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Cetaceans of the Atlantic Frontier, north and west of Scotland

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Abstract

Surveys carried out to the north and west of Scotland have recorded 15 species of cetacean between 1979 and 1998. These were fin whale (*Balaenoptera physalus*), sei whale (*B. borealis*), minke whale (*B. acutorostrata*), humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), northern bottlenose whale (*Hyperoodon ampullatus*), Sowerby's beaked whale (*Mesoplodon bidens*), killer whale (*Orcinus orca*), long-finned pilot whale (*Globicephala melas*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), white-beaked dolphin (*L. albirostris*), Risso's dolphin (*Grampus griseus*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*). Atlantic white-sided dolphin was the most abundant species in the region with a total of 6317 animals recorded. Harbour porpoise was the most frequently sighted cetacean species. The geographical distribution of sightings indicate that cetacean species have varying ecological requirements, with species such as sperm whale, pilot whale and white-sided dolphin favouring deep water off the continental shelf edge, while minke whale, white-beaked dolphin and harbour porpoise were apparently limited to the continental shelf. The diversity of species recorded in the region suggests that the Atlantic Frontier is an important habitat for cetaceans. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The Seabirds at Sea Team (SAST) of the Joint Nature Conservation Committee has been carrying out surveys of seabirds in the waters around Britain and Ireland since 1979. An additional role of the surveys is to collect sightings of marine mammals. Intensive surveys have been conducted along the continental shelf edge to the north and west of Shetland and the

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Western Isles since 1997. These surveys concentrate on waters where seabird and cetacean distribution is poorly known, in particular oil licence blocks granted in the 17th and previous offshore oil licensing rounds. The oil industry requires such information to prepare oil contingency plans and Environmental Impact Assessments, while the government needs such information to help fulfil its nature conservation obligations. The resulting data are added to the European Seabirds at Sea (ESAS) database (Stone et al., 1995) to produce maps of distribution and abundance of seabirds and cetaceans.

Previous studies of cetacean distribution overlap the current study area. SAST projects have documented cetacean distribution north of Scotland primarily between Shetland and the Faroes (Bloor et al., 1996) and also around Ireland (Pollock et al., 1997). The distribution of individual species has also been studied using the SAST database (Northridge et al., 1995, 1997). Larger scale studies such as the North Atlantic Sightings Survey (e.g. Buckland et al., 1993; Sigurjónsson et al., 1989, 1991; Skov et al., 1995) provide further information on cetaceans in the area. Cetacean observations have also been carried out from seismic vessels in the study area (Stone, 1997, 1998). Other cetacean surveys have been carried out around the Hebrides (Evans et al., 1993; Boran and Evans, in press), along continental shelf margins west of Scotland (Evans, 1981) and to the north and west of Shetland and the Hebrides (Hughes et al., 1998). Acoustic monitoring of cetaceans has also been carried out in the area (Clark and Charif, 1998; Lewis et al., 1998).

Of the 27 cetacean species that have previously been noted in UK waters (Evans, 1995), 15 were recorded during SAST surveys. These included seven whale species, seven species of dolphin and the harbour porpoise. SAST surveys represent the first systematic study of the distribution of cetaceans in the area throughout the year.

This paper will present individual accounts for the 15 cetacean species recorded during surveys of the region.

2. Methods

Seabird and cetacean surveys were carried out throughout the year from chartered vessels, ferries and various vessels of opportunity e.g. research vessels. The study area lies between the latitudes 55°00'N and 63°00'N, and between the longitudes 02°00'E and 11°30'W, and includes areas of water over 2300 m in depth (Fig. 1).

Seabird surveys were carried out using standardised SAST methods (Tasker et al., 1984; Webb and Durinck, 1992). Seabirds were counted in a 90° scan ahead of the ship and to one side of the vessel, and were considered to be within transect when recorded within a 300 m band. Opportunistic sightings of cetaceans were recorded throughout the period of the survey. Although the distance and angle to a sighting were not recorded, animals were noted as being within or outside of the 300 m transect band. Cetaceans were recorded at all distances and on either side of the ship while steaming, but the standard seabird methodology utilised resulted in a concentration of observer effort on one side of the vessel only. Additional information recorded included species identification, number and age (if known) of animals, behaviour and direction of travel.

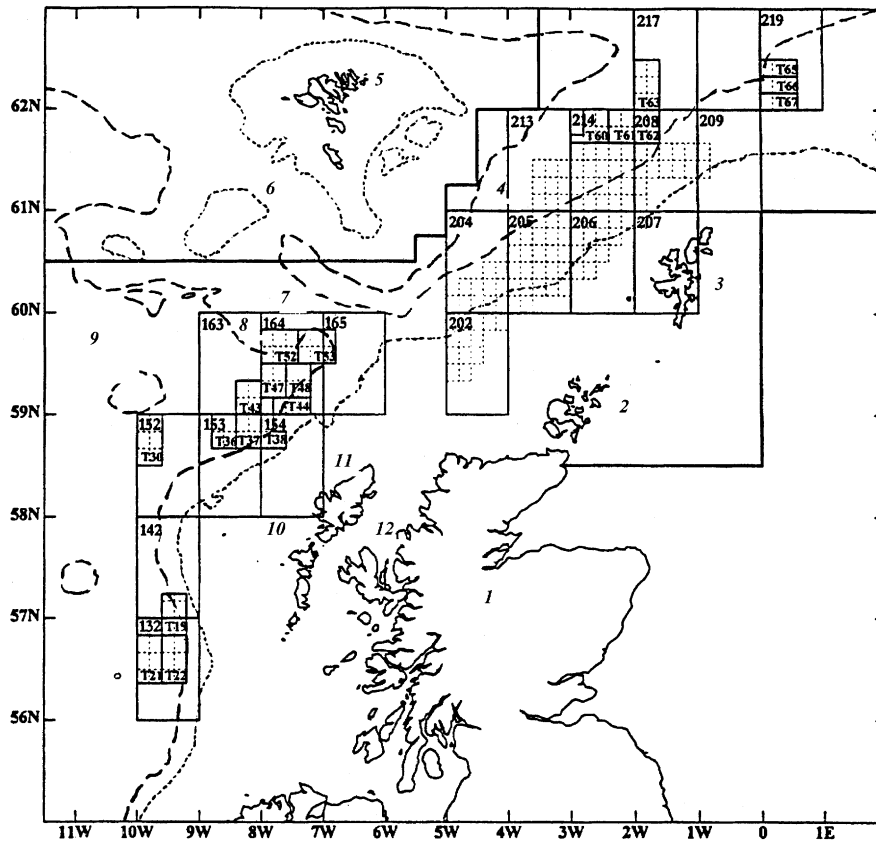


Fig. 1. Map of Atlantic Frontier study area showing targeted licence blocks. Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); Licence quadrants ($1^{\circ}\text{N} \times 1^{\circ}\text{W}$ rectangles); licence blocks ($10'\text{N} \times 12'\text{W}$ rectangles). Place names mentioned in text: (1) Scotland; (2) Orkney Isles; (3) Shetland Isles; (4) Faroe-Shetland channel; (5) Faroe Islands; (6) Faroe Bank channel; (7) Wyville-Thompson Ridge; (8) Ymir Ridge; (9) Atlantic Ocean; (10) Outer Hebrides; (11) Isle of Lewis; and (12) The Minch.

Environmental data including wind speed and direction, sea state, swell height and visibility was recorded every 90 min, or more frequently if conditions changed. The vessel's position, course and speed was calculated or recorded (using a Global Positioning System receiver) every 10 min.

SAST methodology cannot usually be used to estimate absolute population densities for cetaceans due to the opportunistic way in which the data are collected. Data for the most numerous species were therefore resolved into a measure of 'abundance', using the number of individuals sighted per kilometre of trackline travelled. In this paper, cetacean distribution is mapped in three ways: (1) sighting locations are mapped for species with less than 100 animals recorded; (2) numbers of individual animals are mapped for species with a total of 100–1500 animals observed and (3) 'abundance' of species with more than 1500 animals recorded. For the abundance maps, survey effort data were grouped into quarter ICES (International Council for the Exploration of the Sea) rectangles ($15'$ latitude by $30'$ longitude). Maps of cetacean distribution were produced using Dmap for Windows (Morton, 1995). The methodology utilised

during SAST surveys does not allow an accurate comparison between species since cetacean species vary greatly in their detectability, particularly in rough sea conditions (Clarke, 1982). However, for each species a measure of individuals per kilometre travelled provides an indication of relative distribution throughout the study area.

3. Survey coverage

Survey effort data from both the SAST and ESAS databases between 1979 and July 1998 were used in this analysis. A total of 155,308 km of survey coverage was achieved in the survey area. This coverage shows strong seasonal variation, with almost double the level of coverage achieved during the summer months of May to October (100,177 km) than in winter (55,130 km). Most coverage was achieved in July (27,871 km), with least coverage in December (6380 km).

