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**RECENT STUDIES OF THE DISTRIBUTION AND ABUNDANCE OF
GREY SEALS *HALICHOERUS GRYPUS* IN NORTH NORWAY, AND
THEIR POSSIBLE INFLUENCE ON PARASITIC INFESTATIONS IN
FISH**

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ABSTRACT

Distributions of grey seals *Halichoerus grypus* were studied during aerial and ground surveys in North Norway. Surveys were conducted from Lofoten to the Soviet border during the moult (March-April, Finnmark) and breeding (October-December, whole area) periods in 1988-1991. Numbers of grey seals seem to have increased during the past 25-30 years, and the present minimum total estimates are approximately 200 animals in Lofoten, none in Vesterålen, 110 in Troms and 550 in Finnmark. Breeding occurs at a number of sites along the coast, with a delay in the start of the breeding period along a south-north axis. In Lofoten breeding occurs mainly in the first half of October, in Troms/western Finnmark in the middle of November, and in eastern Finnmark in December. Considerable variations were observed in the degree of cod worm *Pseudoterranova decipiens* infestations in cod *Gadus morhua* captured near grey seal breeding sites. There was large variability both from year to year and between areas within the same year. Variations in food habits (e.g., change from demersal to pelagic food chains) of the grey seals (known to be important vectors for cod worm) may have contributed to the observed differences.

INTRODUCTION

In the North Atlantic there are three geographically separated groups of grey seals *Halichoerus grypus*, of which one is distributed in the northeast from the British Isles and northwards along the entire coast of Norway and the Kola Peninsula (Bonner 1981). The grey seal is resident in Norway, apparently preferring the outlying exposed islets and skerries throughout the year, including their autumn pupping time (Wiig 1986).

In his review of the regional distribution of coastal seals (i.e., grey seals and common seals *Phoca vitulina*) in Norwegian waters, Øynes (1964, 1966) reported very low and scanty abundance of grey seals in North Norway north of Vestfjorden (Fig. 1): Only 5-10 breeding females in the Lofoten-Vesterålen area, no breeding activity in Troms, and probably less than 5 breeding females in Finnmark.

To obtain a better basis for management, more extensive studies of the coastal seals and their interactions with inshore fisheries along the Norwegian coast from approximately 62° N to Lofoten were initiated in 1974 by the Institute of Marine Research, Bergen. This continued throughout the 1980ies when the geographical range of the surveys were extended to include the entire Norwegian coast (Wiig 1986, 1987, 1988a, 1989). These recent studies showed that the number of grey seals inhabiting the coastal areas of North Norway to the north of Vestfjorden were probably much larger than previously reported for the early 1960ies by Øynes (1964).

Except for aerial surveys in Lofoten in October and November 1976 (Benjaminsen et al. 1977), grey seal seals have only been registered in Lofoten-Vesterålen and Troms during summer cruises designed mainly to study common seals (Wiig 1988a, 1989). This

is outside the grey seal moulting (March-April) and breeding (October-December) periods which are the two periods during which they are thought to aggregate at certain haul out sites (Bonner 1981, Wiig 1986). For this reason, the surveys presented here, designed to study grey seals at their haul out sites in the suggested breeding season in October-November, were performed in 1988-1990 in the outer coastal areas of Lofoten, Vesterålen and Troms (Fig. 1).

Finmark grey seals were surveyed several times during both moult and breeding during the 1980ies (Wiig 1987). The often bad weather and shortness of daylight in the area during winter, however, hampers field work such that little is known about grey seals in Finmark. For this reason further studies of the species during moult and breeding were carried out in 1989-1991 in this area and the results are presented in this paper.

Besides finding and counting grey seals (pups included) at their breeding and/or moulting haul out sites in the Norwegian coastal areas north of Vestfjorden, the present study was also aimed to estimate an approximate pupping time of the species in these areas. Additionally, the possible effect of grey seal abundance upon cod worm *Pseudoterranova decipiens* infestations in fillets of cod *Gadus morhua* were investigated in grey seal haul out sites in Troms and Lofoten.

