JOINT NATURE CONSERVATION COMMITTEE

THE DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

IN THE ATLANTIC FRONTIER, NORTH AND WEST OF SCOTLAND

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The distribution of seabirds and marine mammals in the Atlantic Frontier, north and west of Scotland.

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Contents

Summary

- Surveys were conducted in waters north and west of Scotland, with emphasis on the deep waters of the continental slope where licences have been awarded for oil and gas exploration.
- All data from surveys between 1979 to 1999 were used to compile this report.
- The main objective was to gain information on seabird and cetacean dispersion patterns along the continental slope, particularly in the offshore blocks licensed in the 17th and earlier rounds.
- A secondary objective was to census several important seabird colonies nearest the licensed areas. The results are dealt with in detail elsewhere.
- Twenty-three species of seabirds breed in the study area, 21 in internationally important numbers.

Seabird dispersion

- A total of 48 seabird species was recorded.
- Twenty-one species associated with fishing vessels, although only fulmar, European storm-petrel, gannet, great skua, herring gull, lesser black-backed gull, great black-backed gull and kittiwake did so in any number.
- Eight species were present all year round; in order of decreasing abundance these were fulmar, gannet, herring gull, great black-backed gull, kittiwake, common guillemot, razorbill and puffin.
- Manx shearwaters, European storm-petrels, Leach's storm-petrels, Arctic skuas, great skuas, lesser black-backed gulls and Arctic terns were summer visitors to the area.
- Iceland gull, glaucous gull and little auk were winter visitors.
- Great and sooty shearwaters, and Pomarine and long-tailed skuas were uncommon migrants.
- Fulmars concentrated along the continental slope in late winter (January to April). High numbers remained here during the breeding season although they were also abundant over the shelf at this time. Generally lower densities were recorded over the slope between August and October and low numbers were recorded everywhere in November and December.
- Great shearwaters were recorded along the continental slope with peak numbers in August.
- Sooty shearwaters were widespread at low density in the study area between July and October.
- Manx shearwaters were mostly recorded between March and October. Highest densities recorded were in shelf waters west of Scotland between June and August. The species was widespread at low density in deep waters at this time.
- European storm-petrels were abundant in the study area between June and August. Highest densities were recorded in deep waters north-west of Scotland in August.
- Leach's storm-petrels were predominantly recorded in deep water (>200 m) with highest densities in August.
- Gannets were widespread throughout the year. Numbers were highest in summer as this species is a partial migrant. Gannets were concentrated north and west of the Western Isles.
- Pomarine skuas were observed in all areas, mainly during spring and autumn passage.
- Low numbers of Arctic skuas were recorded in the study area.
- Long-tailed skuas, also recorded on passage, exhibited a more pelagic distribution pattern.
- Great skuas were widespread at low density during the summer months.
- Lesser black-backed gulls were widespread in the study area between April and August and there were areas of high density along the continental slope. Most birds migrate south during winter.
- The herring gull was primarily a coastal species, but low densities occurred along the continental slope during the winter.
- Iceland gulls were observed in small numbers in the study area between November and March.
- Glaucous gulls were a scarce but regular visitor. Most were recorded in the Faroe-Shetland Channel and along the edge of the Rockall Trough.
- Great black-backed gulls were widespread at low density throughout the year. Highest numbers were recorded around Shetland and along the continental slope in late winter (January to April).

- The kittiwake was the most abundant gull species recorded. High densities were recorded over the shelf throughout the year. Low densities were recorded offshore except during late winter when high concentrations were present along the continental slope.
- Arctic terns were recorded in the study area between May and October. Low densities of birds were recorded in deep water.
- Common guillemots were primarily a shelf species but were recorded at low densities in deep waters (>200 m) throughout the year. High densities were found inshore in late summer as birds gather to moult.
- Razorbills were mostly recorded over the shelf and were thinly distributed in deeper waters. As with common guillemots, this species flocks inshore when moulting.
- Little auks were widespread north of Scotland between September and December, but were mainly seen in shelf waters thereafter.
- Puffins were widespread except in late winter when they disperse out of the area. Highest densities were recorded in shelf waters in June and July.
- Red-throated diver, great northern diver, cormorant, shag, common eider, long-tailed duck, black-headed gull, common gull, common tern and black guillemot were predominately recorded inshore and were rarely recorded offshore.
- Sixteen species of seabird were recorded on less than 20 occasions; black-throated diver, great crested grebe, soft plumaged petrel, Cory's and Mediterranean shearwaters, Wilson's storm-petrel, common and velvet scoters, red-breasted merganser, red-necked and grey phalaropes, little and Sabine's gulls, Sandwich and little terns, and Brünnich's guillemot.

Cetaceans

- Fifteen species of cetacean were recorded.
- Fin, sei and humpback whales were recorded in small numbers mainly in the Faroe-Shetland Channel.
- Minke whales were the most numerous baleen whale recorded and were mostly seen inshore during the summer.
- Sperm whales were encountered in all months except for February and March and mainly in waters deeper than 1,000 m.
- Unidentified beaked whales thought to be of the genus *Mesoplodon* were recorded in deep waters particularly around the 1,000 m isobath. A single animal was positively identified as a Sowerby's beaked whale.
- Northern bottlenose whales were infrequently seen in deep waters.
- Killer whales were recorded in all but two months, mostly in the Faroe-Shetland Channel.
- Long-finned pilot whales were the second most abundant cetacean recorded. Most sightings were in waters deeper than 200 m.
- Atlantic white-sided dolphin was the most numerous cetacean, and was found mainly along the shelf edge and in waters deeper than 1,000 m.
- White-beaked dolphins were almost entirely confined to shelf waters where they were the most abundant species recorded.
- Risso's dolphins were widely distributed in shelf waters, particularly around the Western Isles.
- Bottlenose dolphins were generally uncommon.
- Common dolphins are at the northern extremity of their range and were recorded mainly offshore.
- Harbour porpoise was the most frequently sighted cetacean and was widely distributed inshore.

Pinnipeds

- Three species of seal were recorded. These were common (harbour), grey and hooded seals.
- Common seals were mostly recorded inshore with few records offshore.
- Grey seals were the most numerous seal recorded. They were frequently seen offshore but rarely beyond the 200 m depth contour.
- Hooded seals were rare with only six records. All were in deep water (>200 m depth).

1. Introduction

1.1 Background

The Seabirds at Sea Team (SAST) of the Joint Nature Conservation Committee (JNCC) has been studying the distribution and abundance of seabirds and marine mammals in the waters around Britain since 1979. During the 1970s, with the development of the offshore North Sea oil industry, there was concern over the lack of available data on seabird dispersion at sea. Funding from the United Kingdom government and the oil and gas industry resulted in the establishment of SAST, and enabled surveys to commence in the North Sea. These surveys have continued in British and Irish waters, and along with similar data collected by other European countries, have been incorporated into the European Seabirds at Sea (ESAS) database. This database contains over 1.5 million seabird and over 13,000 cetacean records, and provides information on distribution and abundance throughout the year. Atlases are produced that depict seabird distribution and abundance (e.g. NERC 1998; Pollock *et al.* 1997; Stone *et al.* 1995a; Webb *et al.* 1990), and vulnerability of seabirds to surface pollution (e.g. Carter *et al.* 1993; NERC 1998; Tasker *et al.* 1990; Webb *et al.* 1995).

During the 16th UK offshore oil licensing round of 1994 and 1995, licences were awarded by the Department of Trade and Industry for oil and gas exploration in the poorly known, deep waters of the continental slope and beyond to the north and west of Scotland, the “Atlantic Frontier”. In 1997 further licences were issued in the 17th round. One of the licensing conditions was that information be presented by the licensee on the importance of the area for seabirds and marine mammals prior to exploration in the licence blocks, to fulfil Environmental Impact Assessments and guide oil spill contingency plans. As a result, individual companies and the Atlantic Margin Group (AMG) directly funded some dedicated seabird and cetacean surveys of the area in 1997 and early 1998. A consortium of oil and gas industry companies, via the Atlantic Frontier Environment Network (AFEN), funded surveys in the region from March 1998, and surveys continued until March 1999. This report utilises data collected during this period, and from previous SAST and ESAS surveys (1979-1999), to examine the distribution and abundance of seabirds and marine mammals in the Atlantic Frontier.

1.2 Objectives

The main aims of the project were:

- to gain information on seabird and marine mammal dispersion patterns along the continental slope, particularly in the offshore blocks licensed in the 17th and earlier offshore rounds; and
- to census several important seabird colonies on islands nearest the licensed areas.

This report presents seasonal distribution patterns of all seabirds and marine mammals encountered. Results from the colony censuses are summarised, but will be detailed elsewhere.

1.3 Previous work

Places named within the study area and referred to in the text are illustrated in Figure 1.

The scientific and English names of the species mentioned in this report are listed in Appendix I.

1.3.1 Seabirds

Prior to 1997, much survey coverage of the Atlantic Frontier was achieved, mainly as part of other projects. Early pioneering work by Nicholson (1928), Jesperson (1929) and Rankin and Duffey (1948) covered only a small proportion of the study area, as did later research (e.g. Butcher *et al.* 1968; Sage 1968). In 1979 the Nature Conservancy Council (NCC) Seabirds at Sea Team began systematic survey work in the North Sea (e.g. Blake *et al.* 1984) with later extensions of this programme covering other parts of the North Atlantic around Britain. In the 1980s, there was interest from the oil industry in licensed areas in the North Rockall Trough Basin. At that time, there was limited information available for the area and data were confined to the summer months. In 1986 a year-round survey of seabird distribution began in the waters north and west of Scotland (Benn *et al.* 1988). This was followed by a survey of moulting auks in the area (Burton *et al.* 1987), and a study of the feeding distribution and breeding biology of seabirds around the colonies of North Rona and Sula Sgeir (Benn *et al.* 1987, 1989) and St. Kilda (Leaper *et al.* 1988). Further data on seabird distribution north and west of Scotland were collected as part of a project to survey waters west of Britain (Webb *et al.* 1990). Later research identified concentrations of seabirds vulnerable to surface pollution south and west of Britain

(Webb *et al.* 1995) and in the North Sea but with some overlap with the Atlantic Frontier (Carter *et al.* 1993). Surveys by Ornis Consult of Denmark during the late 1980s (Danielsen *et al.* 1990; Skov *et al.* 1995b) improved knowledge of seabird distribution in the Atlantic Frontier. The area to the south of the Atlantic Frontier has been well-surveyed in recent years, although this largely covered waters around Ireland (Pollock *et al.* 1997). Survey coverage remained inadequate, and increasing interest from the oil industry resulted in a new two-year study of the waters between the Shetland Islands and the Faroe Islands in 1994 (Bloor *et al.* 1996). All data collected by JNCC are added to the European Seabirds at Sea (ESAS) database, which contains seabird records from a number of European organisations. These data were summarised in an atlas of the seabirds of north-west Europe (Stone *et al.* 1995a). Seabird studies around the Faroes are being carried out as part of a separate JNCC project.

1.3.2 Cetaceans

Before dedicated surveys of cetaceans began in the north-east Atlantic, most available information on the distribution and occurrence of cetaceans in the study area resulted from whaling data (e.g. Jonsgård 1974), and from long term strandings records (Berrow & Rogan 1997; Sheldrick 1979). Since 1979, seabird surveys carried out by SAST have opportunistically recorded cetacean species. Whereas most SAST data have been collected in shelf waters around the North Sea, English Channel, Irish Sea and west Scotland (Benn *et al.* 1988; Tasker *et al.* 1987; Webb *et al.* 1990; Webb *et al.* 1995), several offshore surveys have also occurred within the study area. Cetacean data have been published for the Faroe-Shetland Channel (Bloor *et al.* 1996), the southern Western Isles and Ireland (Pollock *et al.* 1997), and on the distribution of individual species throughout UK waters (Northridge *et al.* 1995, 1997). Additional information on the offshore distribution of cetaceans in the Atlantic Frontier study area has been provided by observers on seismic vessels since 1996 (Stone 1997, 1998), and dedicated sightings surveys to the north and west of Shetland and the Western Isles (Hughes *et al.* 1998). Studies aimed at estimating the abundance of whales, such as the North Atlantic Sightings Survey (e.g. Buckland *et al.* 1993; Gunnlaugsson & Sigurjónsson 1990; Sigurjónsson *et al.* 1989, 1991; Skov *et al.* 1995a), have focussed on the waters around the Faroes and along the western British seaboard. Cetaceans in the study area have also been monitored acoustically (Clark & Charif 1998; Lewis *et al.* 1998). Around the Western Isles, general surveys over the continental shelf (Boran & Evans, unpubl.; Evans *et al.* 1993), and along the continental slope (Evans 1981), have been carried out, as well as intensive studies on the minke whale (Gill & Fairbairns 1995) and Risso's dolphin (Atkinson *et al.* 1997) in Hebridean shelf waters.

1.3.3 Seals

Although seals have been well studied around the Atlantic Frontier and adjacent areas, most studies have primarily been concerned with documenting aspects of seal ecology such as the locations of breeding colonies and population sizes, behaviour, diet, fisheries interactions and seal conservation. Almost all such studies are carried out at breeding colonies and haul-out areas. Few studies have concentrated on the distribution of seals at sea, due to the logistical difficulties involved. Previous reports by the NCC/JNCC, have documented the at-sea distribution of cetaceans meticulously (e.g. Bloor *et al.* 1996; Pollock *et al.* 1997) but have not reported records of seals encountered during surveys. The JNCC's *Coastal directory series* documented the distribution of common and grey seal coastal concentrations for regions of Britain and Northern Ireland adjacent to the Atlantic Frontier (Bleakely 1997; Duck 1996, 1997a-d). Movements of marked grey seals at the breeding colonies on North Rona have been studied (Pomeroy *et al.* 1994; Twiss *et al.* 1994) although this system is only of use when the animals come ashore enabling tags to be seen. Radio and satellite tags have greatly aided the study of marine mammal distribution at sea and many studies now apply this technology. Using satellite tags, Thompson *et al.* (1996) examined the distribution and dispersion of common and grey seals in the Moray Firth. Grey seal dispersion in the North Sea and east coast of Britain has been studied using similar methods (Hammond *et al.* 1993; McConnell *et al.* 1994; McConnell *et al.* 1999). The movement of radio-tagged common seal pups from Ireland has also received investigation (Wilson & Corpe 1996). In the Greenland and Norwegian Seas, Folkow *et al.* (1996) studied movements of satellite-tagged hooded seals, some of which dispersed into the Atlantic Frontier.

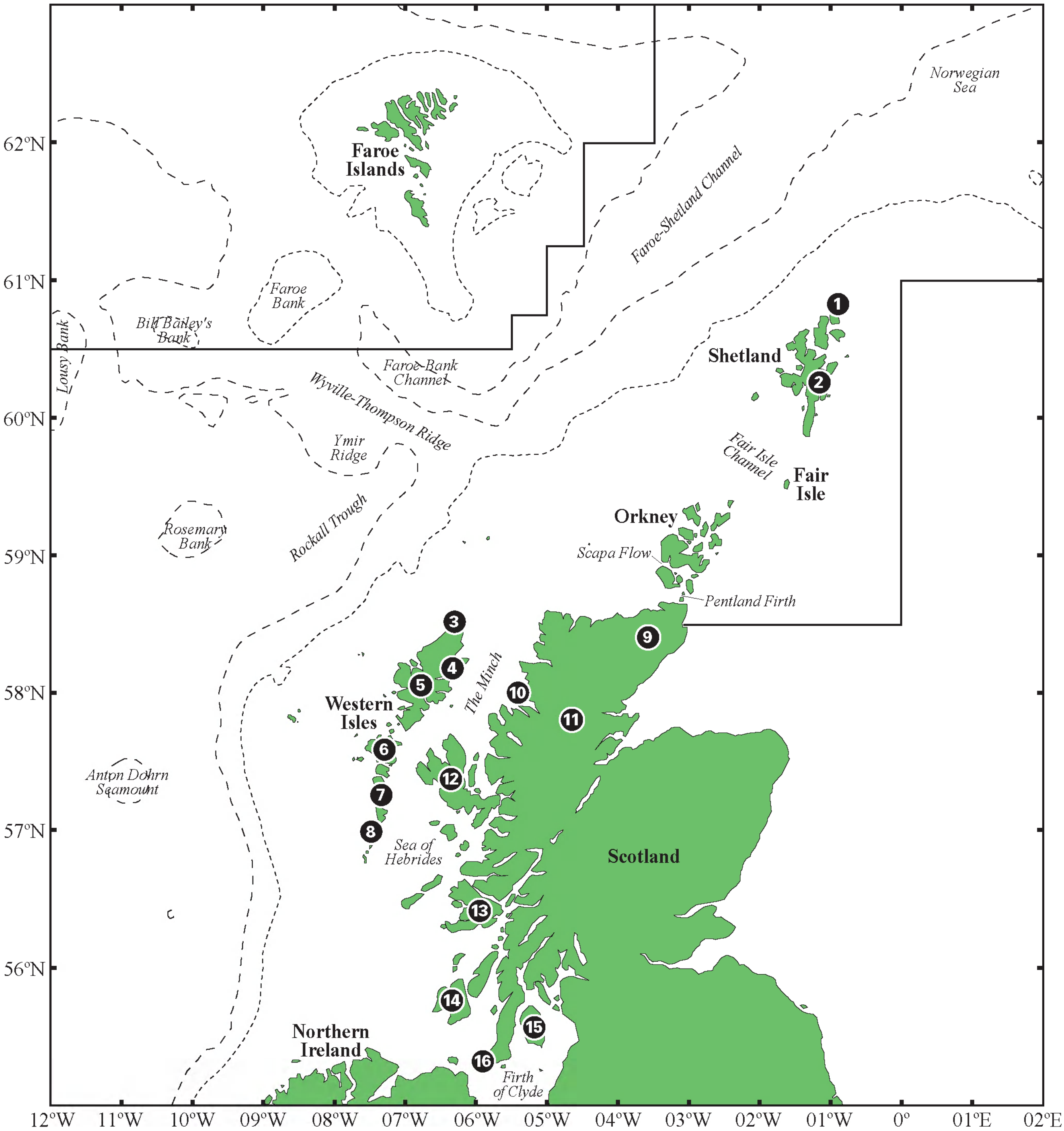


Figure 1. The study area showing place names and bathymetry (see Figure 3 for further named places)

Bathymetry: short dash (200 m isobath); long dash (1,000 m isobath)

1	Unst	9	Caithness
2	Lerwick	10	Summer Isles
3	Butt of Lewis	11	Sutherland
4	Stornoway	12	Isle of Skye
5	Lewis	13	Mull
6	North Uist	14	Islay
7	South Uist	15	Arran
8	Barra	16	Mull of Kintyre

