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Distribution, movements and abundance of killer whales (*Orcinus orca*) in Norwegian coastal waters, 1982–1987, based on questionnaire surveys

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ABSTRACT

Information on killer whales in Norwegian coastal water was solicited through five questionnaire surveys conducted in 1982 (Feb., Sept.), 1986 (Jan., Nov.) and 1987 (March). Participants returned 3.4–6.6 percent ($\bar{x} = 5.1$ percent, 922 of 18,274) of all prepaid questionnaires distributed. Number of killer whales, estimated by totalling all non-duplicate sightings on a given survey day, ranged from 483 to 1507 ($\bar{x} = 1020$) with highest number in January (1507) and February (1401) and lowest number in March (483). Differences in distribution by season indicate that some whales move, likely in response to the recent migration pattern of Norwegian spring-spawning herring; recurring concentrations in some areas (Lofoten, Møre) suggest that some whales are resident in those areas. Changes in killer whale migrations, caused by dramatic changes in herring migration, may explain the increase in abundance of killer whales in Norwegian coastal and inshore waters since the early 1970's, as suggested by fishermen's reports.

INTRODUCTION

Until recently, information on distribution and migration of killer whales (*Orcinus orca*) in Norwegian coastal waters was derived mainly from catches and opportunistic observations (Christensen 1982). The fishery for killer whales has never been large, ranging from 0 to 246 whales (mean about 55 whales per year) through the recorded history of the fishery from 1938 through 1981. About two thirds of these whales, or an annual average of 37, were taken in Norwegian coastal waters (Øien 1988 – this volume).

It has long been known that herds of killer whales follow herring (*Clupea harengus*) (Collett 1877, 1912; Jonsgård and Øynes 1952; Jonsgård and Lyshoel 1970). However, except for Collett's (1883) statement that the killer whale is the most frequently seen delphinid species along the Norwegian coast, there has

been little information with which to assess the number of killer whales in Norwegian waters.

Since the early 1970's, fishermen and their organizations have increasingly claimed that killer whale populations along the Norwegian coast are growing and have expressed their concern that such growth might impede the slow recovery of the herring stock. In response to these concerns, Norwegian authorities permitted catches of killer whales outside as well as during the regular whaling season, though the market and prices for animal feed limited catches in most years. In 1980, the Scientific Committee of the International Whaling Commission (IWC/SC) expressed concern about this fishery and made its first recommendation concerning its regulation (IWC 1981). Norwegian authorities voluntarily acted by provisionally closing the

fishery in 1982. It remains closed at the time of this writing (February 1987).

To obtain more information on killer whales in Norwegian coastal waters, a marking cruise was conducted in 1978 (Christensen 1978). In February 1982, the first in a series of questionnaire surveys sought to collect from volunteer participants information on killer whales (Christensen and Øritsland 1982). The present paper presents results from the original survey as well as from four additional surveys, one in 1982, two in 1986 and one in 1987.

MATERIAL AND METHODS

About three weeks in advance of scheduled survey dates, prepaid postcard questionnaires were distributed randomly to fishermen, whalers and in some surveys, naval patrol boats. In each survey the following information was requested: name and address of observer; date, time and position of the sighting; number of whales seen; and direction of movement. Space was also provided for other information. One specific day was selected for each survey, but reports of sightings on other days were also invited. Surveys were carried out in periods where killer whales most frequently are seen in concentrations along the coast. Well in advance of the selected dates, the surveys were announced in fishermen's trade journals, numerous local newspapers and national broadcasts. A last reminder was broadcast on the survey day.

To evaluate the returned observations, the following procedure was used: Single observations were accepted and recorded as given. Sightings in a small area by more than one observer were compared and evaluated with regard to time of the day, position and numbers. Apparent duplicates of same sightings were thus eliminated. The numbers recorded were either as given on the returned cards or a mean of a range. All observations where numbers were given in indefinite terms, like "many", "hundreds" and so on, were discarded. For sightings where a range was given, the lowest number was used in the esti-

TABLE 1
Distribution and returns of questionnaires in surveys of killer whales in Norwegian coastal waters, 1982-1987.

| Date | No. Distributed | Returns | |
|-----------------------|-----------------|---------|---------|
| | | No. | Percent |
| 17 Feb. 1982* | 5,000* | 332* | 6.6* |
| 22 Sept. 1982 | 5,000 | 205 | 4.1 |
| 30 Jan. 1986 | 2,470 | 140 | 5.7 |
| 20 Nov. 1986 | 2,744 | 142 | 5.2 |
| 30 March . . . 1987 | 3,060 | 103 | 3.4 |
| | 18,274 | 922 | 5.0 |

* From Christensen and Øritsland (1982)

mations. Sightings on other days were added to the total if they were at distances from sighting on the scheduled day sufficiently long so that double sightings could be excluded.

