

ICES C.M. 1996

ICES C.M.1996/M:2  
Anadromous and Catadromous  
Fish Committee

## EXCEPTIONAL RETURN MIGRATION OF BOTHNIAN BAY SALMON

by

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### **Abstract**

The normal return migration pattern of Bothnian Bay salmon is thought to be the route via the Archipelago Sea. However, some salmon have been caught in spring in the mainland bays of the Turku Archipelago for decades. The origin of the salmon has been unknown, even though the catches have been fair even recently when there has been no natural production or stockings in the area. In 1993-1995 scale samples were taken from salmon caught in the mainland bays of the Archipelago Sea. These samples indicated that some of the fish are of wild origin. The timing of the catch, and the smolt age, sea age, size and condition factor of these wild salmon resemble those of the wild salmon in Sub-division 32 coastal catches, which are thought to originate in the rivers entering the Gulf of Bothnia. This suggests that at least some of the wild salmon feed in the Gulf of Finland and enter the mainland bays of the Archipelago Sea on their spawning migration to the northern parts of the Gulf of Bothnia. This possibility was considered here by examining recoveries from taggings made in Bothnian Bay.

## 1. Introduction

According to Järvi (1932) casual salmon fishing occurred in the Archipelago Sea in the early decades of this century, especially in the waters of Finby. In some years there was a fair catch, in others no catch at all. Hurme (1962) was convinced that this fishing depended on natural production in the rivers in the area.

Järvi (1939) reported that about two hundred small salmon were caught in Rymättylä in winter 1938. Judging by smolt age (three years) these fish were probably grilse on their return migration to Bothnian Bay. Järvi concluded that some of the salmon returning from the Baltic Main Basin to the Gulf of Bothnia use the more narrow routes of the Archipelago Sea.

According to Hurme (1967), there has been some salmon fishing in certain areas of the Archipelago Sea, including Paimionselkä, Strömman canal in the bay of Halikonlahti and Lemunlahti, which are long, deep mainland gulfs. He thought that the salmon may have originated from the River Paimionjoki or even from Strömman canal, though no parr have ever been seen in Strömman canal. Salmon fishing did not begin until the 1910 s in Paimionlahti and the 1920 s in Halikonlahti.

Halme (1964) reported one recapture in the Gulf of Finland out of 16 600 Bothnian Bay tagged smolts, and the recapture map appended in his study shows one recapture from rectangle 49H2.

Most of the Baltic salmon originating in the Gulf of Bothnia migrate after smoltification to feed in the southern areas of the Baltic Main Basin, and return, usually after 1-3 years, to spawn in their home rivers. Salmon have been assumed to make the spawning migration from the Baltic Main Basin to their spawning rivers in the Gulf of Bothnia via the western side of the Åland Islands in the Åland Sea (Ikonen 1986). This has led to some trap net fishing in this area in the 1980s. The amount of migration via the eastern side has been difficult to establish, partly because there is very little fishing in this area, which is a result of the sparse population of the Archipelago Sea.

Nowadays there is some salmon stocking in the Archipelago Sea, which is enough to support the salmon fishing in this area. However, the salmon catches of the mainland bays in the area still include some individuals (ca. 20% of the catch) which, according to the scale analyses, are of wild origin, although there is no longer any natural smolt production around the Archipelago Sea. Because Finnish coastal fishery in the Gulf of Finland includes a small proportion (ca. 7%) of wild salmon most probably of northern origin (Ikonen et al. 1993) and because some wild individuals are also found in offshore catches, the question arises, as to whether some salmon of northern origin feed in the northern part of the Baltic Sea and in the Gulf of Finland and make their return migration through the Archipelago Sea. How the fish choose their routes through the Archipelago Sea may depend on the currents in the area and on the depth and temperature of the routes. At least some fish are found in the innermost reaches of deep and narrow mainland bays in the Archipelago Sea.

## 2. Material and methods

The mainland bays in question are situated in Finland's southwestern opening to the Archipelago Sea (Figs 1 and 2). Paimionlahti Bay is about 35 km long and no more than 6 km wide. The River Paimionjoki empties into the northern end of the bay. Halikonlahti Bay is about 45 km long and, for the greater part less than 1 km wide. Strömman canal lies at a distance of about 20 km from the open sea in Halikonlahti Bay. The rivers Halikonjoki and Uskelanjoki discharge into the bottom of the bay. Airistonselkä is a rather shorter and broader bay south of the town of Naantali. All the bays are fairly deep, with maximum depths of more than 20-30 m. The bays of Lemunlahti (north of Naantali) and Mynämäenlahti are shallow, less than 7 m deep, with small rivers discharging into them.

The scale material studied consists of 122 samples taken from wild salmon from the mainland gulfs of Paimionlahti and Airistonselkä (ICES Sub-division 29, rectangle 49H2) in 1993-1995. The comparison material consists of scale samples from wild spawning migrants caught by trap net between 1986 and 1995 from the following areas: the Gulf of Finland (Sub-division 32), 369 samples, the Åland Sea (Sub-division 29, rectangle 49G9), 783 samples, the Bothnian Sea (Sub-division 30), 489 samples, and Bothnian Bay (Sub-division 31), 3396 samples.

The origin, smolt age and sea age of the catch samples were determined from scale impressions using a stereo microscope. Their origin was determined visually according to the criteria presented by Antere and Ikonen (1983).

The condition coefficient (K) for salmon from different areas was determined for length groups <61 cm, 61-80 cm and 81-110 cm by taking the mean of each length group and the respective mean of the condition factor. The formula used was  $K=W/L^3$ . If the weight was expressed as whole weight it was converted to gutted weight by multiplying by 9/10, as in most of the samples weights were expressed as gutted weight.

The length and condition data were treated statistically using the non-parametric Wilcoxon Rank Sums Test (SAS, User's Guide 1988), because not all the material was normally distributed.

The tagging material came from smolt taggings made in Bothnian Bay between 1963 and 1995. The material consisted of 495 553 hatchery-reared smolts and 20 274 wild smolts. In 1963-1967 the wild smolts were caught in the rivers Iijoki and Kiiminkijoki, and from 1972 onwards they were captured by smolt trap net in the River Simojoki. The recapture material is examined as spring-summer (April-July) recaptures and autumn-winter (August-December) recaptures in order to make a distinction between spawning and feeding stock, there being inadequate information concerning the catch device.

### 3. Results and Discussion

#### Scale samples

Figure 3 presents the timing of wild salmon in the catch samples from the Gulf of Finland, the Åland Sea and the Archipelago Sea. Figures 4 a-c present the timing of the older wild salmon (grilse not included) in the coastal catches of the same areas in 1993-1995. It seems that wild fish have shown up in the catches almost concurrently every year in all areas.

Smolt age distribution in different areas for 1993-1995 is presented in Figs 5 a and b. Little difference is seen in the smolt ages of salmon in the Gulf of Finland and the Archipelago Sea in 1993. However, in the Åland Sea sample, age group A.1 is almost lacking and the proportion of four-year-old smolts in the A.2 age group is smaller than in other areas. In 1994 and 1995 the sea age and smolt age distributions are almost identical in all areas studied, although somewhat different from the distributions in 1993.

The sea age distributions of spawning migrators of different sea areas are illustrated in Fig. 6, and those of 1993-1995 in Fig. 7. For comparison, the age distributions of salmon recaptures are illustrated in Fig. 6. These figures show that the proportion of older age groups decreases northwards. The age distribution for the Gulf of Finland bears a greater resemblance to that for the Gulf of Bothnia than that for the Åland Sea except in 1995, when there were only 14 samples of wild salmon from the Gulf of Bothnia and they were caught so late that older fish had probably already passed the area. In 1993, when the proportion of age group A.1 in northern areas was greater than in 1994, the age distribution for the Archipelago Sea was much more like that for the Gulf of Finland than that for the Åland Sea. In 1995, there were no great differences in the age distributions for the three southern areas.

