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MIGRATIONS, MORTALITY AND GROWTH OF COD IN THE NORTHERN BALTIC SEA

by

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Abstract

In all 6 425 cod were tagged in Finland in 1974-78. Of the total recoveries made after the first three months following tagging, 66.5 % were reported outside the Finnish fishing zone. Although the reported recaptures were distributed in all parts of the Baltic Sea proper, the recoveries were not proportional to the catches of the various nations. Migration of cod from the Finnish fishing zone occured primarily in connection with spawning. The mean total instantaneous mortality rate (Z) for 1975-77 in the length groups of 30 cm and over was estimated at 1.09. Calculated from the tagging data, L_∞ was 103 cm and K 0.192.

Résumé

On a bagué au total 6 425 morues en Finlande en 1974-78. De toutes les recaptures faites pendant les trois mois après le bagague, 66.5 % ont été rapportées hors de la zone de pêcherie de Finlande. Les recaptures n'ont pas été en proportion de pêches des différentes nations, bien qu'ils aient été distribuées également dans la population Baltique. La migration de la morue hors de la zone de pêcherie de Finlande a eu lieu principalement en connexion avec la reproduction. Le taux total de mortalité instantané (Z), pour 1975-77 et pour le groupe de longueur ≧ 30 cm, a été evalué, en moyenne, à 1.09. D'après les données du bagague, L_∞ a été evalué à 103 cm et K à 0.192.

Introduction

The Baltic stock of cod (Gadus morhua callarias L.) occuring east of 14°30'E, is distributed up to the northern part of Bothnian Sea and the eastern part of the Gulf of Finland. Cod are also occasionally found in the Bothnian Bay. The abundance of cod in the northern part of the Baltic depends mainly on the spawning success, year class strength, immigration of yound cod and emigration of maturing and mature cod. The Finnish cod catches vary irregularly from year to year but they increased in 1974, since when cod have occured more abundantly. This is primarly due to the strong year classes 1972 and 1976. The aim of the present taggings was to examine the effect of migration of the catch and to estimate the rate of mortality for assessments of the stock of cod in the northern Baltic.

Material and methods

Cod were tagged in the Åland Islands (60°01'N; 20°00'E) and the western part of the Gulf of Finland (59°52'N; 23°45'E) in the years 1974 - 78. The total number tagged was 6 425. The numbers of fish tagged and recovered in the different years are given in Table 1. The major part of taggings were done in the Åland Islands and 61 % of the total fish were tagged in the autumn. The cod were caught with gillnets and long lines. In the Gulf of Finland the cod were held some days in a fish chest before tagging and liberation, but in the Åland Islands they were tagged and liberated immediately after capture. Only cod that were in good condition were tagged. Nearly all the fish tagged were over 25 cm in length, the average being 50.8 cm. The length composition of the tagged cod differed from the length composition of commercial catches (Fig. 1), which mainly consisted of by-catches in herring trawls. The average length of the tagged cod was higher due to the poor condition of the small cod after capture. The following tags were used: The spaghetti tag (5806 fish), Carlin tag (537 fish) and a red plastic flag attached with a thin plastic tube (82 fish). Thus 90 % of the cod were tagged with the spaghetti tag, reported by LAMP & TIEWS (1974) to give the highest return rates. The tagged cod were liberated near the fishing places.

Results

Small cod (20 - 34 cm) gave lower returns than the others (Table 2). From 30 cm onwards southward migration increased with length (Table 3). The recoveries made in the first 12 months after tagging increased with increasing fish size. Of the total first year recoveries, 66 % were made near the tagging place, within a distance of 0 - 30 nautical miles, 6 % were made North of Gotska Sandön, 11 % between Gotska Sandön and the south end of Öland and 17 % south of Öland. Migration to the north and east was negligible. During the first three months after tagging only one recapture was made outside the tagging areas (Fig. 2). Between three and six months after tagging 65 % of the recoveries were reported outside the Finnish fishing zone. Most of them within a distance of 120 - 420 nautical miles from the tagging areas. Southward migration seems to be most pronounced in the first and second quarter of the year (6 - 9 months after tagging). In this period 80 % of the recoveries were made outside the Finnish fishing zone and the major part of these again within a distance of 120 - 420 nautical miles. During the second year after tagging 81 % of the recoveries were made outside the Finnish fishing zone and the major part of these were reported from the Gotland Deep, Slupsk Furrow, Gdansk Depth and Bornholm Basin. During the third and fourth years after tagging there was only one recapture inside the Finnish fishing zone. Four tags were reported from fishing harbours outside the Baltic (Lysekil, Cuxhaven, Port of Hull and Bergen). The places of recapture of these recoveries are unknown, but it is unlikely these cods have been caught outside the Baltic Sea.