MATERIAL AND METHODS

Most of the grey seal studies reported here were carried out as ship-bound registrations and counts of the seals (Table 1). This included pups, which were also attempted aged according to Radford et al. (1978) and thereafter tagged with yellow PVC "Dalton Jumbo Rototags" in the web of one of the hind flippers. Additionally, cod were examined for infestation by cod worm in

some of the largest grey seal colonies.

In most cases, the ship-bound surveys were carried out using a mother ship (F/F'Ottar' (50'), F/F'Hyas (40') or M/S'Polarjo' (37')) for transportation and accomodation, and Zodiac inflatable boats (15' and fitted with 40 hp outboard motors) to survey the seal colonies. A few surveys in Finnmark were carried out by local seal hunters/fishermen using their own small (30'-40') vessels. The ship surveys were carried out in 1988-1991 (Table 1) during the suggested breeding season (October-December) in the whole survey area and, in Finnmark, also in the suggested moulting period in March-April (see Bonner 1981, Wiig 1986, 1987).

Due to bad weather which prevented ship surveys, an aerial survey, using a single-engined Cessna 180 aircraft, was carried out in Lofoten on 25 October 1990. During this survey only pups were registered and counted.

Since it is difficult to age grey seals in the field, all counts from breeding areas are given as numbers of one year old and older seals plus the numbers of pups observed. In moulting areas only the total number of seals is given. Seals were counted directly in the field and/or on photographs taken during field work. The minimum estimate of seals at a locality is given as the maximum count of animals (including pups on the breeding sites). In cases where apparantly acceptable estimates of pup production was obtained, estimates of the minimum size of the population were also made by using a multiplier of 3.5-4.5 of the observed pup counts as described for British grey seal colonies by Harwood & Prime (1978). In a proposal for new management procedures for grey seals in Norwegian coastal waters, Anon. (1990a) divided the species into several "regional management stocks". Although the questions of identity and possible migrations between these hypothetical stocks has yet to be resolved, the present data presentation follow the "stock definitions" given by Anon. (1990a). Due to suggested differences in breeding period in

western (W) and eastern (E) (east of Nordkapp, see Fig. 1) Finnmark (Wiig 1987), data from these two parts of the northmost county in Norway are sometimes treated separately.

Cod to be analyzed for cod worm infestations were caught using hand-lines in two grey seal key areas (Auvær in Troms, 30-50 m depth; Mosken/Røst in Lofoten, 20-40 m depth) and by trawling using prawn trawl in two deeper control areas in Troms (Malangen, 200 m depth, and Vengsøyfjord, 280 m depth) (see Fig. 1). Vengsøyfjord is quite near the Auvær area, whereas Malangen is an area usually not frequented by grey seals. Total lengths were registered for all cod which were then filleted and skinned, and both fillets and the remaining vertebra were screened on a light table. Since the cod worm is probably the only larval nematode to invade the fillet of cod (Berland 1973), no microscopic studies were made and all parasites with which resembled the cod worm (see Berland 1973, Roald and Høigjelle 1984) were allocated to this species. Statistical treatment of the the parasite material was performed using the BMDP (Dixon 1981) programs P1D and P1V, run on a VAX computer.

RESULTS

Grey seal abundance in Lofoten/Vesterålen

During the October 1989 ship survey in Lofoten and Vesterålen (Table 1), grey seals were observed in the southmost areas of the Lofoten archipelago only (Røst, Værøy, Moskenes, Flakstad and Vestvågøy, Fig. 1). Of 143 individuals recorded (Table 2), 46 were pups found at breeding sites in Røst, Værøy and Moskenes (Fig. 1). During the aerial survey in Lofoten on 25 October 1990, 22 pups (in the latest stages of or with completed moulting) were counted. However, several of the actual breeding sites in Lofoten could not be surveyed from the air due to steep mountains and

turbulence, and the normal estimated cover of c. 90-95% by aerial surveys compared with ground surveys (see Benjaminsen et al. 1976, 1977) probably does not hold true here.

