

Photoidentification of killer whales, *Orcinus orca*, off Iceland, 1981 through 1986

Jóhann Sigurjónsson,¹ Thomas Lyrholm,²
Stephen Leatherwood,³ Erlendur Jónsson¹
and Gísli Víkingsson¹

¹ Marine Research Institute, P.O. Box 1390, Skúlagata 4, 121 Reykjavík, Iceland

² Department of Zoology, University of Stockholm, S-10691 Stockholm, Sweden

³ Sea World Research Institute, Hubbs Marine Research Center, 1700 South Shores Road, San Diego, CA 92019, USA

ABSTRACT

Between 10 October and 20 November 1986, ship surveys were conducted off the southern and eastern coasts of Iceland to photographically identify killer whales (*Orcinus orca*). These activities represented the second successive year of a programme to assess population size and structure, vital rates, population status and identity, social organization, movements, and acoustic behaviour of the Icelandic killer whale population(s). Data from the two years were supplemented by a sample of photographs taken incidentally in 1981 and 1984. During the 1986 field season, there were 37 observations of groups of killer whales, including 23 observations that resulted in photoidentification of a total of 111 individuals. Of the 111, 4 had been identified in 1984, 22 in 1985, and 1 in both 1984 and 1985. To date, 143 killer whales have been identified and catalogued in the Icelandic population(s) from photographs taken since 1981. The 143 animals consist of 41 (29%) classified as adult males, 83 (58%) as adult females or subadult males, and 19 (13%) as juveniles or calves. Sixty-one of the 111 animals identified in 1986 and 79 of the 143 total animals have been provisionally catalogued into one of six pods. The remaining 64 animals have been catalogued as "miscellaneous", pending collection of further data on their social associations. Distinguishing marks on most of the 143 photoidentified animals can confidently be regarded as stable enough to be useful in identifying the individuals in future encounters. However, longevity of distinguishing features of some animals (39 of the 84 animals first identified in 1986 and 63 of the 143 total) is less certain. Animals ranged over at least 80 km (43 naut. miles) within the study period and areas in 1985 and 160 km (87 naut. miles) in 1986. To date, there have been no matches with 26 killer whales photoidentified off Norway since 1983.

INTRODUCTION

In Iceland killer whales (*Orcinus orca*) have never been the subject of an organized fishery (Sæmundsson 1932; Sigurjónsson 1984), although takes by Icelanders in 1917 and 1926 were reported. However, catches of killer whales were made by Norwegian small-type whalers in Icelandic waters between 1955 and 1972 (Jonsgård and Lyshoel 1970; Christensen 1975; Øien 1988 - this volume), and in re-

sponse to complaints by fishermen that large numbers of killer whales were not only eating shoals of fish but also damaging fishing gear, the United States Navy was asked in October 1956 to rid the coastal area of killer whales. Reports of the results of this latter programme are contradicting, saying either that "not very many" animals were killed (Anon. 1956a) or that "hundreds" of whales were killed (Anon. 1956b). In the past 15 years, the only direct

take of killer whales in Icelandic waters has been that in a limited live-capture fishery which began in 1976 (Sigurjónsson and Leatherwood 1988 – this volume).

Although killer whales are frequent visitors to Icelandic coastal waters during fall and winter, there has been, until recently, very limited information available on the biology and numbers of this species in Icelandic waters. Sigurjónsson (1984) reported a minimum estimate of 284 animals on the nearshore herring (*Clupea harengus*) grounds in 1982, based on coordinated census from herring fishing vessels. In 1986, an aerial survey conducted in Icelandic coastal waters located animals (6 sightings of 14 animals) all around the country (Gunnlaugsson *et al.* 1988); no animals were observed in an equivalent survey in 1987 (Donovan and Gunnlaugsson in press). In contrast, there were 23 sightings (21 primary sightings) of 175 killer whales (155 primary) during the summer 1987 shipboard surveys conducted simultaneously from three Icelandic sighting vessels in Icelandic waters and adjacent regions (Sigurjónsson *et al.* in press). The animals were widely distributed around Iceland; most sightings were made (see Fig. 7) approximately 40–100 naut. miles east of Iceland (for distribution in the neighbouring Faroese waters, see also Bloch and Lockyer 1988 – this volume). From these sightings, it was estimated that there were 6,847 killer whales in the area surveyed by the Icelandic vessels, with a 95% lower limit of around 4,000 whales (Gunnlaugsson and Sigurjónsson in press); the estimate for the larger region, including sightings made on board the Faroese sightings vessel is 8,272 (coefficient of variation 0.32).

A long-term study was initiated in 1985 to determine the following aspects of the biology and behaviour of killer whales off Iceland: population size and structure, vital rates, population status and identity, social organization and behaviour, movement patterns, and acoustic behaviour. Lyrholm *et al.* (1987) reported on a brief pilot study in which killer whales were photographed and their vocalizations recorded off the Icelandic east coast be-

tween 4 and 27 October 1985. Following procedures now well-established for studying this species (e.g. see Bigg 1982; Leatherwood *et al.* 1984; Bigg *et al.* 1986), investigators used high resolution black-and-white photographs, supplemented by other available information, to identify individuals, determine their age/sex class, and assign them provisionally to the pods to which they appeared to belong. Approximately 1,050 photographic frames from 1985 were analysed. These were supplemented by photographs of killer whales taken off Iceland incidental to other research duties in 1981 (53 frames) and 1984 (487 frames). This latter sample included photographs of varying format, film type and quality. From the material available over the period 1981–1985, a total of 57 whales (11 from 1981 and 1984 combined, and 46 from 1985) were photoidentified and assigned to one of three pods.

Photographic and acoustic research on killer whales around Iceland was continued in 1986. The present paper reports on results of the 1986 photoidentification work and summarizes the overall progress of this project to date. Results from acoustic analysis are presented by Moore *et al.* (1988 – this volume).

MATERIAL AND METHODS

Data collection

The study was conducted from two ships, R/V *Mímir*, a 10 m, 15 ton research vessel, and R/V *Dröfn*, a 26 m, 150 ton research vessel. R/V *Mímir* left Reykjavík on 10 October and sailed through the west and north Icelandic coastal waters on the way to the east coast, where it operated from 19 October through 9 November, mainly inside the fjords and within 15 naut. miles off the coast. R/V *Dröfn* operated off the south coast from 6 through 10 October, and then mainly inshore along the east coast from 11 through 17 November, with a brief trip to the Hvalbakur off shore area (a well known herring fishing ground) before returning to port on 20 November (Fig. 1).

