

Coastal Cod and Skrei in the Lofoten Area

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ROLLEFSEN (1933) found along the Norwegian Coast from Bergen to Finnmark two types of cod, which could be distinguished by the shape of the otoliths, the relative breadth of the zones in the otoliths and their finer structures. One of the otolith types was typical for what ROLLEFSEN (1933) called coastal cod, cod which live all the year round in the coastal area. The other type was typical for skrei (mature Arctic cod) which is in Norwegian water a short time during spring for spawning, and which are living the rest of the year in the Barents sea and in the Bear Island — West Spitsbergen area. In a later paper ROLLEFSEN (1934) showed that the coastal cod had a faster growth, mature at a younger age, had a smaller number of vertebrae, and the weight at the same length was higher for coastal cod than for skrei.

The cod otolith samples taken in January—April from purse seine, gill net, long line and hand line catches in Lofoten contain mostly the skrei type and only a small fraction is coastal cod. Most of the cod taken by Danish seine at the same time are after the fishermen's opinion not the skrei type. The body shape of this cod are more lumped, which are typical for the coastal cod (ROLLEFSEN 1954).

The results of tagging experiments in Lofoten (DANNEVIG 1953) have clearly demonstrated the migrations of skrei in the Norwegian waters, but the knowledge about the migration of coastal cod in these areas has been poor. One of the purposes of the investigations in Lofoten 1960 and 1961 were to increase our knowledge about the biology of coastal cod in these areas, and some of the results are given in the following.

Material

In March 1960 it was off Henningsvær tagged 535 hand line caught and 239 Danish seine caught cod. During April next year 644 purse seine caught cod were tagged at Höla and 300 Danish seine caught cod off Henningsvær. In all experiments were used hydrostatic tags fastened in front of the first dorsal fin. The length of all tagged fish were measured before release.

Age and length samples taken from Danish seine and long line/purse seine catches are studied together with the tagging material. The samples

from the Danish seine catches are from the area off Henningsvær, while the long line and purse seine samples are from catches taken some distance east of Henningsvær. The tagging and the sampling were each year made more or less at the same time.

Age and length

The number of coastal cod estimated on behalf of the character of the otoliths are quite different in samples from Danish seine and long line/purse seine catches. In 1960 and 1961 the Danish seine catches contained 95 and 93 percent coastal cod respectively, while the long line/purse seine catches from the same years contained about 89 and 91 percent skrei (Table 1) respectively.

The age distributions of coastal cod in long line, purse seine and Danish seine catches are different from the age distributions of skrei in the long line/purse seine catches (Fig. 1). The age groups 5, 6 and 7 are dominating among the coastal cod, while 9, 10 and 11 are the main age groups among the skrei. The age groups 8 and older occur but slightly among the coastal cod in the Danish seine samples, but they are more frequent among the coastal cod in the long line/purse seine samples.

The cod tagged from hand line and purse seine catches was on the average bigger (Fig. 2) than the cod tagged from Danish seine catches. There is a good agreement between the length distributions of skrei in the age material and the tagged hand line/purse seine caught cod on the one side and between the length distribution of the coastal cod and tagged Danish seine caught cod on the other side.

Migration

Some recaptured cod tagged in 1960 from Danish seine catches were recaptured during March—April the same year in the western part of Lofoten and in the area outside the Lofoten Islands (Fig. 3). During summer and autumn some recaptured cod were reported from Lofoten and Vesterålen, and the most northerly recovered cod from the 1960

Table 1. *The content of skrei and coastal cod in otolith samples from Lofoten.*

Gear	Date	No. in sample	Skrei per cent	Coastal cod per cent
Danish seine	28th March 1960	126	4.8	95.2
—	8th April 1961	100	7.5	92.5
Long line	4th March—			
	5th April 1960	955	88.9	11.1
Purse seine	13th—27th March 1961	714	90.8	9.2