The total instantaneous mortality rate (Z) was calculated from the taggings carried out in autumns 1974 - 76. The recapture data from these taggings were combined (Table 4) and thus the mortality estimates are the means of the years 1975 - 77 in the whole Baltic Sea proper. The total instantaneous mortality rate ($Z = 1.09$) was estimated by the regression method presented by JONES (1976). The recaptures made during the first three months after tagging were deleted because in that period the tagged cod were not distributed randomly in the general population (Fig. 2). The total instantaneous mortality estimates and instantaneous fishing mortality estimates are presented in Ta-

ble 5; the instantaneous natural mortality rate used here, M = 0.3, is that adopted for subdivisions 25-32 in the Report of the Working Group on Assessment of Demersal Stocks in the Baltic (Anon. 1979).

Growth was examined by recording the lengths of recaptured cod tagged in the years 1974-77. Only such specimens were included whose tagging and recapture were both made during late autumn or early winter, when little or no growth occurs. In all 97 length measurements were considered (Table 6). The growth rate derived from our tagging data agrees with the results obtained from the otolith readings (Table 7). A Walford plot was fitted to facilitate comparisons of growth data from three different sources. The age-length data from 3-10-year-old specimens (KOSIOR 1976) gave L_∞ = 113 cm and K value of 0.142, the Finnish tagging data L_∞ = 103 cm and K = 0.192, and the age-length data from Finnish cod catches in the age groups 3 - 7 L_∞ = 101 cm and K = 0.185.

Discussion

In the Baltic proper (subdivisions 25-28) the stock of cod increased during the first half of the 1970's (Anon. 1979). An increase in the occurrence of cod during the 1970's has also been observed in the northern part of the Baltic (subdivisions 29-32). According to OTTERLIND (1966), abundance of cod in the Åland Sea, Bothnian Sea and Gulf of Finland is caused by increased recruitments and also by the oxygen conditions in the Gotland Deep region, where an oxygen deficiency leads to large-scale northward migration of mainly young cod. However, northward migration of adult cod from subdivisions 25-28 has either not been noticed (OTTERLIND 1962, 1966) or has been insignificant (KONDRATOVICH 1977). The Finnish catches have generally consisted of young cod. The year classes 1972 and 1976 were dominant in the catches made in 1974 and 1978, respectively (Fig. 1). In surveys of young Baltic herring and sprat, 0 - group cod have also been caught. From time to time in the 1970's the oxygen conditions have been favourable in the Bornholm Basin and Gotland Deep and the salinity

has increased considerably (MATTHÄUS 1979a, b) due to the inflow of sea water into the basins. When the cod of the strong year classes 1972 and 1976 were born, there were especially high inflows of sea water into the Bornholm Basin, which is the main spawning area of cod in the Baltic (MÜLLER 1974).

In the first three months after tagging cod seem to be almost stationary. The high number of recaptures near the tagging place during that time was caused by the intensive cod fishing organized for the tagging. Withing the first 12 months after tagging the proportion of the tagged individuals emigrating from the Finnish fishing zone is at least 34 %. The emigration rate is probably higher, because it seems that not all the recaptures are reported. There are few recoveries from the northern Baltic proper. This may be due to the limited extent of cod fishing in that area. The major part of the recoveries made within 6-9 months after tagging fall inside the main spawning area and spawning time of the cod. The emigration is thus spawning migration of maturing and mature cod. The poorer return rate of small cod is probably due to the handling and tagging mortality and to the fact that small cod are under the 50 % retention length of the mesh size used in codends in the Baltic (TIEWS & LAMP 1974). Minimum size of cod south of $59^{o}30'N$ is 30 cm.

The occurrence of cod in the northern Baltic thus seems to be connected with events in the Bornholm Basin and the Gotland Deep, the stock in the northern Baltic evidently being mainly recruited from spawning in the Bornholm Basin and the southern part of the Gotland Deep. During years of high inflow of sea water into the basins, other marine species as well have extended their occurrence to the north (MÖLLER 1979). Similar observations were made in the 1950's (LINDQUIST 1960).