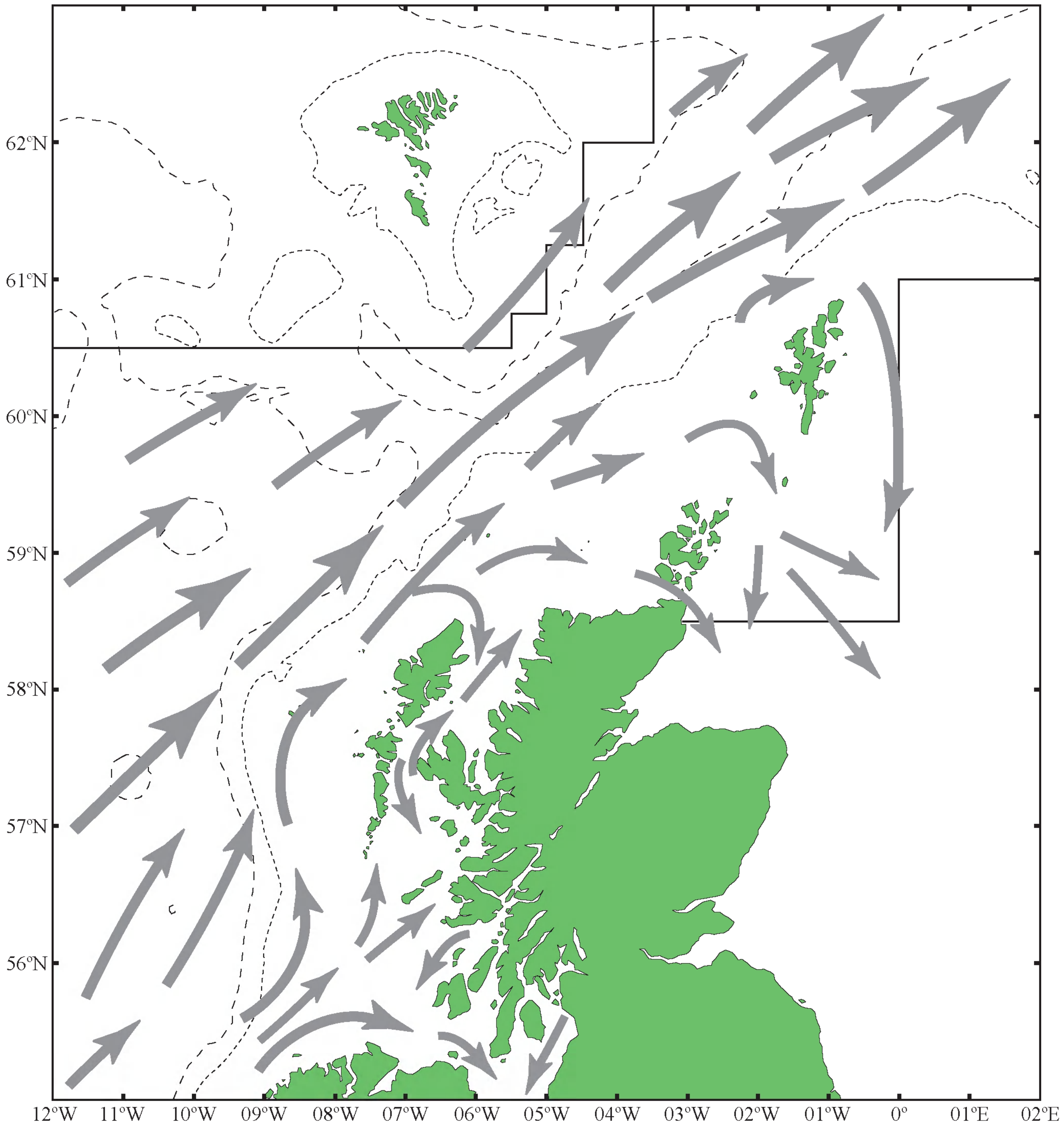


Figure 2. Movement of water currents through the study area

Bathymetry: short dash (200 m isobath); long dash (1,000 m isobath)

2. The marine environment

The ocean is a highly heterogeneous environment, with both large- and small-scale spatial patterns in oceanography (Hunt & Schneider 1987). Changes in physical and biological features of the ocean environment influence the distribution and abundance of marine organisms. Physical processes such as ocean circulatory patterns may have large-scale influences on the dispersion of marine organisms, but important small-scale features, such as eddies, also have an affect. Oceanographic features vary on a temporal scale, with seasonal formation of fronts and annual fluctuations in water temperature, salinity and primary productivity (Dooley *et al.* 1984; Ellett & Blindheim 1992; le Fèvre 1986; Tait 1957).

The distribution of seabirds and marine mammals is patchy rather than even, and is generally related to that of their prey species. Both seabirds and marine mammals feed on zooplankton and fish, and their distribution may be related to movement or abundance of fish stocks (e.g. Evans 1990) or regions of high productivity such as upwelling or fronts (Begg & Reid 1997; Kenney & Winn 1987). The availability of fisheries waste may also have an effect on the distribution of some seabirds (Camphuysen *et al.* 1993, 1995). The occurrence of marine mammals and seabirds is related to oceanographic features such as water temperature, salinity and depth (Harrison *et al.* 1994; Selzer & Payne 1988), but their primary influence is in determining the distribution of prey.

As the distribution and abundance of seabirds and marine mammals is largely governed by oceanographic features, it is important to describe the topography and marine processes occurring in the study area.

2.1 Physical environment and oceanographic features

The study area (Figure 1) includes waters adjacent to the mainland coasts of north and west Scotland and around several island groups: the Western Isles, and the Orkney and Shetland Islands. The currents of the North Atlantic Ocean are the main influence on the west coast of Scotland, the Western Isles and the Orkney and Shetland Islands. The east coasts of Shetland and Orkney are bordered by the North Sea, but retain a North Atlantic influence from currents passing through the Norwegian Trench. The area contains two distinct oceanographic zones: generally shallow waters (<200 m deep) of the continental shelf, and deep oceanic waters (>500 m depth). The continental slope between these regions provides an area of increased production, as nutrients are brought to the surface by turbulent upwelling (e.g. Atkinson & Targett 1983; Brown 1988a).

2.1.1 Bathymetry

The waters to the north and west of Scotland are underlain by varied seabed topography in a series of ridges and channels (Figure 1). The continental slope runs south-west to north-east, with water of over 1,000 m depth forming a large proportion of the study area. Two deep water troughs dominate the region: the Faroe-Shetland Channel (>1,000 m) lying between the Faroe and Shetland Islands, and the Rockall Trough (>2,000 m) off the western shelf edge. Separating these two troughs are the Wyville-Thomson Ridge and the Ymir Ridge at 60ºN. Two seamounts, the Rosemary Bank (<500 m) and the Anton Dohrn Seamount (<1,000 m) provide areas of high seabed relief in the Rockall Trough.

The continental shelf break lies in close proximity to the Northern and Western Isles, approaching to approximately 50 km north of Shetland and 65 km north-west of the Western Isles. The steepness of the slope varies: the 200 m and 1,000 m isobaths are separated by approximately 65 horizontal km to the north of Shetland, but occur within 13 km of each other west of Barra.

2.1.2 Currents and water properties

Complex seabed topography results in a series of surface and deep water currents within the study area (Figure 2). In the upper water column a northward flow of the Gulf Stream combines with cooler water over the continental slope and continues northwards through the Rockall Trough. The current veers north-eastward between the Rockall Bank and the Anton Dohrn Seamount and moves through the Faroe-Shetland Channel into the Norwegian Sea (Tait 1957). To the north of, and below the level of, the Wyville-Thomson Ridge (c. 550 m) lies a body of cold, dense Norwegian Sea water. In the Faroe-Shetland Channel this water mass has a net south-westerly flow but is prevented from entering the Atlantic by the Wyville-Thomson Ridge, though overflow events do cause some exchange (Ellett & Roberts 1973). Another Atlantic current flows west of the Faroe Bank and Faroe Islands and mixes with Arctic Icelandic water to the north of the Faroes (Tait 1957). This Modified Atlantic current flows as an anticyclonic gyre around the Faroe Islands (Dooley & Meincke 1981) and may veer southwards along the east coast of the Faroes, or recirculate in a cyclonic manner back into the Norwegian Sea (Aken & Eisma 1987).

In addition, a current flows northwards along the European continental break, which becomes narrower and faster towards the north-west Scottish slope, before turning north-eastward parallel to the Atlantic Current. This Slope Current mixes with the Atlantic Current, and an offshoot known as the East Shetland Atlantic Inflow moves southward along the east coast of Shetland (Turrell 1992).

Water from the Atlantic also flows through the inner Scottish islands, moving northwards from the south coast of Ireland, through the Irish Sea into the southern Minch. Here it divides into two branches, one travelling northwards through the Minch and the other up the west coast of the Western Isles (Ellett & Edwards 1983). This coastal current mixes with the slope current around Rona, turning eastward along the 100 m isobath. As the mainly wind-driven Fair Isle Current (Dooley 1974), it moves between Fair Isle and Orkney before turning south-eastwards and flowing into the North Sea (Turrell *et al.* 1990).

Water temperature and salinity in the study area are very variable, with large-scale changes occurring between years in hydrographic conditions (Dooley *et al.* 1984). The warm water flowing from the Atlantic through the Faroe-Shetland Channel normally has a salinity in excess of 35.25‰ (Dooley *et al.* 1984). Water temperature in the Rockall Trough ranges from 9.5ºC to 14.5ºC (Ellett & MacDougall 1983). In the Faroe-Shetland Channel, several water masses are present with varying hydrographic properties: warm, saline north Atlantic water moving north-eastward is met by colder less saline water flowing from the north. In the coastal waters of the Minch, freshwater input from rivers results in a lower salinity (Ellett & Edwards 1983). The waters to the south-west of Shetland and in the Fair Isle Current also have a salinity of less than 35.0‰ indicating coastal water (Aken & Eisma 1987; Turrell *et al.* 1990). Over the Scottish continental shelf, variation in water depth and tidal influences results in changes in the structure of the water column. Where well-mixed water meets thermally stratified water, frontal systems may occur (Pingree & Griffiths 1978). Shelf-break fronts also occur along the shelf edge, where water depth abruptly lessens and current speed alters.

2.2 Seabird and marine mammal prey

Zooplankton are the principal food source for several species of fish (Bainbridge & Forsyth 1972; Bainbridge *et al.* 1978), seabirds and cetaceans. Some seabird species, such as the little auk and Leach's storm-petrel, feed directly on zooplankton, and concentrations of these birds may occur over upwellings where surface zooplankton biomass is greatest (Brown 1988a, b). The small-scale distribution of planktonic prey may determine the distribution of seabirds within the broader boundaries set by oceanographic and hydrographic features (Hunt & Schneider 1987; McClatchie *et al.* 1989). The prey-predator relationship between zooplankton and fish may also indirectly affect the distribution and abundance of piscivorous seabirds and marine mammals (Evans 1990; Springer *et al.* 1987).

The primary foods of most seabirds are densely schooling, small, lipid-rich pelagic fishes, crustaceans and cephalopods that occur in the upper- to mid-water column (Hunt *et al.* 1996). As a result their distributions are largely correlated with fish availability during both the breeding (Crawford & Shelton 1978; Springer *et al.* 1986) and non-breeding seasons (Jensen *et al.* 1994). The distributions of fish are in turn governed by the constraints of their environment. Shoals congregate around suitable spawning, nursery or feeding areas which may coincide with areas rich in zooplankton such as eddies and fronts (Atkinson & Targett 1983; Hainey & McGillivary 1985; Schneider 1990).

The species of fish consumed is likely to be controlled by several factors including availability and size (Jensen *et al.* 1994). The foraging behaviour of seabirds further limits the prey available to them. Ashmole (1971) identified six categories of feeding method used by seabirds including underwater swimming, plunging, surface feeding, feeding when flying and piracy. Pursuit divers, such as the auks, are able to dive deeper than all other seabirds and as a result feed on clupeids, gadoids and other demersal fish (Blake 1983, 1984; Harris 1970). Gannets, which plunge dive from a height above the water, and Manx shearwaters, which may surface plunge, concentrate on pelagic fish that shoal close to the surface e.g. mackerel *Scomber scrombus* and sprat *Sprattus sprattus* (Brooke 1990; Wanless 1984). Fulmars and European and Leach's storm-petrels generally surface feed on small fish, cephalopods and crustaceans (Prince & Morgan 1987). Piracy is employed as a feeding method especially by skuas and opportunistically by the larger gulls (Furness 1987a).

Most seabirds show seasonal variation in diet. During the breeding season, sandeels *Ammodytes* spp. and clupeids (e.g. sprat and herring) are important prey for many species in the north-east Atlantic including auks (e.g. Blake *et al.* 1985; Wright & Bailey 1991), terns (e.g. Monaghan & Uttley 1991), kittiwakes (e.g. Hamer *et al.* 1993), Arctic skuas (e.g. Furness 1990) and shags (e.g. Harris & Riddiford 1989; Harris & Wanless 1991). Their distribution at sea can be positively correlated with sandeel density (Camphuysen 1990; Furness 1990; Wright & Bailey 1991). Partial or complete breeding failure may occur if sandeel stocks are low (Uttley *et al.* 1989). Although much information exists on the diet of seabirds during the breeding season there is a lack of information on diet away from the coast and in winter (Jensen *et al.* 1994). In the North Sea and west of Scotland, common guillemots were found to feed more on clupeids and gadoids during the winter (Blake *et al.* 1985; Halley *et al.* 1995).

Baleen whales typically feed on zooplankton, but in the Northern Hemisphere many species may also eat fish and squid depending on the season (Sigurjónsson 1995). Minke whales feed inshore during the summer months mainly on fish such as gadoids and clupeids (Haug *et al.* 1995). The diet of toothed cetaceans (Odontoceti) consists mainly of fish and squid. Harbour porpoises feed on demersal fish such as herring *Clupea harengus* and have been found associated in areas of known seasonal concentrations of spawning herring (Evans 1990). In Scottish waters, harbour porpoises were found to have fed on a variety of fish including sandeels, whiting *Merlangius merlangus*, haddock *Melanogrammus aeglifinus*, poor cod *Trisopterus minutus*, Norway pout *T. esmarkii*, pollack *Pollachius pollachius* and gobies *Gobius* spp. (Martin 1995). Sandeels are important during the summer although gadoids (eg. haddock, whiting, pollack, Norway pout) become increasingly more important during the autumn and winter when sandeels are unavailable (Santos *et al.* 1995). White-beaked dolphins also feed predominantly on gadoids (Santos *et al.* 1995). Risso's dolphins and long-finned pilot whales feed mostly on squid, although in Faroese waters blue whiting *Micromesistius poutassou* can be an important prey species for long-finned pilot whales during certain times of year, especially when squid are scarce (Hoydal & Lastein 1993).

Seabirds and cetaceans often associate with each other when feeding (Evans 1982; Skov *et al.* 1991). Gannets are frequently observed circling over feeding common dolphins and minke whales are often seen with Manx shearwaters (e.g. Evans 1982; Evans *et al.* 1993). Cetaceans may drive fish to the surface while feeding, making them more accessible to seabirds.

2.3 Fisheries north and west of Scotland

The fishing grounds of the Atlantic Frontier are less important than those of the North Sea (Lee & Ramster 1981). Most fishing activity occurs over the shelf and shelf edge with little activity in deeper water. Shallower inshore waters around Shetland, Orkney and the Western Isles are important fishing areas for pelagic species. The most important pelagic species for fisheries in the Atlantic Frontier are herring, mackerel and blue whiting (Anon 1991). Although herring is widely distributed in the North Atlantic this fishery has been in decline since the latter half of the 1970s (Jakobsson 1985). Now most herring are caught to the north-west of Shetland and to the north of Cape Wrath as far as the shelf break. Since the decline of the herring fishery, fishing for mackerel has become more significant. Most mackerel fishing is carried out between November and February when the western stock of mackerel is present in the study area (Saville 1985). Nearly all are caught to the north of Cape Wrath out to the shelf break.

Compared with pelagic fisheries there is less demersal fishing in the area (Anon 1993), most occurring between Shetland and Lewis along the north-west continental shelf. Demersal species caught include cod *Gadus morhua*, haddock, saithe *P. virens*, Norway pout and whiting (Anon 1991). All are widely distributed in the shelf areas of the Atlantic Frontier. Sprats and sandeels are fished in the shallow shelf waters, especially around Shetland and the Western Isles, though the main catching season for each differs. The former is largely fished during the winter whereas sandeels are caught during the summer months.

A commercial fishery for sandeels in Shetland began in 1974 (Monaghan 1992) and peaked in the 1980s with over 52,000 tonnes being landed in 1982 (Avery 1991). The Shetland sandeel fishery relied largely on catches of 0-group fish (post-larval fish in their first year of life), and following the peak catch in 1982, reduced recruitment to the sandeel population lead to a decreasing spawning stock. The subsequent fall in landings led to voluntary restrictions on catches of 0-group fish by fishermen during 1988, and the fishery was closed completely in 1991 (Reeves 1994). Improving levels of recruitment in sandeel stocks resulted in the fishery being re-opened in 1995 on a three year trial basis, with tight restrictions imposed. An annual quota of 3,000 tonnes was set and boat size was limited to less than 18 m. A close season was also implemented, beginning at the end of June (Johnston 1999).

Blue whiting are fished over the shelf-edge during the summer as post-spawning shoals migrate through the Shetland-Faroe Channel to feeding areas in the Norwegian Sea (Hansen & Jakupsstovu 1992). Other species fished in the Faroe-Shetland Channel include Greenland halibut *Reinhardtius hippoglossoides*, greater silver smelt *Argentina silus*, ling *Molva molva* and blue ling *M. dypterygia*, torsk *Brosme brosme*, hake *Merluccius merluccius* and various redfish *Sebastes* spp. (Anon 1992). These species are mostly fished by vessels from Norway, Iceland, Germany, France and the Faroes. To the west of Scotland grenadiers (Macrourids) have also been targeted since the beginning of the deep-sea fishery in 1989, mainly by vessels from France, Russia and eastern Europe (Anon 1992; Biseau 1996).

Shrimp *Nephrops* spp. fishing is concentrated in the Minch and off the west coast of Scotland (Coull *et al.* 1998). Cephalopods represent an increasingly important fishery resource in European waters (Pierce *et al.* 1996). Squid *Loligo* spp. are caught in the northern North Sea and west of Scotland, mostly as by-catch from demersal trawling, although landings have declined since the late 1980s (Pierce *et al.* 1996).

2.3.1 Fisheries and seabirds

Interactions between seabirds and fisheries are diverse and often complex. Fisheries may affect seabirds beneficially by providing discards, or adversely by competing for prey items or causing death by entanglement in fishing gear. Often the key prey of seabirds are also the target of industrial fisheries e.g. sandeels. As a consequence, some seabirds are in potential competition with fisheries and at risk if the stocks are depleted. Years of low breeding success of kittiwakes have been correlated with years of high sandeel landings (Harris & Wanless 1997). A wreck of auks on the North Sea coasts of Scotland and England was thought to have been caused by a combination of adverse weather and starvation due to changing patterns in sprat abundance (Blake 1984); fisheries surveys in the area had shown a decline in sprat stocks over the previous five years. Seabirds, notably auks, may be drowned in fishing nets (Bibby 1972; Mead 1974), or caught on longlines, a problem that especially affects Procellariformes. Seabird mortality due to longline fishing activity, and its subsequent effects on seabird populations, has been well documented for the Southern Hemisphere (Brothers 1991; Gales *et al.* 1998; de la Mare & Kerry 1994) but has received little attention in the North Atlantic.