Grey seal abundance in Troms

During ship surveys in the outer coastal areas of Troms in October/November, minimum numbers of seals (including the numbers of pups which are also given in brackets) observed were 77 (4) in 1988, 105 (1) in 1989 and 88 (5) in 1990 (Table 3). Most seals were seen in the municipalities of Tromsø and Karlsøy where also breeding sites were documented (Fig. 1).

Grey seal abundance in Finnmark

The 1989 ship surveys in Finnmark should be regarded as pilot studies and covered only a few known grey seal haul out sites. We believe that the degree of coverage of the potentially interesting sites in the county increased in 1990 and 1991. The total minimum number of animals observed in Finnmark during moulting in March/April were 264 in 1990 and 554 in 1991 (Table 4). It should be noted that, mainly due to bad weather, the 1990 coverage of the Hasvik/Sørøysund localities and the 1991 coverage of the Måsøy/Nordkapp localities (Fig. 1) during moult were poor. During the breeding period November/December, which was surveyed in 1990 (Table 1), a total minimum number of 231 individuals were recorded, of which 39 were pups. Approximately 65-75% of the Finnmark grey seals were observed in W Finnmark, in particular in Sørøysund, Måsøy and Nordkapp where also several breeding sites were observed (Fig. 1). In E Finnmark the most important breeding site appears to be in Berlevåg, although breeding was also observed at other sites (Fig. 1). Grey seals were never observed to haul out in Porsanger, Lebesby (Laksefjord) or in Sør-Varanger (Varangerfjord) during these surveys.

Pupping times

Assuming the age classification of pups by Radford et al (1978) is applicable to pups in North Norway, it appears that most of the pups observed in Lofoten in 1989 were born in the first half of October (Fig. 2). By the time of the survey (17-19 October), only one newborn pup was observed, suggesting that the birth-giving activity among the females in the area was diminishing.

In Troms and W Finnmark pupping was estimated to have taken place during the period from late October to late November, possibly with a peak in activity by the middle of November (Fig. 2). In the Troms 1988 survey, pups were observed in the water (age class not determined) as early as 1 November, whereas in the 1989 surveys no pupping were observed to have started in this area before 7 November when one newborn pup were found. Several very recently born pups were found during the 16-22 November 1990 survey in Troms. Similar observations were made in W Finnmark on a survey 20 November 1990, whereas only one newborn pup was found at these breeding sites one week later.

Pupping in E Finnmark, which was surveyed during the period 13-31 December 1990 (Table 1), appears to have been confined from late November (as determined from backcalculations) to the end of December (three newborn pups observed during a survey on 27 December) (Fig. 2).

Cod worm infestations in cod

Cod caught within the grey seal colonies (Auvær and Mosken/Røst, Fig. 1) were of similar lengths, whereas those fish taken in the deeper control areas tended to be smaller (Table 5).

In Auvær and Mosken/Røst, all of the examined cod were infested with parasites, whereas in Vengsøy and Malangen the degree of infestations were 90% and 15%, respectively. The number of parasites observed per fish varied considerably at each locality.

As seen from Table 5, particularly large numbers of parasites were found per fish in Auvær in 1989, whereas the degree of infestation observed at this locality in 1990 was similar to the values observed in Mosken/Røst in 1989 and in Vengsøyfjord 1990 (ANOVA, $F_{4,129} = 14.55$, $p < 0.001$). The associated t-test matrix (see Dixon 1981) reveal that the Auvær 1989 sample had a significantly heavier infestation per fish than the infestations in all other samples (all $p < 0.001$). The Auvær 1990 sample differed significantly from the Malangen 1989 sample ($p < 0.05$), whereas no significant variation occurred among the other samples.