The geographical distribution of survey coverage is also variable with respect to season. Over the winter, coverage of deep waters off the shelf edge is poor, with most winter deep-water effort concentrated to the north-west of the Western Isles between November and January (Figs. 2a and d). Survey coverage in deep, offshore waters was both greatest and most widespread between May and July (Fig. 2b). Extensive survey coverage was also achieved between August and October (Fig. 2c), although coverage in deep waters of the Faroe-Shetland Channel and north-west of the Hebrides was less than in May to July. Inshore waters along the continental shelf received a good level of survey coverage throughout the year, particularly the Minches and the Pentland Firth.

The distribution of survey coverage also differs between years. Surveys between 1979 and 1985 concentrated on the North Sea, and mainly covered shelf areas around the Shetland and Orkney Islands in the present study area (Fig. 3a). Emphasis moved to the shelf waters to the north and west of Scotland between 1986 and 1994 (Fig. 3b), with little coverage achieved in deep water off the shelf edge. Offshore data in the deep waters of the Atlantic Frontier have been collected relatively recently, with the majority of offshore surveys occurring between 1995 and 1998 (Fig. 3c).

4. Cetacean distribution and abundance

Between 1979 and July 1998, a total of 11,248 individual cetaceans of 15 species were recorded in the study area (Table 1). An additional 907 animals were not identified to species level.

4.1. *Fin whale*

Fin whales were recorded in the study area only between May and October, with peak numbers of ten whales in May and August. The distribution of fin whales was centred north of 60°N to the south and south-east of the Faroe Islands, and all of the sightings occurred near to or over the 1000 m isobath (Fig. 4). It has been suggested that some fin whales use the shelf edge as a migration channel, spending the summer months feeding at high latitudes before returning south to the wintering grounds (Evans, 1987). Although fin whales may be sighted throughout their North Atlantic range during the summer months (Sigurjónsson, 1995), their abundance increases

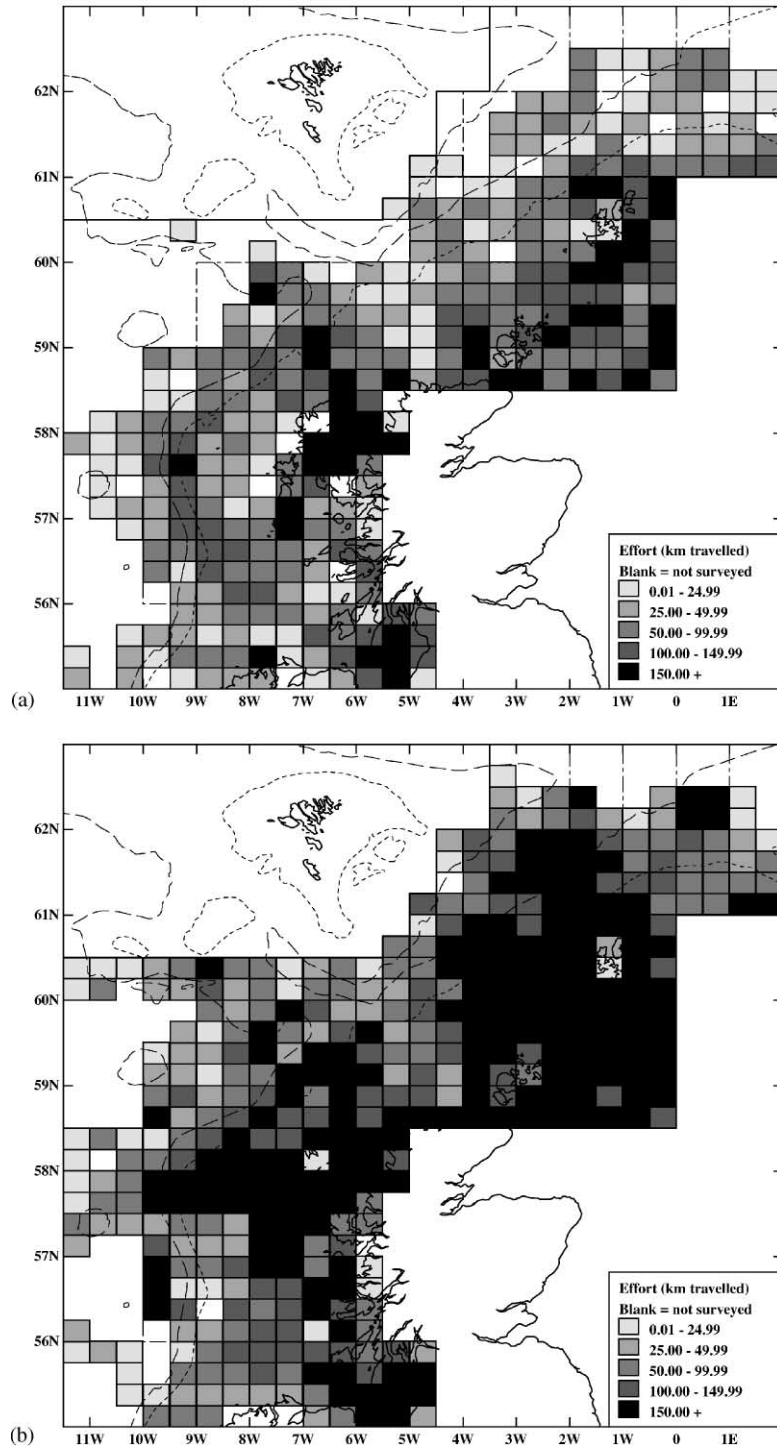


Fig. 2. Survey effort between (a) February and April; (b) May and July; (c) August and October; (d) November and January Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

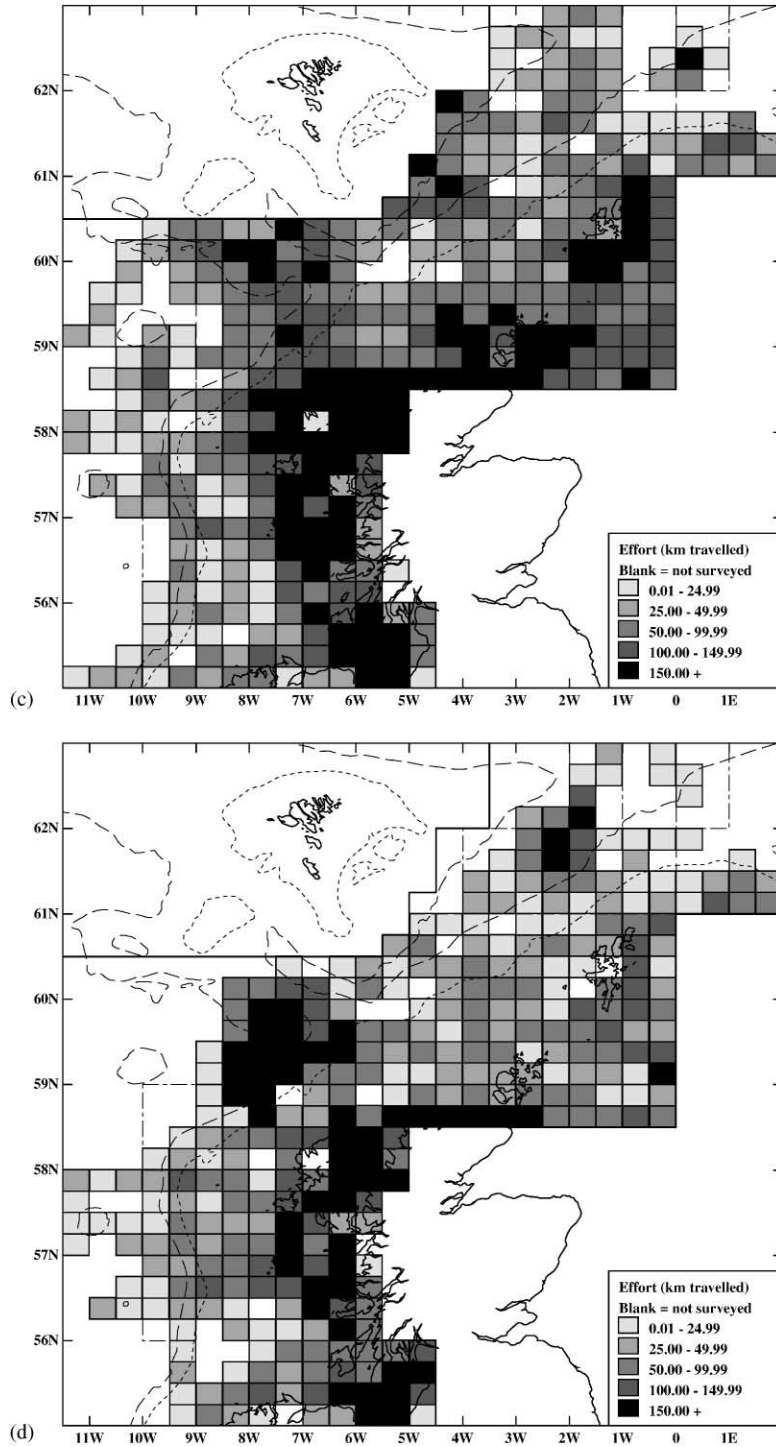


Fig. 2 (Continued).