Fishing activities benefit seabirds in providing an easily exploitable food source. In the North Sea discards from the fishing industry constitute an important part of the diet of many seabirds, especially during the winter months (Camphuysen *et al.* 1993; Camphuysen *et al.* 1995). It is estimated that the average discard from a demersal trawler's catch amounts to 27% by volume (Hudson 1986), and that approximately 945,600 tonnes of discards are available annually (Garthe *et al.* 1996; ICES 1996). During the non-breeding season 28% of all scavenging seabirds in the region are associated with fishing vessels at any one time (Camphuysen *et al.* 1993). Within the north-east Atlantic, 32 species of seabird are known to scavenge around fishing vessels although many do so only occasionally (Camphuysen *et al.* 1993). Regular scavengers obtaining a large proportion of their food from discards include fulmar, great black-backed gull and kittiwake. Herring gull, great skua, gannet, and lesser black-backed gull also commonly scavenge behind fishing vessels in the North Sea (Camphuysen *et al.* 1995). Clearly, discards may have a significant influence on seabird distribution. However, studies on the distribution and scavenging habits of fulmars in the North Sea indicate this species is most abundant where the supply of fishery waste is comparatively low, and that oceanographic features such as regions of thermally stratified water of relatively high salinity may better predict their seasonal distribution (Camphuysen & Garthe 1997).

3. Breeding populations of seabirds

The convoluted coastline and offshore islands on the margins of the Atlantic Frontier offer extensive and varied breeding habitats for seabirds, often in relative isolation from human disturbance. A total of 23 species of seabird breed in the study area, with many of the largest concentrations around the Western Isles, Orkney and Shetland. Of this total, 21 breed in internationally important numbers (>1% of the international population; Table 1. Many of these colonies are protected by legislation due to the high numbers of seabirds present and/or the diverse breeding assemblage they host (Figure 3; Table 2).

Table 1. Total numbers of breeding seabirds within the Atlantic Frontier in an international context

Species	Total for Atlantic Frontier study area	Biogeographic population	Percentage of biogeographic population in Atlantic Frontier study area
Fulmar	510,000	7,540,000	6.8
Manx shearwater	64,900	294,000	22.1
European storm-petrel	23,000	257,000	8.9
Leach's storm-petrel	10,000	955,000	1.0
Gannet	131,000	263,000	49.8
Cormorant	2,340	41,200	5.7
Shag	25,200	85,500	29.5
Arctic skua	3,140	30,000	10.5
Great skua	8,790	13,600	64.6
Black-headed gull	7,650	1,650,000	0.5
Common gull	15,100	124,000	12.2
Lesser black-backed gull	13,700	124,000	11.0
Herring gull	55,300	940,000	5.9
Great black-backed gull	15,500	140,000	11.1
Kittiwake	216,000	3,170,000	6.8
Sandwich tern	1,380	132,000	1.0
Common tern	4,930	122,250	4.0
Arctic tern	39,800	900,000	4.4
Little tern	241	67,700	0.4
Guillemot	***747,000***	***3,360,000***	22.2
Razorbill	***97,700***	***858,000***	11.4
Black guillemot	***35,500***	***78,400***	45.3
Puffin	446,000	901,000	49.5

All counts refer to breeding pairs with the exception of those in bold italics, which are counts of individuals. Sources - Scottish populations: Tasker (1996, 1997a, b, c, d, & e) and Seabird Colony Register (JNCC Seabird Colony Register Database); Irish populations: Seabird Colony Register (JNCC Seabird Colony Register Database); Biogeoraphic populations: JNCC (1999a), Lloyd *et al.* (1991).

During May and June of 1998 and 1999 a selection of seabird colonies on islands north and west of Scotland were surveyed. All-island censuses, using standard techniques (Walsh *et al.* 1995), were conducted on the Flannans (west and south group), Berneray, Mingulay, Sule Skerry, Sule Stack and Sula Sgeir (Figure 3 & Table 3). In addition, the Royal Air Force Ornithological Society (RAFOS) conducted surveys on the eastern group of the Flannans, to complete counts for this island group. The results of these surveys will be published elsewhere. In 1999, the islands of the St. Kilda archipelago (Figure 3 & Table 3) were surveyed. All seabird species were counted where methodology and time constraints allowed. Gannets were censused only on the western and southern groups of the Flannan Isles where a small colony is easily counted from land. All the gannet colonies in Britain are surveyed at ten-yearly intervals. As a full survey of gannet colonies was undertaken in 1994 it was deemed unnecessary to survey this species. The nesting habits of the black guillemot excluded it from being surveyed. The species nests at low densities, with the nest site hidden in cavities in cliffs and amongst boulders on the shore. It is best censused in April, prior to nesting, when adult birds are more visible around intended breeding sites. Unfortunately, no survey work could be carried out at this time. European storm-petrels, Leach's storm-petrels and Manx shearwaters are burrow nesters, which are censused using more intensive methods. Due to time constraints these three species were surveyed only on St. Kilda.

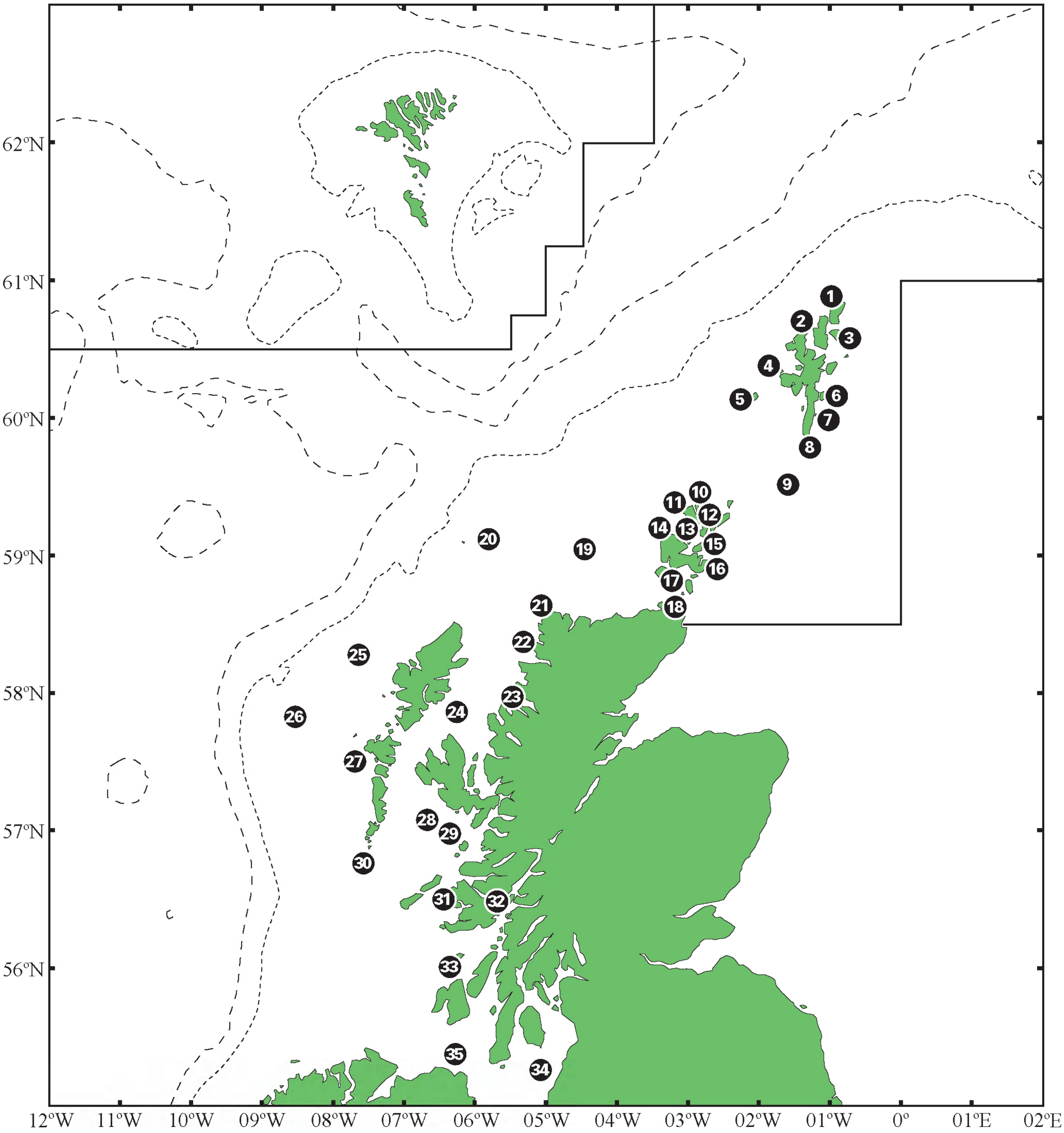


Figure 3. Internationally important seabird colonies within the study area (see Table 2 for key)

Table 2. Internationally important colonies in study area with protected status

Map number	Colony name	Species for which site important	Protected status
1	Hermaness / Saxa Vord	F, Ga, Sh, GS, K, Gu, P	SPA, SSSI,NNR, RSPB
2	Ramna Stacks / Gruney	LP	SPA, SSSI, RSPB
3	Fetlar	F, AS, GS	SPA, SSSI, RSPB
4	Papa Stour	AT	pSPA, SSSI
5	Foula	F, LP, Sh, AS, GS, K, AT, Gu, Raz, P	SPA, SSSI
6	Noss	F, Ga, GS, K, Gu, P	SPA, SSSI, NNR

Table 2 continued. Internationally important colonies in study area with protected status

Map number	Colony name	Species for which site important	Protected status
7	Mousa	SP, AT	SPA, SSSI
8	Sumburgh Head	F, K, AT, Gu	SPA, SSSI, RSPB
9	Fair Isle	F, Ga, Sh, AS, GS, K, AT, Gu, Raz, P	SPA, SSSI
10	Papa Westray	AS, AT	SPA, SSSI, RSPB
11	Westray	F, AS, K, AT, Gu, Raz	SPA, SSSI
12	Calf of Eday	C, Gu	SPA, SSSI
13	Rousay	F, AS, K, AT, Gu	pSPA, SSSI
14	Marwick Head	K, Gu	SPA, SSSI, RSPB
15	Auskerry	SP, AT	SPA, SSSI
16	Copinsay	F, GB, K, Gu	SPA, SSSI, RSPB
17	Hoy and South Walls	F, AS, GS, GBB, K, Gu, P	pSPA, SSSI, RSPB
18	North Caithness cliffs	F, K, Gu, Raz, Pu	SPA, SSSI
19	Sule Skerry / Sule Stack	SP, LP, Ga, Sh, Gu, P	SPA, SSSI
20	North Rona / Sula Sgeir	F, SP, LP, Ga, GBB, K, Gu, Raz, P	pSPA, SSSI, NNR
21	Cape Wrath / Clo Mor	F, GBB, K, Gu, Raz, P	SPA, SSSI
22	Handa	F, GS, K, Gu, Raz	SPA, SSSI
23	Summer Isles	SP	SPA, SSSI, RSPB
24	Shiant Islands	F, Sh, K, Gu, Raz, P	SPA, SSSI
25	Flannan Isles	F, LP, K, Gu, Raz, P	SPA, SSSI
26	St. Kilda	F, MS,SP, LP, Ga, GS, K, Gu, Raz, P	SPA, SSSI, NNR
27	Monach Islands	CT, LT	SPA, SSSI, NNR
28	Canna and Sanday	Sh, HG, K, Gu, P	SPA, SSSI
29	Rum	MS, K, Gu	SPA, SSSI, NNR
30	Mingulay and Berneray	F, Sh, K, Gu, Raz, P	SPA, SSSI
31	Treshnish Islands	SP	SPA, SSSI
32	Glas Eileanan	CT	SPA, SSSI
33	Colonsay	K, Gu	SPA, SSSI
34	Ailsa Craig	Ga, LBB, HG, K, Gu	SPA, SSSI
35	Rathlin Island	F, CG, LBB, HG, K, Gu, Raz, P	SPA, SSSI

Sources: JNCC 1999b, Tasker (1996, 1997a, b, c, d and e)

Key: **Protected status -** SPA = Special Protection Area; pSPA = proposed SPA; SSSI = Site of Special Scientific Interest; RSPB = Royal Society for the Protection of Birds reserve; NNR = National Nature Reserve; **Species -** F = Fulmar; MS = Manx Shearwater, LP = Leach's storm-petrel, SP = European storm-petrel; Ga = Gannet, Sh = Shag; C = Cormorant, AS = Arctic skua, GS = Great skua; LBB = Lesser black-backed gull; HG = Herring gull; GB=Great black-backed gull; K = Kittiwake; AT = Arctic tern; Gu = Common guillemot; Raz = Razorbill; BG = Black guillemot; P = Puffin.

Table 3. Total counts for species surveyed at each island/island group in 1998/1999

Species	Standard count unit	Island(s)							
		Sule Stack	Sule Skerry	Flannan Isles	North Rona	Sula Sgeir	Mingulay	Berneray	St. Kilda
Fulmar	AOS	2	453	7,823	3,520	n/c	8,424	1,596	64,842
Gannet	AOS	n/c	-	1,244	-	n/c	-	-	n/c
Manx shearwater	AOS	-	-	-	-	-	-	-	*
European storm-petrel	AOS	-	n/c	n/c	n/c	n/c	n/c	n/c	*
Leach's storm-petrel	AOS	-	n/c	n/c	n/c	n/c	-	-	*
Shag	AOS	-	724	35	156	54	186	95	2
Great skua	AOT	-	2	1	19		13	-	163
Common gull	AOS	-	-	-	-	-	-	-	1
Lesser black-backed gull	AOS	-	5	-	3	-	18	6	25
Herring gull	AOS	12	29	-	40	8	29	13	6
Great black-backed gull	AOS	33	46	-	983	-	14	16	10
Kittiwake	AOS	-	1,275	2,210	2,913	1,206	2,898	2,613	3,886
Common tern	AOS	-	-	-	-	-	-	-	-
Arctic tern	AOS	-	30	-	10	-	66	5	-
Common guillemot	Ind	1,062	10,331	14,141	8,306	20,877	13,507	19,083	23,457
Razorbill	Ind	10	88	1588	824	801	6,387	16,513	2,545
Black guillemot	AAC	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Puffin	AOS / Ind	-	75,548 / -	27,292 / 629	- / 875	- / 177	1,124 / 3,305	- / 1,979	*

Key:
n/c - not counted but present; * data unavailable at present; AOS - apparently occupied site; AOT - apparently occupied territory; AAC - adult associated with a colony; Ind - Individual birds at colony.

4. Methods

4.1 Study Area

The study area comprised waters to the north and west of Scotland, including the Western Isles, and Orkney and Shetland (Figure 4). The area has been subject to oil and gas exploration, particularly in the region along the continental shelf edge, known as the "Atlantic Frontier". Licences for oil and gas exploration are issued for a framework of quadrants and licence blocks. Each quadrant is defined as 1° latitude north by 1° longitude west, and consists of a series of 30 licence blocks each measuring 10'N by 12'W. The licence blocks are licensed to an operator for a defined period of time for the exploitation of hydrocarbons. With the exception of those in quadrant 202, the licence blocks all occur in water deeper than 200 m along the shelf break and continental slope (Figure 4). Shelf waters of less than 200 m depth were included in the distribution maps to provide context to seabird dispersion patterns, and to highlight important seabird feeding areas and breeding colonies within the Atlantic Frontier survey area that may be vulnerable to pollution.

Survey requirements were identified within 1/4 ICES (International Council for the Exploration of the Sea) rectangles and these were also used as a sampling unit within which seabird densities were mapped. There are eight 1/4 ICES rectangles, each measuring 15' latitude by 30' longitude, in a licence quadrant.

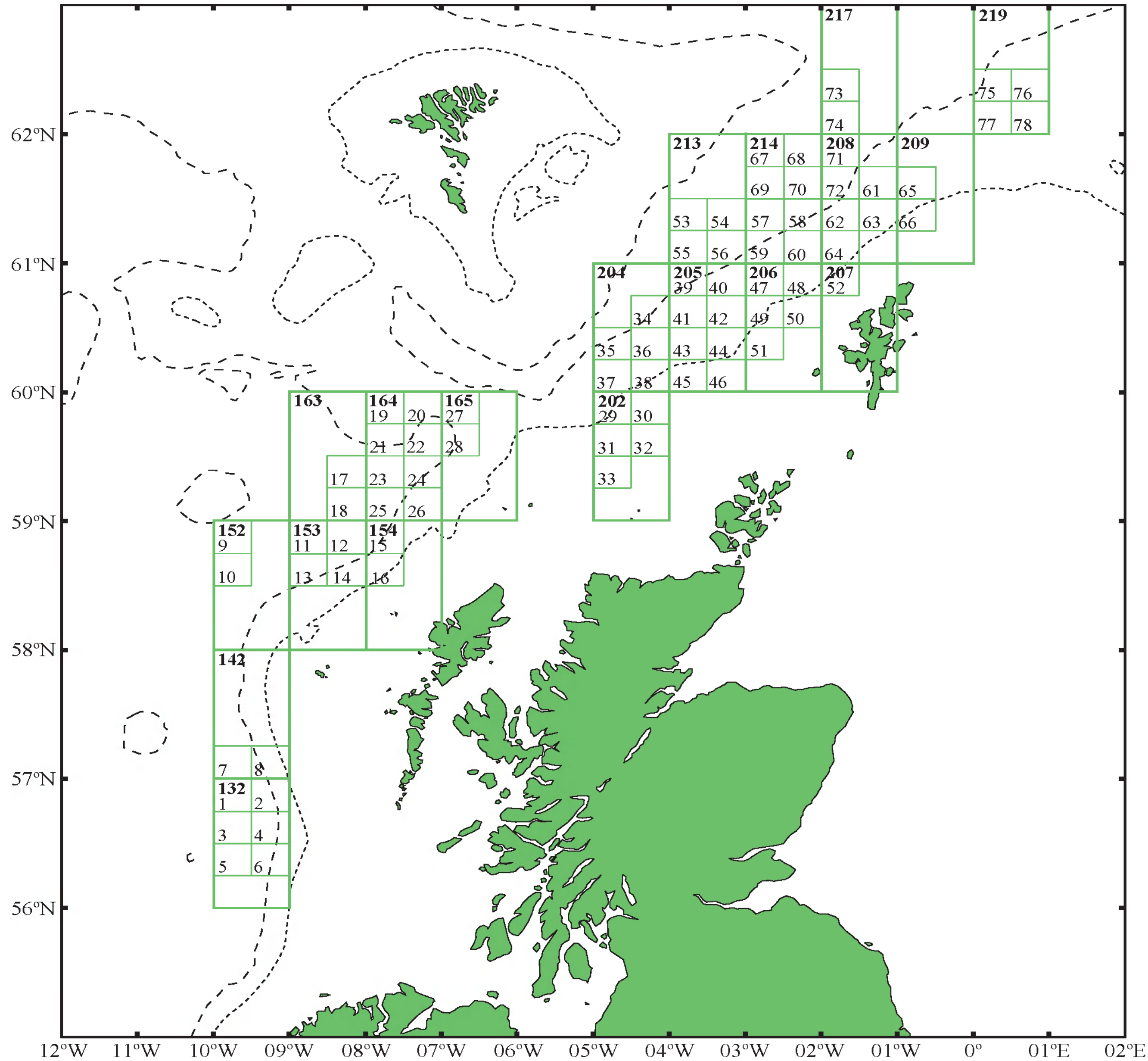


Figure 4. Location of licence quadrants and 1/4 ICES rectangles in the study area (See Appendix II for co-ordinates of each 1/4 ICES rectangle). *Bold solid lines:* licence quadrants; *solid lines:* 1/4 ICES rectangles

4.2 Seabird and marine mammal survey methods

4.2.1 Ship-based surveys

Surveys were conducted from ships using standard methodology for counting seabirds at sea. Full details of the survey technique are given in Tasker *et al.* (1984) and Webb & Durinck (1992). Dedicated chartered vessels were used for survey work in addition to vessels of opportunity such as ferries, research vessels and fishery protection vessels. Data were collected when the ship was steaming, generally at speeds of greater than 5 knots. At regular intervals during surveys, environmental conditions including wind speed and direction, swell height and sea state were noted, and the ship's speed, position and heading were recorded using a Global Positioning System (GPS). The position of fishing vessels encountered while surveying was also noted.