The fishing mortalities (Table 5) agree fairly well with the figures by the ICES Working Group on Assessment of Demersal Stock in the Baltic (Anon. 1979). Because of the incomplete reporting of recaptures, however, tagging cannot be used directly to estimate the fishing mortality (HORSTED 1963). The calculated estimates are usually too low. If the tagged cod are evenly mixed with the whole population, as it seems to be in this case,

the recaptures should be proportional to the catches by the various countries. As regards the taggings made in 1974-76 in Finland, the reports of recaptures made after the first three months following tagging are distributed among the different countries as follows:

	Recaptures (%)	Catch (%)
Finland	3.6 (20.4)[1)]	0.2
Sweden	23.0	8.9
Denmark	26.5	23.3
FRG	17.9	8.0
GDR	3.5	3.6
USSR	8.7	22.7
Poland	0.0	33.3

1) In parentheses percentage when the fishing organized for the tagging is included.

From the above distribution it is possible to estimate that the proportion of the recaptures from these taggings reported in the whole Baltic area is only 25 %. That is why the fishing mortality values cannot be estimated from these taggings. Incomplete reporting of recaptures has also been shown in the southern Baltic (TIEWS & LAMP 1974), where the cod stock is more local (NETZEL 1974) and migration occurs only between the main fishing areas (BAGGE et al. 1974).

The growth parameters estimated from our tagging data agree with the figures adopted by the ICES Working Group on Assessment of Demersal Stocks in the Baltic (Anon. 1973), the figures summarized by THUROW (1974) and those presented by KOSIOR (1976).

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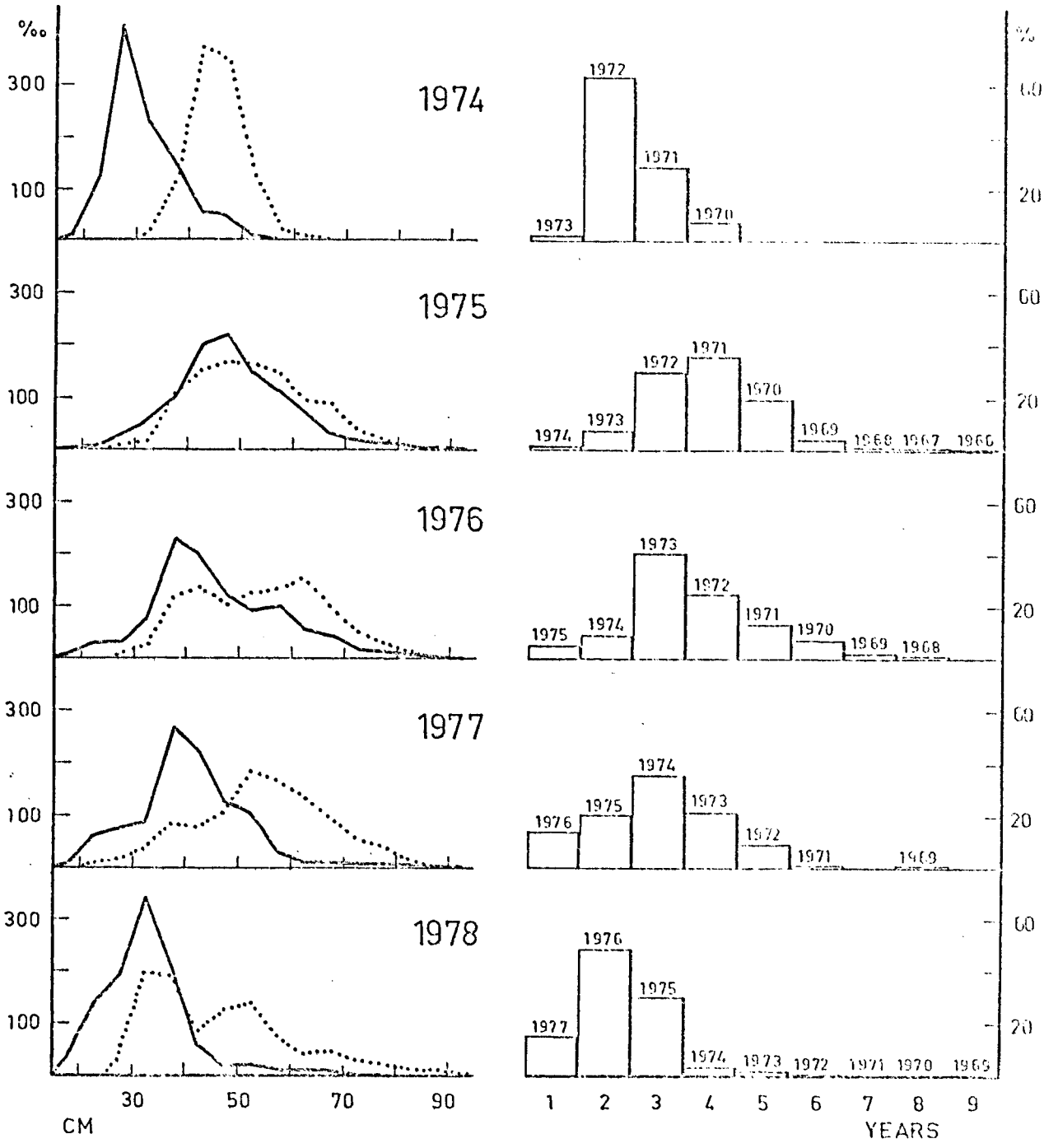

Figure 1. Length and age composition of cod catches and length compostition of tagged cod (•••).