The condition factors calculated for the different size classes of wild salmon are less marked in northern areas (Fig. 8). Comparison of salmon from the Åland Sea and the Gulf of Finland shows that in length classes 61-80 cm and 81-110 cm the condition factors of the Åland Sea are substantially greater (Tables 1 and 2). In length group <61 cm the mean length of the fish from the Åland Sea is also significantly greater.

Comparison of the curves drawn from condition factors of salmon from the Gulf of Finland, the Åland Sea and the Archipelago Sea in 1993-1995 (Fig. 9) shows that in 1993 and 1994, the curves for the Archipelago Sea are situated below those of the Gulf of Finland. In 1995 the curve for the Gulf of Finland lies below that for the Archipelago Sea. However, the condition factors are consistently highest in the Åland Sea.

The greater condition factors indicate that the fish on their spawning migration from the Åland Sea had been feeding in different areas from fish from the Gulf of Finland and the Archipelago Sea. The wild salmon in the spring catches of the Archipelago Sea had probably not followed the same migration pattern as the fish from the Åland Sea, and had more likely taken the same route as the wild salmon from the Gulf of Finland.

## Tagging results

The recapture rate of tagged wild smolts was 9.66%, and that of hatchery-reared smolts 7.85%. The higher recapture rate for wild fish concurs with the results of Jonsson et al. (1991), according to which higher proportions of wild than of hatchery-reared salmon survived in the sea. Most of the recaptures caught in the sea areas (68.2% of wild and 57.6% of reared recaptures, post-smolts not included) came from Sub-divisions 20-28, of which Sub-divisions 25-28 are the most important feeding grounds for salmon (Ikonen and Auvinen 1984) (Fig. 10). Figure 10 also reveals that reared fish are less likely to migrate to the southern areas of the Baltic Sea than wild fish. This may be related to the greater smolt size of the reared fish, because the larger smolts seem to have a greater tendency to stay in the Bothnian Sea area (Salminen et al. 1994).

The majority (94.1%) of the hatchery reared post-smolt recaptures taken from the sea areas (1983 ind.) came from the Gulf of Bothnia. Moreover, most of the post-smolt recaptures in October-December, both wild and reared, came from the Gulf of Bothnia. Thus not all smolts migrate to the southern areas of the Baltic Sea. It has been assumed that post-smolts migrate south first along the Finnish coast to the Quark area and then during July August move to the Swedish side of the Gulf (Ikonen and Auvinen 1984). Some post-smolt recaptures (18=0.9% of all hatchery-reared sea area recaptures; none wild) however, came from rectangles 50H0, 50H1, 49H0, 49H1, 48H1 and 48H2, which indicates that some post-smolt migration takes place via the Archipelago Sea. Moreover, five hatchery-reared post-smolts also came from the Gulf of Finland.

In August-December, five wild and 80 reared salmon of sea-ages A.1-A.3 were caught in the northern Baltic Main Basin and the Archipelago Sea (rectangles 50H0-H1, 49H0-H2 and 48H1-H2). Salmon of sea ages A.1-A.3 were also caught in the Gulf of Finland: seven wild (= 0.48% of the recaptures from the sea areas) and 268 reared (= 0.99% of the recaptures from the sea areas). Three wild and 177 reared fish were caught in April-July. These results suggest strongly that some salmon do not migrate to the southern Baltic to feed but stay in northern areas and some feed in the Gulf of Finland. These fish possibly make their spawning migration by some different route than those feeding in southern areas, the most natural route perhaps being via the Archipelago Sea.

The proportions of recaptures (post-smolts excluded) in Sub-division 29 in spring-summer are shown by rectangle in Figure 11. The figure indicates that most of the recaptures came from the Åland Sea (rectangle 49G9), the most common return migration route, but also that relatively more wild recaptures (6 = ca. 26% of all wild spring-summer recaptures in Sub-division 29) than reared (40 = ca. 9%) have come from rectangle 49H2.

Five of the six wild recaptures from rectangle 49H2 came from Paimionlahti Bay and one from Strömman canal. The corresponding figures for the 40 reared salmon were 20 and 13, four being caught in waters south of Strömman canal and three in the waters near Naantali. Also in rectangle 49H1, four reared salmon were recaptured in waters near Naantali, and one was recaptured in Lemunlahti (rectangle 48H1). Finnish fishermen have additionally returned some tags from rectangles 49H1 and 49H2 from Swedish taggings made in the Gulf of Bothnia, seven from Paimionlahti Bay, five from Halikonlahti Bay and six from waters near Naantali.

Because of the salmon fishery being so sparse, there is a lack of scale samples from the northern Archipelago Sea area in spring-summer and thus no information is available about the number of wild salmon there. Perhaps for the same reason, there are too few tag returns from the Archipelago Sea to evaluate whether the salmon in the mainland bays find routes from the Archipelago Sea to their home rivers. According to Quinn (1993), displacement studies indicate that maturing salmon tend to reverse the sequence of their outward migration as juveniles. It is possible that salmon of northern origin found in the innermost reaches of mainland bays are those that have migrated down as post-smolts through the Archipelago Sea and whose route has been influenced by river waters flowing from the bays. When these fish are on their spawning migration they come into contact with the river waters and are perhaps misled to enter the river mouths. It is hoped that the new tagging programme in progress will tell us more about the migration pattern of wild salmon in the Archipelago Sea.

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Table 1. Mean lengths and condition factors of different length groups of all scale samples

LENGTH						
	Åland Sea	s.d.	G. of Finland	s.d.	Arch. Sea	s.d.
<61 cm	591.9	18.2	572.0	28.1	548.9	26.2
61-80 cm	724.0	55.5	730.1	54.8	738.1	56.0
81-110 cm	901.2	66.9	889.9	72.3	875.8	50.0

CONDITION FACTOR						
	Åland Sea	s.d.	G. of Finland	s.d.	Arch. Sea	s.d.
<61 cm	1.047	0.184	0.895	0.109	0.809	0.084
61-80 cm	1.016	0.203	0.887	0.120	0.863	0.134
81-110 cm	1.094	0.176	0.939	0.125	0.929	0.114

N			
	Åland Sea	G. of Finland	Arch. Sea
<61 cm	27	30	9
61-80 cm	297	177	48
81-110 cm	207	139	64

Table 2. Results of Wilcoxon Rank Sums Test

LENGTH			
	Åland Sea- G. of Finland	Åland Sea- Arch. Sea	G. of Finland- Arch. Sea
<61 cm	***	***	*
61-80 cm	ns	o	ns
81-110 cm	*	**	ns

CONDITION FACTOR			
	Åland Sea- G. of Finland	Åland Sea- Arch. Sea	G. of Finland- Arch. Sea
<61 cm	***	***	**
61-80 cm	***	***	*
81-110 cm	***	***	ns