DISCUSSION

From our censuses, it may be concluded that the present total minimum estimate of grey seals (determined from direct counts and/or conversion of counted pup numbers to stock sizes) inhabiting coastal areas of North Norway from Lofoten to the Soviet border is approximately 860 animals. The numbers observed in the various areas (Lofoten-Vesterålen, Troms and Finnmark) may in some cases differ from previous observations made in the same areas during summer surveys (see Wiig 1986, 1987, 1988a, 1989). However, grey seals are not usually found at the breeding and/or moulting sites throughout the year (Bonner 1981, Wiig 1986), and animals counted during summer might be migratory individuals. The numbers of grey seals seems to have increased in the whole area of investigation during the past 25-30 years. A contributory factor to this may have been legal protection of grey seals in North Norway from hunting during the period 1 May to 30 November from 1973 (from 1985 only to 30 October in Lofoten) (Anon. 1990a).

Evidently, the only grey seal rookeries established in the Lofoten-Vesterålen area are those in the southernmost parts of this archipelago (Fig. 1). If the crude method of estimating the

minimum size of grey seal populations, by multiplying the number of observed pups by 3.5-4.5 (see Harwood & Prime 1978), is applicable in Lofoten (where 46 pups were counted in 1989), a minimum estimate of approximately 200 animals for this area seems reasonable. Øynes (1964) concluded that no grey seals were bred in Vesterålen, while rookeries in southern Lofoten might count as few as 4-6 breeding females in the early 1960ies. Surveys in southern Lofoten in 1976 suggested a minimum production of 27 pups (Benjaminsen et al. 1977). Thus, the present observations confirm an apparent increase in the number of breeding grey seals in the Lofoten rookeries during the past 30 years.

In Troms, grey seal breeding were confirmed at two sites (Fig. 1). From the number of adults observed (105 seen in 1989) one would normally expect to find a larger number of pups than the 5 observed in 1990 in the area. This may be due to seals pupping in Troms (Fig. 2) after the surveys in all the years 1988-1990. With the data available so far the highest total minimum estimate of grey seals that can be given for Troms is approximately 110 animals. Earlier numbers of grey seals breeding in Troms are poorly known. Øynes (1964) did not confirm breeding in this area in the early 1960ies, but reported that observations of several grey seals during late autumn could be an indication that breeding still occurred. Øynes (loc.cit.) emphasized that the outer coastal areas of Troms were traditionally known to be inhabited by several grey seal colonies which were, however, nearly exterminated due to heavy exploitation earlier this century.

The present surveys revealed a minimum of six grey seal breeding areas (of which the Sørøysund area involves several close lying sites) in Finnmark (Fig. 1). This adds one site (Magerøy) to the five reported for Finnmark in the comprehensive review of Wiig (1987). Due to the restricted period of daylight often combined with bad weather, the actual pup production could not always be established, and the numbers given are definitely not representative of the real pup production of the species in

Finnmark. The largest number of grey seals in Finnmark (554, of which the majority were in the western part of the county) was observed in 1991 in the moulting period. During these surveys Måsøy/Nordkapp were poorly covered (Fig. 1) and only 70 animals were observed compared with 141 in 1990. It is thus possible that, with a more complete coverage of these mentioned areas in 1991, a minimum stock estimate of well over 620 animals would have been obtained. This is clearly more than the estimate of 353 animals given previously for Finnmark in the early 1980ies by Wiig (1986, 1987). This does not necessarily imply a dramatic increase in numbers of grey seals in Finnmark in the most recent years, but may also be due to better survey design. Nevertheless, the present results confirm an apparent stock increase here since the early 1960ies when Øynes (1964) reported that the number of breeding grey seal females in Finnmark may have been as few as five.