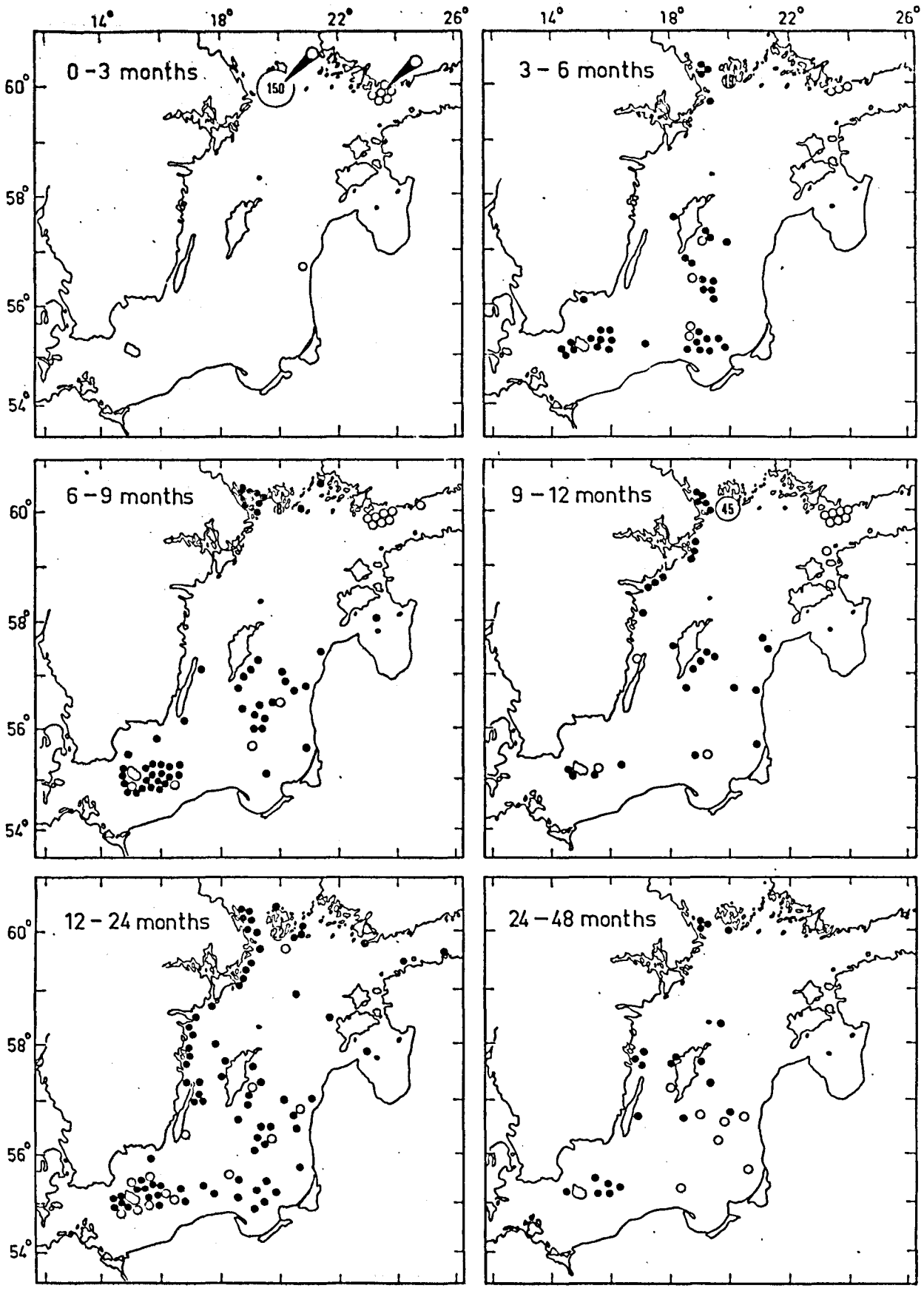

Figure 2. The recoveries of tagged cod in the quarters of the first year, the second year and two to four years after tagging. The numbers inside the circles are the recaptures made near the tagging place (0 - 30 nm). The tagging places are shown with arrows; filled circles = taggings in the Åland Islands; open circles = taggings in the Gulf of Finland.

