Fol. 41 N

This paper not to be cited without prior reference to the authors

International Council for the Exploration of the Sea

C.M. 1992 / N:11
Marine Mammals Committee

SEASONAL DISTRIBUTION AND ABUNDANCE OF KILLER WHALES AROUND LOFOTEN AND VESTERALEN ISLANDS, NORTHERN NORWAY

TIU SIMILÄ (1) AND IVAR CHRISTENSEN (2)

1.The Norwegian College of Fishery Science, University of Tromsö,9037 Tromsö, Norway
2.Institute of Marine Research, P.Box 1870, Nordnes, 5024 Bergen, Norway

Abstract

Killer whales (*Orcinus orca*) have been pohotoidentified around Lofoten and Vesteralen islands northern Norway during fall-winter (October-February) and summer (June-August) in 1990 and 1991. Some background data exists from 1983-1989. To date 302 killer whale individuals belonging to 44 different groups have been identified. The yearly distribution and abundance of whales is closely related to the distribution of spring-spawning herring (*Clupea harengus*) in the area. Since 1987 nearly all of the sexually mature herring in this stock spend the winter in Tysfjord, Ofotfjord and Vestfjord area, and killer whales are most abundant in the area during this time. Based on a capture-recapture estimate, about 500 killer whales are present in the overwintering area of herring. Most of the whales leave the study area in January when herring migrate to the spawning grounds 700 km farther south. Five killer whale individuals have been identified both in the overwintering and in the spawning grounds of herring. Based on the seasonal distribution, killer whale groups can be divided into three different types; whales present in fall-winter (25 groups), whales present both in fall and summer (12 groups) and whales present in summer (six groups).

Information on prey species has been gathered from direct observations of feeding whales; in all but two encounters killer whales have been feeding on herring. The other two types of prey consumed were eider ducks (*Somateria molissima*) and fulmars (*Fulmarus glacialis*).

Introduction

Killer whales (*Orcinus orca*) are found in all oceans and are known to feed on a variety of prey including several kinds of fish, cephalopods, pinnipeds, cetaceans and birds (Matkin and Leatherwood 1986). Seasonal movements of killer whales are known to be responsive to distribution of their preferred prey. In Northeast Atlantic waters the occurrence of killer whales is correlated to the presence of herring (*Clupea harengus*) in waters around Iceland (Sigurjonsson et al. 1988), to herring and salmon (*Salmo spp.*) in waters around the British isles (Evans 1988), halibut (*Hippoglossus hippoglossus*), to herring and mackerel (*Scomber scombrus*) around Faroe islands (Bloch and

(635/93

Lockyer 1988) and herring along the coast of Norway (Christensen 1988). Other known types of prey in Norwegian waters are cod (*Gadus morhua*), squid, seals (Christensen 1978) and bottlenose whales (*Hyperoodon ampullatus*) (Jonsgard 1968). In this study information on prey items has been collected through observations of feeding whales and by comparing seasonal distribution of killer whales and herring in the area.

Killer whales are distributed along the whole coast of Norway (Christensen 1982, 1988). Their numbers and distribution has been estimated from whaling data and incidental sightings (Öien 1988) and questionnaire surveys (Christensen 1988). Christensen (1988) estimated that at least 1500 killer whales might be present in Norwegian coastal waters at times when herring is abundant. This study has been conducted in waters around the islands of Lofoten and Vesteralen in northern Norway, which is one of the three main areas of distribution for killer whales along the coast of Norway (Christensen 1982, 1988, Öien 1988). Previous studies have shown that killer whales are most abundant in these waters in fall-winter when sexually mature herring overwinters in the area (Christensen 1988).

Individual recognition of cetaceans has become a widely used method in different aspects of whale research (Hammond et al. 1990). Killer whale populations have been succesfully studied using this method in various parts of the world (Bigg et al. 1990) and new information has been gathered on their abundance, distribution, population biology and behavior. In Norway killer whales have been photographically identified around Lofoten and Vesteralen islands during summer and fall-winter in 1990 and 1991. Some identification pictures have also been taken in 1983-89. The paper summarizes the results of the photoidentification and gives an abundance estimate for the number of whales seen in the main wintering grounds of sexually mature herring in October-November.