No uniform breeding period seems to exist throughout the area of investigation. A delay in time seems to occur along a south-north axis. In the southernmost rookeries in Lofoten the majority of the grey seals appear to pup during the first half of October, as also observed by Benjaminsen et al. (1977). Thus, grey seal breeding in Lofoten seems to occur simultaneously with breeding in the mid-Norwegian rookeries between 62°N and 67°N, where the largest grey seal colonies in Norway are found (Wiig 1986). Grey seal breeding in Troms and western Finnmark apparently coincide from the end of October and throughout November. Breeding in western Finnmark during this period was confirmed also in censuses performed in the early 1980ies (Wiig 1987). In eastern Finnmark the breeding period occurs later than in Troms and western Finnmark, and the majority of pups appears to have been born in December. According to Wiig (1987), grey seals also breed in these northmost parts of Norway in January. Further east, on the Murman coast, breeding in the grey seal colonies, which counted as much as 500-800 breeding females in the mid-1960ies, occurred in November and the first week of December (Karpovich et al. 1967). Thus, breeding at these Soviet sites, which are

located at latitudes comparable with the Troms rookeries, coincide with breeding in the latter, and clearly occurs before the very late breeding in the northmost colonies in eastern Finnmark.

Of the four fishing localities examined, cod from the deep (200 m) control site in Malangen had the lowest prevalence of cod worm infestation. This agrees with previous studies where increased depth and distance from seal colonies have been shown to result in decreased infestation rates (Benjaminsen et al. 1976, Roald & Høigjelle 1984). At the control site in Vengsøyfjord, which was even deeper (280 m) than the Malangen site but located very close to the Auvær grey seal colony, the cod worm prevalence was markedly higher than in Malangen, and comparable to those found in the Lofoten grey seal colonies in Mosken and Røst. The generally smaller sizes of cod captured in the control areas may have contributed to the low rates of infestation observed here since a positive correlation between fish age and parasite prevalence has been documented (Bjørge 1985). The heaviest infestations were observed in the cod taken in the grey seal colonies in Auvær, Troms, in particular the 1989 material in which the average number of parasites per fish was similar to those found in other grey seal colonies along the coast of Norway (Bjørge 1985). The ecological significance of the strongly reduced mean number of parasites at this site from 1989 to 1990 is, as yet, unresolved, but the generally migratory nature of cod may have contributed to the observed difference. Use of other, more stationary benthic fish (e.g. sea scorpions, Cottidae) has proved suitable for analyses and evaluation of cod worm infestations caused by grey seals in Icelandic waters (E. Hauksson, Icelandic Fisheries Laboratories, Reykjavik, Iceland, pers. comm.). This might well be applied to the problem in North Norway.

Cod caught in grey seal colonies in Lofoten had fewer parasites than those caught in Auvær, even though the estimated number of adult seals, which is known to be correlated with the rate of cod

worm infestations in cod (Rae 1972, Young 1972, Platt 1975), seemed highest in Lofoten. The Lofoten area is both a summering and wintering area of the Norwegian spring spawning herring *Clupea harengus* (Anon. 1990b). The implication of this is an enhanced availability of herring as prey for grey seals in Lofoten compared with, e.g., Auvær. Since grey seals in Norwegian waters are suggested to be opportunistic feeders (Bjørge 1984), this may have contributed to the observed differences in parasite infestations. The life cycle of the cod worm is linked with a benthic food chain (bottom-dwelling crustaceans - cod and other benthic fish - seals, see Bjørge 1979, 1985). A transition from benthic to pelagic (e.g., herring) food items for the seals will, therefore, reduce the cod worm infestations in the seal stomachs with subsequent effects on the infestations in cod in the area (see also Bjørge 1984, Wiig 1988b). The validity of such an explanation for the observed differences in infestation rate should be addressed in future studies.

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Table 1. A summary of the grey seal ship-bound surveys in the moulting (spring) and breeding (autumn) periods in 1988-1991 in North Norway.

AREA SURVEYED	PERIOD	TIME
1988		
Troms	Breeding	25 October - 5 November
1989		
W Finnmark	Moulting	1 April - 5 April
Lofoten/Vesterålen/Troms	Breeding	11 October - 20 October
Troms	Breeding	26 October - 7 November
W and E Finnmark	Breeding	18 December - 19 December
1990		
W Finnmark	Moulting	16 March - 3 April
E Finnmark	Moulting	20 March - 10 April
Troms	Breeding	16 November - 22 November
W Finnmark	Breeding	16 November - 16 December
E Finnmark	Breeding	13 December - 31 December
1991		
W Finnmark	Moulting	8 April - 20 April
E Finnmark	Moulting	26 March - 11 April

Table 2. Maximum counts of grey seals (including number of pups which are also given in brackets) in the suggested breeding period in Lofoten, northern Norway, based on a ship bound survey in October 1989 and an aerial survey (where only pups were counted) on 25 October 1990.