The distribution and returns of postcard questionnaires in each of the five surveys are summarized in Table 1. The survey on 22 September 1982 covered the entire coast. In other surveys, the Skagerak coast from Agder eastwards (Fig. 1), where killer whales are rarely seen, was excluded.

RESULTS

Of 18,274 postcard questionnaires distributed in the five surveys, 922 were returned. This represents an average of 5.0% (Table 1). Results from the first survey on 17 February 1982 were reported by Christensen and Øritsland (1982). Detailed data for the four subsequent surveys are given in Tables 2-5, by district. The distribution and density of observations from all five surveys are shown, also by district, in Figure 1. The estimated number of whales for each district during each survey period is shown in Table 6. The total numbers of whales listed in all tables represent the numbers recorded on the survey date, corrected for obvious or suspected multiple sightings, plus whales reported on adjacent dates at sufficient distance from sightings on the survey date that the possibility they represented repeated sightings can be excluded. It is stressed, however, that reports are rough esti-

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| Returns | |
|---------|---------|
| No. | Percent |
| 32* | 6.6* |
| 5 | 4.1 |
| 10 | 5.7 |
| 12 | 5.2 |
| 3 | 3.4 |
| 22 | 5.0 |

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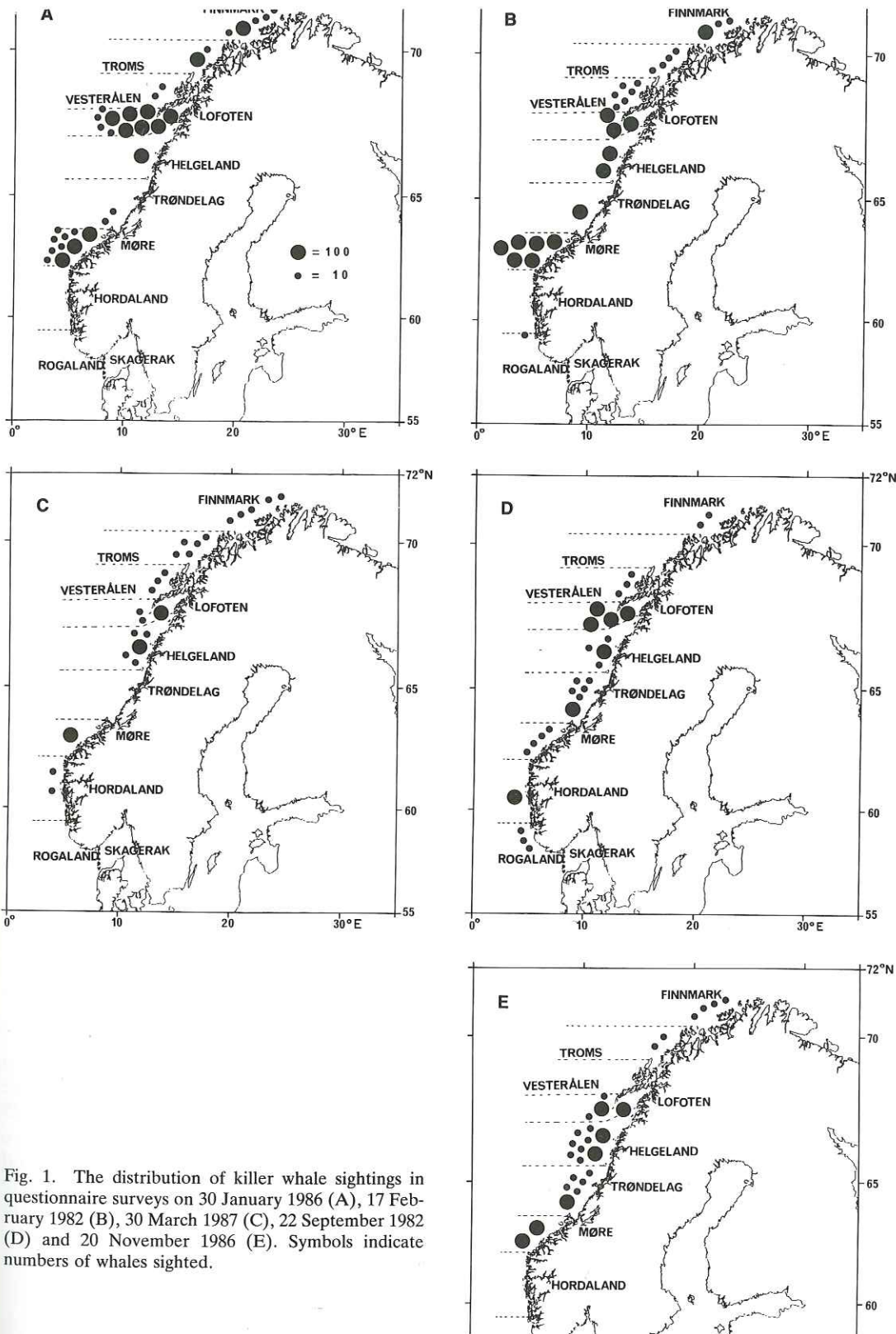