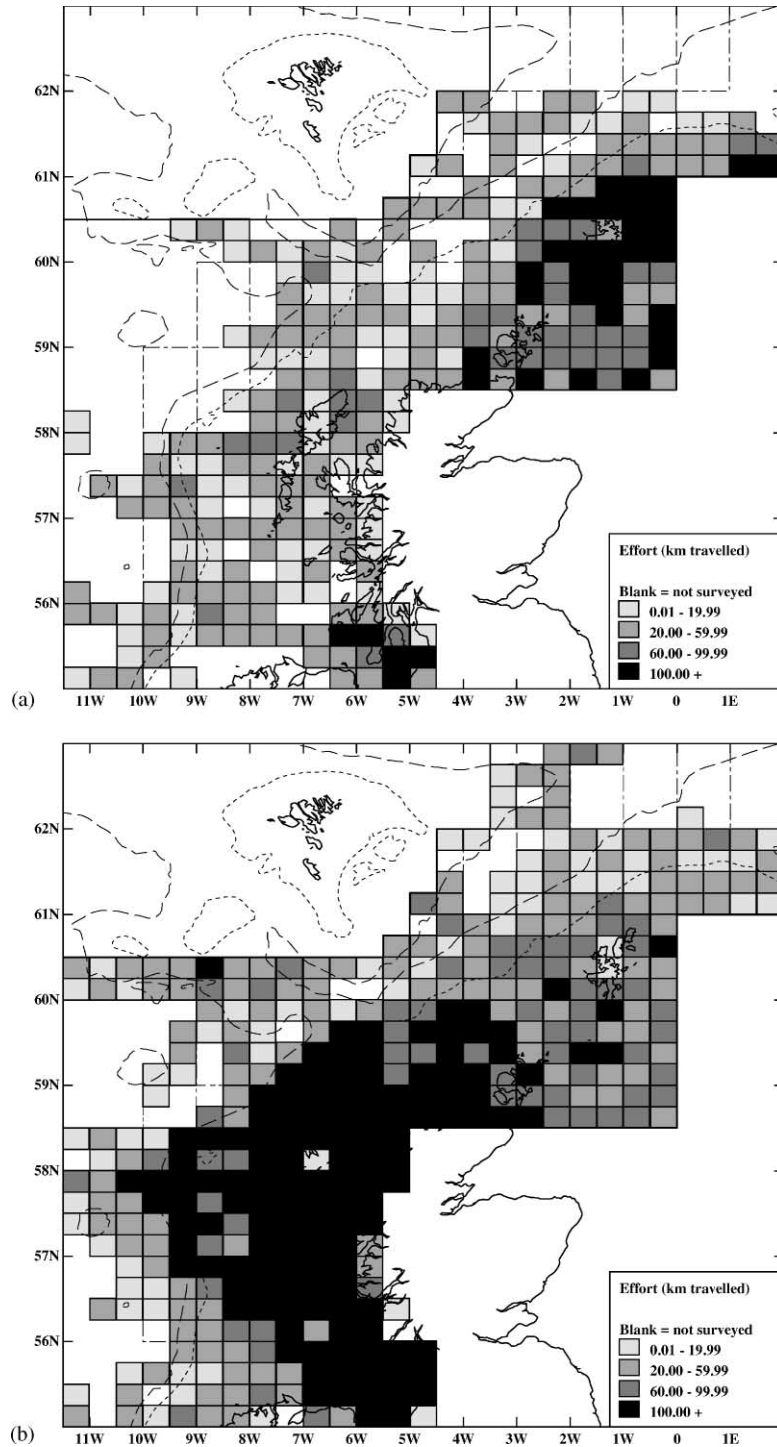


Fig. 3. Survey effort between (a) 1979 and 1985; (b) 1986 and 1994; (c) 1995 and 1998 Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

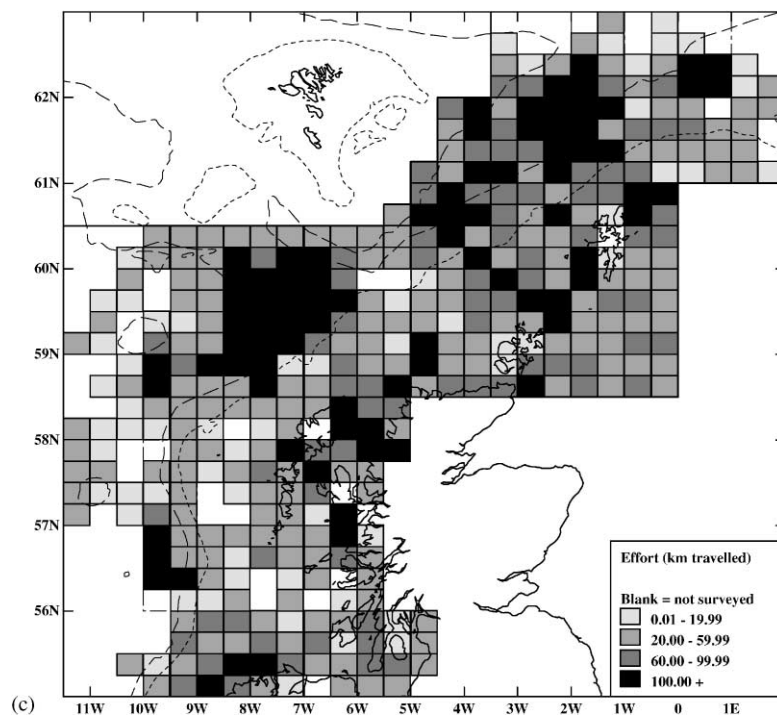


Fig. 3 (Continued).

at high latitudes over the summer supporting some level of seasonal north-south migration (Jonsgård, 1966). However, acoustic monitoring of baleen whales has detected fin whales to the north and west of Scotland in every month of the year, with no sign of systematic direction in their movement (Clark and Charif, 1998), suggesting that a number of animals may be resident in the Atlantic Frontier region. Sightings and stranding of adults with calves off southern Ireland and the channel approaches, also suggest that some fin whales may remain in UK waters over the winter to breed (Evans, 1992).

4.2. Sei whale

Sei whales also were recorded only between May and October, and show a similar pattern of distribution to fin whales (Fig. 4). Sei whale records occurred south of 59°N during June and July, and north of 60°N during all other months. The largest number of animals occurred in August, with 28 individuals all recorded in the Faroe-Shetland Channel. Catches of sei whales were made along the shelf edge between June and August by Scottish whaling stations (Evans, 1992). Sei whales are thought to migrate between high-latitude summer feeding areas and low latitude wintering areas, reaching Scottish waters between April and July, and returning southwards during late August and September (Jonsgård and Darling, 1977). A small number of sightings have occurred between October and December (Evans, 1992), suggesting that some animals may remain at high latitudes over the winter.

Table 1
Total number of each cetacean species recorded in the study area since 1979

Cetacean species	Total number of sightings	Total number of animals recorded
Fin whale <i>Balaenoptera physalus</i>	16	30
Sei whale <i>Balaenoptera borealis</i>	18	40
Minke whale <i>Balaenoptera acutorostrata</i>	130	145
Humpback whale <i>Megaptera novaeangliae</i>	4	5
Sperm whale <i>Physeter macrocephalus</i>	57	68
Northern bottlenose whale <i>Hyperoodon ampullatus</i>	5	12
Sowerby's beaked whale <i>Mesoplodon bidens</i>	1	1
Killer whale <i>Orcinus orca</i>	44	205
Long-finned pilot whale <i>Globicephala melas</i>	121	1642
Atlantic white-sided dolphin <i>Lagenorhynchus acutus</i>	290	4670
White-beaked dolphin <i>Lagenorhynchus albirostris</i>	495	1711
Risso's dolphin <i>Grampus griseus</i>	68	258
Bottlenose dolphin <i>Tursiops truncatus</i>	21	131
Common dolphin <i>Delphinus delphis</i>	74	1012
Harbour porpoise <i>Phocoena phocoena</i>	650	1318
<i>Unidentified cetaceans</i>		
Cetacean sp.	26	56
Whale sp.	93	187
Beaked whale sp.	9	21
Dolphin sp.	232	643

4.3. Minke whale

Minke whales were the most commonly recorded baleen whale species in the study area, with a total of 145 individuals. Of the 130 sightings, only 12 occurred in water depths over 200 m (Fig. 5). Sightings were most frequent in the northern Minch, particularly along the east coast of Lewis where animals were frequently observed feeding with aggregations of white-beaked dolphins. Minke whales in Scottish waters were recorded only between May and October with peak abundance between June and August. Evans et al. (1993) and Boran and Evans (in press) found a similar seasonal pattern in the Minch and the sea of Hebrides. Evans (1980) suggested that some animals probably move south to breed during the winter, before returning to higher latitudes to feed during the summer months (Evans, 1980).