"Regional" stocks are given as defined in Anon. (1990).

LOCALITY (MUNICIPALITY)	"REGIONAL" STOCK	NUMBER OF GREY SEALS IN	
		OCT 1989	OCT 1990
Røst	Røst	44 (17)	(7)
Værøy	Mosken	25 (19)	(11)
Moskenes	Lofotodden	13 (10)	(4)
Flakstad/Vestvågøy	W of Lofoten	15 (0)	(0)
TOTAL LOFOTEN		97 (46)	(22)

Table 3. Maximum counts of grey seals (including the numbers of pups which are also given in brackets) in the suggested breeding period in Troms, northern Norway, based on ship bound surveys in October/November in 1988-1990. "Regional" stocks are given as defined in Anon. (1990).

LOCALITY (MUNICIPALITY)	"REGIONAL" STOCK	NUMBER OF GREY SEALS IN		
		1988 OCT/NOV	1989 OCT/NOV	1990 NOV
Tranøy/Bjarkøy/Torsken	Steinavær	3 (0)	0 (0)	
Berg	Bergsøyan		3 (0)	
Tromsø/Karlsøy	Rebbernesøy	59 (3)	93 (1)	80 (5)
Karlsøy	N-Kvaløy/Vanna	11 (1)	9 (0)	3 (0)
TOTAL TROMS		73 (4)	105 (1)	83 (5)

Table 4. Maximum counts of grey seals (including the numbers of pups which are also given in brackets) in Finnmark, northern Norway, based on ship bound surveys performed in the suggested periods of moulting (March/April) and breeding (November/December) in 1989-1991. "Regional" stocks are given as defined in Anon. (1990). *: Not previously registered.

LOCALITY (MUNICIPALITY)	"REGIONAL" STOCK	NUMBER OF GREY SEALS IN				
		1989 APR	1989 DEC	1990 MAR-APR	1990 NOV-DEC	1991 APR
Loppa	Bergsfjord*	30				
Hasvik/Sørøysund	Sørøya			26	51 (17)	284
Måsøy/Nordkapp	Magerøy		40 (0)	141	84 (5)	70
Porsanger	Porsanger					0
Lebesby	Laksefjord				0 (0)	15
Gamvik	Nordkyn*			27		14
Tana	Tana		8 (4)			
Berlevåg	Kongsfjord			70	34 (16)	112
Båtsfjord	Syltefjord					54
Vardø	Vardø		3 (1)	0	23 (1)	5
Vadsø/Nesseby/ Sør-Varanger	Varangerfjord		0 (0)			
TOTAL FINNMARK		30	51 (5)	264	192 (39)	554

Table 5. Size composition and infestation by cod worm in cod caught in October/November in 1989 and 1990 in grey seal key areas in Troms (Auvær, 30-50 m depth) and Lofoten (Mosken/Røst, 20-40 m depth), and in control areas in Troms (Malangen, 200 m depth; Vengsøyfjord, 280 m depth). N = number of cod examined.