On each vessel, the research team and ship

Fig. 1A. Route of the R/V *Mímir* October 10-November 9, 1986 and dates of main activities in each area of operation. Areas of main activities demarcated with solid lines; broken lines indicate progress of vessel in poor sighting conditions.

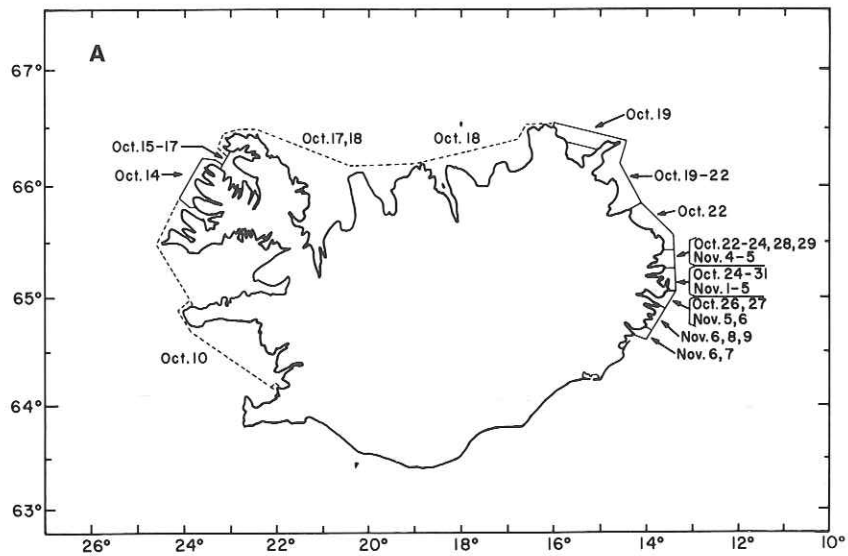
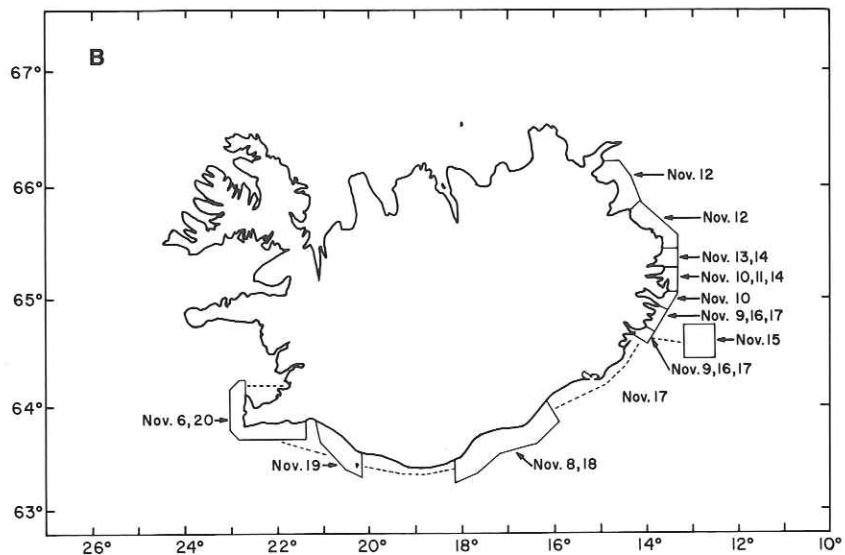


Fig. 1B. Route of the R/V *Dröfn* during November 6-20, 1986 and dates of main activities in each area of operation. Areas of main activities demarcated with solid lines; broken lines indicate progress of vessel in poor sighting conditions.



crew maintained watches for killer whales from a specially installed upper bridge and monitored radio reports of sightings from nearby vessels, including 8 sightings from which there were specially appointed observers during the period 1-14 November. Contact was also made with the four branch laboratories of the Marine Research Institute in W, N, SE, and S Iceland, to obtain as recent local information as possible on killer whale occurrence.

Public awareness of the ongoing killer whale studies was aroused through mass media (announcements, advertisements, and news coverage) to encourage public assistance.

Whenever killer whales were seen, they were carefully approached by the vessel, initial efforts were made to determine whether more than one group of whales was present, and the number of animals in the area was provisionally estimated. Weather permitting,



Fig. 2. Field workers on board a skiff outfitted with metal framework to compensate for movement. Photograph by Th. Karlsson.

an inflatable skiff was launched and the whales were approached, counted, photographed, and sometimes acoustically recorded. The crew of R/V *Dröfn* launched two skiffs for simultaneous work when this was considered advantageous. The skiffs were outfitted with a metal framework (Fig. 2) forward of the steering station; the photographer could brace himself against this framework to compensate somewhat for skiff movement.

Whales were usually approached from astern and the left side, and then paralleled by the skiff as long as necessary to collect photographic data. Photographs were taken using 35 mm motor-driven SLR cameras (Canon T-90 or Nikon FM2, both with data-back indicating time to the nearest minute) with 300 mm telephoto lenses (in a few cases when whales were at a very close range with 30–70 mm zoom lens) and Kodak TRI-X black and white film exposed at ASA 1600 and a shutter speed of 1/1000 second or faster. All photographic methods used in the present study are consistent with those described by Bigg *et al.* (1986) and Leatherwood *et al.* (1984), now widely used among killer whale researchers.

On seven occasions, tape recordings were made in the presence of killer whales. Tapes

were provided to our co-workers (see Moore *et al.* 1988 – this volume) who describe recording methods and results of analysis.

Data analysis

To identify individual whales, the photographic negatives were examined using a Wild M5 stereo dissection microscope with 8 power eyepieces, affording 4.8 to 40.0 power magnification (9.6 power was used most commonly). Whenever possible, identified animals were provisionally assigned to a specific pod based on associations among individuals detected in the photographic material. Each pod was designated by a letter code: I for Iceland, followed by A, B, C, etc., assigned sequentially as pods were catalogued. Within each designated pod, individual whales were sequentially numbered. For example, IB-7 indicates the seventh animal identified in pod B.

In cases where an identified individual could not be assigned to a particular pod, it was given a different type of number or letter designation and included in a "miscellaneous" category pending collection of further data. A 12.7 × 17.8 cm glossy print was made from the best image of each whale and placed into a working catalogue. The catalogue is updated

annually and will be published once it is thought to contain a substantial proportion of the whales in the Icelandic population(s).