Material and methods

Killer whale individuals have been photographically identified according to Bigg et al. (1987). Killer whales can be identified based on the natural markings on the backfin and the grey saddle patch behind the fin. The pictures have been taken with 35 mm SLR cameras using 300 mm lenses and 400 ASA black and white film pushed to 1600 ASA. The films have been analyzed for identifications using stereoscopic microscope. During 1990 and 1991 856 films have been taken and 30 816 photographic frames analyzed. Photoidentification pictures of killer whales have been taken in the study area in 1983-86 by Thomas Lyrholm (Lyrholm 1988) and in 1987-89 by various people who have contributed their material to this study.

The study area includes the waters around Lofoten and Vesteralen islands in northern Norway (fig 1.). Field work has been done in October-November, January-February and June-August using a 31 ft fishingboat M/S "Spekkulf" and a Zodiak. In November ten day sighting surveys have been done in the main overwintering area of herring using R/V "Johan Ruud" from the University of Tromsö (fig.3). Information on sightings has also been received during summer from the whale-watching boats operating outside Andenes (Vesteralen) and from fishing vessels, coastal guard boats, pilot stations and airports. The sightings have been recorded as "sightings" when the whales

have been seen but not identified and as "encounters" when the whales have been identified.

Information on the distribution of herring has been received from the Institute of Marine Research in Bergen (Anon 1991a, 1991b, 1992). Additional information on prey species has been gathered from encounters with feeding whales (prey species observed amongst feeding whales, pieces of prey floating to the surface, underwater observations of feeding whales).

The October-November study area has been sufficiently covered in 1990-91 to make an estimate of the number of killer whales present in the overwintering area of herring. The abundance estimate has been done based on the sightings and resightings of groups (treating all individuals in a known group as identified), not individual whales. This approach was chosen because each pod (group) is equally resightable, whereas on the individual level whales are resighted with unequal probablity . In every pod at least one individual is easily recognized so that each pod can be resighted with equal probability. The size of the groups are usually known and for those groups that have not been reliably counted (fifteen groups in 1990, ten groups in 1991) the size has been estimated to be thirteen individuals, which seems to be a medium size for killer whale pods in the area (n=25). The population size has been calculated using Petersens estimate (see Hammond 1986) which assumes that the proportion of marked animals recaptured in a sample of the population is equivalent to the proportion of marked animals in the total population, N. If n_1 animals are marked in the first sample and m_2 of these are recaptured in a second sample of size n_2 the relationship is

$$m_2 / n_2 = n_1 / N \qquad \text{and } N = n_1 n_2 / m_2$$

Results

Whales and groups identified

A total number of 302 killer whales have been identified in the study area since 1983. The whales have preliminary been divided into to 44 different groups. In 1990-91 38 of these pods were encountered (table 1). Most of the individuals in each group remain poorly documented, but eight groups (NA, NB, NC, NE3, NE5, NE15, NG8, NT) have been sufficiently identified and resighted to conclude that the groups have a stable structure at least each fall, with the same individuals sighted together for consecutive years (Similä, unpubl.data).

Distribution

The number of encounters was 63 in 1990 and 121 in 1991 and the number of sightings 18 in 1990 and 17 in 1991 (table 2). Most of the encounters are from October-November (85% in 1990, 82% in 1991).

In October-November and January-February killer whales were present in Vestfjord, Tysfjord and Ofotfjord (fig 2b). By comparing the distribution maps of herring (Anon 1992, Röttingen 1990)(fig.2a), and killer whales it can be seen that the fall-winter distribution of killer whales in the study area

was correlated to the distribution of herring; the area where killer whales were sighted has been the main overwintering area for sexually mature herring since 1987. Most of the whales left the study area during the first weeks of January, when herring strated migrating to the spawning grounds. During 15.1-15.2 there was only one pod present in 1990 and two pods in 1991 (table 1).

In June-August killer whales occured in waters around Vesteralen islands and around the outermost islands of Lofoten (fig 2b). These areas also correlate well to the areas where herring may be present during summer (Anon 1991b, Röttingen 1990)(fig. 2a).

