surface temperatures (Dutil 1985).

The migration pattern of post-smolts of wild origin (River Simojoki) does not seem to differ from the hatchery reared northern stocks.

The stocking time in the Bothnian Bay area is usually late May or early June. The first post smolts in the Quarken are caught as early as June but the majority of recoveries in June-July still come from the northern Bothnian Bay. In August the first post-smolts reach the southern part of the Gulf of Bothnia and the majority are caught in the Quarken. In September-November most of the recoveries come from the southern part of the Gulf and the first post-smolts have been caught in the Main Baltic. A proportion of the fish released in the River Oulujoki seem to stay near to the releasing place until December. This odd behaviour might be caused by the physiological state of these fish at release. It has been ovserved that some hatchery reared fish that are not fully smoltified will enter rivers after the release. The post-smolts that stay in the Bothnian Bay during the winter will probably die since no recoveries are reported from the spring months although there is an under-ice gill-net fishery.

The tabel below shows the number of tag recoveries from different gear categories in each month.

	Month													
Gear category	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Par	May	Total
Gill net	118	48	11	9	6	12	4		3	2	8	8	12	241
Trawl		10	3	1	1	1		2						18
Trap-net	5	168	31	7		3	3						5	222
Hooks		5		1	1	3	7	2	2	1	1	1	1	25
Dip-net						20	4							24
Total	123	231	45	18	8	39	18	4	5	3	9	9	18	530

Small mesh-sized gill-nets and trap-nets take the bulk of post-smolts during May-July soon after release. Catches by hooks are mainly salmon long-line catches that undersized post-smolts enter from October onwards in the Bothnian Sea and the Main Basin. Dip-net catches are a by-catch of the migratory whitefish fishery in the rivers. These recoveries represent fish that have entered, or stayed in, the rivers after the release.

3.2 Neva stock released in the southern Gulf of Bothnia

The post-smolt migration of salmon smolts released in the southern part of the Gulf of Bothnia is over a very limited area. Post-smolts seem to have a tendency to stay near the releasing area (Fig. 3).

The migration pattern of Neva stock salmon differs from that of the northern stocks. About 90 % of all recoveries come from the Gulf of Bothnia (Ikonen and Auvinen 1984a). In the releases in the Bothnian Bay with northern stocks the corresponding percentages is 50.

Post-smolts have been caught by gill-nets (69 %), by trap-nets (29 %) and by long-lines (2 %). In southern Gulf of Bothnia the number of post-smolt recoveries is very small compared with the northern part of the Gulf. The reason for this is possibly that in this area there is very little fishery capable of catching post-smolts. In the Bothnian Bay the whitefish gill-net fishery is intensive and takes salmon and sea-trout post-smolts as a by-catch (Ikonen and Auvinen 1984b).

3.3 Neva stock in the Gulf of Finland

The Neva stock salmon smolts released in the mouth of the River Kymijoki are caught soon after release in the nearby area with gill-nets (45 % of total post-smolt recoveries). Later in the summer they seem to migrate to the south-east from the rivermouth to the Haapasaari area where they recruit the long-line fishery in October (Fig. 4). This area is also the most important feeding area for adult salmon (Ikonen and Auvinen 1984a) and the migratory whitefish of the River Kymijoki (Ikonen 1982). Longline recoveries constitute 46 % of total recoveries.

Caspian tern predation (Sterna caspia L.) of post-smolts is appreciable in this area. The tern colony is situated on an island 25 km souht-west of the river mouth (Valle 1985).

REFERENCES

Anon. 1984: Action cost 46. Mariculture. Rapport final 1980-1983. Commission des Communautes Europeennes.

Dutil, J.D. 1985: The Danadian research on post-smolts in the Gulf of St. Lawrence. -Appendix in the report of Baltic Salmon and Trout Assessment Working Group, ICES C.M. 1985/ Assess:14.

Ikonen, E. 1982: Migration of river-spawning whitefish in the Gulf of Finland. -Finnish Fisheries Research 4: 40-45.

Ikonen, E. & Auvinen, H. 1984a: Migration of salmon in the Baltic Sea, based on Finnish tagging experiments. -ICES, Doc. C.M. 1984/M:4 (mimeo).

Ikonen, E. & Auvinen, H. 1984b: Migration of sea trout stocks in the Baltic Sea on the basis of Finnish tagging experiments. -ICES, Doc. C.M. 1984/M:5 (mimeo).

Jutila, E. & Alapassi, T. 1982: Report on post-smolt recaptures in Finnish salmon tagging experiments (mimeo).

Larsson, P.O. & Ateshkar, S. 1979: Laxsmoltens vandring från Luleälven. -Fiskeritidskrift för Finland, ny serie 23 (1): 8-9.

Larsson, P.O., Larsson, H.D. and Eriksson, O.C. 1979: Review of Swedish salmon (Salmo salar L.) stocks based on results of tagging experiments. -Salmon Research Institute Report 1979: 5, 28 p.

Lindroth, A., Larsson, P.O. & Bertmar, G. 1982: Where does the Baltic salmon go? -In: Muller, K. (ed.): Coastal Research in the Gulf of Bothnia. -Dr. W. Junk Publishers, The Hauge, Boston, London. pp. 387-414.

Palosuo, E. 1976: Atlas of surface water temperatures and salinites in the Gulf of Bothnia. Summer period I. -Report Series in Geophysics 2. University of Helsinki.

Valle, E. 1985: Predation of birds on salmon and sea-trout smolts and post-smolts. - ICES, Doc. 1985/M:22 (mimeo).

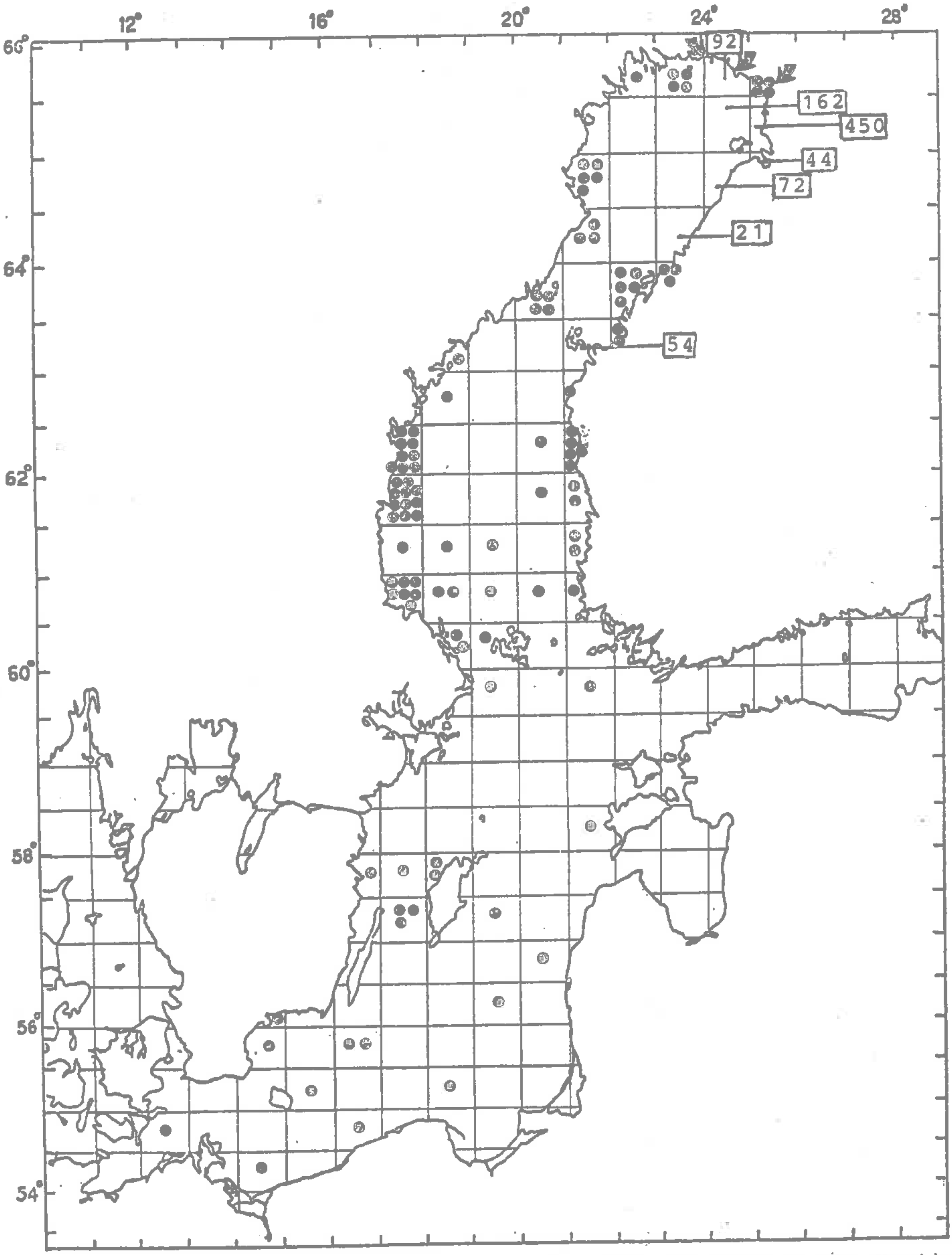

Figure 1 Post-smolt tag recoveries of salmon released in the Kemijoki, Simojoki and Oulujoki rivers in the Bothnian Bay
Figures and dots indicate number of recoveries in rectangle
releasing place

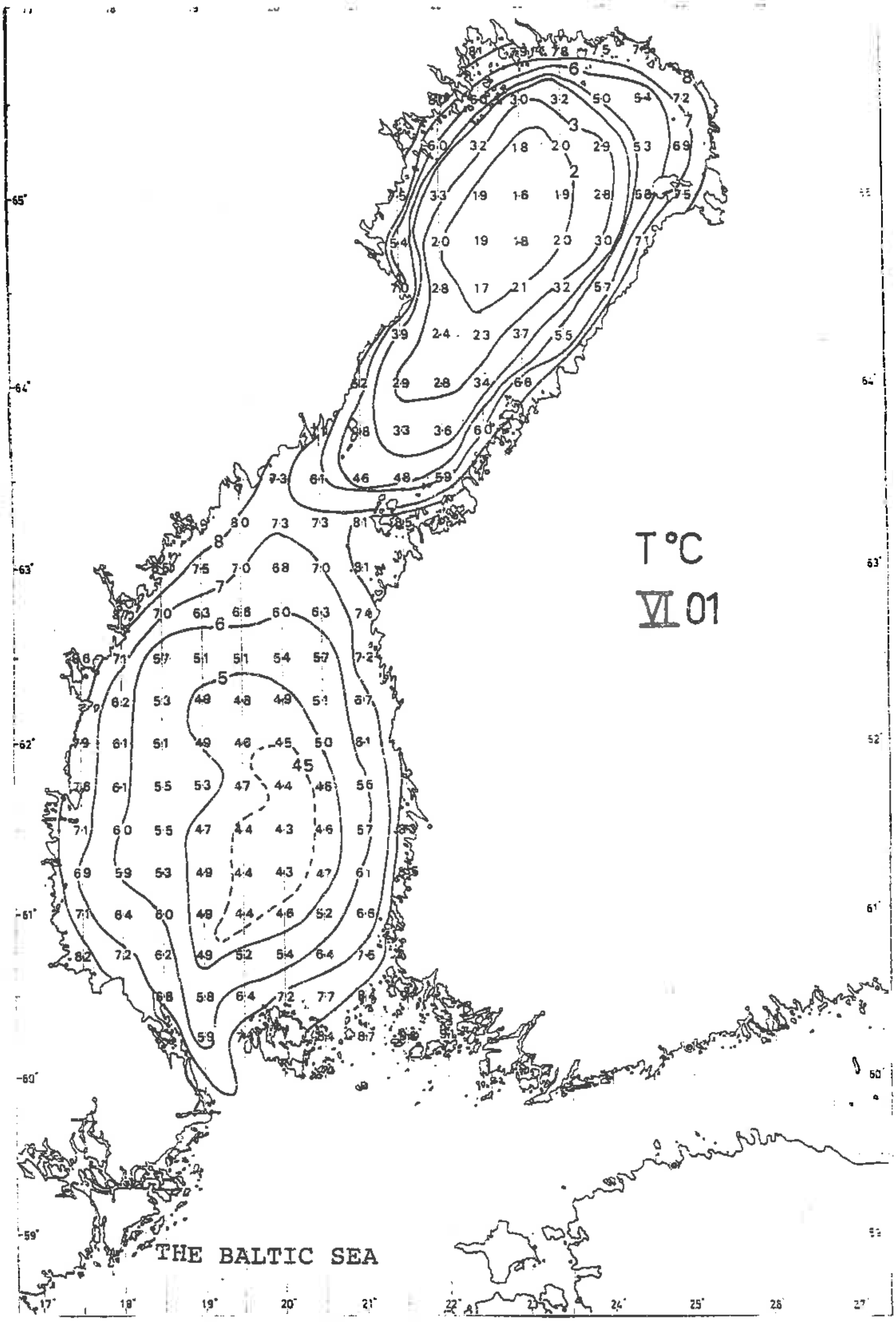

Figure 2 Surface water temperature in the Gulf of Bothnia during early June (Palosuo 1976)

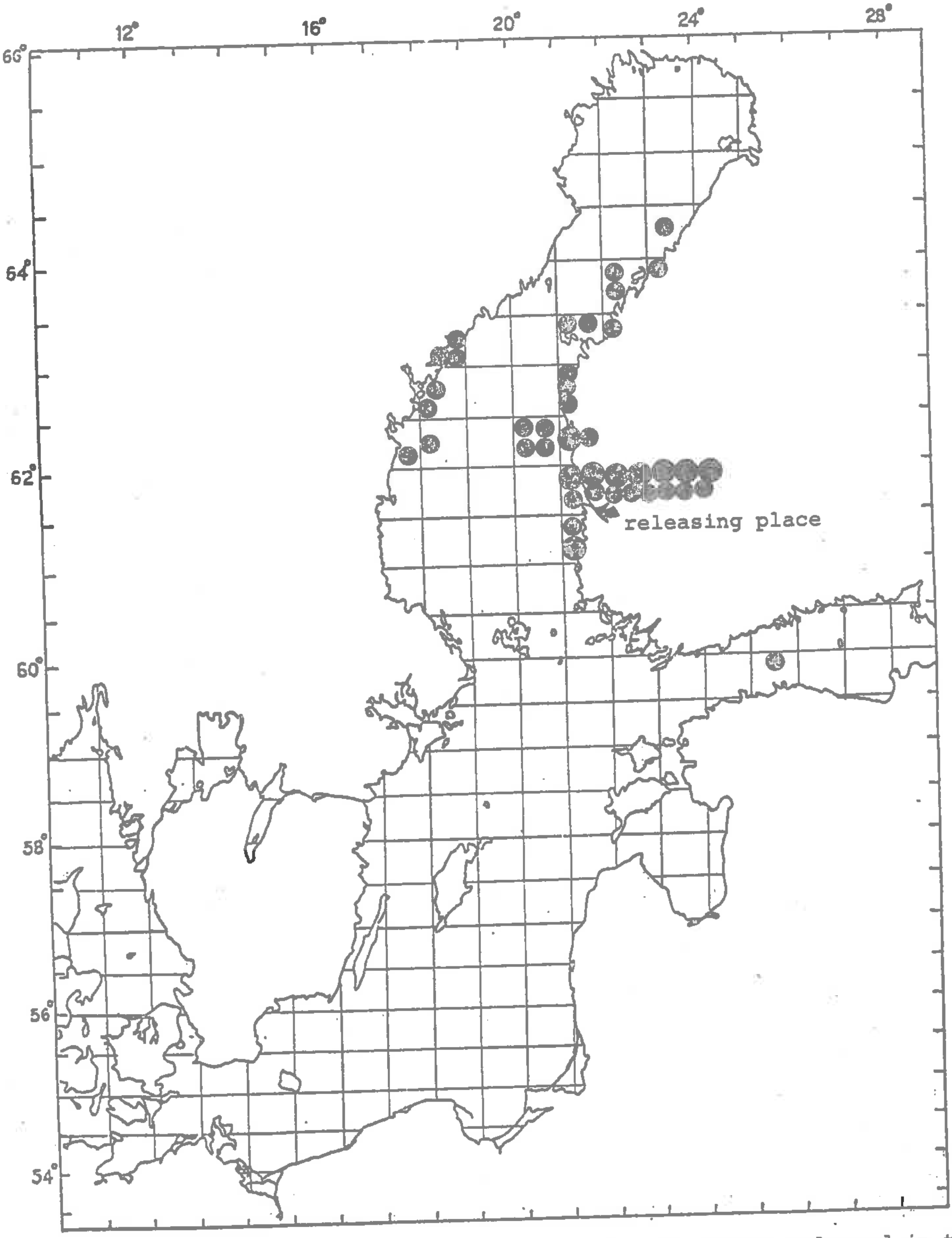

Figure 3 Post-smolt tag recoveries of salmon released in the Kokemäenjoki river in the Bothnian Sea
Dots indicate number of recoveries in rectangle
● one recovery ● 10 recoveries

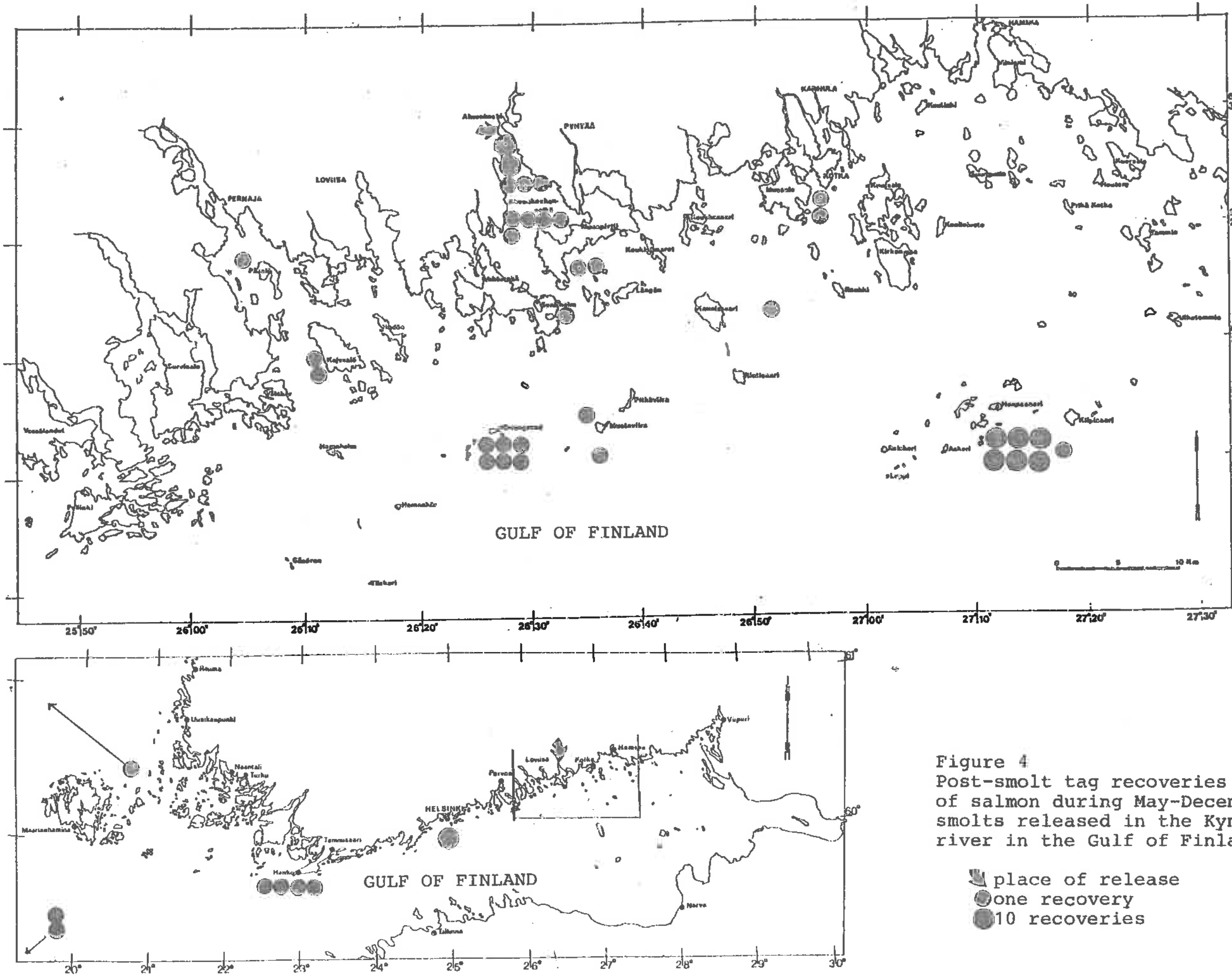

Figure 4
Post-smolt tag recoveries of salmon during May-December, smolts released in the Kymijoki river in the Gulf of Finland

- place of release
- one recovery
- 10 recoveries

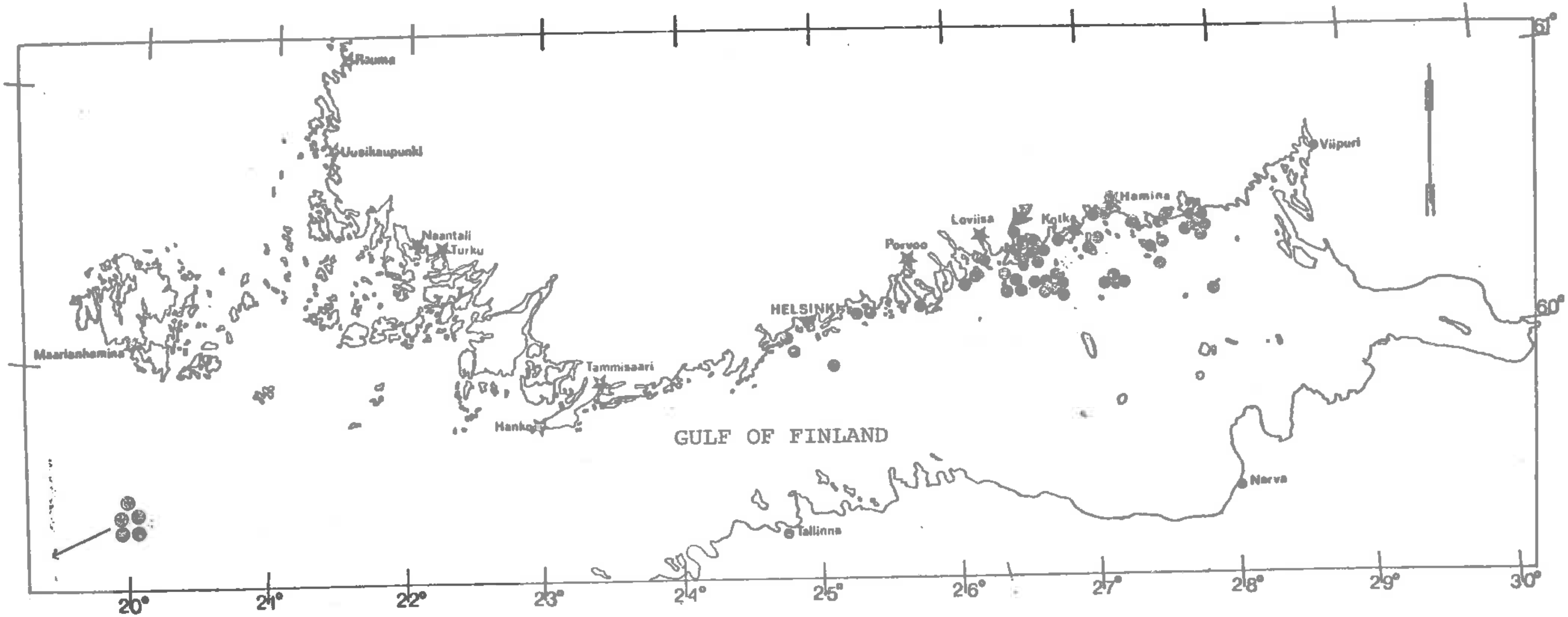

Figure 4b
Post-smolt tag recoveries of salmon during the second calender year (January-May), smolts released in the Kymijoki river in the Gulf of Finland

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PARR DENSITIES AND GROWTH RATE OF SEA TROUT (SALMO TRUTTA M. TRUTTA) IN THE RIVER VANTAANJOKI

by

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Abstract

Feeding sea trout fry were released in the rapids of the river Vantaanjoki in 1982 and 1983. The aims were to study the size of the densities of 1 + parr that will be achivied using different stocking densities, to establish the survival rate of fry with different stocking densities and to determine whether the growth of fry and parr is dependent on parr density. A comparison of growth rate of parr was also made between two tributaries of this river system in 1984.
Initial densities were 100, 1000 and 2000 fry per 100 m^2. Parr densities of age group 1 + varied between four and 47 parr per 100 m^2. The higher the stocking density the lower the survival, varying between 2.3 and 9.2 % during the first 14 months. The growth rate of parr does not seem to be dependent on parr density, and in the two rapids each of which was situated on a different tributary, the growth rates of parr did not differ.

Résumé

Des alevins d'élevage de truite de mer ont été lâchés en 1982 et 1983 dans les rapides de la rivière Vantaanjoki dans le but d'étudier la taille des densités de 1 + tacons obtenue selon les densités de peuplement utilisées, afin d'établir le taux de survie des alevins en fonction des différentes densités et de déterminer si la croissance des alevins est dépendante ou non de la densitéde tacons. Une comparaison du taux de croissance des tacons a également été effectuée en 1984 pour deux affluents du même réseau hydrique. Les densités initiales étaient de 100, 1000 et 2000 alevins au m^2. Les densités de tacons du groupe d'âge 1 + ont varié entre 4 et 47 tacons pour 100 m^2. Plus forte était la densité de mailles et plus faible la survie, variant entre 2,3 et 9,2% durant les 14 premiers mois. Le taux de croissance des tacons ne semble pas dépendre de la densité de tacons et, dans les deux rapides, situés chacun sur un affluent différent, les taux de croissance des tacons ne présentaient pas de différence.

Introduction

Sea trout previously existed in the river Vantaanjoki, which flows into the Gulf of Finland, but the stock was destroyed by damming and pollution of the river. Since the 1970s the water quality has been improved through waste water purification procedures. Experiments in restocking the river with sea trout (Salmo trutta m. trutta) were therefore carried out.

Sea trout alevins were released into two rapids on the Vantaanjoki in 1982 and 1983. Parr densities and growth rates of sea trout populations were studied yearly by electrofishing surveys in 1982-1984. The aim of this experiment was to monitor year class 1 + parr dansities, growth rates and survival in the different rapids originating from the different stocking densities. Similar experiments with sea trout have been made by Huovila (1982) in the river Kiiminkijoki, which flows in to the Gulf of Bothnia, and by McCarthy (1984) in Ireland with salmon fry.

Materials and methods

This study was carried out in the two rapids (Ruutinkoski and Kaukaksenkoski) of the Vantaanjoki and its tributary, the Keravanjoki (Fig. 1.).
The most important hydrological data on these rapids are presenten in (Table 1.).
The tributaries of the Vantaanjoki flow through humus soil, /c which impacts a brownish colour to the water. The middle and lower reaches of the river pass through an area of clay soil, where intensive farming is practised. Hence the river changes from brownish to clay-grey in its lower reaches.Because of this clay and the farming, the river water is well buffered. There are also none of the problems with low pH which can be found in many other Finnish rivers. Nutrients are leached into the river in abundance from the farmed area.

The most numerous fish species in the rapids before the release of sea trout, were gudgeon (Gobio gobio), bullhead (Gottus gobio), chub (Leuciscus cephalus), roach (Rutilus rutilus), bleak (Alburnus alburnus) and burbot (Lota lota) caught by electrofishing in 1980 and 1981.

Stocking with sea trout alevins was carried out in May 1982 and 1983. (Table 2.)

Moreover in 1984 sea trout alevins were released into both rapids in order to obtain information about 0+ sea trout growth during this year.

Sea trout alevins were distributed in an area of 1200 square metres in the upper reaches of the Ruutinkoski rapids. In the Kaukaksenkoski rapids the alevins were released just above the rapids.

Before the release of the alevins, the water in which they were transported and the river water were equalized by mixing river water into the tank.

The stock of released alevins originated from the river Isojoki, which flows into the Gulf of Bothnia. The eggs originated from the hatchery-reared spawners kept in the Porla fish hatchery in Lohja. Incubation water in the Porla hatchery comes from wells (temperature 6 $^{\circ}C$). That is why the eggs were already hatched in January and the mean length of the feeding fish was 3.8cm during the May release.

Electrofishing surveys were carried out in July 1983 and 1984 using Lugab 1000 (1000W) apparatus run by a Mase 600 generator. The apparatus produces pulsed direct current. The voltage used was 400-600 volts depending on the conductivity of the water.

Electrofishing surveys were made in the experimental areas surrounded by smallmesh nets. Each area was fished three times, with an interval of 10-20 minutes between each fishing. The fish caught were released into the same place in the rapids immendiately after measuring. The data on experimental areas are presented in Table 3 .

Parr densities ($\hat{N}$) and catchabilities ($\hat{p}$) of sea trout were estimated using the successive removal method (Junge & Libosvarsky 1965) as follows:

$$\hat{N} = \frac{6x^2 - 3xy - y^2 + y\sqrt{y^2 + 6xy - 3x^2}}{18(x-y)}$$

$$\hat{p} = \frac{3x - y - \sqrt{y^2 + 6xy - 3x^2}}{2x}$$

where $x = 2C_1 + C_2$

$y = C_1 + C_2 + C_3$

and C_1 is the first fishing
C_2 is the second fishing
C_3 is the third fishing

$$\hat{SE}(\hat{N}) = \sqrt{\frac{\hat{N}\ (1-\hat{q}^3)\ \hat{q}^3}{(1-\hat{q}^3)^2 - 9\hat{p}^2\ \hat{q}^2}}$$

where $\hat{q} = 1 - \hat{p}$

Because of the fairly small number of parr in individual experimental areas, the results from these areas were combined so that only one bigger area remained annually in both rapids (Table 4.). Parr densities are calculated from these bigger areas (Table 5.).

Different stocking densities were used to study the survival of fish, the size of 1 + parr density which will be achived and the effect of density on the growth rate of parr.
In the parr density studies, attention has been paid to 1 + parr. Catchability of 0 + parr was not constant during the three fishings. Hence this method gives an unreliable result for 0 + parr densities.

On the other hand 2 + parr cannot be used because at this latitude most sea trout smolt migrate to the sea at the age of two.

In 1983 the density-dependent studies for year classes 1982 (1+) and 1983 (0+) were examined and in 1984 year class 1983 (1+) was studied.

In the growth rate studies year classes 1982, 1983 and 1984 were used.

Results

Parr densities in the Ruutinkoski rapids varied between 3.8 and 10.9 individuals per 100m^2.The density was much higher in the Kaukaksenkoski rapids, varying in the range 37-166 individuals per 100m^2. The catchability of age group 0 + is about 45% and of age group 1 + between 60% and 85% (Table 5.).

It has been observed that when stocking density increases from 100 individuals to 1000 individuals per 100m^2 the parr density of age group 1 + in the rapids also increases, but when stocking density continues to increase (from 1000 ind. to 2000 ind./100m^2) it has only a slight effect on 1 + parr density (Table 6. and Fig.2.).

In these rapids parr densities vary greatly in different areas but the growth rate does not seem to be dependent on the density (Table 7.).

In summer 1984 the growth rate of sea trout parr was studied mouthly in these rapids. No differences in growth rate were observed in either age group 0 + or 1 +. 0 + parr reach a length of 100mm by the end of September and 1 + parr 165mm during the same period. (Fig. 3.).

The survival rate from alevins to 1 + parr depends on stocking density. There is no reason to greatly increase stocking density because the survival rate decreases at higher densities. It seems that 100-1000 alevins per 100m^2 is the level beyond which the profitability of stocking decreases Fig.4 and Table 6.).

Discussion

The catchability of 0 + parr is notably poorer than that of age group 1 + , mainly ouwing to the behaviour of fish in the electric field (electrotaxis and electronarcosis). The bigger the fish, the greater the body voltage between their head and tail (Vibert 1967). Small fish are also more difficult to see in the clay-grey water.

In the Ruutinkoski rapids notable differences were observed in parr densities (1+) between years 1983 and 1984 (9,2 and 3,8 / 100 m^2) even though the stocking density was the same (100 alevins / 100m^2). This might be because of the large amount of unregulated angling in the rapids in 1984.
Total parr densities in research areas have varied between 20 and 200 individuals per 100m^2. Kangur and Ling (1984) have concluded that the maximal total parr density in Estonian rivers may be as high as 100 or more individuals per 100m^2. In the river Lapväärtin-Isojoki sea trout parr densities have varied between one and ten individuals per 100m^2. Hatchery-reared parr have also been released in some rapids (Ikonen 1985 unpublished).Saltveit and Styrvold (1984) studied two regulated Norwegian rivers flowing into the Atlantic Ocean, and they observed that total parr density in the Suldalelva was 17-36 parr per 100m^2 and in the Laerdalelva densities varied between 36 and 61 per 100m^2.

Although parr density is much lower in the Ruutinkoski rapids than in the Kaukaksenkoski rapids, there are no marked differences in the growth rate of parr. This might be because in the Ruutinkoski rapids, other fish species, mainly gudgeon (Gobio gobio), are so numerous that they compete with sea trout parr, resulting in a lower growth rate. In the Ruutinkoski rapids the proportion of sea trout is about 10% and in the Kaukaksenkoski rapids about 90%. In the latter, therefore, sea trout compete only with themselves. It was also observed that the parr densities of age group 1 + do not effect the length of the age group 0 + parr or vice versa. Egglishaw and Shackley (1976) made similar observations in a Scottis river. The reason why high stocking densities are not profitable is that the survival rate decreases when the stock density is greatly increased. The mortality rate of sea trout during the first two or three months is notable. Mortensen (1976) studied the mortality rate of sea trout in three small rivers during the first six months. When this initial density increased to 310 fry per 100m^2, the mortality rate became more dependent on the density. On the other hand, with high stocking densities it is possible to create parr densities high enough for sea trout, which with their marked territorial behaviour will soon achieve a dominant position. among the other species in the rapids. This has been observed in the Kaukaksenkoski rapids.

Clay-grey water with abundant nutrients permits smaller territorial areas than do the clear and oligotrophic waters of rivers in northern Finland. Hence parr densities in the southern reacher of the Vantaanjoki can be notably high.

References

EGGLISHAW, H.J. and SHACKLEY 1976. Growth, survival and production of juvenile salmon and trout in a Scottish stream, 1966-75. - J. Fish Biol. 11: 647-672.

HUOVILA, J. 1982. Vastakuoriutuneina istutettujen meritaimenenpoikasten menestymisestä Kiiminkijoen latvavesillä.- Pro gradu- tutkielma. Oulun yliopisto. 77pp.

JUNGE, C.O. and LIBOSVARSKÝ, J. 1965. Effects of size selectivity on population estimates based on successive removals with electrical fishing gear. - Zool.listy 14: 171-178

KANGUR,M. and LING, P. 1984. Reproduction of sea trout in the southern part of the Gulf of Finland basin.-Finnish Fish.Res.(in press

McCARTHY, D.T. 1985. Stocking of salmon fry and ova in rivers. - Department of fishers and forestry, Duplin. Fisheries handbook No.2. 11pp.

MORTENSEN, E. 1977. Density-dependent mortality of trout fry (salmo trutta L.) and its relationship to the management of small streams. - J.Fish Biol.11: 613-617

SALTVEIT, S.J. and STYRVOLD, J.O. 1984. Density of juvenile atlantic salmon (Salmo salar L.) and brown trout (Salmo trutta L.)in two norwegian regulated rivers.- In : Lillehammer, A. and Saltveit, S.J. (ed). Regulated rivers. 309-319.

VIBERT, R. 1967. Fishing with electrisity -Fishing News (Books), 276pp.

Table 1. Data on the hydrology of the rapids Ruutinkoski and Kaukaksenkoski

	Ruutinkoski	Kaukaksenkoski
Length	285m	170m
Width	35m	2.9m
Area	10 000m	$500m^2$
MQ	$11.5m^3/s$	$0.8m^2/s$
Height	3.5m	8m
Precipitation area	$1\ 270km^2$	$84km^2$
Electrical conductivity (July 1984)	170ys/cm	70ys/cm

Table 2. Stocking of sea trout

	Ruutinkoski rapids		Kaukaksenkoski rapids	
year	ind.	$ind/100m^2$	ind.	$ind/100m^2$
1982	10 000	100	5 000	1 000
1983	10 000	100	10 000	2 000

Table 3. Number and mean sice of experimental areas and their share of the whole rapids

	Ruutinkoski rapids			Kaukaksenkoski rapids		
year	number	mean area(m^2)	share(%)	number	mean area(m^2)	share(%)
1983	3	83	2.5	3	101	60
1984	7	127	8.9	4	88	70

Table 4. The size of combined experimental areas in 1983 and 1984

Year	Ruutinkoski rapids (m^2)	Kaukaksenkoski rapids (m^2)
1983	250	303
1984	889	352

Table 5. Parr densities and catchabilities of sea trout parr in combined areas in the Ruutinkoski and Kaukaksenkoski rapids.

rapids	year	comb.area (m^2)	age group	parr. density $\hat{N}$ / 100m^2	stand. error SE($\hat{N}$)	catch-ability $\hat{p}$	stand. error SE($\hat{p}$)
Ruutin-koski	1983	250	0+	10.9	1.9	0.46	0.150
			1+	9.2	0.1	0.84	0.075
	1984	889	1+	3.8	0.1	0.71	0.085
Kaukak-senkoski	1983	303	0+	167.6	7.6	0.44	0.036
			1+	37.0	1.1	0.64	0.053
	1984	352	1+	46.6	1.6	0.59	0.048

Table 6. The effect of stocking density to 1 + parr density and survival rate (S)

rapids	stocking density (year) (ind./100m^2)	parr density (year) (ind./100m^2)	S(%)
Ruutin-	100 (1982)	9.2 (1983)	9.2
koski	100 (1983)	3.8 (1984)	3.8
Kaukak-	1000 (1982)	37.0 (1983)	3.7
senkoski	2000 (1983)	46.6 (1984)	2.3

Table 7. Mean length of sea trout parr from the different parr densities. Letters A,B,C and D indicate the same experimental area fished at the same time (same action).

action	age group	parr density (ind./100m^2)	mean length (mm)	SD	n
A	0+	1.6	75.7	5.1	15
B	0+	10.8	76.0	6.2	24
C	0+	13.5	87.5	7.0	37
D	0+	167.6	73.8	7.6	383
A	1+	3.8	151.7	8.5	65
B	1+	9.2	161.7	10.2	28
D	1+	37.0	153.6	17.4	110
C	1+	46.6	155.9	15.6	178

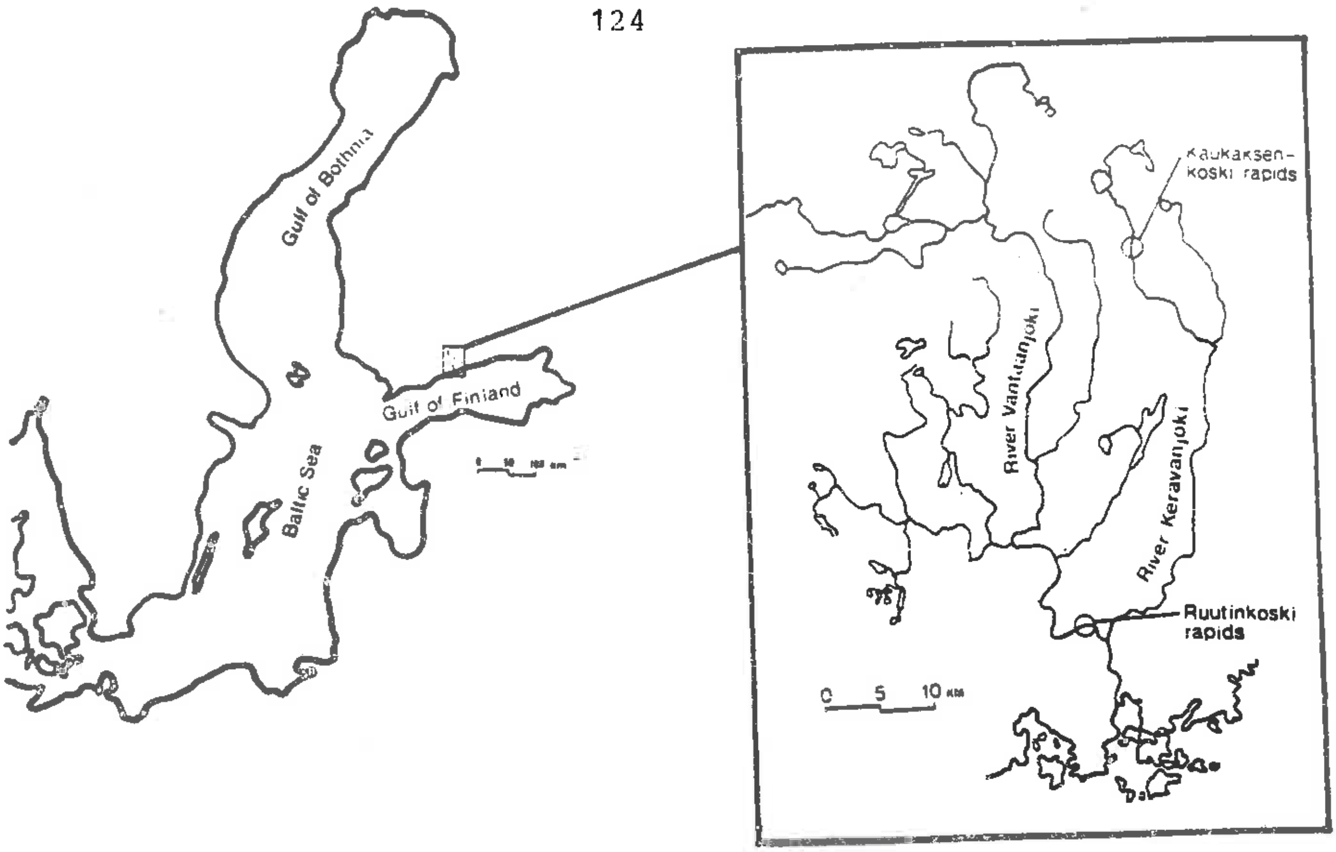

Figure 1. Research area.

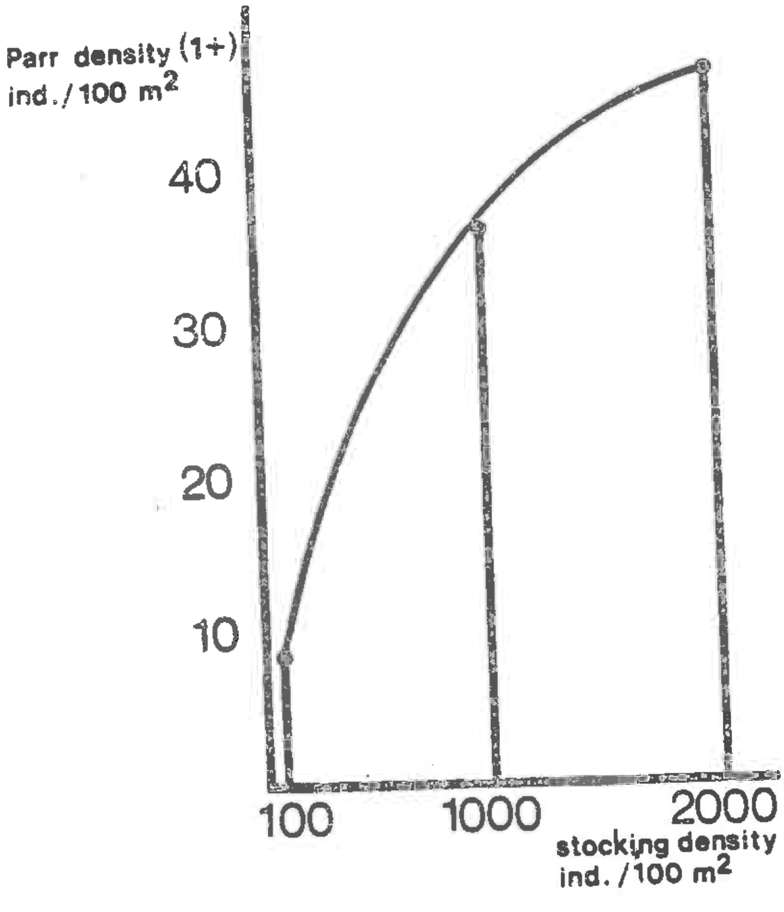

Figure 2. Parr density (1+) as a function of stocking density.