All seabirds on the water within 90º or 180º of the ship's track-line to a distance of 300 m (or 200 m in poor conditions) were recorded. Birds on the water were assigned to one of four transect bands (A= <50 m, B= 51 m-100m, C= 101-200 m, D= 201-300 m), according to their perpendicular distance from the ship's track. A snapshot technique was used to sample flying birds to minimise the biases of the movement of flying birds relative to the movement of the ship. The frequency of snapshots is determined by the speed of the vessel and the distance at which flying birds are detected. Details on behaviour, age and moult of seabirds were recorded. Seabirds associating with fishing vessels were also counted, and noted as such.

Marine mammals (cetaceans and pinnipeds) were recorded concurrently with the seabird survey. Sightings were recorded using the same methodology and distance bands as with seabirds, and information such as species, number of animals and behaviour were noted.

4.2.2 Aircraft surveys

Aircraft surveys were carried out as counts along a defined transect zone in a straight line. The width of transect, altitude, speed and timing of the surveys were dependent on the species being counted. For a full description of aircraft survey methods, see Webb & Tasker (1988) and Pihl & Frikke (1992). Between 1987 and 1989, ten aerial surveys were carried out along the coastlines of Scotland and Northern Ireland, excluding the coastlines of Orkney and Shetland (Barton *et al.* 1994; Webb *et al.* 1990). These surveys were conducted along two fixed routes at 4 km and 9 km from land. Counts were made of birds occurring within a 180 m strip transect to one side of the aircraft, while flying at heights as close as possible to 60 m above sea level. Birds were recorded either as being on the water or as flying. The constant high speed during aircraft surveys removes the risk of overestimating flying birds, so these were counted continuously. In order to maximise detectability of birds on the sea surface, surveys were carried out mostly in a wind force less than Beaufort Force 3. Marine mammals were noted when seen.

4.3 Data Analysis

All data in the ESAS database for the Atlantic Frontier study area were used in the analysis. Data collection methods between ESAS members vary slightly, such as the number of observers and use of binoculars for detecting birds, but all data have been considered together.

4.3.1 Ship-based surveys

Observations of seabirds and marine mammals made during ship-based surveys were primarily recorded using paper forms. The data were subsequently coded and entered onto computer for analysis. Coded data were checked manually by an independent person. During the preparation of data for map production, data were grouped to obtain a total number of birds for each 10 min period of the survey. These totals were used to calculate densities and prepare sightings and abundance maps. When calculating seabird densities only the number of birds within 300 m of the ship's track, either on the water or flying 'in snapshot', were used.

4.3.2 Aircraft surveys

Observations made during aircraft surveys were initially recorded into a tape recorder, and were later transcribed to paper recording forms. Data were coded, entered onto computer database and subsequently calculated as number of birds seen per one minute survey period.

4.3.3 Correction factors

Correction factors were applied to birds on the water to account for variations in detectability at different distances from the ship's trackline (Table 4). As mentioned, birds on the water were recorded in one of four distance bands (A= <50 m, B= 51 m-100m, C= 101-200 m, D= 201-300 m). Correction factors were calculated using the following formula:

$$\frac{(nA + nB) \times 3}{(nA + nB + nC + nD)}$$

where nA, nB, nC and nD equal the number of birds recorded on the water in the respective transect bands (Tasker *et al.* 1987). Two correction factors were calculated depending on transect width (200 or 300 m).

Only data from the study area and not the entire ESAS database were used to calculate correction factors. Correction factors were not calculated for uncommon species (those with a sample of less than 1,000 birds recorded on the water within transect) in the study area, and instead those used in Stone *et al.* (1995a) were applied. Correction factors were applied only to species where density was calculated. Species that were closely related and similar in size and appearance (e.g. guillemot and razorbill) were grouped together when calculating correction factors, as their detection rates are similar. Preliminary examination of the data for the effect of increased sea state on sighting rate indicated that certain species groups (auks and petrels) became more difficult to detect as sea state increased. For these species, correction factors were calculated taking sea state into account.

Correction factors were applied only to birds on the water, with the exception of European and Leach's storm-petrels, which were treated as a special case. Their small size and habit of flying close to the water renders them easily overlooked, especially at high sea state; therefore the correction factors were also applied to flying storm-petrels within the 300 m band transect.

Correction factors were applied to the data collected in each survey period, by multiplying the number of birds recorded for a species by its calculated correction factor to give a corrected value with which to calculate the density of each seabird species (the corrected number of seabirds recorded per km^2 survey coverage).

Table 4. Correction factors used in study area

Species group	Sea state	300m	200m
Fulmar	all	1.2	1.1
Shearwaters	all	1.1	1
Storm-petrels	0-2	1.3	1.1
Storm-petrels	>=3	1.6	1.5
Gannet	all	1	1
Shag	all	1.1	1
Ducks*	all	1	1
Skuas*	all	1.3	1.1
Small gulls	all	1.2	1.1
Large gulls	all	1	1
Terns*	all	1.7	1.3
Guillemot/Razorbill	0-2	1.3	1
Guillemot/Razorbill	>=3	1.6	1.3
Black guillemot*	all	1.4	1.2
Puffin/Little auk	<=3	1.4	1.2
Puffin/Little auk	>3	1.7	1.3

* correction factors from Stone *et al.* (1995a)

4.3.4 Data Presentation

Seabird and marine mammal accounts are presented in taxonomic order; species for which density or sightings maps were produced are presented first, with a summary of rare species afterwards. Monthly distribution maps for each species were generated using Dmap for Windows version 6.5b (Morton 1998). Where the pattern in distribution and density of a species was similar between adjacent months, maps were amalgamated. The average number of birds per 1/4 ICES rectangle over the monthly range was then used to produce grouped density maps.

The method of mapping each species in this report was determined by how numerous the species was within the study area. Three separate types of map were produced:

Density maps. For common (>150 birds after correction factors were applied) seabird species, maps were produced of seabird density. The total number of birds (the corrected numbers of birds on the water within 300 m, plus flying birds in snapshot) was divided by the total area surveyed in each 1/4 ICES rectangle, and presented as the number of birds per square kilometre (birds/km^2).

Abundance maps. Cetacean species of which more than 1,000 animals were recorded were mapped as the number of animals per km travelled. All sightings were used and correction factors were not applied.

Sightings maps. Maps showing location of sightings were produced for uncommon (over 20 records but less than 150 birds recorded after correction factors were applied) seabird species, cetacean species for which less than 1,000 animals were recorded and all pinniped records. Cetacean maps are shown as number of individuals when over 100 animals were recorded. In producing these maps all data were used, including data from beyond the transect and all flying birds.

In addition, seabird species encountered on less than 20 occasions were classed as rare and data are presented as a species summary rather than mapped.

4.3.5 Variation within and limitations of survey data

The ESAS database contains records collected by a large number of observers from many different survey platforms. Large vessels provide a higher observer eye height which may result in improved visibility. Smaller vessels afford a more detailed look at seabirds on the water, but may be limited by weather conditions. The use of fishery protection vessels may result in high densities of seabirds associating with fishing vessels, resulting in problems in recording methods. Ferries and seismic vessels generally follow pre-determined routes and may travel at speeds that are less suitable for accurately recording seabirds. Variation in eye height, vessel speed and stability of the platform in adverse weather conditions may cause biases in data collected from both ships and aircraft. These possible biases have not been corrected for within this report.

A further major variation within ESAS data is the environmental conditions under which the survey was carried out. In Atlantic Frontier waters, high sea states and wind speeds affect survey coverage for much of the year, particularly during the winter. Almost 60% of all cetacean records on the SAST and ESAS database are of animals seen between June and August, when sea and wind conditions are calmer, and the day length is longer. This may partly reflect an actual increase in cetacean numbers during the summer, but it is likely that favourable recording conditions are also responsible. High sea states result in biases towards larger, more conspicuous species of seabird and marine mammals. Species flying high above the water such as fulmars and gannets are more readily detectable in rough weather conditions than small species on the water such as European storm-petrels and auks. Similarly, the size and behaviour of cetacean species may affect the likelihood of their detection. Certain species that surface inconspicuously, such as the minke and beaked whales, and smaller species such as the harbour porpoise, show a markedly reduced sighting rate as sea state increases (Clarke 1982; Palka 1996). The behaviour of cetaceans also influences their sighting rate, since some species such as common dolphins regularly approach the vessel to bow-ride, increasing the chances of their detection.

When interpreting the species distribution and abundance maps that follow, it is important to do so with respect to the possible biases outlined here.

4.4 Survey Coverage

This report summarises all SAST and ESAS data collected in the study area between June 1979 and March 1999.

The monthly survey effort from vessel-based and aircraft surveys is shown in Table 5. Figures 5 and 6 depict monthly effort as km^2 surveyed and km travelled respectively. Total coverage in $^1/_4$ ICES rectangles for each month is shown in Appendix II. Survey effort and coverage was greatest during summer and least during the winter, when reduced day length, strong winds and increased swell heights restricted both ship speeds and numbers of days suitable for surveying. Inshore surveys from aircraft were conducted around north and west of Scotland between 1987 and 1989 (Barton *et al.* 1994; Webb *et al.* 1990). Overall survey effort from aircraft was low (Table 5).

Table 5. Monthly survey effort (km^2) from ships and aircraft: 1979-1999

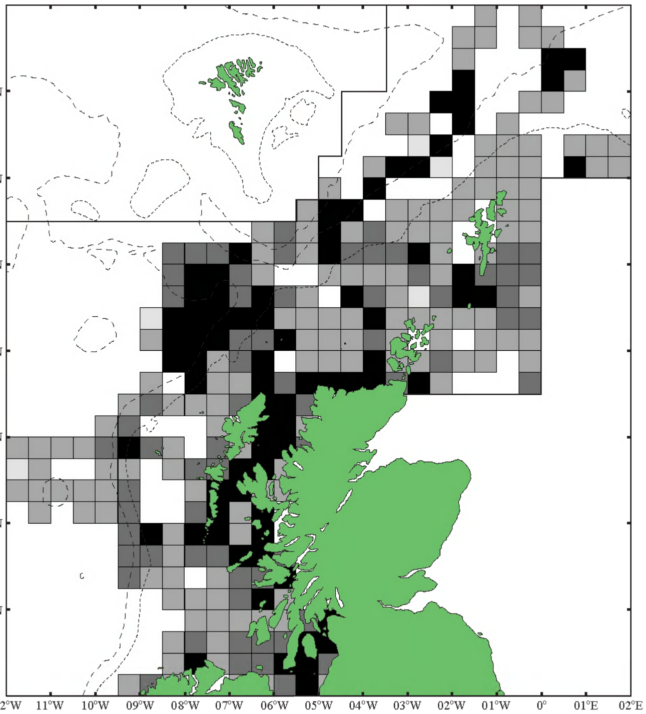
Month	Ship	Aircraft	Total	% survey effort
January	3,201	591	3,792	8
February	2,444	0	2,444	5
March	3,800	109	3,909	8
April	2,687	0	2,687	6
May	4,126	579	4,705	10
June	5,047	0	5,047	10
July	8,130	560	8,690	18
August	6,507	0	6,507	13
September	2,782	551	3,333	7
October	2,889	0	2,889	6
November	2,330	97	2,427	5
December	1,499	292	1,791	4
Total effort	45,442	2,779	48,221	100

The distribution of survey effort has not been consistent between years; effort was concentrated on shelf waters of the North Sea and Western Isles prior to 1996. Since 1996, emphasis has included deep, offshore waters, and a dedicated survey vessel was chartered between May 1997 and March 1999 to carry out extensive surveys over the deep waters of the licence blocks along the shelf edge. The aim was to survey a minimum of 20 km^2 in each $^1/_4$ ICES rectangle that contained part or all of a licence block, for each month of the year.

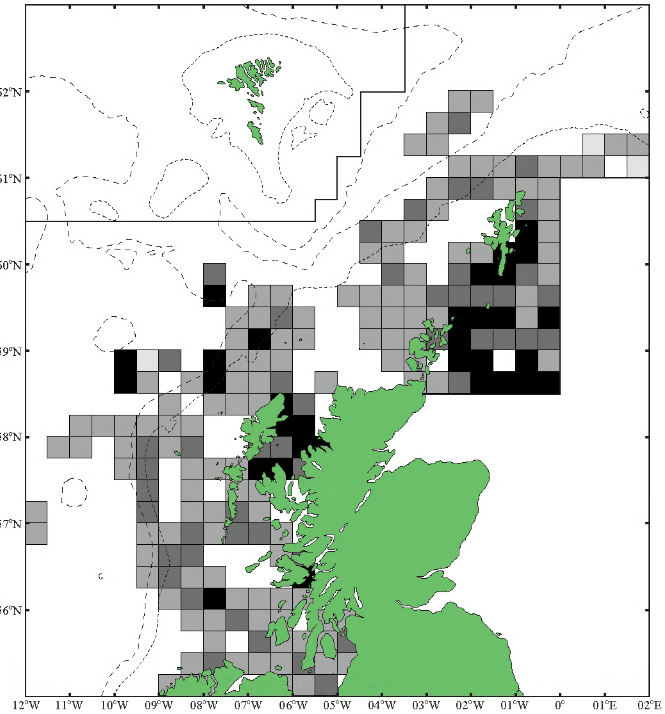
Two water depth categories; shelf waters (< 200 m deep) and slope/oceanic waters (>200 m deep) are considered in this report (Figure 7). Overall, 67% of survey effort was in shelf waters (total effort 48,221 km^2). Over half the coverage in deep waters was as a result of the dedicated surveys that began in 1997 (Table 6).

Table 6. Survey coverage (km^2) in shelf and slope/oceanic waters between 1979 and 1999

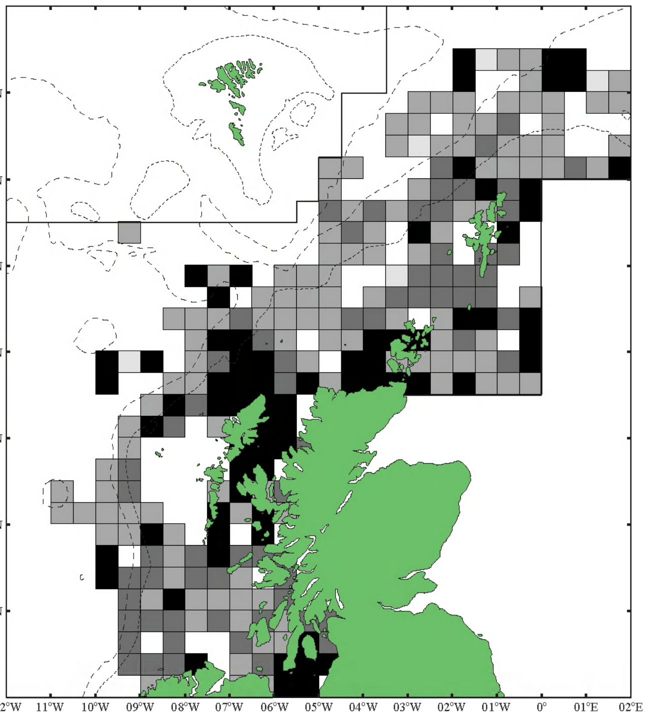
	Shelf	Slope/oceanic
June 1979 - April 1997	28,752	7,629
May 1997 - March 1999	3,695	8,144
June 1979 - March 1999	32,447	15,773