Fig. 1. The distribution of killer whale sightings in questionnaire surveys on 30 January 1986 (A), 17 February 1982 (B), 30 March 1987 (C), 22 September 1982 (D) and 20 November 1986 (E). Symbols indicate numbers of whales sighted.

TABLE 2
 Number of returned questionnaires and estimated numbers of whales
 by district (cf. Fig. 1D) in killer whale survey on 22 September 1982.

| District | Total | Reports on scheduled date | | | With obs. other days | Est. whales | |
|----------------------|-------|---------------------------|-------------------------|---------------------|----------------------------|-------------|---------|
| | | With obs. | With poor weather | With nil obs. | | No. | Percent |
| Skagerak | 2 | 0 | 0 | 1 | 1 | 0 | 0.0 |
| Rogaland | 10 | 0 | 1 | 4 | 5 | 27 | 3.3 |
| Hordaland | 5 | 0 | 0 | 2 | 3 | 31 | 3.8 |
| Møre | 22 | 1 | 10 | 5 | 6 | 40 | 4.9 |
| Trøndelag | 11 | 0 | 3 | 4 | 4 | 150 | 18.5 |
| Helgeland | 33 | 5 | 2 | 16 | 10 | 129 | 15.9 |
| Lofoten | 81 | 18 | 6 | 5 | 52 | 391 | 48.2 |
| Vesterålen | 9 | 0 | 1 | 7 | 1 | 25 | 3.1 |
| Troms | 15 | 0 | 0 | 14 | 1 | 0 | 0.0 |
| Finnmark | 17 | 1 | 1 | 10 | 5 | 19 | 2.3 |
| Total | 205 | 25 | 24 | 68 | 88 | 812 | |

TABLE 3
 Number of returned questionnaires and estimated numbers of whales
 by district (cf. Fig. 1A) in killer whale survey on 30 January 1986.

| District | Total | Reports on scheduled date | | | With obs. other days | Est. whales | |
|----------------------|-------|------------------------------|---------------------|-----|----------------------------|-------------|---|
| | | With obs. | With nil obs. | No. | | Percent | |
| Skagerak | — | — | — | — | — | — | — |
| Rogaland | 4 | 0 | 3 | 1 | 0 | 0.0 | |
| Hordaland | 2 | 0 | 2 | 0 | 0 | 0.0 | |
| Møre | 27 | 16 | 0 | 11 | 370 | 24.6 | |
| Trøndelag | 5 | 1 | 2 | 2 | 15 | 1.0 | |
| Helgeland | 9 | 3 | 4 | 2 | 95 | 6.3 | |
| Lofoten | 67 | 40 | 3 | 24 | 735 | 48.8 | |
| Vesterålen | 5 | 2 | 2 | 1 | 16 | 1.1 | |
| Troms | 14 | 4 | 2 | 8 | 108 | 7.2 | |
| Finnmark | 7 | 0 | 2 | 5 | 168 | 11.2 | |
| Total | 140 | 66 | 20 | 54 | 1,507 | | |

mates rather than accurate counts, particularly when sightings included many whales or groups of whales.