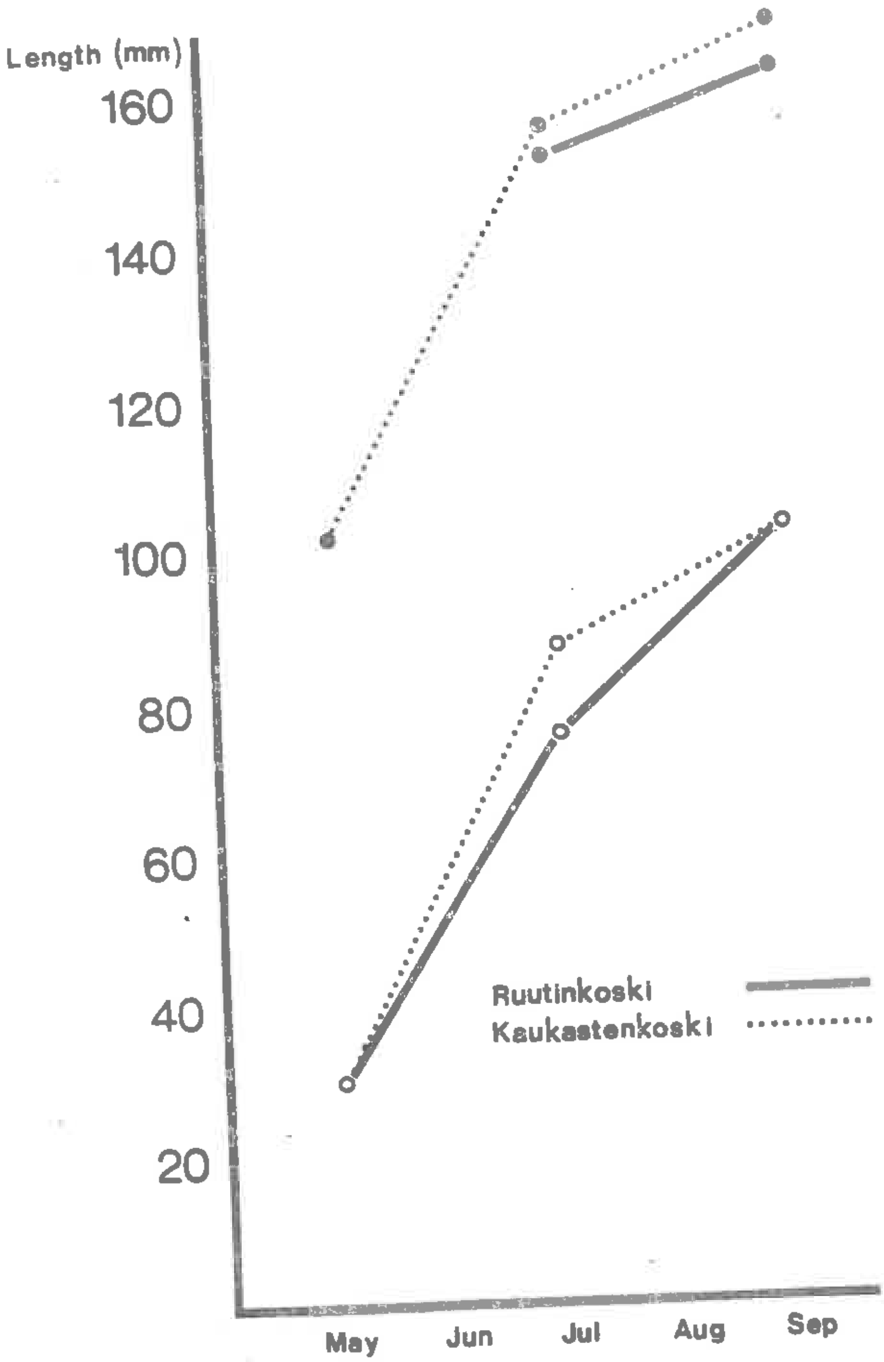

Figure 3. Growth rate of 0 + and 1 + parr in summer 1984 in Ruutinkoski and Kaukaksenkoski rapids.

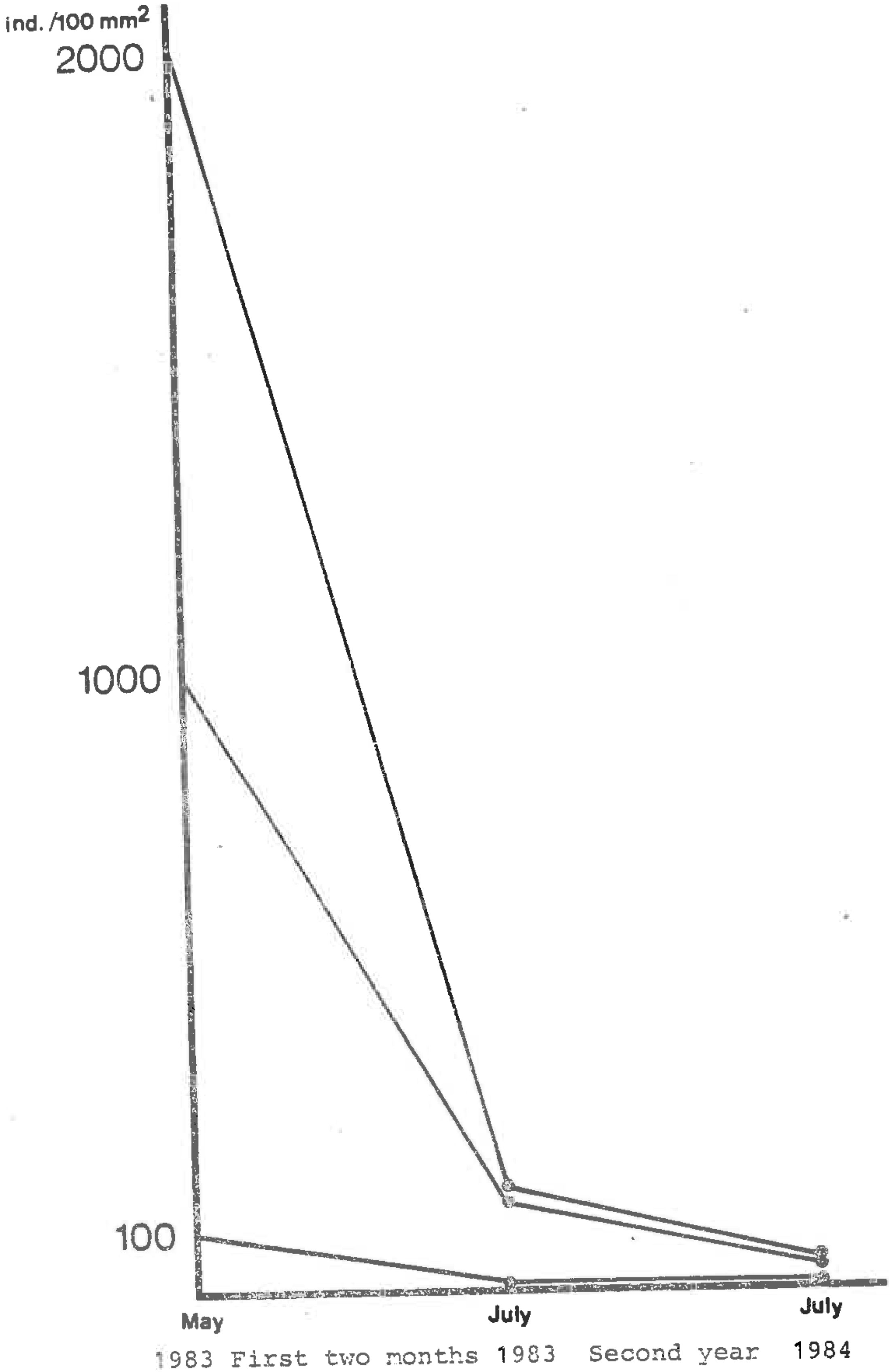

Figure 4. Survival of planted sea trout alevins during the first 14 months after stocking (May 1983).

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FOOD COMPOSITION OF SALMON POST-SMOLTS (Salmo salar L.) IN THE NORTHERN PART OF THE GULF OF BOTHNIA

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Abstract

Food composition of salmon post-smolts, sampled by pelagic trawl fishery, has been studied in June-August 1982-1983 in the northern part of the Gulf of Bothnia. In the beginning of their sea migration, salmon post-smolts fed mainly on insects and fish in the surface layer of the sea. Main food animals were insects, 88 % of food volume in 1982 and 76 % in 1983. In 1982 11 % of food was fish, in 1983 23 %. Insects were mostly of terrestrial origin. Prey fish were sticklebacks (Gasterosteus aculeatus L.). Results of the food analyses have been compared with data collected by sampling of potential food organisms and by following the development of temperature and salinity conditions in the sea.

Résumé

On a étudié la composition de la nourriture des post-saumoneaux d'aval, relevés par chalutage pelagique, en juin-août 1982-1983 dans la partie nord de la Baie de Bothnie. Au début de leur migration marine, les post-saumoneaux se nourrissent principalement d'insectes et de poissons dans la couche de surface de la mer. Les insectes représentent la nourriture principale: 88 % du volume en 1982 et 76 % en 1983. En 1982, 11 % de la nourriture se composait de poissons et 23 % en 1983. Les insectes étaient principalement d'origine terrestre. Le poisson le plus souvent absorbé était l'épinoche (Gasterosteus aculeatus L.). Les résultats de l'analyse de la nourriture ont été comparés à des données collectées par échantillonage d'organismes nutritifs potentiels et en suivant le développement des conditions thermiques et de salinité en mer.

Introduction

In the Baltic area the high mortality of salmon post-smolts is a great problem. One of the factors affecting the survival, growth, and migration of smolts is the quantity and quality of available food. However, there are rather few data on food and feeding of post-smolts in the Baltic (EICHELBAUM 1916, HENKING 1931, LINDROTH 1961, THUROW 1968, MITANS 1970).

This paper deals with food studies of salmon post-smolts, carried out in the northern part of the Gulf of Bothnia, which is one of the most important stocking areas of salmon smolts in Finland. The River Tornionjoki and the River Simojoki with their natural stocks of Baltic salmon also empty into this area of the sea. These studies have been carried out in connection with the international COST Project 46/4 "Sea ranching of Atlantic salmon", by the Finnish Game and Fisheries Research Institute (Anon. 1983).

Materials and methods

In food studies of salmon post-smolts, it is difficult to obtain good samples from the open sea area. Post-smolt samples were collected in 1981-1983 as a bycatch of the fyke-net fishery of vendace and whitefish, and by pelagic trawl fishery of Baltic herring and vendace. The stomachs of post-smolts caught in connection with fyke-net fishery were in general almost or totally empty. Post-smolts caught by pelagic trawl proved to be more suitable for food studies. This study deals with post-smolt samples taken between 21.6.-9.8.1982 (46 salmon) and 5.6.-29.7.1983 (70 salmon) by pelagic trawl fishery in the northernmost part of the Gulf of Bothnia (Figure 1).

Salmon post-smolts were preserved with formaldehyde solution. The length of each fish was measured in millimeters and the weight in grams, in the laboratory. The age of the fish was determined from its scales. The food animals in the stomachs of the post-smolts were identified by orders or genera using a binocular microscope with the exception of fish, which were identified by species. The relative fullness of the stomachs was rated in % (0-100); and the proportion of various food items was rated correspondingly as a % of the actual food volume.

Samples of potential food items were gathered in June-August 1982-1983 near the surface of the sea off the mouth of the River Tornionjoki. A modified Gulf V sampler was hauled at a depth of 0.5 m below the surface along 3 sampling lines, which all together were a total of 6 nautical miles long (Figure 1). The mesh size of the Gulf V sampler was 300 μm and the haulage speed 4 knots. The results of this sampling are given only for the summer of 1982. Simultaneously with Gulf V sampling, a water surface sampler was hauled along the surface. The sampler was formed of a hoop net with a mesh size of 1-2 mm and a front frame 37 cm x 37 cm square (Figure 2). The surface sampling zone extended about 20 cm above and below the actual water surface.

Development of the temperature and salinity of the water was followed in June-August 1982 in a 16 m deep sea about 20 km off the mouth of the River Tornionjoki (Figure 1).

Results

The size of the sampled post-smolts was on average 16 cm and 36 g in 1982, and 18 cm and 47 g in 1983 (Table 1). The great majority of the fish were hatchery-reared, mainly 2-years-old (1-3 years). Only a few post-smolts were wild, originating probably from the natural stocks of Baltic salmon in the River Tornionjoki and in the River Simojoki.

The main food animals of the post-smolts were insects, 88 % of the food volume in the summer of 1982 and 76 % in the summer of 1983 (Table 1). The most abundant insect order was Diptera, of which especially the suborder Nematocera was common. Another important insect group was Hymenoptera, in which ants (Formicidae) were common prey animals. As regarded occurrence, coleopterans were rather frequent, too. In the summer of 1983, the order Homoptera, especially plant lice (Aphididae), were abundant in the diet of post-smolts. Almost all the insects were aerial, and mainly of terrestrial origin. Fish accounted for 11.5 % of food in the summer of 1982. In the summer of 1983, the corresponding percentage was 22.8. The smallest post-smolts feeding on fish were about 16 cm long. All of the prey fish were sticklebacks (Gasterosteus aculeatus L.). Spiders (Arachnida) and Crustacea formed less than 1 % of food.

In Gulf V samples of potential food animals, the abundance of large zooplankton was smallest at the beginning of the summer, increasing to a maximum in August 0.5 m below the sea surface in the water layer (Table 2). Cladocera was the most common group of animals (30-4 300 ind./m^3). The maximum abundance of large Copepoda and Leptodora kindtii was less than 50 ind./m^3, while that of large Rotatoria was less than 100 ind./m^3. Trichoptera and Chironomidae were the most frequent insects found in this water layer. The abundance of fish was highest at the end of June and in July. Nearly all of the sampled fish were identified smelt (Osmerus eperlanus L.). The average length of the smelt was 4-15 mm.

Insects were the most frequent animals in samples taken on the sea surface and in the adjacent layers of water and air by means of the surface sampler (Table 3). Of the insects, Chironomidae and other Diptera, Homoptera and Hymenoptera were abundant in all the samples. The occurence of orders Trichoptera and Coleoptera was occasional. Rather few fish were found in the samples taken in June, while in July the number of fish was highest. All the fish were sticklebacks (Gasterosteus aculeatus L.), with an average length of 18-70 mm.

In the northern Gulf of Bothnia off the mouth of the River

Tornionjoki, fresh river water is stratified in the uppermost layers of the sea in the beginning of the summer (Figure 3). The salinity of this 5-10 m thick water layer was less than 1 $^{o}/oo$. In the brackish water near the bottom the salinity was 2-3 $^{o}/oo$ in the summer of 1982. This stratification of different water layers could be seen in the temperature and salinity values of the sea until the end of July, when the temperature of the whole water body was about +15 ^{o}C and the salinity about 2.5 $^{o}/oo$.

Discussion

The results of the food analyses of salmon post-smolts were rather similar to those found in other, similar studies carried out in the Baltic (CHRISTENSEN & LARSSON 1979, Anon. 1983), even if the importance of insect food was more evident than in the Bothnian Sea (LINDROTH 1961), in the Gulf of Riga (MITANS 1970) or in the southern Baltic (EICHELBAUM 1916, HENKING 1916, THUROW 1968). In the northern Gulf of Bothnia the proportion of fish in the diet was correspondingly lower than in the southern areas. Sticklebacks were the only prey fish in the northern Gulf of Bothnia, while elsewhere in the Baltic other species have been found e.g. autumn spawning herring in the Gulf of Riga (MITANS 1970). The main reason for this is probably the shortage of suitable prey fish, especially in the beginning of the summer, which may later affect the growth and mortality of the post-smolts. The greater percentage of fish in the diet of post-smolts in 1983 (about 20 % of the food) compared to 1982 (about 10 % of the food) may be in part due to the greater size of the post-smolts sampled in 1983. This supports the conclusion that post-smolts become piscivorous at the earliest opportunity, but eat other surface organisms (insects) as available (MITANS 1970, Anon. 1983). Other animals than insects and fish e.g. zooplankton, were not much in evidence in the diet of post-smolts in the northern Gulf of Bothnia.

It is evident that salmon post-smolts mainly feed very near the surface of the sea. Almost all the insects in the stomachs of the post-smolts were winged, aerial insects of terrestrial origin. The main groups of animals found in the food of post-smolts were nearly the same as that gathered by water surface sampling in the sea. It is interesting that the only prey fish of post-smolts, sticklebacks, have been found only in samples taken from the water layer of 0-20 cm from the surface. Samples taken from a depth of c. 0.5 m from the surface contained only smelt, which were not found in the diet of post-smolts.

In Spring, the rising temperature of river water is the main factor in starting the smolt run in the River Simojoki (TOIVONEN & JUTILA 1982). During the smolt run salmon smolts feed intensively on insects. It is most likely that after entering the sea the post-smolts prefer the warm surface water of the sea and avoid cold, more saline, bottom water. This stratification in temperature and salinity lasts in the northern Gulf of Bothnia almost until the end of July, i.e. the entire period when the majority of post-smolts leave the northern Gulf. An indication of feeding and migration near the water surface are the relatively great numbers of tag recoveries of salmon post-smolts in remnants of meals in Caspian tern colonies (JUTILA & ALAPASSI 1985, VALLE 1985). If post-smolts avoid feeding in cold bottom waters, surface feeding offers more food than feeding in the lower water layers because of a concentration of wind-blown aerial insects floating on the water surface.

The diet and growth of post-smolts in the Gulf of Bothnia appears to be greatly dependent on weather conditions in the spring and early summer, and on the timing of the smolt run. Cold weather periods and unfavourable winds may decrease the amount of terrestrial insects drifting on the sea. Because of the habit of surface feeding and of the dependence on insect food, the growth of post-smolts is more influenced by weather conditions than it was earlier, during the river phase, when larval insects and nymphs were available, or later in the sea during the piscivorous phase. THUROW (1968) has estimated 25 cm to be the threshold size for piscivorous feeding. Though post-smolts may be resistant to starvation (ÖSTERDAHL 1965), shortage of food reduces growth and, at least indirectly, survival. It is probable that mortality is high among those salmon post-smolts which do not achieve the piscivorous phase until the onset of winter.

References

Anonymous, 1983. Action COST 46 Mariculture. Rapport final 1980-1983 Commission des Communautes Europeennes. 94 pp.

CHRISTENSEN, O. and LARSSON, P.O. 1979. Review of Baltic salmon research. ICES, Coop. Res. Rep. 89:1-124.

EICHELBAUM, E. 1916. Reife und Nahrung von eingesandten Lachsen. In: Henking Die Lachsfrage im Ostseegebiet II. Rapp. P.-v. Réun. Cons.int.Explor.Mer, 23(2).

HENKING, H, 1916. Die Lachsfrage im Ostseegebiet II. Ibid. 23(2).

HENKING, H. 1931. Untersuchungen an Salmoniden. Teil II. Ibid., 73:1-122.

JUTILA, E. and ALAPASSI, T. 1985. Recaptures of salmon post-smolts (*Salmo salar* L.) during the first summer after release in Finnish tagging experiments. ICES, Doc. C.M. 1985/M:28.

LINDROTH, A. 1961. Sea food of Baltic smolts. ICES, Doc. C.M. 1961/No. 8.

MITANS, A. P. 1970. Feeding of Baltic salmon smolts in the river and sea. Vopr.Ikthiol., 10(1), 60.

THUROW, F. 1968. On food, behaviour and population mechanism in Baltic salmon. L.F.I. Medd. 1968/4:1-16.

TOIVONEN, J. and JUTILA, E. 1982. Report on parr population densities, tagging experiments and river catches of the salmon stock of the River Simojoki in 1972-1980. ICES, Doc. C.M. 1982/M:40.

VALLE, E. 1985. Predation of birds on salmon and sea trout smolts and post-smolts. ICES, Doc. C.M. 1985/M:22.

ÖSTERDAHL, L. 1965. Experimental starving of salmon smolts in brackish water. L.F.I.Medd.,4.

Table 1. Stomach contents of salmon post-smolts, sampled by pelagic trawl fishery in June-August 1982-1983 in the northern part of the Gulf of Bothnia (See Figure 1).

Sampling period	21.6.-9.8.1982		5.6.-29.7.1983	
Total no of stomachs	46		70	
Empty stomachs	2		6	
Stomachs with food	44		64	
Length of sampled post-smolts	16.3	(9.9-26.0)cm	17.8	(11.0-25.0)cm
Weight of sampled post-smolts	36	(9-107)g	47	(11-128)g
Fullness of stomachs with food	33	(5-100)%	34	(5-100)%

Stomach contents	Occurrence %	% of food volume	Occurrence %	% of food volume
Insecta				
Homoptera	-	-	32.8	14.8
Lepidoptera	2.3	0.9	1.6	0
Diptera	61.4	64.0	43.8	21.4
Coleoptera	15.9	2.2	12.5	2.2
Hymenoptera	20.5	9.3	23.4	14.8
Other insect groups	6.8	0.6	4.7	2.5
Undet. insects	25.0	11.0	34.4	20.8
Insecta in total	84.1	88.0	92.2	76.5
Arachnida	4.5	0.3	1.6	0.2
Crustacea	2.3	0.2	4.7	0.5
Pisces	11.4	11.5	15.6	22.8
Other/Undet. material	75.0	-	23.4	-

Table 2. Abundance of zooplankton (mean of ind./m^3) and other animals (mean of ind./100m^3) at a depth of c. 0.5 m from the water surface, sampled by modified Gulf V sampler along sampling lines A, B and C in June-August 1982 (see Figure 1). Mesh size of the line 300 μm.

Date	Cladocera ind/m^3	Leptodora ind/m^3	Copepoda ind/m^3	Rotatoria ind/ m^3	Trichoptera ind/100 m^3	Chironomidae pupa&imago ind/100 m^3	Fish ind/100 m^3	Other animals ind/100 m^3
19.-21.6.	29	-	7	-	-	3	1	<1
29.6.	41	2	1	-	-	10	6	<1
22.7.	655	15	31	-	9	11	9	<1
28.7.	1952	21	39	<1	1	7	3	2
5.8.	4311	24	46	85	8	26	<1	1

Table 3. Abundance of insects and other animals near the water surface (mean of ind./nautical mile), sampled by water surface sampler along sampling lines A, B and C in June-August 1982-1983 (see Figures 1 and 2). The front frame of the surface sampler 37 cm x 37 cm and mesh size of the line 1-2 mm.

Date	Sampling lines	Insects: Chironomidae ind/n.m.	Other Diptera ind/n.m.	Homoptera ind/n.m.	Trichoptera ind/n.m.	Coleoptera ind/n.m.	Hymenoptera ind/n.m.	Fish ind/n.m.	Other animals ind/n.m.
					1982				
19.-21.6.	ABC	7.0	0.3	1.5	0.1	1.6	-	-	6.7 Mollusca
29.6.	ABC	6.6	1.5	0.6	-	0.2	0.6	0.2	0.2 Arachnida
22.7.	ABC	9.5	1.3	1.1	-	-	1.1	0.5	-
28.7.	ABC	34.4	3.4	20.3	1.3	-	3.3	1.1	0.9 Crustacea
5.8.	ABC	69.2	1.7	18.9	0.2	1.6	0.4	0.4	1.4 Arachnida
					1983				
7.-8.6.	ABC	2.5	-	1.3	-	1.7	0.2	0.1	0.1 Mollusca
13.-14.6.	ABC	1.6	-	0.5	-	2.9	4.8	-	1.9 Arachnida
20.-22.6.	ABC	5.4	1.7	12.5	0.8	0.5	3.3	-	2.4 Arachnida
7.7.	AB	5.5	-	2.4	-	-	0.3	-	-
21.7.	AC	13.4	0.4	13.7	-	-	1.0	9.5	0.3 Arachnida
25.7.	ABC	8.8	0.2	0.5	0.3	-	0.3	25.5	0.7 Ar.&Crust.
8.8.	AB	8.8	0.5	1.0	2.8	-	0.9	2.5	0.5 Crustacea

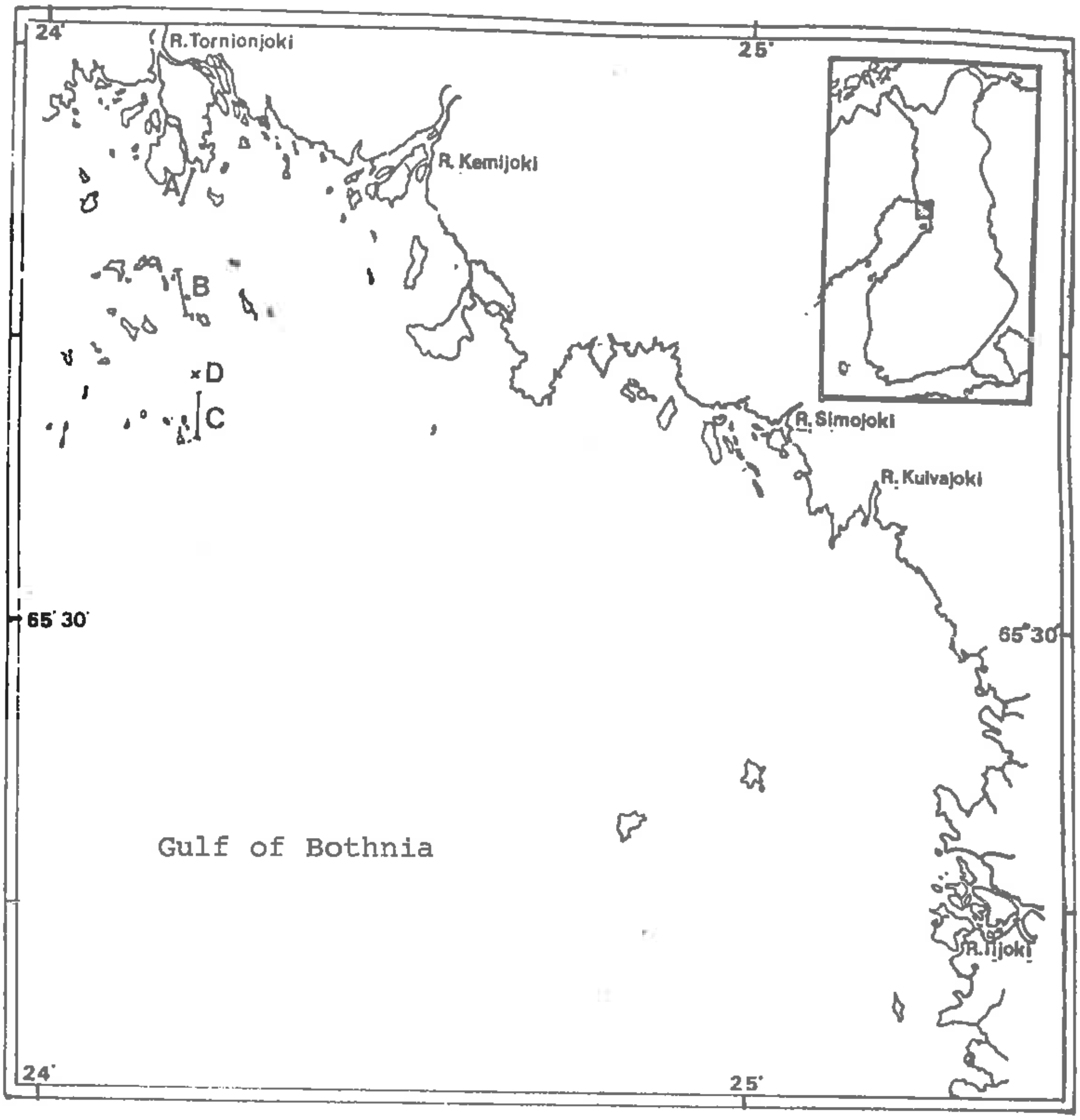

Figure 1. Sampling area of salmon post-smolts. A, B and C= sampling lines of Gulf V sampler and water surface sampler. D=sampling point for water temperature and salinity.

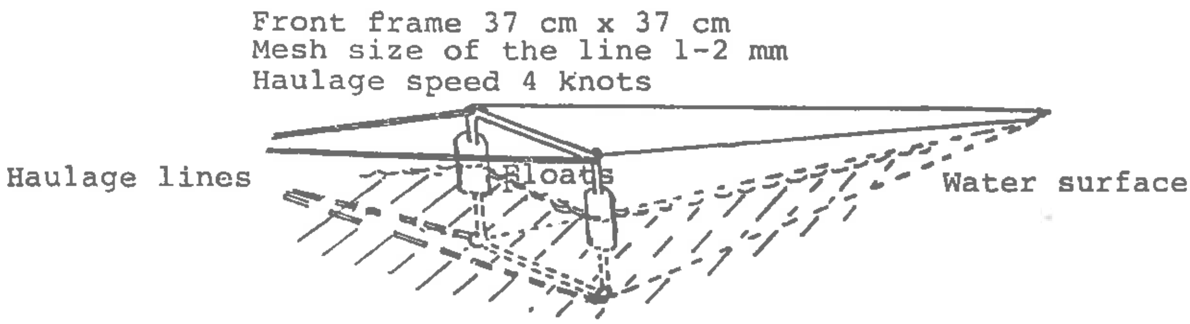

Figure 2. Water surface sampler.

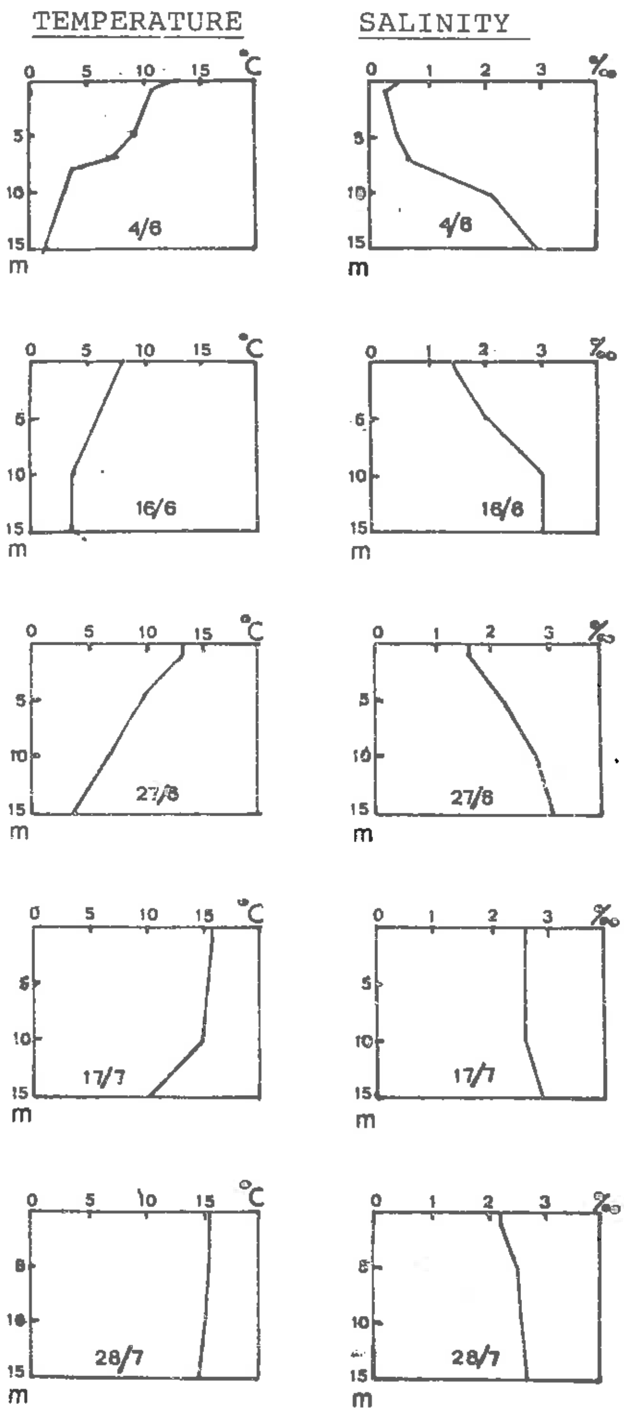

Figure 3. The temperature (°C) and salinity (°/oo) of the sea off the mouth of the River Tornionjoki at sampling point D (see Figure 1).

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PREDATION OF BIRDS ON SALMON AND SEA TROUT SMOLTS AND POST-SMOLTS

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Abstract

The study consisted of fish tags recovered since 1970 from birds in the areas of Finnish salmon and sea trout stockings in the Baltic Sea; as well as fish tags found in gull pellets at two rivers in Northern Finland, in connection with the marking of wild salmon smolts. In addition, 15 gulls, 4 mergansers and 1 red-breasted diver were shot for stomach analysis. Of the 653 fish tags recovered from birds in the Baltic Sea, 87 % were found in the nests or pellets of Caspian tern, and 4 % in the nests or pellets of gulls. The bird species was unindentified in the remaining 9 %. At the Näätämönjoki and Vetsikkojoki Rivers, not only gulls but also mergansers and red-throated divers had preyed on salmon smolts.

Résumé

Le domaine de la présente étude concerne les queues de poissons récupérées depuis 1970 dans l'estomac d'oiseaux des régions de la pêche finlandaise du saumon et de la truite de mer ainsi que des queues de poissons trouvées dans les boulettes d'aliments regorgés par les mouettes dans deux rivières de la Finlande septentrionale, lors du marquage de smolts sauvages. De plus, 15 mouettes, 4 harles bièvre et un plongeon catmarin ont été abattus pour procéder à des analyses de l'estomac de ces oiseaux. Sur les 653 queues de poissons fournier par les oiseaux de la Baltique, 87 % ont été découvertes dans les nids ou les boulettes regorgées par des sternes caspiennes et 4 % dans les nids ou boulette regorgées par des mouettes. Les espèces ornithologiques non identifiées représentaient la proportion de 9 %. Dans les rivières Näätämönjoki et Vetsikkojoki, les mouettes n'étaient pas les seules à prende des smolts, mais étaient imitées par des harles bièvre et des plongeons catmarins.

Introduction

The mortality of stocked salmon and sea trout smolts during their first months in the sea is very high. It has been suggested that the main determining factor in the success of smolt stocking is predation (e.g. Action COST 46). Predation by other fish, especially by burbot and pike on stocked salmon smolts, has been found to be considerable in some Swedish rivers (LARSSON & LARSSON 1975, LARSSON 1985). Of the predatory birds, it is known that mergansers can cause remarkable damage to salmon stocks (LINDROTH 1955, LINDROTH & BERGSTRÖM 1959). Gulls and terns are mentioned as predatory birds on salmon smolts in a report of LARSSON & ATESHKAR (1979), and Caspian tern in that of SOIKKELI (1973).

Material and methods

The study consisted of the fish tags recovered from birds in the areas of Finnish salmon and sea trout stockings in the Baltic Sea since 1970. Three of the biggest colonies of Caspian tern (*Hydroprogne caspia* Pont.) have been studied by ornithologists almost every summer since 1970. At the Näätämönjoki River in 1977-1978 and Vetsikkojoki River in 1975, fish tags were recovered from gull pellets in connection with marking of wild salmon smolts. In addition, at the Näätämönjoki River, 15 gulls (*Larus* sp.), 4 mergansers (*Mergus merganser* L.), and 1 red-throated diver (*Gavia stellata* Pont.) were shot for stomach analysis in 1978. Carlin tags were used in the study.

Results

Baltic Sea

The number of tag recoveries from birds are given in Table 1. Of the tags recovered in the Baltic Sea, 87 % were found in the nests or pellets of Caspian tern and 4 % in the nests or pellets of gulls. The bird species was unindentified in the remaining 9 %.

Figures 1-9 give the amount and time of tags recovered in tern colonies. The predation has taken place both rather soon after the releases when the fish still were in schools, and for salmon also after southward migrating had begun. The hunting range of Caspian tern is mentioned to be usually 10-20 km, but sometimes even more.

Tags were recovered from almost every second salmon stocking and every third sea trout stocking made in the north of the Gulf of Bothnia. However, not more than 10 tags were recovered from any one stocking, representing at maximum only 1 % of the amount of fish stocked. The surface currents in that area flow north along the Finnish coast, which may explain why there are more tag recoveries from stockings made to the south of the tern colony of Iin Krunnit Islands than to the north.

From the 36 experimental salmon groups stocked in the estuary of the Kymijoki River, tags recovered from Caspian tern, came from 35 stocked groups, 1-22 tags from each group, representing at maximum 2 % of the salmon stocked.

Both the average length of the salmon prey, 17.2 cm, and that of the sea trout prey, 18.9 cm, of Caspian terns, are nearly the same as the average length of the smolts released.

Yet, gulls breeding in the Valassaaret Islands,had preyed on salmon, whose length of 16.7 cm was smaller than the average size of the smolts stocked. During migration, these smaller tagged salmon smolts probably tired more easily and were therefore more easily caught. Only 2 sea trout smolts were found among the prey of gulls.

Näätämönjoki and Vetsikkojoki Rivers

Merganser and red-throated divers in the Näätämönjoki River appeared to learn to effectively utilize the site of repeated stockings. The same thing was observed of gulls in the Vetsikkojoki River. One of the four mergansers shot had eaten 38 tagged smolts in 9 days; and other three mergansers together had eaten a total of 7 tagged smolts. The red-throated diver had eaten 37 tagged smolts in 8 days. Predation by gulls on salmon smolts in the Näätämönjoki River was rather small; but in the Vetsikkojoki River it accounted for 6 % of the total number of salmon smolts tagged. At its highest, predation by gulls was 13 % of the tagged smolts tagged during one day.

Predation also occurred at "night", as it was summer and light all the time. The water in both the Näätämönjoki River and the Vetsikkojoki River is shallow and clear, making the smolts and their tags clearly visible to the birds. Predation occurred almost immediately after the smolts were released. The birds did not select their prey fish on the basis of size.

Discussion

The only remarkable bird predator on salmon and sea trout post smolts in the open sea seems to be the Caspian tern, which usually breeds in colonies of tens or even hundred of birds and also often hunts in flocks. The size of Caspian tern fish prey, according to SOIKKELI (1973), is 9-25.5 cm, so the stocked salmon and sea trout smolts are on average of a size suitable, for Caspian tern prey. Yet, according to the number of tags found in the three colonies of 50-150 couples studied, the amount of the predation on salmon or sea trout smolts does not seem to be of any remarkable size. SOIKKELI (1973) also found that the total number of Caspian tern breeding in the area of the Baltic Sea is so low that they can hardly constitute any great threat to salmon stockings.
Yet, results at the Vetsikkojoki and Näätämönjoki Rivers show that in certain circumstances, even predation by gulls alone may be considerable. Further, if there are large numbers of predatory merganserns and divers, their influence on salmon stockings in some areas can be very detrimental.

References

Action COST 46. Mariculture. Rapport final 1980-1983. 1982. - Commission des communautes europeennes, 94 pp.

LARSSON, H-O. & LARSSON, P-O. 1975. Predation på nyutsatt odlad smolt i Luleälven 1974. - Laxforskningsinst. Medd. 9, 7 pp.

LARSSON, P-O. 1985. Predation on migrating smolts as an important regulating factor for salmon (Salmo salar L.) populations. - J. Fish Biol. 26 (4): 391-397.

LARSSON, P-O. & ATESHKAR, S. 1979. Laxsmoltens vandring från Luleälven. - Fiskeritidskrift för Finland 23 (1): 8-9.

LINDROTH, A. 1955. Mergansers as salmon and trout predators in the river Indalsälven. - Rep. Inst. Freshw. Res. Drottningholm 36: 126-132.

LINDROTH, A. & BERGSTRÖM, E. 1959. Notes on feeding technique of the goosander in streams. - Rep. Inst. Freshw. Res. Drottningholm 40: 165-175.

SOIKKELI, M. 1973. Tagged salmon smolts in the diet of the Caspian tern. - Laxforskningsinst. Medd. 3, 3 pp.

Table 1. Smolt tags recovered from birds

Bird species	Baltic Sea Hatchery reared Salmon	Baltic Sea Hatchery reared Sea trout	Näätämönjoki and Vetsikkojoki Rivers Wild salmon	Total tags Salmon and Sea trout
Caspian tern	449	119	-	568
Gulls	25	2	192	219
Arctic tern	1	-	-	1
Merganser	-	-	44	44
Red-breasted diver	-	-	37	37
Unindentified species	54	3	-	57
Total tags	529	124	273	926

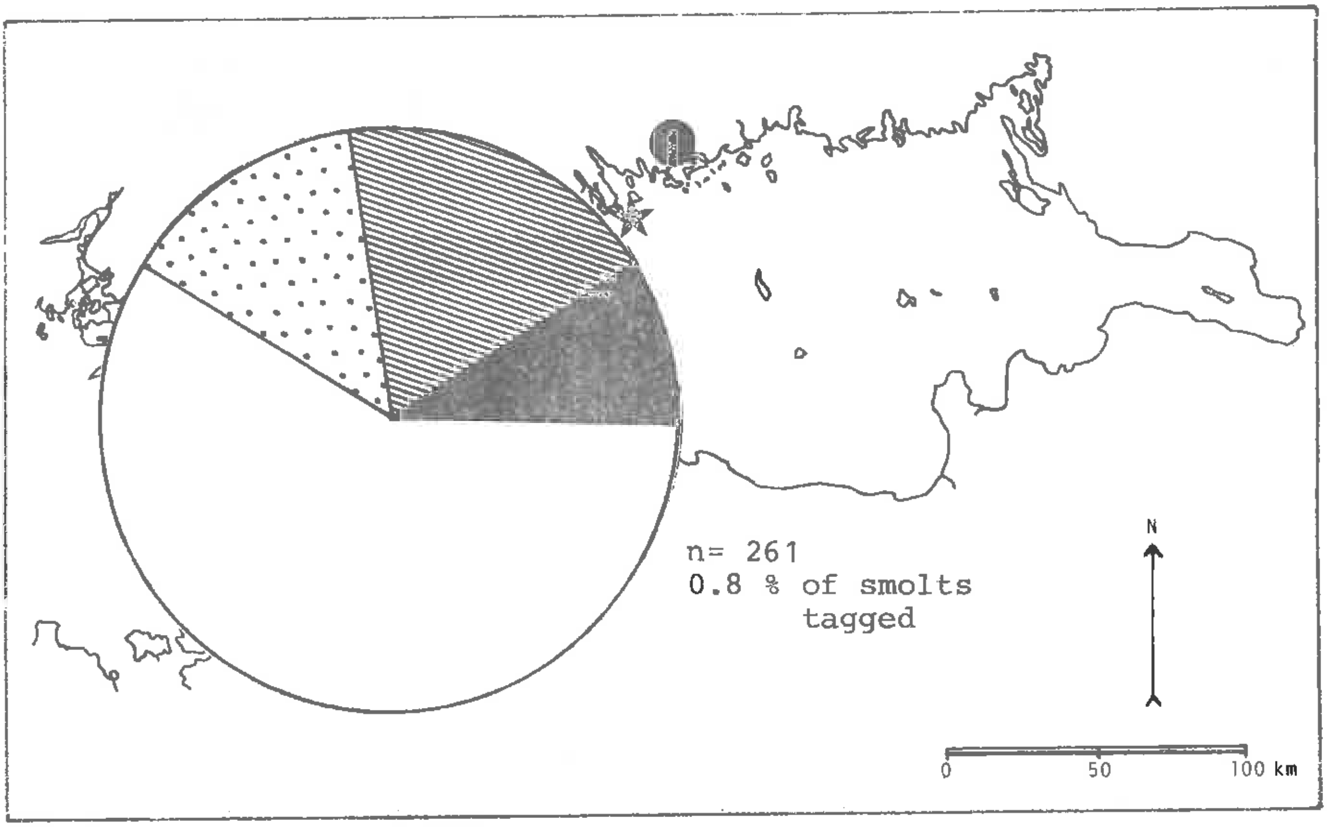
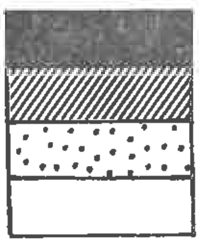


Figure 1. Tags recovered from the salmon stockings made in the Kymijoki River.

Key to Figures 1-9. The black dot marks the release site, and the star the recovery site.

Tags recovered:

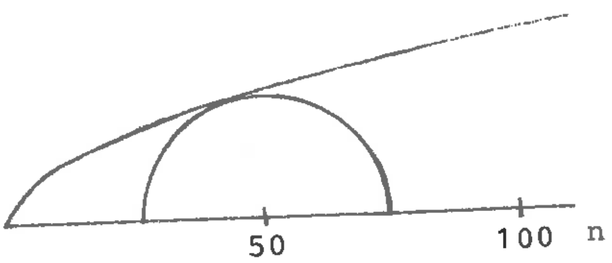


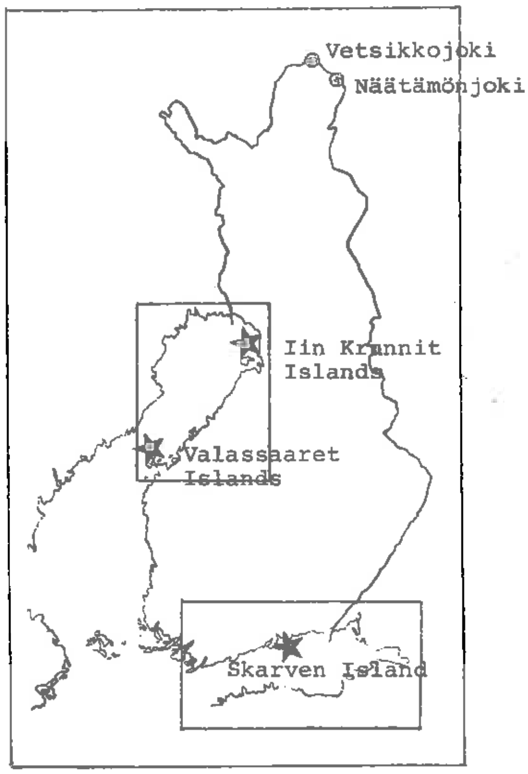
within 1-30 days

within 31-60 days

within the year of stocking, more than 60 days

in another year





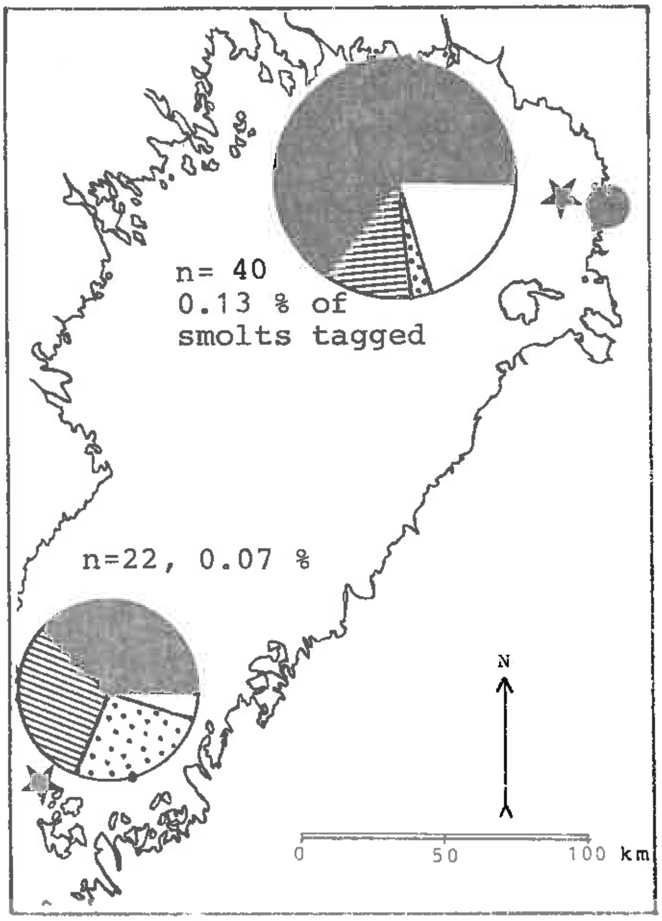


Figure 2. Tags recovered from the salmon stockings made in the Iijoki River.