The identified individuals were also provisionally assigned to one of the three following broad age/sex categories: 1) adult males, 2) adult females and subadult males and 3) calves or juveniles. Features permitting such age/sex classification are detailed in Bigg (1982), Leatherwood *et al.* (1984) and Ellis *et al.* (in press). Adult males can be distinguished by their tall dorsal fin and large size, while females/subadult males and calves or juvenile animals are classified according to their apparent size and behaviour in the field. Data obtained to date are provisional. A more refined age/sex determination of the animals will eventually be confirmed by long-term observations.

The whales photoidentified off Iceland were compared with a small sample of 26 killer whales photoidentified off northern and southwestern Norway between 1983 and 1986 (Lyrholm 1985, 1988 – this volume; Lien *et al.* 1988 – this volume).

RESULTS

During the short transits in October through the Vestfirðir area (Westfjord area) and off the north coast of Iceland, and in November off the south coast (Fig.1), no killer whales were observed. This may have been partly due to poor sighting conditions, although we were able to search the traditional herring grounds in the Vestfirðir area (where reliable reports on groups of animals one month earlier were received), off Vestmannaeyjar (Westmann Islands, S), and at Hrollaugseyjar (SE) under relatively good sightings conditions.

All killer whale observations were made off the east or southeast coasts of Iceland, within the area from 64°30' to 66°30'N and 13°30' to 15°00'W. After entering that area, we had only one reliable report of animals elsewhere, i.e. a group of animals seen on 19 November off Vestmannaeyjar. In addition, on 15 November we recorded two groups of animals (14 whales) in the Hvalbakur area to the southeast of Iceland (64°30'N, 13°15'W). De-



Fig. 3. Herring shoal kept at the surface by a group of killer whales in Bakkaflói, E Iceland, October 1986. Note the water disturbance at the surface created by one of the killer whales. Photograph by Th. Karlsson.

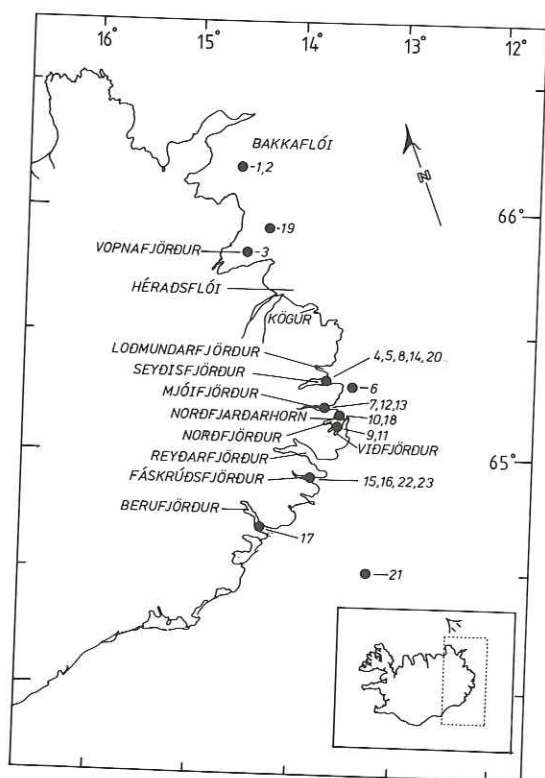


Fig. 4. "Encounters" (animals photoidentified) with killer whales in 1986. Encounter numbers refer to Table 1.

spite repeated attempts, however, weather permitted less than one day's work in that area; several reports of animals were received from observers on board fishing vessels operating there in the preceding days.

Killer whales were most often found in areas where we could either locate herring shoals by acoustic devices or where the whales were seen feeding on shoals of herring in the surface layer. Sometimes the fish could even be seen jumping as the whales fed on them and apparently kept them at the surface in dense concentrations (see Fig. 3). White-beaked dolphins (*Lagenorhynchus albirostris*) were on five occasions found with killer whales, apparently feeding on the same shoals of fish or near the herring fishing vessels. The animals proved easy to approach and photograph.

Observations of killer whales were logged either as "encounters" (observations which resulted in a photographic identification of individual whales) or as "sightings" (all other observations, including those in which photos were taken but no animals could subsequently be identified). Both encounters and sightings often involved several groups of animals or pods. Between 19 October and 16 November 1986 there were 23 encounters (Table 1 and Fig. 4) and 14 sightings (Table 1 and Fig. 5). A total of 2,182 photographs containing images of killer whales were analyzed.

One hundred and eleven individuals were photoidentified (Table 2) from various combinations of the following characteristics: shape and size of the dorsal fin; details of pigmentation and scarring in the "saddle patch", the light area below and behind the dorsal fin;

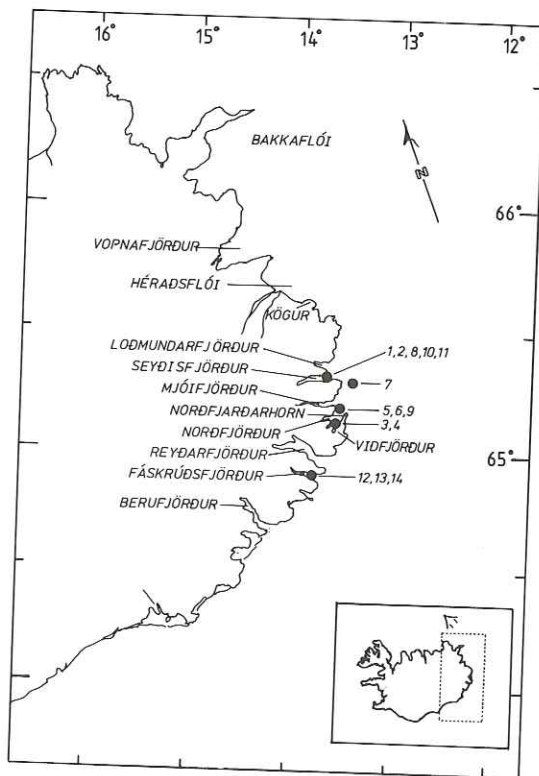


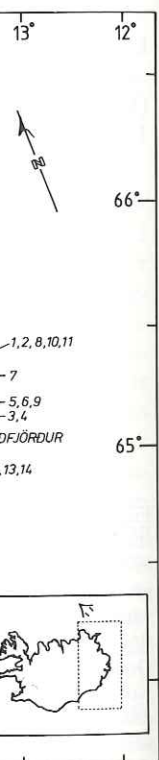
Fig. 5. "Sightings" (no animals identified from photographs) of killer whales in 1986. Sighting numbers refer to Table 1.