In all but two encounters where the prey amongst feeding killer whales was identified (53 observations) the prey was herring. In October 1991 killer whales were seen feeding on eider ducks (*Somateria molissima*) and in a recent encounter in july 1992 whales were seen feeding on fulmars (*Fulmarus glacialis*). Whales have also been seen playing with jellyfishes both in summer and fall, but it is not known wether they were consumed. Most of the data where prey species amongst feeding whales have been identified are from fall-winter (48 encounters).

Fishermen from Röst (Lofoten) have reported that killer whales have been seen chasing grey seals (*Halichoerus grypus*) in May, but to date this information has not been verified. Fishermen from Andöy in Vesteralen have also reported that killer whales have been seen during summer in areas where mackerell is present. In summer 1991 mackerell was abundant in waters outside Vesteralen islands (Anon 1991a) and the sightings of killer whales might be correlated not only with herring but also with mackerell.

There seems to be a difference in the seasonal distribution of the killer whale pods. Most of the pods (28) have been seen only in the fall-winter. Eleven pods have been seen both in summer and fall-winter and five pods have only been seen in summer (table 1).

Killer whales have been photoidentified also at the coast of Möre which is the main spawning grounds for the spring spawning stock of herring (Röttingen 1990). By comparing identification pictures taken in the study area and at the coast of Möre (A. Bisther, D. Vongraven, pers. comm.) five killer whales have been sighted in both areas.

Abundance of killer whales in the overwintering area of herring

In October-November most of the field work was done in Tysfjord and Ofotfjord. In late November sighting cruises were done in the whole Tysfjord-Ofotfjord-Vesfjord area to estimate the distribution and abundance of whales in the whole study area. Most of the sightings were done either in Tysfjord or Ofotfjord (fig. 3) and the whales encountered in Vestfjord were all pods previously seen in Tysfjord or Ofotfjord.

In 1990 32 killer whale pods (423 individuals) were encountered in the area, in 1991 29 pods (375 individuals) were encountered. In 1991 82 % of the whales (24 pods, 325 individuals) were resightings from 1990. By using the Petersens estimate (Hammond 1986) the number of killer whales present in the overwintering area of herring can be estimated from the equation $N=n_1*n_2/m_2$ when $n_1=423$, $n_2=375$ and $m_2=325$

N= 423*375 / 325= 488

In the abundance estimate all of the pods were treated as having a stable structure (same individuals sighted together each fall). This assumption was based on the eight sufficiently identified Norwegian killer whale pods. The assumption is supported by knowledge from other killer whale populations; killer whales have been shown to live in stable groups in waters around Vancouver island (Bigg et al.1990), Crozet islands (Guinet 1991), Patagonia (Lopez and Lopez 1985) and Alaska (G. Ellis, pers.comm).

The pods were not all present simultaneously. In 1990 ten pods were present through October-November, in 1991 12 pods. Rest of the pods were encountered for a period of one to fourteen days.

DISCUSSION

Killer whales were sighted in the study area most often during fall-winter when sexually mature herring of the spring spawning stock of North Atlantic herring overwinters in the fjords. Based on questionnaire surveys, Christensen (1988) estimated that at least 1500 killer whales might be present along the coast of Norway when herring is abundant. The results of photoidentification indicate that one third of the estimated coastal population of killer whales might be present in the overwintering area of herring. However the capture-recapture estimate should be treated as a preliminary result until all individuals in each group have been identified. The high number of resightings in fall 1991 shows that the same whales were present in the study area as in 1990.

There is a clear seasonal difference in the distribution of killer whales in the waters around the islands of Lofoten and Vesteralen. The fall-winter distribution is correlated to the distribution of herring. The area where killer whales are seen during summer months correlates well with the area where herring may occur in June-August. To date there are only few direct observations of prey consumed by killer whales during summer, but in four of the five observations prey has been herring.

The stomach content analyses from killer whales caught in Lofoten during September-January also indicated herring as the most important type of prey (Christensen 1982). The other species found in the stomachs were squid and cod. Although these formed an insignificant part of prey during fall-winter, they might be be more important during other times of the year.

The only other types of food besides herring that was observed consumed by killer whales were eider ducks and fulmars. Both of these observations represent a minor part of the encounters with feeding whales (one observation each) which suggests that these birds do not form an important part of the diet.