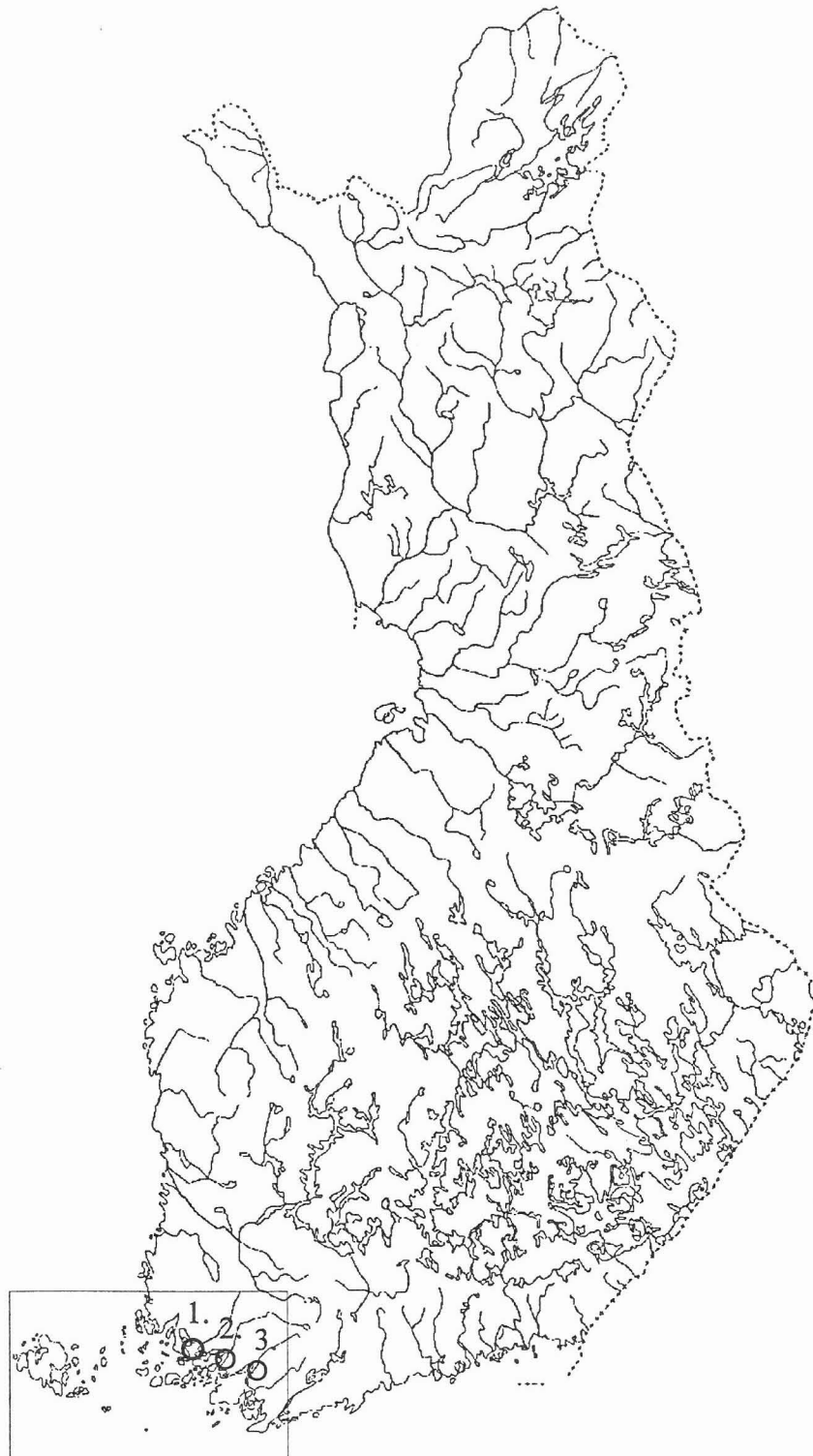


Fig. 1. The study area, the bays of Airistonselkä (1.), Paimionlahti (2.) and Halikonlahti (3.) marked with circles.

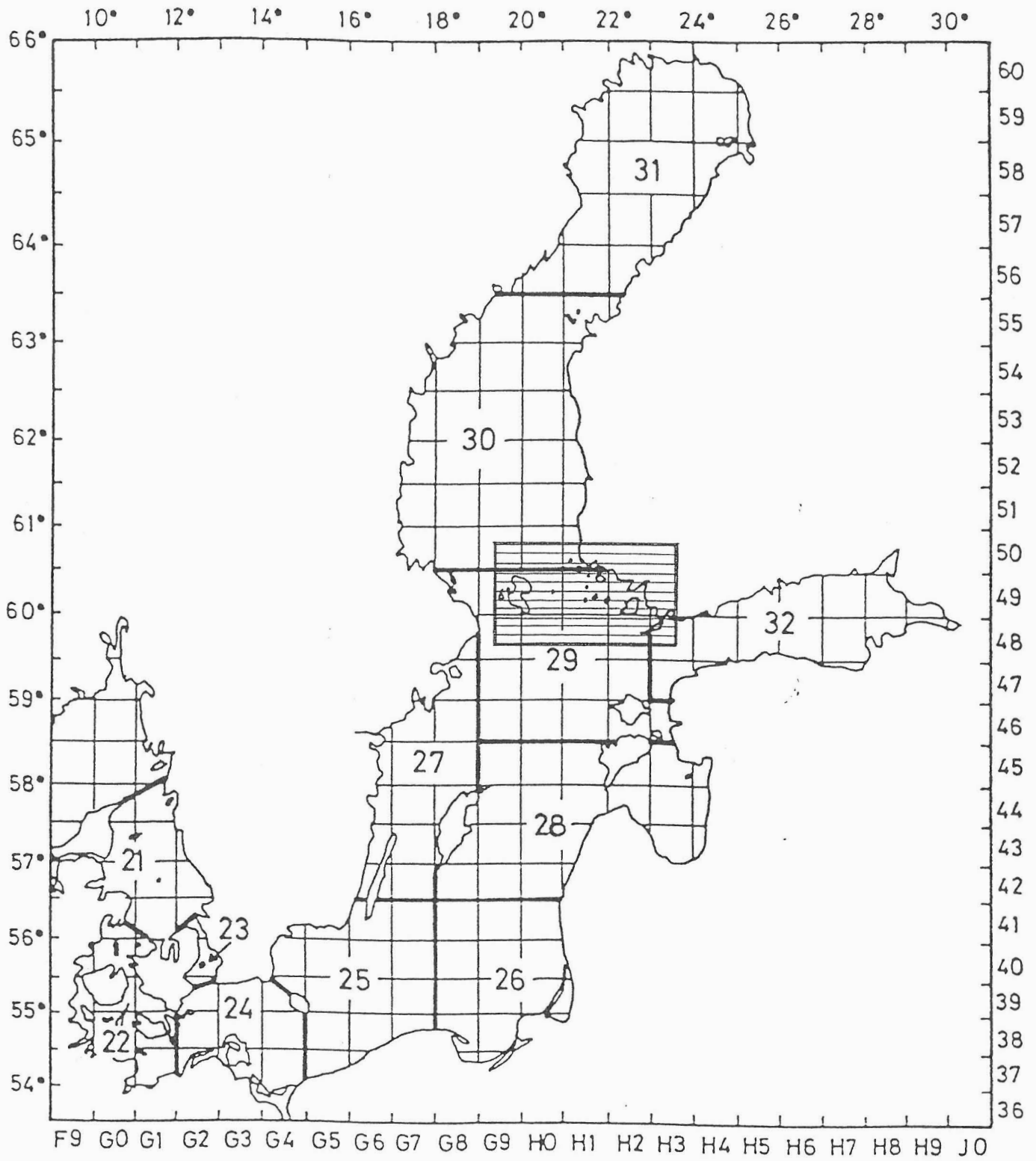


Fig. 2. The ICES Sub-divisions and rectangles of the Baltic Sea area.