TABLE 1
 "Encounters" (animals photoidentified) and "sightings" (no animals photoidentified) of killer whales in 1986. Encounter numbers refer to Fig. 4; sightings numbers refer to Fig. 5.

| Encounter no. | Sighting no. | Date | Location | Pods identified | Estimated number | Comments |
|---------------|--------------|------------|-----------------|-------------------|---------------------------------------|--|
| 1 | | 19 Oct. 86 | Bakkaflóadjúp | Misc. | 15-20, 8-12, 5-8 | Three groups |
| 2 | | 20 Oct. 86 | Bakkaflóadjúp | IA, IB, IE, Misc. | 60-80 | Dispersed, feeding on herring |
| 3 | | 21 Oct. 86 | Vopnafjörður | IA, IB, Misc. | 60-80 | Dispersed, 2 groups formed late same day |
| 4 | | 23 Oct. 86 | Seyðisfjörður | ID | 20-23, 15-20 | Located twice |
| 5 | | 23 Oct. 86 | Seyðisfjörður | IB, Misc. | 14-18, 15-20 | Located twice |
| | 1 | 23 Oct. 86 | Seyðisfjörður | | 5-7 | Photographed but not identified |
| | 2 | 23 Oct. 86 | Seyðisfjörður | | 10-15 | Too dark to photograph |
| | 3 | 25 Oct. 86 | Viðfjörður | | 10-12 | Photographed but not identified |
| 6 | | 25 Oct. 86 | Dalatangi | IE | 10-15 | + 7 white-beaked dolphins |
| 7 | | 28 Oct. 86 | Mjóifjörður | ID, Misc. | 14-18 | |
| 8 | | 28 Oct. 86 | Seyðisfjörður | IE | 12-15, 10-12 (8-12) | Located at 12:10-13:00 & 13:20-14:00 with 10-15 white-beaked dolphins |
| 9 | | 29 Oct. 86 | Viðfjörður | IB | 15-18 | |
| | 4 | 29 Oct. 86 | Viðfjörður | | ? | Too dark to photograph, white-beaked dolphins around |
| 10 | | 30 Oct. 86 | Norðfj.flói | IB | ca. 20 | Group 1 located at 09:30 |
| | 5 | 30 Oct. 86 | Norðfj.flói | | 2 | Two males approaching group 1 at 13:30 |
| | 6 | 30 Oct. 86 | Norðfj.flói | | 15-20 | Group 2 approaching group 1 at 14:30 |
| 11 | | 31 Oct. 86 | Viðfjörður | IA, IB | 16-20 | Two groups formed later |
| 12 | | 3 Nov. 86 | Mjóifjörður | IB | 6-7 | |
| 13 | | 3 Nov. 86 | Mjóifjörður | IE | 16-22 | |
| | 7 | 4 Nov. 86 | Dalatangi | | 4 | Not photographed |
| 14 | | 4 Nov. 86 | Seyðisfjörður | IB, IE | 22-27 | |
| | 8 | 4 Nov. 86 | Seyðisfjörður | | 15-25 | Part of encounter no. 14? Dispersed and fast swimming |
| 15 | | 4 Nov. 86 | Fáskrúðsfjörður | IF | 20-30 | Photographed onboard herring purse-seiner Porri |
| 16 | | 6 Nov. 86 | Fáskrúðsfjörður | IF | 12-15 | Difficult to approach |
| 17 | | 7 Nov. 86 | Berufjörður | IF | 6 | Difficult to approach |
| | 9 | 10 Nov. 86 | Norðfj.flói | | 25-30 | Two groups (6 & ?) mixed, formed a group of 25-30; feeding on herring |
| 18 | | 11 Nov. 86 | Norðfj.flói | IB, IE, IF | 7-9/8-10, 20-25, 15-20, 8-10, 4, 8-10 | At least 6 groups photographed, 2-4 white-beaked dolphins with one group |
| 19 | | 12 Nov. 86 | Vopnafjörður | Misc. | 10, 10-15, 20-25, 5-7, 25-30, 15-20 | At least 6 groups; white-beaked dolphins feeding with one group |
| 20 | | 13 Nov. 86 | Seyðisfjörður | IB | 8 | Another group nearby |
| | 10 | 13 Nov. 86 | Seyðisfjörður | | 8 | Encounter no. 20 nearby |
| | 11 | 13 Nov. 86 | Seyðisfjörður | | 4, 5 | Two groups |
| 21 | | 15 Nov. 86 | Hvalbakur | Misc. | 5, 9 | Two groups |

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TABLE 1 (continued).

| Encounter no. | Sighting no. | Date | Location | Pods identified | Estimated number | Comments |
|---------------|--------------|------------|-----------------|-----------------|------------------|---|
| 22 | | 16 Nov. 86 | Fáskrúðsfjörður | Misc. | 8 | Sighting no. 12 or 13? |
| 23 | | 16 Nov. 86 | Fáskrúðsfjörður | IE | 15-19 | |
| | 12 | 16 Nov. 86 | Fáskrúðsfjörður | | 9 | Photographed but not identified |
| | 13 | 16 Nov. 86 | Fáskrúðsfjörður | | 8-9 | Photographed but not identified. Sighting no. 12? |
| | 14 | 16 Nov. 86 | Fáskrúðsfjörður | | 4-5 | Neither sighting no. 13 nor 12 |

patterns of nicks, gouges, and scars on the dorsal fin; and significant body scars. Sixty-nine of the photoidentified animals bore markings which we feel confident are sufficiently permanent to be valuable for recognition in future years. Each of the remaining 42 animals were clearly distinguishable from the other animals, but the longevity of their distinguishing features is less certain.

In 1985 some animals ranged at least 80 km (43 naut. miles) within the study area and period (Lyrholm *et al.* 1987). In 1986, the range of the population extended to at least 160 km (86 naut. miles).

Twenty-seven of the 111 whales photoidentified in 1986 had been identified previously within roughly the same study area: 4 in 1984, 22 in 1985, and one in both 1984 and 1985 (Tables 3 and 4). Sixty-one of the 111 whales were provisionally assigned to one of the 3 pods (IA, IB, and IC) designated in 1985 (Lyrholm *et al.* 1987) or one of the three new pods (ID, IE, and IF) first designated in 1986 (Table 3). This now brings the total number of killer whales photoidentified in Icelandic coastal waters to 143 (Table 5) and the total number of animals both photoidentified and assigned to pods off Iceland since 1981 to 79 (Table 3). The history of encounters with each pod and the progressive refinement in age/sex classification is given in Tables 3, 4, and 5, and is summarized briefly below.