4.4. Humpback whale

The humpback whale is a rare species in the Atlantic Frontier study area with only four records comprising five individuals since 1979. Sightings between May and July occurred over the 1000 m isobath, while a sighting in April was in water less than 200 m depth (Fig. 4). Seasonal migration of humpback whales is documented in the north-west Atlantic, where animals move between high-latitude summer feeding areas, and sub-tropical winter breeding grounds (Martin et al., 1984).

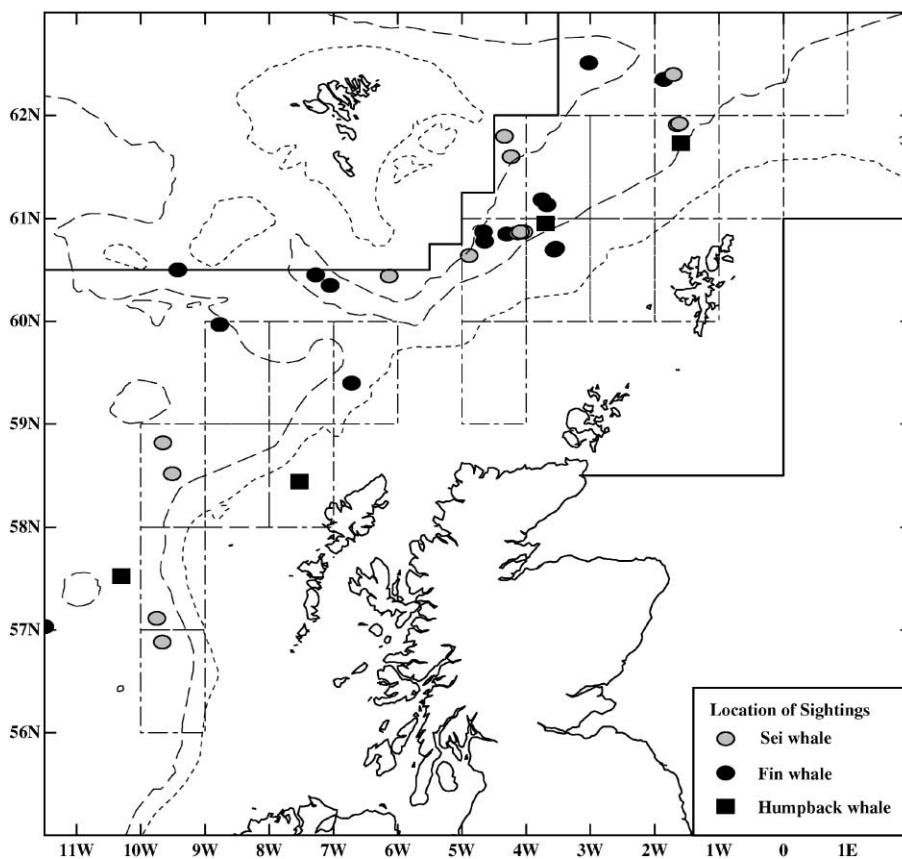


Fig. 4. Distribution of fin, sei and humpback whale sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

The seasonal records of animals in the Atlantic Frontier study area suggest that such movement may also occur in the north-east Atlantic. The population of humpback whales in the north-east Atlantic is only slowly recovering from over-exploitation, although it may never have been particularly abundant in the region (Evans, 1987, 1992). However, the occurrence of four sightings since 1988, and the annual summer return of up to three humpback whales to the inshore waters around the Shetland Islands since 1992 (P. Fisher, pers. comm.), may indicate a recent return of this species to the region.

4.5. *Sperm whale*

The sperm whale was the most regularly sighted large whale in the Atlantic Frontier study area, and was recorded in every month except February and March. 86% of sperm whale sightings involved single animals and it is probable that animals sighted at these latitudes are sub-adult or mature males, which account for the majority of sightings and stranding in British and Irish waters (Berrow et al., 1993). All sperm whale sightings were distributed adjacent to or over the

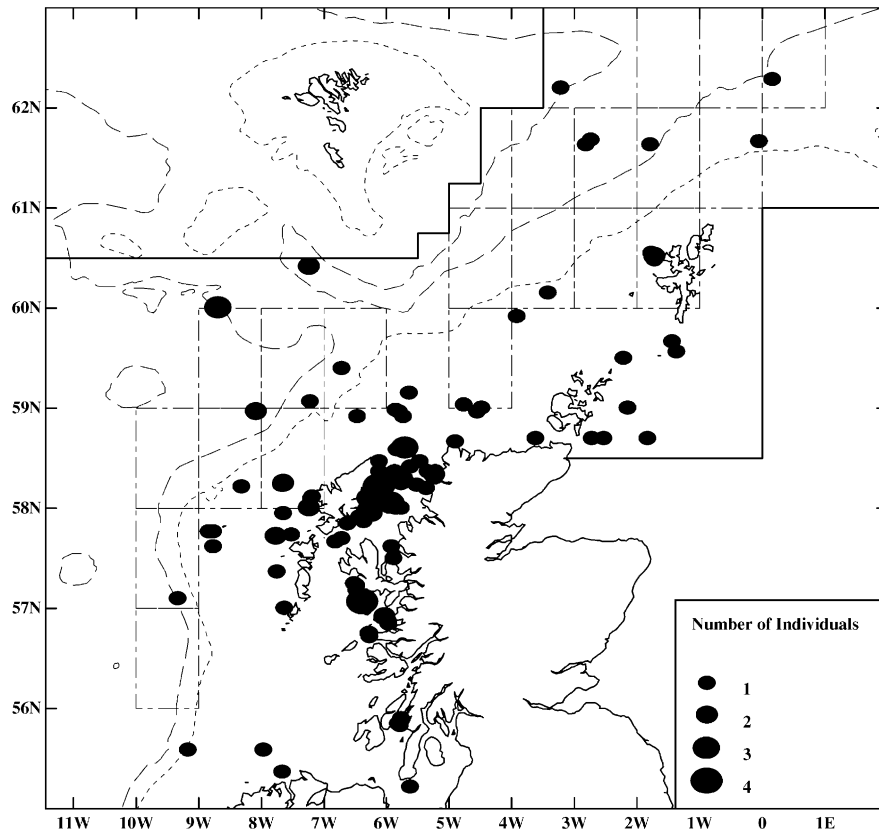


Fig. 5. Distribution of minke whale sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

1000 m isobath to the north and west of Scotland (Fig. 6), and this is likely to be related to the distribution of their prey, particularly cephalopod populations that occur in intermediate and deep waters (Rice, 1989). The high frequency of sperm whale sightings is partly a result of their behaviour; animals tend to occur at the surface for several minutes after a long dive, increasing the time available for detection by an observer. The conspicuous and distinctive blow of the sperm whale also aids identification of this species, and results in a higher number of animals being positively identified in comparison with baleen whale species.

4.6. Unidentified beaked whale species

Beaked whales are of particular importance in the waters of the Atlantic Frontier since they are poorly known deep-water species that are rarely seen and difficult to identify at sea. A total of 21 unidentified individuals were recorded in the area, most of which were thought to belong to the genus *Mesoplodon*. Beaked whales were only recorded north of 58°N and the majority of sightings were located to the north-west of the Outer Hebrides (Fig. 7). Sightings occurred in May and

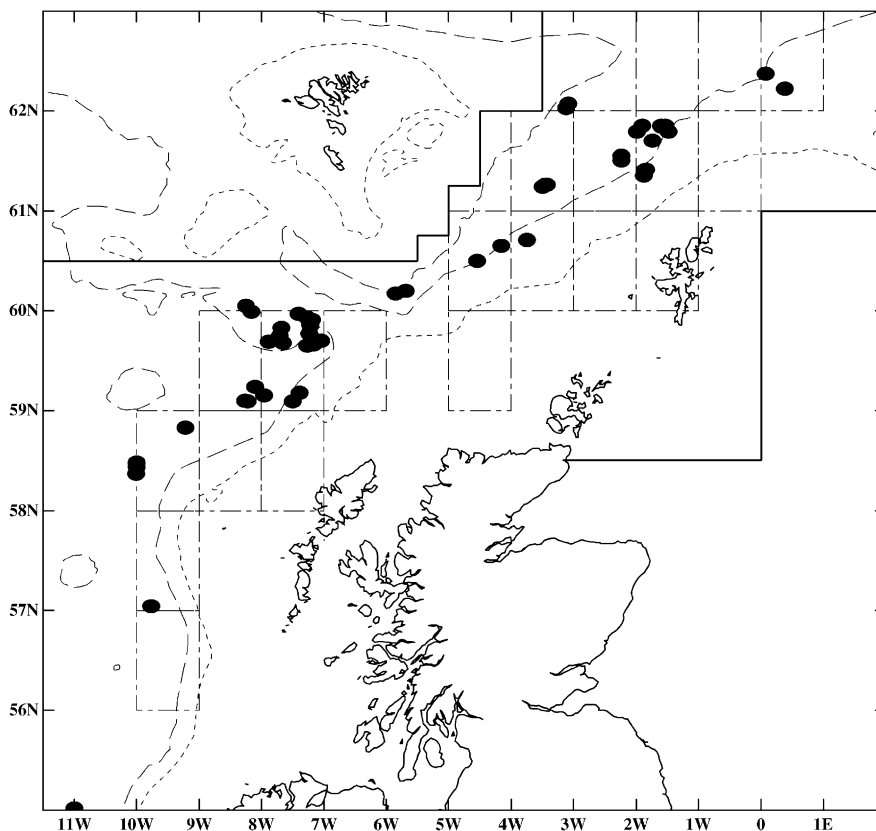


Fig. 6. Distribution of sperm whale sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

between August and January and consisted of an average of 2.3 animals. All sightings of beaked whales occurred over or near the 1000 m isobath where the animals dive for long periods of time presumably in search of squid. Like sperm whales, beaked whales have long dive duration, but their smaller size and inconspicuous surfacing behaviour may explain the lower number of sightings at sea.