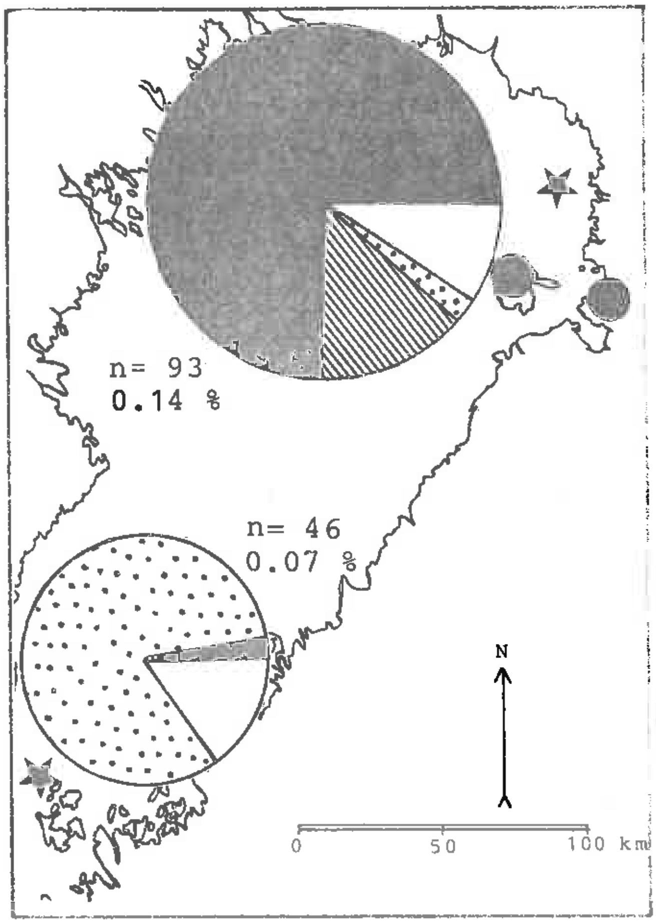


Figure 3. Tags recovered from the salmon stockings made in the Oulujoki River.

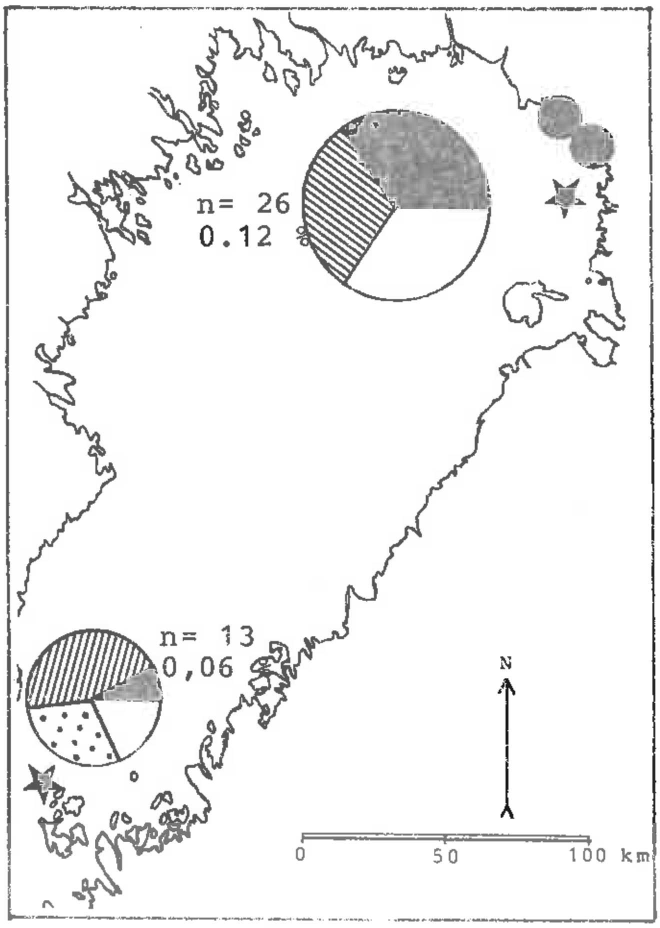


Figure 4. Tags recovered from the salmon stockings made in the Simojoki River.

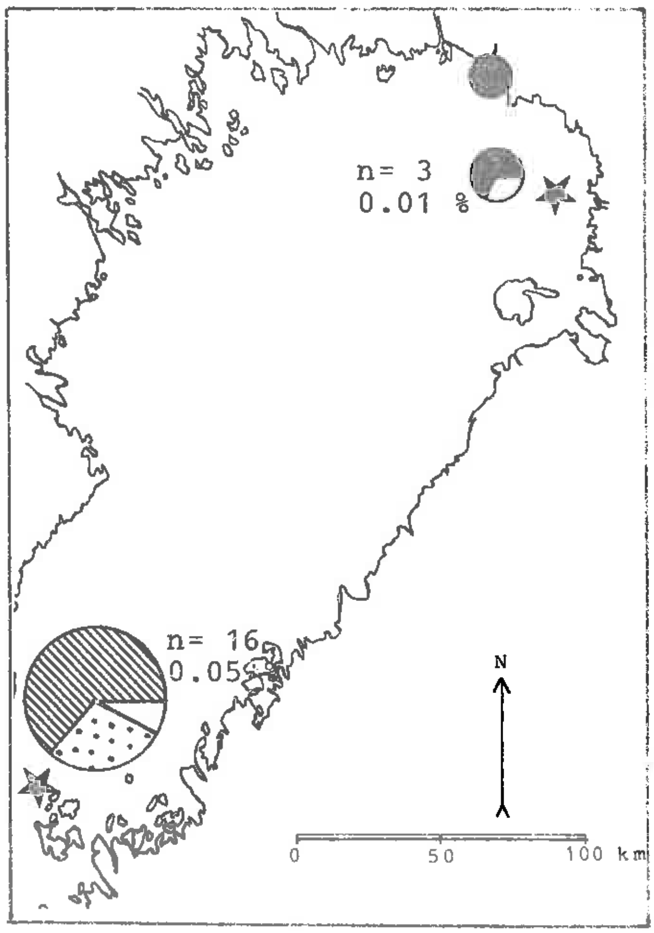


Figure 5. Tags recovered from the salmon stockings made in the Kemijoki River.

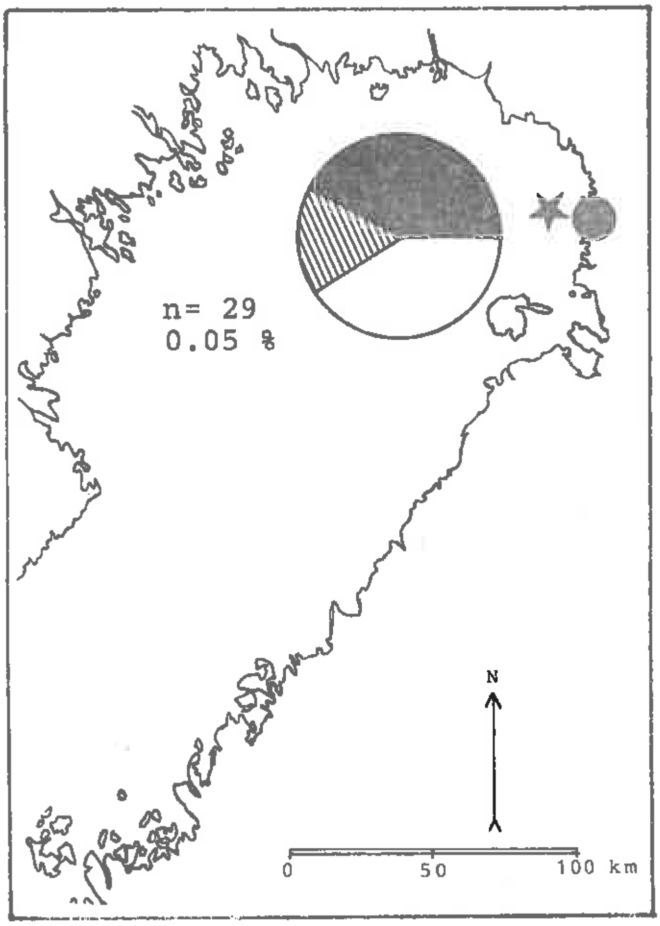


Figure 6. Tags recovered from the sea trout stockings made in the Iijoki River.

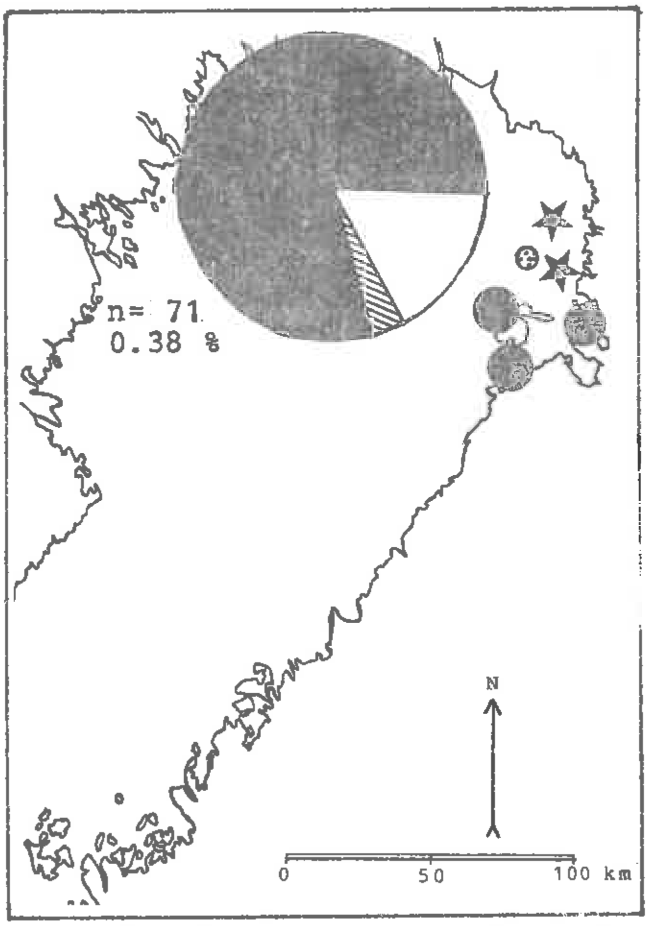


Figure 7. Tags recovered from the sea trout stockings made in the Oulujoki River.

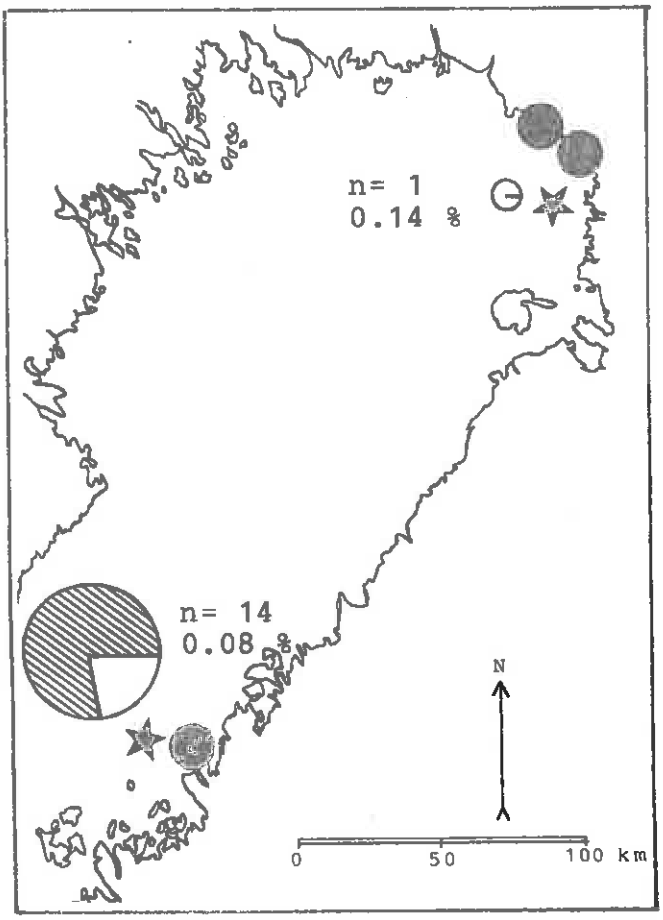


Figure 8. Tags recovered from the sea trout stockings made in the Kuivajoki River and in the area of Kokkola.

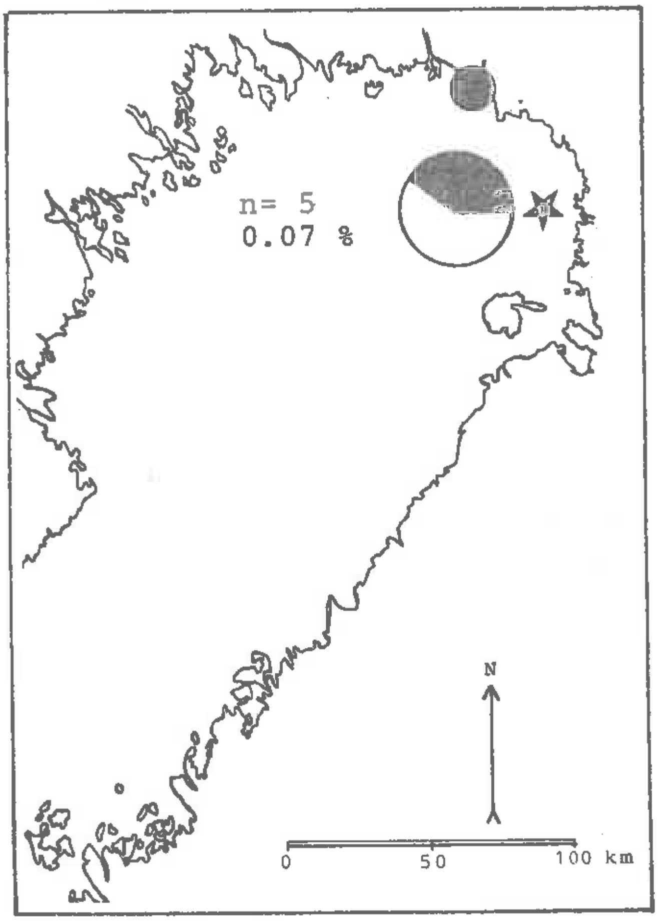


Figure 9. Tags recovered from the sea trout stockings made in the Kemijoki River.

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Salmon (Salmo salar) Parr Densities in the Teno River

by

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ABSTRACT

Changes in the parr densities have been studied in the Teno river drainage since 1979. There are fiftysix permanent research stations which are electrofished annually during July and August using the removal method. Young salmon has been dominant with the mean being in river Utsjoki 82.9 %, in the river Inarijoki 72.0 % and in the river Teno 79.4 % of the total number of the fish caught. Alevin emerge on the gravel in the middle of July with their percentage being 56.9 % of the total salmon population. The low portion of older parr and pre-smolts (particularly that of the 3+ and 4+ cohorts) is due to both smoltification and preference to a deeper biotop. The estimated salmon densities have been in the river Teno 21.3-63.6, in the river Utsjoki 30.9-97.9 and in the river Inari 18.9-55.4 fish/100 m^2. There has been a slight increase in young salmon densities since 1979 in the river Teno watercourse.

RESUME

Les variations de densité de tacons ont été étudiées dans les eaux de la rivière Teno depuis 1969. Cinquante-six stations d'observation permanentes sont procèdent chaque année à la pêche électrique (utilisation d'électrochocs) en juillet-août, au moyen de la méthode successive (removal method). Parmi les poissons pris, le jeune saumon dominait, représentant en moyenne 82,9% des captures dans la rivière Utsjoki, 72,0% dans la rivière Inarijoki et 79,4% dans la rivière Teno. Les alevins font leur apparition sur le gravier vers la mi-juillet, représentant alors 56,9% de la population totale de saumons. La faible proportions de tacons plus âgés et de pré -smolts (en particulier ceux des cohortes 3+ et 4+) s'expique tant par la smoltification que par la préférence pour un biotope plus profond. Les densités de saumons estimées étaient respectivement, pour la rivière Teno, de 21,3 à 63,6 poissons/100 m^2, dans la rivière Utsjoki de 30,9 à 97,9 et dans la rivière Inari de 18,9 à 55,4. Une légère augmentation de la densité de jeunes saumons est constatée depuis 1979 dans le cours d'eau de la rivière Teno.

INTRODUCTION

The Teno River drainage, comprising some 16 000 square kilometers, includes about 1 000 km of known adult salmon migratory streams. Only part of this migration area is suitable for salmon parr production. This latter part produces 150 metric tons of adult salmon catch in river annually as well as a substantial catch in the North Atlantic.

Since the increasing commercial and recreational fishing stressed the salmon production capacity, the governments of Finland and Norway agreed in 1979 to have a new mutual set of fishing regulations for the in-river portion of the salmon fishery. The design criteria for one section of these rules, concerning fishing season length, gear types, and number of fishing days per week, was to allow incteased spawner access to headwater spawning sites. This paper presents salmon parr density data obtained in an effort to monitor population changes in relation to regulation effect.

METHODS

Of the two principal methods of determining fish numbers in a stream, the removal method was chosen over the mark-recapture method as being less expensive and more easily repeatable. A total of 46 stations were chosen in 1979 from the Teno, Inari and Utsjoki Rivers to encompass as wide a range of accessable salmon habitat as the system offers. An additional 10 sites were added in 1980 (Figure 1). In 1981, station numbers and the upstream limit for a given area were permanently marked on the site to facilitate relocation in successive years.

Most of the established sites were fished annually from 1979 to 1984 with direct current electrofishing apparatus delivering an output voltage of 600-800 volts at 0.1 amp. Surrounding nets were used on the majority (90%) of areas. The normal method employed during fishing followed the three pass procedure outlined by Karlström (1976). However, if fewer than 5 salmon were caught on the first two passes, the last pass was omitted. Total lenghts and scalesamples were collected from salmonids (except 0+) and otoliths from non salmonids (except minnow, *Phoxinus phoxinus*), in addition to the number of fish caught (by species) for each pass.

There were a few major exceptions to the standard procedure above. Blocking nets were used only 44% of the stations fished in 1981, 74% of those fished in 1979 and not at all in 1980. Salmon scale samples were not collected from 35% of the sites in 1979 and 50% 1980. Only 27 sites (48%) were fished in 1981 due to high water levels. The number of fishings per site varied during the first two years. One pass was made on 33% of the stations fished in 1979, and on 37% of those fished in 1980.

Fishing began during the third week in July, and continued into the latter part of August each year. This allowed sufficient time for 0+ emergence and coincided generally with the low water level of the year (Figure 2). The order in which the stations were sampled each year remained constant to minimize effects due to variability in annual timing for a given site. Daily sampling activities were suspended from 21.00 to 08.00 for the comparable reason.

Scales were used for age determination of salmonids and analysed on a microfishe projector. For the years 1981 to 1984, scales were collected from all fish for each pass, and ages were thus determined for each sample. In 1979 and 1980 ages were determined from length-age frequencies of a sub sample.

When the number of fishings was two or three, density estimates were made using the regression method.

RESULTS

In addition to salmon, 9 incidental species were encountered over the course of the study period. Salmon dominated in the catch in terms of the number of individuals captured, ranging from 53.1% to 96.6% of the catch (mean 79.3%) for a given river and year. Minnow (Phoxinus phoxinus) comprised 15.28%, with the other 8 species accounting for less than 6% of the total catch (Table 1). Incidental species encountered during salmon (Salmo salar) electrofishing density studies from the Teno River drainage, 1979-1984 were as follows: burbot (Lota lota), flounder (Platicthys flesus), minnow (Phoxinus phoxinus), sculpin (Cottus gobio), brown trout (Salmo trutta), arctic char (Salvelinus alpinus), grayling (Thymallus thymallus), three spined stickleback (Gasterosteous aculeatus), and whitefish (Coregonus sp.).

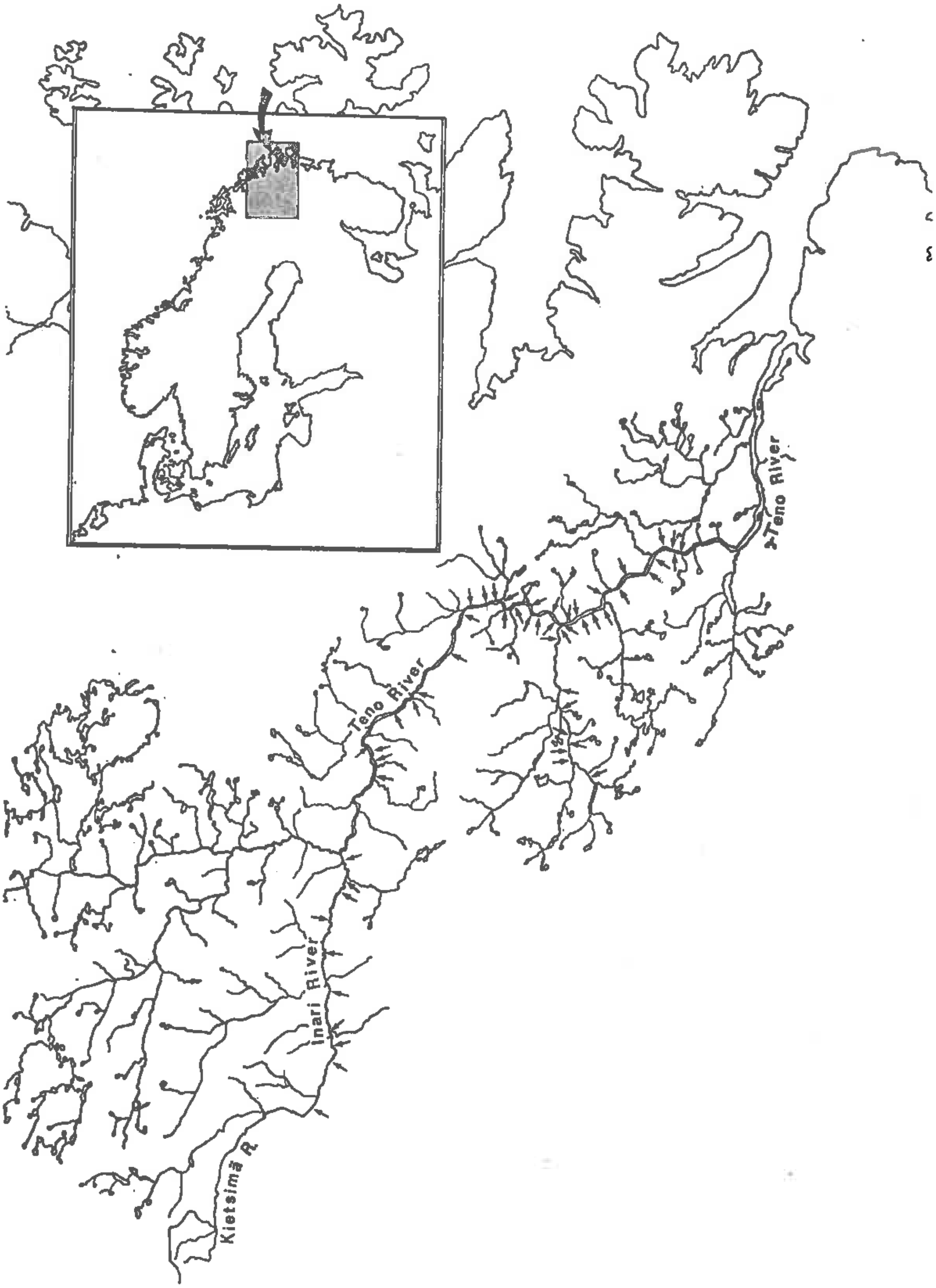

Figure 1. Map of the Teno River drainage showing permanent electrofishing study sites (arrows).

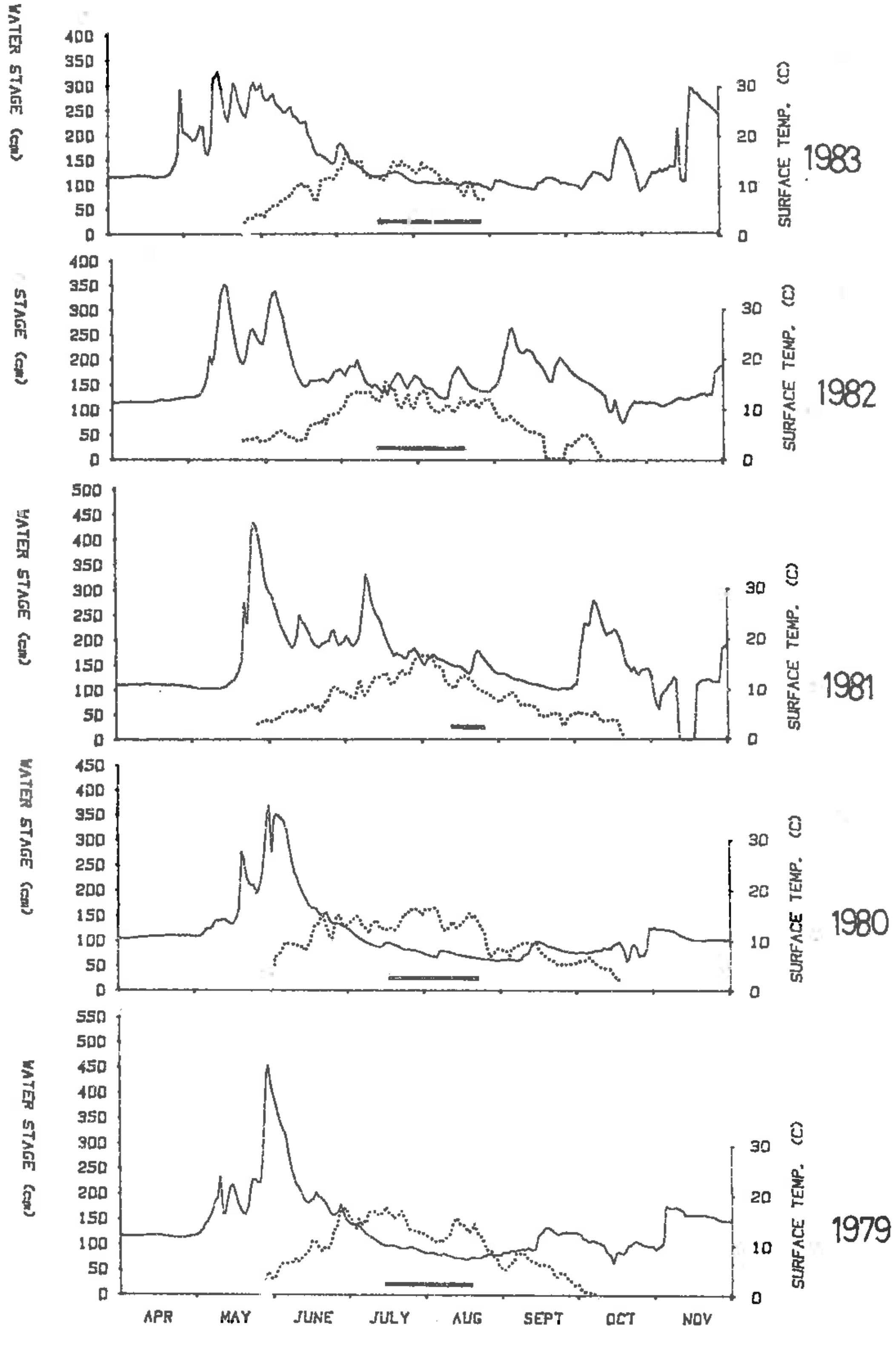

Figure 2. Water stage (————) and surface temperature (............) from Onnelansuvanto recording station, Teno River, 1979-1983. Horizontal bar on each graph represents duration of electrofishing period.

Table 1. Percent species composition of electrofishing catch from the Teno River watercourse, 1979 to 1984.

Year	River	salmon	burbot	minnow	grayling	whitefish	stickleback	trout	sculpin	char	flounder
1979	Teno	85.20	1.90	8.20	4.00	.20	.05				
	Inari	53.10	2.40	38.70	5.90						
	Uts	82.50	.20	11.70	1.60		2.20	1.60	.20		
	total	78.20	1.00	15.40	3.00	.40	1.40	.90	.10		
1980	Teno	82.70	1.70	10.20	4.70	.20	.20	.10			.10
	Inari	67.90	1.50	27.90	2.80						
	Uts	64.10	1.60	29.10	2.60		1.90	.60			
	total	73.60	1.60	20.10	3.60	.10	.70	.20			.04
1981	Teno	37.10	3.90	57.10	1.90						
	Inari	90.40		9.60							
	Uts	96.60	.60					.90	1.90		
	total	79.30	1.40	17.20	.50			.50	1.10		
1982	Teno	65.20	1.60	32.80			.10	.50			
	Inari	70.50	3.10	26.40							
	Uts	92.40		5.90			.20	1.30	.20		
	total	72.50	1.40	25.40			.10	.50	.05		
1983	Teno	83.90	1.80	7.80	4.50	1.60	.10	.20			
	Inari	83.00	.90	11.80	4.20						
	Uts	79.00	.20	16.10	.60		.30	.40	3.30	.10	
	total	82.40	1.20	10.70	3.40	.90	.10	.30	.90	.03	
1984	Teno	89.70	1.60	4.10	3.80	.10	.30	.40			
	Inari	75.20	1.10	23.20	.50						
	Uts	88.90	.40	6.00	.10		.40	.40	3.60		
	total	87.00	1.20	7.90	2.30	.10	.30	.30	1.00		
Totals	Teno	79.43	1.78	14.44	3.33	.57	.19	.24			.01
	Inari	72.04	1.52	23.64	2.80						
	Uts	82.98	.44	12.10	.96		1.05	.96	1.49	.02	
	total	79.32	1.28	15.28	2.43	.28	.45	.44	.51	.01	.01

Salmon parr ages ranged from 0+ to 4+. Annual age frequencies and their corresponding percentage of the salmon catch are presented in table 2, and average length for each age group by year in Table 3. Length frequencies for a given age group remained fairly constant between years for the same station, though there appeared to be some change in fish length from river to river within a given year (Figure 3).

The number of parr captured proved variable between sites for a given year (not tested). The 0+ cohort also displayed more variability in number between years, both for a given site and between sites, than for the other age groups (Figure 4). Though the total number of salmon parr caught in the older age groups (1+ and older) has varied with river over a given year, the percent of the total caught has shown a general increase over at least the last three years. This is also true of the main stem Teno and Utsjoki (Table 4). Patterns are not comparable over the first three years, due in part to differences in methods, as well as annual variation.

Since the main object of this study has been to follow changes in the spawning success of the previous year, salmon parr were divided into two main cohorts (0+ and $\geq$ 1+) for density determination. Mean catch density ranged from 1.99 to 52.2 fish / 100m^2 for 0+ and 3.9 to 40.7 for the older parr. Total estimated densities were in all but one case higher than absolute densities (Table 4). Both absolute and estimated total salmon parr densities have shown general increase over the 1979 levels in the main stem Teno - Inari River for both cohorts. The Utsjoki River has varied annually for both groups, and though lower than the 1979 absolute total of 92.89 parr / 100m^2, there was an increase in total density from 1980 to 1983.

Absolute catch densities for all years and all species are shown in Table 5. While there appears to have been no functional decrease response in catch densities of incidental species, salmon parr total absolute densities have increased in both the 0+ and 1+ and older components.

Table 2. Total annual electrofishing catch of salmon (*Salmo salar*) from the Teno River watercourse, 1979 - 1984, by age group. Figure under each total is percent of total catch for the given period.

Year	River	0+	1+	2+	3+	4+	total
1979	Teno	127	230	94	75	3	529
		24.00	43.50	17.80	14.20	.60	
	Inari	84	53	35	45	8	225
		37.30	23.60	15.60	20.00	3.60	
	Uts	634	305	197	38		1174
		54.00	26.00	16.80	3.20		
	total	845	588	326	158	11	1928
		43.80	30.50	16.90	8.20	.60	
1980	Teno	478	249	106	26		859
		55.76	29.00	12.40	3.00		
	Inari	270	86	42	17	1	416
		64.90	20.70	10.10	4.10	.20	
	Uts	81	209	63	38	4	395
		20.50	52.90	16.00	9.50	1.00	
	total	829	544	211	81	5	1670
		49.60	32.60	12.60	4.90	.30	
1981	Teno	61	27	7	1		96
		63.60	28.20	7.20	1.00		
	Inari	56	77	8	1		142
		39.40	54.30	5.60	.70		
	Uts	315	98	86	10	2	511
		61.60	19.20	16.80	2.00	.40	
	total	432	202	101	12	2	749
		57.70	27.00	13.40	1.60	.30	
1982	Teno	676	148	66	18	1	909
		74.40	16.20	7.30	2.00	.10	
	Inari	118	29	28	4		179
		65.90	16.20	15.60	2.30		
	Uts	343	140	12	5		500
		68.60	28.00	2.40	1.00		
	total	1137	317	106	27	1	1588
		71.50	20.00	6.70	1.70	.06	
1983	Teno	1096	427	159	49		1731
		63.35	24.62	9.19	2.83		
	Inari	239	218	43	8		508
		47.00	42.90	8.50	1.60		
	Uts	420	250	102	11	1	784
		53.57	31.90	13.00	1.40	.10	
	total	1755	895	304	68	1	3023
		58.10	29.60	10.10	2.20	.03	
1984	Teno	817	301	112	37		1267
		64.50	23.75	8.84	2.92		
	Inari	179	80	62	7		328
		54.57	24.39	18.90	2.13		
	Uts	348	188	48	10		594
		58.58	31.64	8.08	1.68		
	total	1344	569	222	54		2189
		61.40	26.00	10.10	2.50		
All years -- total		6342	3115	1270	400	20	11147
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Table 3. Total average length (cm,x) and associated standard error (S_x) of salmon (Salmo salar) electrofishing catch from the Teno River watercourse, 1979 - 1984, by age group.

Year		0+	1+	2+	3+	4+
1979	x	4.37	7.42	10.37	12.57	14.89
	S_x	.0003	.0004	.0016	.0061	.4361
1980	x	3.90	7.21	10.63	13.67	16.96
	S_x	.0003	.0004	.0003	.0184	1.8397
1981	x	3.94	8.27	11.38	13.91	15.80
	S_x	.0003	.0027	.0109	.3530	10.8187
1982	x	3.41	6.70	10.17	12.28	
	S_x	.0001	.0011	.0092	.0897	
1983	x	3.66	6.79	10.19	12.83	
	S_x	.0001	.0002	.0018	.0230	
1984	x	3.79	7.10	9.98	12.68	
	S_x	.0002	.0004	.0029	.0314	

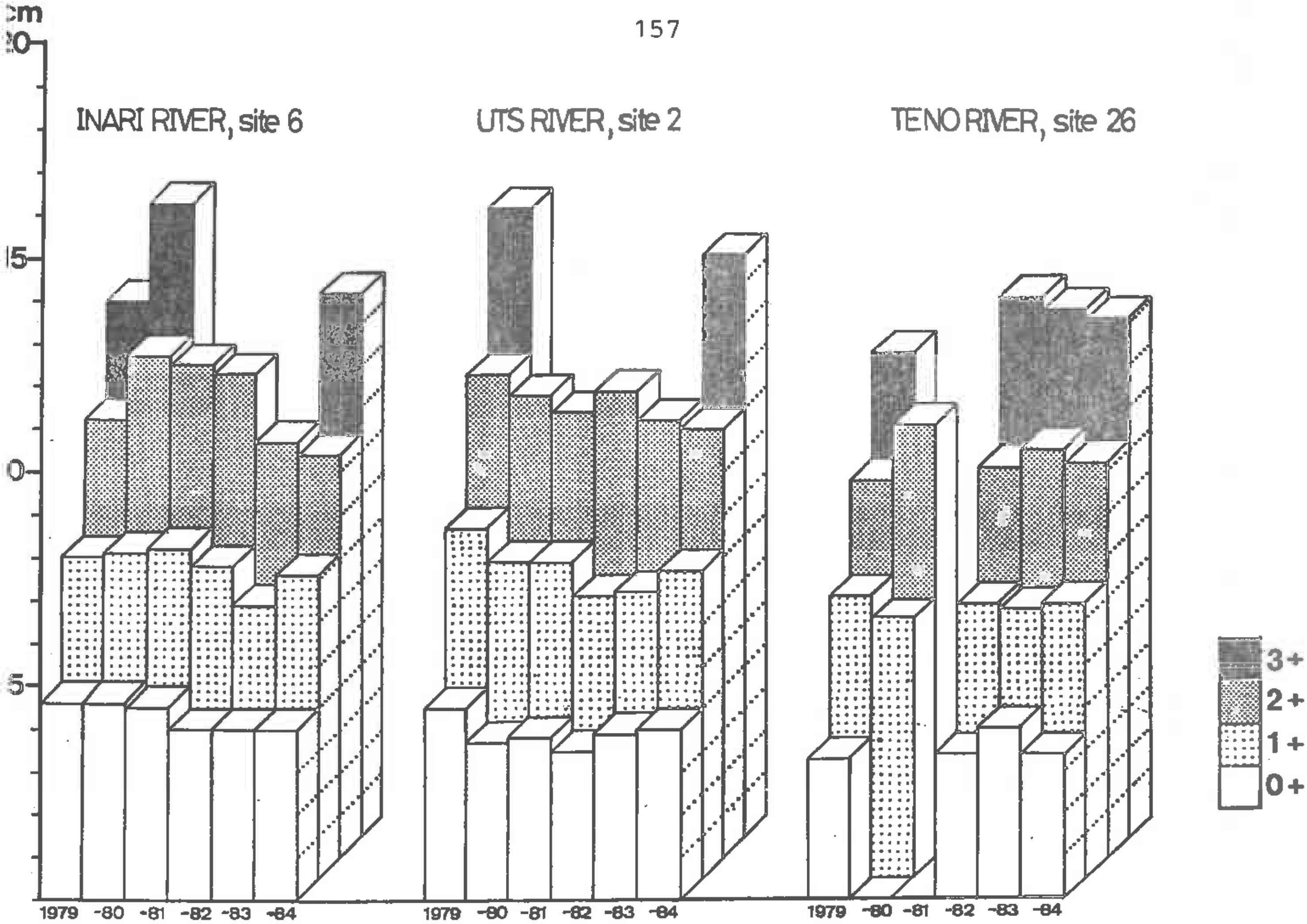

Figure 3. Mean parr salmon (<u>Salmo salar</u>) length frequencies over a 6 year period for three electrofishing stations in the Teno River watercourse.

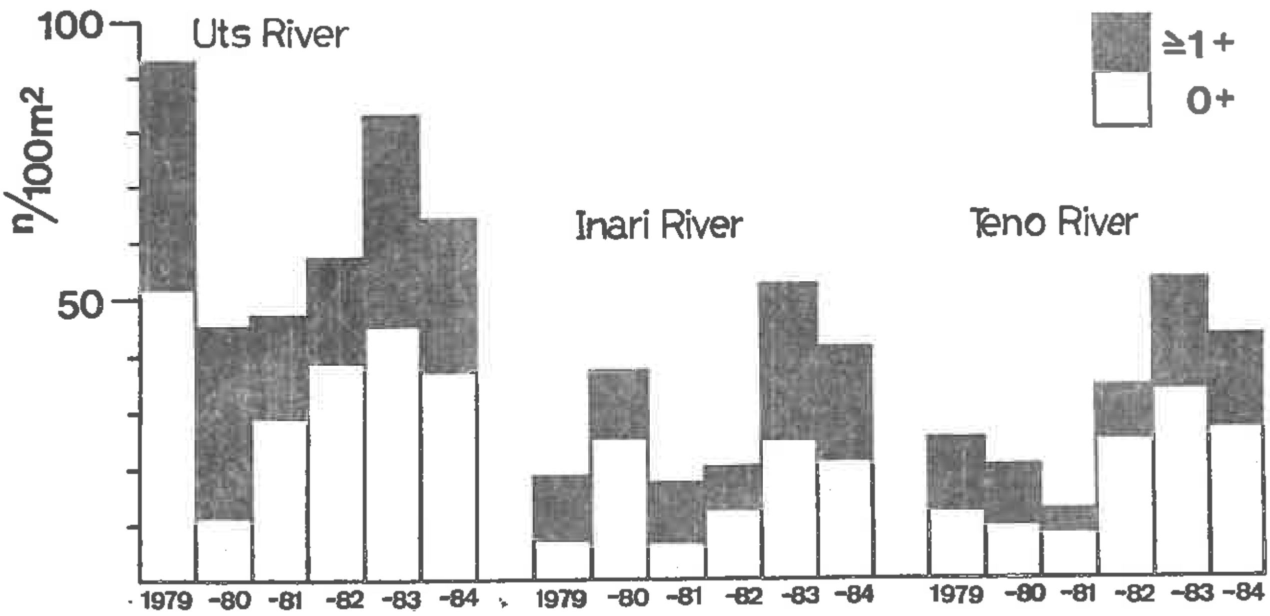

Figure 4. Total absolute densities of salmon (<u>Salmo salar</u>) parr over a 6 year period for three electrofishing stations in the Teno watercourse.

Table 4. Mean and estimated mean densities (#/100 m^2) for the number of stations fished (n) in the Teno watercourse, 1979-1984.

River	0+	est.	1+-->	est.	Total	est
1979						
Tenojoki						
n	24.00	9.00	24.00	9.00	24.00	9.00
mean	1.99	.07	13.22	20.71	15.22	21.33
S_x	1.88	.07	2.26	5.81	2.49	6.00
Inarijoki						
n	10.00	10.00	10.00	10.00	10.00	10.00
mean	6.78	7.30	11.21	11.82	17.99	18.91
S_x	3.06	3.26	2.27	2.89	4.02	4.43
Utsjoki						
n	11.00	11.00	11.00	11.00	11.00	11.00
mean	52.16	59.55	40.73	41.33	92.89	97.93
S_x	29.37	32.01	9.79	9.93	35.16	37.29
1980						
Tenojoki						
n	35.00	24.00	35.00	24.00	35.00	24.00
mean	9.59	27.13	10.73	14.96	20.74	42.09
S_x	5.64	21.12	2.11	2.94	5.98	20.65
Inarijoki						
n	9.00	9.00	9.00	8.00	9.00	8.00
mean	25.02	31.06	12.19	13.90	37.21	44.72
S_x	11.55	14.20	3.99	4.19	12.01	14.12
Utsjoki						
n	11.00	11.00	11.00	10.00	11.00	10.00
mean	12.32	14.26	32.60	38.01	44.88	53.36
S_x	11.40	13.25	10.31	11.50	17.20	21.30
1981						
Tenojoki						
n	9.00	7.00	9.00	7.00	9.00	7.00
mean	8.17	22.14	3.98	4.13	11.95	26.11
S_x	5.45	16.25	1.54	2.14	6.41	16.51
Inarijoki						
n	9.00	6.00	9.00	6.00	9.00	6.00
mean	6.74	10.32	9.32	12.47	16.21	23.09
S_x	3.87	5.70	3.34	4.53	6.59	9.00
Utsjoki						
n	9.00	8.00	9.00	8.00	9.00	8.00
mean	28.93	40.51	17.66	21.40	46.71	62.13
S_x	14.41	18.65	6.36	7.54	17.83	22.93

Table 4. (cont.)

1982						
Tenojoki						
n	35.00	30.00	35.00	30.00	35.00	30.00
mean	25.25	37.08	8.54	10.77	33.80	47.98
S_x	10.94	16.98	1.22	1.44	11.08	16.79
Inarijoki						
n	10.00	9.00	10.00	10.00	10.00	10.00
mean	12.64	14.49	6.96	7.42	19.58	20.96
S_x	7.86	9.22	2.03	2.30	9.39	10.05
Utsjoki						
n	11.00	11.00	11.00	11.00	11.00	11.00
mean	38.63	39.85	18.23	18.99	58.55	30.96
S_x	28.49	28.64	5.70	6.01	31.27	14.71
1983						
Tenojoki						
n	35.00	35.00	35.00	35.00	35.00	35.00
mean	33.58	41.86	19.24	21.48	52.92	63.60
S_x	7.66	9.63	2.75	2.84	8.44	9.86
Inarijoki						
n	10.00	10.00	10.00	10.00	10.00	10.00
mean	24.52	38.18	27.74	29.31	52.23	55.44
S_x	7.34	15.71	4.42	4.78	7.95	9.37
Utsjoki						
n	11.00	11.00	11.00	11.00	11.00	11.00
mean	45.30	46.02	37.30	29.58	82.61	83.83
S_x	23.95	24.00	12.64	10.85	35.72	35.73
1984						
Tenojoki						
n	35.00	35.00	35.00	35.00	35.00	35.00
mean	26.71	33.26	15.95	16.40	42.60	48.05
S_x	6.03	7.71	2.04	2.08	6.34	7.48
Inarijoki						
n	10.00	10.00	10.00	10.00	10.00	10.00
mean	21.41	22.95	19.88	22.21	40.58	43.94
S_x	8.91	9.72	3.85	4.90	9.55	10.86
Utsjoki						
n	11.00	11.00	11.00	11.00	11.00	11.00
mean	37.32	38.78	26.93	27.54	64.16	68.03
S_x	13.84	16.53	9.00	9.12	20.51	20.09

Table 5. Total electrofishing catch densities (number / 100 m^2) from the Teno River watercourse, 1979 to 1984. m^2 is the area fished.