IA pod

On three occasions in 1986, some of the 13 whales provisionally assigned to this pod in 1985 were encountered. IA-1, 2, and 10 were photographed on 20 October in an estimated

aggregation of 60-80 whales. IA-7 was photographed on 21 October during an encounter with a similar aggregation. On 31 October, IA-13 was photographed in an encounter with an estimated aggregation of 16-20 whales, some of which were identified as members of the IB pod.

IB pod

In 1985 and 1986 combined, 29 individuals have been positively identified and provisionally assigned to the IB pod. Of these, seventeen had been identified based on markings judged to be of certain longevity. Eight members previously assigned to this pod were not identified in 1986.

Some animals assigned to this pod in 1985 and other animals first photoidentified and/or assigned to this pod in 1986 were encountered on ten occasions between 20 October and 13 November 1986. Of the 19 members first catalogued in 1985, 12 (i.e. IB-1, 5, 7, 8, 9, 10, 11, 14, 15, 16, 19, and 20) were reidentified in 1986 (IB-8 had also been photoidentified in 1984). In addition, three whales (Misc: I, XVI, and XVII) which had been photoidentified in 1985 in large aggregations (including members of the IB pod as then known) but which could not at that time be assigned to pods, were assigned to the IB pod in 1986. Again, they were identified with IB animals. Eight new members of the IB pod were first identified in 1986, bringing the total number of known members to 29. Twenty three of them were identified in 1986. Eight to 27 whales were estimated to be present in the 10 encounters, and as many as 16 members were photographed in a single encounter. In some

TABLE 3
Summary of individual killer whales assigned to pods which were identified in the period 1984-1986.

| Pod | Year | Animal identification number | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|------|------------------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| IA | 1985 | x | x | x | x | x | x | x | x | o | o | o | x | o | x | | | | | | | | | | | | | | | | | |
| | 1986 | x | x | | | | | x | | | o | | | | | | | | | | | | | | | | | | | | | |
| IB | 1984 | | | | | | | | x | | | | | x | | | | | | | | | | | | | | | | | | |
| | 1985 | x | x | x | o | x | | o | x | x | x | x | o | x | o | o | x | | o | x | o | o | x | | | | | | | | | |
| | 1986 | x | | | | x | | o | x | x | x | x | | x | | | | | | | | | | | | | | | | | x | |
| IC | 1985 | x | o | x | o | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1986 | x | x | x | x | o | x | o | x | o | | | | | | | | | | | | | | | | | | | | | | |
| IE | 1984 | | | | | | x | | | | | | x | | | | | | | | | | | | | | | | | | | |
| | 1986 | x | x | x | x | x | x | x | o | x | x | x | x | o | o | o | o | o | o | | | | | | | | | | | | | |
| IF | 1986 | x | x | x | x | o | | | | | | | | | | | | | | | | | | | | | | | | | | |

x: Positive identifications for which markings are judged to persist over years.
o: Identifications which could be positively separated from others, but for which marking might not be long-term persistent.

instances, IB whales were photographed with whales assigned to other pods. In addition, individuals from the IB pod were encountered twice in aggregations estimated to contain 60-80 whales.

IC pod

A group of at least five whales was encountered near Hafnarfjörður town (SW Iceland) on 10 October 1985. Four members were photoidentified and catalogued (Lyrholm *et al.* 1987). No members of this pod were positively identified in 1986.

ID pod

This newly designated pod was encountered on 23 and 28 October 1986. Nine whales were identified in the first encounter; four of these were also encountered in the second. It is estimated that 14-23 whales were present in the two encounters. Identities of the additional animals present were not determined.

IE pod

Nineteen whales have been provisionally assigned to this newly designated pod. Two members (IE-6 and IE-11) had been photographed in 1984, but none in 1985. Animals from IE pod were encountered seven times between 20 October and 16 November 1986. No more than 10 individuals were photoiden-

tified in any one encounter. An estimated 8-27 animals were present in six of the encounters, 60-80 animals in the seventh.

IF pod

This is the third pod first designated in 1986. The whales were photoidentified four times between 4 and 11 November 1986. Although an estimated number of 6 to 30 animals were present in the four encounters, only five whales were recognized as members of pod IF. All five were photographed together on one occasion, three on another, and one in each of the two other encounters. Identity of other whales present in the encounters could not be determined.

Comparison with animals off Norway

A small sample of 26 photoidentified animals off Møre and Lofoten on the Norwegian coast since 1983 (Lyrholm 1985, 1988 - this volume; Lien *et al.* 1988 - this volume) have been compared with the present material from Icelandic waters. No matches of photos have been found.

DISCUSSION

As can be seen in Table 3, animals have been assigned to the same pod after being identified together in one or more encounters.

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At present, however, these pod designations must be regarded as tentative, and it is still not confirmed whether or not they represent long-term associations of the stability reported for pods in the waters off British Columbia, Washington, and off southern Alaska (Bigg 1982; Balcomb *et al.* 1982; Ellis *et al.* in press). This research needs to continue for several years before conclusions can be reached concerning patterns of associations in killer whales off Iceland.

In some of the encounters presented here, our ability to describe associations have been further confounded by occurrence of aggregations of about 60–80 killer whales, suspected to involve several pods. In such multipod encounters, it is difficult to accurately ascertain associations among individuals. Naturally, pod composition can best be determined in encounters with a single pod. It is interesting, however, that several of the whales assigned to the IB pod association found in 1985, were

TABLE 4
Summary of miscellaneous killer whales photoidentified in the period 1981–1986 but not assigned to pods.