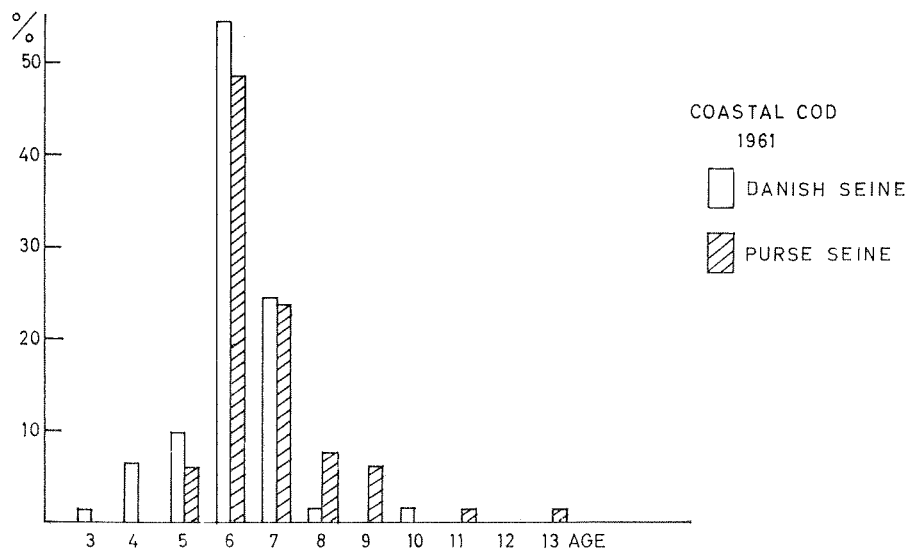
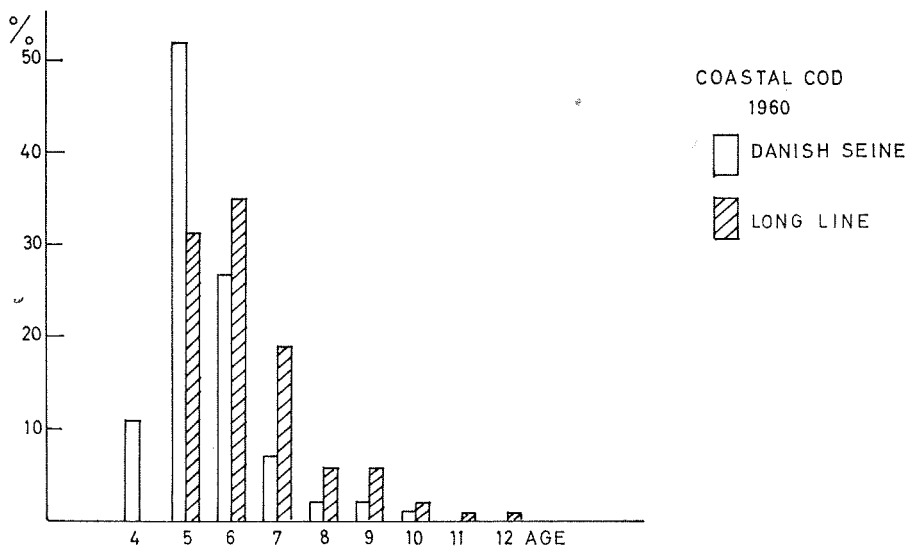
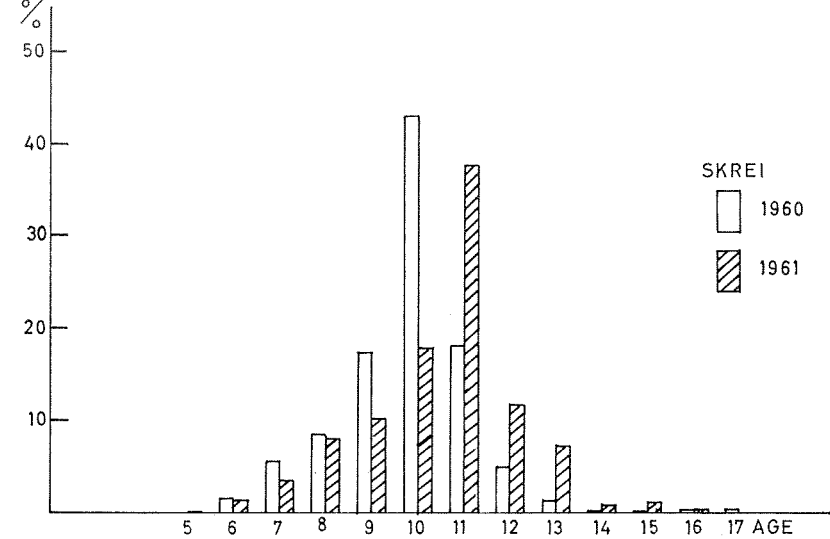


Fig. 1. Age distributions of skrei and coastal cod caught in Lofoten 1960 and 1961 by hand line and purse seine respectively, together with age distributions of coastal cod caught by Danish seine on nearly the same time and localities (See Table 1).