River	1979	1980	1981	1982	1983	1984	Total
Teno River m^2	3101.70	3841.30	955.30	2897.60	3450.80	3035.00	17281.10
other species	3.0	4.7	17.1	16.7	9.6	4.8	8.1
all species	20.0	27.0	27.1	48.1	59.7	46.5	39.3
Inari River m^2	1390.60	1057.50	818.50	909.00	931.40	779.10	5886.10
other species	14.3	18.6	1.8	8.2	11.2	13.9	11.8
all species	30.5	58.0	19.2	27.9	65.7	56.0	42.4
Uts River m^2	1316.50	1166.70	969.50	852.70	982.20	819.70	6107.30
other species	21.0	18.9	2.8	4.8	21.3	9.0	13.3
all species	108.1	52.8	54.6	63.4	101.1	81.5	78.1
All Rivers m^2	5808.30	6065.50	2743.30	4659.30	5364.40	4633.80	29275.10
other species	9.3	9.9	7.1	12.9	12.0	7.0	9.9
all species	42.5	37.4	34.4	47.0	68.4	54.3	48.0

DISCUSSION

Salmon parr densities in southern rivers are often quite low (Egglishaw and Shackley 1977, Karlström 1977) comparing to Teno River. Toivonen (1982) reported 5 to 10 parr per 100 m^2 on undisturbed portions of the other free flowing stream in Finland (the Simo River) in which production depends on natural spawner stocks as in the Teno. Karlström (1977) found salmon parr densities of 0 to 8.5 fish / 100 m^2 in rivers of northern Sweden.

The between year variation in number of salmon caught (and thus density) can be attributed to several natural causes, among which are physiological conditions and habitat selection (Karlström, 1976). The accompanying changes in flow level have a direct influence on catch from two stadpoints. First, though a given station may have started from a static point marked on the river bank, the water level at the time of fishing effectively changed the lateral placement. A resulting shift can have caused a change in the microhabitat actually fished. Karlström (1977) notes that parr are distributed across the water velocity and substrate gradients by age group; younger, smaller fish are associated with smaller substrates and lower velocities. In this work it was also apparant that depth was important. Larger and older parr were found in deeper areas given sufficiently large cobble. Lateral shifts resulted in corresponding annual shifts in habitat suitability for a given parr age group. Catches in deep water (over 60cm) may be biased because of limitations of the equipment and reduced visibility. This could, in turn, account for some of the differences in total catch between 1979 (the lowest water year sampled to date) and later years.

There has been an increase in the Norwegian sea fishery effort in Finnmark over the course of this study, as well as in the river. The effect of fishing pressure on returning adults and subsequent changes in parr populations is still unclear.

REFERENCES

Egglishaw H. J. and P. E. Shackley. 1977. Growth, survival and production of juvenile salmon and trout in a Scottish stream, 1966 - 1975. J. Fish. Biol. 11, 647 - 672.

Karlström, Ö. 1976. Quantitative methods in electrical fishing in Swedish salmon rivers. ZOON 4, 53 - 63.

Karlström, Ö. 1977. Habitat selection and population densities of salmon (Salmo salar) and trout (Salmo trutta) parr in Swedish rivers with some reference to human activities. Doctoral thesis abstract 404, University of Uppsala, Sweden. 12 pp.

Toivonen, J. and Jutila, E. 1982. Report on parr population densities, tagging experiments and river catches of the salmon stock of the River Simojoki in 1972 - 1980. ICES Report C. M. 1982/M:40. 14pp.

Preliminary Seatrout (Salmo trutta L.) Investigations in the Teno River

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ABSTRACT

Seatrout (Salmo trutta) from the Teno River between Finland and Norway comprise a previously undocumented subarctic population. Adult fish were caught mainly by local fishermen using gill nets during 1981 and 1982; a fyke trap was used for smolts from 1974 to 1976. Adult seatrout backcalculated lengths and ages at smoltification were in good agreement with emperical smolt tagging data. Respective outmigrant backcalculated age means were 5.8 and 6.0, compared to 5.3 for smolts. Analyses of variance showed differences in mean lengths for fish smolting the same year from different age groups, and generally no difference in mean smolt length of a given age between years. Neither adult nor smolt timing data are conclusive. The adult catch was bimodal; the early mode was probably outmigrant spawners from the previous season. Seatrout begin to return after only a short time following their first sea year. Females were favored in adult sex ratios by 4 to 1.

RESUME

La truite de mer (Salmo trutta L.) de la rivière Teno, frontière naturelle entre la Finlande e la Norvège, comprend une population subarctique non recensée jusque-là. Les adultes capturés l'ont èté principalement par des pêcheurs locaux utilisant des filets courants, en 1981 et 1982; entre 1974 et 1976, une nasse était utilisée pour prendre les jeunes smolts descendant vers la mer. Les longueurs et les âges des truites de mer au moment de leur descente vers la mer, calculés ultérieurement, coincidaient bien avec les données empiriques fournies par le marquage des smolts. Les moyennes d'âge des poissons migrant vers la mer étaient de 5,8 et 6,0 ans conte 5,3 pour les smolts. Les analyses de la variance ont fait apparaître des différences dans les longueurs moyennes pour les poissons appartenant à des groupes d'âge différents mais descendant à la mer pour la première fois. Ni les données concernant les adultes ni celles relatives aux smolts ne sont concluantes. La prise d'adulte était bimodale; le mode précédent concernait probablement des migrants de la fraye de la saison précédente. La truite de mer entreprend le voyage du retour après seulement une courte période suivant leur première année en mer. Parmi les adultes, les femelles prédominaient, repésentées dans un rapport de 4 à1.

Introduction

It is almost axiomatic that, in the study of natural populations, species lying at or near the extreme limits of their range and having the least economic impact are the least well documented. In the case of seatrout (Salmo trutta L.), an abundance of literature exists for mid- latitude stocks (particularly from Great Britain), while high latitude populations are little studied. In 1979 an agreement between Finland and Norway concerning use and division of the Teno River watershed established a base for joint investigations of the fisheries resources in the area. Under this agreement, a sampling program was established to provide a data base for the management of the 14 freshwater species, particularly salmonids, known to inhabit the system. This paper presents some initial results of an ongoing study of population structure in a subarctic population of seatrout inhabiting the Teno River drainage.

Study Area and Methods

The Teno River, together with its upper tributaries Inari and Kietsimä, forms the border between northern Finland and Norway for 270 km. The lower 60 km flows through Norway. With a drainage area of 16000 sq. km. the Teno is probably the largest entirely free flowing system in northern Europe, of major importance both historically and currently as a major Atlantic salmon (Salmo salar L.) source (Figure 1).

In 1981 and 1982, the sampling season began in mid-May, the time of the ice breakup on the main river. The bulk of the collections were made by local fishermen with net or weir rights who were employed part-time to make concurrent salmon and seatrout collections through to the end of Septemper. Also, until the end of August, additional samples were purchased from other fishermen using weirs, nets, or rod and reel (only artificial lures are allowed). Approximately 2% of the material was obtained by project personnel as incidental catches during a 1981 whitefish survey. Gill nets used by local fishermen, whether standing or weir, were of twisted strand with mesh sizes 40 - 45 mm, or 58 mm and over when fishing specifically for seatrout. However, fishing for other species is possible during summer using various mesh monofilament nets in which adult seatrout often become entangled. The remainder were collected by research staff using a monofilament nylon series of mesh sizes from 15 to 16 mm in 5 mm increments.

Data from adults included date, place, length, weight, sex, gonad development, and gear type.

The backcalculated lengths and determined ages obtained from adult scales were compared with similar data from seatrout outmigrants captured coincidentally during salmon tagging operations conducted from 1974 - 1976 (Tuunainen, et. al., in press). During these years fish were taken, from June to early July, with a f yke-type trap in the Vetsikko River, a tributary of the Teno. A total of 50 silvered seatrout smolts were marked with Carlin tags during the 3 years. Data obtained from smolt tagging records included timing, length, weight and (with the exception of 1976) scales.

Scales were read with a microfische projector incorporating a 17mm primary objective. The projected image (approximately 37 times normal) was measured for back calculation using the Fraser-Lee method (Hile, 1970). Washed scales were mounted in water for reading, since plastic impressions resulted in loss of detail.

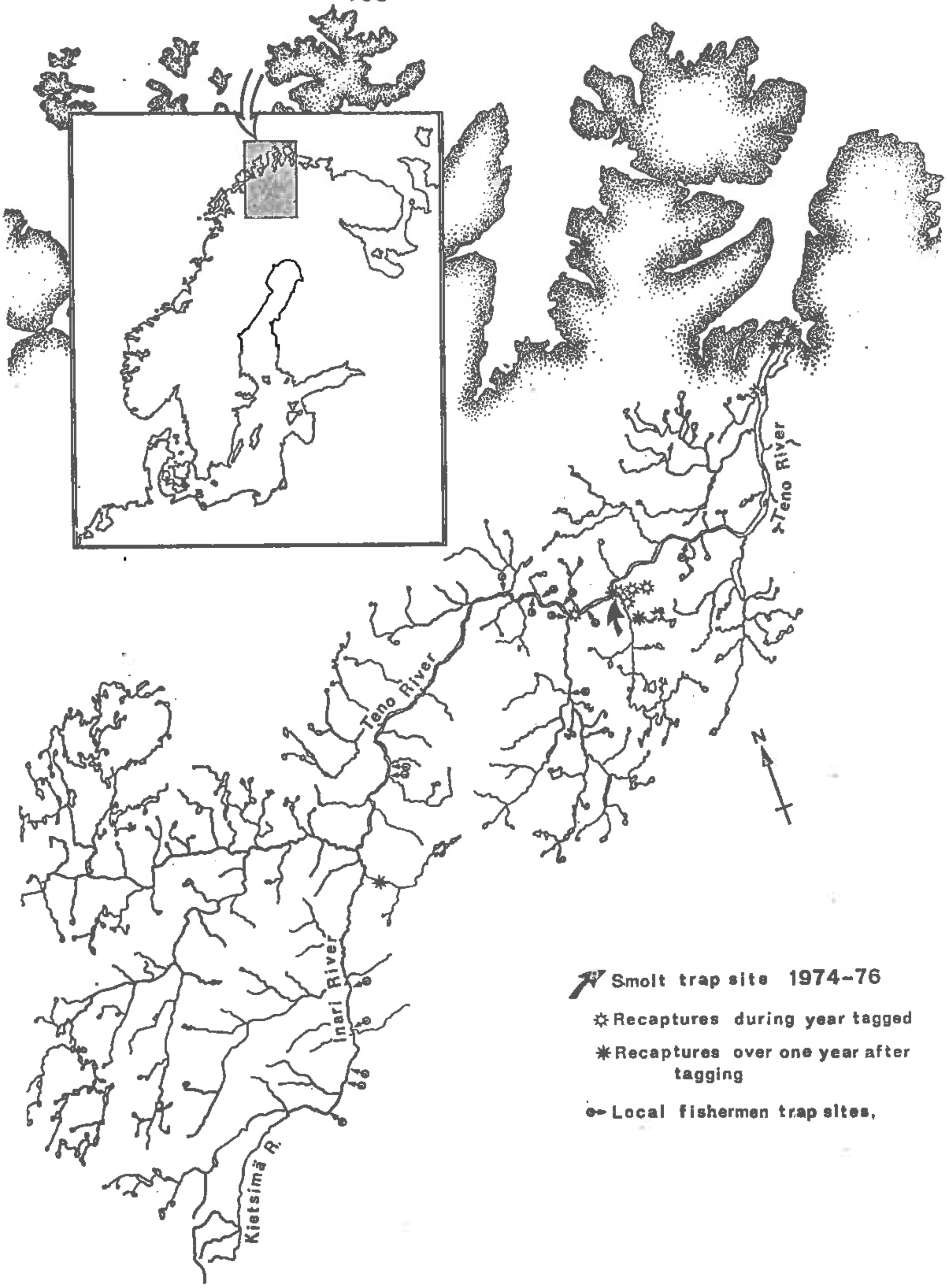

Figure 1. Map of the Teno River drainage showing smolt trap site, recapture areas of outmigrants tagged as seatrout (Salmo trutta) smolts, and main 1981 & 1982 adult catch sites.

Results

Totals of 142 and 165 adult seatrout were caught in 1981 and 1982 respectively. The smolt sample constituted 50 fish from 1974 to 1976, of which 2 were tagged in 1974, 42 in 1975, and 6 in 1976. Fish having scales displaying measureable ocean growth were termed adults, regardless of sexual maturity, to facilitate discussion involving smolts. A backcalculation constant of 2.7 was derived from regression of total fish length against total scale radius of pooled smolt and adult data. Catch length, weight, and back calculated means in length are presented for adults and tagged Vetsikko River smolts on tables 1 and 2 respectively.

The adult catch ranged in length from 19.0 to 65.0 cm. and in weight from 130 to 3400 g for the two years, with means of 36.7 cm and 565 g. Students t-tests on the 1981-1982 data showed no difference in either mean annual catch length or weight at the 95% confidence level. Since both lengths (Figure 2) and weights (Figure 3) were positively skewed, the t-test is not a strictly valid comparison. Tagging data from 1974 - 1976 revealed that smolt means at capture were fairly normally distributed about means of 22,8 cm and 105g in length and weight respectively (not tested).

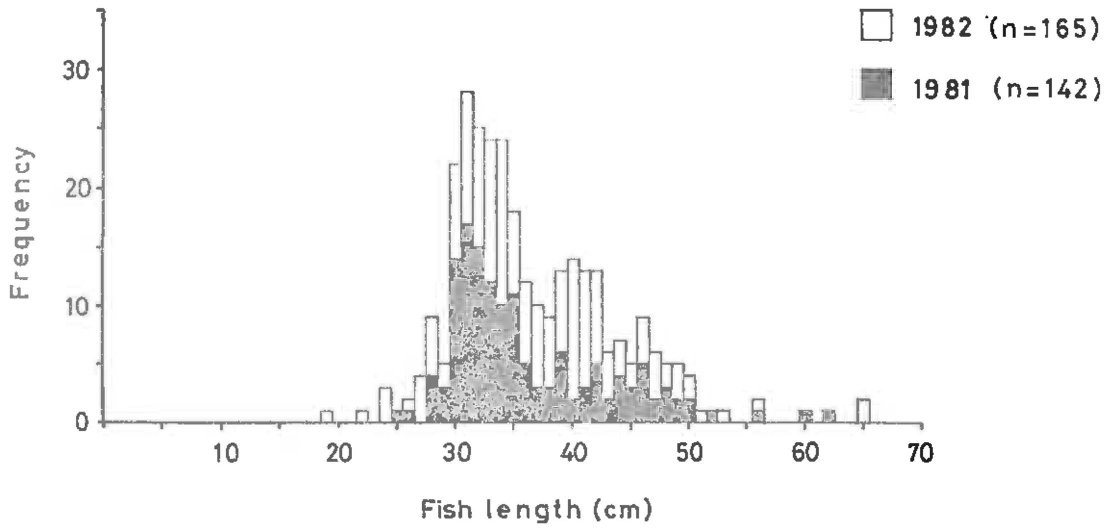

Figure 2. Length frequency histogram for adult seatrout (Salmo trutta) from the Teno River caught by local fishermen in 1981 & 1982.

One way analysis of variance tests for differences in mean length between different age groups smolting in the same year were positive in all cases (Table 3). A similar set of tests generally show no difference in mean length of smolts of the same age, regardless of whether the sample is made from back calculation or direct measurements, when tested at the 95% level (Table 4). The notable exception is the 5 year- old cohort, where t-tests indicate a significant difference between tagged smolt and back calculated smolt lengths, though not between 1981-82 back calculated smolt lengths.

Total ages for adults ranged from 4 (4/+) to over 9 (8/1+, 7/2+, 6/3+) with a mean of 6.5 years. Since backcalculated smolt ages for 1981 and 1982 were 5.8 and 6 years respectively with a collective mode of 6 years (Figure 4), it appears that adults in this study spent an average of one summer at sea before capture. Smolts from 1975 tagging studies had remained parr for an average of 5.3 years before the first seaward migration.

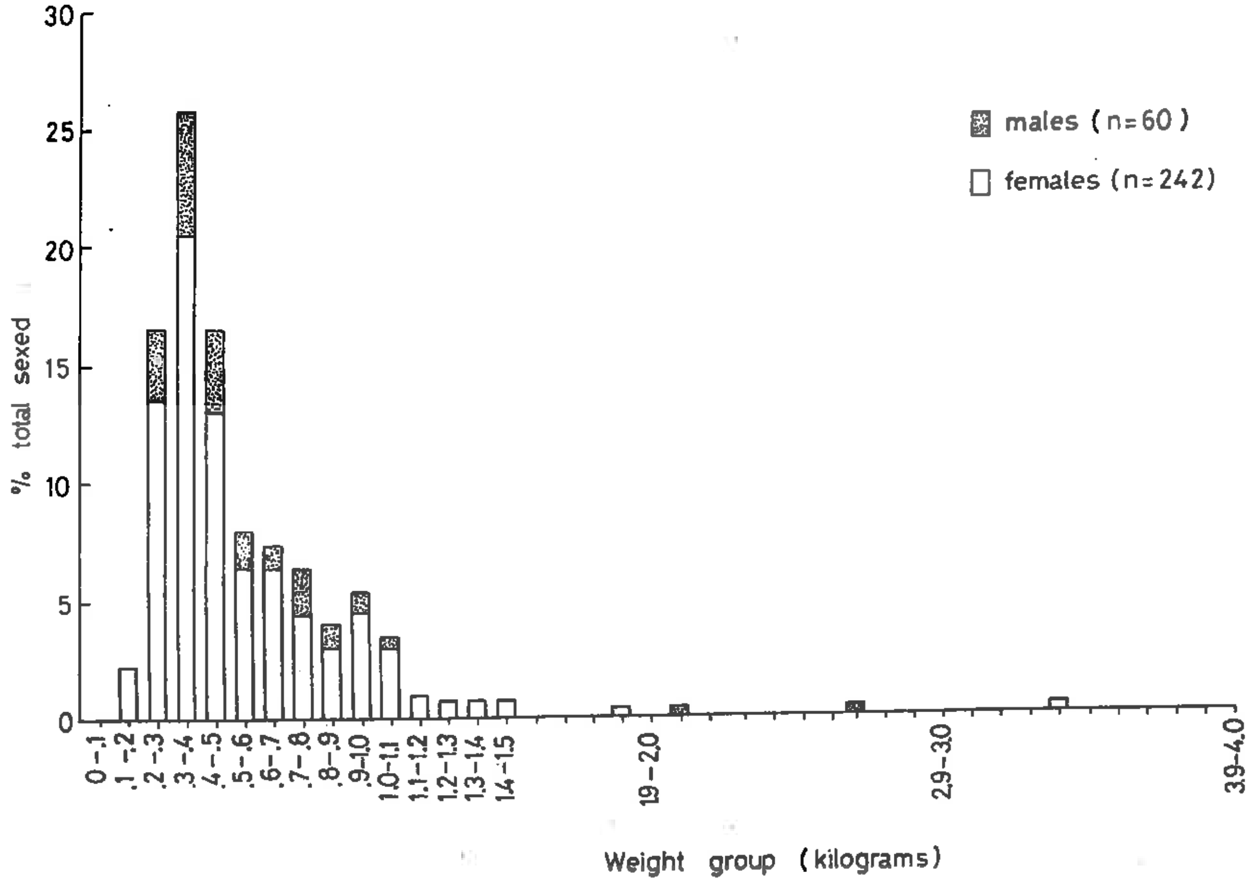

Figure 3. Weight frequency histogram for adult seatrout (Salmo trutta) from the Teno River caught by local fishermen in 1981 &1982.

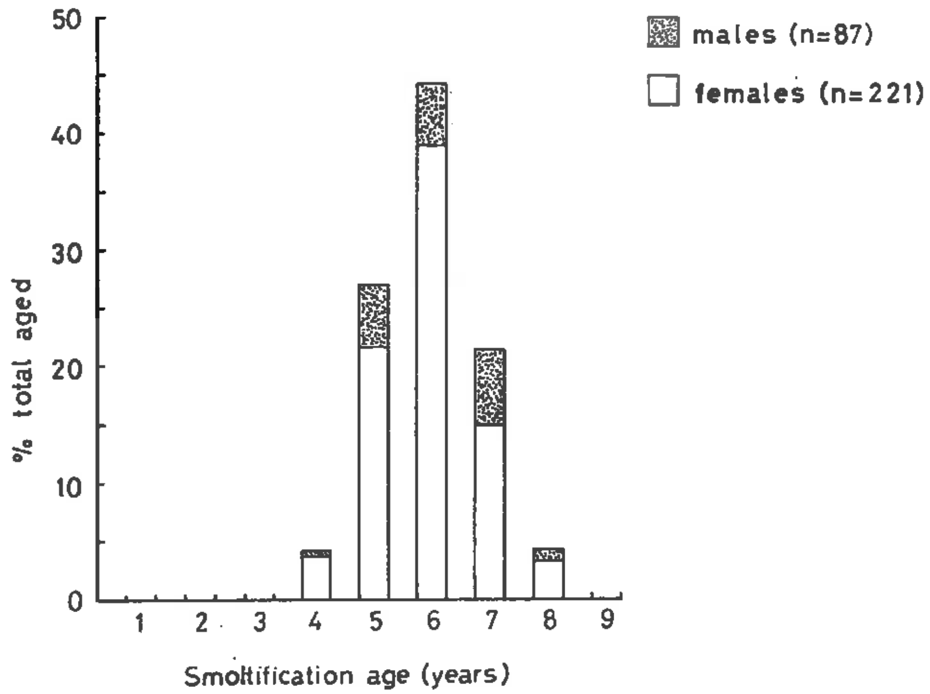

Figure 4. Percent frequency of backcalculated smolt lengths in various age groups in the Teno River, from the combined 1981 & 1982 adult seatrout (Salmo trutta) catch.

Table 1. Mean catch length (cm), weight (g), and backcalculated mean length (cm) at indicated age for adult seatrout (Salmo trutta) taken in the Teno River; 1981 & 1982 (combined). Figures under each mean are 95% confidence intervals for sample sizes greater than 4.

Capture Age	n	% catch	Length	Weight	Freshwater age 1	2	3	4	5	6	7	8	Ocean age 1	2	3
4/+	5	1.6	30.0	318	6.1	11.4	16.8	21.6							
			±1.8	±53	±.6	±1.2	±1.5	±1.4							
5/+	43	14.1	31.7	336	5.7	10.0	13.8	18.9	23.4						
			±9.7	±20	±.2	±.6	±.8	±.5	±.6						
6+	82	27.0	31.4	361	5.6	9.1	13.1	16.8	20.5	24.5					
			±.7	±23	±.2	±.3	±.4	±.4	±.4	±.6					
7/+	27	8.9	34.1	427	5.5	9.2	12.7	16.1	19.2	22.5	26.3				
			±1.4	±50	±.3	±.4	±.5	±.4	±.8	±1.1	±1.3				
8/+	5	1.6	37.6	585	5.4	8.9	12.9	16.7	19.5	22.8	25.8	29.9			
			±1.2	±280	±1.1	±1.4	±2.6	±4.0	±5.1	±5.6	±6.1	±7.2			
4/1+	4	1.3	33.8	385	5.4	10.4	15.1	20.8					29.3		
5/1+	36	11.8	38.6	632	5.7	9.9	14.3	18.5	22.9				32.8		
			±1.7	±96	±.3	±.4	±.5	±.7	±.9				±1.4		
6/1+	40	13.2	38.5	616	5.6	9.5	13.2	16.6	19.8	23.4			31.1		
			±2.0	±76	±.2	±.4	±.6	±.7	±.7	±.8			±1.3		
7/1+	26	8.6	41.3	773	5.5	9.3	12.6	16.1	19.0	22.4	26.3		36.1		
			+2.2	±137	±.2	±.5	±.5	±.7	±.8	±.9	±.9		±1.9		
8/1+	7	2.3	42.5	792	5.3	8.5	12.1	15.3	18.3	20.8	22.8	26.8	36.4		
			±4.1	±181	±.5	±.7	±.9	±.6	±.9	±1.2	±2.0	±1.4	±3.2		
4/2+	3	1.0	41.9	591	5.3	8.3	12.4	16.8					26.0	37.0	
5/2+	4	1.3	43.8	771	5.3	9.5	14.2	18.7	22.8				33.2	41.4	
6/2+	11	3.6	47.9	990	5.7	9.8	14.3	17.7	21.0	25.1			37.8	46.6	
			±3.0	±245	±.3	±.9	±1.2	±1.0	±1.1	±1.5			±2.4	±2.4	
7/2+	5	1.6	46.9	929	5.5	8.7	12.3	15.8	18.9	21.6	24.6		38.1	46.8	
			±3.0	±133	±.4	±1.7	±1.9	±1.6	±2.1	±3.2	±3.2		±1.5	±2.9	
4/3+	1	.3	44.0	650	5.4	10.9	14.7	17.9					23.4	32.0	42.4
6/3+	3	1.0	57.3	2433	5.6	10.5	14.4	18.0	21.7	25.1			36.4	47.0	54.4
7/3+	2	.7	59.2	3265	5.3	9.9	14.0	16.5	19.5	21.8	24.4		36.7	46.3	54.0
Totals			36.7	545	5.6	9.5	13.4	17.3	20.8	23.4	25.8	28.1	33.5	44.4	52.3
			±.8	±55	±.1	±.2	±.2	±.3	±.3	±.4	±.8	±3.7	±.9	±1.8	±6.8

Table 2. Mean catch length (cm), weight (g), and backcalculated mean length at indicated age for tagged seatrout (Salmo trutta) smolts from the Vetsikko River, 1975. Figures under each mean are 95% confidence intervals for samples greater than 4.

Catch Age	n	% catch	Length	Weight	Freshwater age 1	2	3	4	5	6	7
3	1	7.1	18.0	46	6.4	12.2	18.0				
4	6	14.3	20.3 ± 3.0	71 ±15	6.3 ±.8	11.1 ±.7	15.5 ± .7	20.5 ± 1.2			
5	18	42.9	21.8 ±1.0	88 ±3	5.8 ±.1	10.5 ±.2	14.3 ±.2	18.2 ±.2	21.5 ±.3		
6	8	19.0	22.9 ±2.0	118 ±17	6.2 ±.4	9.5 ±.4	13.5 ±.7	15.2 ±.7	19.6 ±.7	22.6 ±.7	
7	6	14.3	27.1 ±4.2	169 ±38	5.7 ±.6	8.9 ±.5	12.4 ±.7	16.1 ±2.4	19.6 ±1.7	23.1 ±2.0	26.4 ±2.8
Total			22.8 ±1.1	105 ±8	6.0 ±.3	10.2 ±.5	14.2 ±.7	18.1 ±.9	20.7 ±.9	22.8 ±1.7	26.4 ±6.2

Table 3. Analysis of variance test results of mean smolt age vs. length at smoltification within a given year.

H_o	Year*	n	$F_{calc.}$	$F_{crit.}$	Conclusion
$X_4 = X_5 = X_6 = X_7$	1975	38	7.828	2.89	Reject H_o
$X_4 = X_5 = X_6 = X_7 = X_8$	1981	138	5.626	2.445	Reject H_o
$X_4 = X_5 = X_6 = X_7 = X_8$	1982	165	17.239	2.42	Reject H_o

Table 4. Analysis of variance test results of mean smolt length of a given age class vs year of catch.

H_o	n	$F_{calc.}$	$F_{crit.}$	Conclusion
$X_{4,75*} = X_{4,81*} = X_{4,82*}$	19	1.106	3.63	Accept H_o
$X_{5,75*} = X_{5,8*}1 = X_{5,82*}$	101	3.270	3.09	Reject H_o
$X_{6,75*} = X_{6,81*} = X_{6,82*}$	143	2.606	3.06	Accept H_o
$X_{7,75*} = X_{7,81*} = X_{7,82*}$	66	0.423	3.14	Accept H_o

* Year indicated is for capture data, not necessarily smoltification time

From records of date of catch, it appears that adult migration timing is bimodal, with one group caught from April through June, and another from late August to the end of October. The late run is composed chiefly of 0+ (62%) and 1+ (34%) sea age cohorts (Figure 5). Adults 2 sea-years and older accounted for only about 4% of the late season catch.

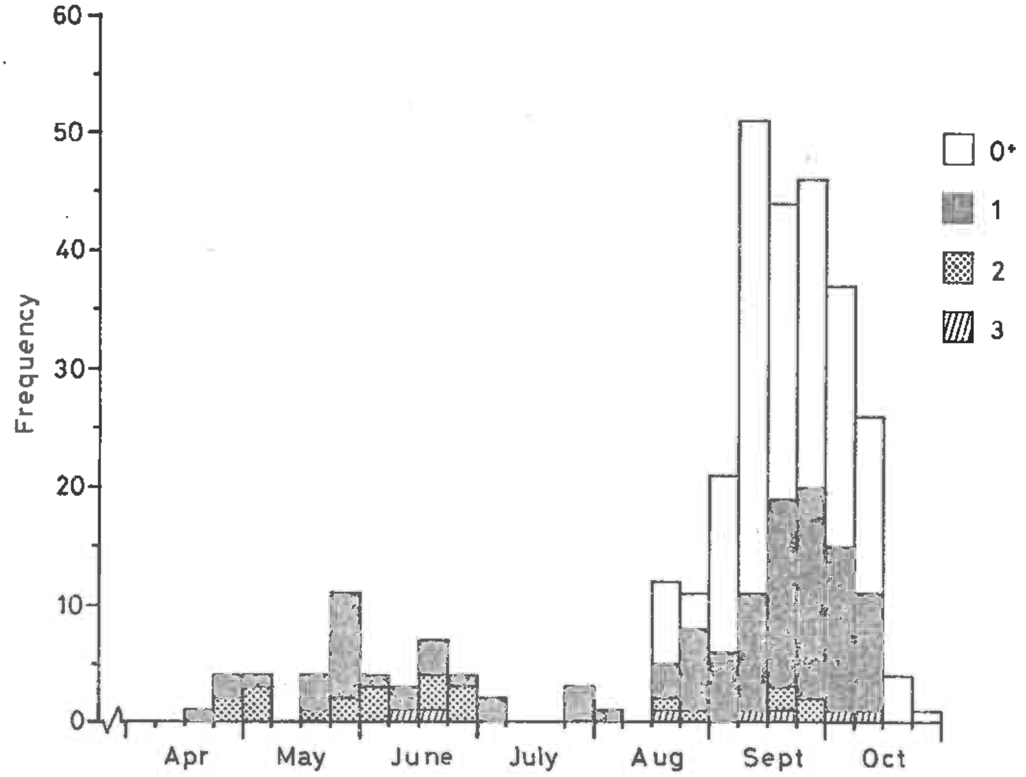

Figure 5. Weekly adult seatrout (Salmo trutta) catch frequencies by sea age, from the Teno River, 1981 & 1982 combined.

Due to the small smolt sample size and the fact that the smolt tagging operation was geared to salmon, timing of the peak seatrout smolt outmigration is unclear. However, a plot of the 1975 smolt catch against discharge and surface temperature in the main river suggests that the seatrout run is earlier than for salmon, and may be positively correlated to flows (Figure 6).

Females predominated over males in the adult catch by a 4 to 1 ratio. Reported gonad development indicates that fish returning during the autumn of their first sea year (i.e. 0+) have the greatest number of sexually immature individuals, particularly in the female contingent. Of the 263 samples reporting gonad development, only 8 (2.9%) were ripe females; all these were in their second ocean year (1+). Mature males comprised 9% of the adult catch, divided among 0+, 1+, and 2+ ocean age cohorts (Figure 7).

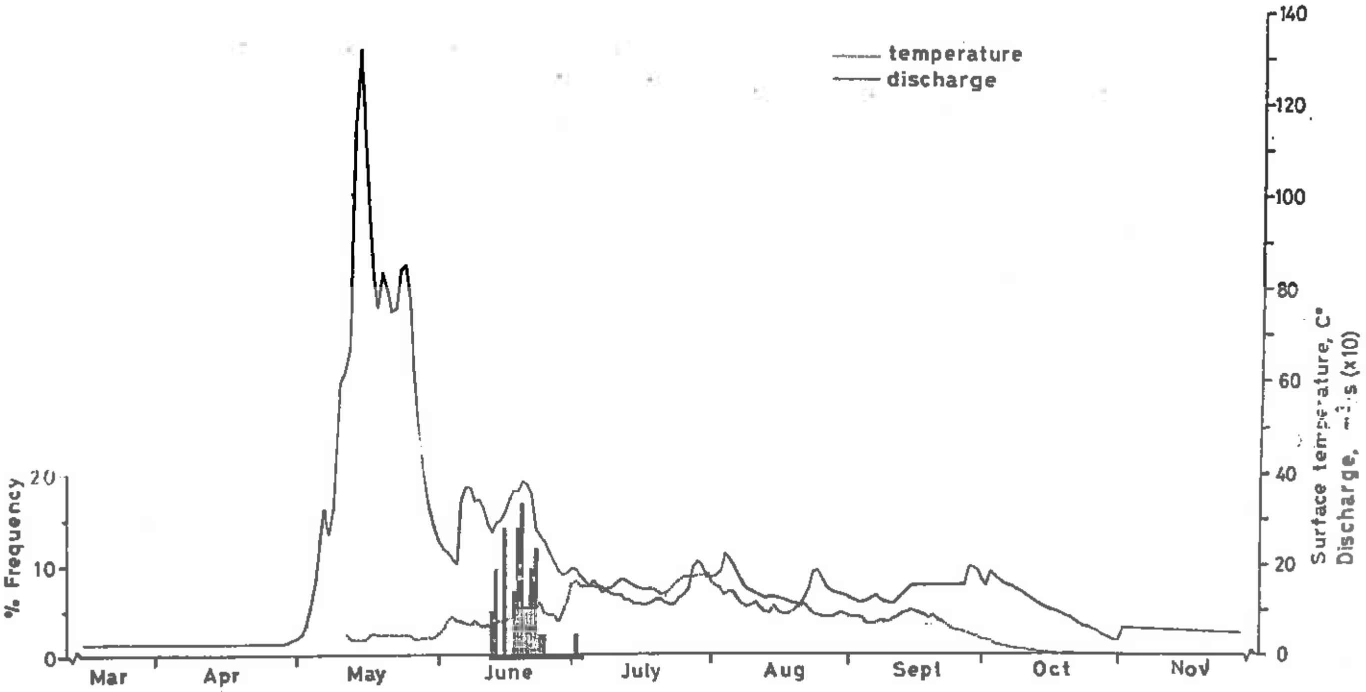

Figure 6. Timing of the 1975 daily smolt catch (vertical histogram) plotted with surface temperature and discharge from permanent recording station data. Bar from mid-June to early July represents the duration of the trapping period.

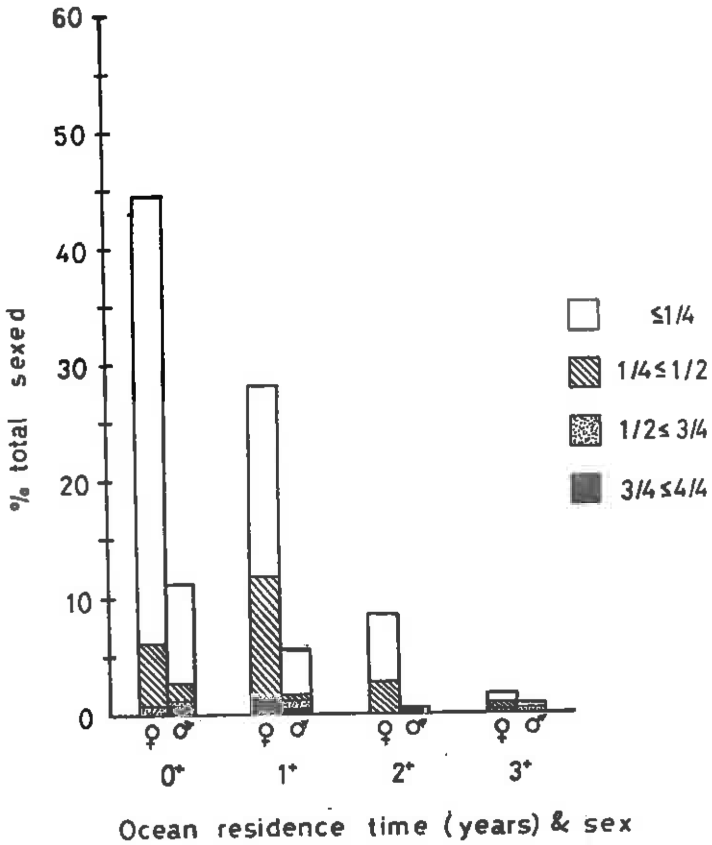

Figure 7. Percent frequency gonad development of adult seatrout (Salmo trutta) catch by sea age and sex, from the Teno River, 1981 & 1982 combined.

DISCUSSION

Sampling methods for adults undoubtedly biased data obtained for this study in a number of ways. Effort, in terms of trap site selection, was almost certainly directed toward the more commercially valuable salmon until the end of the salmon fishing season (August 30), and toward seatrout in September and October. Again, since the majority of adults were taken with only three mesh sizes (Figure 8), length frequencies and maturity data probably favored younger, smaller and therefore less mature individuals during the late season catch (data on net mesh size was not recorded for all specimens). Though sex determination by local fishermen is accurate, maturity estimates in females caught early in the season (April to July) indicate only apparent development of the gonad, not regression due to spawning. Thus, individuals caught early may have been spawners from the previous season. Coupled with a lack of spawning checks on scales, this precludes an estimate of the number of repeat spawner outmigrants, which may constitute a significant proportion of the spring contingent (Jensen 1968).

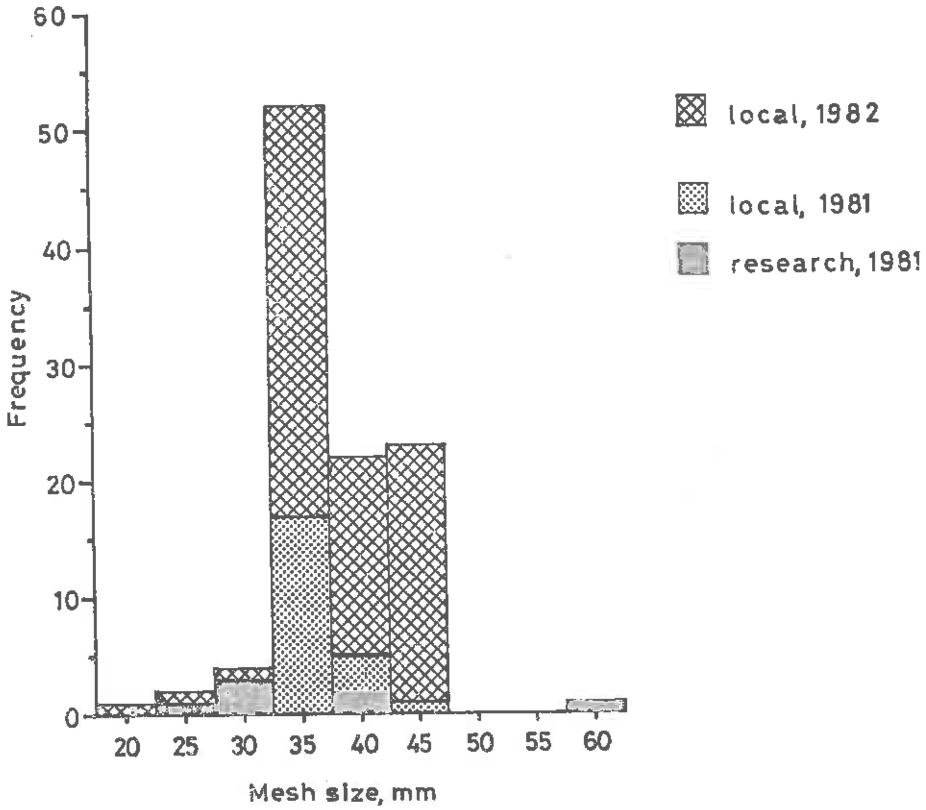

Figure 8. Catch frequency of adult seatrout (Salmo trutta) by net mesh sizes used on the Teno River, 1981 & 1982 combined. Note that the 1981 data is divided into local fisherman and incidental research catch (stippled areas).

From the timing of 1975 smolt captures and the first adult returns from the 1981-1982 data it appears that seatrout begin to return to fresh water after only a short ocean residence, which supports earlier findings (Johnsen 1978, Aandahl 1974, Jensen 1968). The fact that the 1-summer (0+) sea age group is predominant in catches may be an artifact associated with timing and the type of gear used when these data are compared with other reports. For instance, rod and reel catches from the Alta River, in northern Norway, have produced more second summer seatrout (Heggberget et.al. 1984), and weir traps tend to show a similar trend toward older sea age spawners (Jensen 1968).

Sex ratios are also consistant with other reports of female dominance in adult seatrout populations (Heggberget et. al. 1984, Johnsen 1978a, Hagala and Heggberget 1976).

The results presented here with regard to smolt age are encouraging, since empirical and backcalculated data concerning the range and magnitude of smolt ages are in fair agreement. The lower mean from the tagged smolt ages may be associated with factors other than ageing and backcalculation processes. The smolts were all from one tributary, whereas the adult catch was from a mixed stock, assuming that there is more than one stream in the Teno drainage contributing to the seatrout population. Also, annual variation in growth rate probably accounts for some of the variation in ages.

The smolt lengths and ages under discussion are respectively longer and older than have been reported previously, but tend to support a general pattern of positive correlation between smoltification age and increasing latitude. Pratten and Shearer (1983), for example, recorded predominately 2 and 3 year-old smolts in a study of the North Esk in Scotland. In Norway, most outmigrants smolted at 3 years from Vangsvatnet in the southwest (Jonsson 1985), 3.5 to 4.6 year mean smolt ages were reported from central regions (Jensen 1979, Johnsen 1978a, Johnsen 1978b, Johnsen 1978c, Johnsen 1976), and 4.5 to 4.6 years in the northerly Alta River (Heggberget et. al. 1984, Aandahl 1974). Though backcalculated lengths within the same age group from different systems is probably not valid due to differences in methods of backcalculation.

The growth topic for adult data will be the theme of a future report, when more material, utilizing a variety of collection methods, can be brought to bear.

The material presented lends support to the general correlation in latitude and smolt age in seatrout. Using this, and formerly presented, data as a basis, it would seem reasonable to consider the mechanisms controlling this effect, with a possible objective of more effective brown trout and seatrout management through morph segregation.

ACKNOWLEDGEMENTS

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REFERENCES

Aandhal, A. 1974. Fisken av fisket i Altaelva og Tverrelva. Alta-Prosjektet Fiskeribiologiske Forundersokeler 1972 - 1974 dell 2: 53-58

Hagala P. and T. G. Heggebert. 1976. Merking av sjoorret i Ervikvassdraget, Harstad. Harstad og Omland Sportsfiskereforbund Rapport 1976: 72 pages

Heggberget, T. G., R. A. Lund, and B. Veie-Rosvoll. 1984. Konsesjonsundersokelser i Alta-Kautokeinovassdragget 1981 - 1983 - Fisk. 5: 25-29

Hile, R. 1970. Body scale relation and calculation of growth in fishes. Trans. Amer. Fish. Soc. No 3 (1970) : 468-474

Jensen, A. J. 1979. Fiskerbiologiske undersokelser i de laksforende deler av Kobbelv- og Sorfjordvassdragene. Direktoratet for Vilt og Ferskvannfisk Reguleringsundersokelsene Rapport nr 6: 40-41

Jensen, K. J. 1968. Seatrout (Salmo trutta, L.) of the River Istra, western Norway. Institute of Freshwater Research Drottningholm Report No 48: 187-213

Johnsen, B. O. 1976. Fiskbiologiske undersokelser i de lakseforende deller av Vefsnavassdraget. Direktoratet for Vilt og Ferskvannfisk Reguleringsundersokelsene i Nordland Rapport nr 5: 31-44

Johnsen, B. O. 1978a. Fiskbiologiske undersokelser i de lakseforende deller av Saltdalsvassdraget. Direktoratet for Vilt og Ferskvannfisk Reguleringsundersokelsene i Nordland Rapport nr 1: 41-45

Johnsen, B. O. 1976b. Fiskebiologiske undersokelser i de lakseforende deller av Lakselva i Misvaer. Direktoratet for Vilt og Ferskvannfisk Reguleringsundersokelsene i Nordland Rapport nr 3: 36-39

Johnsen, B. O. 1978c. Fiskebiologiske undersokelser i de lakseforende deller av Ranavassdraget. Direktoratet for Vilt og Ferskvannfisk Reguleringsundersokelsene i Norland Rapport nr 7: 39-41

Jonsson B. 1985. Life history patterns of freshwater resident and sea-run migrant brown trout in Norway. Trans. Am. Fish. Soc. 114 (1985):182-194

Pratten . and W. M. Shearer. 1983. Sea trout of the River North Esk. Fish. Mgmt. 14(2): 49 65

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RECAPTURES OF SALMON POST-SMOLTS (*Salmo salar* L.) DURING THE FIRST SUMMER AFTER RELEASE IN FINNISH TAGGING EXPERIMENTS

by

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Abstract

Recaptures of salmon post-smolts during the first summer after release have been studied in Finnish tagging experiments performed in the northern part of the Gulf of Bothnia in 1967-1978. The recapture percentage of post-smolts was on average 0.3-1.2 % for hatchery-reared smolts from different release sites, and 0.6 % for wild smolts from the River Simojoki. Fyke-nets and gill nets were the most common fishing gears used. A considerable number of returned tags were found in colonies of Caspian tern. On the basis of recapture data, most post-smolts remain within 10 km zone around the release site during the first period of 10 days. In the first 10-20 days, the majority of the recaptures were from a zone 10-20 km, and after 6 weeks from a zone of c. 100 km from the release site. Post-smolts migrated mainly in western and southern directions, against the main current.