| Identification number | Sex/ Age ¹ | Year identified/encounter number ² | | | | Identification number | Sex/ Age ¹ | Year identified/encounter number ² | | | |
|-----------------------|--------------------------|---|------|------|-------|-----------------------|--------------------------|---|------|------|-------|
| | | 1981 | 1984 | 1985 | 1986 | | | 1981 | 1984 | 1985 | 1986 |
| 129* | a | x | — | — | — | 21* | b | — | — | — | 2 |
| 130 | b | x | — | — | — | 23* | a | — | — | — | 2, 19 |
| 131 | b | x | — | — | — | 25* | a | — | — | — | 2 |
| 132* | a | x | — | — | — | 27 | a | — | — | — | 2, 3 |
| 133* | b | x | — | — | — | 28* | c | — | — | — | 2 |
| 39 | a | — | x | — | 3 | 29* | c | — | — | — | 3 |
| 117 | b | — | x | — | 14 | 30* | b | — | — | — | 3 |
| 118* | b | — | x | — | — | 31* | b | — | — | — | 3 |
| 119* | a | — | x | — | — | 32 | a | — | — | — | 3, 19 |
| 120* | c | — | x | — | — | 35* | b | — | — | — | 3 |
| 121* | b | — | x | — | — | 36 | b | — | — | — | 3 |
| 116 | a | — | — | 10 | 5, 7 | 37 | b | — | — | — | 3 |
| 122* | b | — | — | 4, 6 | — | 40* | a | — | — | — | 3 |
| 123 | a | — | — | 6, 8 | — | 50 | a | — | — | — | 5 |
| 124 | a | — | — | 6, 8 | 2 | 51 | b | — | — | — | 5 |
| 125 | a | — | — | 6, 8 | 2 | 53 | c | — | — | — | 5 |
| 126* | a | — | — | 8, 9 | — | 55* | b | — | — | — | 5 |
| 127* | c | — | — | 8 | — | 56 | b | — | — | — | 5 |
| 128 | b | — | — | 8 | — | 57 | b | — | — | — | 5 |
| 1* | b | — | — | — | 2 | 60* | b | — | — | — | 5, 7 |
| 2* | b | — | — | — | 2 | 61 | b | — | — | — | 7 |
| 3 | a | — | — | — | 2 | 98* | b | — | — | — | 19 |
| 4 | b | — | — | — | 2 | 99* | a | — | — | — | 19 |
| 10 | b | — | — | — | 2 | 100 | a | — | — | — | 19 |
| 11 | b | — | — | — | 2 | 102* | b | — | — | — | 19 |
| 13 | c | — | — | — | 1, 2 | 103* | b | — | — | — | 19 |
| 14 | b | — | — | — | 2 | 104 | b | — | — | — | 21 |
| 15 | a | — | — | — | 2, 19 | 105* | c | — | — | — | 22 |
| 16 | a | — | — | — | 2 | 106* | c | — | — | — | 22 |
| 17* | b | — | — | — | 2, 19 | 107* | c | — | — | — | 22 |
| 18* | b | — | — | — | 2 | 110* | a | — | — | — | 21 |
| 20 | a | — | — | — | 2 | 113* | c | — | — | — | 2 |

* Animals in which distinctive features which permitted identification might not be long-term persistent.

¹ a: Adult males, b: Adult females/subadult males, c: Juveniles/calves.

² Encounter numbers were not assigned in 1981 and 1984.

again found in 1986.

Fifty whales photoidentified in 1986 could not be assigned to pods, even provisionally. These were placed into a miscellaneous category (Table 4). Five of these whales had been identified in previous years, two in 1984 and three in 1985 (Fig. 6). Some animals placed in the miscellaneous category in 1985 were in 1986 placed in a known pod. However, a total of 64 killer whales photoidentified since 1981 remains still in the miscellaneous category.

This total includes five whales photographed at the northwest coast in 1981, in an area not studied since.

Tables 3, 4 and 5 summarize the history of identifications of individual animals from 1981 through 1986. A total of 143 individual killer whales has been photoidentified: 5 off the northwest coast in 1981; 4 off the southwest coast in 1985 (IC pod); and 134 from a relatively small study area off the east coast. To date, we have found no matches with the

TABLE 5

Preliminary age/sex classification of killer whales photoidentified 1981–1986. ¹ *Miscellaneous animals not assigned to pod.* * *Animals whose identification characteristics might not be long-term persistent.*

A) 1986. ^x *Animals also photoidentified in 1985.* ⁺ *Animals also photoidentified in 1984.* ² *First number in bracket indicates the number of identified animals that were also photographed in 1984, the second number those in 1985.*

| Pod | No. identified ² | Adult males No. ID-codes | Adult females/subadult males No. ID-codes | Juveniles/calves No. ID-codes | Comments |
|--------------------|-----------------------------|---|--|--|--|
| IA | 5 (0, 5) | 1 IA-2 ^x | 4 IA-1 ^x , 7 ^x , 10 ^x , 13 ^x | — | 13 animals preliminarily assigned to IA pod in 1985. |
| IB | 23 (1, 15) | 4 IB-1 ^x , 15 ^x , 21 ^x , 29 | 15 IB-5 ^x , 7 ^x , 8 ^{x+} , 9 ^x , 10 ^x , 11 ^x , 14 ^x , 20 ^x , 22 ^x , 24, 25, 27, 28, 30 ^x , 31 | 4 IB-16 ^x , 19 ^x , 23, 26 | 20 animals preliminarily assigned to IB-pod in 1985 with current data adding up to 31, including 3 from 1985 not previously assigned to pod. |
| ID | 9 | 2 ID-2, 3 | 7 ID-1, 4, 5, 6, 7, 8, 9 | — | |
| IE | 19 (2, 0) | 7 IE-2, 3, 5, 6 ⁺ , 7, 11 ⁺ , 12 | 10 IE-1, 4, 9, 10, 13, 14, 15, 16, 18, 19 | 2 IE-8, 17 | |
| IF | 5 | 2 IF-2, 3 | 2 IF-1, 4 | 1 IF-5 | |
| Subtotal | 61 (3, 20) | 16 | 38 | 7 | |
| Misc. ¹ | 50 (2, 3) | 17 — | 25 — | 8 — | |
| Total | 111 (5, 23) | 33 | 63 | 15 | |

B) 1985 and 1986. Figures in brackets indicate sums excluding individuals marked with*.

| Pod | No. identified | Adult males No. ID-codes | Adult females/subadult males No. ID-codes | Juveniles/calves No. ID-codes |
|--------------------|----------------|---|--|---|
| IA | 13 (9) | 2 IA-2, 3 | 10 IA-1, 5, 6, 7, 8 [*] , 9 [*] , 10 [*] , 11, 12 [*] , 13 | 1 IA-4 |
| IB | 29 (17) | 6 IB-1, 4 [*] , 13, 15 [*] , 21 [*] , 29 | 19 IB-2, 3, 5, 7 [*] , 8, 9, 10, 11, 12 [*] , 14 [*] , 18 [*] , 20 [*] , 22, 24 [*] , 25, 27, 28, 30, 31 [*] | 4 IB-16, 19, 23 [*] , 26 [*] |
| IC | 4 (2) | — | 3 IC-1, 3, 4 [*] | 1 IC-2 [*] |
| ID | 9 (6) | 2 ID-2, 3 | 7 ID-1, 4, 5 [*] , 6, 7 [*] , 8, 9 [*] | — |
| IE | 19 (12) | 7 IE-2, 3, 5, 6, 7, 11, 12 | 10 IE-1, 4, 9, 10, 13, 14 [*] , 15 [*] , 16 [*] , 18 [*] , 19 [*] | 2 IE-8 [*] , 17 [*] |
| IF | 5 (4) | 2 IF-2, 3 | 2 IF-1, 4 | 1 IF-5 [*] |
| Subtotal | 79 (50) | 19 (16) | 51 (31) | 9 (3) |
| Misc. ¹ | 55 (28) | 19 (13) | 27 (13) | 9 (2) |
| Total | 134 (78) | 38 (29) | 78 (44) | 18 (5) |

TABLE 5 (continued).