Fig. 3. Timing of wild salmon in trap net catches

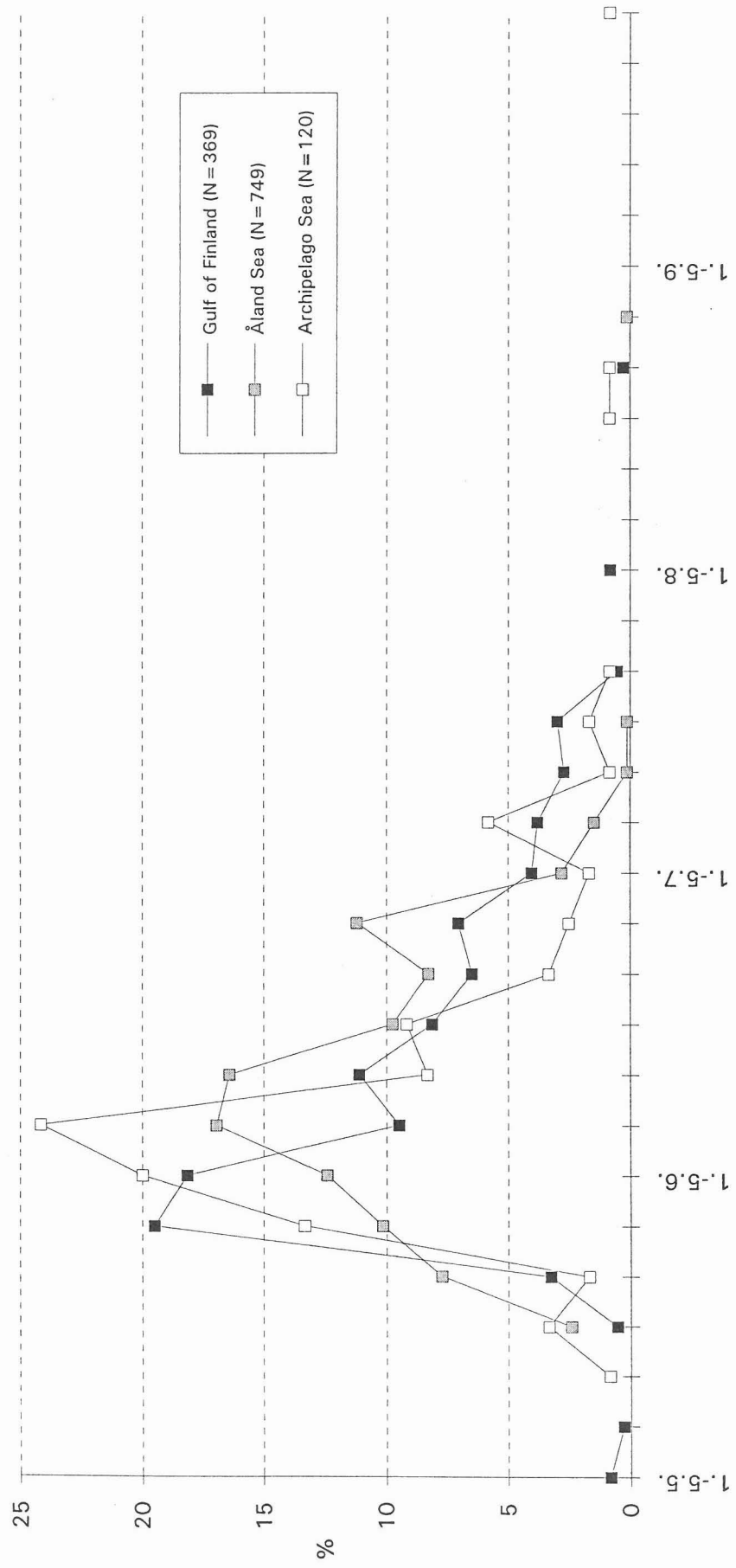


Fig. 4 a. Timing of wild salmon, grilse excluded

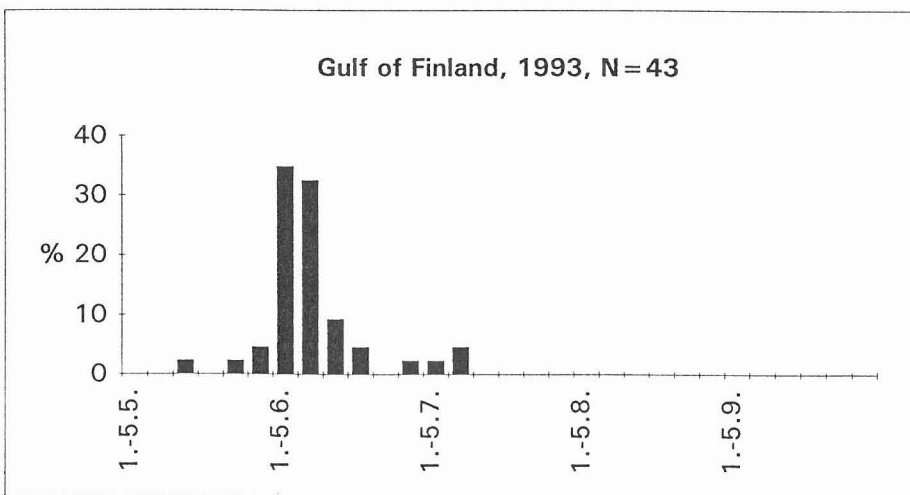
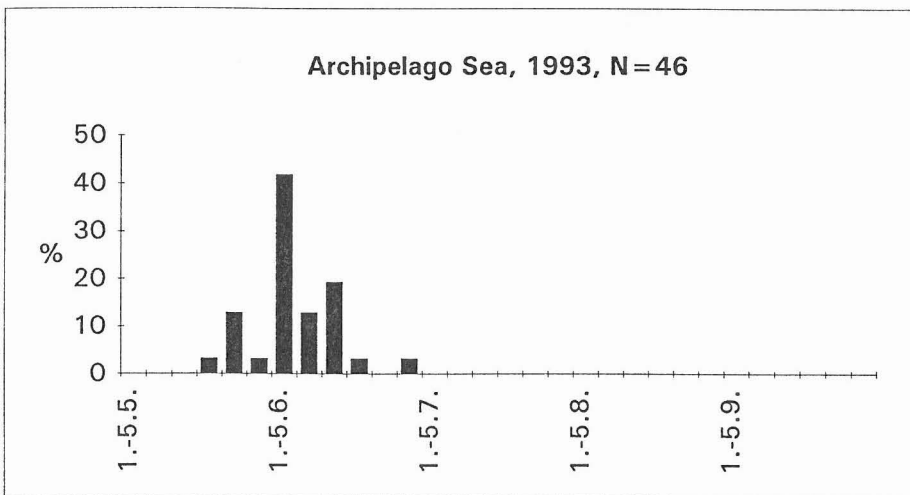
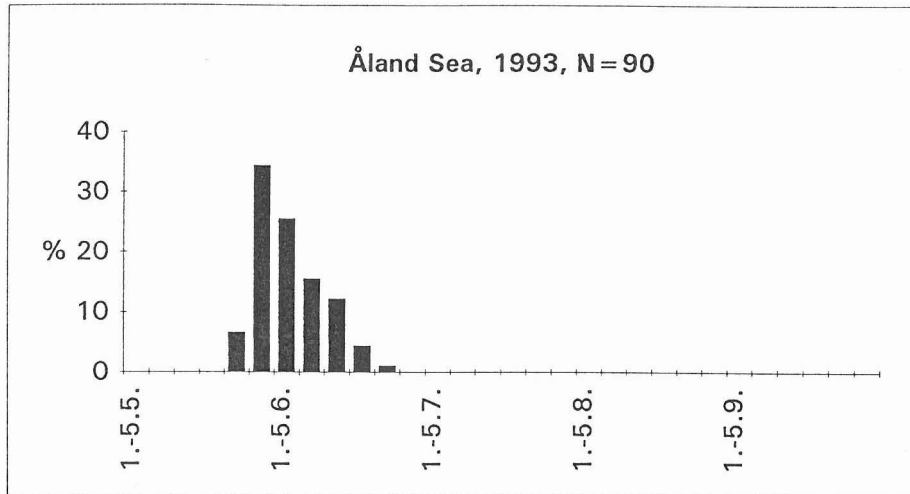