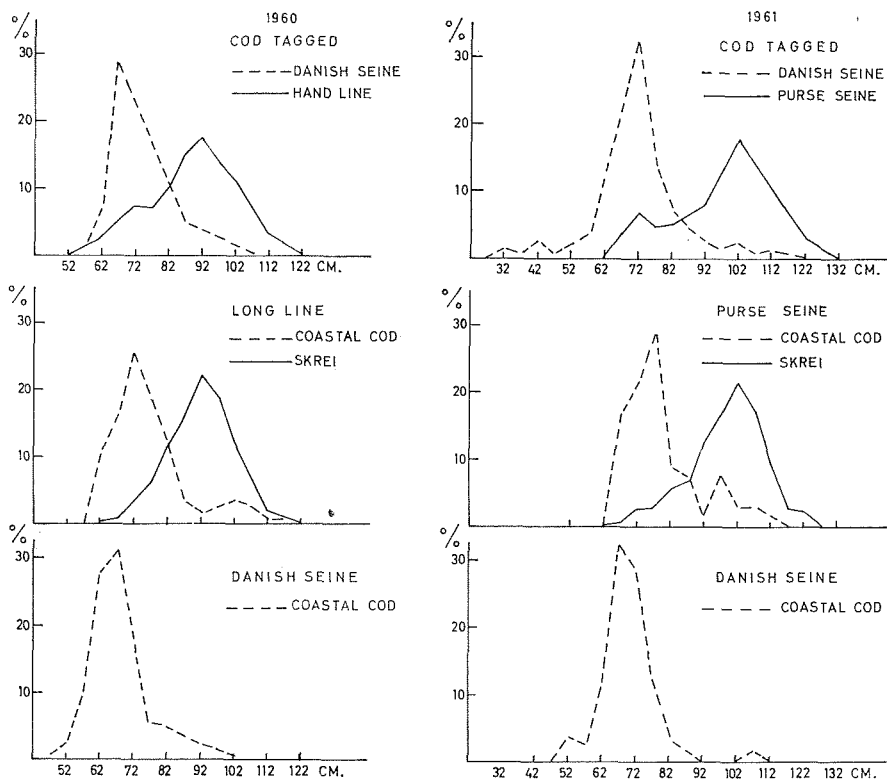


Fig. 2. Length distributions of tagged cod in 1960 and 1961 caught by Danish seine and hand line/purse seine and length distributions of coastal cod caught by Danish seine and long line/purse seine, together with length distributions of skrei caught by long line/purse seine.

experiments was reported from a locality near Tromsø. The geographical distribution of recaptured cod in 1961 from the tagging this year give the same picture. However, this year the most northerly recovered cod was recaptured in August off Bear Island.

The cod tagged in 1960 from hand line catches was during March—April recaptured from the western part of Lofoten and from the area Röst—Nordkapp. The geographical distribution of recaptured cod in 1961 of cod tagged from purse seine catches in 1961 is similar (Fig. 4), but in addition some recaptures were recorded from the districts north and east of Nordkapp.

Cod tagged from Danish seine catches was recaptured in Lofoten in most of the months after tagging in the tagging year. However, the main part was recovered during March—June (Table 2), while the recaptures in the following years were concentrated in February—April.