In the first survey, on 17 February 1982, it was estimated that there were 600 or more whales in the Møre area, about 43 percent of the estimated total of 1,401 for the entire coast (Christensen and Øritsland 1982, see Fig. 1B).

The survey on 22 September 1982 (Table 2) was compromised by unfavourable weather conditions along most of the coast. Among 25 returns reporting sightings on that day, there was only one report each from Møre and Finnmark; all others were from Nordland County (Helgeland to Lofoten), as shown in Figure 1D. This is the only survey which covered also the Skagerak coast eastwards, but

no killer whale sightings were reported in the two returns received from that part of the coast.

The survey on 30 January 1986 was favoured by relatively good weather (Table 3), and cards were returned from all counties canvassed except Sogn and Fjordene. Concentrations were reported at Lofoten and Møre (Fig. 1A). On 30 January, attempts were also made to survey killer whales from

two fixed-wing aircraft, each carrying two observers. Killer whales were sighted at or near the locations where they were also reported by fishermen, but poor visibility limited coverage such that the data are inadequate for estimates of abundance.

For the survey on 20 November 1986, weather conditions were poor for sightings, both at Møre and at Lofoten. Even so, about 200 killer whales were reported from each

TABLE 4
Number of returned questionnaires and estimated numbers of whales by district (cf. Fig. 1E) in killer whale survey on 20 November 1986.

| District | Total | Reports on scheduled date | | | With obs. other days | Est. whales | |
|------------|-------|---------------------------|-------------------|---------------|----------------------|-------------|---------|
| | | With obs. | With poor weather | With nil obs. | | No. | Percent |
| Skagerak | — | — | — | — | — | — | — |
| Rogaland | 11 | 0 | 0 | 9 | 2 | 0 | 0.0 |
| Hordaland | 12 | 0 | 1 | 8 | 0 | 0 | 0.0 |
| Møre | 42 | 3 | 5 | 28 | 6 | 200 | 22.3 |
| Trøndelag | 11 | 4 | 0 | 5 | 2 | 150 | 16.7 |
| Helgeland | 22 | 9 | 0 | 12 | 1 | 270 | 30.0 |
| Lofoten | 25 | 7 | 4 | 4 | 10 | 221 | 24.6 |
| Vesterålen | 2 | 0 | 0 | 1 | 1 | 0 | 0.0 |
| Troms | 6 | 1 | 0 | 2 | 3 | 23 | 2.6 |
| Finnmark | 11 | 0 | 1 | 6 | 4 | 35 | 3.9 |
| Total | 142 | 24 | 11 | 75 | 32 | 899 | |

TABLE 5
Number of returned questionnaires and estimated numbers of whales by district (cf. Fig. 1C) in killer whale survey on 30 March 1987.

| District | Total | Reports on scheduled date | | | With obs. other days | Est. whales | |
|------------|-------|---------------------------|-------------------|---------------|----------------------|-------------|---------|
| | | With obs. | With poor weather | With nil obs. | | No. | Percent |
| Skagerak | — | — | — | — | — | — | — |
| Rogaland | 1 | 0 | 0 | 1 | 0 | 0 | 0.0 |
| Hordaland | 6 | 1 | 0 | 2 | 3 | 18 | 3.7 |
| Møre | 15 | 1 | 3 | 4 | 7 | 85 | 17.6 |
| Trøndelag | 3 | 0 | 0 | 3 | 0 | 0 | 0.0 |
| Helgeland | 11 | 5 | 1 | 1 | 4 | 140 | 29.0 |
| Lofoten | 33 | 9 | 0 | 16 | 8 | 119 | 24.6 |
| Vesterålen | 9 | 2 | 0 | 4 | 3 | 26 | 5.4 |
| Troms | 9 | 1 | 0 | 5 | 3 | 45 | 9.3 |
| Finnmark | 16 | 0 | 3 | 8 | 5 | 50 | 10.4 |
| Total | 103 | 19 | 7 | 44 | 33 | 483 | |