4.7. Northern bottlenose whale

Northern bottlenose whales were the most frequently recorded species of beaked whale in the Atlantic Frontier region, with a total of 12 individuals seen. The average group size of bottlenose whales sighted in the study area was 2.4 animals. Evans (1980) also reported frequent sightings of two animals in British waters and suggested that animals may occur as pairs. Reeves et al. (1993) found the distribution of northern bottlenose whales to be centred in cold, deep waters near or seaward of the 1000 m isobath, and this is certainly the case in the Atlantic Frontier study area (Fig. 7). In Atlantic Frontier waters, sightings of northern bottlenose whales occurred in March, April, May, August and November, which may indicate a degree of seasonal migration, as

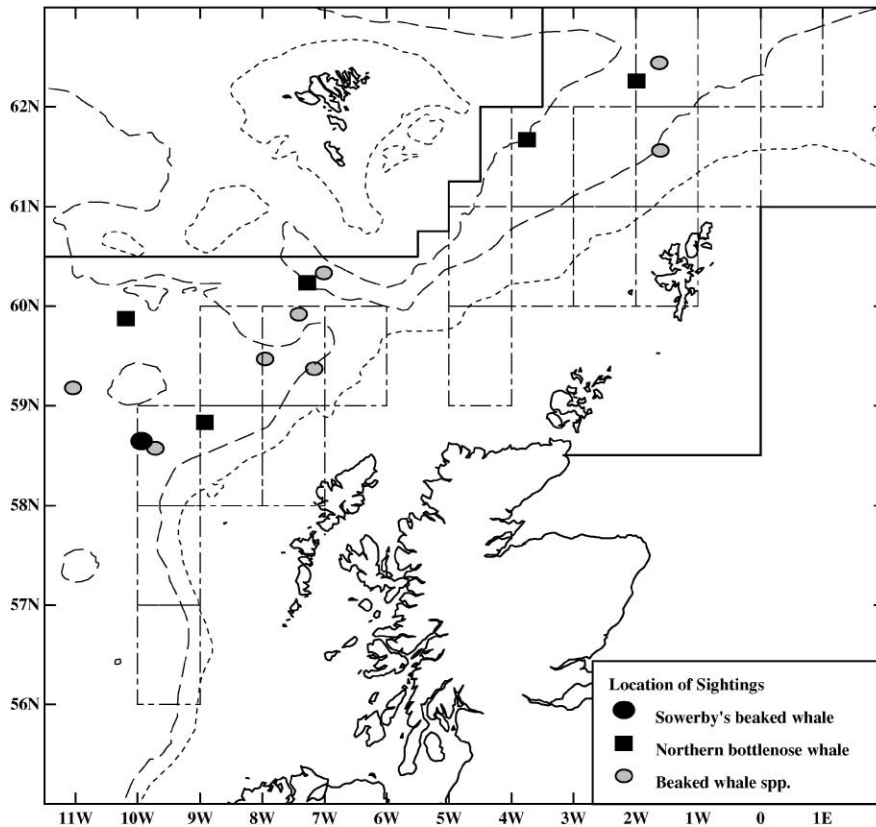


Fig. 7. Distribution of beaked whale sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

suggested by Evans (1980). However, it is possible that further sightings of bottlenose whales within the study area may show a year-round occurrence, as has been found in areas of the north-west Atlantic (Whitehead et al., 1997).

4.8. Sowerby's beaked whale

Sowerby's beaked whale was positively identified once during SAST surveys when a single individual surfaced in close proximity to the vessel in June 1998. The sighting occurred in deep water north-west of the Outer Hebrides (Fig. 7). Species of *Mesoplodon* can generally only be distinguished by the position of the teeth on the lower jaw of adult males, resulting in difficulties with identification of animals seen at a distance from the vessel. Previous live sightings in the north-east Atlantic (Carlström et al., 1997), and regular stranding of this species in British waters (Mead, 1989) suggests that many of the unidentified beaked whales recorded in Atlantic Frontier waters may also be of this species.

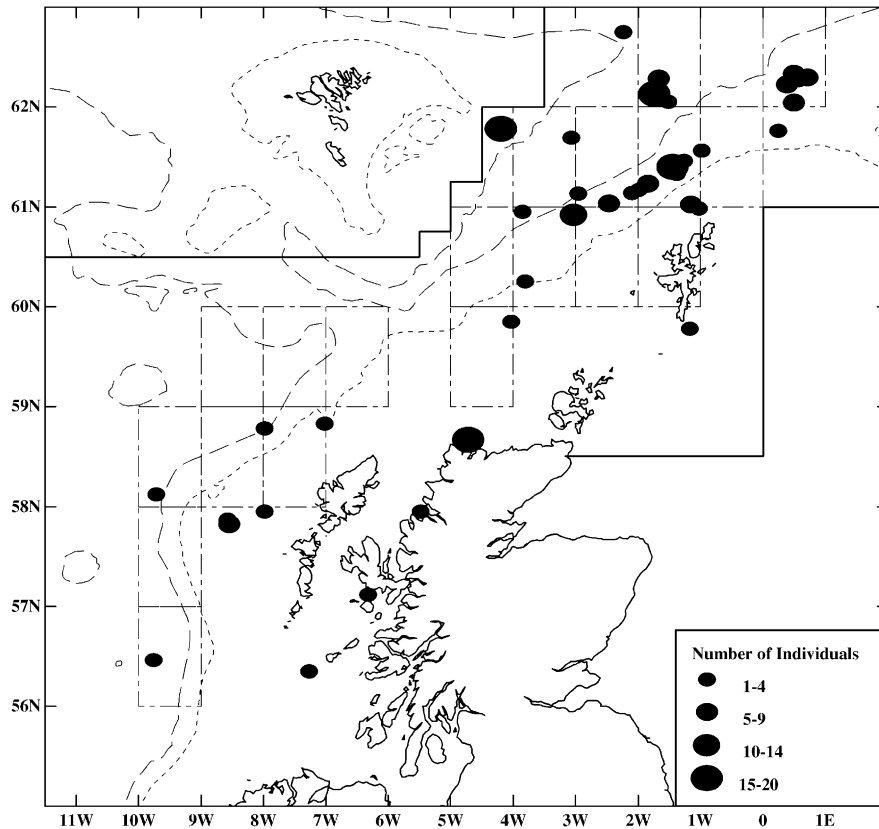


Fig. 8. Distribution of killer whale sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

4.9. Killer whale

Killer whales were widely dispersed in the study area in most months of the year, although the main concentration of sightings occurred to the north and north-west of Shetland (Fig. 8). The average group size within the study area of 4.6 animals, was also found by Evans (1988) for British waters. Groups of killer whales within the 200 m isobath tended to comprise fewer animals than those found in deeper water. Half of the total number of animals observed were recorded during June. During May and June, sightings were primarily distributed in offshore waters of between 200 m and 1000 m depth, to the north of the Shetland Islands. Throughout the rest of the year sightings were widespread over the study area, indicating that individual killer whale pods may range over a wide area (Evans 1988).