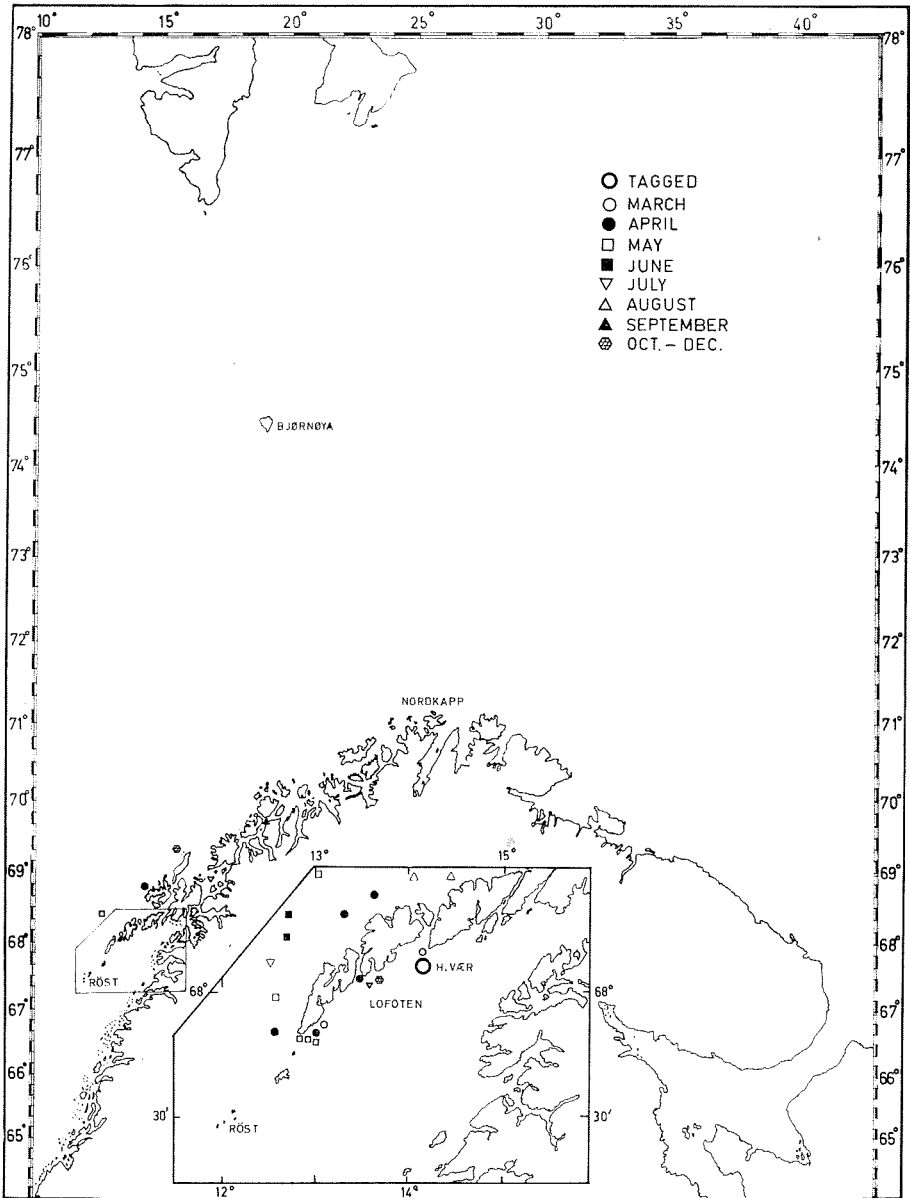


Fig. 3. Danish seine tagging experiments in Lofoten 1960. Recaptures in the tagging year.

Recoveries from the district Röst—Nordkapp were recorded in almost all months after tagging in the tagging year and in most of the months in following years.