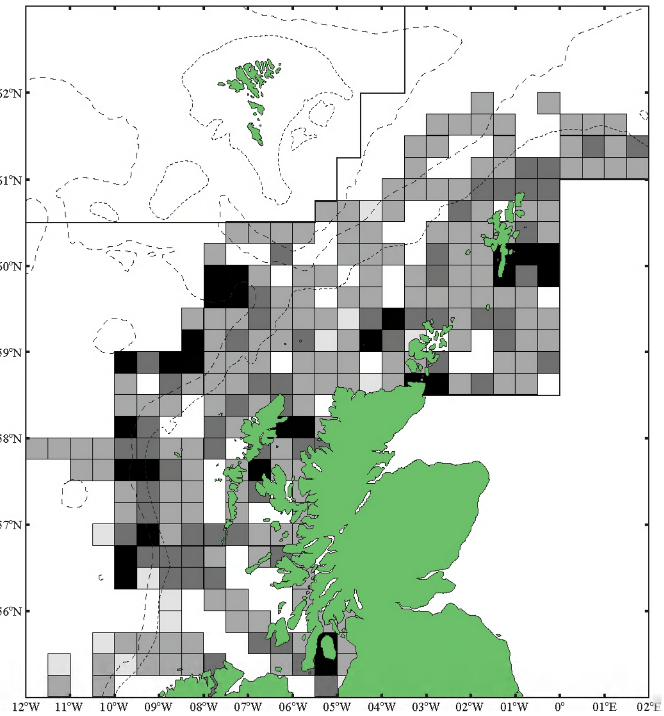
a) January



b) February



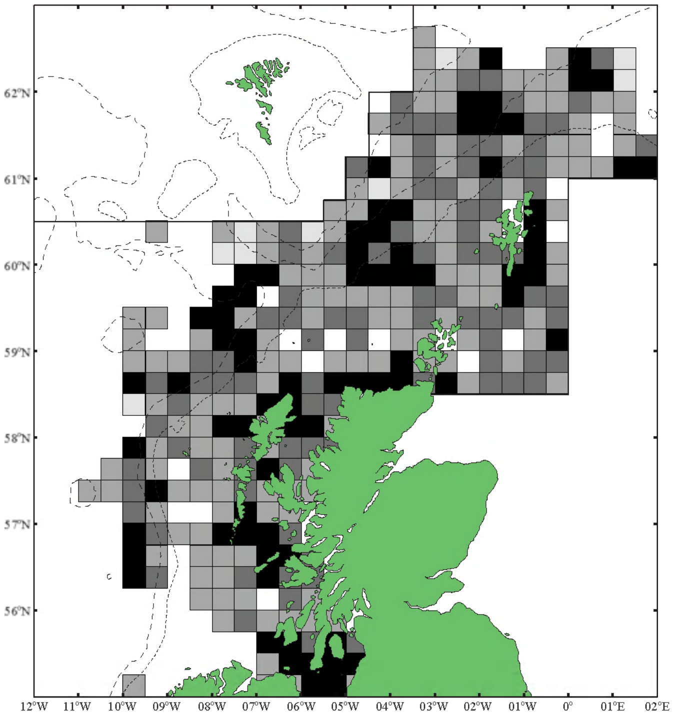
c) March



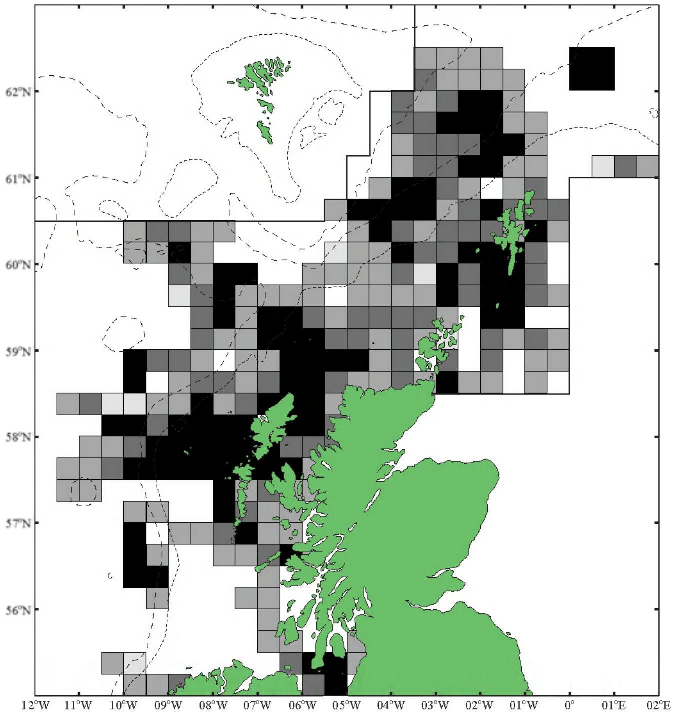
d) April

Figure 5 a) - d). Survey effort (km²) from ships and aircraft 1979 to 1999

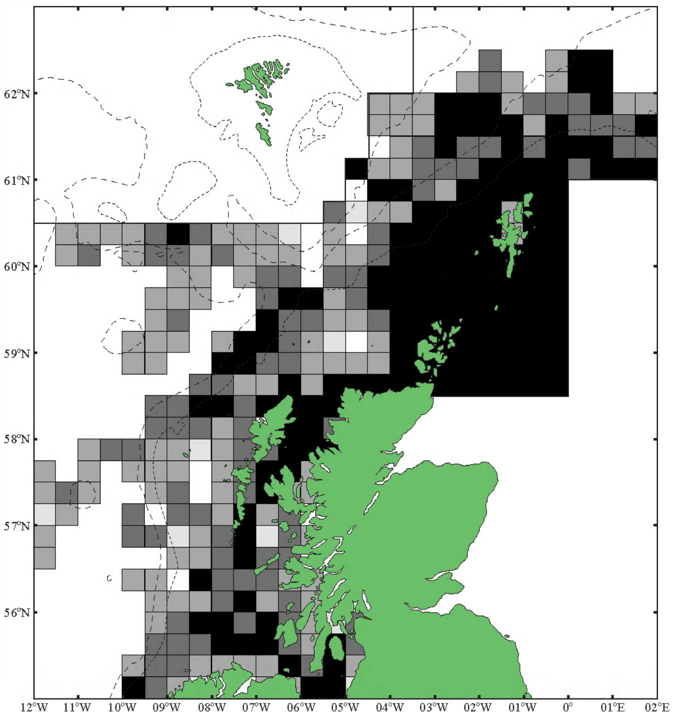
Blank = No coverage | 0.01-0.99 | 1.00-9.99 | 10.00-19.99 | 20.00+



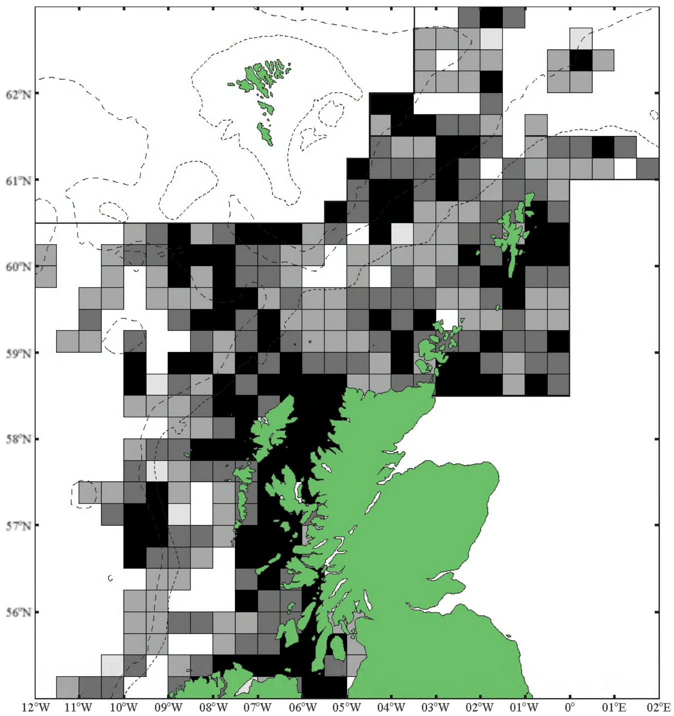
e) May



f) June



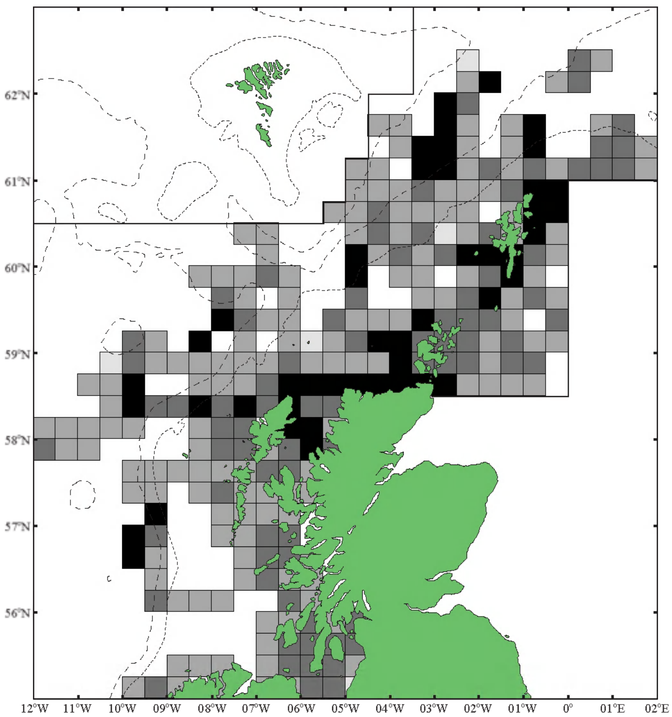
g) July



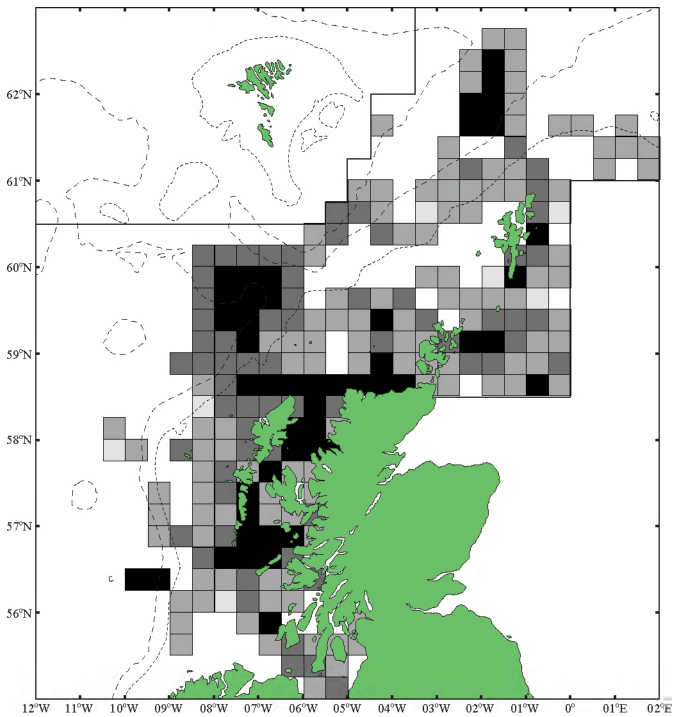
h) August

Figure 5 e) - h). Survey effort (km^2) from ships and aircraft 1979 to 1999

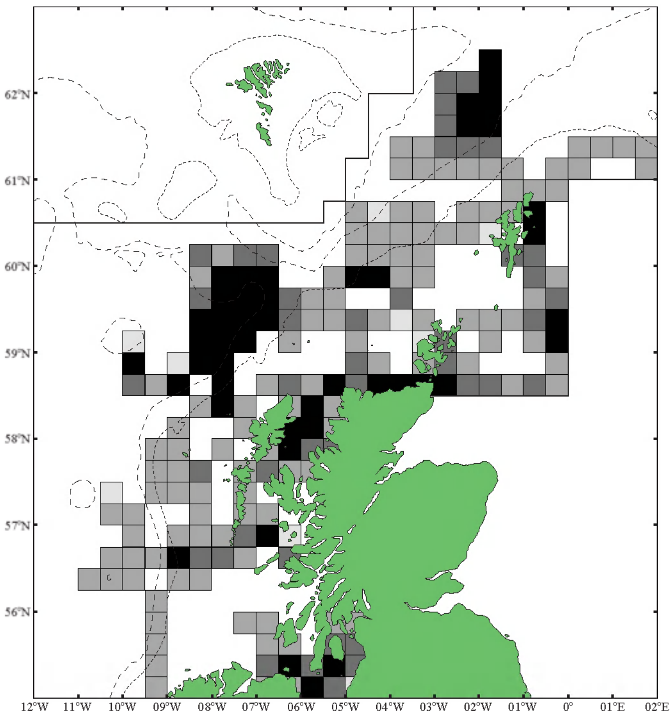
Blank = No coverage ☐ 0.01-0.99 ☐ 1.00-9.99 ☐ 10.00-19.99 ■ 20.00+



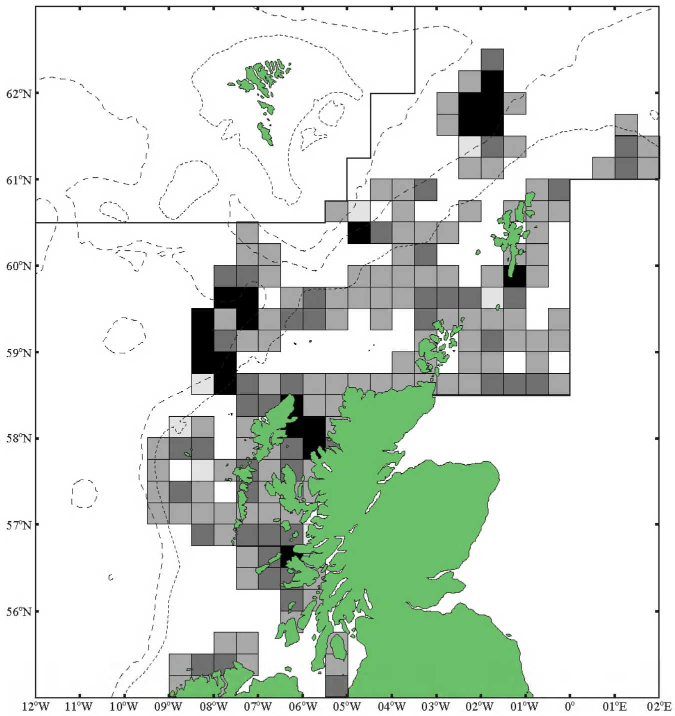
i) September



j) October



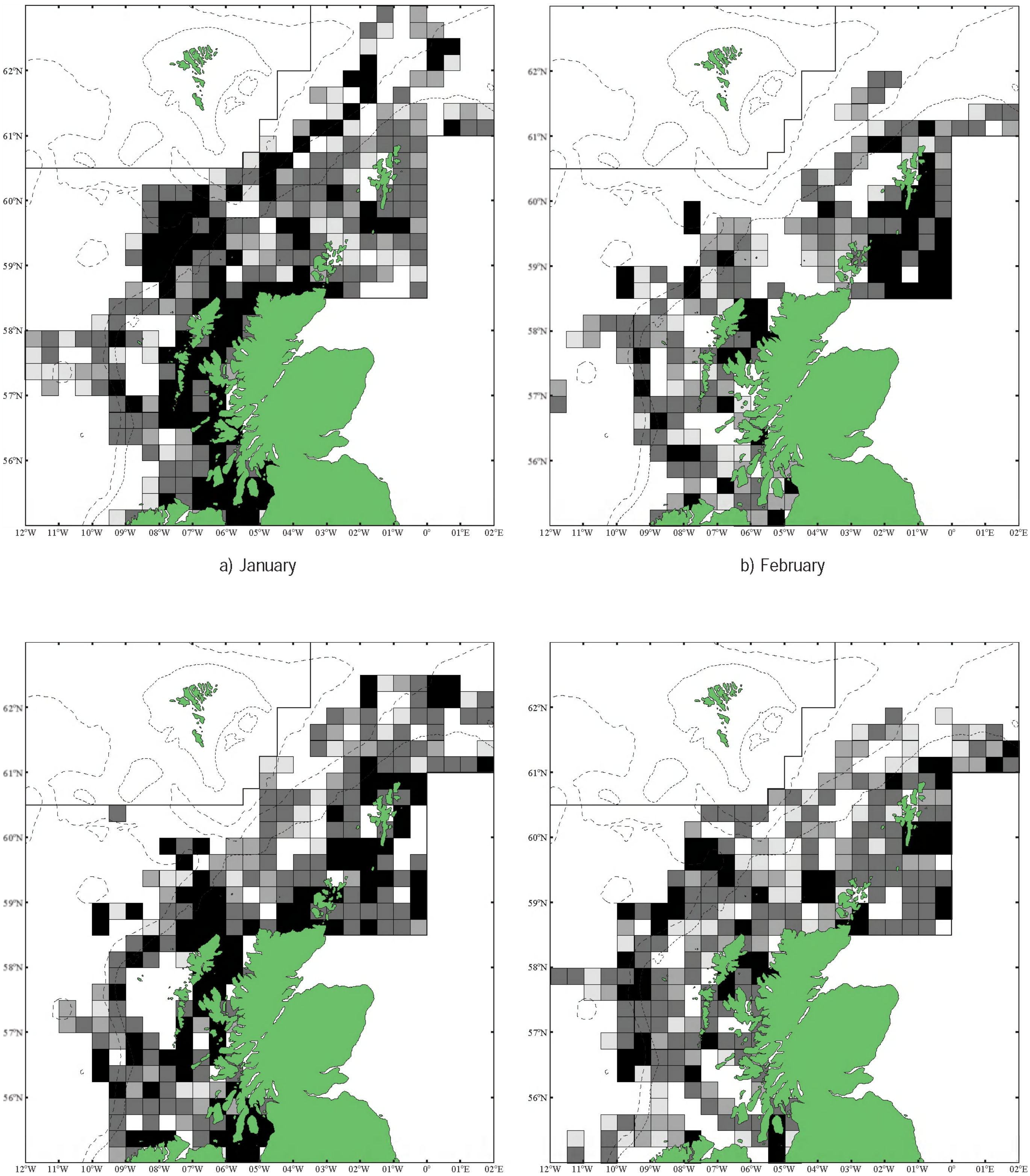
k) November



l) December

Figure 5 i) - l). Survey effort (km²) from ships and aircraft 1979 to 1999

Blank = No coverage ☐ 0.01-0.99 ☐ 1.00-9.99 ☐ 10.00-19.99 ■ 20.00+



a) January

b) February

c) March

d) April

Figure 6 a) - d). Survey effort (km travelled) from ships and aircraft 1979 to 1999