LOCALITY	YEAR	N	LENGTH OF COD (cm)			NUMBER OF PARASITES		
			RANGE	MEAN	S.D.	RANGE	MEAN	S.D.
Røst/Mosken	1989	17	38-68	48.4	8.1	1-12	5.76	3.70
Malangen	1989	20	22-50	35.4	7.4	0- 8	0.50	1.79
Auvær	1989	43	34-77	52.5	9.3	0-70	21.00	18.64
Auvær	1990	34	40-69	49.6	5.7	1-28	7.68	6.41
Vengsøyfd	1990	20	38-55	43.2	4.7	0-30	5.80	7.72

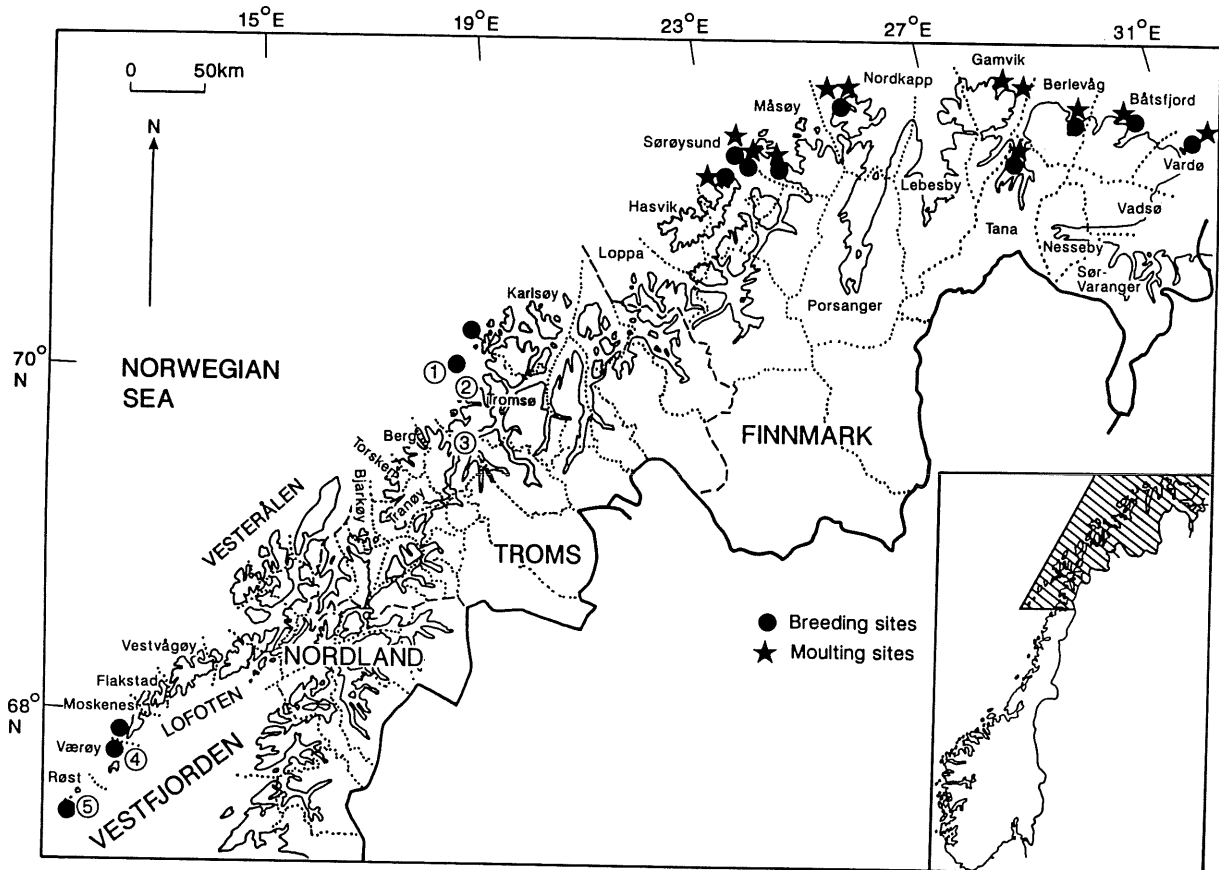


Fig. 1. Map of the study area in North Norway, showing the coastal municipalities where grey seals were observed at their breeding and moulting sites. The numbers indicate the fishing sites where cod worm infestations in cod were recorded: 1 = Auvær, 2 = Vengsøyfjord, 3 = Malangen, 4 = Mosken, 5 = Røst.