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TABLE 6

Estimated numbers of killer whales in Norwegian coastal waters from sightings reported in questionnaire surveys 1982–1987. Means include all surveys but estimated numbers of whales per report (total number of returns) in the last column were calculated from Tables 2–5 and do not include the survey on 17 Feb. 1982.

| Area | 30 Jan. (1986) | 17 Feb. (1982) | 30 March (1987) | 22 Sept. (1982) | 20 Nov. (1986) | Mean | No. Rep. |
|----------------------|-------------------|-------------------|--------------------|--------------------|-------------------|-------|-------------|
| Skagerak | — | — | — | 0 | — | 0 | (0.0) |
| Rogaland | 0 | 6 | 0 | 27 | 0 | 7 | 1.1 |
| Hordaland | 0 | 3 | 18 | 31 | 0 | 10 | 3.3 |
| Møre | 370 | 607 | 85 | 40 | 200 | 260 | 6.6 |
| Trøndelag | 15 | 104 | 0 | 150 | 150 | 84 | 10.5 |
| Helgeland | 95 | 180 | 140 | 129 | 270 | 163 | 8.5 |
| Lofoten | 735 | 280 | 119 | 391 | 221 | 349 | 7.1 |
| Vesterålen | 16 | 64 | 26 | 25 | 0 | 26 | 2.7 |
| Troms | 108 | 37 | 45 | 0 | 23 | 43 | 4.0 |
| Finnmark | 168 | 120 | 50 | 19 | 35 | 78 | 5.3 |
| Total | 1,507 | 1,401 | 483 | 812 | 899 | 1,020 | 6.4 |

(Table 4, Fig. 1E). The killer whales in Møre County were recorded in the inner fjords, those in the Trøndelag County in the southern part, i.e. close to the northern border of Møre.

The last survey was carried out on 30 March 1987 (Table 5, Fig. 1C). As in the survey on 22 September 1982, most of the whales seen were in Nordland County, from Helgeland to Lofoten, while poor weather limited sightings along the rest of the coast.

The results of all five questionnaire surveys to date are summarized in Table 6. Presuming that the annual pattern of distribution has remained roughly constant throughout the years covered by these surveys, the data might be used to surmise seasonal changes in abundance and distribution, by area.

There were an estimated 1,401 killer whale on 17 February 1982, 1,507 on 30 January 1986 and lower figures for surveys in March (483), September (812), and November (899) when coverage was less complete.

The highest numbers of killer whales were recorded in Lofoten, Nordland County, the second highest in Møre County. The data suggest there is movement of some animals between Lofoten and Møre in early February, and then between Møre and Lofoten through the spring and summer. However, the esti-

mated numbers of whales per returned questionnaire suggest there is also a concentration of killer whales in the Trøndelag County, adjoining the Møre district, with the highest numbers reported in the autumn (September and November).

DISCUSSION

In addition to effects of weather and winter darkness on visibility, such other factors as the seasonal presence or absence of migrating fishes and regulations permitting or restricting fisheries also affected the amount of activities at sea and consequently the effort in the five questionnaire surveys.

The mere repetition of the surveys may also have affected the rate of returns. Thus the lower than usual returns in the surveys on 22 September 1982 and 30 March 1987 may reflect a loss of interest among fishermen. Reporting certainly is influenced by the presence or absence of whales, but the presence or absence in a given area of whaling tradition and awareness probably affected level and consistency of interest. For example, killer whales are present in some numbers throughout the year at the Møre and at Lofoten, where also the highest estimated means are recorded. Traditionally, these two districts are the main

TABLE 7

Catches of killer whales in Norwegian coastal waters 1938–1981, compared to the distribution inferred from reported sightings in questionnaire surveys 1982–1987.

| Area | Catches 1938–1981 | | Sightings Percent |
|--|-------------------|---------|----------------------|
| | No. | Percent | |
| Skagerak–Southern Rogaland . . | 25 | 1.6 | 0.6 |
| Northern Rogaland–Hordaland . | 104 | 6.5 | 2.3 |
| Møre–Southern Trøndelag | 747 | 47.0 | 33.6 |
| Northern Trøndelag– Helgeland | 32 | 2.0 | 15.8 |
| Lofoten | 485 | 30.5 | 33.9 |
| Vesterålen–Troms | 132 | 8.3 | 6.4 |
| Finnmark | 66 | 4.2 | 7.6 |
| | 1,591 | | |

centres of whaling on the Norwegian coast. However, the average estimated numbers per report (Table 6) suggest that killer whales are also abundant between these two areas, i.e. at Trøndelag and Helgeland.