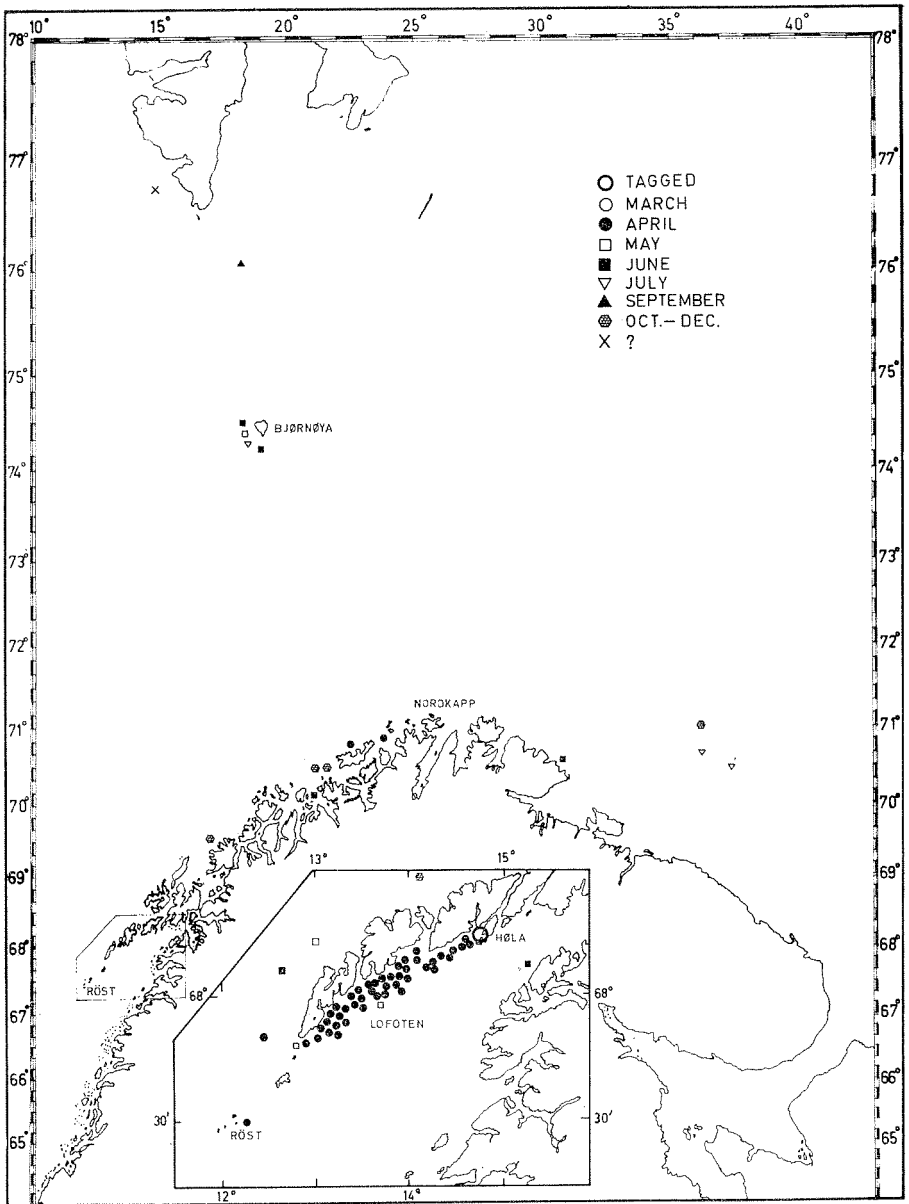


Fig. 4. Purse seine tagging experiments in Lofoten 1961. Recaptures in the tagging year.

The monthly distribution of the recaptured cod tagged from hand line/purse seine catches is different. The recoveries taken in Lofoten both in the tagging year and in the following years are concentrated in March—

Table 2. Danish seine caught cod tagged in Lofoten 1960 and 1961. Number of fish recaptured in different areas.

Recapture locality	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	?	Total
<i>Lofoten</i>														
Tagging year			13	20	30	23	4	4	1		3	1	30	129
Following years	4	8	40	18	4	4				1		1	6	86
<i>Norwegian coast Røst—Nordkapp</i>														
Tagging year				3	3	3	2	3	2	3	2		1	22
Following years	3	2		1	4	1		1		1	1		1	15
North and east of <i>Nordkapp</i>	1							1						2
Norwegian coast south of <i>Lofoten</i> ...		1	1		1	1								4
?													1	1

Table 3. Hand line/purse seine caught cod tagged in Lofoten 1960 and 1961. Number of fish recaptured in different areas.

Recapture locality	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	?	Total
<i>Lofoten</i>														
Tagging year			50	60	6	1							6	123
Following years	3	43	166	46	1	1							9	269
<i>Norwegian coast Røst—Nordkapp</i>														
Tagging year				2	3	1				4	1		2	13
Following years	10	23	11	5	3								4	56
North and east of <i>Nordkapp</i>	4	1	1	1	3	10	6		1	1	2	2	3	35
Norwegian coast south of <i>Lofoten</i> ...		1												1
?	1		2	1		2	2						7	15

Table 4. *Recaptured cod tagged from Danish seine catches.*

Recapture area	Otolith present		Lack of otolith	Total
	Skrei	Coastal cod		
Lofoten	11	45	159	215
Røst—70° N		17	17	34
70° N—Nordkapp			3	3
North and east of Nordkapp			2*	2
South of the Vestfjord	1	1	2	4
?			1	1
Total	12	63	184	259

* One recaptured by foreign fishermen.

April and February—April respectively (Table 3), and very few are recaptured later than April. Most of the recaptures from the districts Røst—Nordkapp are made during April—May in the tagging year, and mostly during January—April in the following years. In the area north and east of Nordkapp the recaptured cod were taken during the whole year, with some concentration in the summer months.

Tagged Danish seine caught cod recaptured in the area Røst—70° N (Table 4) are in all cases, where the otoliths of the recaptured fish are present, determined as coastal cod. The cod recaptured in the same area but tagged from hand line/purse seine catches, are only one fifth determined as coastal cod (Table 5). In the area 70° N—Nordkapp are all together reported 15 recoveries (Table 4 and 5), but there are only otoliths from 9 of them, all tagged from hand line/purse seine catches.