Résumé

On a étudié les recaptures de post-saumoneaux d'aval marqués dans la Baie de Bothnie, au cours du premier été suivant le lâchage, de 1967 à 1978. Le pourcentage de recapture des post-saumoneaux d'aval a été en moyenne de 0.3 à 1.2 % pour les saumoneaux élevés en alevinier en différents lieux de lâchage et de 0.6 % pour les saumoneaux d'aval sauvages de la rivière Simojoki. Un nombre considérable de marqueurs retournés furent retrouvés dans les colonies de sterne Caspienne. D'après les recaptures, la plupart des post-saumoneaux d'aval restent pendant la première période de 10 jours à l'intérieur d'une zone de 10 km autour du lieu de lâchage. Pendant la période allant du 10ème au 20ème jour, la majorité des recaptures le furent dans une zone de 20 à 50 km, et après 6 semaines dans une zone de 100 km du point de lâchage. Les post-saumoneaux d'aval émigrèrent surtout vers l'ouest et le sud, dans la direction opposée au courant principal.

Introduction

Tagging experiments using Baltic salmon have been carried out in Finland since 1959, first in the 1960s by the Bureau for Fisheries Research, and since 1971 by the Finnish Game and Fisheries Research Institute. This paper deals only with the tagging experiments on salmon smolts in the Gulf of Bothnia in 1967-1978. Only recaptures during the first summer after release have been examined in this connection. As the data of the post-smolt recaptures was collected in 1982, the numbers of total recaptures are in part incomplete. Many of the taggings have been done in connection with various experiments in rearing, feeding, handling, etc. Thus the results of different experimental groups are not necessarily directly comparable with each other. Results of these tagging experiments have been presented e.g. by TOIVONEN (1977), IKONEN and AUVINEN (1982, 1985) and VALLE (1985).

Material and methods

The material of this study consists of recoveries received from tagging experiments with a total of 80 700 salmon smolts. Nearly 17 000 of the tagged smolts were taken from the salmon stock of the River Iijoki and reared at the Central Fish Culture Station of Northern Finland. The release sites of these smolts were the mouths of the River Iijoki (7 980 smolts, 15 experimental groups) and the River Kemijoki (8 794 smolts, 13 experimental groups). About 58 000 smolts were from the salmon stock reared at the Montta Hatchery, which is situated on the River Oulujoki. These smolts were released at the mouths of the River Oulujoki (46 824 smolts, 44 experimental groups) and the River Simojoki (11 239 smolts, 12 experimental groups). In addition to the hatchery reared smolts, a total of 5 882 wild smolts from the salmon stock of the River Simojoki were captured, tagged, and released at the mouth of the river. Hatchery reared smolts were two to three years old, and wild smolts two to four years old. Release dates varied from the latter half of May to the latter part of June.

The smolts were usually tagged in spring, some days before their release, with tags of the Carlin type. MS-222 solution was used in anesthetizing of smolts. The transport distances varied between 40 and 200 km.

Results

The recapture numbers of post-smolts varied according to the various release sites and years, but overall they remained almost unchanged during the 1970s. The recaptures of tagged post-smolts during the first summer were usually lowest in the northern rivers, and relatively highest in the southernmost river. The recaptures of post-smolts accounted on an average 0.3 % (0-1.2 %) of tagged smolts in the River Kemijoki; 0.7 % (0-1.45 %) of tagged wild smolts and 0.4 % (0-1.25 %) of reared smolts in the River Simojoki; 0.6 % (0-1.40 %) in the River Iijoki and 1.2 % (0-9.1 %) in the River Oulujoki (Tables 1-4). The corresponding numbers of total recaptures of tagged salmon were 4.1 % (0-20.8 %) in the River Kemijoki, 11.9 % (5.5-25.1 %) for wild and 9.5 % (1.6-20.6 %) for reared salmon smolts in the River Simojoki, 11.0 % (2.4-34.2 %) in the River Iijoki, and 9.0 % (0.1-25.2 %) in the River Oulujoki. A rapid decrease in total recaptures can be seen towards the end of the 1970s. In relation to the total recaptures of salmon, the proportion of post-smolt recaptures correspondingly increased during this period. The recaptures of salmon in the post-smolt stage were 8.4 % (0-40.0 %) of total tagged salmon recaptures in the River Kemijoki; 9.8 % (0-23.6 %) for wild smolts and 5.9 % (0-18.8 %) for reared smolts in the River Simojoki; 16.2 % (0-58.2 %) in the River Iijoki; and 15.2 % (0-50.0 %) in the River Oulujoki.

In all the recapture areas, fyke-nets and gill nets were the most inportant fishing gears used for the recoveries of the salmon post-smolts (Table 5). In six of the eight areas around the release sites, most of the recoveries made by fishermen were from fyke-net fishery. Set gill nets were the most important fishing method in only one of the release areas (River Oulujoki, Virpiniemi). In some areas the category "Others", in which the fishing method used usually was not known, was a rather numerous category. Only four of salmon smolt tags were found in the stomachs of predatory fish. For half of the different release sites, most of the returned tags were found in remnants of meals in Caspian tern colonies on the Krunnit Islands in the Gulf of Bothnia and the Valassaaret Islands in the Quark area.

About 1/2 of the recaptured post-smolts had been taken within a distance of 10 km, and nearly 2/3 within a distance of 20 km, from the releasing site (Figures 1-5). About 1/4 of the recoveries were from a zone 20-50 km, and about 1/10 from distances over 50 km from the release sites. Most of the returned tags in the zone 20-50 km from the release sites were found in the Caspian tern colony on the Krunnit Islands. This colony is situated within the range of Caspian tern, about 30 km from nearly all the release sites. No tags from River Kemijoki salmon stockings were recovered from the Caspian tern colony on the Krunnit Islands. However, tags from these stockings were recovered later in the summer from the Caspian tern colony on the Valassaaret Islands.

Over 70 % of tag recoveries were made during the first 30 days from the smolt release date. Over half of all the recaptures of post-smolts were during the period of the first 20 days after release (Table 6). After this period recaptures declined sharply to the end of the summer. Around 20 % of all the recaptures were recorded during the second 30 day period, about 5 % during the third, and less than 1 % during the fourth month after release.

According to recapture data most post-smolts stay within 10 km zone the first period of 10 days after the release (Figure 6), although some post-smolts reach distances of about 50 km. During the period of 10-20 days after release, the majority of post-smolt recaptures are made in zones 20-50 km from the release sites. A few have migrated to distances of over 100 km. After 20 days, most of the recaptures are still from zones of less than 50 km from the release site, but the proportion of recaptures in the zone of over 100 km increases. By the latter part of the second month, most of the post-smolts appear to have migrated to this zone.

Discussion

According to the recapture data, salmon post-smolts remain near their release site for a period of 10 days after release. In the northern Baltic Sea this period lasts for two weeks (LARSSON and ATESHKAR 1979). Actual migration begins after this adaptation period. In 10-20 days most post-smolts reach distances of 20-50 km from the release site. Later in June and July post-smolts migrate in the northern Gulf of Bothnia, (Bothnian Bay) entering the southern Gulf of Bothnia (Bothnian Sea) before the middle of August. Some of the post-smolts remain near the release site even in August. On the basis of the tag recoveries, the migration speed of the post-smolts has been calculated at an average 1-6 km/day, or 10-40 km/week, although the speed may also be greater. LARSSON and ATESHKAR (1979) estimated the average speed to be about 50 km/week.

LARSSON and ATESHKAR (1979) observed that the post-smolt migration from the River Lule seems to follow the main sea currents southwards. On the Finnish coast of the northern Gulf of Bothnia the main current flows northwards. However, Finnish tagging experiments show post-smolts migrating mainly in western and southern directions, against the main current.

Post-smolts probably migrate southwards in the open sea area, as there are only a few recaptures in the coastal fishery in the southern Gulf of Bothnia. According to JUTILA and TOIVONEN (1985) post-smolts prefer warm surface water and feed on insects and small fish near the surface of the sea. Also, tag recoveries in the nests of Caspian tern show that post-smolts swim near the sea surface during migration.

In the Finnish tagging experiments, a general trend observed was that salmon stockings with good total results have rather low recapture numbers during the post-smolt period. However, small recapture numbers of post-smolts do not necessarily indicate good total recaptures. For example, in the mouth of the River Oulujoki, both the recaptures of post-smolts and the total tagged salmon recaptures are greater than in the River Kemijoki mouth.

Rather great variations can be seen between different release sites in the numbers of post-smolt recaptures e.g. in salmon stockings at the mouth of the River Oulujoki. These variations depend among other factors on the intensity of the coastal fishery near the release site.

Post-smolts are most exposed to the coastal fishery immediately after release. Later in the summer most tag recoveries were made in the Caspian tern colonies. Only a few tags were found in the stomachs of predatory fish, but such tags are very difficult to see and are often overlooked. Selection of release sites and development of releasing methods may reduce smolt mortality caused by coastal fishery and predators. One reason for the high mortality of post-smolts may be that rather many post-smolts remain in the northern Gulf of Bothnia up until August. The mortality among these smolts may be high if they do not reach the piscivorous phase until autumn. This indicates that the quality and size of smolts could be important in efforts to decrease mortality among post-smolts.

References

IKONEN, E. and AUVINEN, H. 1982. Results of stocking with Baltic salmon in Finland in 1969-1980. - ICES, Doc. C.M. 1982/M:38.

IKONEN, E. and AUVINEN, H. 1985. Migration of salmon post-smolts (Salmo salar L.) in the Baltic. ICES, Doc. C.M. 1985/M:19.

JUTILA, E. and TOIVONEN, J. 1985. Food composition of salmon post-smolts (Salmo salar L.) in the northern part of the Gulf of Bothnia. ICES, Doc. C.M. 1985/M:21.

LARSSON, P.-O. and ATESHKAR, S. 1979. Laxsmoltens vandring från Luleälven. Fiskeritidskrift för Finland 23(1): 8-9.

TOIVONEN, J. 1977. Differences in recaptures of wild and hatchery-reared salmon smolts. - ICES, Doc. C.M. 1977/M:7.

VALLE, E. 1985. Predation of birds on salmon and sea trout smolts and post-smolts. ICES, Doc. C.M. 1985/M:22.

Table 1. Results of stocking with tagged salmon smolts in the Gulf of Bothnia, River Kemijoki

Release site	Date of release	Number released	Total recaptures		First summer recaptures		First summer recaptures as of all recaptures
	Year Month Day		Number	%	Number	%	%
Isohaara	670522	1000	20	2.0	2	0.20	10.0
River mouth	680613	1000	16	1.6	0	0	0
"	700625	1800	68	3.8	0	0	0
Munaluoto	750605	250	52	20.8	0	0	0
"	750605	250	0	0	0	0	0
Ajos harbour	770615 1)	994	23	2.3	3	0.30	13.0
Kiikkara	770608 1)	500	19	3.8	6	1.20	31.6
"	770508 1)	500	21	4.2	1	0.20	4.8
Valmarinniemi	770609 1)	500	19	3.8	3	0.60	15.8
Pitkäluoto	770608 1)	500	5	1.0	2	0.40	40.0
Valmarinniemi	770609 1)	500	28	5.6	2	0.40	7.1
Kiikkara	770608 1)	500	11	2.2	2	0.40	18.2
Off the river mouth	780605 1)	500	10	2.0	0	0	0
	Total	8794					

1) Data on results are still incomplete.

Table 2. Results of stocking with tagged salmon smolts in the Gulf on Bothnia, River Simojoki.

Release site	Date of release Year Month Day	Number released	Total recaptures Number	%	First summer recaptures Number	%	First summer recapture as % of all recaptures %
Tainijoki	690606	1000	25	2.5	0	0	0
4-road bridge	700528	1000	122	12.2	1	0.10	0.8
"	710522	1000	206	20.6	0	0	0
Suukoski Rapids	720610 1)	450	113	25.1	0	0	0
Campground beach	720606	1000	186	18.6	1	0.10	0.5
Suukoski Rapids	730619 1)	70	13	18.6	0	0	0
Palokari beach	730613	1000	157	15.7	7	0.70	4.5
Halttula, Kuivaniemi	730528	500	70	14.0	3	0.60	4.3
Suukoski Rapids	740608 1)	936	98	10.5	3	0.32	3.1
"	740608 1)	500	46	9.2	4	0.80	8.7
Campground beach	740611	100	5	5.0	0	0	0
Palokari beach	740611	900	74	8.2	6	0.67	8.1
Suukoski Rapids	750523 1)	550	66	12.0	8	1.45	12.1
Campground beach	750714	150	5	3.3	0	0	0
Palokari beach	750606	1000	61	6.1	9	0.90	14.8
Suukoski Rabids	760528 1)	1382	87	6.3	19	1.37	21.8
Simo fishing harbour	760611	962	62	6.4	12	1.25	19.4
River mouth	770612 1)	1994	110 2)	5.5 2)	26	1.30	23.6 2)
Suukoski Rapids	760605 1)	1641	126 2)	7.7 2)	11	0.67	8.7 2)
Halttula, Kuivaniemi	780531	986	16 2)	1.6 2)	3	0.30	18.8 2)
	Total	17121					
Reared smolts	Total	9598					
1) Wild smolts	Total	7523					

2) Data on results are still incomplete.

Table 3. Results of stocking with tagged salmon smolts in the Gulf of Bothnia, River Iijoki

Release site	Date of release (Year Month Day)	Number released	Total recaptures		First summer recaptures		First summer recaptures as % of all recaptures
			Number	%	Number	%	%
Praavanlahti	730527	500	90	18.0	2	0.40	2.2
Finninkari	730527	500	66	13.2	1	0.20	1.5
"	730527	499	139	27.9	3	0.60	2.2
Raasakka Dam, down river	730530	500	79	15.8	3	0.60	3.8
Kauneus Dam, down river	730530	499	67	13.4	3	0.60	4.5
Krunnit Islands	730530	500	85	17.0	4	0.80	4.7
"	730530	500	171	34.2	1	0.20	0.6
Praavanlahti	770611[1)]	495	12	2.4	3	0.61	25.0
"	770608[1)]	499	15	3.0	4	0.80	26.7
"	770611[1)]	500	18	3.5	3	0.60	16.7
"	770611[1)]	499	24	4.8	4	0.80	16.7
"	770609[1)]	500	20	4.0	0	0	0
"	770609[1)]	500	13	2.6	4	0.80	30.8
River mouth	780602[1)]	990	26	2.6	13	1.31	50.0
"	780601[1)]	499	12	2.4	7	1.40	58.3
	Total	7 980					

1) Data on results are still incomplete

Table 4. Results of stocking with tagged salmon smolts in the Gulf of Bothnia, River Oulujoki.

Release site	Date of release Yr Mo Day	Number released	Total recaptures Number	Total recaptures %	First summer recaptures Number	First summer recaptures %	First summer recaptures as % of all recaptures %
Virpiniemi	690528	1175	120	10.2	37	3.15	30.8
"	720527	1000	229	22.9	8	0.90	3.5
"	720523	1000	236	23.6	10	1.00	4.2
"	730511	2000	360	18.0	136	6.80	37.8
"	750526	1000	130	13.0	13	1.30	10.0
"	750526	1000	113	11.3	11	1.10	9.7
"	750527	1000	91	9.1	11	1.10	12.1
	Total	8175					
Kello,Kiviniemi	690522	1039	199	19.2	94	9.05	47.2
Kellonlahti	700521	2000	176	8.8	2	0.10	1.1
Kello,Kiviniemi	710517	1000	122	12.2	17	1.70	13.9
	Total	4039					
Oulunsalo,timber dock	690523	1706	101	5.7	19	1.06	18.8
"	700523	1000	84	8.4	0	0	0
"	700523	1000	69	6.9	0	0	0
"	710512	1000	130	13.0	1	0.10	0.8
"	720526	1000	255	25.5	9	0.90	3.5
"	720529	1000	221	22.1	7	0.70	3.2
"	730514	2000	258	12.9	33	1.65	12.8
"	740531	1000	79	7.9	3	0.30	3.8
"	740612	1000	148	14.8	1	0.10	0.7
"	750528	1000	139	13.9	18	1.80	12.9
"	750527	1000	84	8.4	11	1.10	13.1
"	750523	1000	87	8.7	16	1.60	18.4
"	760531	937	52	5.2	9	0.90	17.3
"	770601[1)]	1000	39	3.9	4	0.40	10.3
"	780531[1)]	996	41	4.1	11	1.10	26.8
"	780530[1)]	990	29	2.9	12	1.21	41.4
"	780530[1)]	969	26	2.7	10	1.03	38.5
"	780531[1)]	997	30	3.0	5	0.50	16.7
"	780530[1)]	665	4	0.6	2	0.30	50.0
Hailuoto,timber dock	710514	1000	149	14.9	0	0	0
"	770601	992	34	3.4	4	0.40	11.4
"	780530[1)]	996	28	2.8	6	0.60	21.8
	Total	23308					
Hailuoto, Marjaniemi	690616	1000	64	6.4	9	0.90	14.1
"	700525	1000	84	8.4	1	0.10	1.2
"	740530	1000	98	9.8	20	2.00	20.4
"	760602	747	1	0.1	0	0	0
"	760602	1029	53	5.2	20	1.94	37.7
"	760602	484	16	3.3	5	1.03	31.3
Hailuoto, Peltimala	770531[1)]	999	35	3.5	4	0.40	11.4
	Total	6259					
Lumijoki, Varjakka	760601	975	38	3.9	9	0.92	23.7
"	760601	999	47	4.7	6	0.60	12.8
"	770531[1)]	996	37	3.7	3	0.30	8.1
"	770530[1)]	999	54	5.4	3	0.30	5.6
"	780529[1)]	994	35	3.5	4	0.40	11.4
	Total	4963					

1) Data on results are still incomplete

Table 5. Recaptures of tagged salmon smolts during the first summer by recapture method.

Release site	Fyke-net	Set gill net	Caspian tern	Other predators	Others	Total
River Kemijoki	4	2	10		5	21
River Simojoki, wild	42	2	13	4	9	70
" reared	24	4	9		5	42
River Iijoki	4	3	29		3	39
River Oulujoki						
- Virpiniemi	21	93	26		82	222
- Kello	22	3			87	112
- Oulunsalo, timber dock	49	26	55		36	166
- Hailuoto-Marjaniemi	21	10	9		18	58
- Lumijoki	6	3	13		2	24

Table . Number of recaptures during the first summer.

Distance from release site km	Release site	First month after release days 0-10	days 11-20	days 21-30	Second month after release days 0-10	days 11-20	days 21-30	Third month after release days 0-10	days 11-20	days 21-30	Four month after release days 0-10	days 11-20
0-10	River Kemijoki	3		1		3						
	River Simojoki, wild	20	8	10	1							
	reared	21	1		1							
	River Iijoki	7	3	1								
	River Oulujoki											
	- Virpiniemi	125	2		19					1		
	- Kello	2	2	16	4	35	1					
	- Hailuoto-Ouluns.	15	15	2	2		1			1		
	- Hailuoto-Marjaniemi	25	5									
	- Lumijoki		1									
	Subtotal	218	37	30	17	38	2			2		
10-20	River Kemijoki											
	River Simojoki, wild	1	1	3				1				
	reared	3										
	River Iijoki	2	10	3	1		2	1				
	River Oulujoki											
	- Virpiniemi	8	1	2	1				2	10		
	- Kello					6						
	- Hailuoto-Ouluns.	5	2	3								
	- Hailuoto-Marjaniemi											
	- Lumijoki			3								
	Subtotal	19	14	14	2	6	2	2	2	10		
20-50	River Kemijoki											
	River Simojoki, wild	2	1	5								
	reared	2		1		2	1					
	River Iijoki	3	4									
	River Oulujoki											
	- Virpiniemi	3	21	3		2	3	1				
	- Kello							1	5			
	- Hailuoto-Ouluns.	7	57	13	9			2				
	- Hailuoto-Marjaniemi				1							
	- Lumijoki	2	1		1							
	Subtotal	19	88	22	12	4	4	4	5			
50-100	River Kemijoki	1		1								
	River Simojoki, wild	1	2				1	1				
	reared											
	River Iijoki											
	River Oulujoki											
	- Virpiniemi		1									
	- Kello											
	- Hailuoto-Ouluns.		3	2	2				1			
	- Hailuoto-Marjaniemi			1	1							
	- Lumijoki		2									
	Subtotal	2	8	4	3		1	1	1			
> 100	River Kemijoki				1		9	1				
	River Simojoki, wild				2		7			1	1	
	reared		1									
	River Iijoki				1		10					
	River Oulujoki											
	- Virpiniemi			1		1		2				1
	- Kello				1			1				
	- Hailuoto-Ouluns.			1	1			6		1		
	- Hailuoto-Marjaniemi				1			2				
	- Lumijoki							4				
	Subtotal		1	2	7	1	26	16		2	1	1
	Total	258	148	72	51	49	35	23	8	14	1	1

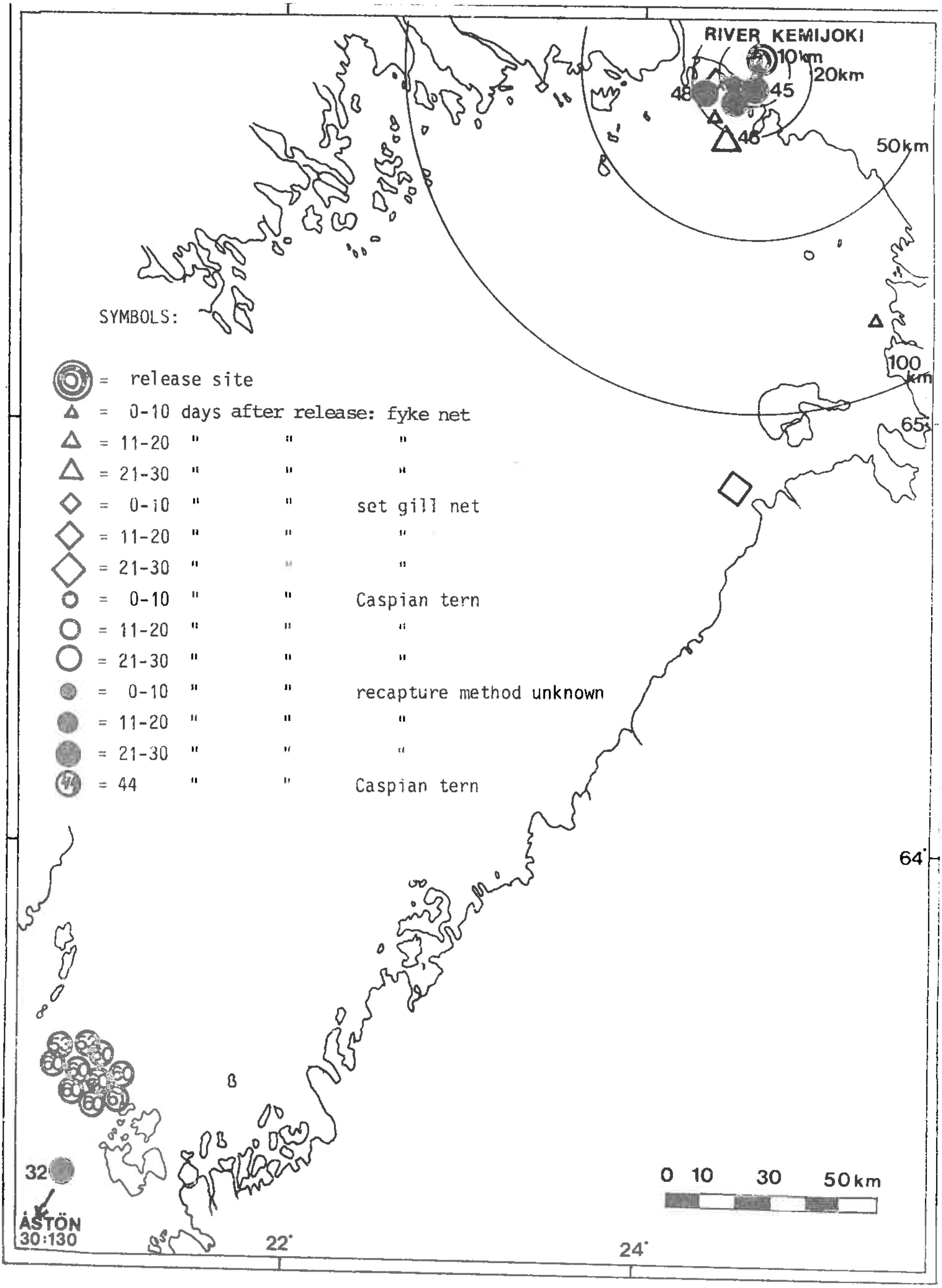

Figure 1. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Kemijoki in 1967-1978.

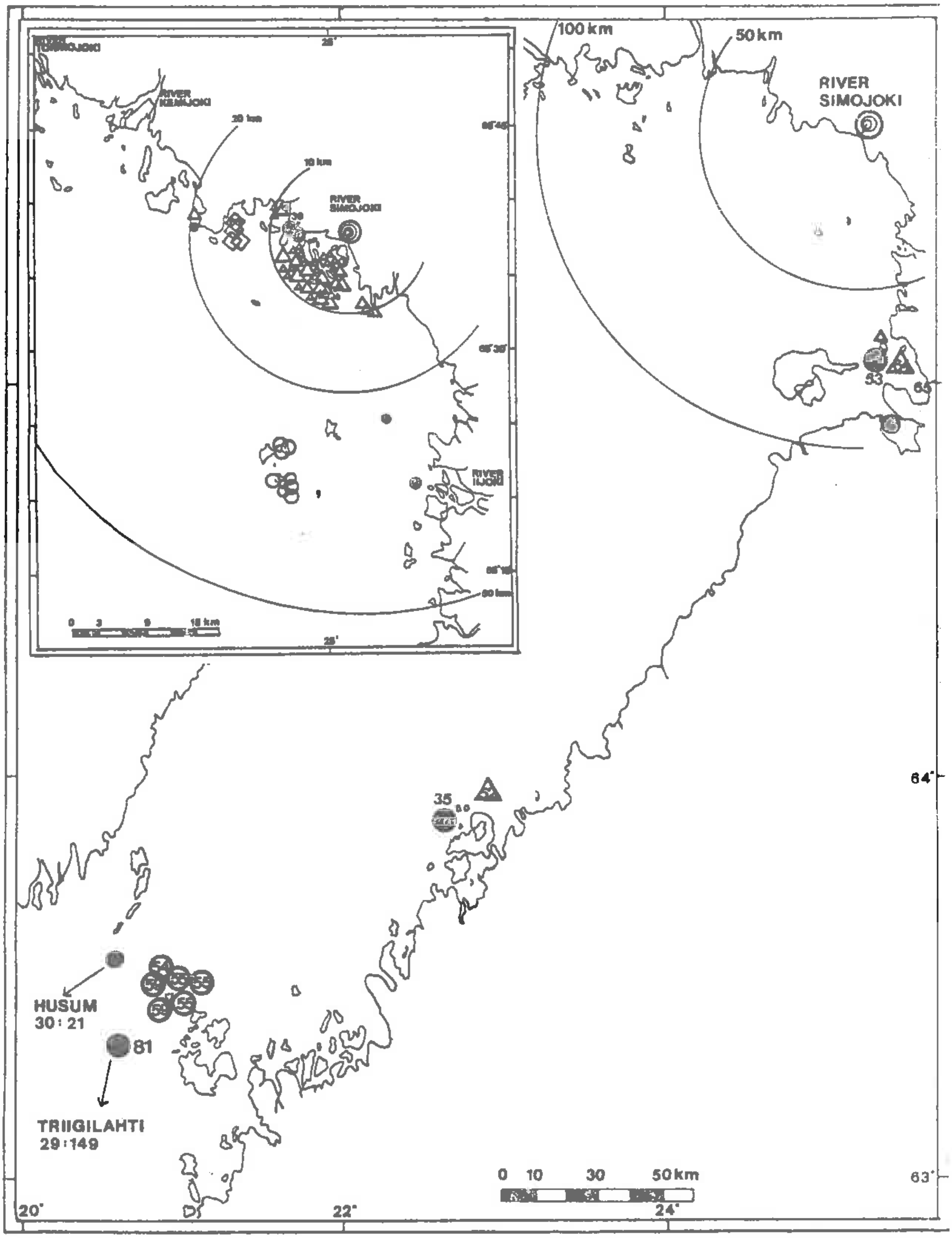

Figure 2. Tag recoveries of post-smolts in stockings with tagged salmon. Wild smolts, released in the mouth of the River Simojoki in 1972-1978. Symbols: See Figure 1.

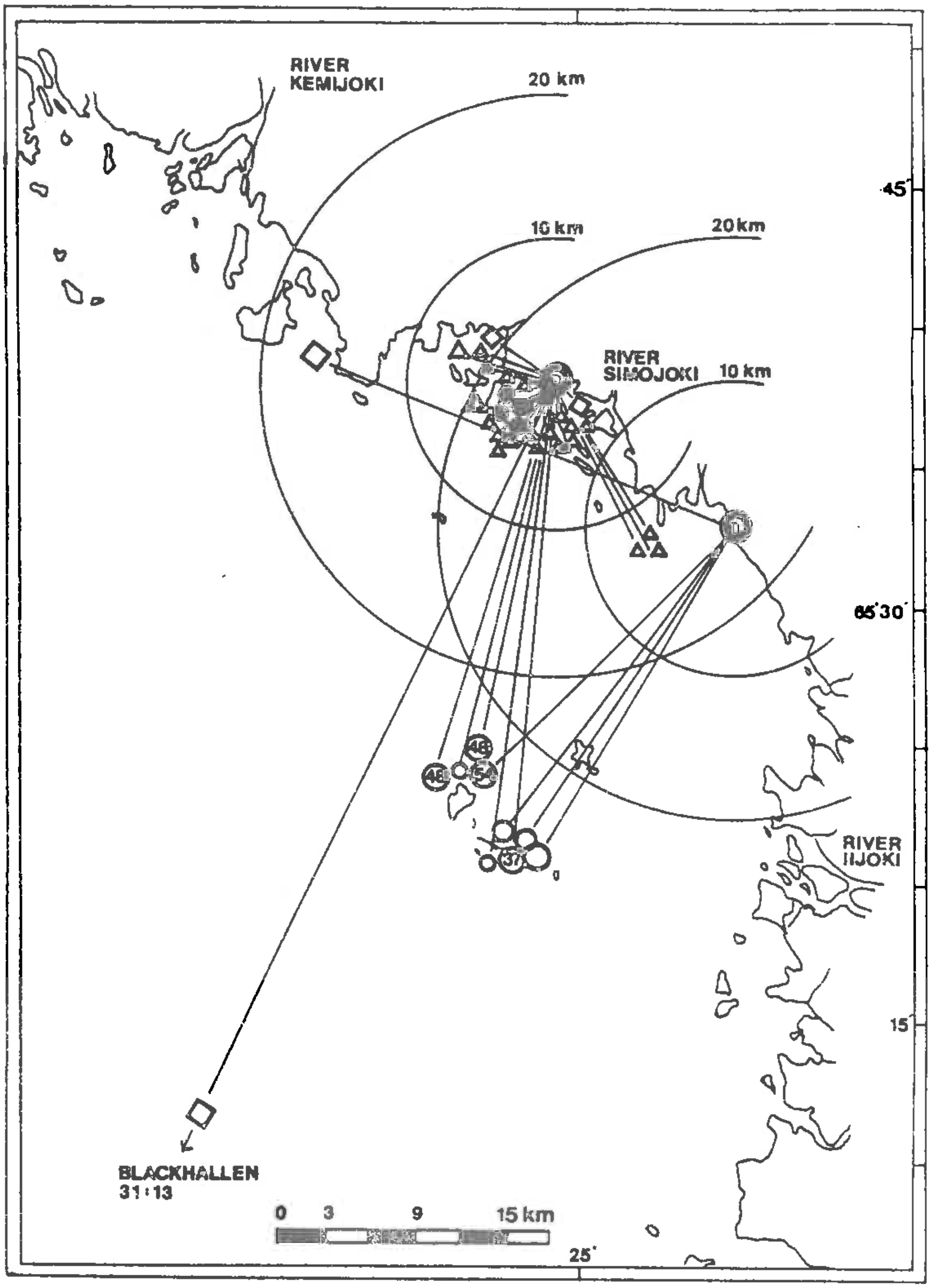

Figure 3. Tag recoveries of post-smolts in stockings with tagged salmon. Hatchery reared smolts, released in the mouth of the River Simojoki in 1969-1978. Symbols: See Figure 1.

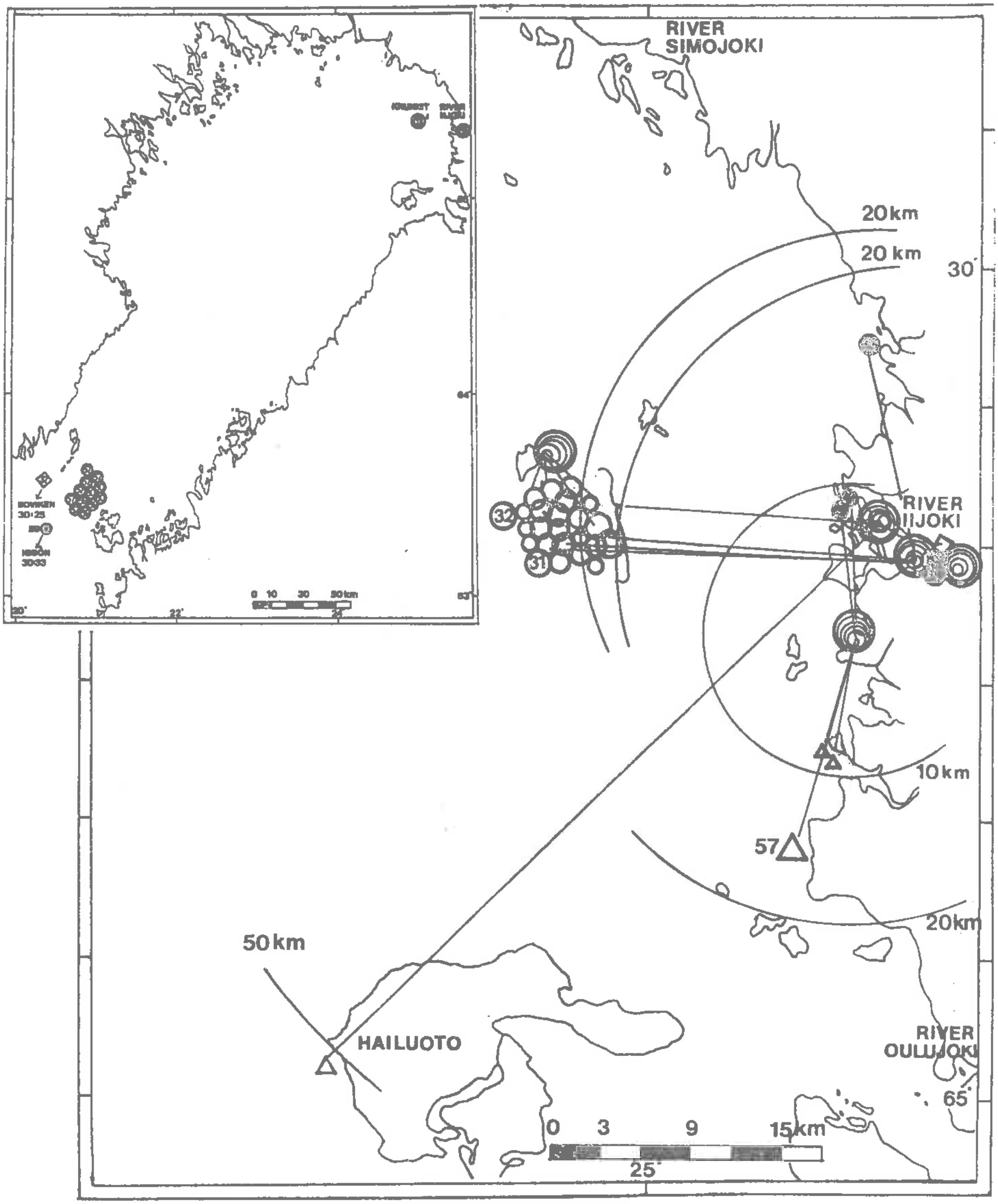

Figure 4. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Iijoki in 1973-1978. Symbols: See Figure 1.

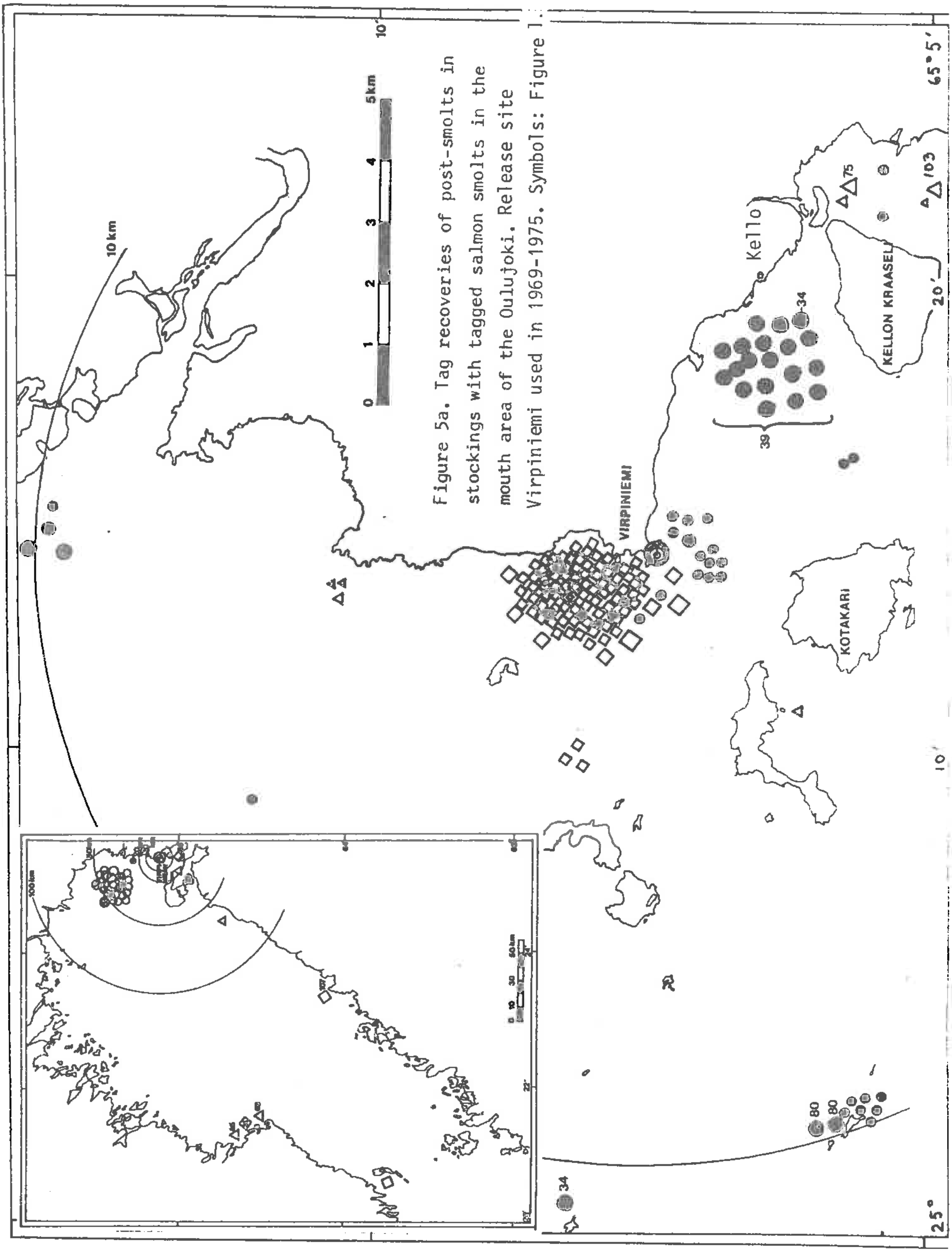

Figure 5a. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth area of the Oulujoki. Release site Virpiniemi used in 1969-1975. Symbols: Figure 1.

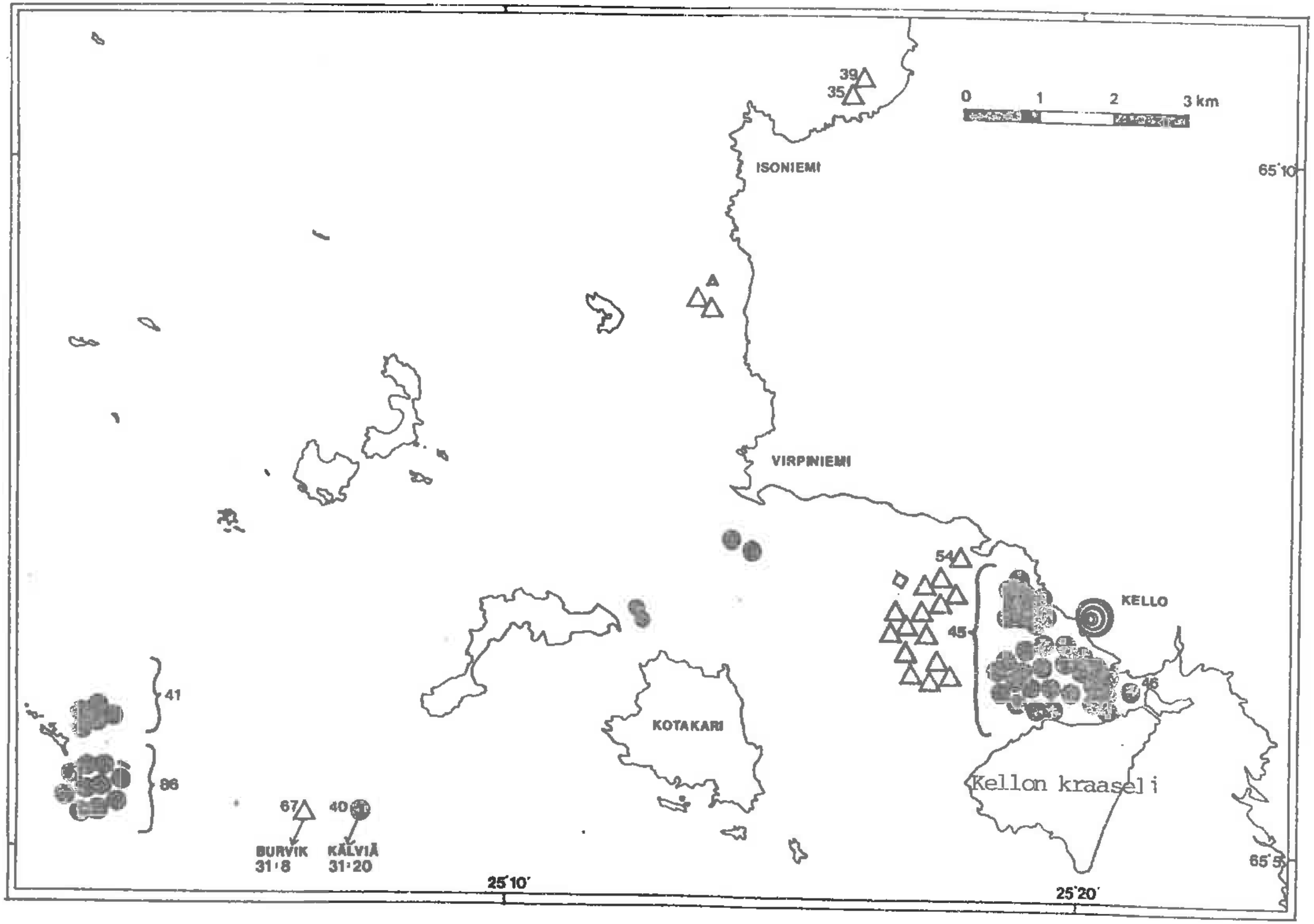

Figure 5b. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Oulujoki. Release site Kello used in 1969-1971. Symbols: See Figure 1.