Catches in Norwegian coastal waters 1938–1981 (Table 7) confirm the general distribution of killer whales implied by results of the questionnaire surveys. Both show concentrations at Møre and Lofoten. If the exceptionally high catches at Møre in 1969–1970 and at Lofoten in 1979 are excluded (Øien 1988 – this volume), the distributions surmised from the two approaches are nearly identical. To some unquantified extent, the concentrations of both catches and sightings may well reflect the distribution and concentration of observers as well as the distribution and concentrations of whales. The fact remains, however, that killer whales are abundant both at Lofoten and at Møre. Table 6 also suggests a seasonal shift in abundance between the two districts.

The highest numbers were reported from Lofoten in January (1986) and from Møre in February (1982). There were numerous whales between the two districts at both times. Numbers appear to continue to decrease in Lofoten through March (1987), when the highest numbers are recorded at Helgeland, but poor weather, limiting the information from other parts of the coast, pre-

vents drawing firm conclusions. Sightings reported in September (1982) and November (1986) indicate a relatively even distribution of killer whales along the coast between the fjords of Møre and Lofoten. These apparent seasonal changes in local abundance may be taken as indicative of seasonal migrations of killer whales between Møre and Lofoten. That some killer whales move between Møre and Lofoten was documented by two individual whales first photoidentified at Møre in April 1984 and reidentified at Lofoten in September–October 1985 (Lyrholm 1988 – this volume).

Jonsgård and Lyshoel (1970) stated that although killer whales seem to occur from East Greenland to Novaya Zemlya and from Spitsbergen to the North Sea, catches are concentrated in specific localities off Rogaland, Møre, Lofoten and Varanger (Finnmark). They did not, however, indicate limits of these areas precisely.

Before the collapse of the Norwegian spring-spawning herring stock at the end of 1960's (Dragesund and Ulltang 1978), the herring migrated between feeding areas in the Norwegian Sea, between Iceland and Jan Mayen, and spawning grounds on the coast of Norway. Young and adolescent herring dispersed along the coast, mainly of northern Norway and the Barents Sea. Jonsgård and

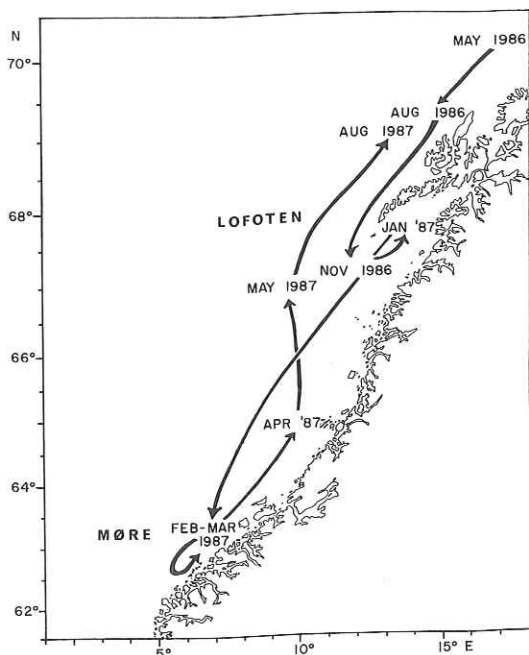


Fig. 2. Migrations of Norwegian spring-spawning herring as indicated by recorded concentrations of the 1983 year class during the period May 1986 – August 1987 (From Røttingen 1987).

Lyshoel (1970) found correspondance between the occurrence of killer whales and the occurrence of herring off eastern Iceland and western Norway, and suggested that killer whales migrate with the herring between these two areas. After this stock collapsed, the herring no longer migrated into the Norwegian Sea, instead remaining in the fjords and coastal waters of Norway until maturity and spawning, thereby establishing a new migration pattern.