Table 5. *Recaptured cod tagged from hand line/purse seine catches.*

Recapture area	Otolith present		Lack of otolith	Total
	Skrei	Coastal cod		
Lofoten	161	25	206	392
Røst—70° N	27	7*	23	57
70° N—Nordkapp	6	3**	3	12
North and east of Nordkapp	22	2***	11	35
South of the Vestfjord			1	1
?	1		14	15
Total	217	37	258	512

* One recaptured by a foreign fisherman.

** One recaptured by a foreign fisherman.

*** Two recaptured by foreign fishermen.

Table 6. Total number recaptured in different length groups.

Tagging		Length group cm	Number tagged	Recaptured before 1st May in tagging year		Maximum back in the sea at 1st May in tagging year.	Recaptured in the rest of the tagging year and the next year.	
gear	year			Number	Percent		Number	Percent
Danish seine	1960	<85	211	37	17.5	174	70	40.2
Danish seine	1961	<85	273	20	17.3	253	91	36.0
Hand line	1960	<85	171	16	9.4	155	26	16.8
Purse seine	1961	<85	135	10	7.4	125	52	41.6
Danish seine	1960	> 84	28	3	10.7	25	8	32.0
Danish seine	1961	> 84	27	—	—	27	11	40.7
Hand line	1960	> 84	364	54	14.8	310	70	22.6
Purse seine	1961	> 84	508	36	7.1	472	160	33.9
Danish seine	1960	Total	239	40	16.7	199	78	39.2
Danish seine	1961	«	300	20	6.7	280	102	36.4
Hand line	1960	«	535	70	13.1	465	96	20.6
Purse seine	1961	«	644	46	7.1	598	213	35.6

Three of these were determined as coastal cod and six as skrei. Of cod recaptured north and east of Nordkapp, two were determined as coastal cod (Table 5). They were both tagged in 1960 from hand line catches. One of these was in July 1960 recaptured on the Skolpen Bank. The fish was at that time 6 years old, and had been spawning for the first time that year. The other one was recaptured in March 1961 at the Finnmark coast at an age of 11 years and had this year been spawning for the second time. However, in the last case the determination of the type was a little uncertain. Of the recaptures taken south of Lofoten (Table 4 and 5) where otoliths are present one is determined as coastal cod and two as skrei.

Exploitation

The tagging experiments have been carried out during the last part of the main fishing season in Lofoten. Tagged fish will not at once be distributed in a representative manner within the population occurring in Lofoten (DANNEVIG 1953) and the fishing vessels are not randomly distributed. The percent recovery in the first months after tagging does not therefore give adequate information with respect to the exploitation of the stock. The recaptures made in Lofoten within the 30th April in the tagging year are therefore necessary to leave out of consideration. The number of tagged fish unaccounted for at the end of April is taken as basis when calculating the percent recovery in the following periods.

It was during March and April 1960 reported recaptured 17 and 13 percent of the cod tagged in 1960 from hand line and Danish seine catches respectively (Table 6), while the corresponding figures of the 1961 experiments are 7 percent in both cases. The recapture rate of the Danish

Table 7. *Total number recaptured.*

Tagging		Recaptured			Total
gear	year	Lofoten before 1st May in tagging year	Lofoten later	Other localities	
Danish seine	1960	40	60	26	126
Danish seine	1961	20	95	18	133
Total	.....	60	155	44	259
Hand line	1960	70	89	41	200
Purse seine	1961	46	187	78	311
Total	.....	116	276	119	511

Table 8. *Recaptures taken outside Lofoten.*

Tagging		Recaptures taken by				
gear	year	foreign countries	Norway			
		trawl	trawl	Danish seine	other gear	?
Danish seine	1960			13	11	2
Danish seine	1961	1		5	10	2
Total	.....	1		18	21	4
Hand line	1960	17	2	1	18	3
Purse seine	1961	25	11	1	39	2
Total	.....	42	13	2	57	5

seine experiments in 1960 and 1961 based on the total number recaptures taken during May in the tagging year and December the following year are 39 and 36 percent respectively, while the estimated rate of the hand line/purse seine experiments in 1960 and 1961 are 21 and 36 percent respectively.