Fig. 4 b. Timing of wild salmon, grilse excluded

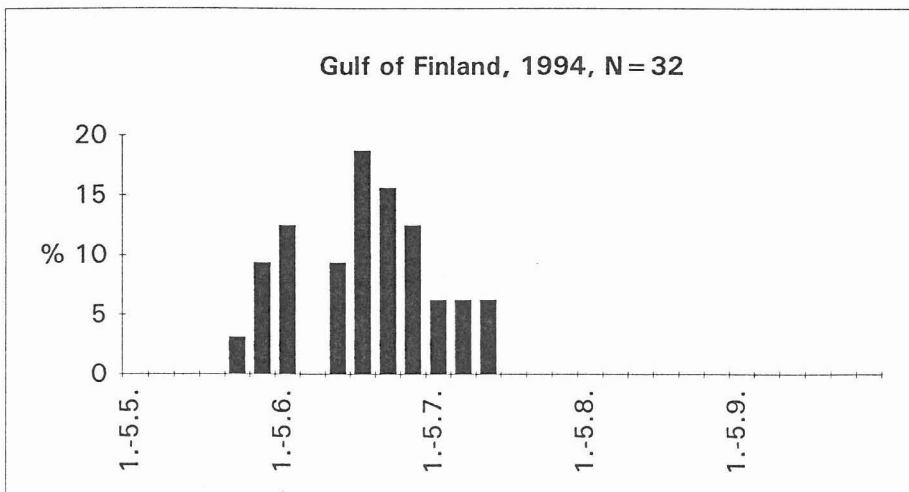
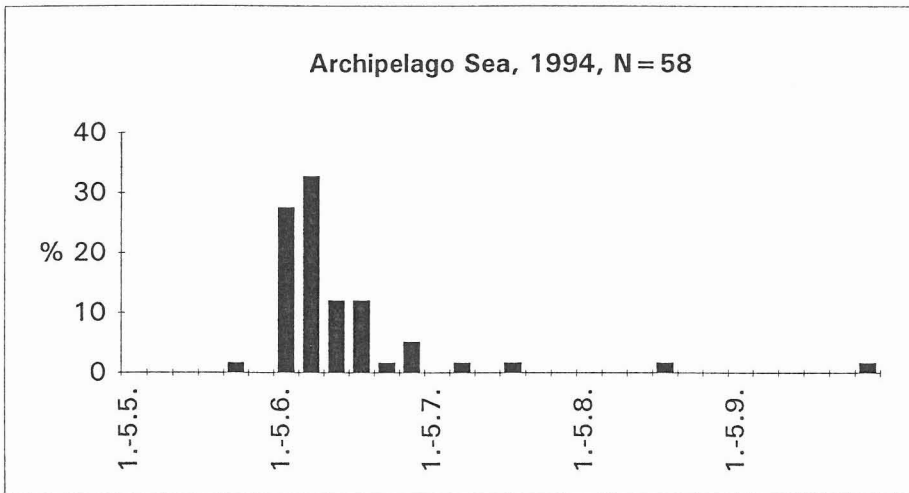
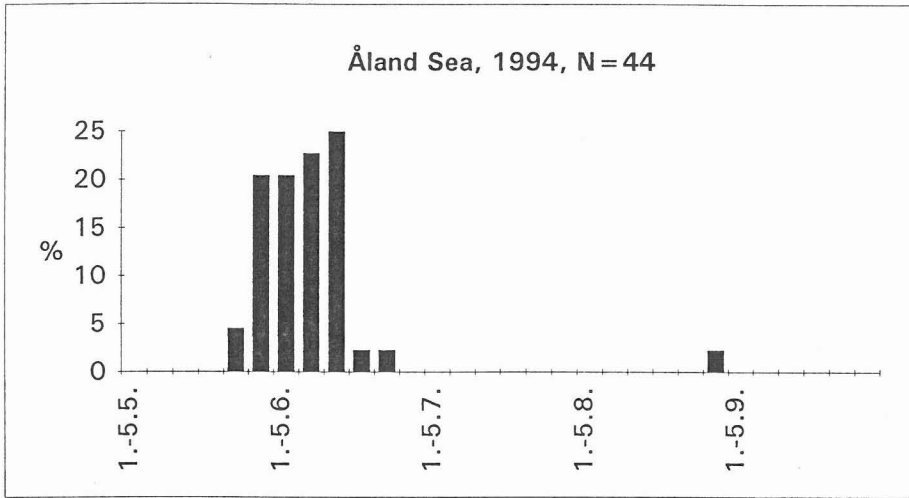


Fig. 4 c. Timing of wild salmon, grilse excluded

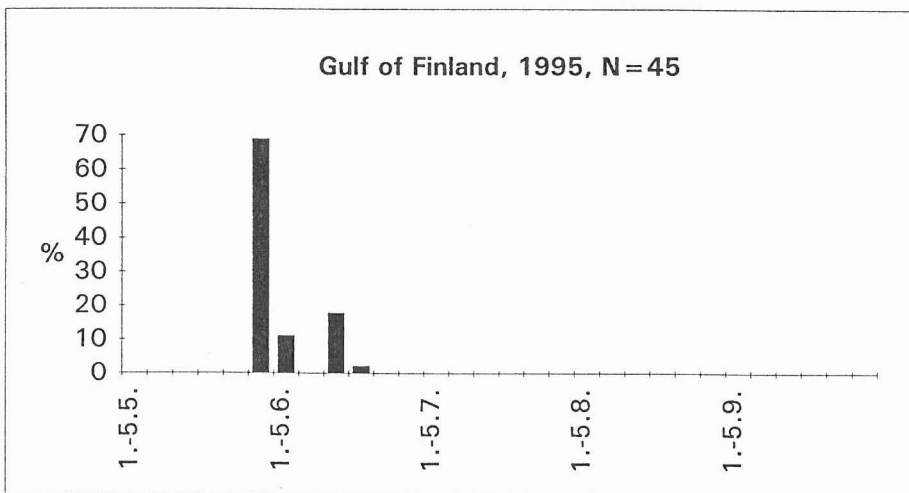
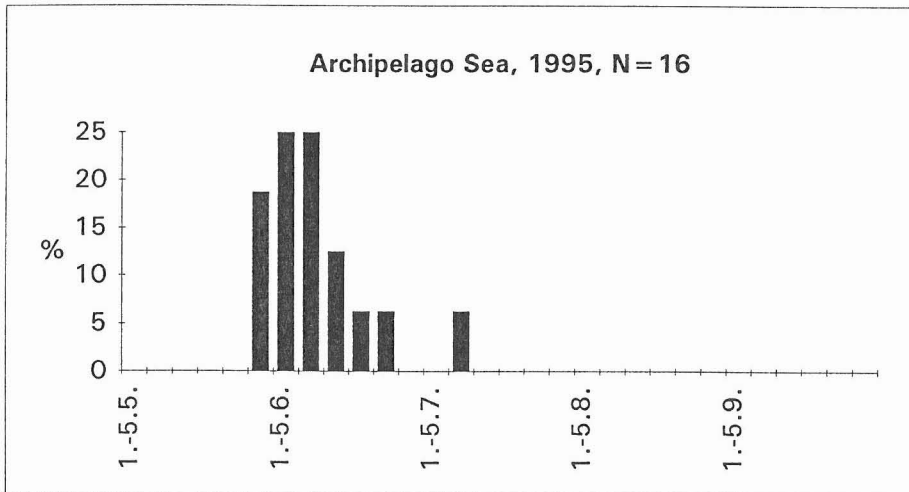
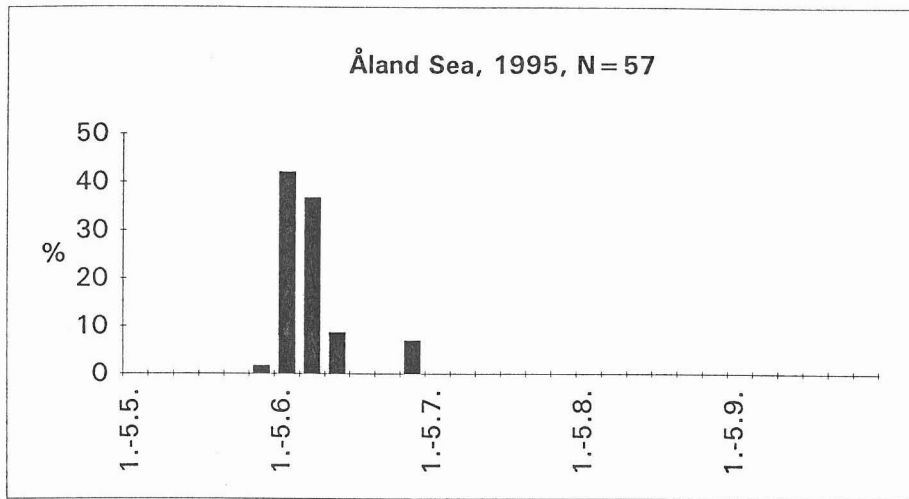