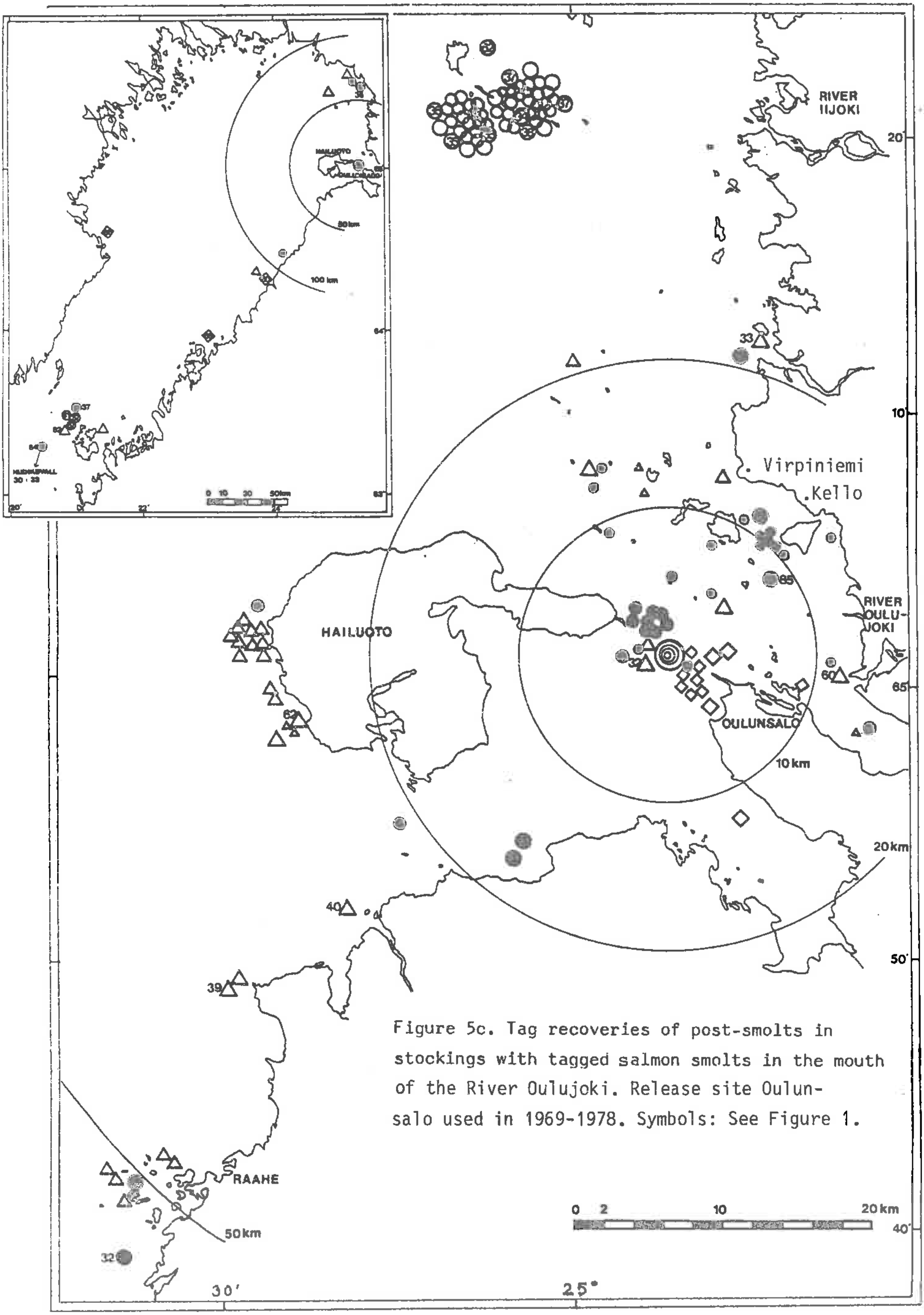

Figure 5c. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Oulujoki. Release site Oulunsalo used in 1969-1978. Symbols: See Figure 1.

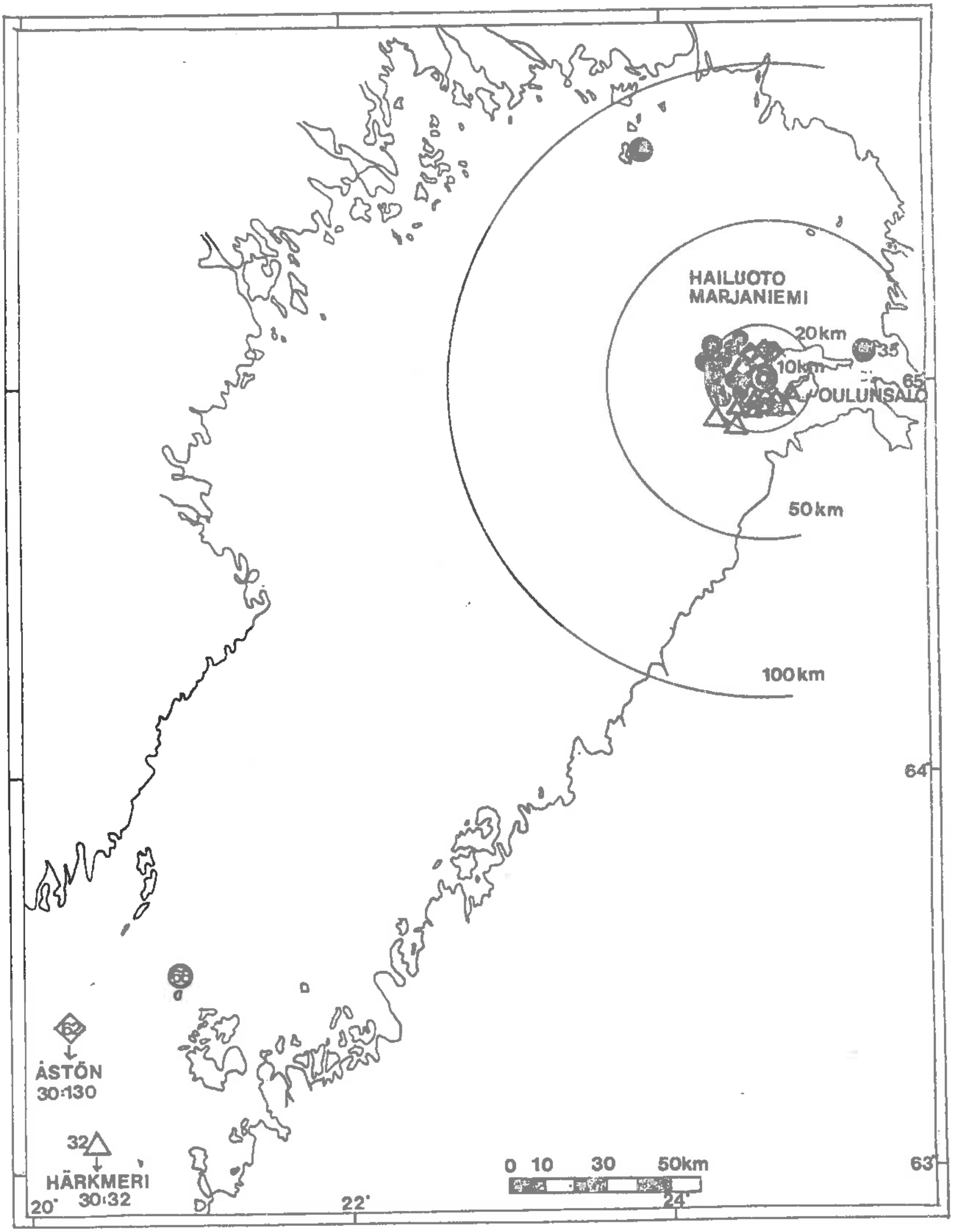

Figure 5d. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Oulujoki. Release site Hailuoto used in 1969-1977. Symbols: See Figure 1.

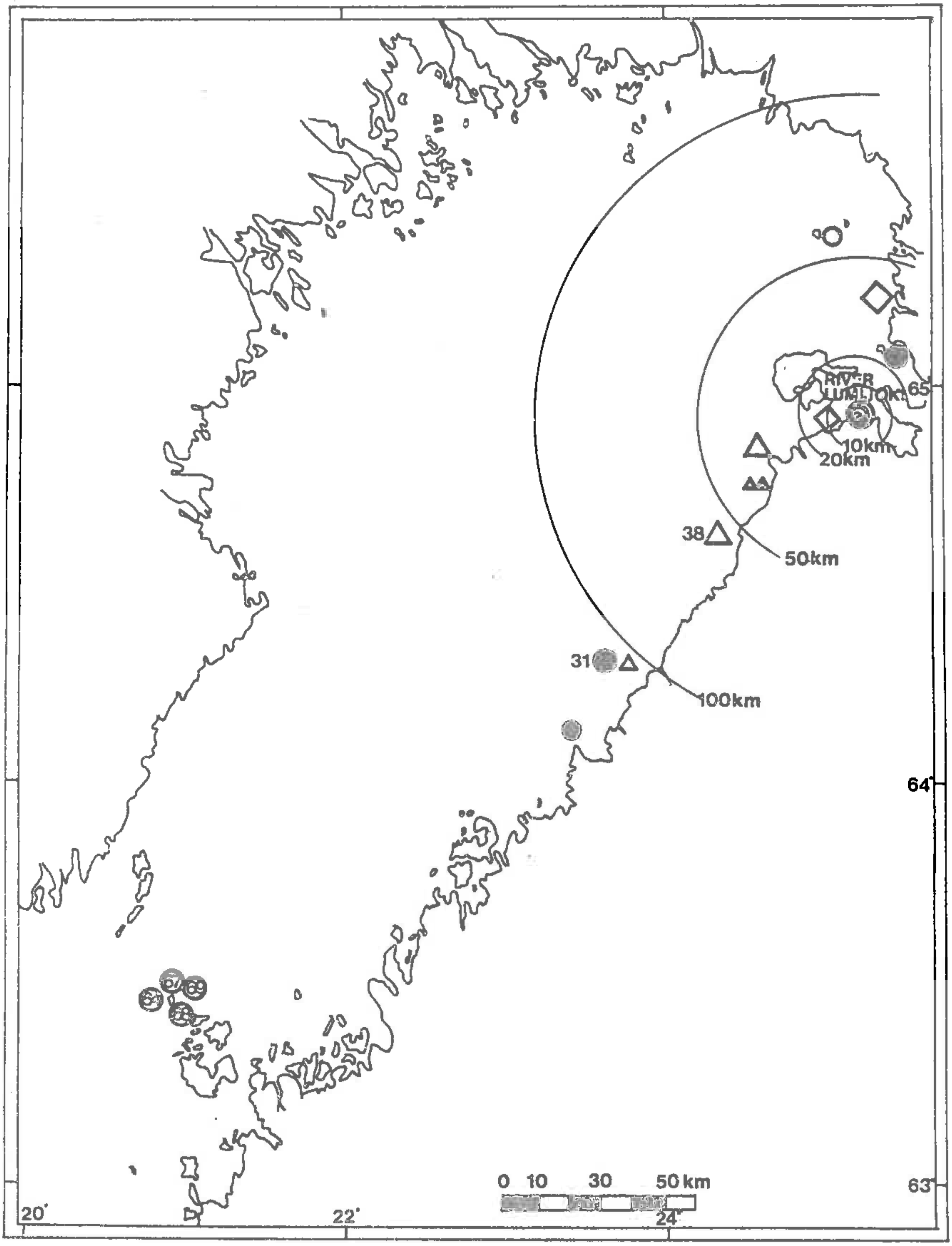

Figure 5e. Tag recoveries of post-smolts in stockings with tagged salmon smolts in the mouth of the River Oulujoki. Release site Lumijoki used in 1976-1978. Symbols: See Figure 1.

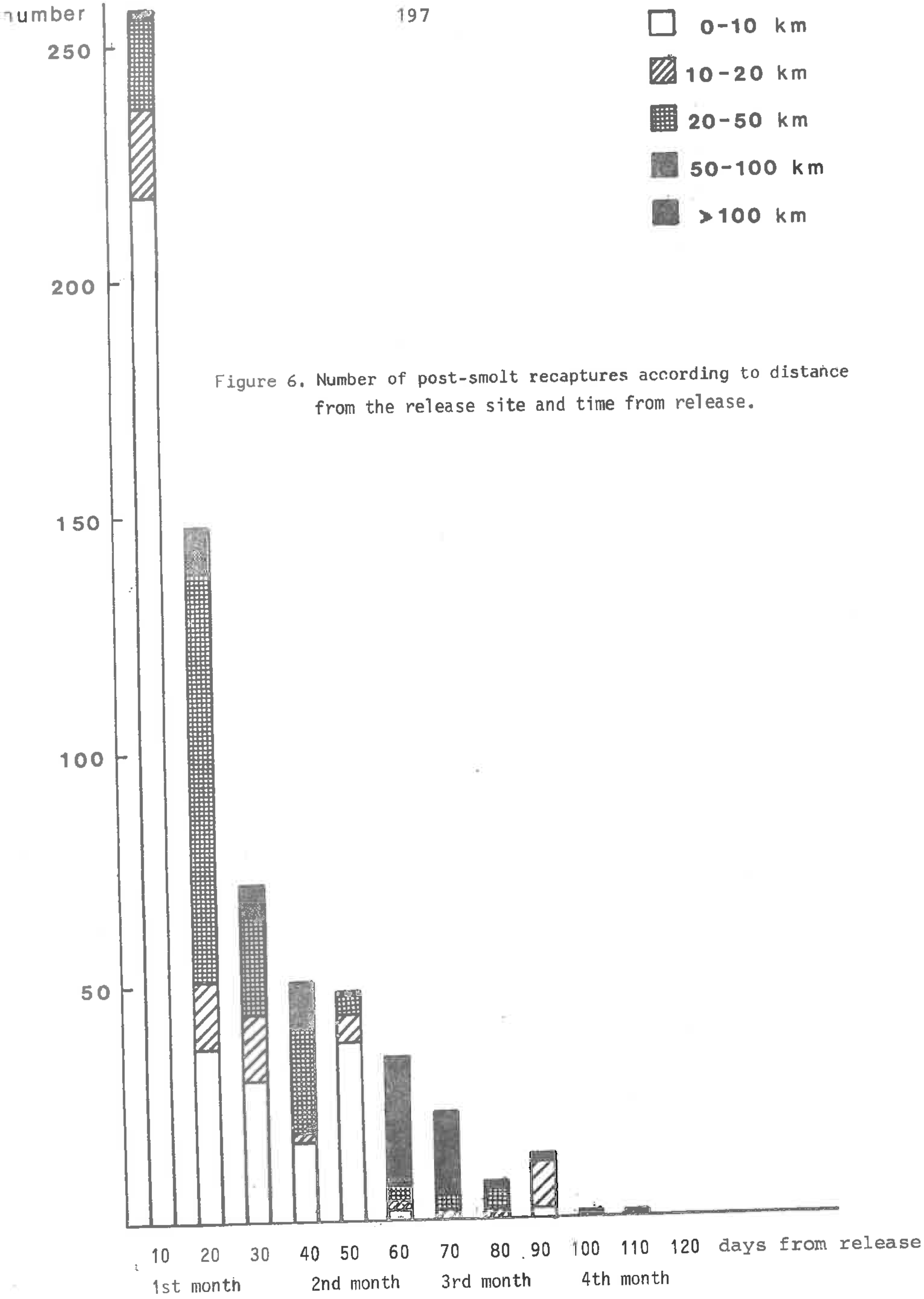

Figure 6. Number of post-smolt recaptures according to distance from the release site and time from release.

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RECAPTURES OF BALTIC HERRING TAGGED OFF THE COAST OF FINLAND IN 1982-85

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ABSTRACT

In 1982-85 altogether 18 190 herring were marked with the plastic hydrostatic Lea tag. By 1 December 1985, the tag recoveries totalled 843 (4.6 %). The latest recoveries were obtained during the fourth year after tagging. Most tags were returned from large-meshed gillnets used for other species than herring. Of the total recaptures, 94.1 % were made within a radius of 150 km from the tagging place. The stationariness of herring in the northern Baltic Sea suggests that the herring stock assessments should be based on fairly small areal units.

RESUME

Au cours des années 1982-85, 18 190 harengs ont été marqués à l'aide du système Lea en plastique hydrostatique. Au 1er décembre 1985, 843 marquages, soit 4.6 %, avaient été repris. Les dernières recaptures ont été faites au cours de la quatrième année suivant le marquage. La plupart des marquages ont été repris au moyen de filets à larges mailles utilisés pour d'autres espèces que le hareng. 94.1 % de la totalité des recaptures eurent lieu dans un rayon de 150 km autour du point de marquage. La sédentarité du hareng dans le nord de la mer Baltique, suggère donc que les estimations des stocks de harengs par secteur, devraient être faites sur d'assez petites unités.

Introduction

Tagging of Baltic herring was initiated in spring 1975, with the aim of obtaining information on the distribution and mixing of the stocks off the coast of Finland, for use in stock assessments. The results of the tagging conducted in 1975-81 have been presented earlier (PARMANNE & SJÖBLOM 1982a). This report gives the recaptures of fish tagged in 1982-85.

Material and methods

The herring for tagging were caught with trapnets during the spawning time of the spring-spawning Baltic herring and marked with the plastic hydrostatic Lea tag (34 x 5 mm) (STOTT 1970, Fig. 4.2). The tag was attached below the dorsal fin with an acid-resistant steel wire. Altogether 18 190 herring were tagged.

About 100-200 fish were taken from the gear with a hand net having a water-tight lower part. The fish were transported to the tagging place in plastic containers with running water and the duration of the transport was mainly 5-30 min. Before tagging the fish were kept in net cages (about 1 m^3) for 0-36 hours.

The fish were caught and kept in a cradle for measuring and tagging. Special care was taken to avoid any loss of scales. Tagged fish were released within 0-5 minutes. The mortality of tagged fish before releasing was usually below 5 %, but during warm weather or strong winds it could be higher.

Results

By 1 December 1985, 843 tags (4.6 %) had been returned. The latest recoveries were obtained during the fourth year after tagging.

The tagged fish were mainly recaptured in gear used for other species than Baltic herring (Table 1), mostly with large-meshed gillnets. The same observation has been made earlier with Lea-tagged Baltic herring (HANNERZ 1956, PARMANNE & SJÖBLOM 1982a). The reason for the large proportion of recaptures from large-mesh gears is that the wire with which the Lea tag is attached easily fastens in nets.

The proportion of tags recovered from herring gears (trapnet, gill-net, trawl and winter seine) was 29.3 %. The percentage recovery from the trapnet catch was lowest in Åland and highest in Kustavi (Table 1). This corresponds to the differences in the number of nets used (PARMANNE & SJÖBLOM 1982b).

The herring dispersed from the tagging place fairly evenly in all directions (Figs. 1-6) and no directed migration was observed.

The herring in the northern parts of the Baltic Sea are rather stationary. Most of the tagged herring were recaptured close to the releasing place, even after several years. Of the total recaptures, 94.1 % were made within a radius of 150 km from the tagging place (Table 2).

Discussion

The recaptures are concentrated close to the coast (Figs. 1-6). This is due to the fact that the greater part of the fishing takes place in the coastal areas. In the open sea, only salmon fishing with driftnets and driftlines and some trawl fishing are conducted, and the amount of recaptures in these catches is low.

Only 1.5 % of the recaptures are from the trawl catch, although the greater part of the Finnish herring catch (PARMANNE & SJÖBLOM 1986) is taken with trawls. This indicates that the Lea tags are easily overlooked in the trawl catch.

Practically all the recoveries from the Swedish side are from gears used for other species than herring, mainly from large-meshed gillnets. Thus the number of recaptures cannot be related to the herring catch, but to the number of gears set for other species than herring.

In earlier taggings conducted in the eastern part of the Gulf of Finland (ICES subdivision 32) no recoveries were made outside the

Gulf of Finland (PARMANNE & SJÖBLOM 1982a). Some of the herring tagged in the western part of the Gulf of Finland (Fig. 6) were recaptured in the Archipelago Sea, and one off Gotland. No recaptures have been reported from the southern part of the Gulf of Finland.

A considerable part of the recaptures of fish tagged in the Bothnian Sea (ICES subdivision 30) (Fig. 4) were made relatively far from the tagging place. Recaptures made far from the tagging place in autumn and winter have been considered to be connected with the discharge of TiO_2 waste waters (PARMANNE & SALMI 1986).

A herring tagged on 30 May 1984 in the Archipelago Sea in Kustavi (Fig. 2) was caught on 23 October in the same year in Hanö Bay, Sweden. The shortest distance between the tagging and recapture sites is about 700 km. This is the most remote recapture of a herring tagged on the Finnish coast so far made.

The taggings made to date indicate that the herring in the northern areas are more stationary than in the southern parts of the Baltic Sea (OTTERLIND 1958, 1959, BIESTER 1979, JÖNSSON & BIESTER 1979, 1981). The stationariness of herring in the northern Baltic Sea suggests that the herring stock assessments should be based on fairly small areal units.

References

BIESTER, E. 1979: The distribution of the Rügen spring herring. - ICES C.M. 1979/J:31 (mimeo).

HANNERZ, L. 1956: Preliminary results of the herring investigations in the Bothnian Sea 1954. - Ann. Biol. 11: 156-158.

JÖNSSON, N. & BIESTER, E. 1979: Result of tagging experiments on the Rügen spring herring 1977/78. - ICES C.M. 1979/J:29 (mimeo).

JÖNSSON, N. & BIESTER, E. 1981: Herring tagging experiments 1980/81 along the coast of GDR. - ICES C.M. 1981/J:29 (mimeo).

OTTERLIND, G. 1958: Preliminary results of Swedish herring tagging experiments in the Baltic. - Ann. Biol. 13: 213-215.

OTTERLIND, G. 1959: Report on Swedish herring tagging in the

Baltic. - Ann. Biol. 14: 189-190.

PARMANNE, R. & SALMI, J. 1986: (Migrations of Baltic herring in the Bothnian Sea as revealed by tagging conducted in spring 1982). In Finnish, English summary. - Meri (manuscript).

PARMANNE, R. & SJÖBLOM, V. 1982a: Recaptures of Baltic herring tagged off the coast of Finland in 1975-81. - ICES C.M. 1982/J:19 (mimeo).

PARMANNE, R. & SJÖBLOM, V. 1982b: Fishing effort and catch per unit of effort of Baltic herring and sprat in Finnish fisheries in 1976-80. - ICES C.M. 1982/J:21 (mimeo).

PARMANNE, R. & SJÖBLOM, V. 1986: Baltic herring in the seas around Finland in 1982 and 1983. - Ann. Biol. 40: 137-140.

STOTT, B. 1970: Marking and tagging. - In: Ricker, W.E. : Methods for assessment of fish production in fresh waters. IBP Handbook No. 3: 78-92.

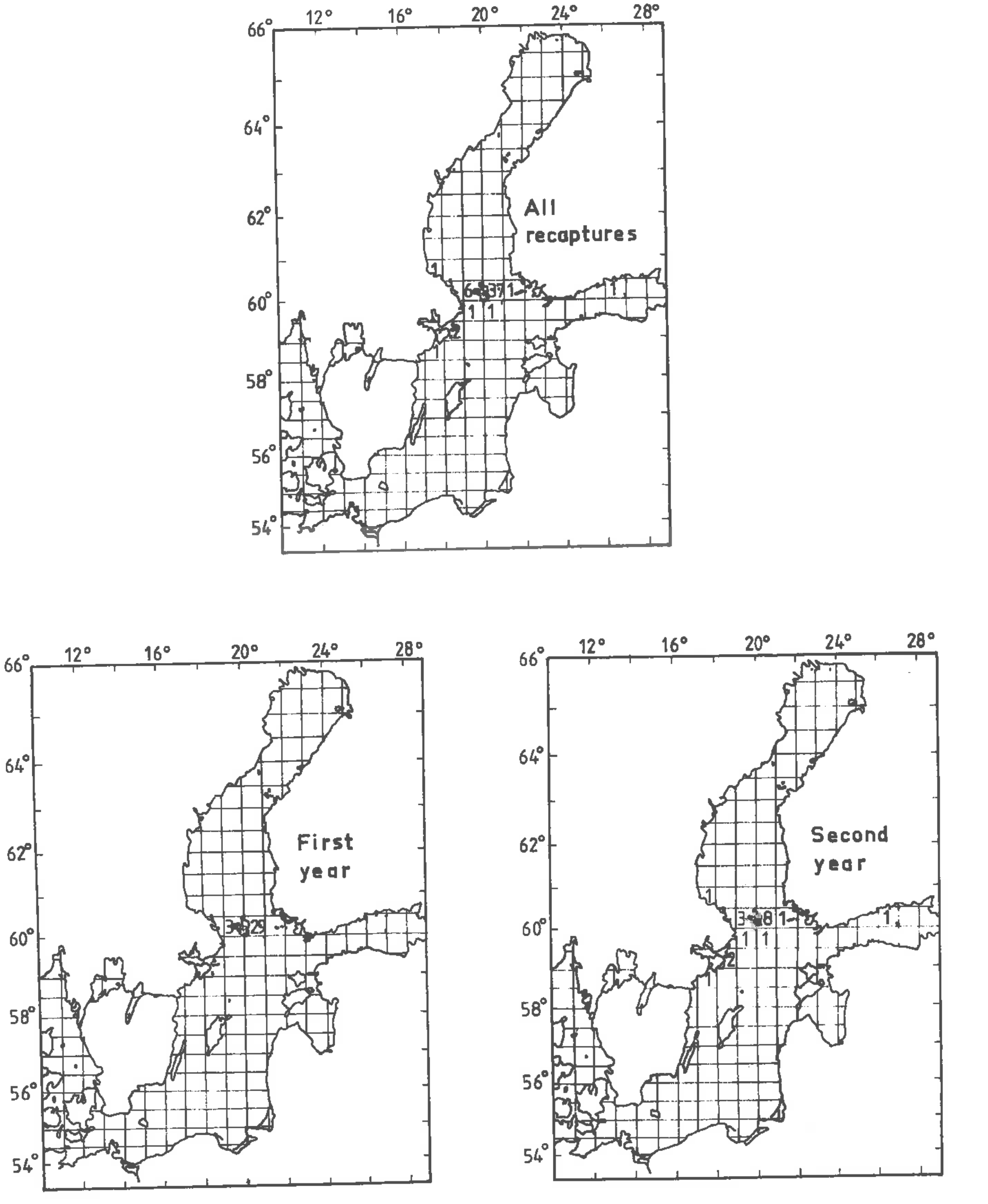

Fig. 1. Recaptures of 2 626 Baltic herring tagged in Åland in spring 1982-84.

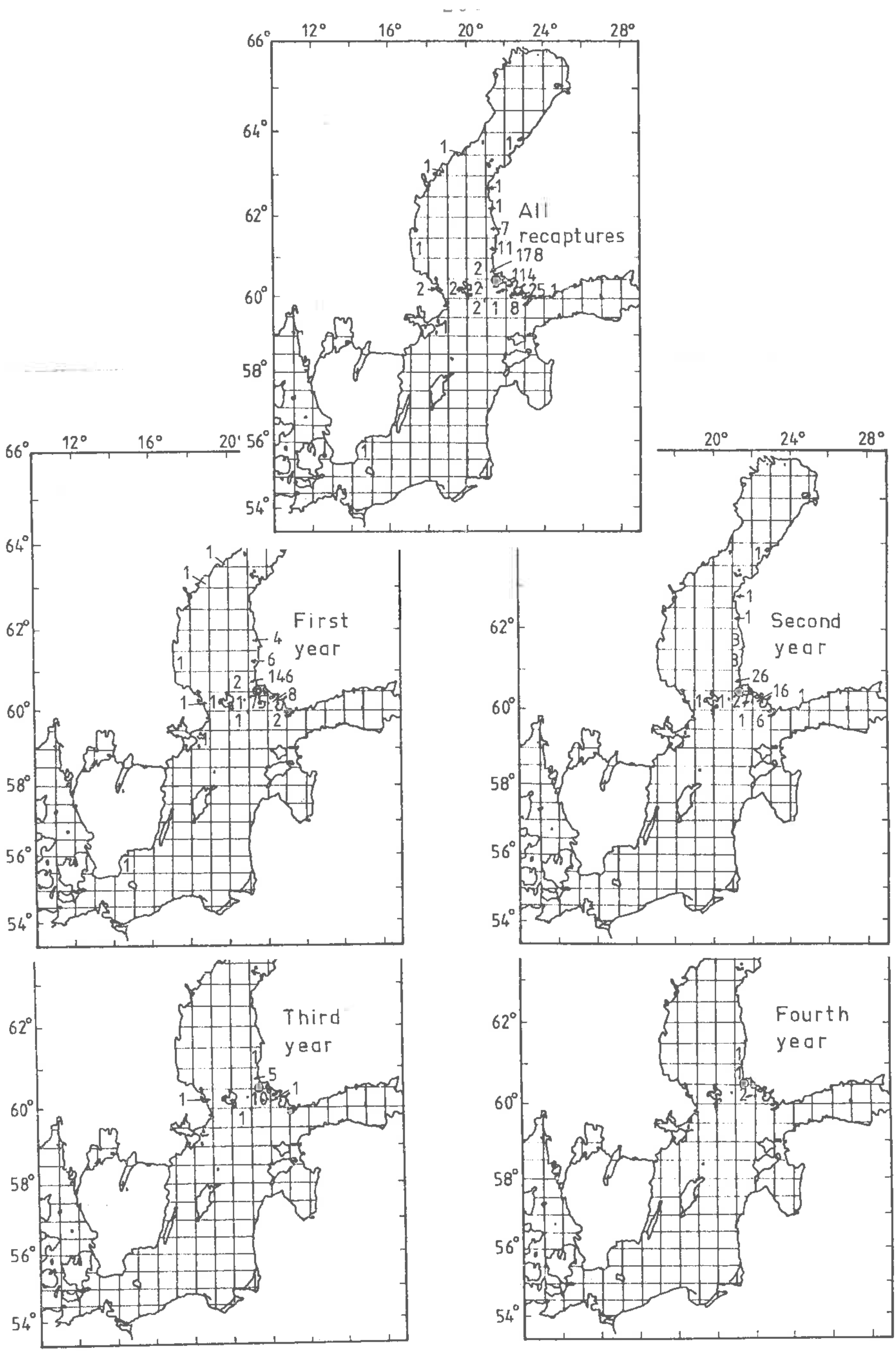

Fig. 2. Recaptures of 5 805 Baltic herring tagged in Kustavi in spring 1982-85.

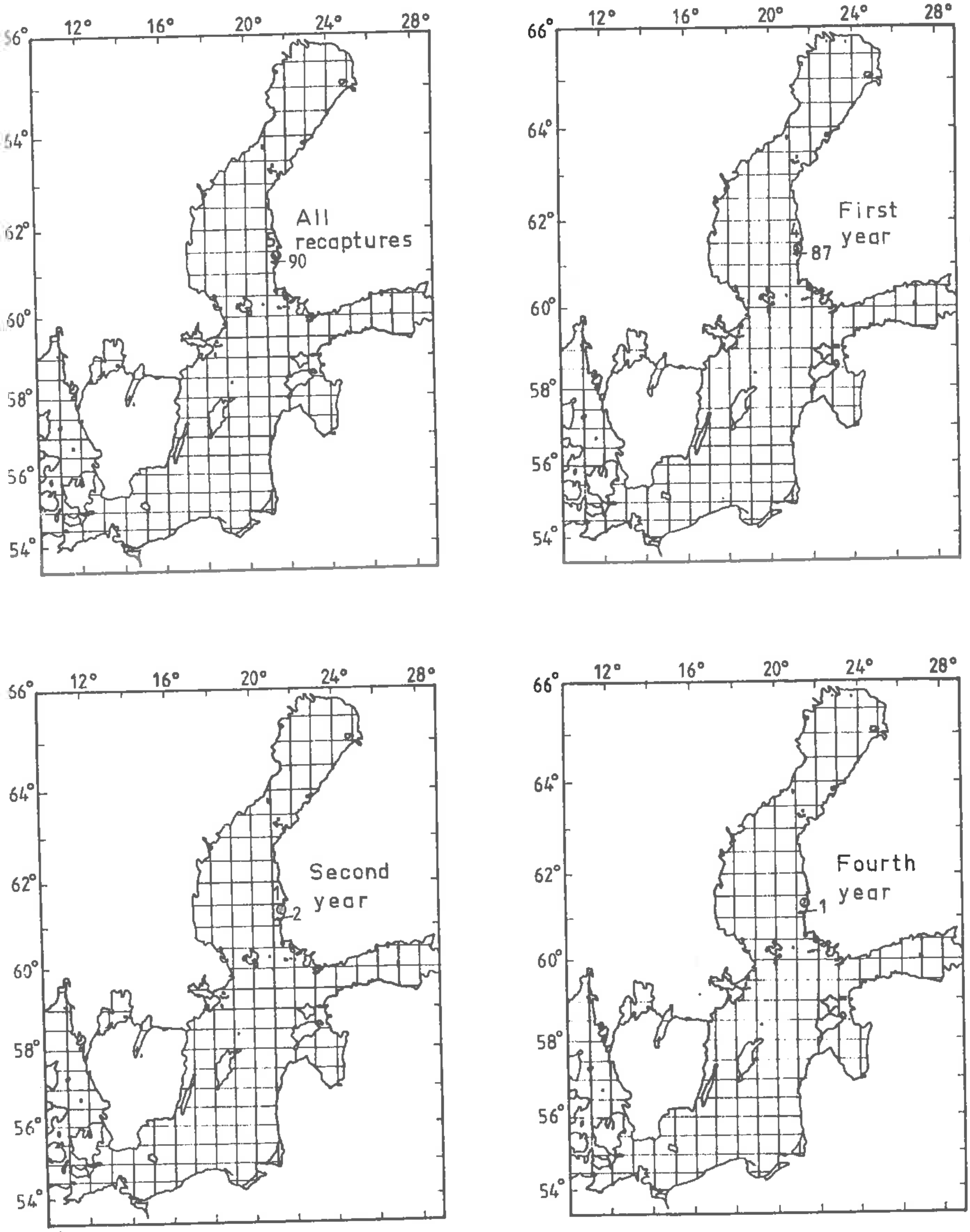

Fig. 3. Recaptures of 557 Baltic herring tagged in Luvia in spring 1982.

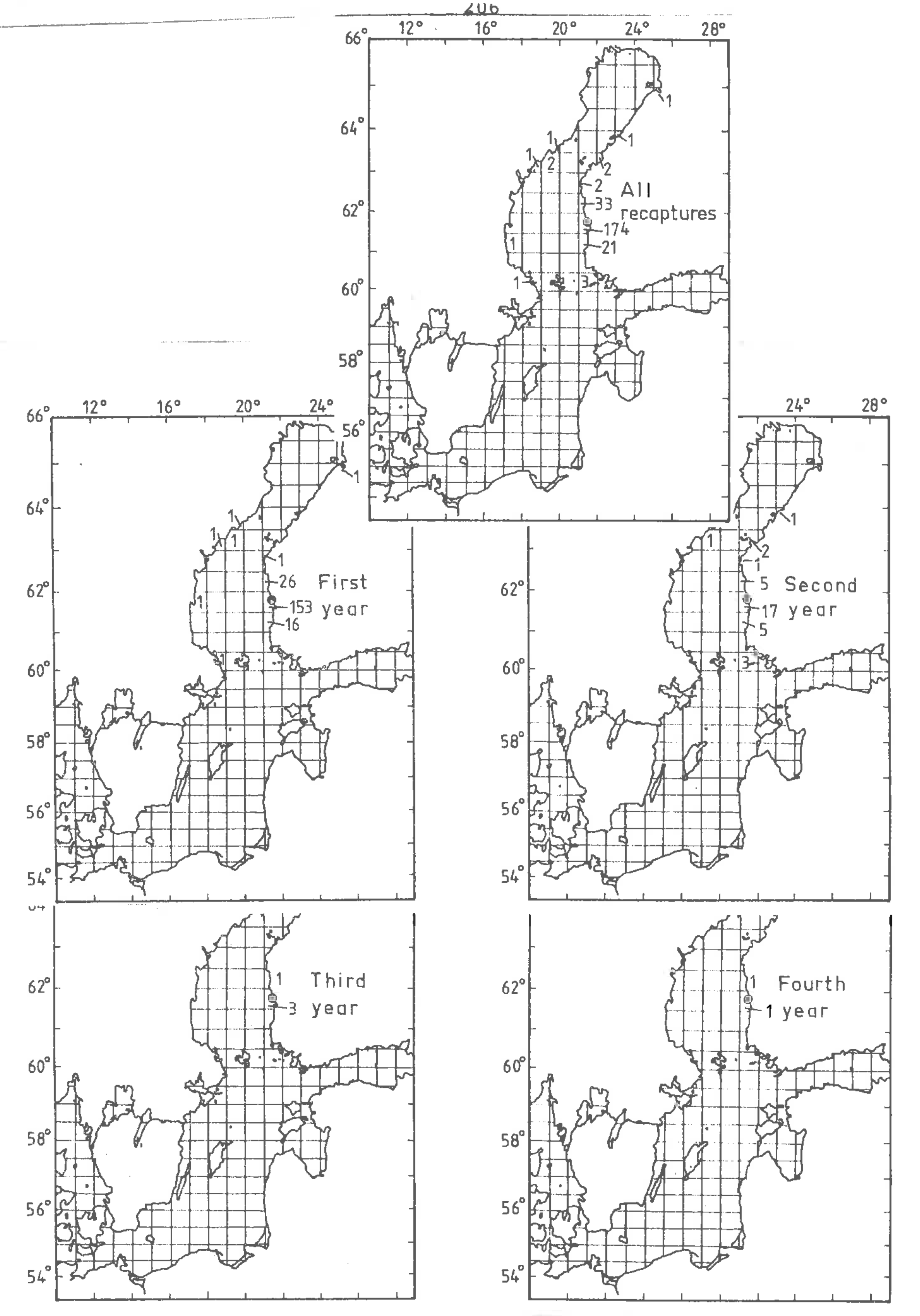

Fig. 4. Recaptures of 4 253 Baltic herring tagged in Merikarvia in spring 1982.

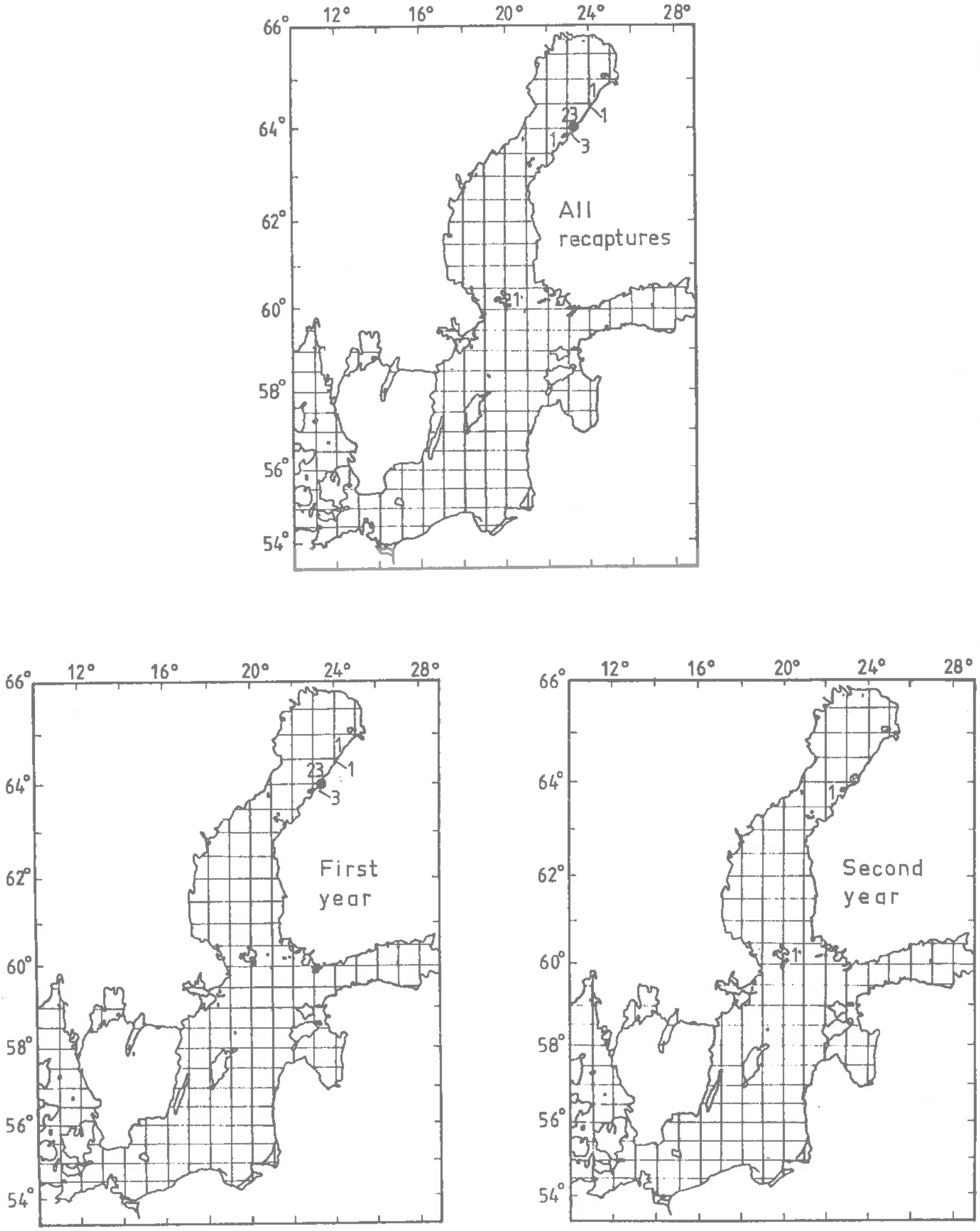

Fig. 5. Recaptures of 1 400 Baltic herring tagged in Kalajoki-Himanka in spring 1982 and 1984-85.

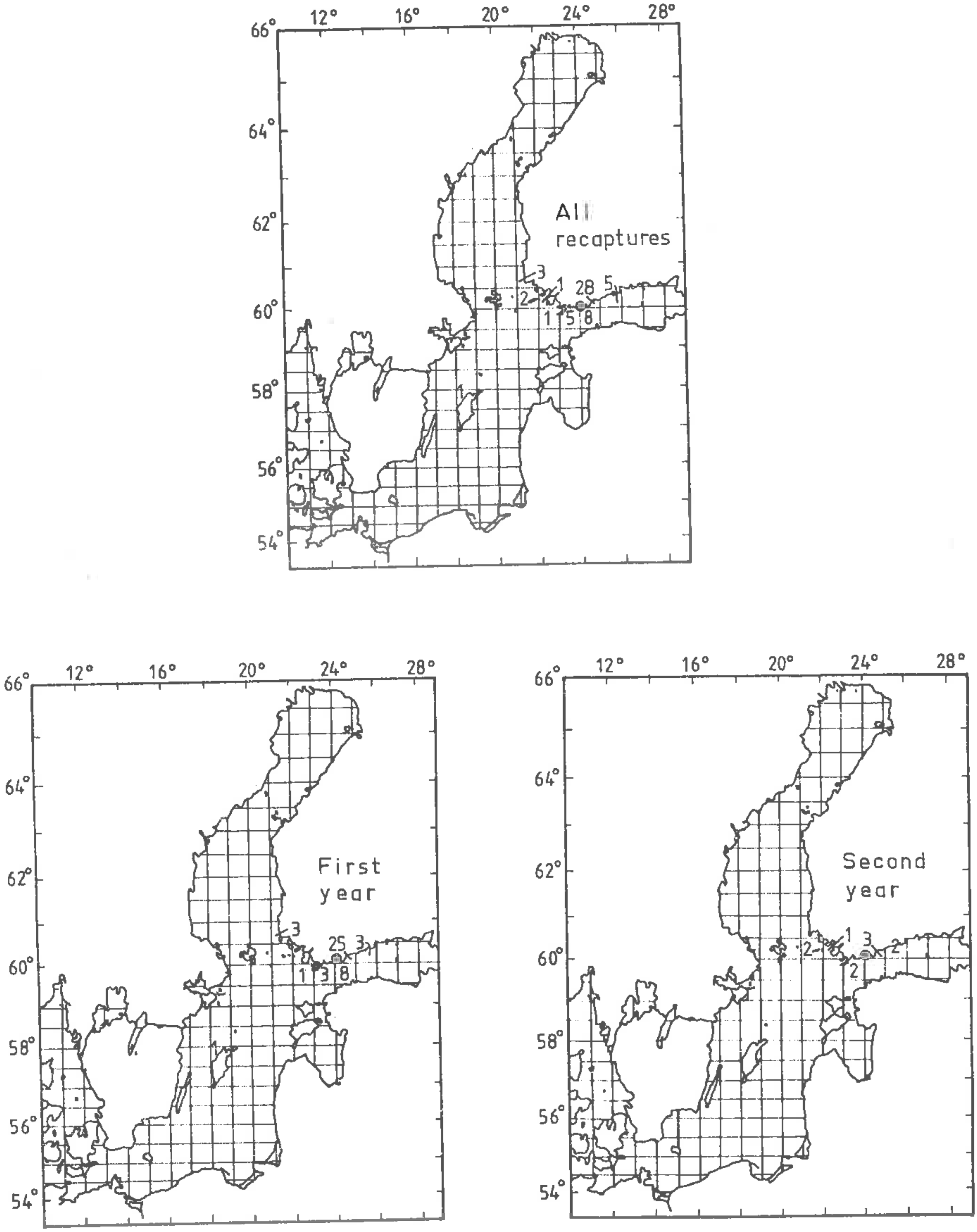

Fig. 6. Recaptures of 3 549 Baltic herring tagged in Inkoo-Kirkkonummi in spring 1983-84.

Table 1. Percentages of Baltic herring recaptures from various sources.

	Aland (sub-division 29)	Kustavi (29)	Luvia (30)	Merikarvia (30)	Himanka-Kalajoki (31)	Inkoo-Kirkkonummi (32)	All areas (29-32)
Herring trapnet	0	37.3	25.3	6.0	6.5	25.9	22.7
Salmon trapnet	0	0.3	0	6.0	0	6.9	2.4
Herring gillnet	6.1	5.5	1.1	4.4	6.5	8.6	5.0
Other gillnet	73.5	47.2	73.7	74.6	74.2	43.1	60.5
Herring trawl	2.0	2.8	0	0.4	3.2	0	1.5
Winter seine	0	0.3	0	0	0	0	0.1
Other (predatory fish, sea gull)	6.1	0.3	0	2.8	0	8.6	1.9
No information	12.2	6.4	0	5.6	9.7	6.9	5.9
Total	100	100	100	100	100	100	100
No. of recaptures	49	362	95	248	31	58	843

Table 2. Percentage of Baltic herring recaptures made in the ICES statistical rectangle in which the tagging took place or in the neighbouring rectangle (maximum distance about 150 km). In brackets, if the recaptures number less than five.