4.10. Long-finned pilot whale

The Atlantic Frontier is an important area for long-finned pilot whales which show a strong association with deeper waters over the shelf edge (Fig. 9). Concentrations of animals occurred

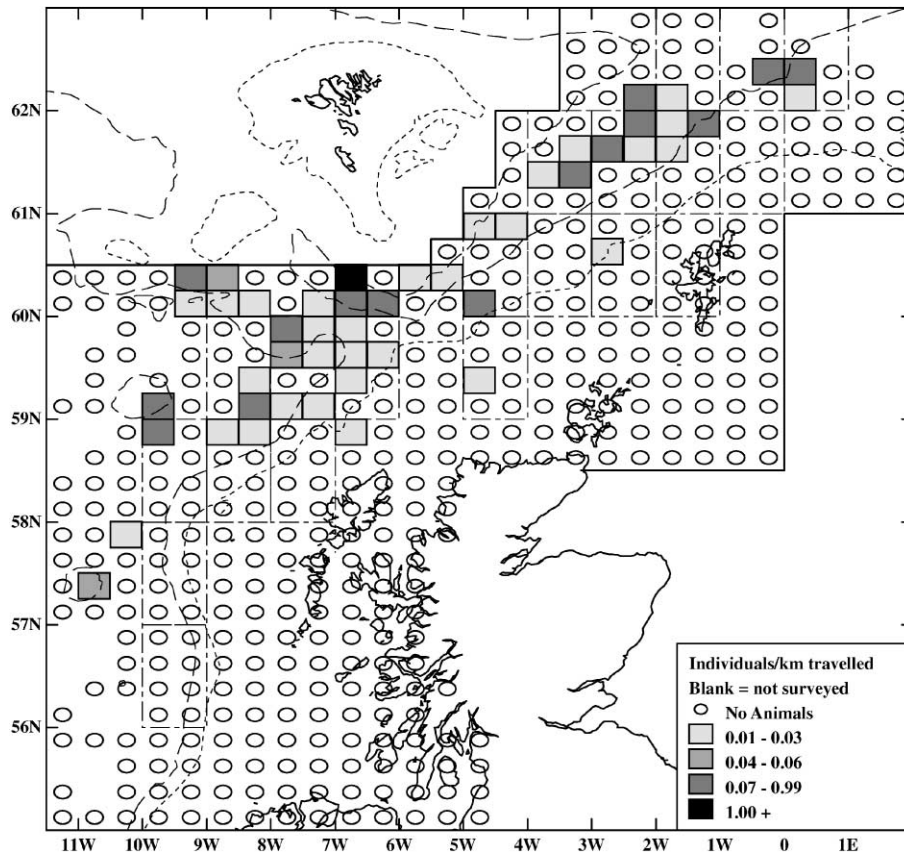


Fig. 9. Abundance of pilot whales (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

along the Faroe-Shetland Channel and the Faroe Bank Channel, which may be related to the distribution of deep-water squid, their main prey (Bloch et al., 1993). Although this was only the fifth most frequently sighted species in the study area, the gregarious nature of pilot whales resulted in an average school size of 13.6 animals, making it the third most abundant species recorded in the Atlantic Frontier region. The peak number of pilot whales (51% of total animals observed) was recorded during August. Pilot whales were often recorded in mixed species aggregations with Atlantic white-sided dolphins, and occasionally with bottlenose dolphins.

4.11. Atlantic white-sided dolphin

The Atlantic white-sided dolphin was the most numerous species recorded in the Atlantic Frontier study area, with a total of 4670 individuals observed. Dolphins were recorded in all months of the year, with a higher number recorded between June and August, and during October and November. White-sided dolphins were most abundant in deep water along the shelf edge, especially over the Faroe-Shetland Channel and the Faroe Bank Channel (Fig. 10). The increased

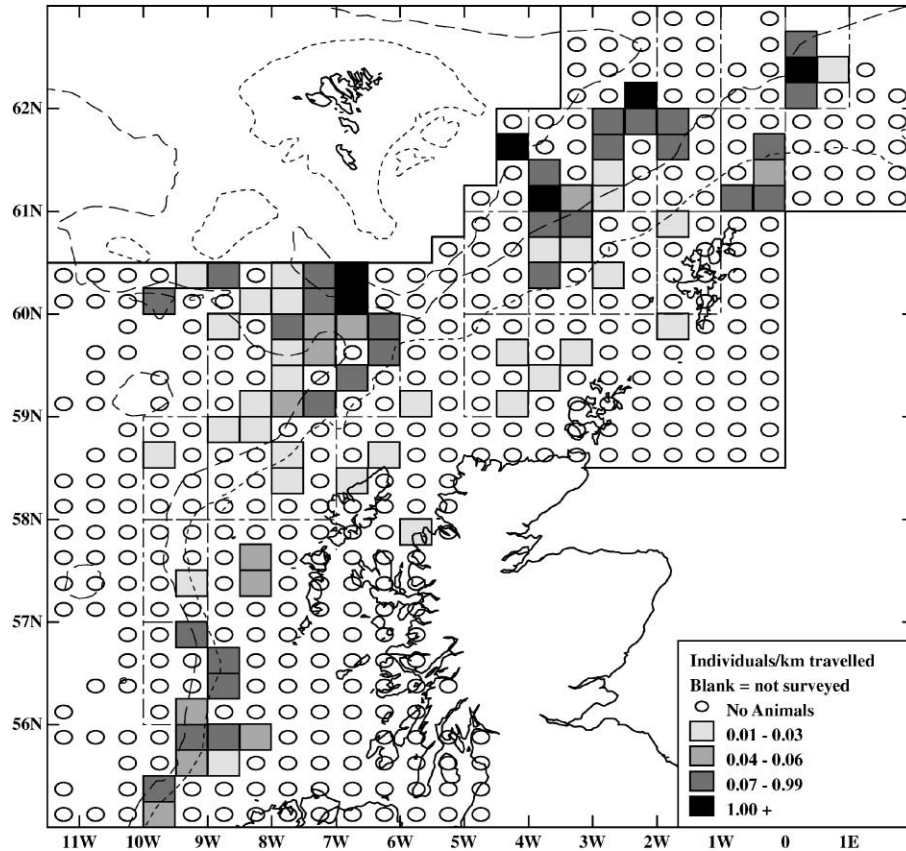


Fig. 10. Abundance of Atlantic white-sided dolphins (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

occurrence of this species over areas of high seabed relief has also been documented in the north-west Atlantic (Selzer and Payne, 1988). Groups of white-sided dolphins became more frequent in waters less than 1000 m depth during July and August. An inshore movement of this species during the summer months has also been recorded in areas of the western Atlantic (Northridge et al., 1997). White-sided dolphins are a gregarious species, with an average group size of 16.1 animals. During August there was a large increase in numbers of white-sided dolphins in the study area, with twice as many dolphins recorded as in any other month. Aggregations containing over one hundred animals were recorded on 13 occasions.

4.12. *White-beaked dolphin*

The white-beaked dolphin was the most frequently sighted dolphin species in the inshore waters of the Atlantic Frontier study area, and its distribution was almost entirely confined to shelf areas within the 200 m isobath. Sightings of white-beaked dolphins have occurred in every year that data has been collected, and they are generally considered to be the most common inshore species

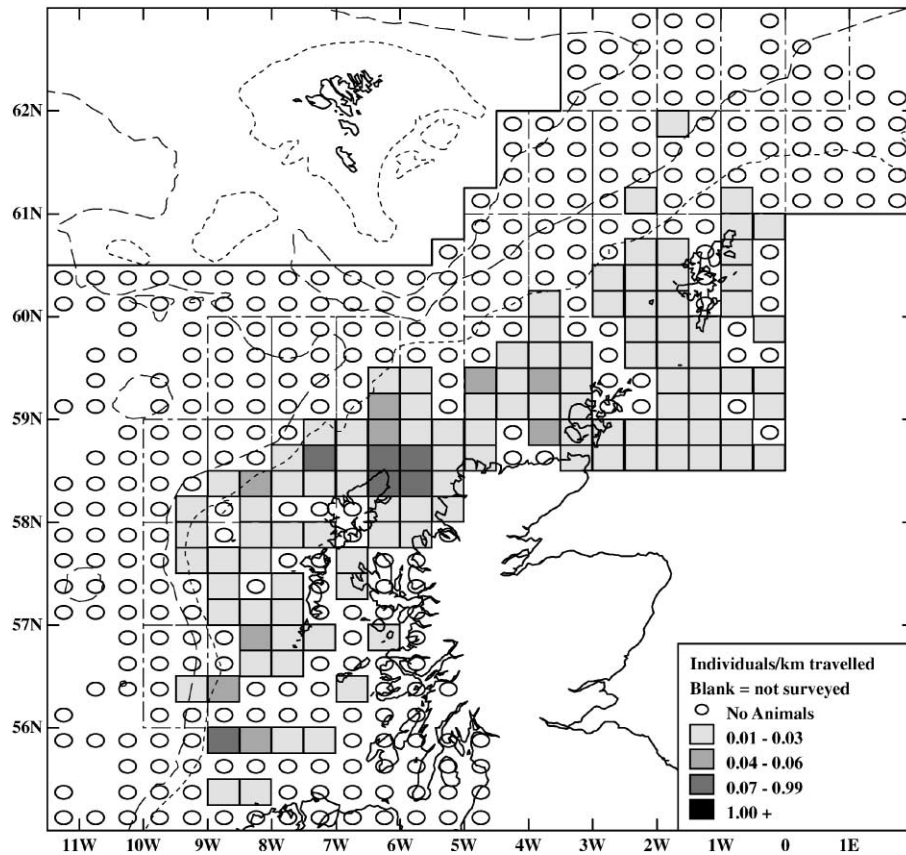


Fig. 11. Abundance of white-beaked dolphins (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

of dolphin off Scotland (Evans, 1987). Dolphins were recorded in every month of the year, with an increase in numbers between May and September, and a peak during August. The distribution of white-beaked dolphins was centred around north Scotland, in particular the northern Minch (Fig. 11). During June, dolphin numbers peaked in the Minch and on the shelf west of the Hebrides. While the Minch contained large numbers of white-beaked dolphins throughout the summer months, they also became widespread in the northern North Sea during July, and reached a peak in numbers in this region during August. The peak in numbers off north Scotland during August may be associated with concentrations of spawning herring (Evans, 1980). Although white-beaked dolphin schools comprised only an average of 3.5 animals, the high frequency with which they were observed rendered this species the second most abundant cetacean in the study area.