Fig. 5 a. Smolt age distribution in different sea age groups

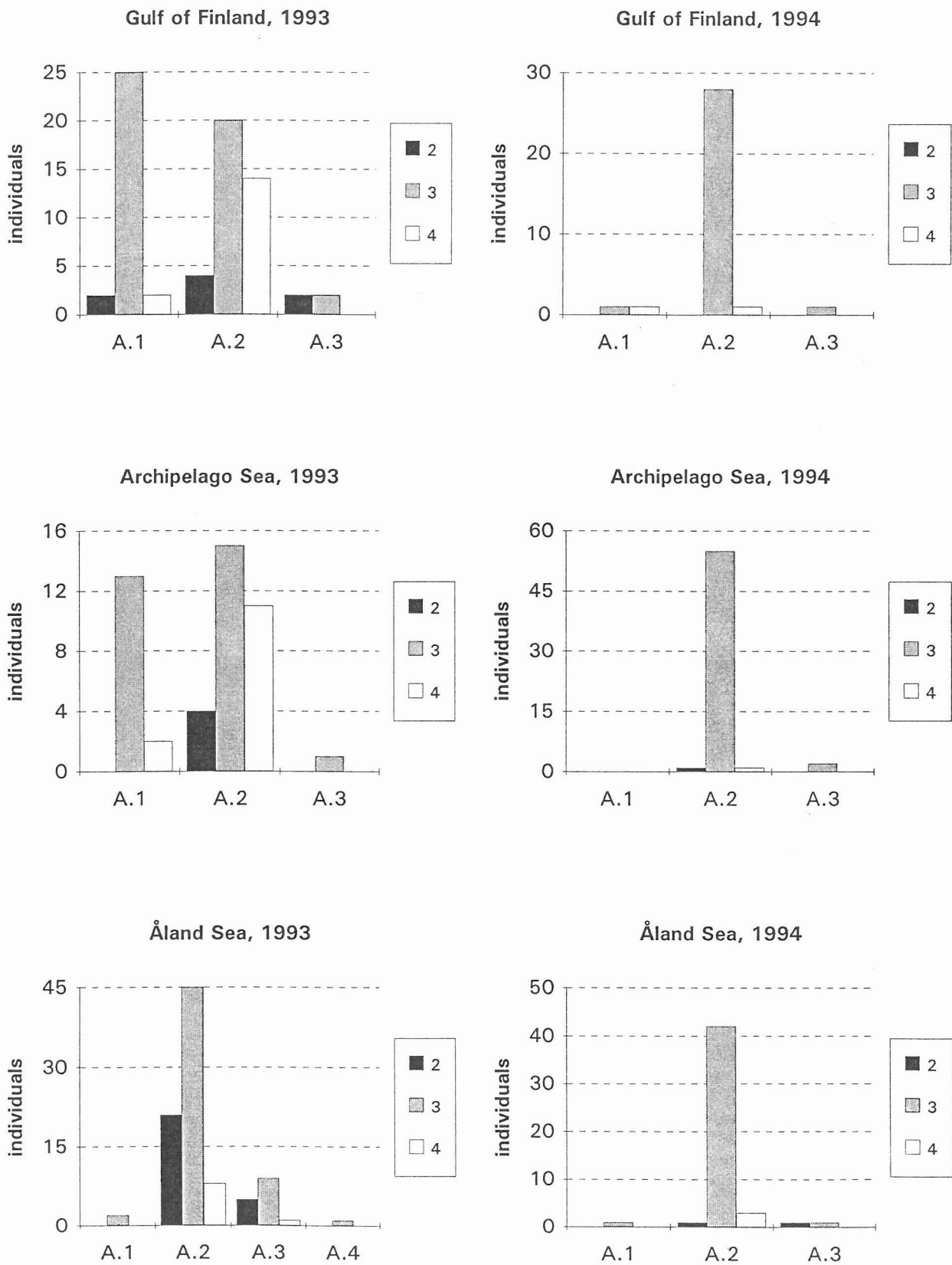


Fig. 5 b. Smolt age distribution in different age groups

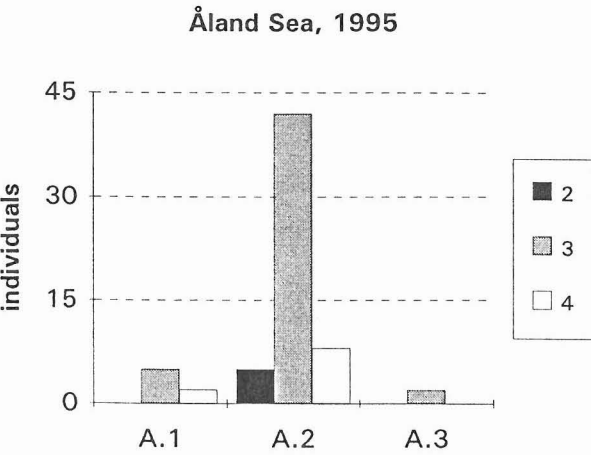
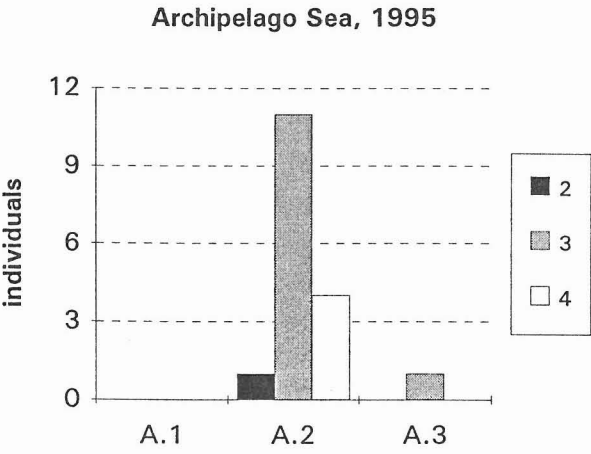
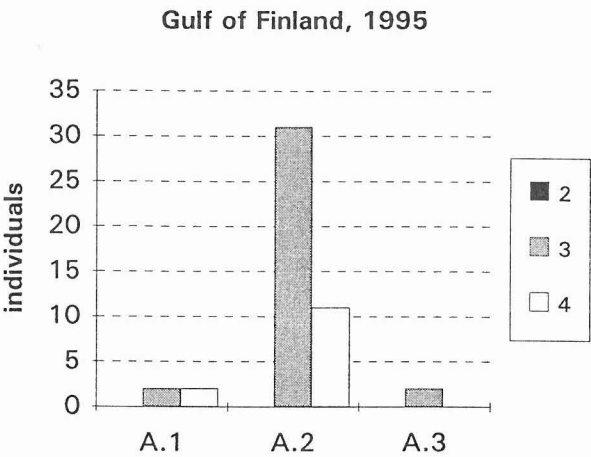




Fig. 6. Age distributions of wild salmon in scale samples and those of recaptured salmon (N on top of column)