Blank = No coverage   0.01-9.99   10.00-19.99   20.00-49.99   50.00+

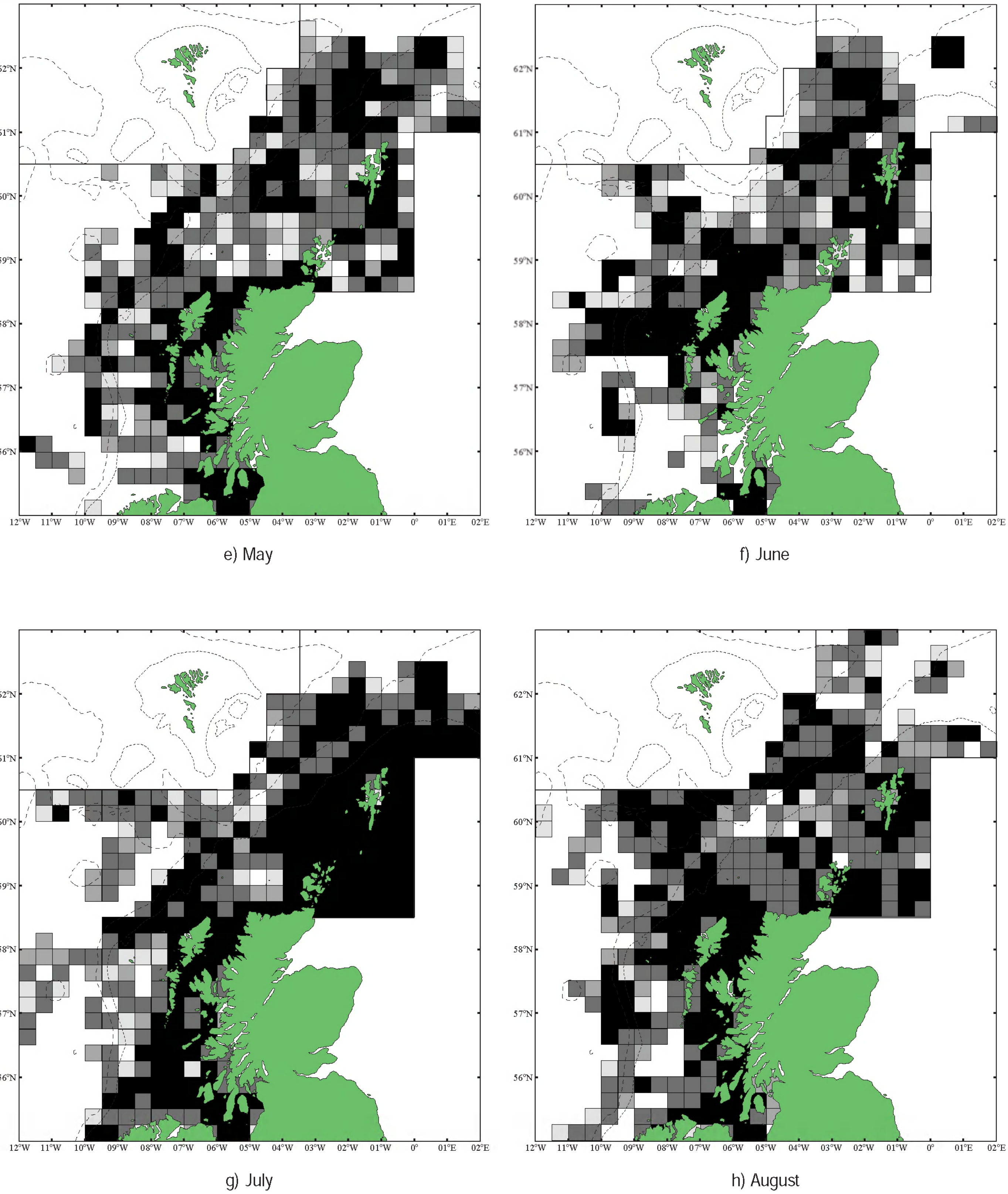
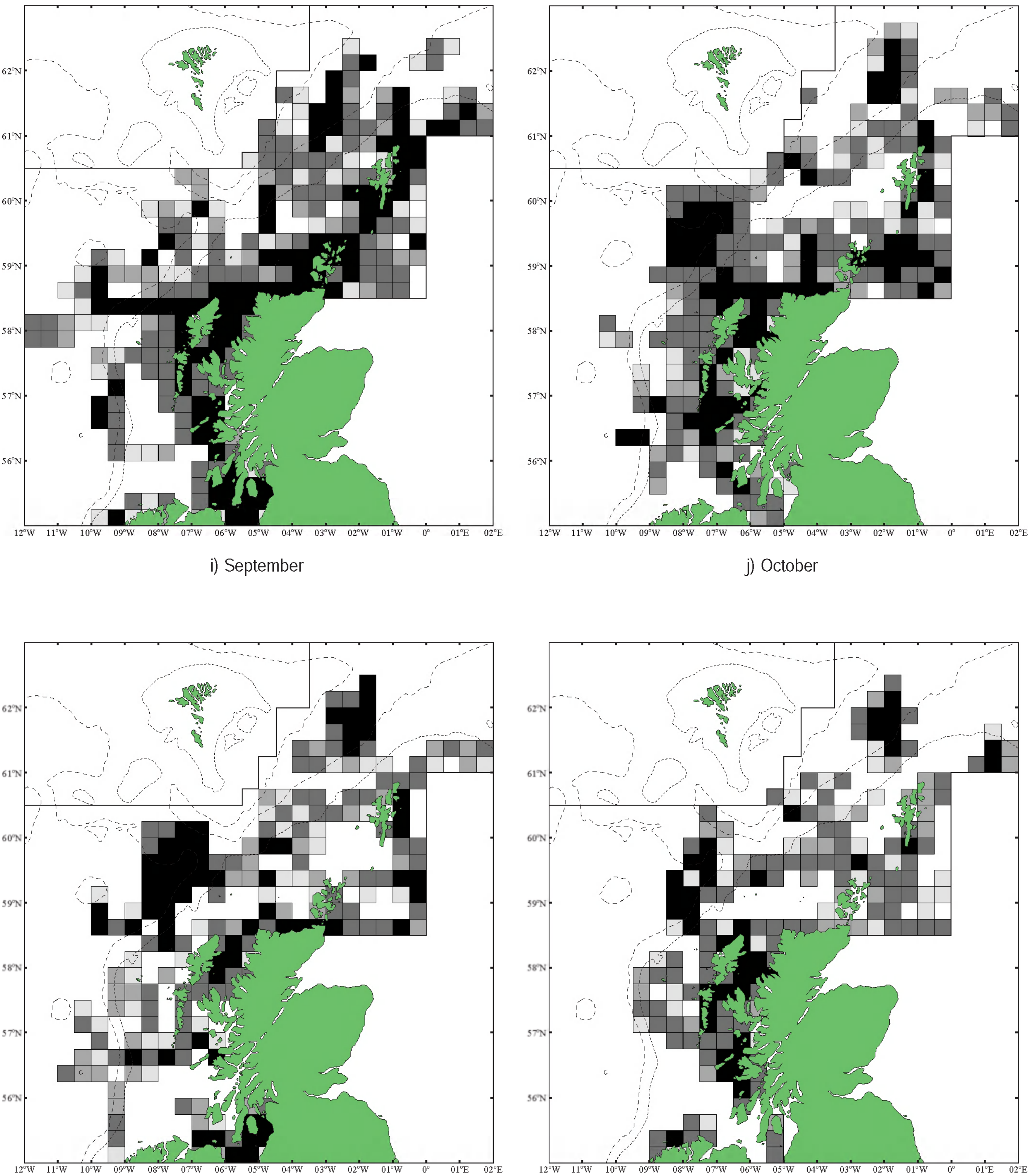


Figure 6 e) - h). Survey effort (km travelled) from ships and aircraft 1979 to 1999

Blank = No coverage 0.01-9.99 10.00-19.99 20.00-49.99 50.00+



i) September

j) October

k) November

l) December

Figure 6 i) - l). Survey effort (km travelled) from ships and aircraft 1979 to 1999

Blank = No coverage ▢ 0.01-9.99 ▢ 10.00-19.99 ▢ 20.00-49.99 ■ 50.00+

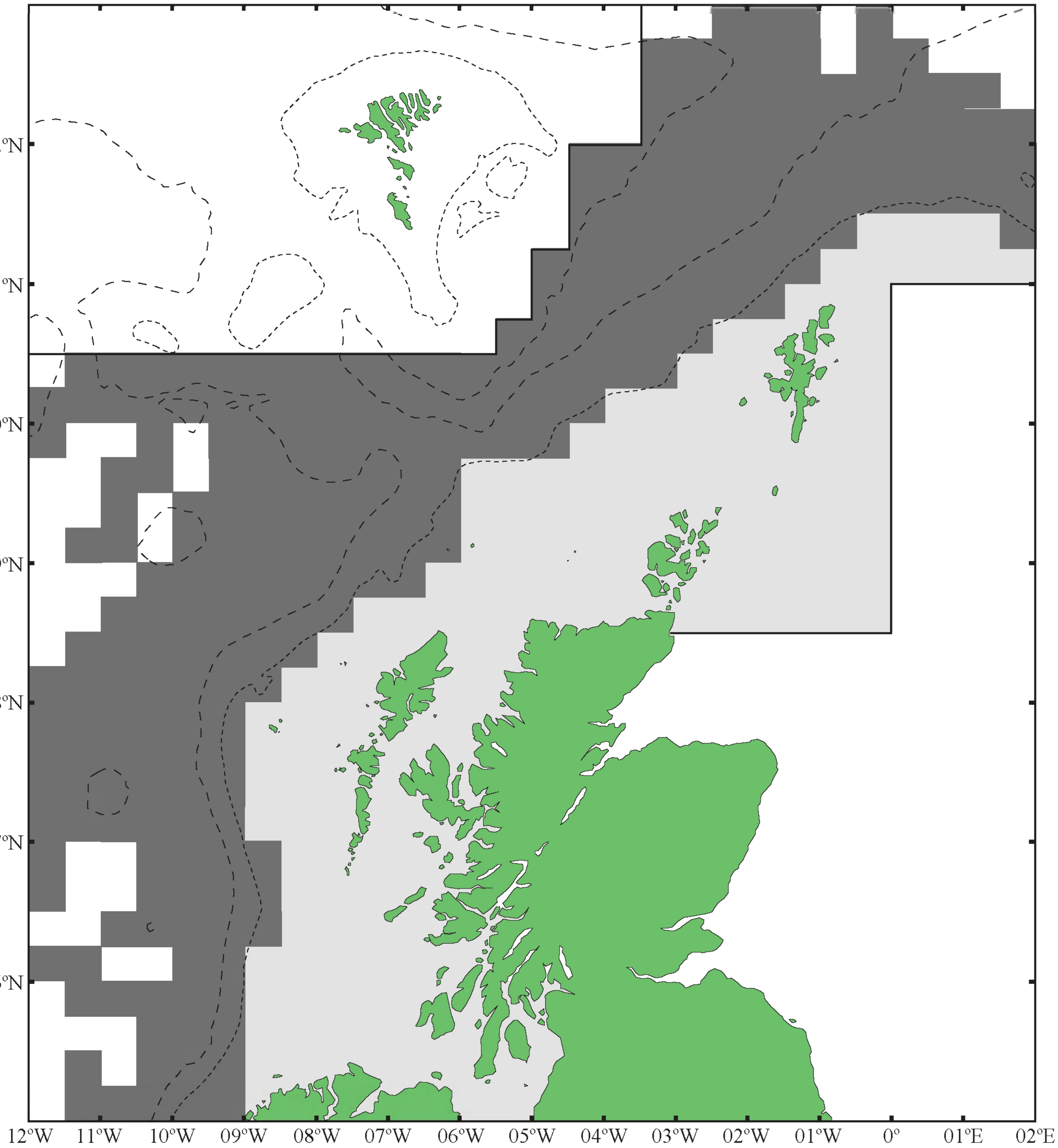


Figure 7. Shelf and slope/oceanic waters surveyed in the study area.

Bathymetry: short dash (200 m isobath); long dash (1,000 m isobath) Depth categories: shelf slope/oceanic

5. Seabird distribution at sea

A total of 48 species of seabird in ten taxa was recorded in the study area (Table 7). Petrels were the most abundant taxon, followed by auks and gulls (Figure 8). Apart from petrels, all other taxa were more abundant in shelf waters than in deep waters along or beyond the shelf edge (Figure 9). The most frequently recorded species was fulmar, but common guillemots, kittiwakes, puffins and gannets were also numerous in the study area (Figure 10). Overall, a total of 45 seabird species was recorded in shelf waters and 40 in slope and oceanic waters. Both species diversity and the number of individuals recorded were higher on the continental shelf than those along and beyond the shelf edge. In shelf waters, ten prominent species (i.e. species accounting for >1% of the total recorded in shelf waters) were recorded, while in slope and oceanic waters, there were eight species (Figure 11). Survey effort was slightly higher in shelf waters (67% of total effort) than in shelf edge and oceanic waters, and 72% of the total number of birds were recorded over the shelf. This is reflected in seabird density, with an average of 13.7 birds/km^2 over the shelf compared with 10.9 birds/km^2 in slope and oceanic waters. Auks were more prevalent in shelf waters (Figure 11). Although the most common species in both depth categories, the fulmar was considerably more important in deeper waters, where it accounted for almost 80% of birds seen there (Figure 11). If fulmars are excluded from the density calculations, a figure of 10.1 birds/km^2 emerges for shelf waters with a much lower value of 2.4 birds/km^2 for slope and oceanic waters.

Eight species were present over the deep water of the Atlantic Frontier throughout the year. In order of decreasing abundance they were: fulmar, gannet, kittiwake, puffin, great black-backed gull, common guillemot, herring gull and razorbill (Figure 12). Apart from fulmar, all species were found in greater numbers over the shelf. Seven seabird species were classed as summer visitors to the Atlantic Frontier. In order of decreasing abundance, they were European storm-petrel, lesser black-backed gull, great skua, Leach's storm-petrel, Manx shearwater, Arctic tern and Arctic skua (Figure 13). Although all these species were also found in shelf waters, over 97% of Leach's storm-petrels and 45% of European storm-petrels were recorded in deep waters (>200 m). To a lesser extent, these waters were also important for lesser black-backed gulls and great skuas. Three species are winter visitors to the study area: Iceland gull, glaucous gulls and little auk (Table 7). Four seabird species - great shearwater, long-tailed skua, Pomarine skua and sooty shearwater - are migrants that pass through the Atlantic Frontier study area (Table 7). Sooty shearwater was the most abundant of these four species.

Although occasionally recorded in the deep waters of the Atlantic Frontier, the following ten species had a largely inshore distribution: red-throated diver, great northern diver, cormorant, shag, common eider, long-tailed duck, black-headed gull, common gull, common tern and black guillemot (Table 7).

Twenty-one species were recorded associating with fishing vessels, but only fulmar, European storm-petrel, gannet, great skua, herring gull, lesser black-backed gull, great black-backed gull and kittiwake did so in any number.

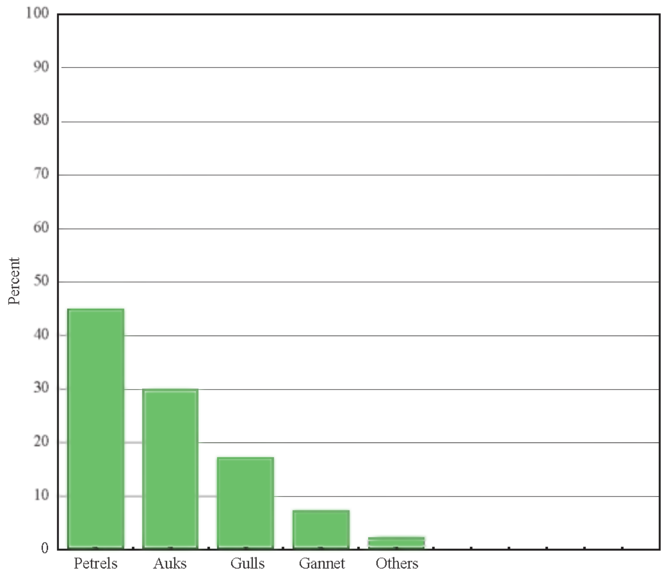


Figure 8. Relative proportions of each taxa recorded

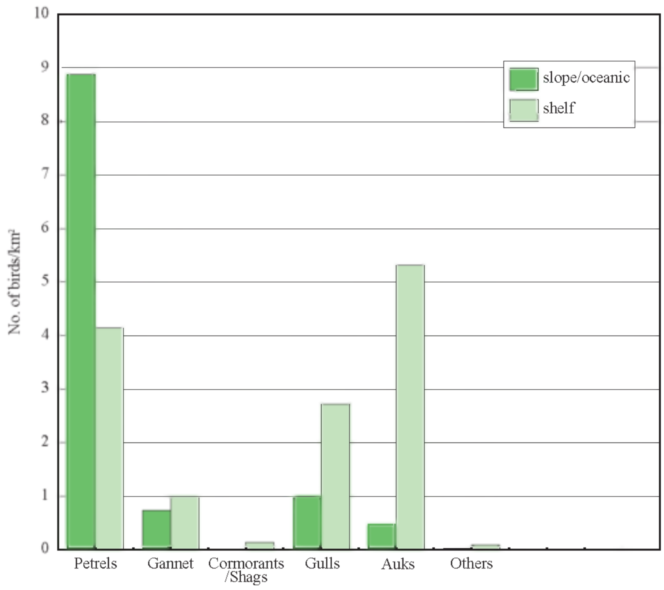


Figure 9. Densities of each taxon recorded in shelf and slope/oceanic waters

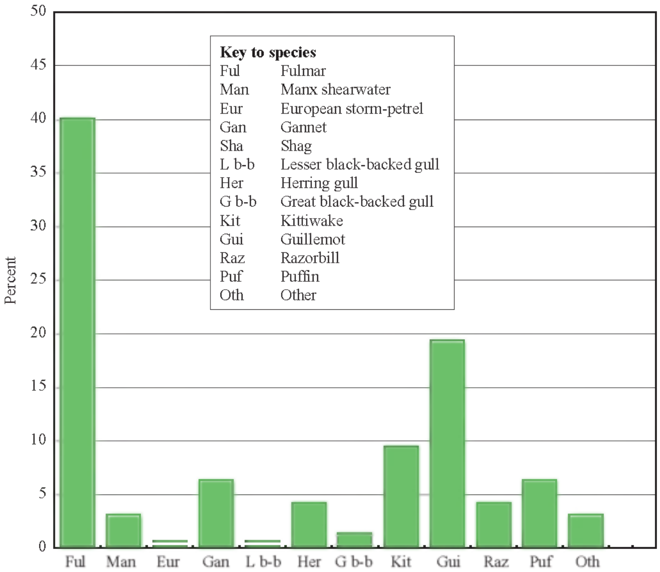


Figure 10. Number of birds seen for each species as a percentage of the total number of birds recorded

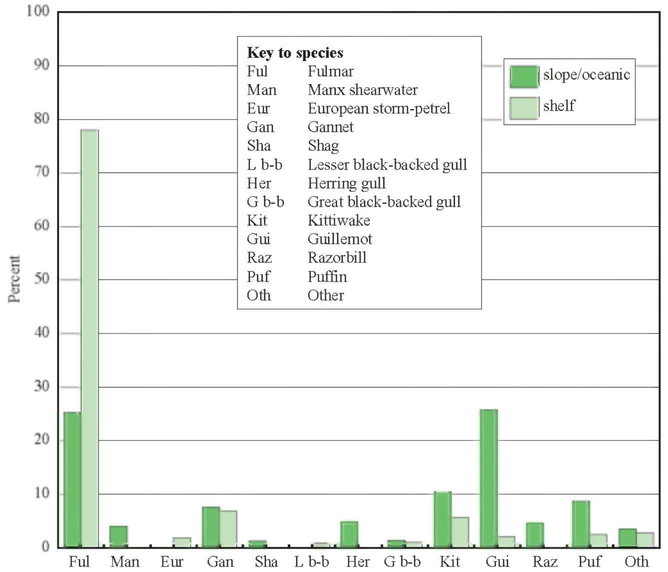


Figure 11. Number of birds seen over shelf and deep water as a percentage of the total number of birds recorded in these habitats