4.13. Risso's dolphin

Risso's dolphins were relatively uncommon in the Atlantic Frontier region but showed a widespread distribution throughout the shelf waters of north Scotland, Orkney and Shetland

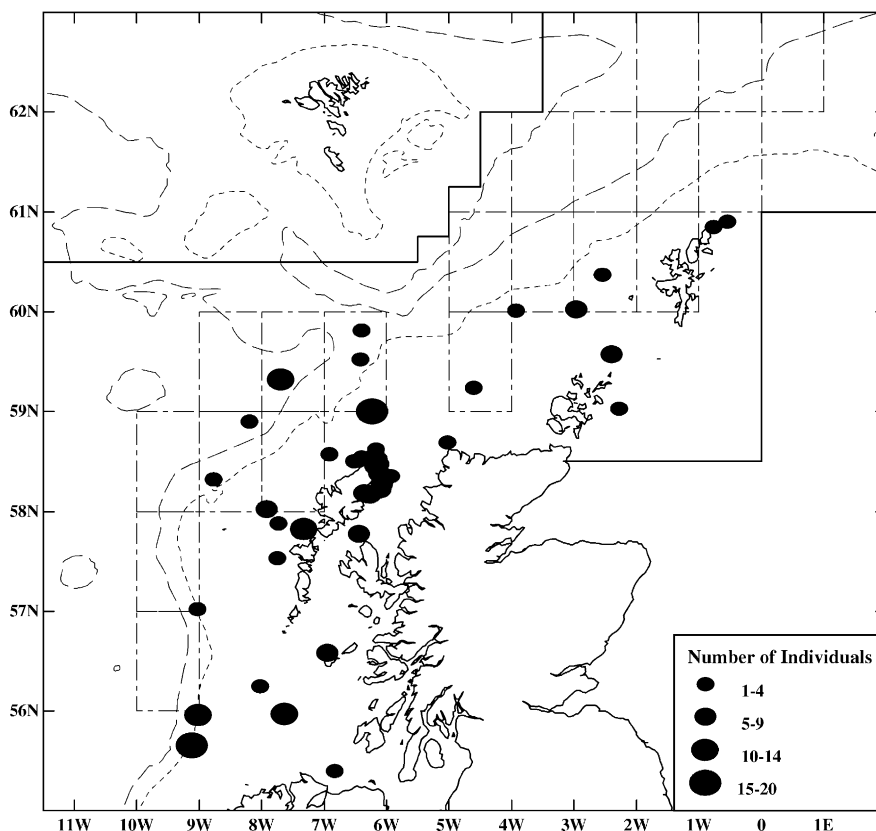


Fig. 12. Distribution of Risso's dolphin sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

particularly along the west coast (Fig. 12). Although most sightings occurred in water of less than 200 m depth, dolphins were also recorded along the shelf edge between July and November. The number of animals in the region peaked between July and September, and they were recorded less frequently between December and May. Risso's dolphins are probably resident in certain areas of the study area, in particular the waters north-east of the Outer Hebrides where identified individuals are seen repeatedly (Atkinson et al., 1997).

4.14. Bottlenose dolphin

Bottlenose dolphins were generally uncommon in the study area, with a total of 21 sightings (131 animals) since 1979. Coastal sightings in water less than 150 m depth occurred north-east of the Outer Hebrides and south of Shetland. Bottlenose dolphins were also recorded along the Atlantic Frontier shelf edge close to the 1000 m isobath. Dolphins were sighted offshore between September and November (Fig. 13) with deep-water sightings along the Wyville Thomson and Ymir Ridges. School size ranged from one to 30 individuals, with an average overall group size of 6.2 animals which increased to an average of 13 animals during the offshore sightings in

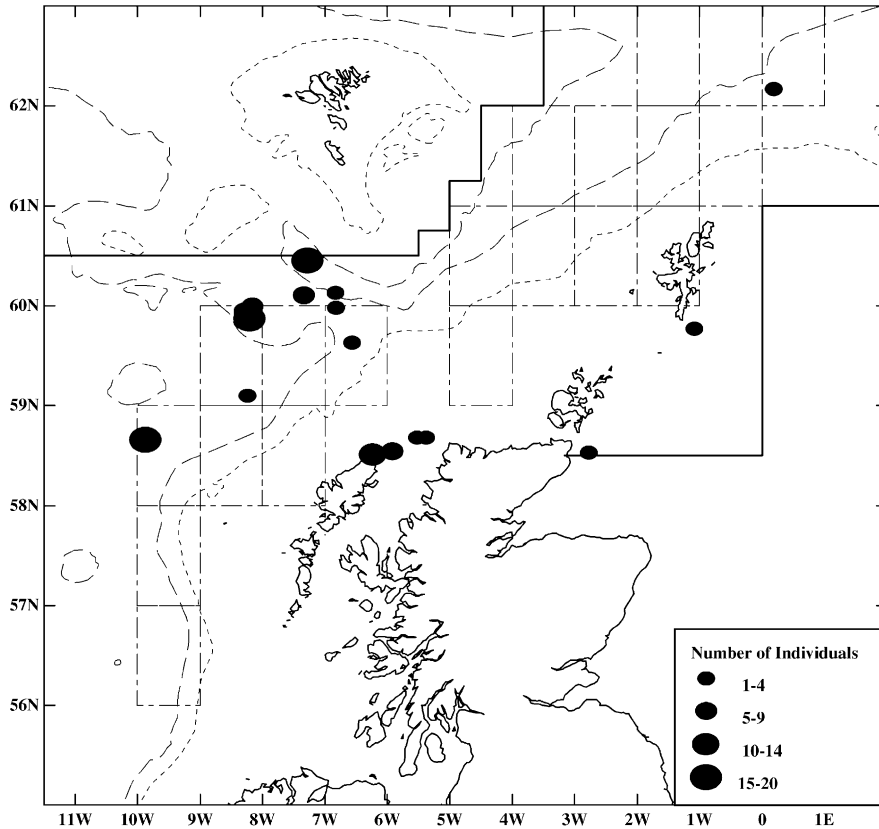


Fig. 13. Distribution of bottlenose dolphin sightings (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

September and October. Inshore and offshore forms of bottlenose dolphins occur throughout their range (Shane et al., 1986), and a distinct inshore and offshore distribution of bottlenose dolphin sightings has been recorded during other surveys in British waters (Evans, 1981) and in the north-west Atlantic (Kenney, 1990).

4.15. Common dolphin

There have been 74 sightings of common dolphins in the Atlantic Frontier study area, where they occur towards the northern extremity of their distribution. There was only one record north of 60°N latitude (Fig. 14). The majority of common dolphin sightings were recorded around the 1000 m isobath. Common dolphins were found in the Atlantic Frontier area in almost every month of the year, but with numbers peaking in September and November. Notable concentrations occurred on the West Hebrides Shelf to the north-west of the Hebrides during October and November. Common dolphins were more sociable than many species, with an average group size of 13.7 animals, and three recorded aggregations of over one hundred animals.

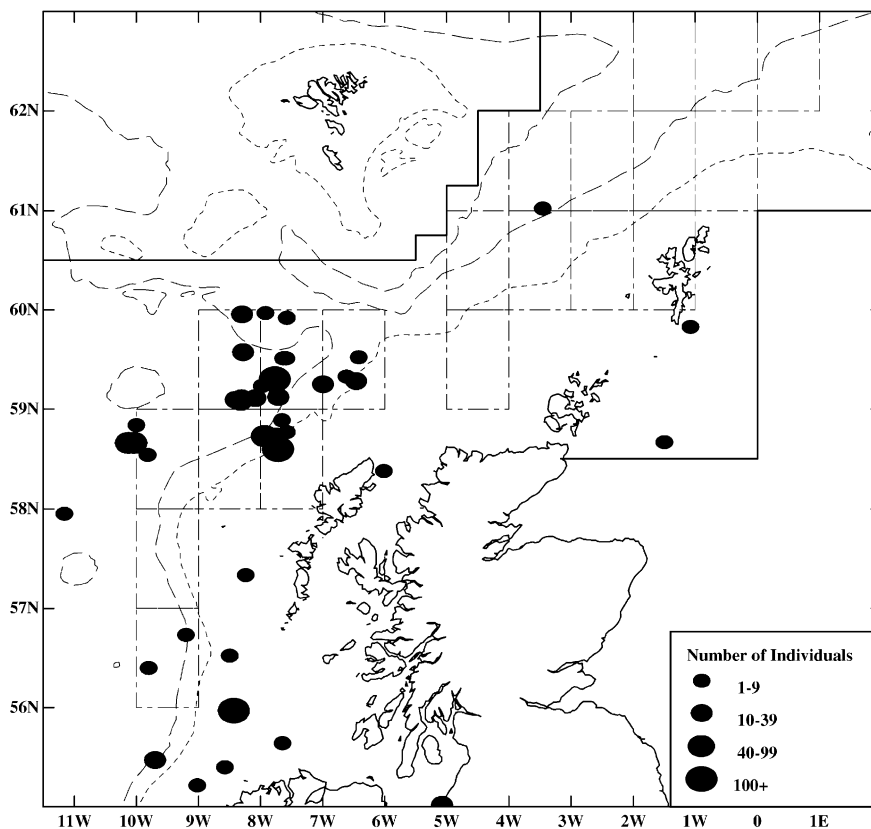


Fig. 14. Distribution of common dolphin sightings (1979–1998). Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

4.16. Harbour porpoise

Harbour porpoises were the most frequently sighted cetacean in the study area and were widely distributed in shelf waters, particularly those of the Outer Hebrides and Shetland Islands (Fig. 15). Small numbers of porpoises were recorded between November and March, mainly in the Minch and around the Shetland and Orkney Islands. Porpoise numbers increased between June and September, and reached a marked peak during July and August when animals may form larger groups after calving (Evans, 1980, 1992). During the summer months, porpoises were found throughout shelf waters in the study area, and occasionally in deep waters off the shelf edge.