The differences in the seasonal distribution of the killer whale groups identified in the area might be related to differences in diet. Killer whale groups are known to have different feeding habits within the same geographical areas (Bigg et al. 1987, 1991). Christensen (1988) suggested that there might be two types of killer whales around the islands

of Lofoten since whales are sighted in the area year around, even at times when herring is not present. One type would follow the main concentration of herring year around and the other would stay in the area and feed on other prey than herring at times when herring is not abundant. This study has been conducted during times when herring is most abundant in the area and thus it can not be confirmed wether such difference in behavior exist. However it is possible that the sightings of the same killer whales in both the main overwintering and spawning areas of herring represent a regular migration pattern of at least some of the pods.

The study shows the feasibility of the photoidentification method in studying distribution and abundance of killer whales. However initially the method is time consuming (learning the technique, starting to catalogue the individuals) and for best results the identification work needs to continue for several years. In the long term the use of this method will provide useful information on the ecology of killer whales in northern Norway as a result of studying known killer whale individuals and pods over several years.

ACKNOWLEDGEMENTS

This study has been financed by the Academy of Finland, World Wildlife Fund, University of Tromsö and the Norwegian Council of Fisheries Research.

REFERENCES

Anon 1991a. Havforskningsinstituttet, Intern totkrapport XXXVI-91. (Report of the Institute of Marine Research)

Anon 1991b. Havforsknungsinstituttet, Intern toktrapport XXXVIII-91. (Report of the Institute of Marine Research)

Anon 1992. Havforskningsinstituttet, Intern toktrapport XVIII-92. (Report of the Institute of Marine Research)

Bigg, M.A., Ellis, G.M., Ford, J.K.B., and Balcomb, K.C. 1987. Killer whales: A study of thweir identification, genealogy and natural history in British Columbia and Washington State. Phantom Press and Publishers Inc. Nanaimo, B.C.

Bigg, M.A.,Olesiuk, P.F., Ellis, G.M., Ford, J.K.B., and Balcomb, K.C.1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and washington state. Rep.Int. Whaling Comm.Spec.Issue No 12 pp.383-405.

Bloch, D. and Lockyer, C.1988.Killer whales (*Orcinus orca*) in Faroese waters. Rit. Fiskideildar 11:55-64.

Christensen, I. 1978. Spekkhoggeren (*Orcinus orca*) i det nordöstlige Atlanterhav (the killer whale (*Orcinus orca*) in the northeast Atlantic). Fisken. Hav.1.23-31.

Christensen, I. 1982. Killer whales in Norwegian coastal waters. rep.Int. Whaling Comm. 32:633-672.

Christensen, I. 1988. Distribution, movements and abundance of killer whales (*Orcinus orca*) in Norwegian coastal waters, 1982-1987, based on questionnaire survey. Rit. Fiskideildar 11:79-88.

Evans, P.G. 1988. Killer whales (*Orcinus orca*) in British and Irish waters. Rit. Fiskideildar 11:42-54.

Guinet,C. 1991. Intentional stranding apprenticeship and social play in killer whales (*Orcinus orca*). Can.J.Zool.69:1451-1483.

Hammond, P.S. 1986.Estimating the size of naturally marked whale populations using capture-recapture techniques. Rep.int Whaling Comm. (special issue 8): 253-282.

Hammond, P.S., Mizroch, S.A., Donovan, G.P. (editors). 1990. Individual recognition of Cetaceans: Use of photo-identification and other techniques to estimate population parameters. Report of the International whaling Commission, Special Issue 12. Cambridge 1990.

Jonsgard, A. 1968. A note on the attacking behavior of the killer whale (*Orcinus orca*). Norsk. Hvalfangsttid.57:84-85.

Lopez, J.C. andLopez, D. 1985. Killer whales of Patagonia and their behavior of intentional stranding while hunting near shore.J.Mammal.66(1):181-183.

Lyrholm,T.1988.Photoidentification of individual killer whales *Orcinus orca* off the coast of Norway 1983-1986.Rot. Fiskideildar 11:89-94.