	First year	Second year	Third year	Fourth year	All recaptures
Åland (subdivision 29)	100.0	73.7	-	-	90.2
Archipelago Sea, Kustavi (29-30)	95.6	90.9	94.7	(100.0)	94.5
Bothnian Sea, Luvia (30)	100.0	(100.0)	-	(100.0)	100.0
Bothnian Sea, Merikarvia (30)	96.5	77.1	(100.0)	(100.0)	93.8
Bothnian Bay, Kalajoki-Himanka (31)	100.0	(50.0)	-	-	96.7
Gulf of Finland, Inkoo-Kirkkonummi (32)	88.6	70.0	-	-	85.2
All areas (29-32)	96.5	84.1	95.7	100.0	94.1
Total no. of recaptures	649	157	23	7	836

ICES

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SPAWNING MIGRATION OF SALMON (*Salmo salar* L.) IN THE COASTAL WATERS OF THE GULF OF BOTHNIA

by

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Baltic salmon stocks originating from the Finnish rivers flowing into the Gulf of Bothnia migrate to the Baltic Proper for feeding. Spawning migration begins in March-April from the Baltic Proper. The spawning migrants enter the Gulf of Bothnia in late April-May. The main migration route goes along the west coast of the Åland island, and up the Finnish coast of the Gulf of Bothnia to the home rivers. Migration in the coastal zone is at least partially guided by thermal fields in the surface layer of the sea. Salmon of wild origin form the majority of the fish during the early spawning run. Hatchery-reared fish migrate later, probably because fish for breeding purposes are taken from the spawners ascending the river later.

INTRODUCTION

A great deal of attention has been paid to salmon migration. The migration routes and marine feeding areas are of considerable interest because salmon are fished in the sea with drift nets during feeding migration and with bag nets during spawning migration. The migration, biology and population dynamics of the salmon have been studied earlier by Alm (1934), Järvi (1935, 1938, 1948), Carlin (1965, 1969a, 1969b), Lindroth (1965), Thurow (1966, 1968), Toivonen (1973), Christensen & Larsson (1979), Larsson (1980, 1983), Ikonen (1983) and Ikonen & Auvinen (1984). Earlier studies on fish migration and its mechanisms include those of Harden-Jones (1968), Brannon (1984), Westerberg (1984) and McKeown (1984). The aim of this paper is to describe the spawning migration routes and timing of migration of salmon of wild and hatchery origin. The possible reasons for the choice of migration routes and differences in the timing of the spawning run between wild and hatchery-reared salmon will be discussed.

MATERIAL and METHODS

The data on the migration routes were obtained from tagging experiments carried out in 1969-1982 (Ikonen & Auvinen 1984). A total of 2230 scale samples were collected from the salmon bag-net fishery in 1982-1984.

During scale sampling it was not possible to distinguish salmon of wild and hatchery origin. The salmon were separated on the basis of the scale structure. In hatchery-reared fish, the structure of the scale in the freshwater differs from that in wild salmon. The method of separation has been described by Antere & Ikonen (1983).

Hydrological characters of the Gulf of Bothnia, such as surface currents, salinity and surface temperature are presented in figures 1, 2 and 3 (Toivonen & Tuhkunen 1975 and Palosuo 1976).

RESULTS

The post-smolt migration of these northern salmon stocks follows the eastern coast of the Gulf of Bothnia to the Quark, which is the narrowest part of the Gulf. The post-smolts swim over the Quark and continue their migration southward along the west coast of the Gulf, reaching the Baltic Proper in the beginning of their second calendar year (Ikonen & Auvinen 1984 and 1985). The main feeding areas of these salmon stocks are in the Baltic Proper, the most important being the surroundings ot the Gotland, Bornholm and Gdansk deeps. During the spawning migration, salmon start to enter to the Gulf of Bothnia in late April and May. The main migration route seems to go through the Åland Sea. These data have been collected from the bag-net fishery carried out off the western coast of the Åland Islands. Migration has not been observed east of the Åland Islands in the Archipelago Sea.

Tagging recaptures reveal that after passing through the Åland Sea, the migration route goes along the boundary between the Archipelago Sea and the southern edge of the Gulf of Bothnia. The migration then follows the Finnish coast up to the nothern part of the Gulf, where the mouths of the home rivers are situated. A small part of the migrants seem to swim to the Swedish side of the Gulf in the Quark area and then proceed along the Swedish coast to the home rivers (Ikonen & Auvinen 1984). According you tagging experiments, the wild and hatchery-reared salmon have similar migration routes (Ikonen & Auvinen 1984). The proportions of wild and hatchery-reared salmon in the catch samples are presented in Table 1.

The reasons for the stability of the migration routes are not known. A possible factor guiding the migrants is the surface currents, whose direction is northward along the Finnish coast and southward along the Swedish coast (Fig. 1). The displacement of isohalines (Fig. 2) and isotherms (Fig. 3) by surface currents due to the Coriolis force or by the wind probably creates clear paths in the surface layer of the sea, which can be followed by salmon.

The timing of migration seems to differ between salmon of wild and hatchery origin. In the samples from the bag-net catch taken west of the Åland islands in 1983-1984 49 % of salmon that had spent more than one winter in the sea were of wild origin. Fishing was started in the middle of May and until the middle of June the bulk of the catch consisted of salmon of wild origin (Fig. 4). In the waters off Merikarvia, the bag-net catch contained mainly salmon of hatchery origin during May, but from the beginning of June the amount of wild salmon increased so much that the majority of the salmon caught during 1-24 June were of wild origin (Fig. 5). In the area off Merikarvia 42 % of the salmon originated from natural spawning. In the bag-net fishery carried out in the Quark, 69 % of the salmon catch was of wild origin. The majority of these fish were caught on June 18-28 (Fig. 6). The salmon caught with bag nets in the northernmost part of the Gulf consisted of fish that had spent more than one winter in the sea and 73 % were of wild origin. During June the great majority of the fish were of wild origin. In July the salmon catch decreased and a great many of the fish originated from hatcheries (Fig. 7).

DISCUSSION

In the Gulf of Bothnia, the currents caused by the Coriolis force flow northward along the eastern and southward along the western coast. Christensen and Larsson (1979) have reported that the post-smolt migration seems to follow the main current in the Gulf of Bothnia. According to Finnish tagging data, part of the post-smolt salmon seem to follow the current in sub-division 31, but the greater number appear to migrate against the current to the Quark. In this area post-smolts move to the Swedish coast and then swim southward with the current (Ikonen & Auvinen 1984). The reason why post-smolts choose this route is not known. The salinity of the sea in the northern part of the Gulf is below 4 $^{o}/oo$ and the migration route does not seem to follow the isohalines in this area. In the

Quark, however, and in the souther part of the Gulf, the post-smolt migration route follows the isohalines. The most probable reason for the migration route of the post-smolts could be the surface temperature fields in the sea. The isotherms of 7 and 8 °C follow the Finnish coast in the northern part of the Gulf and the coasts of the southern part of the Gulf (ICES 30). If post-smolts tend to keep in contact with water warmer than 7 °C, this temperature field will guide the fish along the route shown by the tag recoveries. It is not clear why Finnish post-smolts move to the Swedish side in the Quark. The explanation might be that the temperature field which they follow leads the post-smolts so near the Swedish coast that the migration continues in this temperature field along the western coast of the Gulf. If the fish continued along the Finnish coast, they would have to swim into a higher salinity concentration. Off the Swedish coast they can remain in the same salinity field, since it extends in the same direction as the temperature fields.

The spawning migration does not seem to follow the same route as the post-smolt migration. The timing of the bag-net fishery indicates that these gears catch only spawning migrants. The home rivers of almost all the salmon of wild origin caught in the Gulf are situated in sub-division 31. It appears that the spawning migration in the Gulf area is also guided by certain surface-water fields. During late May and June, when the spawners enter the Gulf, the isotherms 6 and 7 °C extend from the Main Basin along the western side of the Åland islands to the north, following the Finnish coast. If spawner entering the Gulf follow this temperature field, they will easily reach the mouth of their home river. The salmon bag nets are anchored floating gears placed at varying distances from the coastline. If these gears were placed across the temperature field along which salmon migrate, their effectiveness might be good. The field along which spawners migrate is caused by currents and winds. Sometimes it lies rather far from the coast, when only nets far from the coastline catch salmon, and sometimes the situation is the opposite. Fishermen report that salmon catches depend greatly on the direction of the wind. Off the Finnish coast of the Gulf of Bothnia southwestern and southern winds are the best for the catches. Segerstråle (1983) suggested that salmon fyke-net catches varied according to the direction of the wind, increasing in some gears but decreasing in others when the wind changed. Westerberg (1984) has also suggested that salmon orientate at least partially by following the thermal field.

Salmon spawners enter the Gulf in May-June. Off the Åland islands the catches of the first four weeks have mainly consisted of salmon of wild origin. In the next sampling area, off the Merikarvia coast, this group of wild salmon will be found in the sample some days later. However, this sample, will also contain many salmon originating from hatcheries. These hatchery-reared fish were also caught before this wild group of salmon came into the area, but did not occur in the samples from the Åland island catches. It seems that these fish did not enter the Gulf along the same route as the wild ones. It is also possible that they entered the Gulf before the gears had been put out in the Åland islands, but the catches in this area were very poor during the whole of May. If fish occurred in this area in early May, the fishermen would certainly have taken them too. In the Quark the group of wild salmon was observed in the samples some days later than in the Merikarvia area, but there was no trace of the early migrating hatchery fish. In the sample from sub-division 31 the majority of the salmon were of wild origin. The migration route and destination of these hatchery fish is not known. Perhaps they were merely on feeding migration inside the Gulf and this was why they did not occur in the Åland island samples. On the other hand, they did not appear in the gears north of the Merikarvia area. The explanation might be that they were not migrating to sub-division 31 at all, but their home river was situated somewhere in sub-division 30. Lindroth et al. (1982) have suggested that salmon from the River Dalälven swim northward along the Finnish coast in the same area, where sampling was done off the coast of Merikarvia. Thus those hatchery fish might belong to the River Dalälven salmon population.

The catch samples show that the spawning run is mainly early among wild salmon and that the hatchery-reared fish come later. With the exception of the Merikarvia area, all these samples give similar information. However, a curious feature is evident in the samples; the percentage of wild salmon is much higher than could be expected from the wild and hatchery-reared smolt production figures, according to which the percentage of wild salmon should be less than 20. In samples collected from the Finnish catches in the Main Basin, the percentage of wild salmon has been 16 (Anon. 1986).
If wild and hatchery-reared salmon originating from sub-division 31 have a similar migration route to the Baltic Proper, as they seem to have (Ikonen & Auvinen 1984), the difference in the timing of migration may be caused by human selection during breeding. Salmon entering the river mouth early in the summer are very difficult to catch and keep alive until September, when the eggs and milt are ready for stripping. For this reason salmon for fish rearing are often not taken before late August or September. The salmon which enter the river mouth or river early are caught in the commercial or sport fishery, so that the salmon taken for fish rearing purposes are mainly those which have entered the river late. This may explain why the spawning run is later in hatchery fish than in wild salmon.

In salmon fishery management this difference the timing of migration will make it possible to regulate the fishery of wild stocks, which are suffering from a lack of spawners. Regulation of the bag-net fishery at the time when the wild salmon stocks are migrating in the area will allow more spawners from these wild stocks to reach the home river.

REFERENCES

Alm, G. 1934: Salmon in the Baltic precints. - Rapports et Procés-Verbaux des Réunions, Conseil International pour l'Exploration de la Mer, 92:17-18.

Anonymous 1986: Report of the Baltic Salmon and Trouts Assessment Working Group. - ICES C.M. 1986/Asess 22 (Mimeo).

Antere, I. & Ikonen, E. 1983: A method of distinguishing wild salmon from those originating from fish farms on the basis of scale structure. - ICES C.M. 1983/M:26 (mimeo).

Brannon, E.L. 1984: Influence of Stock Origin on Salmon Migratory behaviour. - In: Mechanisms of Migration in Fishes (ed. McCleave, I.D., Arnold, G.P., Dodson, J.J. and Neill, W.H.) pp 103-112. New York 1984.

Carlin, B. 1965: Redogörelse för laxmärkningar. In: Årsberättelse för år 1964. Laxforskningsinst. Medd., 1.

Carlin, B. 1969a: The migration of Salmon. Swedish Salmon Research Institute. - Report, Laxforskningsinst. Medd., 2.

Carlin, B. 1969b: Salmon tagging experiments. - In: Årsberättelse för år 1968. - Laxforskningsinst. Medd. 3.

Christensen, O. and Larsson, P.-O. (ed.) 1979: Review of Baltic Salmon Research. A synopsis compiled by the Baltic Salmon Working Group. - ICES Coop. Res. Rep. 89. 124 pp.

Harden-Jones, F.R. 1968: Fish Migration. - 325 pp London 1968.

Ikonen. E. 1983: The salmon in its sea phase. - Salmo salar symposium. Luleå 1983 (in print).

Ikonen, E. and Auvinen, H. 1984: Migration of Salmon in the Baltic Sea, based on Finnish tagging experiments. - ICES C.M. 1984/M:4 (mimeo).

Järvi, T.H. 1935: Om laxens färdvägar i Östersjön. - Finl. Jakt- och Fiskeritidskr. 30, 53-63.

Järvi, T.H. 1938: Fluctuations in the Baltic Stock of salmon. - Rep. P.-v. Réun. Cons. int. Explor. Mer, 106: 1-114.

Järvi, T.H. 1948: On the periodicity of salmon reproduction in the northern Baltic area and its causes. - Rapp. P.-v. Réun. Cons. int. Explor. Mer, 119:1-131.

Larsson, P.-O. 1980: Smolt Rearing and the Baltic Salmon Fishery. - In: Salmon Ranching, (ed. J. Thorpe), pp. 157-186. London 1980.

Larsson, P.-O. 1983. Some characteristics of the Baltic Salmon (Salmo salar L.), population. - Thesis, Zoologiska Institutionen, Stockholm. 80 pp.

Lindroth, A. 1965: The Baltic Salmon Stock. - Mitt. int. Verein. theor. angew. Limnol. 13, 163-192.

McKeown, B.A. 1984: Fish Migration. - 224 pp. London 1984.

Palosuo, E. 1976: Atlas of Surface Water Temperatures and Salinites on the Gulf of Bothnia. Summerperiod I. Report Series in Geophysics 2. University of Helsinki.

Segerstråle, C. 1983: Havslaxen (Salmo salar L.) i Finska viken (Salmon in the Gulf of Finland). - Vilt- och fiskeri-forskningsinstitutet, Fiskeriforskningsavdelningen. Meddelanden 17:60-74.

Thurow, F. 1966: Beiträge zur Biologie und Bestandkunde die Atlantischen Lachses (Salmo salar L.) in der Ostsee. - Ber. dt. wiss. Komm. Meeresforsch. XVIII (3/4),223-379.

Thurow, F. 1968: On food, behaviour and population mechanism of Baltic salmon. Laxforskningsinst. Medd. 4.

Toivonen, J. 1973: The stock of salmon in the Gulf of Finland. - ICES, Doc. C.M. 1973/M:17 (mimeo).

Toivonen, J. and Tuhkunen, A. 1975: Migration of sea trout along the coastal waters of Finland on the basis of tagging experiments. - ICES C.M. 1975/M3 (mimeo).

Westerberg, H. 1984: The Orientation of Fish and Vertical Stratification at Fine- and Micro-Structure Scales. In: Mechanisms of Migration in Fishes (ed. McCleave, J.D., Arnold, G.P., Dodson, J.J. and Neill, W.H.) pp 179-204. New York 1984.

Table 1. Percentages of salmon of wild origin in the bag-net catch samples in the Gulf of Bothnia

		A+		A1+		A2+		A3+		TOTAL	
Year	Sub-div.	% wild	No.of fish	% wild	No.of fish	% wild	No.of fish	% wild	No.of fish	% wild	No.of fish
1980	31	-	2	83	18	87	128	92	24	86	172
1981	30	-	-	34	59	63	829	55	164	60	1052
	31	-	1	34	107	75	249	82	64	66	421
1982	30	-	-	40	5	43	522	30	160	40	687
	31	-	-	83	24	81	149	60	25	78	198
1983	30	-	-	57	191	44	495	42	84	47	770
	31	-	6	56	36	70	124	80	15	66	181
1984	30	-	-	69	58	64	817	43	54	63	929
	31	-	2	69	315	69	568	54	175	67	1060
1985	30	-	-	34	105	50	614	49	135	48	854
	31	-	1	28	586	77	409	65	173	51	1169

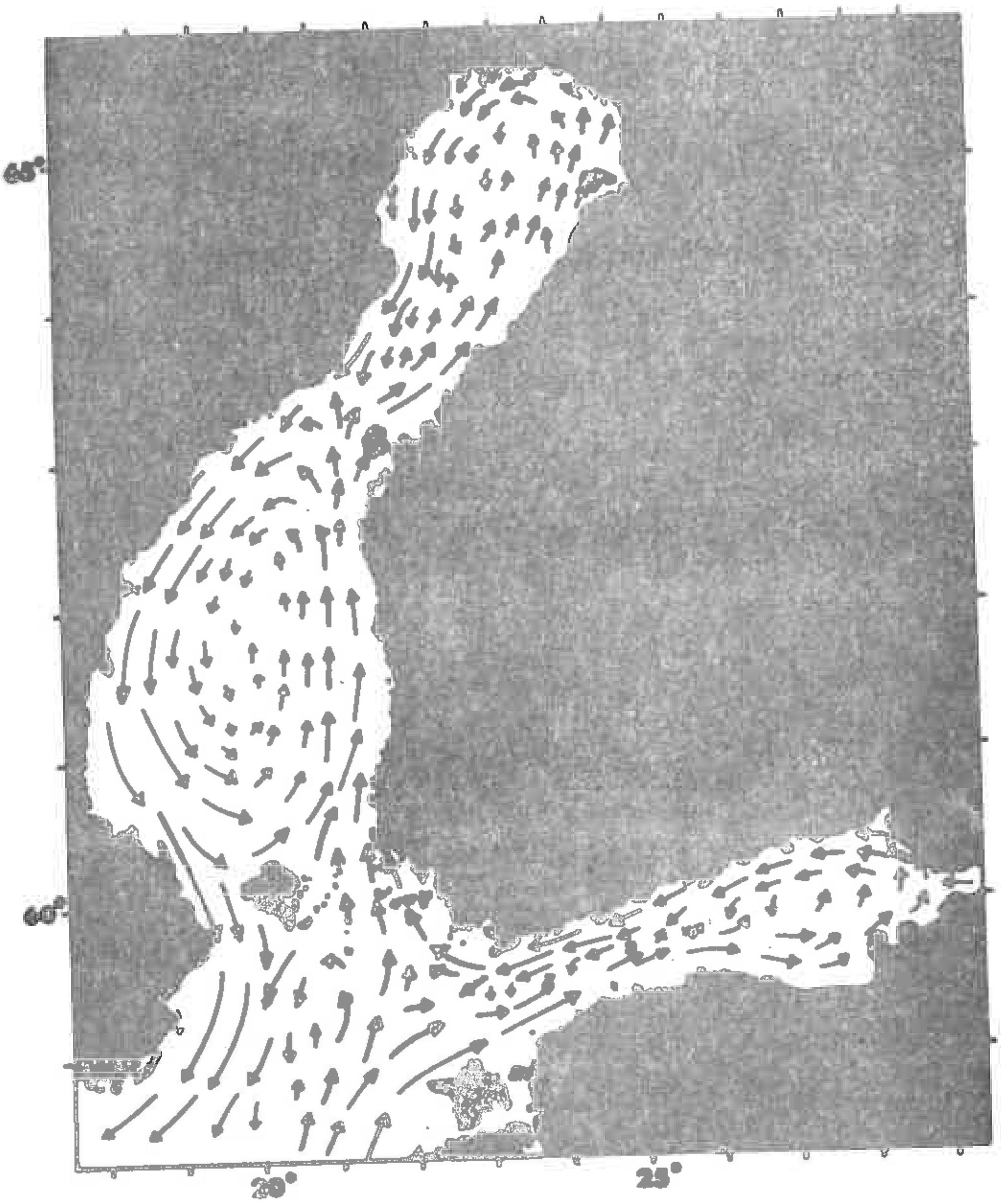

Figure 1. Surface currents; mean vectors in the Gulf of Finland and in the Gulf of Bothnia. (Toivonen and Tuhkunen 1975)

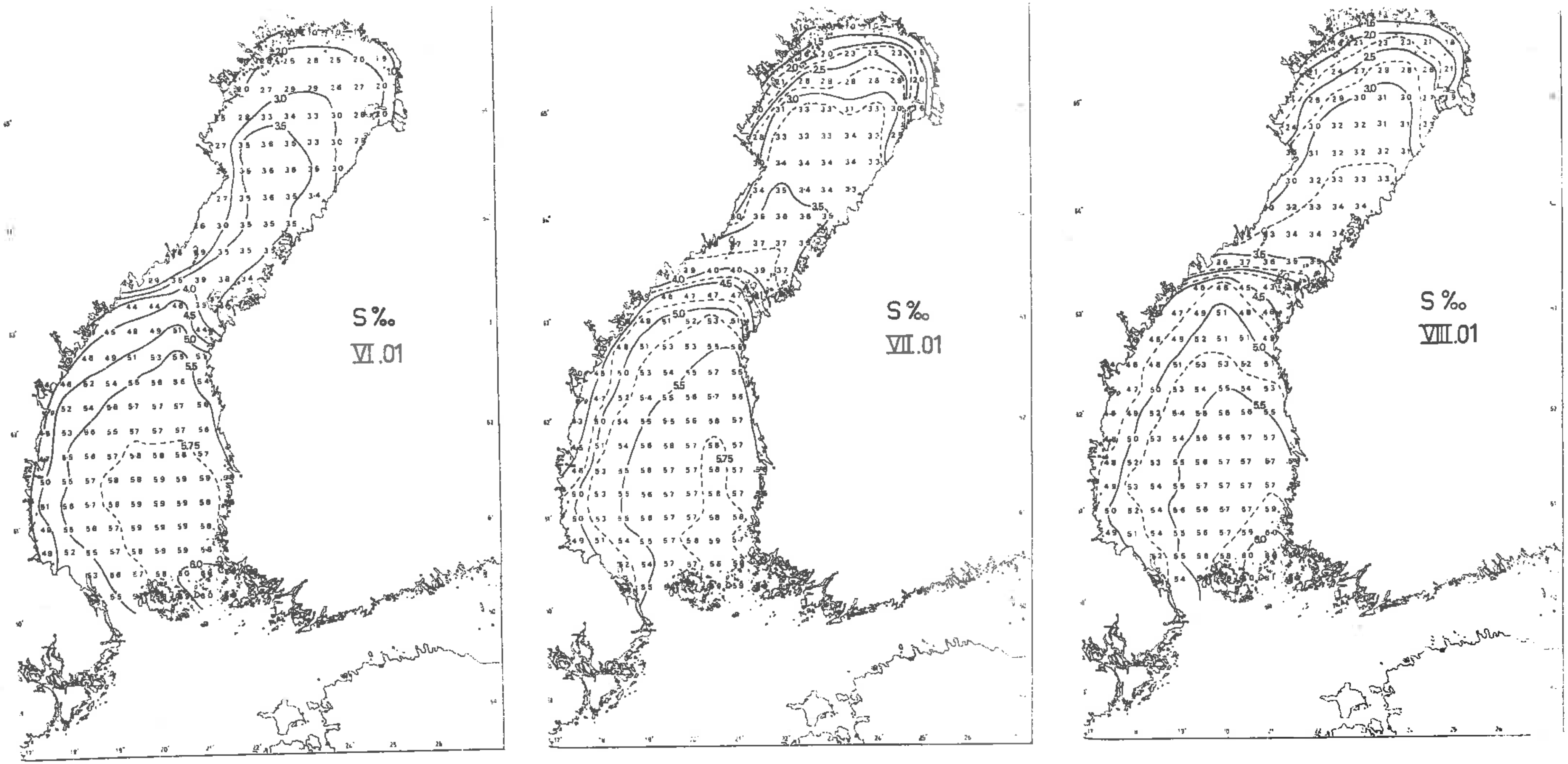

Figure 2 Salinity of the Gulf of Bothnia (Palosuo 1976)

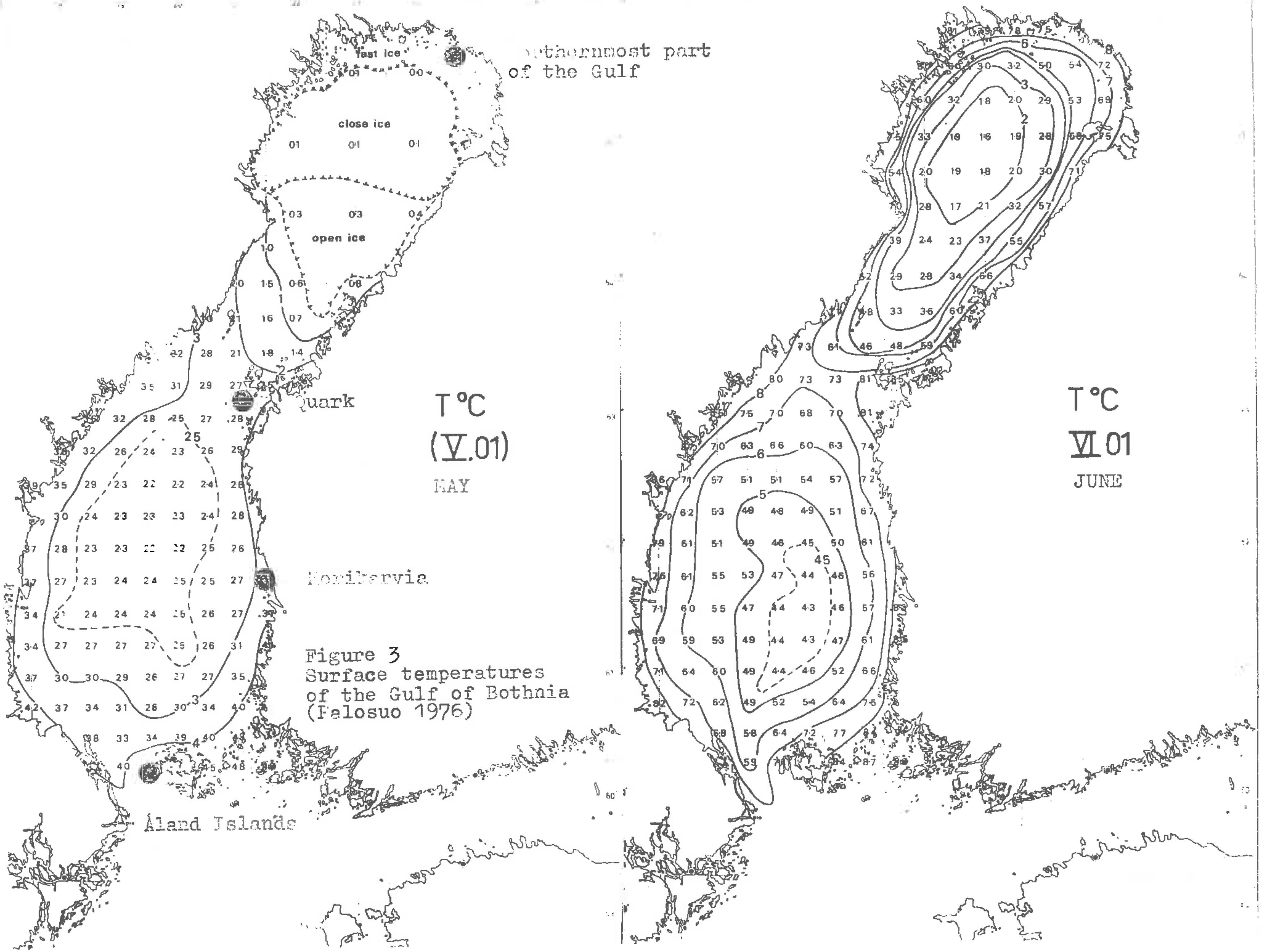

Figure 3
Surface temperatures
of the Gulf of Bothnia
(Palosuo 1976)

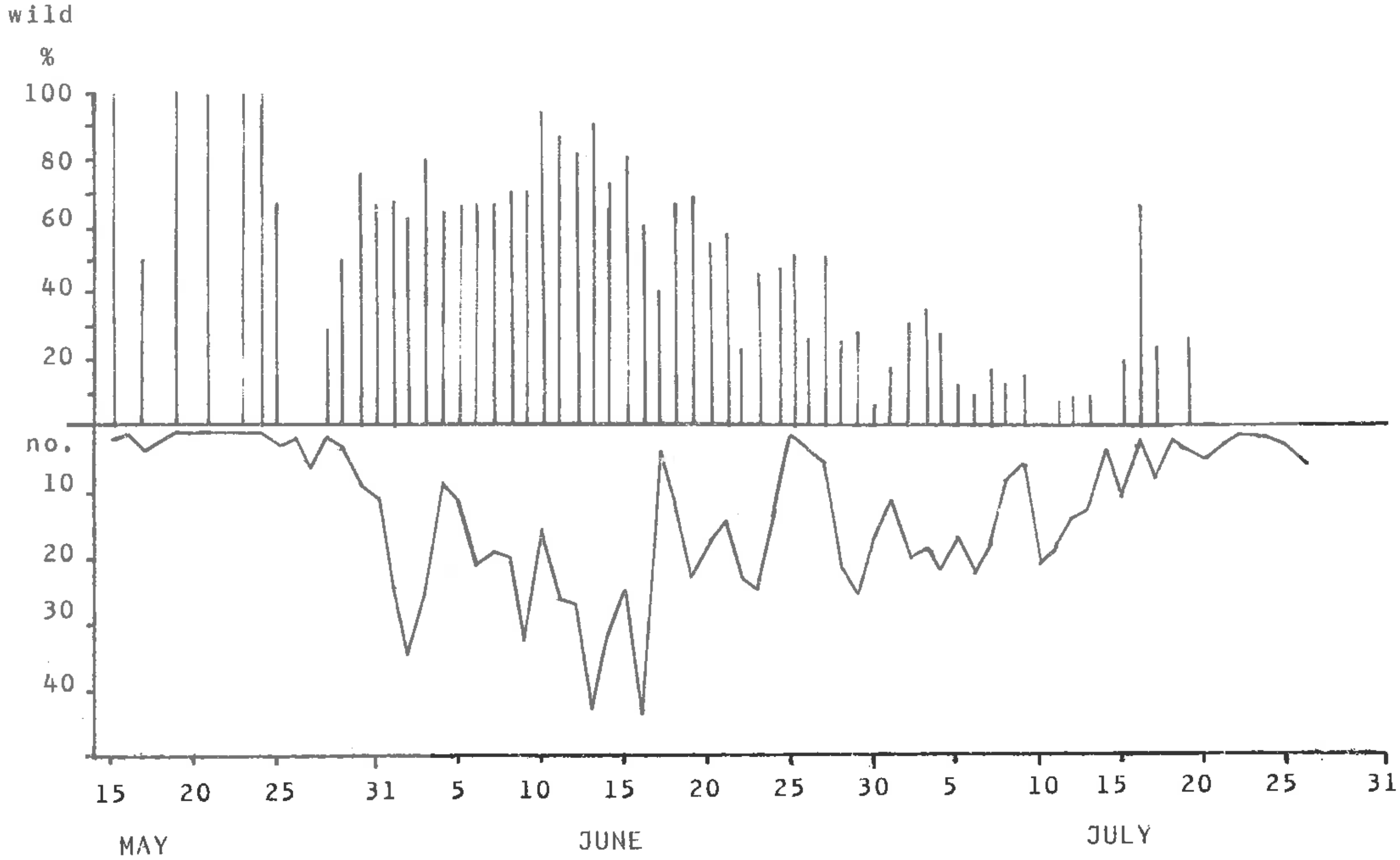

Figure 4.
Percentage of salmon (A2+ and older) of wild origin in the bagnet catch samples in the Åland Islands in 1983 and 1984.
No of sample 932, 49 % salmon of wild origin.

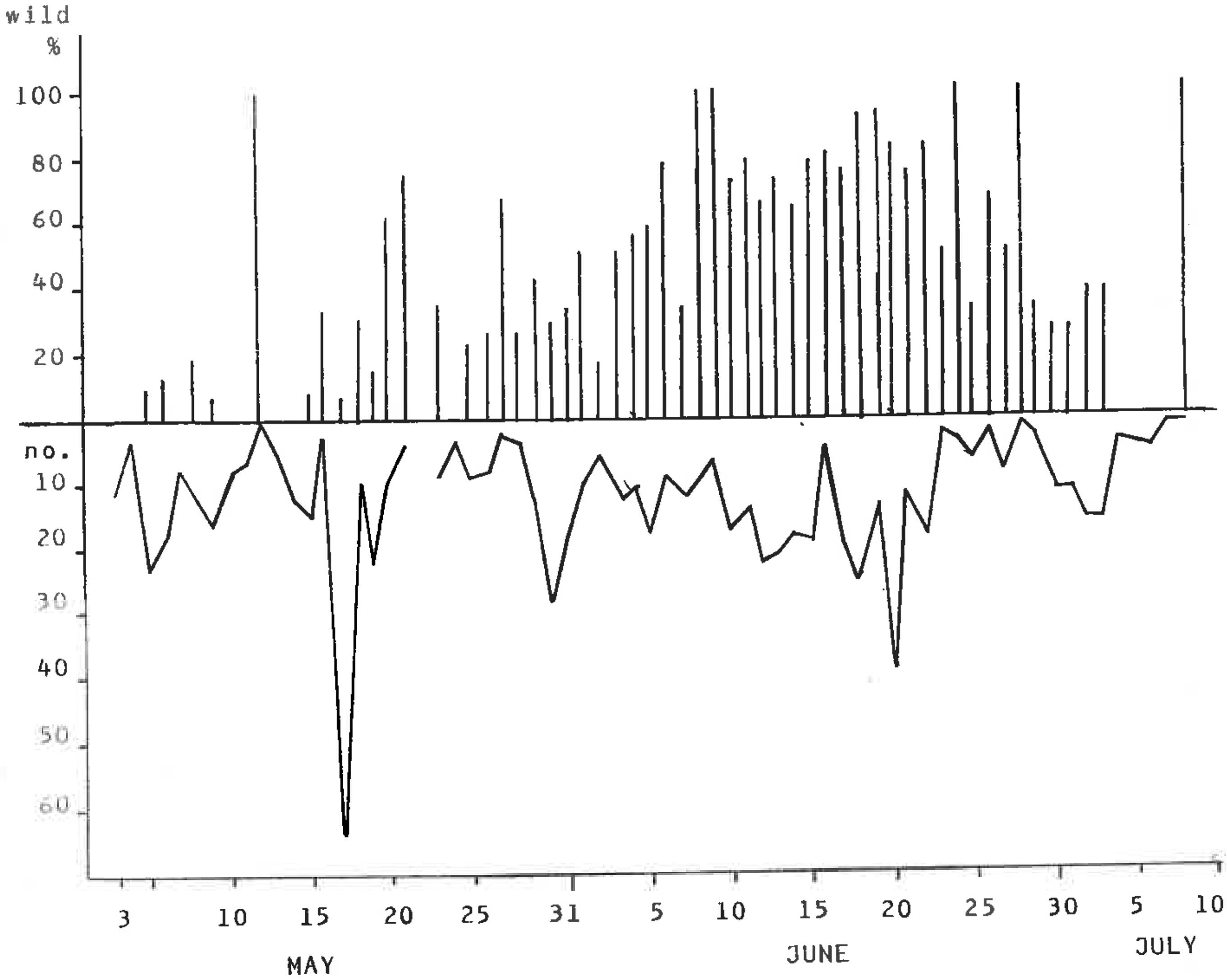

Figure 5.
Percentage of salmon (A2+ and older) of wild origin in the bagnet catch samples off Merikarvia in 1982-1984.
No of sample 749, 42 % salmon of wild origin.

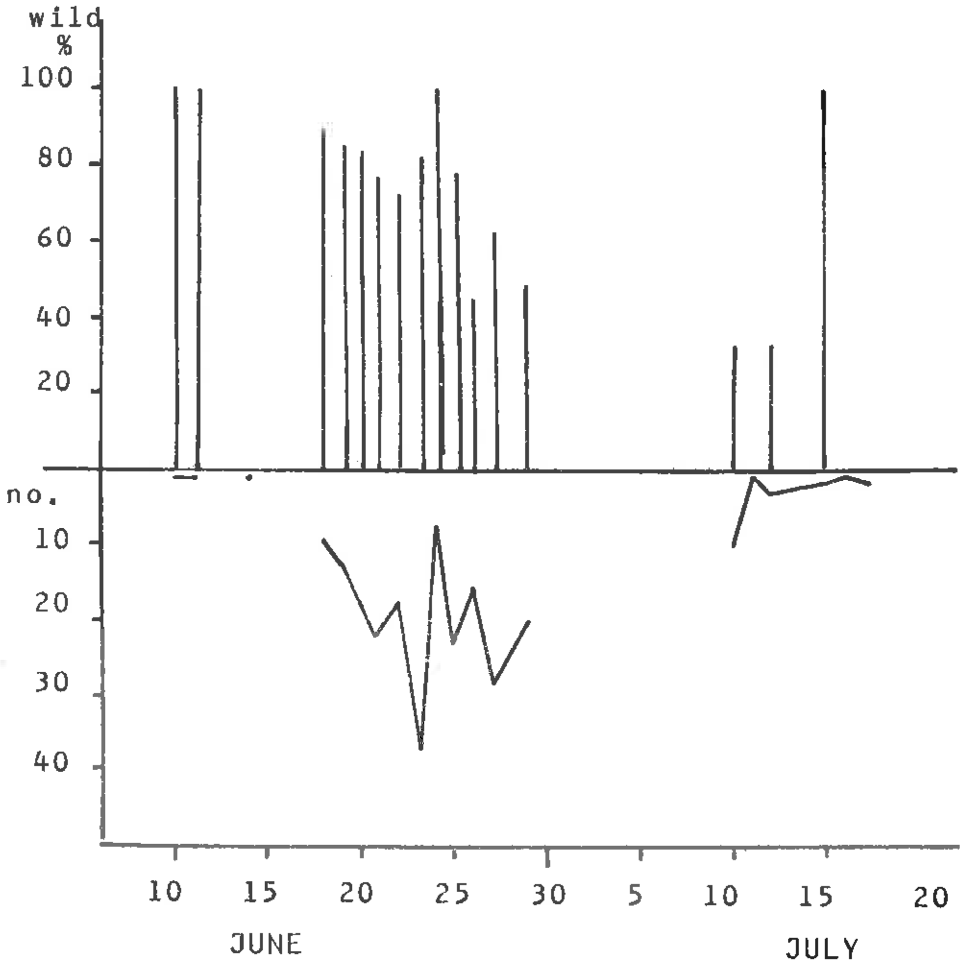

Figure 6.
Percentage of salmon A2+ and older) of wild origin in the bagnet catch samples in the Quark in 1983 and 1984.
No of sample 233, 69 % salmon of wild origin.

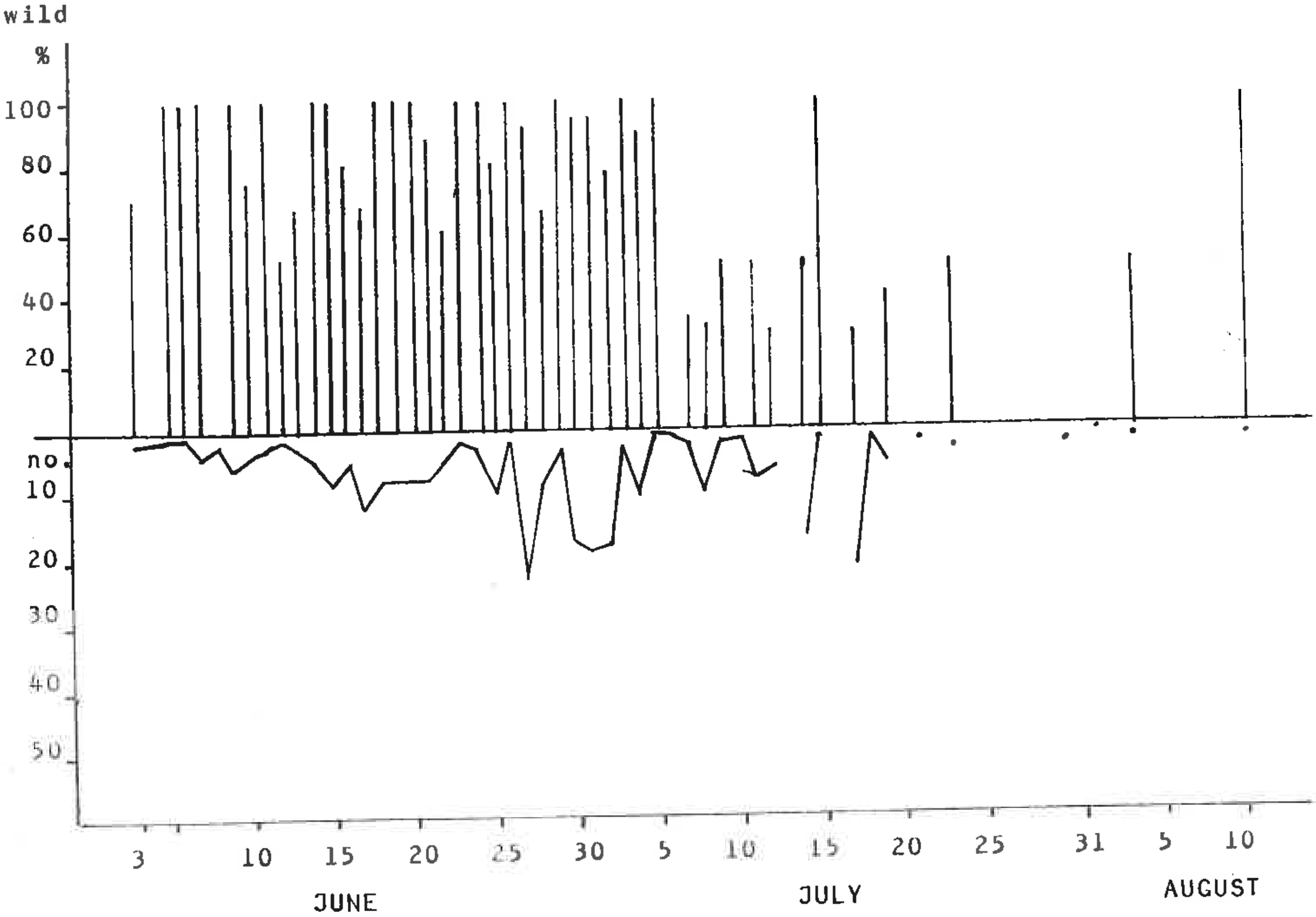

Figure 7.
Percentage of salmon (A2+ and older) of wild origin in the bagnet catch samples in the northermost part of the Gulf of Bothnia in 1983 and 1984. No of sample 316, 73 % salmon of wild origin.

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MANAGEMENT OF THE SALMON STOCK IN THE TORNIONJOKI RIVER

by

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ABSTRACT

The natural salmon stock in the Tornionjoki River has declined. The population densities of juveniles, especially in the uppermost reaches of the river, and the annual salmon catch from the river have decreased markedly. The age and size composition of the spawning stock has changed due to selective fishery. The breeding stock has become on average younger; and the age-specific size has decreased.

Because regulation of fishery has not been sufficient to maintain natural production, the salmon stock has been managed by catching wild spawners and releasing smolts and juveniles.

To counterbalance selective fishery, preference should be given to 3-sea-year salmon for use as broodfish. Obtaining fish of this age is more probable, if spawners are collected in June. Only wild spawners will be taken; the origin of those caught in the river mouth will be checked by scale examination.

Other management methods are also discussed in this paper.

INTRODUCTION

The Tornionjoki River, which forms part of the border between Sweden and Finland, is one of the last two remaining rivers which support a natural salmon stock in Finland. The Tornionjoki salmon stock has declined due to overexploitation, especially from offshore fishery. The annual salmon catch from the river between 1700 and 1900 was 300-400 tons; in the early part of this century it was still sometimes over 100 tons, but recently it has been only 3-5 tons (Tuunainen et al. 1984, Pruuki et al. 1985). Current smolt production is only c. 30 % of that of the 1960s (Lohikantojen säätelytoimikunta, 1984).

The age and weight composition of the spawning stock has changed as the result of selective offshore fisheries (Table 1).

Table 1. The age and weight composition of the spawning stock between 1930-1935 (Järvi 1938) and 1976-1983 (Pruuki et al. 1985, Kallio & Pruuki 1986).

Sea Years	Percent (%) of Spawning Stock		Mean weight (kg)	
	1930-1935	1976-1983	1930-1935	1976-1983
A.+	0.1	0.6	-	0.3
A.1+	25.5	56.9	1.4	1.2
A.2+	38.7	28.3	5.7	3.6
A.3+	29.1	12.7	12.1	7.3
A.4+	3.1	0.5	16.9	11.3
A.5+	0.4	-	19.7	-

The older and larger spawners migrate earlier on the average and swim further upriver than do the younger, smaller ones (Kallio & Pruuki 1986). The decrease in the percentage of 3-sea-year fish has probably caused the marked decline in the population densities of juveniles in the uppermost reaches of the river.

Because maintenance of natural production of the stock through fishery regulation has not been successful, the rearing and stocking of smolts was begun as early as 1972 (Table 2). Since 1979 1-year old parrs have also been released in the empty spawning grounds.

The most important point in the management of a natural fish stock is to maintain its adaptive genetic variation. The genetic structure of the breeding stock depends on the catch site of the spawners and month of the capture, and the origin, number, and characteristics of the spawners.