Røttingen (1987) describes a yearly cycle (November 1986 – November 1987) for the 1983 year-class of spawning herring, which is currently assumed to be the stock's typical annual migration route. In November the herring congregated on the banks off Helgeland and Lofoten; in January they concentrated in more restricted areas, occurring in larger and denser schools, especially at Lofoten; in February–March they were recorded on the spawning grounds at Møre; in April the

majority of the year class was located north of the spawning ground; in May, June and July the northward migration continued, and in August dense concentrations of the 1983 year class were observed in the same areas off Lofoten (Fig. 2) which they had left the previous November (Røttingen 1987).

The seasonal and spatial distribution of killer whales in Norwegian coastal waters inferred from results of the questionnaire surveys fits well with the above described distribution of spring-spawning herring. It may therefore be assumed that at least some of the whales follow the herring throughout the year. However, records of killer whales in the fjords of Møre in November and January and in the Lofoten area throughout the year suggest that some whales are "resident" year-round in both areas. Such mixture of "transients" and "residents" are found elsewhere in the world (e.g. British Columbia, Bigg 1982; southern Alaska, Leatherwood *et al.* 1984). There is not enough information in the survey data to assess the proportions of "resident" and "transient" whales in any area.

The migrations of killer whales between Møre and Iceland inferred by Jonsgård and Lyshoel (1970) probably did not continue after the change in herring migrations. Provisional results from photoidentification of 143 killer whales in Icelandic and 26 in Norwegian waters have failed so far to demonstrate any recent movement between these two areas (Sigurjónsson *et al.* 1988 – this volume).

Because of incomplete coverage, the numbers of killer whales estimated from these surveys (Table 6) must be regarded as minimum estimates. Presumably, the large and dense concentrations of herring off Lofoten in January and on the spawning-grounds off Møre in February–March attract both "resident" and "transient" killer whales. Therefore, surveys which cover these areas and seasons might well include a large proportion of the total stock in Norwegian coastal waters. The comparable estimates of about 1,500 and 1,400 animals obtained in January and February, respectively, strongly suggest that at

least fifteen hundred killer whales are present in the coastal waters of Norway when schools of herring congregate in January and in February–March.

The appreciably lower estimates of killer whales in September and November (Table 6) occurred when herring are widely dispersed over the offshore banks (Røttingen 1987). The lower number may be at least partly artifact of unexplained sampling bias or compromises of survey efficiency. However, if killer whale distribution is correlated with the distribution of herring at such times, surveys planned for autumn should include extensive areas of oceanic as well as coastal regions.

Collectively these surveys indicate that the largest concentrations of killer whales may be found on the coast from Møre to Lofoten (about 62° – 68°N) at any time of the year. Some 200–300 whales were recorded farther to the north in the January (1986) and February (1982) surveys (Table 6), and even higher numbers (300–400) have been reported from the two northern counties, Troms and Finnmark, by occasional observers in April and May. These whales may well be “transients”, possibly from the south. The surveys indicate there are low numbers of whales south of Møre.

Observations show that in summer, at least, killer whales are found on the offshore banks and over the continental slope (Øynes 1974; Øien 1988 – this volume).

There is no evidence from these questionnaire surveys to support claims by fishermen that killer whale numbers have increased rapidly in Norwegian waters in recent years. Bigg (1982) calculated an average net annual increase of no more than 2.52% for the once exploited killer whale “population” off Vancouver Island. The formerly more extensively exploited stock in Norwegian waters may have a higher rate of recruitment, with females bearing on the average one calf every third year (Christensen 1984). However, average catches of 37 per year in coastal waters up to 1981 (Øien 1988 – this volume), or about 2.5% of the estimated total number for the coast, would have slowed any increase. Unless

immigration from other areas has contributed significantly in recent years, it must therefore be assumed that the increases apparently have been caused by changes in migration patterns, which probably can be explained by a drastic change in the annual migrations of herring. After the spawning season in 1973, the herring did not leave for the feeding grounds in the Norwegian Sea but rather stayed in coastal waters over the summer and moved into the fjords for the winter (Hamre 1983). It is probably no coincidence that reports from fishermen of increasing numbers of killer whales started in the early 1970's (Christensen 1978).

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