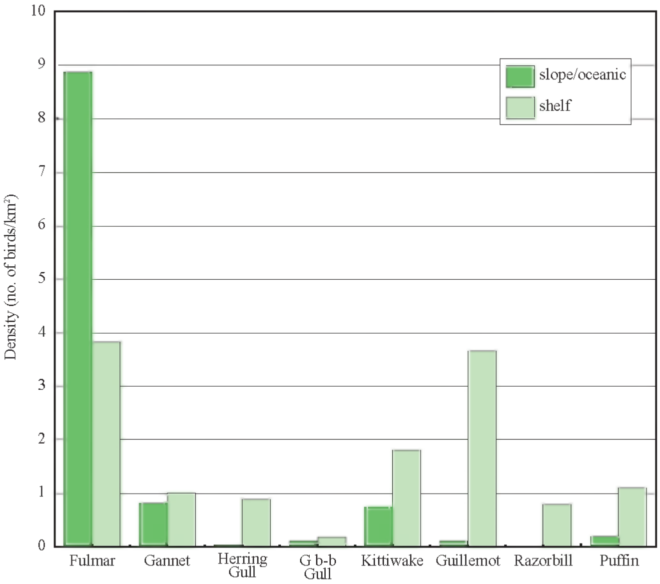


Figure 12. The average densities of seabird species present throughout the year in shelf and slope/oceanic waters

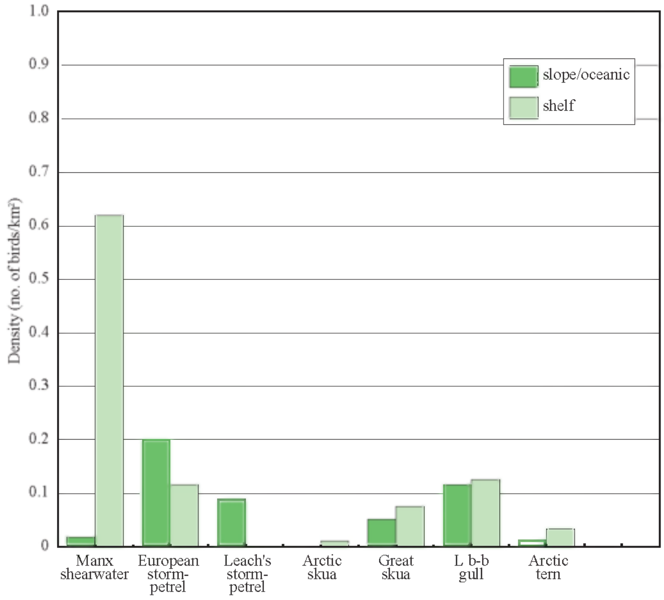


Figure 13. The average densities of seabird species which are summer visitors in shelf and slope/oceanic waters

Table 7. List of seabird species recorded in the Atlantic Frontier study area
(Status:- **A** – all year, **S** – summer, **W** – winter, **M** – passage migrant, **I** – inshore, **R** – rare)

Family	Species	A	S	W	M	I	R
Divers	Red-throated diver					■	
	Black-throated diver						■
	Great northern diver					■	
Grebes	Great crested grebe						■
Petrels	Fulmar	■					
	Soft-plumaged petrel sp.						■
	Cory's shearwater						■
	Great shearwater				■		
	Sooty shearwater				■		
	Manx shearwater		■				
	Mediterranean shearwater						■
	European storm-petrel		■				
	Leach's storm-petrel		■				
	Wilson's storm-petrel						■
Gannets	Gannet	■					
Cormorants	Cormorant					■	
	Shag					■	

Table 7 continued. List of seabird species recorded in the Atlantic Frontier study area
(Status:- **A** – all year, **S** – summer, **W** – winter, **M** – passage migrant, **I** – inshore, **R** – rare)

Family	Species	A	S	W	M	I	R
Ducks	Common eider					■	
	Long-tailed duck					■	
	Common scoter						■
	Velvet scoter						■
	Red-breasted merganser						■
Phalaropes	Red-necked phalarope						■
	Grey phalarope						■
Skuas	Pomarine skua				■		
	Arctic skua		■				
	Long-tailed skua				■		
	Great skua		■				
Gulls	Little gull						■
	Sabine's gull						■
	Black-headed gull					■	
	Common gull					■	
	Lesser black-backed gull		■				
	Herring gull	■					
	Iceland gull			■			
	Glaucous gull			■			
	Great black-backed gull	■					
	Kittiwake	■					
Terns	Sandwich tern						■
	Common tern					■	
	Arctic tern		■				
	Little tern						■
Auks	Common guillemot	■					
	Brünnich's guillemot						■
	Razorbill	■					
	Black guillemot					■	
	Little auk			■			
	Puffin	■					

5.1 Red-throated diver *Gavia stellata*

January to December: Red-throated divers were recorded in inshore waters, in all months except December (Figure 14). A single bird was recorded in the Faroe-Shetland Channel in July. This species breeds on fresh-water lochs and moves to coastal waters outside the breeding season (Cramp & Simmons 1977). Approximately 60% of the British population breeds in the Northern Isles (Gibbons *et al.* 1997).

In this study, 74% of red-throated divers were recorded between May and September. In autumn, migrant birds arrive from Scandinavia, Faroes, Iceland, and Greenland (Cramp & Simmons 1977). In late September, red-throated divers moult and are flightless for about a month (Ginn & Melville 1983), during which time they are very susceptible to surface pollution.

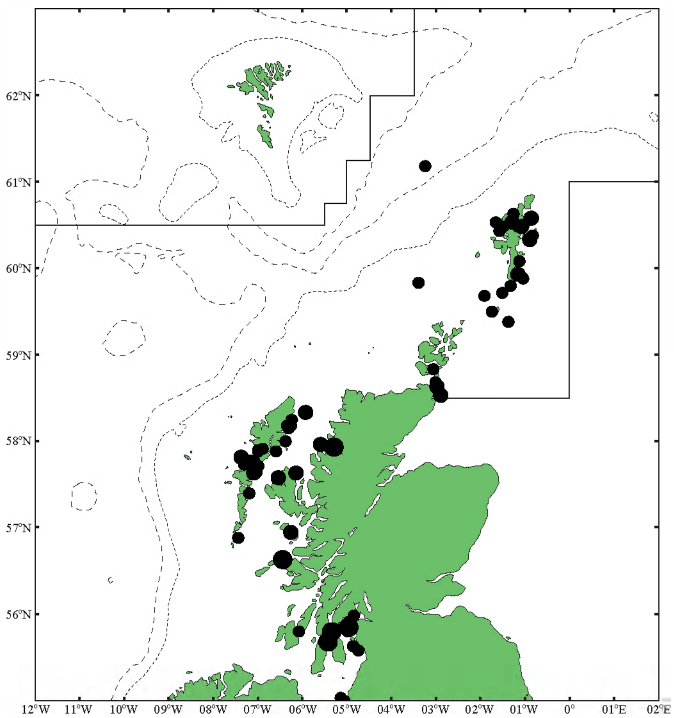


Figure 14. Red-throated diver sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

5.2 Great northern diver *Gavia immer*

October to May: The great northern diver is an inshore species, which is primarily a winter visitor to the study area (Cramp & Simmons 1977). It is estimated that 75% of the Western Palearctic wintering population are found in British waters, mostly within the study area (Parrack 1986).

Most sightings were located around the Northern and Western Isles as well as inshore waters west of Scotland (Figure 15). Almost half the birds were recorded in December and January. Sightings in the Atlantic Frontier (>200 m) were mostly in October and November and were possibly migrating birds from colonies in Greenland, Canada and Iceland (Weir *et al.* 1996).

Great northern divers moult between late March and early May (Ginn & Melville 1983), during which time they are flightless and are especially vulnerable to surface pollution.

June to September: Only four birds were recorded during this time.

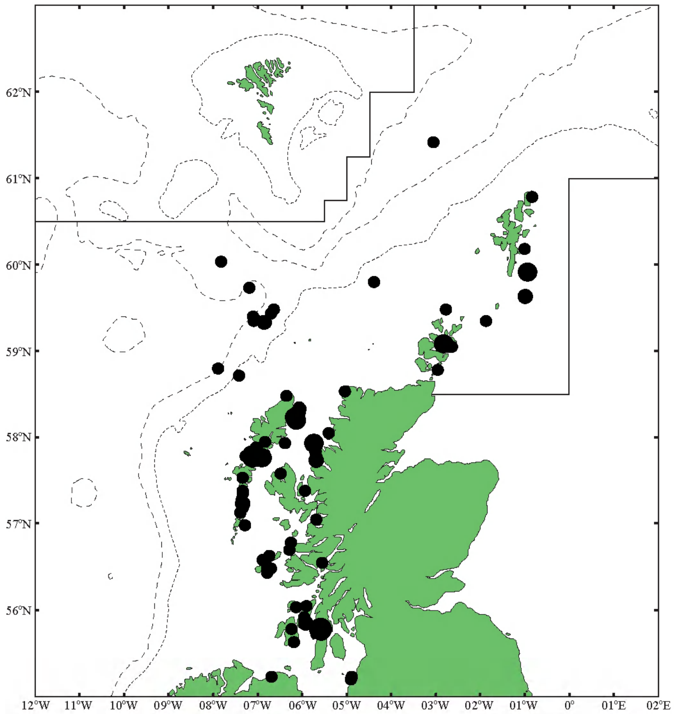


Figure 15. Great northern diver sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

5.3 Fulmar *Fulmarus glacialis*

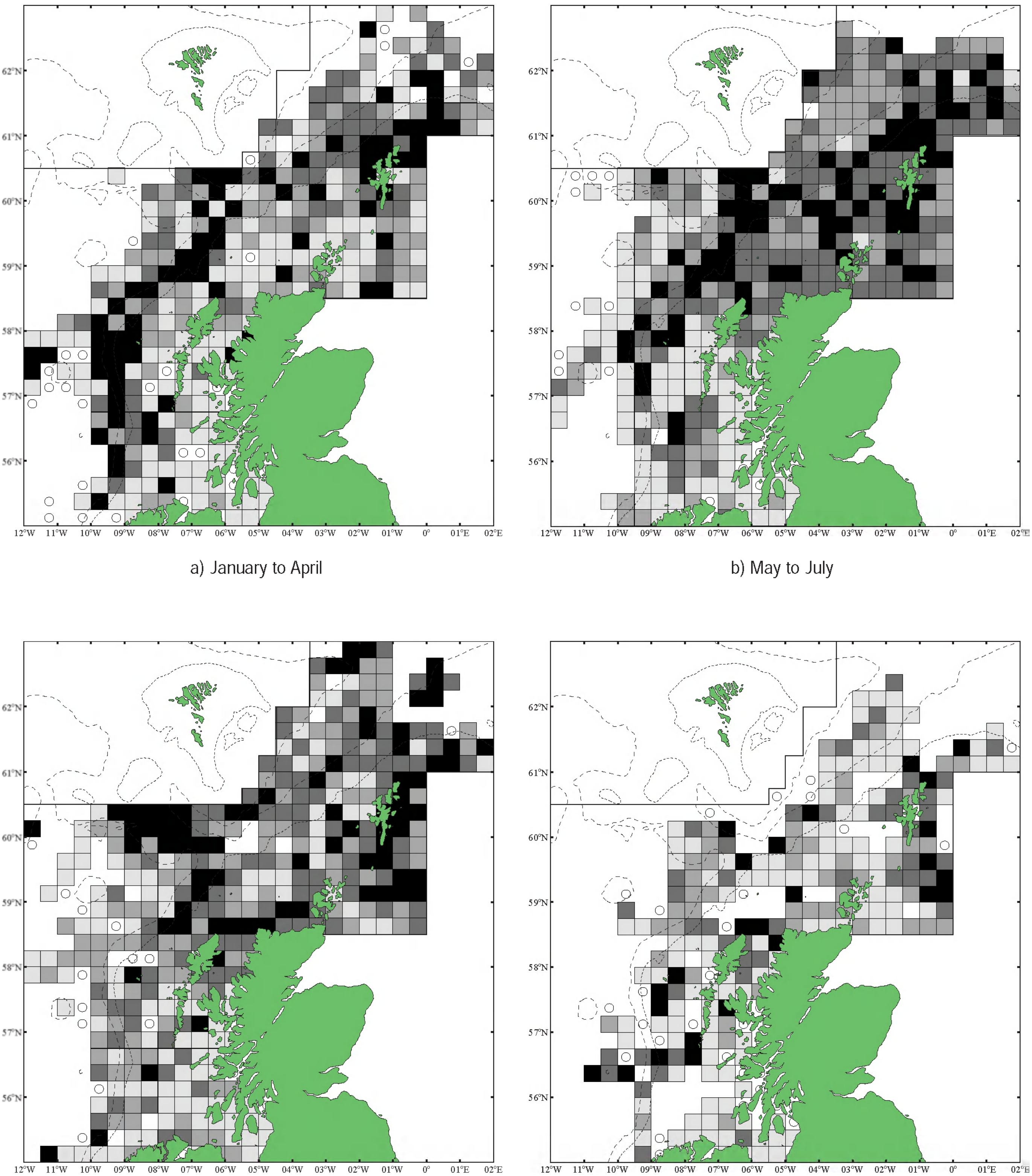
The fulmar was the most abundant species recorded in this study as well as being the most widespread.

January to April: From January to April, prior to the breeding season, highest densities of fulmars were concentrated along the continental slope south of 60°N and around Shetland (Figure 16a). This was most pronounced in April when they are known to leave their colonies on a "pre-laying exodus" (Dunnet *et al.* 1963; Macdonald 1977a). Many fulmars encountered along the continental slope were associated with fishing vessels, particularly in April. Fulmars regularly follow fishing vessels, scavenging on discards (e.g. Camphuysen *et al.* 1993), although the overall distribution of fulmars at sea is thought not to be influenced by the availability of discards (Camphuysen & Garthe 1997). On the shelf, densities were generally low to moderate except around and to the north-west of Shetland. Birds associated with fishing vessels mainly around Shetland.

May to July: During the breeding season, from May to July, higher densities occurred over the continental shelf, mostly in the vicinity of Shetland and Orkney, with generally moderate densities of fulmars widespread over the remaining areas of the continental shelf (Figure 16b). Beyond the continental shelf moderate to high densities of fulmars were recorded over the deep waters of the Norwegian Sea and following the continental break north and west of Scotland. Fulmars associated with fishing boats along the slope north-west of the Western Isles and the waters around Orkney. Fulmars range widely when feeding even during the breeding season, and have been recorded up to 466 km away from their colonies (Dunnet & Ollason 1982). Fulmars leave their colonies to moult in late summer.

August to October: Between August and October, relatively lower densities of fulmars were present in waters deeper than 200 m except for areas of high density over the Wyville-Thomson Ridge and over the shelf-break to the north-west of the Western Isles (Figure 16c). Over shelf waters, there were high-density areas north of Scotland and around Shetland, possibly reflecting the presence of recently fledged birds during late August and September (Fisher 1952), although high densities were associated with fishing vessels in these waters.

November and December: By November and December, recorded average densities were considerably lower (Figure 16d). Ringing recoveries suggest much of the breeding population remains within a few hundred kilometres of breeding colonies in winter, while young disperse over large distances travelling as far as Newfoundland (Dunnet *et al.* 1979; MacDonald 1977b). All sightings in the study area were less than 200 km from the nearest colony suggesting low densities of juvenile birds. Over the continental shelf the highest concentrations were over the southern stretch of the Fair Isle Channel and scattered around the Western Isles. Very few birds were recorded associating with fishing vessels.



a) January to April

b) May to July

c) August to October

d) November and December

Figure 16 a) - d). Fulmar distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

5.4 Great shearwater *Puffinus gravis*

August to October: After breeding on islands in the South Atlantic, great shearwaters are thought to complete a clockwise migration circuit of the Atlantic Ocean (Bourne 1995; Voous & Wattel 1963). The majority were recorded between August and October, with peak numbers in August. The species had an offshore distribution, with only two inshore records from the Minch (Figure 17). Sightings were spread along the continental slope north and west of Scotland and over the Wyville-Thomson and Ymir Ridges.

November to February: Single birds were seen in January and February to the west of the Western Isles close to the shelf break.

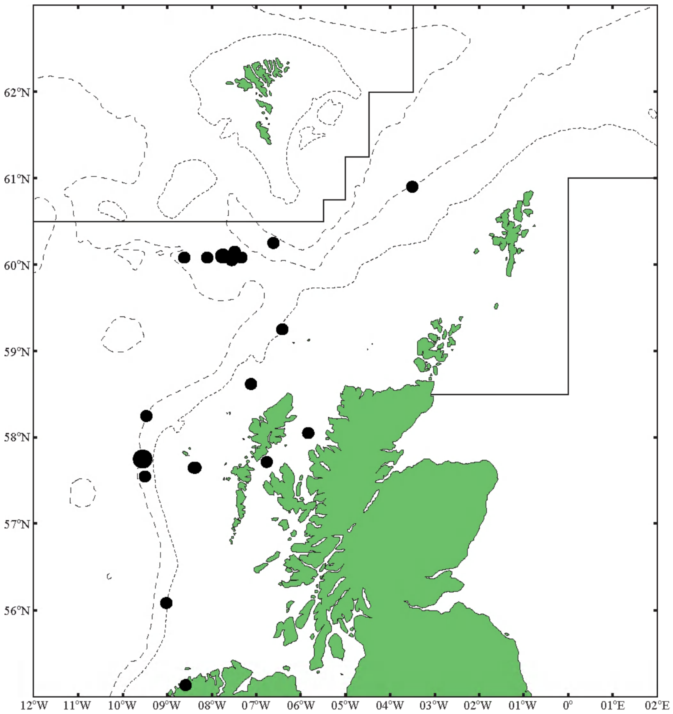


Figure 17. Great shearwater sightings from August to October

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

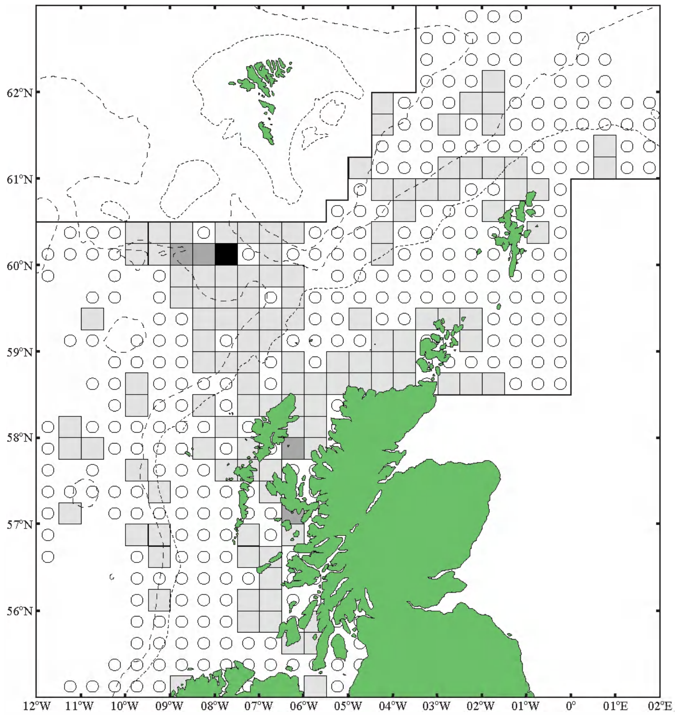


Figure 18. Sooty shearwater distribution from July to October.