C) 1981-1986. Figures in brackets indicate sums excluding individuals marked with*.

| Pod | Year | | | | | Adult males | | Adult females/subadult males | | Juvenile/calves | |
|--------------------|----------------|-------|-------|---------|---------|-------------|----------------------------|------------------------------|--|-----------------|---------------------|
| | No. identified | | | | | No. | ID-codes | No. | ID-codes | No. | ID-codes |
| | 1981-6 | 81 | 84 | 85 | 86 | | | | | | |
| IA | 13 (9) | | 0 | 13 (9) | 5 (4) | 2 | IA-2, 3 | 10 | IA-1, 5, 6, 7, 8*, 9*, 10*, 11, 12*, 13 | 1 | IA-4 |
| IB | 29 (17) | | 2 | 21 (13) | 23 (14) | 6 | IB-1, 4*, 13, 15*, 21*, 29 | 19 | IB-2, 3, 5, 7*, 8, 9, 10, 11, 12*, 14*, 18*, 20*, 22, 24*, 25, 27, 28, 30, 31* | 4 | IB-16, 19, 23*, 26* |
| IC | 4 (2) | | 0 | 4 (2) | 0 | — | | 3 | IC-1, 3, 4* | 1 | IC-2* |
| ID | 9 (6) | | 0 | 0 | 9 (6) | 2 | ID-2, 3 | 7 | ID-1, 4, 5*, 6, 7*, 8, 9* | — | |
| IE | 19 (12) | | 2 | 0 | 19 (12) | 7 | IE-2, 3, 5, 6, 7, 11, 12 | 10 | IE-1, 4, 9, 10, 13, 14*, 15*, 16*, 18*, 19* | 2 | IE-8*, 17* |
| IF | 5 (4) | | 0 | 0 | 5 (4) | 2 | IF-2, 3 | 2 | IF-1, 4 | 1 | IF-5* |
| Subtotal | 79 (50) | | 4 | 38 (24) | 61 (40) | 19 (16) | | 51 (31) | | 9 (3) | |
| Misc. ¹ | 64 (30) | 5 (2) | 6 (2) | 8 (5) | 50 (26) | 22 (13) | | 32 (15) | | 10 (3) | |
| Total | 143 (80) | | | | | 41 (29) | | 83 (46) | | 19 (5) | |

small sample (26 animals) of killer whales photoidentified off Norway since 1983. Comparison with photographs from elsewhere in the North Atlantic continues. However, the lack of photographic matches between Norway and Iceland, and the indications of limited similarities of acoustic characteristics in animals encountered off Norway and Iceland (Moore *et al.* 1988 - this volume), raise doubts (see Sigurjónsson in press) whether migrations of animals between the two areas occur at present as was suggested by Jonsgård and Lyshoel (1970). These authors based their conclusion on the fact that killer whales were caught along the migration route of the Atlanto-Scandian herring. The question remains whether such migration has stopped after the collapse of the herring stock in the late 1960's (Jakobsson 1985). More photographic and acoustic data are needed from both areas and from the Norwegian Sea to adequately address this question.

Of the 111 whales photoidentified in 1986, 33 (30%) were provisionally classified as adult males, 63 (57%) as adult females/subadult males, and 15 (14%) as juveniles/calves. Of the 143 whales identified from 1981 through 1986, 41 (29%) have been classified as adult males, 83 (58%) as adult females/subadult

males, and 19 (13%) as juveniles/calves (Table 5). The percentage of males in the present study is somewhat higher than the 19 to 23% found by Bigg (1982) and Ellis *et al.* (in press) in different areas of the eastern North Pacific, but is the same as that observed at Marion Island in the southern Indian Ocean (Condy *et al.* 1978). One must use caution, however, in comparing figures on age-sex composition from field studies of killer whales, as different investigators use slightly different criteria and precision in classifying animals. Furthermore, information on pod composition usually improves with time as new data accumulate. Therefore, the above age/sex classifications must be regarded as preliminary. Work is being continued and the classifications will be updated as new data become available. It should be noted in particular that adult males are likely to be accurately classified since they can be readily distinguished on the basis of their tall dorsal fins. In multi-pod aggregations the males are usually the first animals to be identified and may thus have been over-represented in the photoidentified sample. Newborn calves can also be assigned with a high degree of certainty because of their small size and very close association with an accompanying adult. However, they