The relative number of recaptures taken outside Lofoten after 30th April in the tagging year is 22 percent for the Danish seine experiments and 30 percent for the hand line/purse seine experiments (Table 7). Only one of the tagged Danish seine caught cod is recovered by a foreign fisherman, while 11 percent of the tagged cod from the hand line/purse seine experiments are recaptured by fishermen from foreign countries (Table 8). In the area fished by all nations the foreign fishermen have returned about 35 percent of the recaptured cod from the hand line/purse seine experiments. In total 46 percent of the recaptured cod were taken in this area by trawl and two tagged cod were found in Danish seine catches (Table 7 and 8). From the same localities 41 percent of the recaptured cod from the Danish seine experiments were taken by this gear and only one tagged cod was taken by trawl.

During the tagging year about 5/6 of the total number recaptured in Lofoten of cod tagged from Danish seine catches were taken by Danish seine, while in later years about 3/5 of the recaptures were taken by gill net, long line, hand line and purse seine. On the other hand only 3 percent of the recaptured tagged hand line/purse seine caught cod were taken by Danish seine.

Discussion

The length distribution of the cod tagged from hand line/purse seine catches have nearly the same trend as the length distribution of skrei in

the age material (Fig. 2), while the length distribution of the tagged Danish seine caught cod have the same trend as coastal cod in the age material. It is therefore probable that the skrei type was the main part of the cod tagged from hand line/purse seine catches, and that the coastal cod was the main part of the cod tagged from the Danish seine catches.

The results of the recent skrei taggings confirm earlier investigations (DANNEVIG 1953). During March—April the skrei are migrating out of Lofoten and northwards along the Norwegian coast. Some cod move towards Bear Island and West Spitsbergen and some reach the South-East Barents Sea (Fig. 3), where they arrive in early summer. The cod are during autumn living in the Northern area (Table 3), and in the last months of the year they start migrating towards the Norwegian coast. In January the first cod arrive at Lofoten again.

The taxation of the 1960 tagged hand line caught cod after ended Lofoten fishery in 1960 and to the end of the next year have been 21 percent, which is of the same order as the figures calculated for the experiments in 1947—1951 (DANNEVIG 1953) and 1954—1959 (HYLEN et. al. 1961), except the 1958 experiment. The estimated rate for the experiments in 1958 and 1961 were 34 and 36 percent respectively. This high taxation was caused by the high availability and good weather conditions during the fishing season 1959 and 1962.

Some coastal cod from purse seine and hand line catches may have in earlier years been tagged, but the migrations have not been recognized. The tagging experiments of Danish seine caught cod in 1960 and 1961 have demonstrated a migration in the spring months out of Lofoten and northwards (Fig. 2). Most of the coastal cod seems to stop in the area Röst—70° N (Table 4 and 5), and very few are reaching the Barents Sea and the Bear Island — West Spitsbergen area.

Some coastal cod are staying in Lofoten during summer months in the tagging year (Table 2). Tagged hand line/purse seine caught cod recaptured during summer and early autumn (Table 2) may therefore be coastal cod. Seven recaptures are actually in this connection, but there are only otoliths from two of them, which both were determined as coastal cod.

Most of the fishing effort in Lofoten by gill net, long line, hand line and Danish seine is concentrated in January—April, but seining are to some extent going on through the whole year. A delayed westward migration of coastal cod (in proportion to skrei) in Lofoten during the tagging year or an overstay in Lofoten (Fig. 3 and Table 2) may have caused that a much higher number of tagged Danish seine caught cod are recaptured by Danish seine than tagged hand line/purse seine caught cod (Table 9). The increased relative number of Danish seine caught cod

Table 9. *Number of tagged cod recaptured in Lofoten.*

Tagging		Recapture gear	Tagging year			1st year aft. tag.			2nd year aft. tag.			3rd year aft. tag.			?	Total
			Recapture month													
gear	year		01-04	05-08	09-12	01-04	05-08	09-12	01-04	05-08	09-12	01-04	05-08	09-12		
Danish seine	1960	Danish seine	33	30		7		1	3		1					75
« «	1961	« «	18	26	2	12	5		1							64
« «	1960	Other gears	7	1	1	11	2		1							23
« «	1961	« «	2	5	1	31			6							45
« «	1960	?				2										2
« «	1961	?		2	1	1	1		1							6
Hand line	1960	Danish seine	2	3		1	1		1							8
Purse seine	1961	« «	4	1		2										7
Hand line	1960	Other gears	67			58			21							146
Purse seine	1961	« «	42	1		137	2		131							313
Hand line	1960	?	1			2			1			1			1	6
Purse seine	1961	?	1	2		6			5						1	15

recaptured in later fishing seasons in Lofoten by long line, gill net and hand line, may be a consequence of the great effort expanded in January—April by these gears in proportion to that by the Danish seine. It may also indicate a change in the behavior of the coastal cod.