Table 1. Data on cod tagging in the years 1974-78 and recoveries up to the end of 1979.

Tagging date	Tagging place	Number tagged	Mean length	Type of tag	Recoveries No.	Recoveries %
Nov-Dec 1974	Gulf of Finland	416	44.8	Carlin tag	44	10.6
Jan	Gulf of	106	46.7	Carlin tag	8	7.5
May	Finland	29	50.3	Plastic flag	3	10.3
Oct-Nov 1975		45	50.2	Spaghetti tag	3	6.7
Apr	Åland	15	53.0	Carlin tag	3	20.0
Apr-June	Islands	53	49.0	Plastic flag	5	9.4
Oct-Nov 1975		966	53.1	Spaghetti tag	119	12.3
May	Åland	51	43.3	Spaghetti tag	1	2.0
Sep-Nov 1976	Islands	949	54.9	Spaghetti tag	79	8.3
June	Åland	53	46.6	Spaghetti tag	3	5.7
Sep-Oct 1977	Islands	1 536	51.5	Spaghetti tag	148	9.6
June-Aug 1978	Åland Islands	2 206	47.2	Spaghetti tag	105	4.8

Table 2. Length composition of tagged cod and recoveries in various length groups.

Length group (cm)	Number tagged	Recoveries	
		Number	%
20-24	12	-	-
25-29	112	1	0.9
30-34	540	12	2.2
35-39	840	56	6.7
40-44	769	83	10.8
45-49	887	73	8.2
50-54	972	91	9.4
55-59	743	62	8.3
60-64	571	60	10.5
65-69	442	30	6.8
70-74	247	22	8.9
75-79	167	20	12.0
80-84	67	7	10.5
85-89	31	2	6.5
90-	25	2	8.0
Total	6 425	521	
Mean length (cm)	50.8	52.9	

Table 3. Migration of cod in the first year after tagging

Length group (cm)	Number tagged	Recovered					Distance migrated (nautical miles)										
		Total number	Near the tagging place		After migration (at least 30 nm)		North of Gotska Sandön			Gotska Sandön-South end of Öland			South of Öland				
			Number	%	Number	%											
							30-59	60-89	90-119	120-149	150-179	180-209	210-239	240-269	270-299	300-329	330-420
20-29	124	1	1	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
30-39	1 380	44	34	77.3	10	22.7	1	1	-	-	3	-	-	-	1	2	2
40-49	1 656	112	82	73.2	30	26.8	3	-	2	2	2	4	3	2	3	4	5
50-59	1 715	112	70	62.5	42	37.5	9	-	-	2	3	1	6	4	6	5	6
60-69	1 013	70	39	55.7	31	44.3	6	-	1	-	3	2	2	1	3	3	10
70-79	414	29	18	62.1	11	37.9	1	-	-	-	1	2	2	1	1	2	1
80-89	98	9	6	66.7	3	33.3	-	-	-	-	2	-	-	-	-	-	-
90-	25	2	1	50.0	1	50.0	-	-	-	-	-	-	1	-	-	-	1
Total	6 425	379	251		128		20	1	3	4	14	9	14	8	14	16	25

Table 4. Recaptures of tagged cod in various length groups in the first three years after tagging.

Length group (cm)	Number	Recaptures			
		1st year	2nd year	3rd year	Total
30-39	299	13	8	3	24
40-49	791	47	20	5	72
50-	1 229	64	27	6	97
Total	2 319	124	55	14	193

Table 5. Estimates of total mortality rates (Z) with corresponding fishing mortality rates (F) in various length groups (M = 0.3; Anon. 1979).

Length group (cm)	Z	F
30-39	0.73	0.43
40-49	1.12	0.82
50-	1.18	0.88
Of the total	1.09	0.79

Table 6. The growth of cod during the first, second and third year after tagging (number of specimens in parentheses).

Length group at tagging (cm)	1st year	2nd year	3rd year
30-39	10.5 (15)	19.3 (3)	-
40-49	11.5 (29)	17.3 (3)	29.3 (2)
50-59	8.9 (21)	12.3 (6)	17.8 (3)
60-69	7.2 (8)	16.3 (2)	-
70-79	3.9 (5)	-	-

Table 7. The yearly length increments of cod calculated from tagging data and otolith readings.

Length group (cm)	Yearly increment (cm)		
	Kosior (1976)	Tagging data	Otolith readings
30-39	10.1	10.5	9.9
40-49	9.3	11.5	9.0
50-59	8.1	8.9	8.9
60-69	6.4	7.2	-
70-79	6.0	3.9	-