Matkin, C.O. and leatherwood, S. 1986. general biology of the killer whale *Orcinus orca*. *In* Behavioal biology of killer whales. *Edited by* B.C. Kirkevold and J.s. lockard.A.R.Liss Publ.New York.pp.35-68.

Röttingen, I. 1990. A review of variability in the distribution and abundance of Norwegian spring spawning herring and Barents Sea Capelin. Polar Research 8:33-42.

Sigurjonsson,J., Lyrholm, T.,Leatherwood,S.,Jonsson,E. and Vikingsson, G.1988. Photoidentification of killer whales off Iceland 1981 through 1986. Rit.Fiskideildar 11:1185-1189.

Öien, N.1988. The distribution of killer whales (Orcinus orca) in the North Atlantic based on Norwegian catches, 1938-1981, and incidental sightings, 1967-1987. Rit.Fiskideildar 11:65-78.

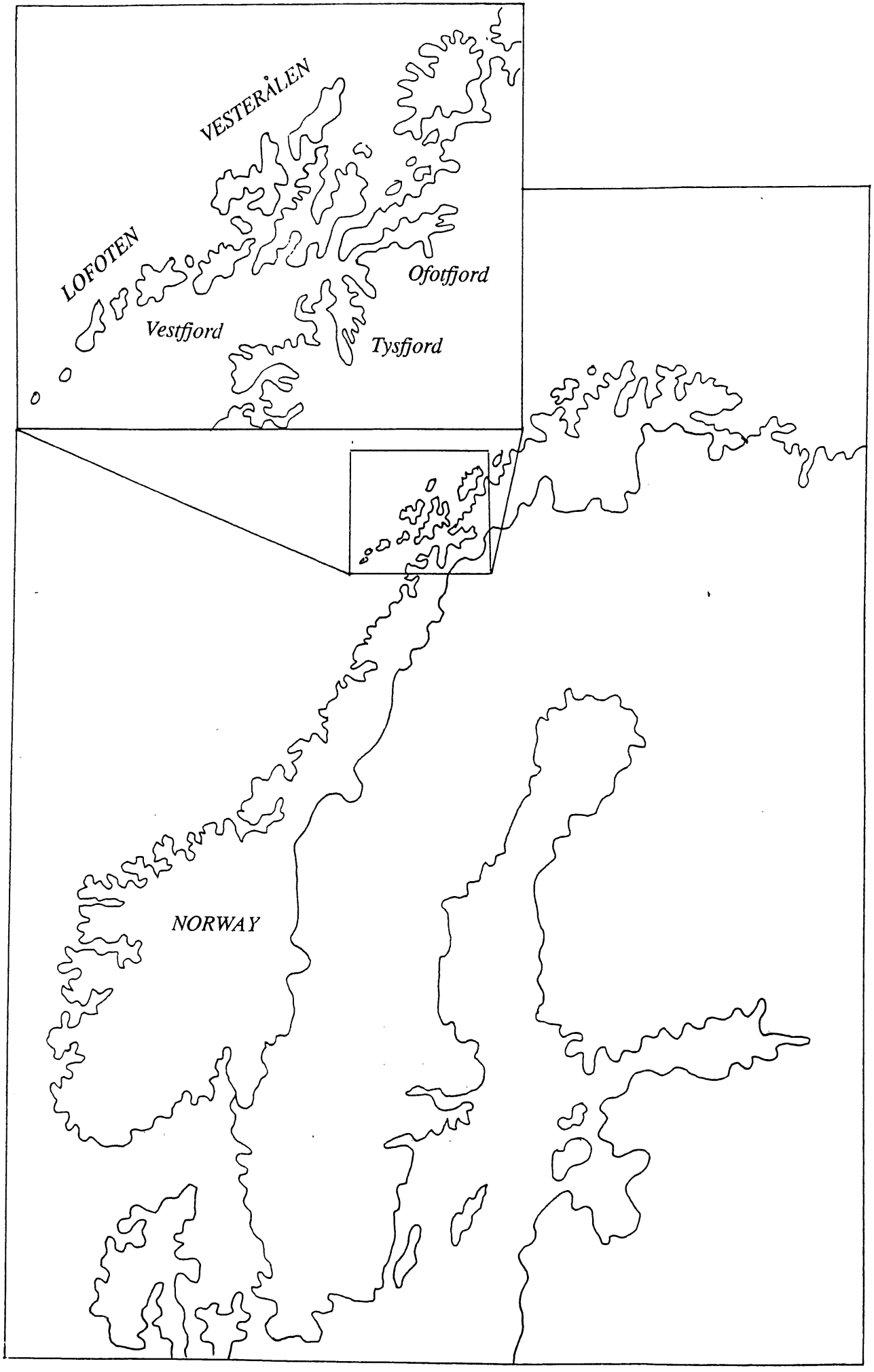

Figure 1. Study area

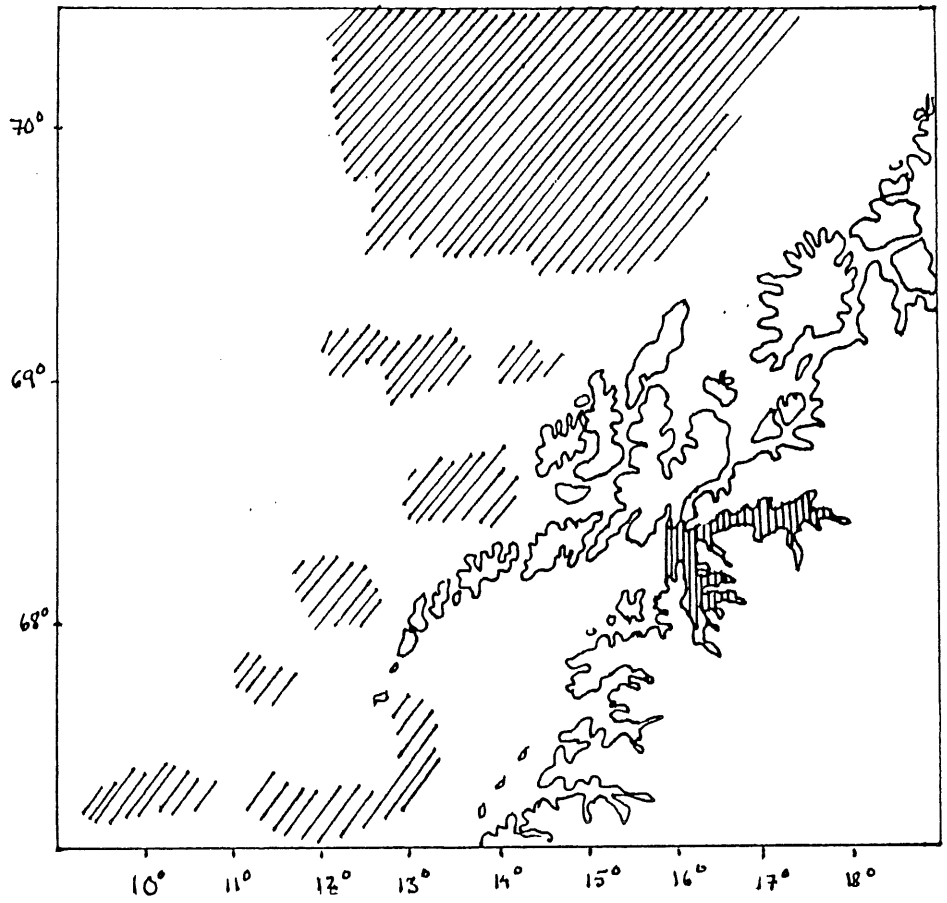

Figure 2a Distribution of herring in the study area

8-18.8.1991 (Anon 1991b)