Since long line are selective for fish up to about 65 cm (SÆTERS DAL 1957) and for fish more than 95 cm (HYLEN 1962) the age and length data from long line samples are biased. Age and length samples from purse seine catches are however, more representative for the population fished by long line, gill net, hand line and purse seine. In 1961 the coastal cod more than 75 cm are more abundant in the population fished by purse seine, than the population fished by Danish seine (Fig. 2). The difference may be even greater, because the Danish seine are selective for smaller fish. It is therefore possible, that the coastal cod with increasing length, join the skrei shoals and follow the skrei out of Lofoten. A tendency of a higher proportional recapture of bigger fish from the area outside Lofoten than inside (Table 10) support this. Change in behavior of coastal cod may happen when the fish are maturing, as also mentioned by HYLEN (1964) for the coastal cod living in the Smöla—Fröya district. The consequences should then be a higher proportion of mature coastal cod in the purse seine catches than in the Danish seine catches. Unfortunately the maturity stage of the gonads in our samples are missing. The proportion of cod otoliths with spawning zones in our samples might be a help too, but since it is very difficult to distinguish between the first time spawners and the immatures at this time of the year, no conclusion is drawn.

Most of the tagged cod less than 85 cm are coastal cod (Fig. 2). An attempt to compare the recapture rate of coastal cod tagged from Danish seine and hand line/purse seine catches is made by estimating the recapture rate for the time between 1st May in the tagging year and the following year (Table 6). The estimated rate is about the same for the two groups of cod tagged in 1961 (Table 6), but the estimated recapture rate for the group of tagged hand line caught cod in 1960 is less than the half of the rate estimated for the group tagged in 1960 from Danish seine catches. A part of this difference may be due to a higher tagging mortality.

The great number of tagged Danish seine caught cod recaptured by Danish seine, hand line, long line and gill net outside Lofoten in proportion to the small number recaptured by trawl (Table 8), indicate a higher availability of coastal cod for other gears than trawl. Since foreign fishermen are using only trawl in these areas, the coastal cod tagged in Lofoten during winter months, is later mainly fished by Norwegian fishermen (Table 7).

Table 10. Total number tagged from Danish seine catches and the number recaptured in Lofoten and outside Lofoten.

Localities ↓	Length →	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	Total
		34	39	44	49	54	59	64	69	74	79	84	89	94	99	104	109	114	119	
Tagged	2		6		4	12	50	135	151	79	45	22	12	9	8	1	1	2	539	
Recaptured Lof. in tagging year	1		1		2	5	15	35	35	18	10	2	2	1	1			1		129
Recaptured outside Lofoten in tagging year								3	3	8	5	2	1	1						23
Recaptured Lofoten in later years								7	18	30	9	9	5	3	1	4				86
Recaptured outside Lofoten in later years									7	3	3	3	2		1	1				20
Total recaptured	1		1		2	5	25	63	76	35	24	10	6	3	6			1		258

Summary

1) Otolith samples and length measurement of cod taken in Lofoten during March—April 1960 and 1961 by long line/purse seine and Danish seine are studied together with the recaptures of cod tagged in the same years from catches taken by hand line/purse seine and Danish seine.

2) The cod in the otolith samples was splitted into skrei and coastal cod by the structure of the zones in the otoliths. The relative number of coastal cod in the Danish seine catches was 73—92 percent, while the content of coastal cod in the long line/purse seine catches was estimated to 9—11 percent. The dominating age groups among skrei and coastal cod were 9—11 and 5—7 respectively, and the older age groups among the coastal cod were more abundant in the population fished by long line/purse seine than the population fished by Danish seine.

3) Both coastal cod and skrei were during spring and summer migrating out of Lofoten. A very small part of the coastal cod seems to migrate further north than 70° N, while the skrei spread into the northern waters from Bear Island and West Spitsbergen to the South-East Barents Sea. On the migration from Lofoten in the tagging year the coastal cod and the skrei seem to some extent to be separated, but as the coastal cod grow older they join the skrei shoals.

4) Considerable inroads have been made by the fishermen on both the coastal cod and the skrei present in Lofoten during March—April 1960 and 1961. While several nations have been fishing the skrei, the coastal cod has mainly been fished by Norwegian fishermen.

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