CATCH SITE

In principle, every differentiated substock should be managed separately in a water system. In practice, the state of the salmon stock in the Tornionjoki River is so weak that the spawners of the separate substrains are no longer available in sufficient numbers in the spawning grounds. The only requirement that can be made is that the spawners taken as broodfish are originally from the Tornionjoki River. Spawners caught in the river most likely belong to the original Tornionjoki salmon stock. Until now, the practice has been to buy spawners taken in commercial fishery from the river mouth. Scale analyses have shown that only a very few of the purchased spawners have been hatchery reared (Pruuki et al. 1985).

To prevent cross-breeding with foreign genetic material, hatchery-reared spawners should be avoided. A scale examination (Antere & Ikonen 1983) should be carried out on all spawners collected from the river mouth to ensure they come from wild stock. In future, the proportion of reared spawners will increase as the result of stocking of 0 and 1-year old parrs. Since these parrs cannot be distinguisted from wild fish by scale examination, adipose fin clipping has been used to mark the stocked parrs. It is important to ensure the genetic quality of the stocked juveniles, because their proportion in the naturally spawning population will increase in future.

CATCH MONTH

In recent years, the spawners have been collected equally in June and July. Because the proportion of the larger, older spawners has decreased in the breeding stock (Table 2) (Toivonen 1983, Pruuki et al. 1985), and since these older fish migrate on average earlier than the smaller, younger ones, collection of spawners should take place primarily in June. Another benefit of concentrating spawner collection in June is that the likelihood of taking wild fish would increase, since wild fish migrate on average earlier than hatchery-reared salmon (Ikonen, personal communication). There is also a difference between sexes in the timing of seasonal spawning migration, with females migrating earlier (Kallio & Pruuki 1986). Further, spawners are more tolerant of handling in June because of the cold water. Collection of spawners should continue to some extent up the end of July, in order to collect a representative sample from the entire spawning population, as well as to obtain a sufficient number of male spawners.

NUMBER OF SPAWNERS

Between 1972-1985, the number of stripped females varied annually from 10 to 100, and the number of males from 5 to 30

Table 2. Number of spawners stripped in the Tornionjoki River 1972-1985.

Year	Females No	Males No	Eggs Liter
1972	9	5	4,9
1973	10	21	25,2
1974	10	5	18,0
1975	12	8	5,0
1976	16	26	17,8
1977	23	21	40,1
1978	60	*	69,4
1979	*	*	*
1980	25	29	45,8
1981	*	*	76,0
1982	52 (1)	17	84,5
1983	10 (1)	18 (2)	25,0
1984	108 (9)	23 (1)	121,8
1985	59	21	93,1

( ) = number of reared spawners according to scale analysis

* = no data available

(Table 2). These numbers are relatively small. The number of males has clearly been too low in relation to recommendations for maintaining genetic variation. FAO recommendations state that the minimum, effective population size (N_e) for short-term conservation of the genetic resources of a fish stock is 50 (FAO, 1981). For the long-term preservation of the genetic resources, conserning the Tornionjoki salmon stock also, a population size of 500 has been recommended (Franklin 1980, Frankel and Soule' 1981). In addition insufficient natural eggs have been collected to meet the planned goal of stocking 300 000 1-year old parr every year.

To fulfill the requirements fo the stocking plan, there should be at least 100 females and at least 70 males so that the effective size of brood stock would be close to the minimum recommended value. The ICES Working Group on Genetics (ICES, 1984) proposed a broodstock for the Tornionjoki salmon stock with at least 70 female and 70 male spawners. The ICES Report (1984) also proposed the re-spawning of females. The rehabilitation of females in sea cages did not succeed, however. They refused to eat after spawning and all died.

An effective population size sufficiently large to conserve genetic variation in the brood stock is important, because stocking is being done to establish a new, naturally reproductive salmon stock in the empty spawning grounds of the upper reaches of the river, as well as to rehabilitate the whole stock. The effective size is affected by the number of parents, sex ratio, reproductive effort of each parent, and variation in the spawning population.

SELECTION OF SPAWNERS

Selection of spawners is not in general recommended when a natural stock is maintained by stocking. The age and weight composition of the spawning population of the Tornionjoki River has, however, changed so much as the result of selective fishery that the some spawner selection is justified. Because age at maturation and growth rate are inheritable traits (Naevdal et al. 1978, Gjerde & Gjedrem 1984), it may be assumed that the changes brought about by selective fishery will change the genetic composition of future generations. Although the age and weight structure of the spawning population has indeed changed, there is no evidence as yet of inherited effects. Genetic changes are expected if selective fishery continues to the same extent as at present, with no counter-selection.

In order to slow the decrease in the age at maturation, the grilses have not been used for breeding.

Maturation as a parr in a river, and as an adult at sea, have been found to be two, independent, inherited traits (Glebe et al. 1980, Gjerde 1984). The ICES Working Group on Genetics (ICES, 1984) has recommended the use of the precocious males in matings. Use of these males can provide some benefits: (1) the effective population size can be increased; (2) The origin of parrs is certain, because they are collected in the river; and (3) fishery selection has not yet affected this generation. In practice, it has been very difficult to obtain precocious males from the Tornionjoki River.

REFERENCES

Antere, I. & Ikonen, E. 1983. A method of distinguishing wild salmon from those originating from fish farms on the basis of scale structure. ICES. C.M. M:40. 16 pp.

FAO, 1981. Conservation of genetic resources of fish: problems and recommendations. Report of the Expert Consultation on the genetic resources of fish. Rome, 9-13 June 1980. FAO Fish. Tech. Pap.,(217):43 pp.

Frankel, O.H. & Soule', M.E. 1981: Conservation and evolution. Cambridge University Press, New York.

Franklin, I.A. 1980: Evolutionary change in small populations. In Conservation biology: an evolutionary ecological perspective, edited by M.E. Soule' & B.A. Wilcox. Sunderland, Mass., Sinauer Assosiates, pp. 11-34.

Gjerde, B. 1984. Response to individual selection for age at sexual maturity in Atlantic salmon. Aquaculture 38:229-240.

Gjerde, B. & Gjedrem, T. 1984. Estimates of phenotypic and genetic parameters for some carcass traits in Atlantic salmon and rainbow trout. Aquaculture 36:97-110.

Glebe, B. D., Eddy, W. & Saunders, R. L. 1980. The influence of parental age at maturity and rearing practice on precocious maturation of hatchery-reared Atlantic salmon parr. ICES. C.M. F:8. 8pp.

ICES, 1984. Report of the Working Group on Genetics. ICES. C.M. F:4.

Järvi, T. H. 1938. Vaihtelut Itämeren lohikannassa (1921-1935). Suomen kalatalous 13: 1-170.

Kallio, I. & Pruuki, V. 1986. The diversity and seasonal spawning migration of salmon (Salmo salar L.) in the River Tornionjoki. EIFAC / FAO Symposium on Selection, Hybridization and Genetic Engeering in Aquaculture of Fish and Shellfish for Consumption and Stocking. Bordeaux. France.- 27-30. May 1986. 23 pp.

Karlström, Ö. 1983. Hur är situationen för laxbestånden i våra naturliga och odlade laxälvar. Fiskeriintendenten. Övre norra distriktet. 11 pp. Unpublished manuscript.

Lohikantojen säätelytoimikunta, 1984. Lohikantojen säätelytoimikunnan mietintö (Betänkande avgivet av kommissionen för reglering av laxbestånden). Komiteamietintö 1984: 4. 133 pp.

Naevdal, G., Holm, M., Ingebrigtsen, O. and Möller, D. 1978. Variation in age at first spawning in Atlantic salmon (Salmo salar). J. Fish. Res. Board. Can. 35: 145-147.

Pruuki, V., Anttinen, P. & Ahvonen, A. 1985. Tornion- Muonionjoen vesistön kalataloustutkimus. RKTL. Kalantutkimusosasto. Finnish Game and Fisheries Research Institute, Fisheries Division. Monistettuja julkaisuja 32. 238 pp.

Toivonen, J. 1983. Lohi tutkimuksen, hyödyntämisen ja hoidon kohteena. (Abstract: Salmon as a subject for research, exploitation and management.) RKTL. Kalantutkimusosasto. Suomen kalatalous 51: 29-39.

Tuunainen, P., Nylander, E., Alapassi, T. & Aikio. V. 1984. Kalastus ja kalakannat Tornionjoen vesistössä. RKTL. Kalantutkimusosasto. Finnish Game and Fisheries Research Institute, Fisheries Division. Monistettuja julkaisuja 25. 86 pp.

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THE DIVERSITY AND SEASONAL SPAWNING MIGRATION OF SALMON (*SALMO SALAR* L.) IN THE RIVER TORNIONJOKI

by

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ABSTRACT

The age variation within the salmon stock originating from the natural strain in the River Tornionjoki was correlated with the seasonal spawning migration in the river and with the length of the upstream migration. The more years a salmon spent in the sea, the earlier in the spring it tended to migrate into the river. The female spawners that had spent four years in the river migrated first.

The timing of the seasonal spawning migration of the male was nearly the same for all smolt age groups. Salmon parr usually spend 2 to 4 years in the river. The relative number of salmon that had spent two years in the river among the spawners in the catch was significantly greater in the lower part of the run than in the middle or upper part of the river. The age variation in the salmon stock relative to the length of the upstream spawning migration in the River Tornionjoki indicated that the length of the life history of the spawners increased gradually from south to north.

The drastic reduction in the population density of juvelines, especially in the upstream part of the migration route, is most likely a consequence of preferential removal of the larger and older fish by selective fishery. It is those fish with long life histories that appear to spawn further upstream. The adaptive genetic and ecological diversity of the salmon stock in the River Tornionjoki can be maintained by allowing the upstream migration of a sufficiently large breeding stock to take place throughout the whole spawning season.

THE DIVERSITY AND SEASONAL SPAWNING MIGRATION OF SALMON (SALMO SALAR L.) IN THE RIVER TORNIONJOKI

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CONTENTS

1. INTRODUCTION

Atlantic salmon (Salmo salar L.) show great variability in phenotypic and genotypic characteristics (Nyman and Pippy, 1972; Schaffer and Elson, 1975; Riddell and Leggett, 1981; Koljonen, 1985). The diversity among salmon stocks from different streams is called stock differentiation, and it results from the adaptation to local environments and the homing behaviour of fish (Leggett, 1977). The stock-specific variation in the life histories of salmon from different rivers in the Baltic region and along the coast of eastern North America is associated with environmental conditions in the native streams (Alm, 1934; Schaffer and Elson, 1975). Both the Baltic and Atlantic salmon stocks exhibit genetic, stock-specific variation (Nyman, 1966; Payne, 1974; Koljonen, 1985).

Salmon stock differentiation in genetic, ecological, or morphological traits occurs also within each water body (Saunders, 1967; Möller, 1970; Ryman et al., 1979; Ståhl, 1981). Saunder's (1967) investigation on salmon stocks in the Miramichi River on the East Coast of North America showed that there were two stocks, one that makes early run and spawns in the upper reaches of the river, and another that undertakes a late run and spawns further downstream. Möller's (1970) data on the transferrin pattern indicates genetic differentiation between these two salmon stocks in the northwestern Miramichi. Ryman et al. (1979) discovered two sympatric populations brown trout (Salmo trutta L.)

with apparently complete reproductive isolation in Lake Bunnersjöarna, Sweden. The genetic difference between these brown trout stocks was very small, but they showed great variability in their ecological and morphological characteristics. A pattern of stock subdivision in natural Baltic salmon populations of the main drainage system between the Lainio and Tornio Rivers in northern Sweden has also been found (Ståhl, 1981).

In this drainage system, stock differentiation of salmon and trout is often associated with the spawning migrations (Saunders, 1967; Saunders and Allen, 1967; Schaffer and Elson, 1975). On the northeastern coast of North America, the larger salmon tend to migrate upstream in the spring when the run-off is greatest, and smaller fish do so in the summer when water velocities are slowest (Schaffer and Elson, 1975). In the Miramichi river system, the early-run spawners have spent more years in the river than those making the late runs (Saunders, 1967).

Salmon stock differentiation has recently attracted interest for investigations on life history evolution. It can be assumed that variation in the demographic parameters among and within semi-isolated salmon stocks is adaptive and the result of natural selection (Schaffer, 1979).

In this paper, the age and size variation within salmon stock originating from the natural strain in the River Tornionjoki have been related to the timing of the seasonal spawning migration and the length of the upstream migration. This kind of knowledge about the ecological and genetic variation within a salmon strain is necessary for monitoring the performance of the strain and for monitoring the effects of stocking activities. The data on stock-specific variation in salmon is useful in conjunction with the planning of temporal and local control of fishing and in rehabilitation and breeding programmes.

The upstream migration of salmon in the River Tornionjoki starts at the beginning of June and continues as late as September and October (Petersson, 1975). The spawning migration of salmon can cover over 400 km from the mouth of the river to the farthest upstream spawning areas in Finland and Sweden (Nordqvist, 1904; Toivonen, 1962; Karlström, 1963). Spawning continues for about six weeks from September to the end of October (Karlström 1963).

2. MATERIALS AND METHODS

The salmon studied were caught in 1983 and 1984 in the Rivers Tornionjoki , Muonionjoki, and Könkämöeno by fishermen (Pruuki et al., 1985 ; pers. comm.) (Fig. 1). They included 74 wild spawning salmon in 1983 and 164 wild and 7 hatchery-reared ones in 1984. Only wild fish were examined in this investigation. The other 393 wild spawning salmon came from the coast between the mouths of the Rivers Tornionjoki and Kemijoki in 1982 and 1984 (Kallio, 1986). These wild fish from the coast probably belonged to the natural salmon strain of the River Tornionjoki since there is no any other large natural salmon stock in the northern part of the Botnian Bay region (Ikonen and Auvinen, 1984). These salmon were caught for stripping and selected from the catch because of their large size.

The size, sex, and season and place of capture of the salmon were recorded. I. Antere of the Finnish Game and Fisheries Research Institute examined the scales to determine how many years had been spent in the river and how many in the sea, as well as to detect possible hatchery origins (Antere and Ikonen 1983).

The dates of capture of the salmon were assumed to mark the progress of the seasonal migration in the river. The length of the upstream migration is the distance between the mouth of the river and the site of capture.

The effect of the time spent in the stream on the age and size at maturation of the salmon was determined by comparing the smolt age groups with each other. The significance of the differences between these groups was calculated using the t-test (Dixon, 1981).

The relationship of the age variation within a salmon stock to the timing of the upstream migration was determined by comparing the regression lines between the years of life in the sea with the dates of upstream migration by the different smolt age groups, and computing the mean times of the upstream spawning migrations by each group establish accorging to the number of years the fish spent in the sea. The distributions of the years of stream life by spawners in the different parts of the river were tested using the chi-squared test. The statistics were compiled using BMDP programs (Dixon, 1981).

3. RESULTS

3.1. Association of river life with age and size at maturation

The age and size at maturation were not found to vary with the length of time spent in the river by the spawners either in 1983 or in 1984 in the river material (Table 1). In contrast, a comparison of the smolt age groups with spawners at the mouths of the Rivers Kemijoki and Tornionjoki revealed that the number of years in the stream increases with the number of years in the sea. The female spawners that had spent four years in the river were larger and older at maturity than the female spawners after three years in the river ($p < 0.05$ and $p < 0.1$; Table 2). The male spawners after three years in the river had spent more years in the sea and had reached a larger size than migrants after only two years in the river ($p < 0.05$; Table 2).

3.2. Age variation and upstream migration

The number of years of spawning salmon spent in the sea was correlated with the timing of the seasonal spawning migration (Fig. 2; Table 3). The more years a salmon had spent in the sea, the earlier in the spring it tended to migrate upstream. After three years in the sea, most spawners migrated upstream in June, while after only two years in the sea, they can be found migrating from the middle of June to the end of August. After only one year in the sea, the salmon began to migrate upstream at the beginning of July (Table 4).

The length of time female spawners have spent in the river is also correlated with the timing of the seasonal upstream migration. Most female spawners after four years in the river migrated at the end of June, while after only three years, the females swam upstream mainly in the middle of July. All salmon caught before June 10 were females that had spent four years in the river (Table 3; Fig. 2).

The entry of female spawners into the rivers occurred earlier in the season than in the males (Fig. 2; Table 3). The females in all smolt age groups had also averaged more winters in the sea than the males. The smolt age composition of the male spawners was the same during the whole season (Fig. 2).

Salmon parr usually spent 2 to 4 years in the River Tornionjoki. The percentage of spawning salmon that had spent only two years in the river was significantly higher in the catch from the lower part of the run than in those from the middle or upper parts of the river (Table 5).

4. DISCUSSION

4.1. Effect of smolt age on sea life

Many fishery scientists have recognized stock-specific variation in the age and length of the time spent in the river or sea by species in Salmonidea. Alm (1934), Hutton (1937), Stewart (1949), Ritter (1974) and Thorpe (1980) reported inverse ratios between the numbers of years in the rivers and in the sea. However, Dahl (1937) did not observe any relationship between smolt age and the number of spent years in the sea by salmon stocks. The data on fishes from the coast revealed that when the number years in the river increased, so did the number years in the sea, but the data on fishes from the river did not indicate this kind of relationship.

Variation within a stock is not nessesarily the same as variation between the stocks. It is obvious that relationship between the number years in the river and those in the sea is not constant, either between or within stocks of Atlantic salmon. Rather, the variation in these traits is stock-specific and sexually dependent and has to be explained on the basis of several variables.

Slow-growing parr were found to spend more years in the river than the fast growning parr, on the average (Menzies, 1927; Elson 1957; Jones 1959; Shearer 1973). The growth rate in streams seems to affect age at smoltification, if this occurs at a definite size. It is probable that salmon grow more slowly in the northern part of the river, where the growth period is shorter, than in the southern part. That a greater procentage of spawners with only two previous years in the river are found in the lower reaches than in the middle or upper part of the river provides evidence for this. The observations of Dahl (1916) and of Alm (1959) that the number of years salmon spend in the rivers increase from south to north in the Northern Hemisphere lend additional weight to this theory. The relationship between the growth rate in the river and the size and age of the smolts was not investigated by scale examination.

4.2. Age variation and upstream migration

The age variation of spawners during the whole seasonal upstream migration was investigated. It was clear that both male and female salmon that had spent more years in the sea undertook the upstream migration earlier. Moreover, the female spawners after four years in the river, migrate upstream at the beginning of summer, but female salmon after only two years in the river migrate during the whole season.

The age distribution of smolt in various parts of the river indicated that most salmon with only two years in the river were caught in the lowest part and near the mouth of the river. The majority of the data came from the lowest part of the river, where some spawners just beginning the longer upstream migration were probably also caught. These observations support the hypothesis that big, old salmon, especially female spawners, migrate further up the river than young, small ones. It has also been observed during investigations on the differences among salmon stocks that the spawners in a long river are older on average, than the salmon in a short river (Schaffer and Elson, 1975; Thorpe and Mitchell, 1981) and that the percentage of salmon that have spent only one year in the sea is lower in longer rivers (Scarnecchia 1983).

Homing, reproductive isolation and natural selection form amd maintain adaptive sub-stocks. The salmon strain of the River Tornionjoki can be divided into the genetically separate populations (Ståhl, 1981). The correlations of the age and size variation with the timing and length of the upstream migration by salmon of the strain in the River Tornionjoki is insufficient to indicate that there the salmon stocks differ considerably in life history traits. However, it is evident that the life history traits change gradually from south to north.

4.3. Age of female and male salmon at maturation

The variation in the life history within the stock was correlated with sex. The male spawners had spent fewer years in the sea than the females, and they migrated upstream later. The differences between males and females may be explained by the allocation of energy to reproduction and by the reproductive capacity of the sexes.

The resources available to an organism in any particular age class for reproduction, growth and maintenance are always limited. Increasing the resource allocation to reproduction can be expected to increase the immediate reproduction, but this can reduse the survival or fecundity in the future. The organism maximizes fitness during its whole life cycle (Gadgil and Bossert, 1970; Schaffer, 1979). The salmon may reproduce several times during its life, but the likelihood of its breeding at least twice is very low. According to the observations of Järvi (1932), 3.8 % of the salmon in the catch from the River Tornionjoki in 1930 and 1931 had reproduced earlier. The percentage of such fish among present spawners is below 1 % (Pruuki *et al.*, 1985). Thus, the first breeding essentially represents the reproductive effort of the whole life.

Egg production by females is associated with the size of the fish (Pope *et al.*, 1961; Larsson and Pickova, 1978; Kallio, 1986). The female salmon obviously benefit from spending several years in the sea, which increases their reproductive capacity and allows them to store up energy for the spawning migration. The farther upstream the female salmon migrate the more they have to produce eggs in relation to the cost of upstream migration. The cost of migrating upstream to the Atlantic salmon is demonstrated in various ways, for instance by the fact that large salmon migrate during periods of high water flow, and the small salmon travel during periods of low water flow (Schaffer and Elson, 1975).

The reproductive capacity and weight of male salmon do not increase as much as those of females in the sea. Large males have better chances of breeding with a large female salmon (Belding, 1934; Jones and King, 1949; Jones 1959). However, small, precocious males and grilses are able to take part in breeding along with the large male spawners as so-called satellite males, and as such, when they attempt to fertilize some of the eggs. If precocious males or those that have spent only one year in the sea do indeed manage to fertilize eggs, natural selection maintains maturation as a parr or after one year in the sea. The maturation of precocious males and their age at maturation in the sea are two independently heritable traits (Glebe et al,. 1980; Gjerde 1984).

4.4 Changes in size and age distribution in spawning population

A comparison of the present age distribution of the salmon stock of the River Tornionjoki with the age distribution at the beginning of the century reveals that the proportion of young fish in the spawning population has increased. For example, the procentage of three sea year salmon has fallen from 29 % to 13 % in the period between 1930 and 1970, and the percentage of spawners that have spent four years in the river, had fallen from 28 % to 21 % in the same period (Järvi, 1938; Pruuki et al,. 1985). The relatively great decrease in the oldest class of fish is assumed to be associated with a decline in the spawning population reaching the uppermost part of the river. The decreases in the juveline densities have been most marked in this part (Karlström, 1983).

The age of salmon at maturation has been shown to be a heritable trait that can be affected by selection (Schaffer and Elson, 1975; Saunders, 1981; Thorpe et al,. 1983). The age composition of the spawning stock has tended to become younger, and the age-specific mean weight has decreased (Toivonen, 1983; Pruuki et al,. 1985). This age-specific mean weight decrease is greatest in those fish that have spent many years in the sea. Apparently, selective fishing causes the heritable changes in those genes affecting the age at maturation. Moreover, selective fishing takes fast growing salmon more often from the later-maturing groups than from the earlier maturing ones. Both these points have obviously affected the observed changes in the spawning salmon stock in the River Tornionjoki. The changes in the growth rate in the sea among different groups of spawners that have spent different periods of the time in the sea are not known, but it is possible to investigate this by scale examinations.

4.5. Conclusions

Since the salmon stock in the River Tornionjoki consists of differentiated substrains with different life cycles and homing behaviour it is necessary to maintain as much diversity as possible within the stocks and among sub-stocks by rehabilitation management and fishing limitations. The fishery should be regulated so that the spawning stock remains of adequate size during the whole seasonal upstream migration, and so that the natural stock is able to use all the nursery grounds of the species. In particular, it should guarantee the spawning success of the large salmon that have spent many years in the sea, because the substrains in the upper part of the river have decreased the most. It is reasonable to identify mating groups from captured salmon spawners, established on the basis of the time of the seasonal upstream migration, the age of the fishes, and their size at maturation.

5. REFERENCES

Alm, G., Salmon in the Baltic precincts. Rapp.P.-v. Reun. Cons.int.
1934 Explor. Mer. 92:1-63.

Alm, G., Connection between size age and maturity in fishes. Inst.
1959 Freshwat.Res.Drottningholm.Rep. 40:5-145.

Antere, I. and E. Ikonen, A method of distinguishing wild salmon
1983 from those originating from fish farms on the basis of scale structure. ICES. C.M. 1982/M:40. 16 pp.

Belding, D.I., The spawning habits of Atlantic salmon. Trans. Am.
1934 Fish.Soc. 64:211-216.

Dahl K ., Salmon and trout: a handbook. The Salmon and Trout
1916 Association. London. 107 pp.

Dahl, K., Parr life of salmon. Salm.Trout Mag. 86:10-13.
1937

Dixon, W.J.(Ed.), BMDP Statistical software. Berkeley. University
1981 of California Press. 725 pp.

Elson, P. F., The importance of size in the change from parr to
1957 to smolt in Atlantic salmon. Can.Fish.Cult. 21:1-6.

Gadgil, M. and W. Bossert, Life historical consequences of natural
1970 selection. Am.Nat. 104:1-24.

Gjerde, B., Response to individual selection for age at sexual
1984 maturity in Atlantic salmon. Aquaculture 38:229-240.

Glebe, B.D., W. Eddy, and R. L. Saunders, The influence of parental
1980 age at maturity and rearing practice on precocious maturation of hatchery-reared Atlantic salmon parr. ICES. C.M. 1981/ F:8. 8 pp.

Hutton, J. A., Wye parr and smolts. The inverse ratio theory of
1937 river and sea life. Salm.Trout.Mag. 87:119-123.

Ikonen, E., and H. Auvinen, Migration of salmon in the Baltic Sea
1984 based on Finnish tagging experiments. ICES. C.M. 1984/M:4 14 pp.

Jones, J. W., The Salmon. New York. Harper & Bros. 192 pp.
1959

Jones, J. W., and G. M. King, Experimental observations on the
1949 spawning behaviour of the Atlantic salmon (Salmo salar Linn.) Proc.Zool.Soc. 119:33-48.

Järvi, T. H., Syntyväisyydestä ja kuolleisuudesta Itämeren lohi-
1932 kannassa. Suomen Kalastuslehti 39:97-107.

Järvi, T. H., Vaihtelut Itämeren lohikannassa (1921-1935). Suomen
1938 kalatalous 13:1-170.

Kallio, I., Istutettujen ja luonnonkudusta peräisin olevien emo-
1986 lohien (Salmo salar L.) fekunditeetti ja mätimunien koko. RKTL. Kalantutkimusosasto. Monistettuja julkaisuja, 1986. In press.

Karlström, Ö., Torne älvs vattensystem. In: Pettersson, Å. 1975:
1963 Torneälven. Bilaga 7.

Karlström, Ö., Hur är situation för laxbestånden i våra naturliga
1983 och odlade laxälvar. Fiskeriintendenten, Övre norra distriktet. 11 pp. (mimeo)

Koljonen, M.-L., Suomen lohikantojen entsyymigeneettinen muuntelu.
1985 RKTL. Kalantutkimusosasto. Monistettuja julkaisuja, 37:1-94.

Larsson, P.-O., and J. Pickova, Egg size of salmon (Salmo salar)
1978 in correlation to female age and weight in three river stocks. Salmon Research Institute Report 2. 6 pp.

Leggett, W. C., The ecology of fish migrations. Ann. Rev. Ecol.Syst.
1977 8:285-308.

Menzies, W. J. M., Some aspects of the growth of salmon in river
1927 and sea as observed from scale examination of Dee (Aberdeen) and Spey salmon 1921 to 1923 inclusive. Fisheries Scotland, Salmon Fish. 1927. I.

Möller, D., Transferrin polymorphism in Atlantic salmon (Salmo
1970 salar). J.Fish.Res.Board.Can. 27:1617-1625.

Nordqvist, O., Laxens uppstigande i Finlands och norra Sveriges
1904 elfvar. Statistiskt bidrag laxens biologi. Fennia 22.

Nyman, L., Geographic variation in Atlantic salmon (Salmo salar
1966 L.). Swed.Salm.Res.Inst.Rep. LFI. Medd. 3:1-6.

Nyman, O. L., and J. H. C. Pippy, Differences in Atlantic salmon
1972 Salmo salar from North America and Europe. J.Fish.Res. Board.Can. 29:179-185.

Payne, R. H., Transferrin variation in North American populations
1974 of the Atlantic salmon, Salmo salar. J.Fish.Res.Board. Can. 31:1037-1041.

Petersson, Å., Torneälven. Rapport över fiske, fiskeundersökningar
1975 mm. Fiskeriintendenten, Övre norra distriktet. (mimeo).

Pope, J. A., D. H. Mills, and W. M. Shearer, The fecundity of
1961 Atlantic salmon (Salmo salar Linn.). Freshwater and Salmon Fisheries Research. Dep.Agr.Fish.Scot.Rep. 26. 12 pp.

Pruuki, V., P. Anttinen and A. Ahvonen, Tornion- Muonionjoen vesis-
1985 tön kalataloustutkimus. RKTL. Kalantutkimusosasto. Monistettuja julkaisuja, 32/1985. 238 pp.

Riddell, B. E., and W. C. Leggett, Evidence of an adaptive basis
1981 for geographic variation in body morphology and time of downstream migration of juveline Atlantic salmon (Salmo salar). Can.J.Fish.Aquat.Sci. 38:308-320.

Ritter, J. A. Relationships of smolt size and age with age at first
1974 maturity in Atlantic salmon. ICES. C. M. 1974/M:25. 6 pp.

Ryman, N., F. W. Allendorf, and G. Ståhl, Reproductive isolation
1979 with little genetic divergence in sympatric populations of brown trout (_Salmo trutta_). _Genetics_ 92:247-262.

Saunders, R. L., Seasonal pattern of return of Atlantic salmon in
1967 the Northwest Miramichi River, New Brunswick. _J.Fish. Res.Board.Can._ 24:21-32.

Saunders, R. L., and R. K. Allen, Effects of tagging and fin-clipping
1967 on the survival and growth of Atlantic salmon between smolt and adult stages. _J.Fish.Res.Board.Can._ 24:2595-2610.

Scarnecchia, D. L., Age at sexual maturity in Icelandic stocks of
1983 Atlantic salmon (_Salmo salar_). _Can.J.Fish.Aquat.Sci._ 40:1456-1468.

Schaffer, W. M., The theory of Life-History Evolution and its
1979 Application to Atlantic Salmon. _Symp. Zool.Soc. Lond._ 44:307-326.

Schaffer, W. M., and P. F. Elson, The adaptive significance of
1975 variations in life history among local populatons in North America. _Ecology_ 56:577-590.

Shearer, W. M., A Study of the Atlantic salmon populations of the
1973 North Esk, 1961-1970. M.Sc. Thesis, University of Edinburgh.

Stewart, R. N., Iceland and its salmon. Some details of recent
1949 attempts at conservation. _Salm.Trout Mag._ 125:20-22.

Ståhl, G., Genetic differentiaton among natural populations of
1981 Atlantic salmon (_Salmo salar_) in northern Sweden. In: Ryman, N. (Ed.). Fish Gene Pools - Preservation of Genetic Resources in Relation to Wild Fish Stock. _Ecol.Bull._ Stockholm. 34:95-105.

Thorpe, J. E., Growth-rate and smolting-rate of progeny of male
1980 Atlantic salmon parr (Salmo salar L.). J.Fish.Biol. 17:451-460.

Thorpe, J. E. and K. A. Mitchell, Stocks of Atlantic salmon (Salmo
1981 salar) in Britain and Ireland: discreteness and current management. Can.J.Fish.Aquat.Sci. 38:1576-1590.

Toivonen, J., Kalastus.- Tornionjoki C 1:3. Imatran Voima Osakeyhtiö.
1962 22 pp. (mimeo)

Toivonen, J., Lohi tutkimuksen, hyödyntämisen ja hoidon kohteena.
1983 (Abstract: Salmon as a subject for research, exploitation and management.) RKTL. Kalantutkimusosasto. Suomen kalatalous, 51:29-39.

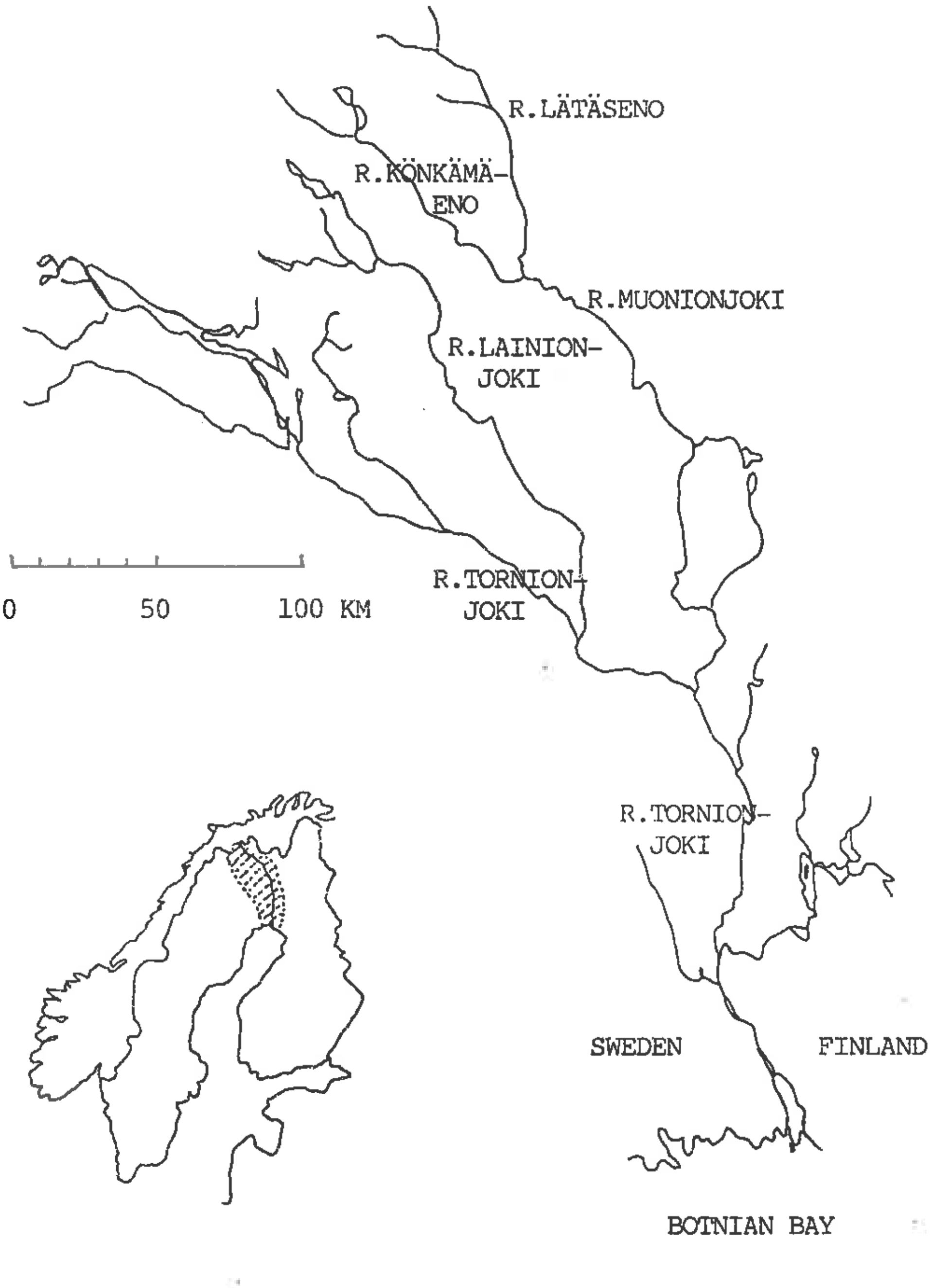

Figure 1. The main drainage system of the River Tornionjoki.

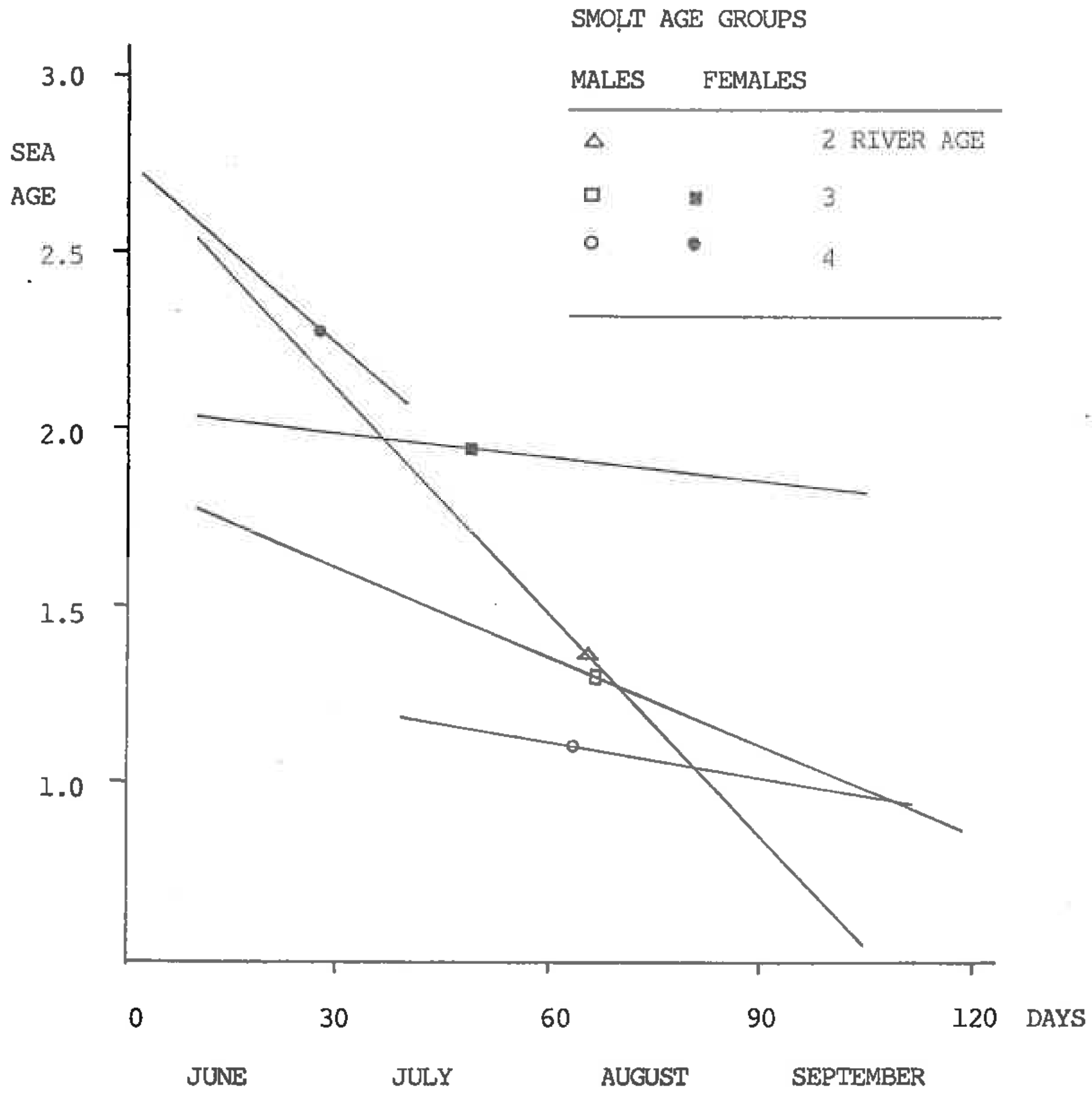

Figure 2. The regression lines between years in the sea and date of upstream migration by male and female salmon spawners in the different smolt age groups in the River Tornionjoki in 1984. The parameters can be found in Table 3.

Table 1. Weight, length and years in the sea of salmon spawners in the different smolt age groups in the River Tornionjoki in 1984. The differences between the smolt age groups have been determined using the t-test. Mean = $\bar{x}$, standard deviation = s, number of fish = n. Significance levels; $p < 0.05$ *, $p < 0.10^{o}$, $p > 0.1^{ns}$.

MATERIALS AND TRAITS	SMOLT AGE GROUPS 2.a $\bar{x}$	s	n	p	3.a $\bar{x}$	s	n	p	4.a $\bar{x}$	s	n
FEMALES AND MALES											
WEIGHT (KG)	4.13	3.82	16	o	2.76	2.81	119	ns	3.46	3.16	29
LENGTH (CM)	73.6	28.1	16	ns	62.7	14.5	119	ns	66.0	16.2	29
SEA YEARS (Y)	1.60	0.73	15	ns	1.42	0.59	117	ns	1.55	0.82	29
FEMALES											
WEIGHT (KG)	9.16	6.33	3	*	4.43	3.17	25	ns	6.36	4.08	9
LENGTH (CM)	110.0	50.4	3	ns	75.3	15.5	25	ns	80.6	18.6	9
SEA YEARS (Y)	2.50	0.70	2	ns	1.91	0.58	24	ns	2.33	0.86	9
MALES											
WEIGHT (KG)	2.96	1.92	13	ns	2.30	2.50	93	ns	2.15	1.40	20
LENGTH (CM)	65.2	12.5	13	o	59.1	12.3	93	ns	59.4	9.8	20
SEA YEARS (Y)	1.46	0.66	13	ns	1.29	0.52	92	ns	1.20	0.52	20

Table 2. The weight, length and years in the sea of salmon spawners in the different smolt age groups near the coast and the mouths of the Rivers Kemijoki and Tornionjoki in 1982 and 1984. The differences between smolt age groups have been determined using the t-test. Mean = $\bar{x}$, standard deviation = s, number of fish = n. Significance levels; $p < 0.001^{***}$, $p < 0.01^{**}$, $p < 0.05^{*}$; $p < 0.10^{o}$, $p > 0.1^{ns}$.

MATERIALS AND TRAITS	SMOLT AGE GROUPS 2.a $\bar{x}$	s	n	p	3.a $\bar{x}$	s	n	p	4.a $\bar{x}$	s	n
FEMALES AND MALES											
WEIGHT (KG)	4.19	2.21	94	ns	4.41	2.10	228	*	5.34	2.44	35
LENGTH (CM)	76.6	11.9	95	**	80.4	10.1	260	o	83.5	12.3	38
SEA YEARS (Y)	2.04	0.51	90	*	2.19	0.49	252	*	2.43	0.60	37
FEMALES											
WEIGHT (KG)	4.96	2.15	62	ns	4.54	1.85	176	*	5.54	2.32	29
LENGTH (CM)	80.7	10.2	62	ns	81.1	9.1	194	ns	84.5	11.9	31
SEA YEARS (Y)	2.21	0.41	61	ns	2.25	0.45	194	o	2.48	0.62	31
MALES											
WEIGHT (KG)	2.69	1.40	32	*	3.99	2.91	52	ns	4.37	3.01	6
LENGTH (CM)	69.0	11.2	33	***	78.2	12.3	66	ns	78.9	13.8	7
SEA YEARS (Y)	1.68	0.54	29	*	1.98	0.57	58	ns	2.16	0.40	6

Table 3. The regression lines between years spent in the sea and the date of upstream migration for the different salmon smolt age groups in the River Tornionjoki in 1984. Parameters: a = intercept, b = regression coefficient, s_b = standard error of the coefficient, r = correlation coefficient, 100 x r^2 = total proportion variation explained, F_1 = the F ratio that tests significance of the regression, F_2 = the equality of the regression lines.

MATERIALS NUMBER OF FISH		MEAN AND RANGE OF SEA YEARS	OF TIME OF UPSTREAM MIGRATION	REGRESSION STATISTICS a	b	s_b	r 100x r^2%	F_1	F_2
FEMALES AND MALES									
131	3.a, 4.a	1.41 1-3	61.3 2-119	2.06	-.010	.001	-.504 25.47	44.0^{***}	
105	3.a	1.41 1-3	63.2 10-119	2.02	-.009	.001	-.496 24.61	33.6^{***}	1.7^{ns}
26	4.a	1.42 1-3	53.8 2-111	2.35	-.017	.004	-.591 34.99	12.9^{**}	
FEMALES									
26	3.a, 4.a	2.03 1-3	43.6 2-105	2.34	-.007	.004	-.284 8.06	2.1^{ns}	
19	3.a	1.94 1-3	49.3 10-105	2.12	-.003	.004	-.180 3.25	0.6^{ns}	1.4^{ns}
7	4.a	2.28 1-3	28.0 2-40	3.23	-.033	-023	-.547 30.02	2.1^{ns}	
MALES									
113	2.a,3.a,4.a	1.27 1-3	65.8 10-119	1.88	-.009	.001	-.511 26.14	39.2^{***}	
8	2.a	1.37 1-3	65.6 10-105	2.72	-.020	.006	-.778 60.63	9.2^{*}	2.4^{*}
86	3.a	1.30 1-3	66.3 10-119	1.91	-.009	.001	-.529 28.01	32.6^{***}	
19	4.a	1.10 1-2	63.3 39-111	1.30	-.003	.003	-.220 4.85	0.86^{ns}	

Table 4. The timing of the seasonal spawning migration in the River Tornionjoki by salmon in different groups according to the time spent in the sea.

		MALES NUMBER OF YEARS IN THE SEA			FEMALES NUMBER OF YEARS IN THE SEA		
		1	2	3	1	2	3
MEAN TIME OF UPSTREAM MIGRATION	(DAY)	73	47	10	41	57	19
RANGE OF UPSTREAM MIGRATION	(KM)	39-119	15-111	10-11	32-53	14-105	2-36
NUMBER OF FISH	(N)	86	26	4	6	13	8

Table 5. The distribution of spawning salmon according to the number of years spent in the Rivers Tornionjoki and Muonionjoki in 1984. The differences have been tested with the chi-squared test. N = number of fish. X^2 = Chi-squared test. Significance levels; $p < 0.05^*$, $p < 0.01^{**}$.

DISTANCE FROM THE MOUTH OF THE RIVER, KM	YEARS SPENT BY SPAWNING SALMON IN THE RIVER								X^2
	2		3		4		ALL AGE GROUPS		
	N	%	N	%	N	%	N	%	
0 - 50	13	23	36	64	7	13	56	35	12.9^{**}
51 - 100	1	2	34	68	15	30	50	31	9.0^*
OVER 100	2	4	47	85	6	11	55	34	6.0^*

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