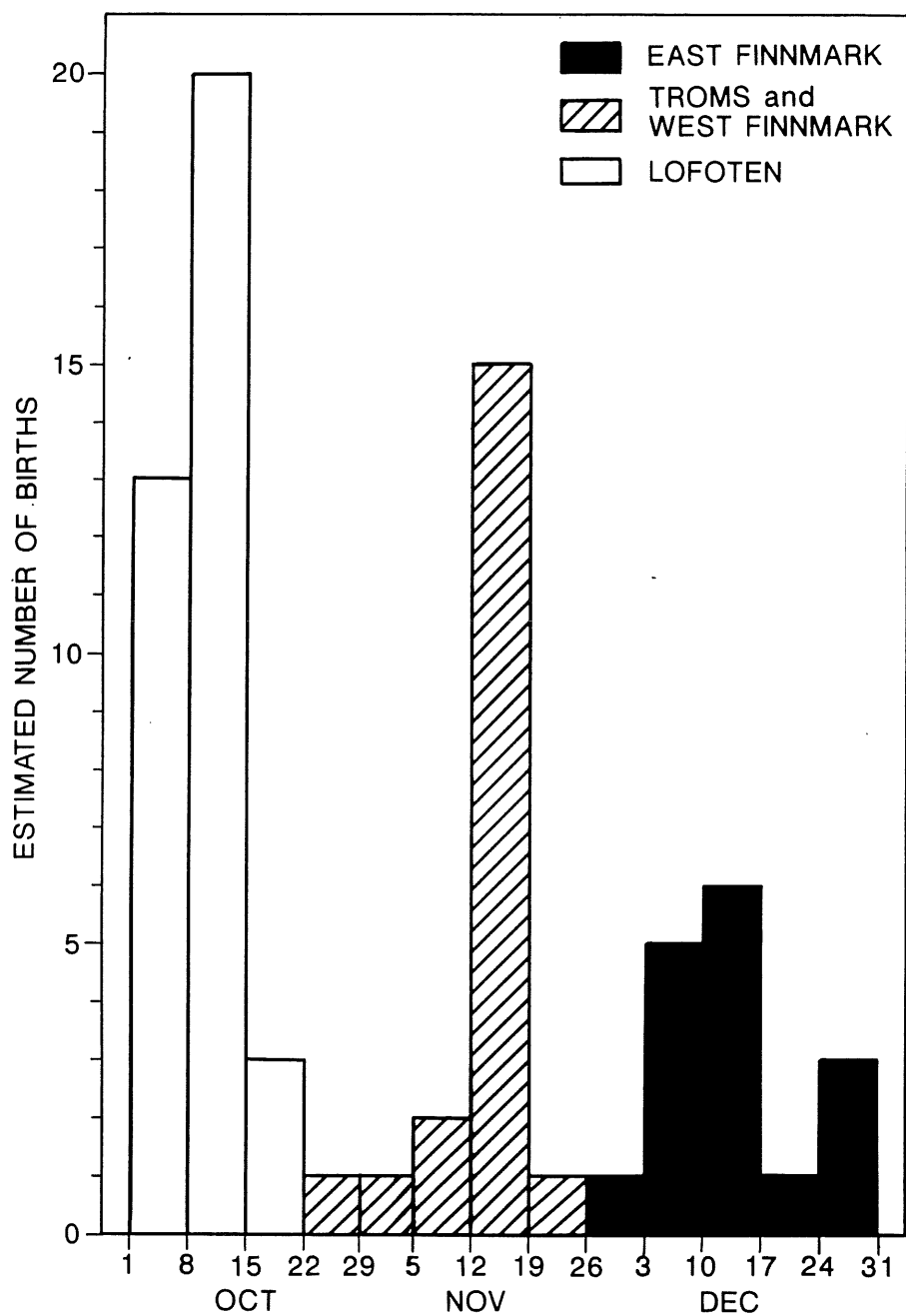


Fig. 2. Estimated number of grey seal births by one week periods during autumn in Lofoten, Troms/West Finnmark and East Finnmark.