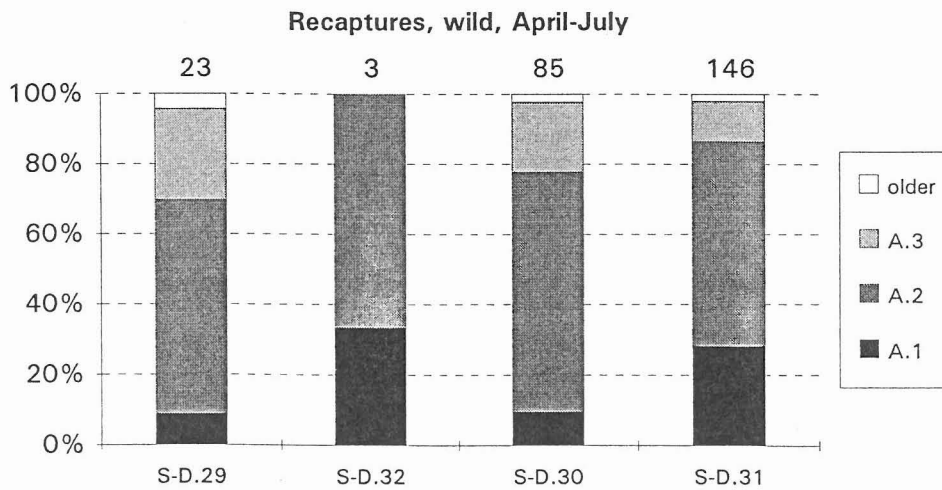
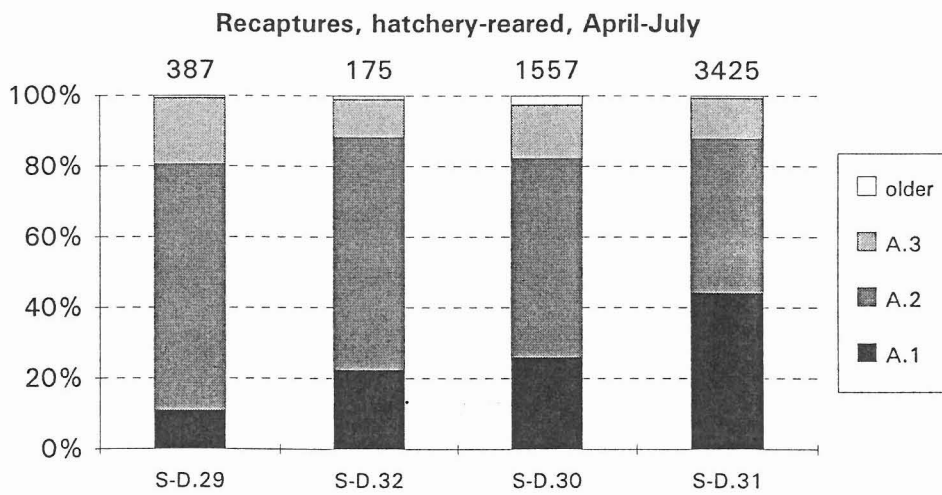
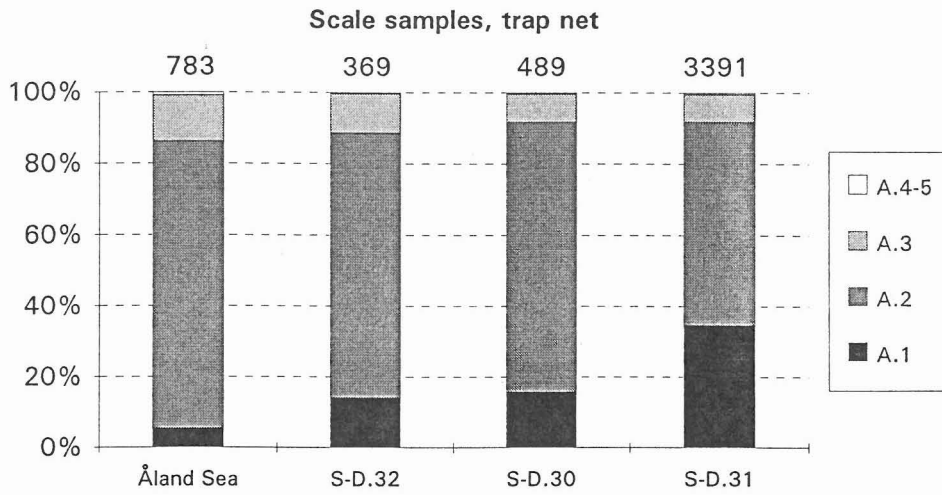