5. Discussion

The spatial and temporal distribution of cetaceans in the study area may reflect variation in ecological requirements and seasonal use of habitats amongst species. While such patterns might provide insight into factors governing cetacean distribution, variations in observer, survey vessel,

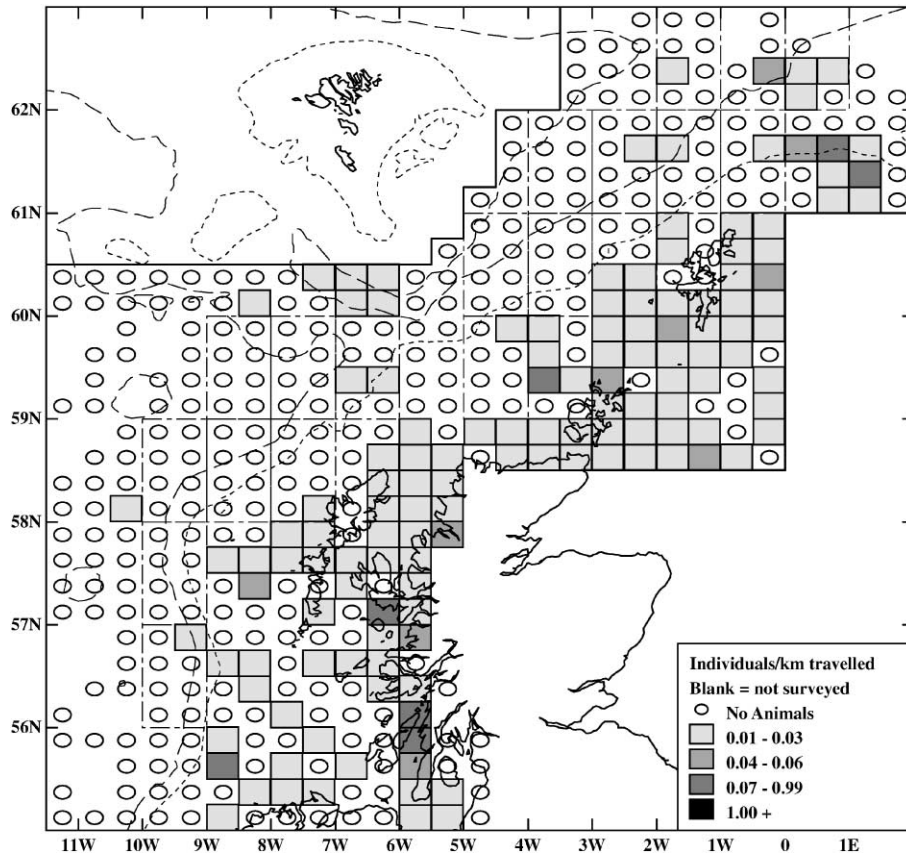


Fig. 15. Abundance of harbour porpoises (1979–1998) Bathymetry: short dash (200 m isobath); long dash (1000 m isobath); dot-dash (Licence quadrants).

and weather conditions, and uneven levels of survey coverage may result in inconsistencies in the distributions described.

In particular, the extent of geographical survey coverage achieved varies with season, which may affect the number of sightings of some species. This would seem most likely to be the case for large whale species, which generally inhabit deep waters where coverage is more difficult to achieve during the winter months. However, sightings of other deep-water species such as sperm and pilot whales and white-sided dolphins occurred throughout the year, and beaked whales were sighted between August and January when a reduced amount of survey coverage in deep-water regions was achieved.

A degree of seasonal migration has been reported previously for baleen whales species in the study area (Christensen et al., 1992), and would appear to be supported by our data. However, the area in the southern Faroe-Shetland Channel where the majority of fin whales were sighted received little survey coverage during the winter, and it is probable that while some seasonal migration may occur, poor survey coverage is also responsible for lack of sightings. Indeed, certain populations of fin and sei whales may remain in deep water at high latitudes throughout

the year, having been detected using hydrophone arrays in the Atlantic Frontier region during winter months (Clark and Charif, 1998).

The inshore waters of the Minch received a high level of survey coverage in every month of the year. Species recorded on the shelf such as minke whales, white-beaked dolphins and harbour porpoises are therefore more likely to be accurately described than deep-water species. Despite this, all three shelf species showed a seasonal summer peak in numbers, and the most commonly sighted baleen whale within the study area, the minke whale, was not sighted at all between November and April. This suggests that the seasonal variation in sighting rate and number of some species is not necessarily a result of bias in survey effort.

Surveys of this nature are inherently restricted by weather conditions during the year, which affects both the geographic location that can be surveyed, the amount of coverage that can be achieved, and the ease of detecting various cetacean species. During the winter, high swell heights and increased sea state result in reduced sighting rates particularly for inconspicuous species such as beaked and minke whales, and small species such as harbour porpoises (Palka, 1996). Although it is not possible to correct for discrepancies in observer, platform and weather conditions, overall trends in species distribution and occurrence may still be revealed (Evans, 1980).

The oceanographic features of the Atlantic Frontier study area are diverse, with the Gulf Stream influence moving north along the west coast of Scotland, and cold, deep-water channels in the north. This results in a high diversity of cetacean species with distribution patterns that can often be related to physical factors such as undersea topography and water depth (Evans, 1990). Fin, sei, humpback, northern bottlenose, sperm, pilot and beaked whales, and white-sided and common dolphins were all typically sighted in deep, oceanic waters, although inshore movements of some of these species appeared to occur during the summer. In contrast, minke whales, white-beaked dolphins and harbour porpoises were almost entirely recorded in shelf waters within the 200 m isobath (Northridge et al., 1995). Three species, the killer whale, Risso's dolphin and bottlenose dolphin were found in small numbers throughout the study area. These three species are found in both deep, offshore waters and shallow, shelf waters throughout their geographical range (Evans, 1987).

The distribution of two closely related species, the white-beaked and white-sided dolphin showed an allopatric pattern, with white-sided dolphins replacing white-beaked dolphins in waters over 200 m depth. While mixed schools have been reported (Evans, 1980, 1987; Northridge et al., 1997), the pattern of distribution for these species suggests some degree of mutual exclusion. This may be related to prey type, or to another factor.

Common dolphins were also replaced by white-sided dolphins at latitudes greater than 60°N, although both species inhabit deep, pelagic waters. Selzer and Payne (1988) suggest that the differences in distribution of these two species may be related to environmental factors such as temperature, with common dolphins following the Gulf Stream and being replaced by white-sided in colder waters further north.

Although distribution of cetacean species can be described and correlated to oceanographic features such as water depth, it is likely that prey abundance and movement are the most important factor in determining the occurrence and movements of cetaceans (Gaskin, 1982; Evans, 1987; Selzer and Payne, 1988). Indeed, species that commonly feed on the same prey items such as offshore bottlenose dolphins, Atlantic white-sided dolphins and pilot whales, are often recorded together in mixed species schools (Evans, 1987).

The waters of the Atlantic Frontier are of particular significance for beaked whales, whose distribution in the north-east Atlantic is poorly understood. Sightings of *Mesoplodon* spp. at sea are scarce, partly as a result of their behaviour and habitat requirements. *Mesoplodon* spp. are rarely sighted in some areas where northern bottlenose whales are frequently observed such as the Gully off Nova Scotia (Hooker and Baird, 1999), suggesting that species of *Mesoplodon* may be generally uncommon throughout much of their range. The ten sightings of 22 *Mesoplodon* individuals reported during SAST surveys between 1995 and 1998, indicate that the deep waters to the north of, and particularly to the north-west of Scotland, may be an important habitat for beaked whale species.

Species such as long-finned pilot whales and Atlantic white-sided dolphins occur in high numbers over the Atlantic Frontier throughout the year, but the area is also of importance for several other species such as minke whales on a seasonal basis. Licences issued during the 17th oil round should therefore take account of a significant occurrence of cetaceans in Atlantic Frontier waters.

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