Oct-Nov 1990-91

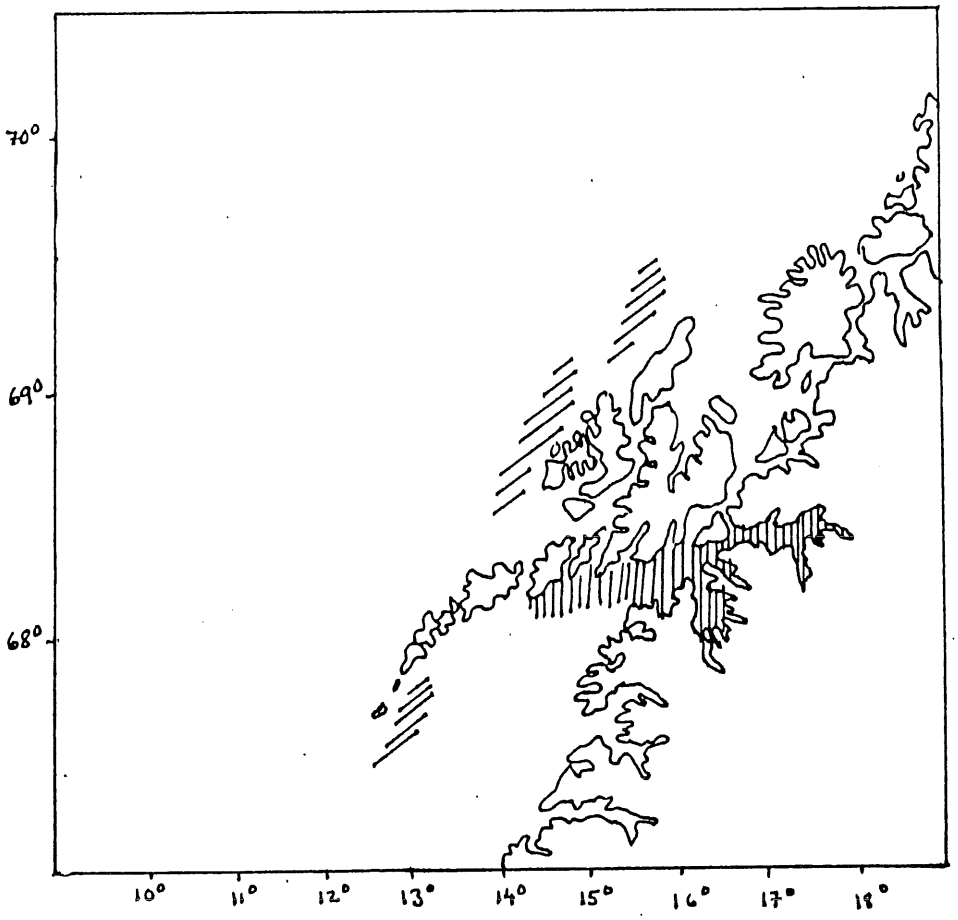

Figure 2b Distribution of killer whales in

June-Aug. 1990-91

Oct-Nov, Jan-Feb 1990-91

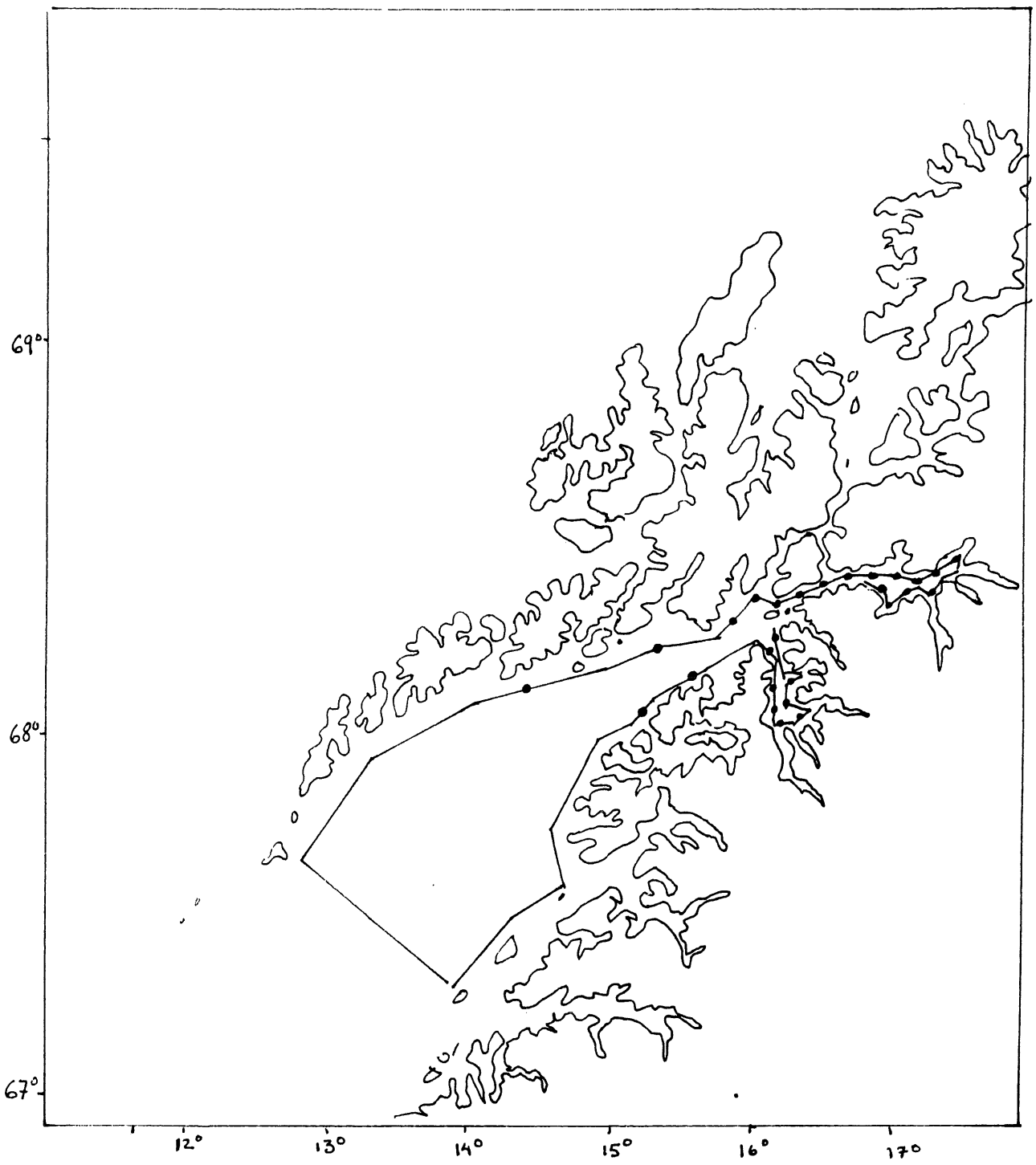

Figure 3. Area covered during sighting surveys 18-28.11 1990-91. Areas where killer whales have been sighted marked with ●

		1983	1985	1986	1987	1988				1989			1990			1991		
Pod	Size	F	F	F	S	F	W	S	F	W	S	F	W	S	F	W	S	F
NA	14		x			x			x						x			x
NB	13	x		x							x				x			x
NC	27	x		x							x				x			x
ND	10								x						x			
NE3	10							x	x						x			x
NE5	12		x				x	x	x			x		x	x			x
NE15	13											x		x	x		x	x
NF	13*							x										
NG8	12					x			x						x			x
NG45	15					x			x						x			x
NH	13*										x							
NI	13*										x							
NJ	13*										x							
NK	9										x			x			x	
NL	25										x					x	x	
NN	24												x			x		
NO	15													x	x			x
NP	14														x		x	x
NQ	20		x	x											x			x
NR	11														x			x
NS	10														x			
NT	10														x		x	x
NU	13*																	x
NV	6																	x
NW	12														x			x
NX	8																	x
NY	16														x			x
NZ	7																	x
KA	8														x			x
N-42	13*														x			x
N-51	13*														x			
N-68	12														x			x
N-71	13*														x			
N-72	13*														x			x
N-73	13*														x			x
N-78	13*														x			
N-98	13*														x			
N-99	13*														x			
N-100	13*													x	x			x
N-105	13*														x			x
N-106	13*														x			
N-120	13*														x			x
N-128	13*														x			x
N-130	13*																	x

Table 1. Killer whale pods identified 1983-1991. Encounters during different field seasons marked with x , W= winter (Jan.-Feb), S= summer (June-Aug), F= fall (Oct.-Nov.). Pod sizes marked with * are estimates.

	1990			1991		
	W	S	F	W	S	F
Encounters	2	7	54	15	7	99
Sightings	-	8	10	2	6	9

Table 2. Number of encounters and sightings of killer whales in 1990-91. W= winter (Jan.-Feb), S=summer (June-Aug.), F=fall (Oct.-Nov.)