Fig. 7. Age distributions of wild salmon from different sea areas in 1993-1995

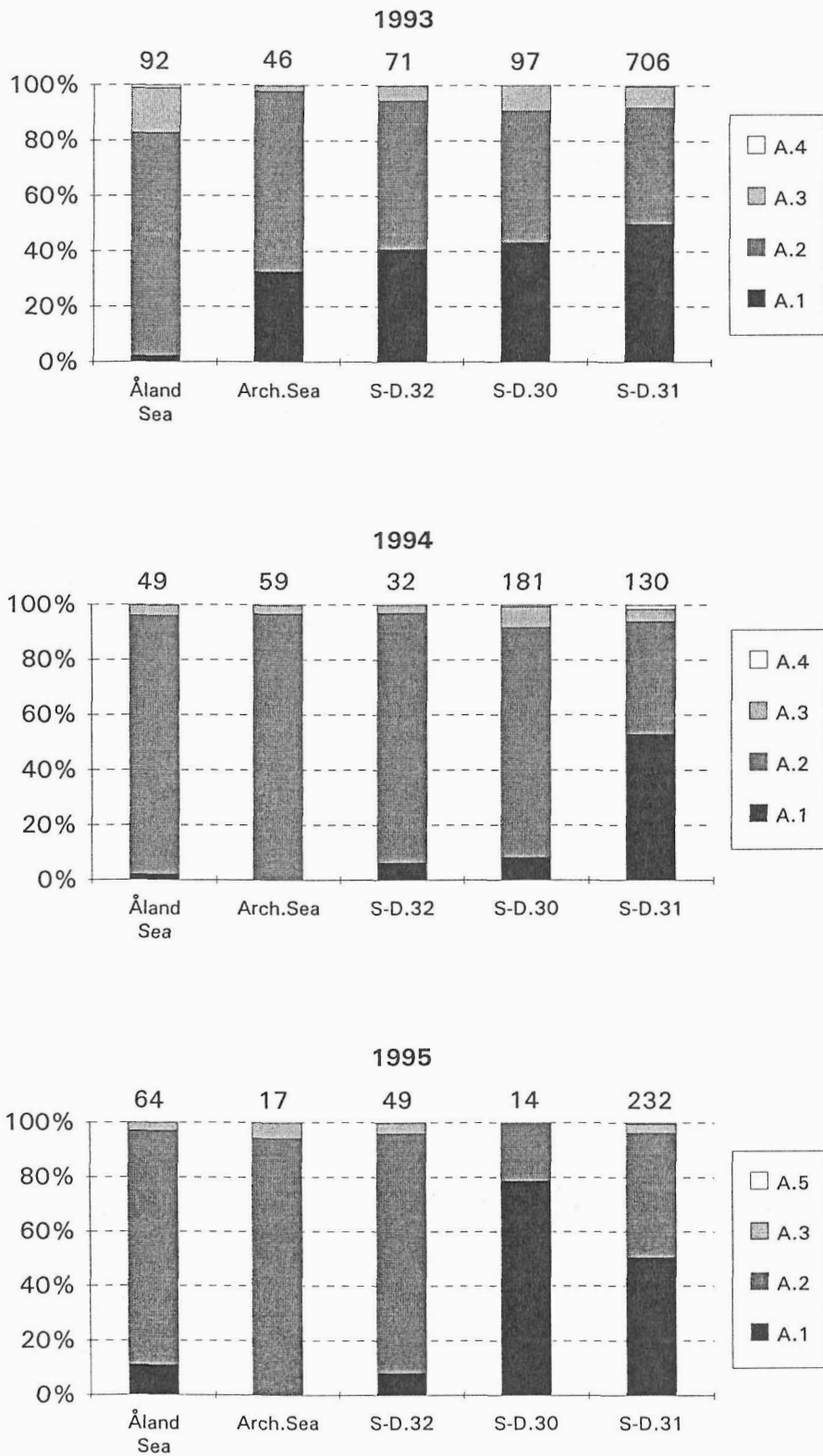


Fig. 8. Condition factors of wild salmon, trap net

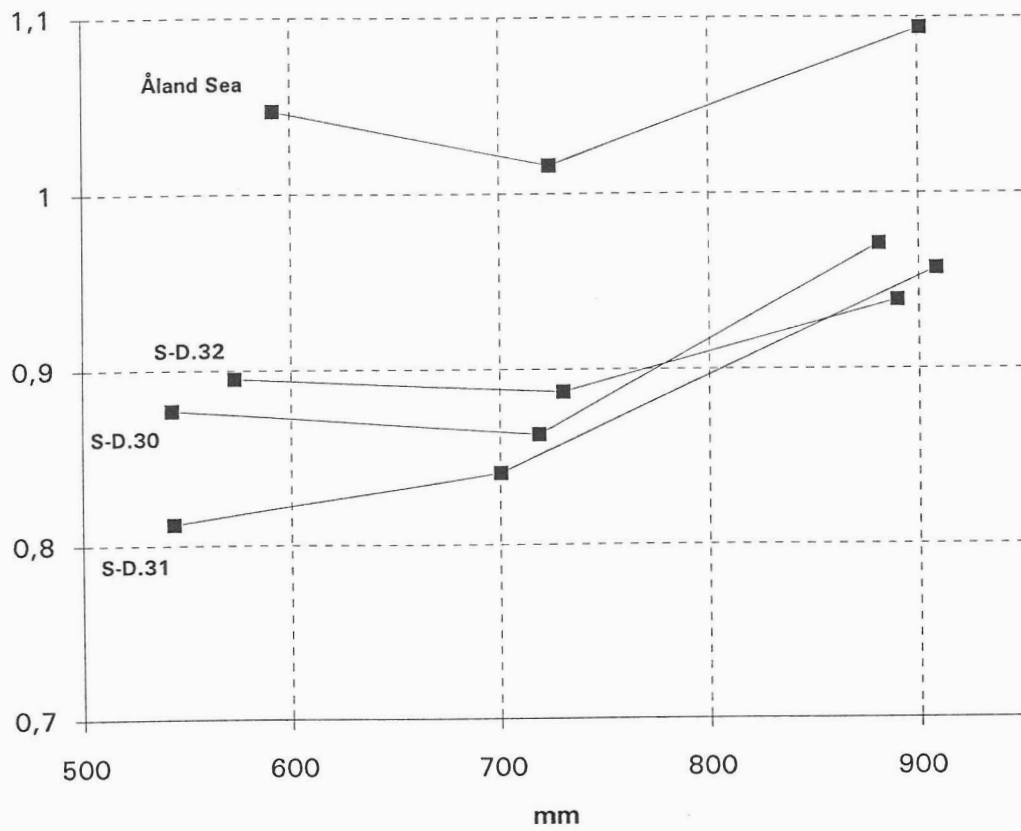


Fig. 9. Condition factors of wild salmon from the Gulf of Finland, the Åland Sea and the Archipelago Sea in 1993-1995

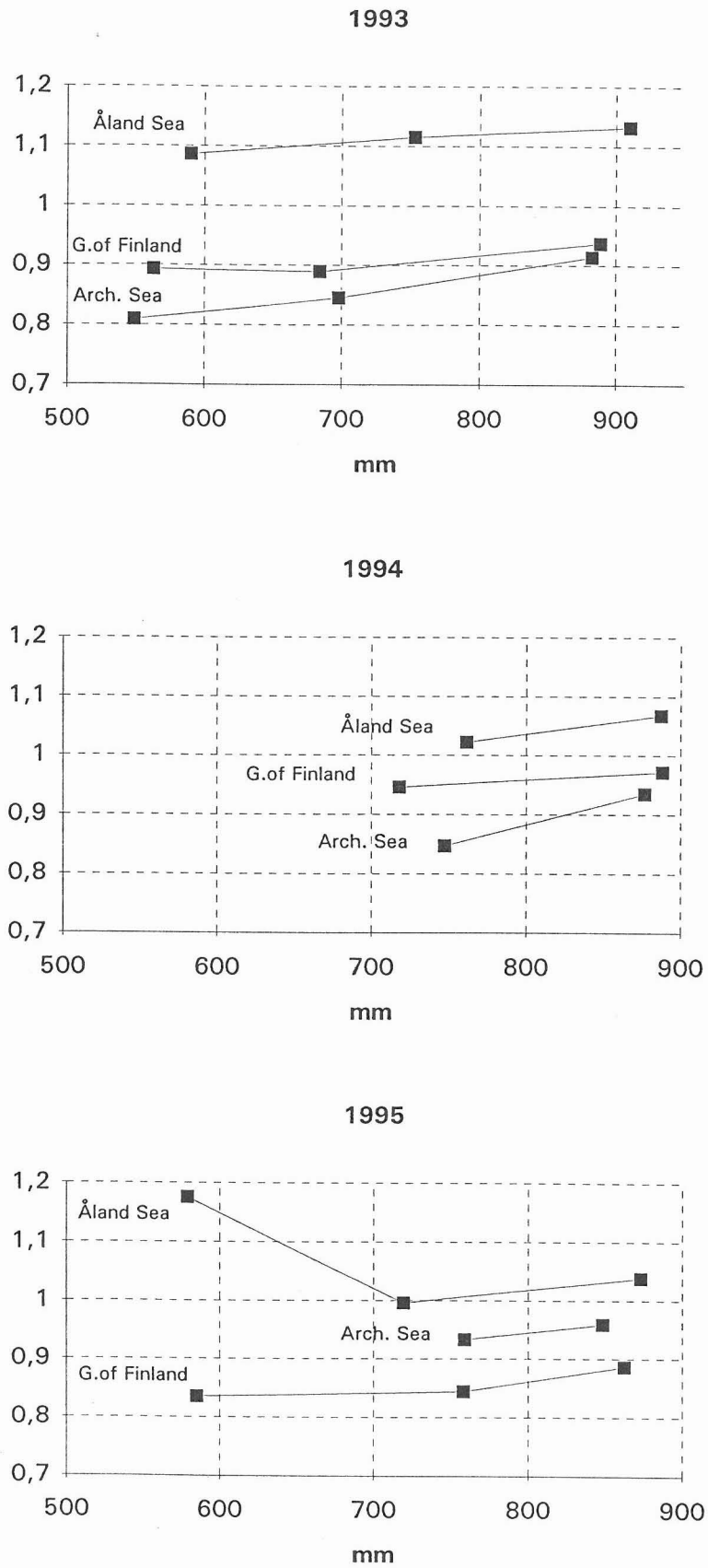


Fig. 10. Distribution of recaptures from sea areas by Sub-division, post-smolts not included

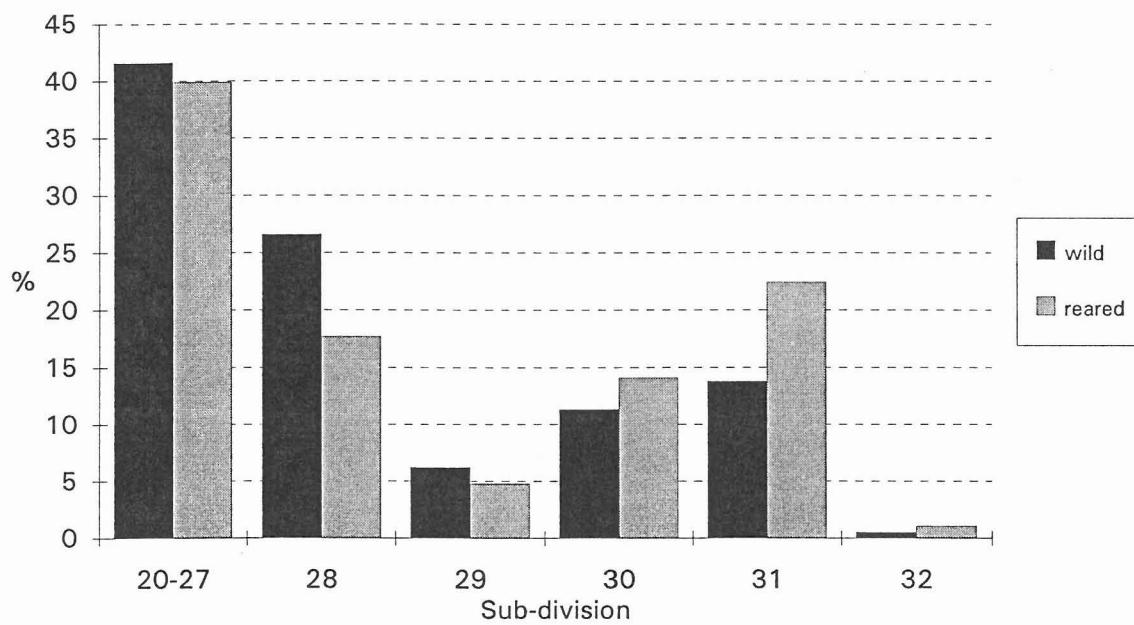


Fig. 11. Distribution of recaptures by rectangle from Sub-division 29 in April-July