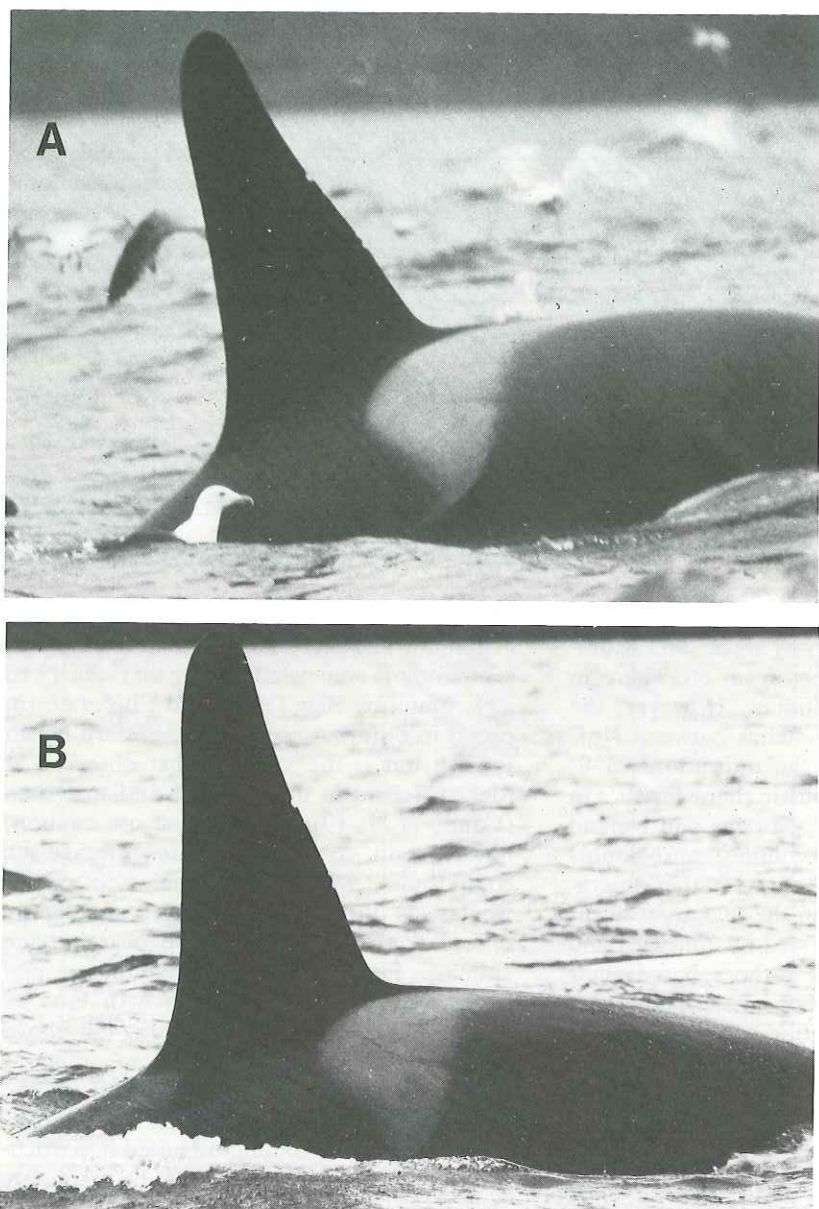


Fig. 6. One of the killer whales (Misc. no. 116) identified in subsequent years east off Iceland; A in Seyðisfjörður on 23 Oct. 1985; B same date and location in 1986. Photographs by, E. Þórðarson (A) and E. Jónsson (B).

may be more easily over-looked in large aggregations. Other animals must be assigned to the broad categories "adult females/sub-adult males" and "juvenile/calves", and cannot reliably be classified more accurately, i.e. into "adult males", "known cows", or "sub-adult males" (following Ellis *et al.* in press),

until specific details have been accumulated on sex and development of individuals.

In this study, all sighted animals have not been photoidentified nor have all known (photoidentified) animals been photographed in each encounter. There may also be differences in the ease with which animals of differ-

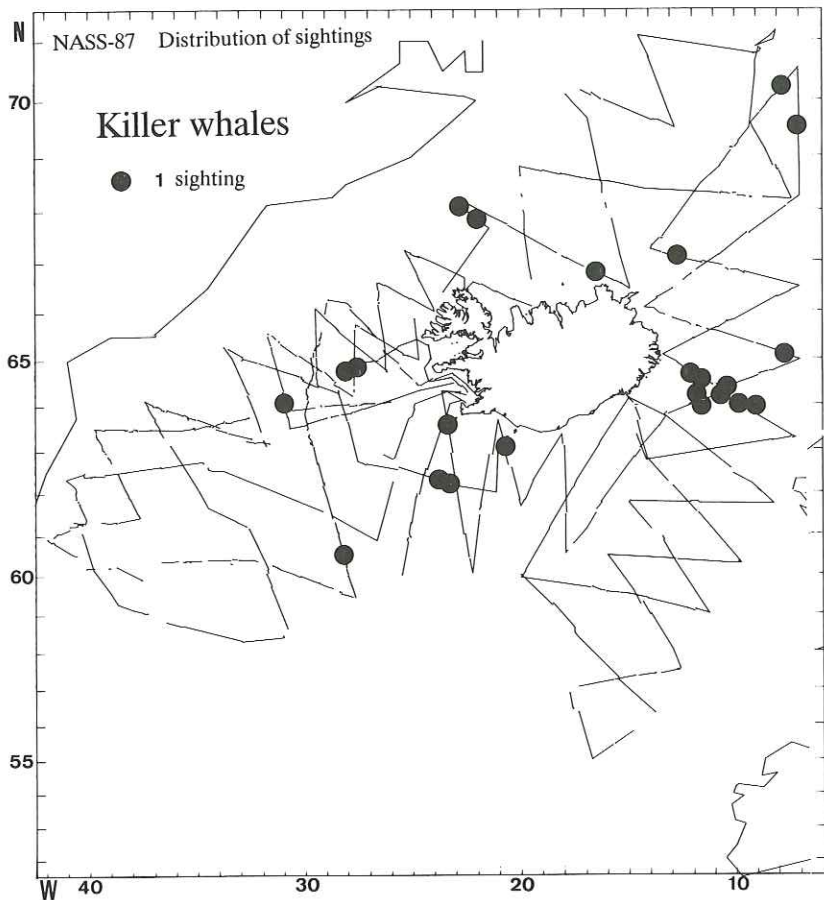


Fig. 7. Distribution of sightings of killer whales during shipboard surveys June-July 1987. (Modified from Sigurjónsson *et al.* in press).

ent age/sex classes can be approached, photographed, and identified. Nevertheless, the present account demonstrates encouraging progress in documentation of killer whales for demographical studies of the population(s) off Iceland and for comparative studies of populations elsewhere.

The limited area coverage of this study should be noted. Our study area is mostly restricted to the relatively small inshore area off the eastern Icelandic coast, while killer whales are known to occur in other areas around Iceland, as the five animals photoidentified at the northwest coast in 1981 and the IC pod identified in the southwestern area in 1985 clearly demonstrate. Unfortunately, due to unfavourable weather conditions, our efforts in 1986 failed to cover the areas farther off the coast,

which would have improved our sample from the Iceland area. It is evident, however, that the 143 animals so far photoidentified, represent a conservative estimate of the population(s) off Iceland. This seems particularly so in the light of data collected during summer of 1987 onboard the three Icelandic sighting vessels in Icelandic and adjacent waters, which indicated a widely distributed summer stock of killer whales, numbering at least 4,000 animals in the areas surveyed (Sigurjónsson *et al.* in press; Gunnlaugsson and Sigurjónsson in press). An analysis of photographic material obtained onboard the survey vessels is underway, and may throw some new light on the summer range of the killer whale aggregations occurring in East Icelandic nearshore areas in late fall and winter.

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