Density (birds/km^2): ○ No birds ☐ 0.01-0.49 ☐ 0.50-0.99 ☐ 1.00-1.99 ■ 2.00+

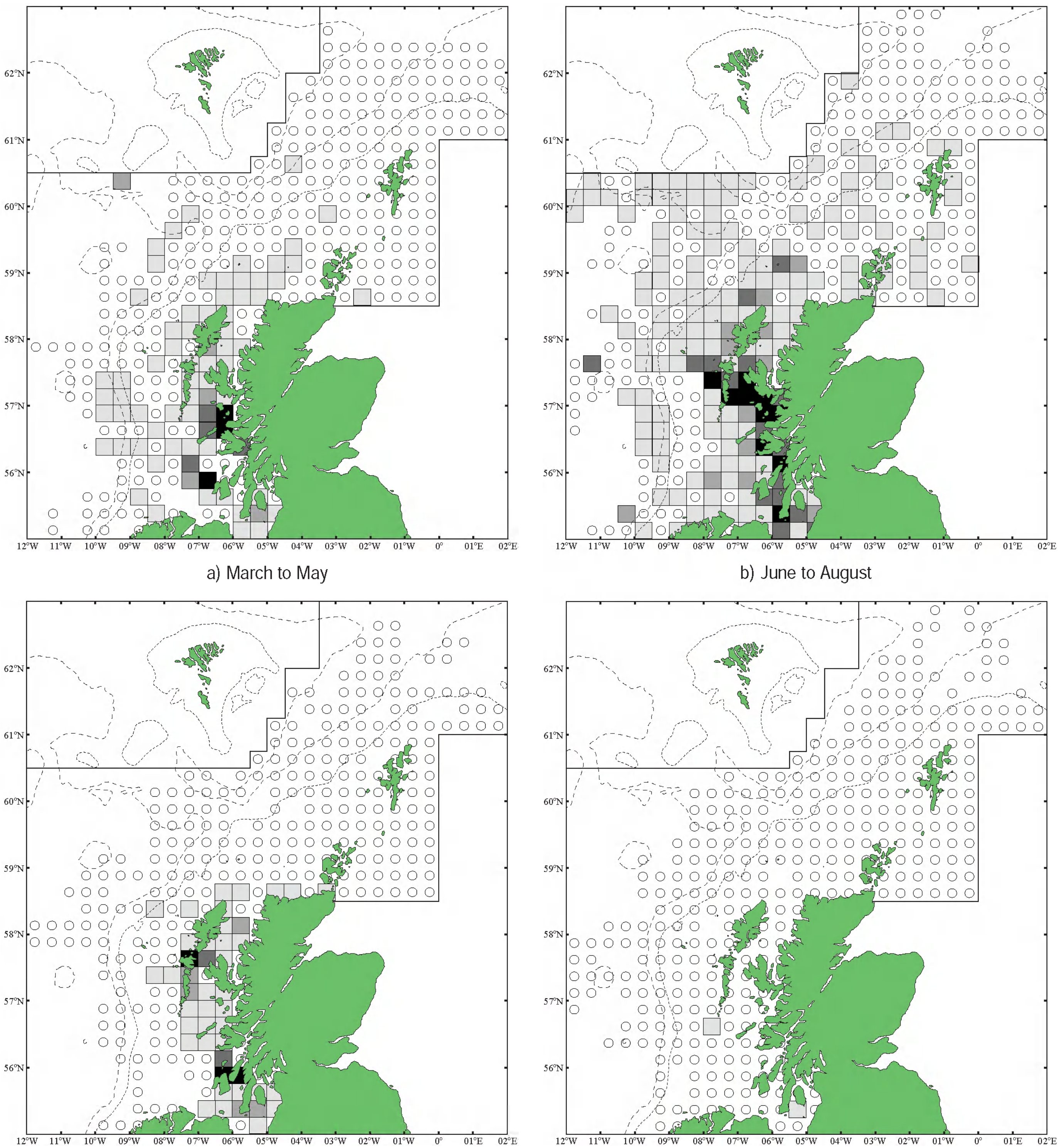
5.5 Sooty shearwater *Puffinus griseus*

June to November: This species breeds in vast numbers on the oceanic islands of the Southern Hemisphere. It has been suggested that a number of non-breeding birds complete a clockwise migration route in the Atlantic, where the prevailing westerly winds bring them from the east American seaboard into the Atlantic Frontier (Phillips 1963a). Long-distance crossings of deep water are probably made rapidly, before the species reaches feeding areas on the continental shelf where most birds are recorded (Phillips 1963b). Sooty shearwaters were recorded between June and November with the majority occurring during July to October (Figure 18). The sooty shearwater was widespread at low densities throughout the study area. Peak numbers were recorded in August, with a small concentration over the Wyville-Thomson Ridge.

5.6 Manx shearwater *Puffinus puffinus*

March to May: Manx shearwaters begin returning to the breeding colonies in March (Brooke 1990). Low densities were recorded throughout the study area between March and May, mostly to the south of 60°N and west of 4°W, with high densities encountered near Rum (Figure 19a). This island holds one of the largest Manx shearwater colonies in the world with an estimated population of 61,300 pairs (Furness 1997). Low densities recorded over the shelf-break to the south-east of the Wyville-Thomson Ridge may be accounted for by birds returning to more northerly colonies in the Faroes and Iceland.

June to August: Between June and August, Manx shearwaters were widespread at low densities over the continental shelf edge (Figure 19b) with the highest densities once again around the main west coast colonies. Low densities were also widely distributed over the Rockall Trough and Wyville-Thomson Ridge as far west as the Lousy Bank. Birds had also penetrated north-eastwards along the Faroe-Shetland Channel and east towards Shetland and Orkney. Sightings in these two areas may relate to immature non-breeding birds, which visit the breeding grounds from their second summer onwards (Brooke 1990).



a) March to May

b) June to August

c) September and October

d) November to February

Figure 19 a) - d). Manx shearwater distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

Also, Brooke (1990) estimated that breeding birds are able to commute 360 km each way on a day feeding trip so these birds may be from colonies in the Western Isles or Faroes.

September and October: In September and October Manx shearwater distribution had contracted and densities reduced as birds began to move southward. Despite adequate coverage over most of the study area the species was found to be restricted to inshore waters south along the west coast, with areas around North Uist and Jura holding high densities (Figure 19c). Numbers at this time comprise adults that have finished breeding and left the colonies and chicks which fledge in mid-September (Brooke 1990).

November to February: Manx shearwaters were rarely recorded in the Atlantic Frontier between November and February (Figure 19d). Two birds in December and one in January were the only records. Most Manx shearwaters have migrated southwards by this time, spending the winter off the east coast of South America (Brooke 1990).

5.7 European storm-petrel *Hydrobates pelagicus*

April and May: European storm-petrels were recorded in the region between April and November. In April and May (Figure 20a), low numbers were recorded as they began to return from wintering grounds off Africa (Cramp & Simmons 1977). None were recorded associating with fishing vessels in April. During May, low densities were associated with fishing vessels only in two areas – to the north of the Butt of Lewis and south-west of St. Kilda, over the shelf and continental slope respectively.

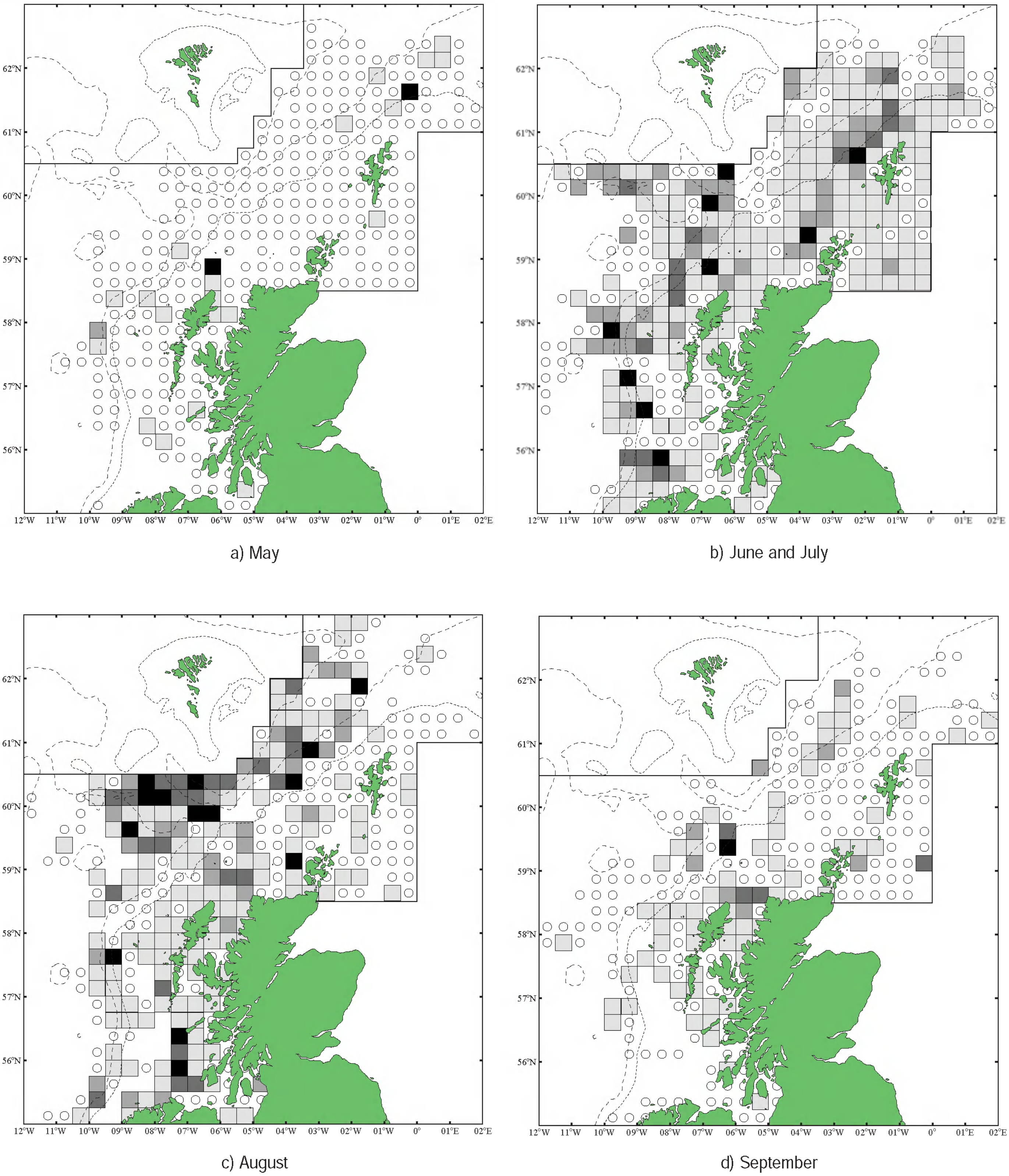


Figure 20 a) - d). European storm-petrel distribution

Density (birds/km²): ○ No birds ☐ 0.01-0.49 ☐ 0.50-0.99 ☐ 1.00-1.99 ■ 2.00+

June and July: In June and July, European storm-petrels were widespread (Figure 20b). The most important colonies in the study area are located at Sule Skerry and Shetland (Lloyd *et al.* 1991), and the deep water of the shelf edge is within the feeding range of breeding adults. Many non-breeders, numbering tens of thousands, may be present in the study area from the end of June, as has been shown by ringing studies in Shetland (Fowler *et al.* 1982). European storm-petrels were associated with fishing vessels in both these months. The highest densities were recorded over the shelf edge to the west and north-west of the Western Isles, especially during July. Over the shelf low densities were widespread around Lewis, Orkney and Shetland.

August: Highest concentrations were located in deep waters around the south of the Faroe-Shetland Channel (Figure 20c). Densities were lower in shelf waters north of Scotland. An area of high density was observed in the Sea of Hebrides. Associations with fishing vessels were recorded only in the Minch.

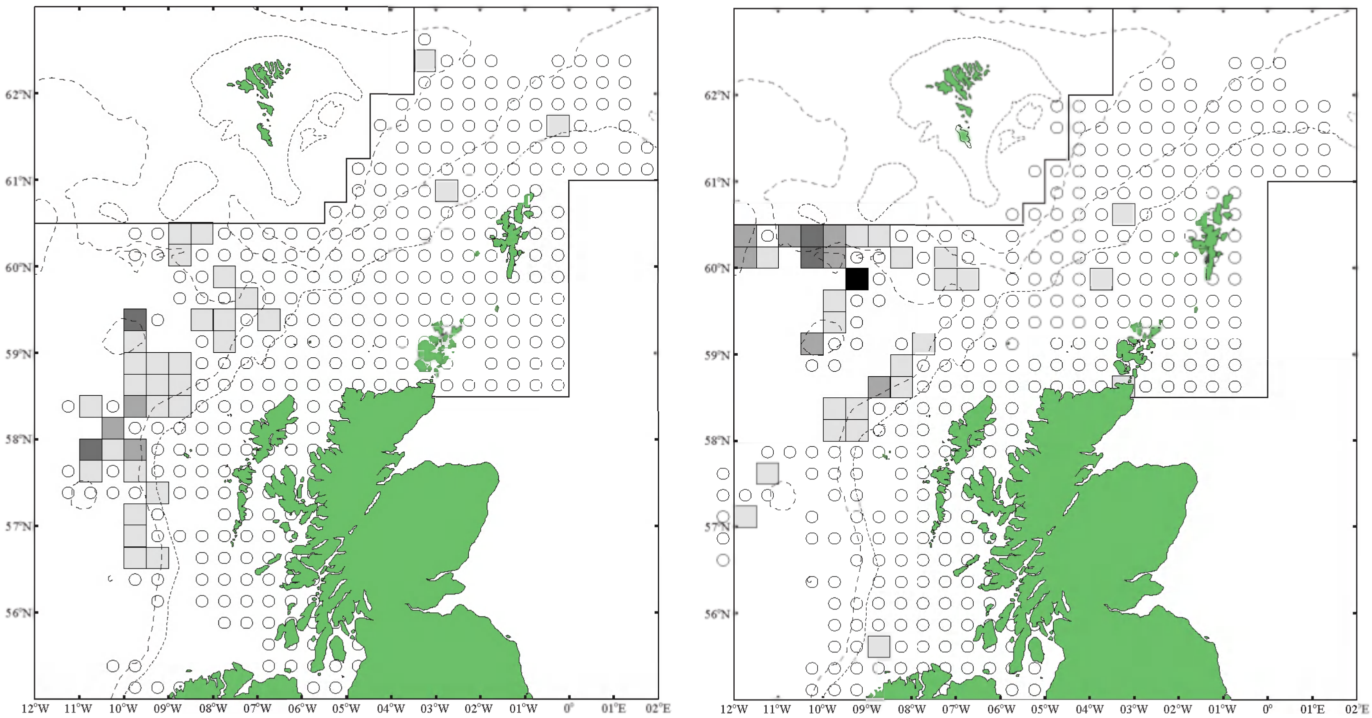
September to November: Lower numbers of European storm-petrels were recorded in September (Figure 20d) which may indicate the departure of the large non-breeding population, as many birds from Shetland and more northern colonies are still breeding during September (Cramp & Simmons 1977; P. Harvey pers. comm.). Even fewer were observed in October and November and no birds were sighted between December and March.

5.8 Leach's storm-petrel *Oceanodroma leucorhoa*

May and June: Leach's storm-petrels were first recorded in April in very small numbers, becoming more evident in May and June (Figure 21a). Low densities of birds were recorded over and to the west of the shelf-break; highest densities were found around the near Rosemary Bank and the Anton Dohrn Seamount. Very few Leach's storm-petrels were seen in the study area to the north-east of the Ymir and Wyville-Thomson ridges.

July: Most sightings were located over waters deeper than 1,000 m north-west of Scotland (Figure 21b). Moderate to high densities were recorded to the east of Lousy Bank, and south of the Faroes and Bill Bailey's banks. Low densities were observed along the continental slope to the north-west of the Western Isles. Leach's storm-petrels feed on plankton over deep water, and commute between their feeding areas and breeding colonies only during the hours of darkness, thus few birds were recorded in shelf waters. The main breeding site in Britain and Ireland is on St. Kilda, although few birds were recorded near these islands (Lloyd *et al.* 1991).

August: Highest densities of Leach's storm-petrels were recorded in August. The centre of distribution was similar to July, situated in deep waters north-west of Scotland, although the overall distribution was widespread over the Ymir and Wyville-Thomson ridges (Figure 21c). More birds were recorded in the north-east of the study area, along the Faroe-Shetland Channel, than in other months. Low to moderate densities were again observed along the continental slope to the west of the Western Isles.



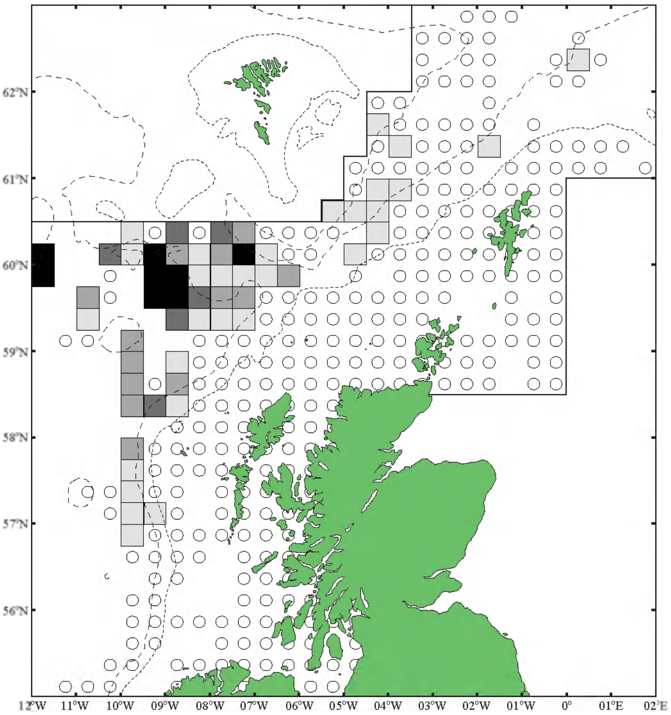
a) May and June

b) July

Figure 21 a) - b). Leach's storm-petrel distribution

Density (birds/km^2): No birds | 0.01-0.49 | 0.50-0.99 | 1.00-1.99 | 2.00+

September to January: Leach's storm-petrels are migratory, departing the breeding grounds in autumn to winter in the tropics (Cramp & Simmons 1977; Rankin & Duffey 1948). Very few birds were recorded in September, and only five were recorded between October and January, when stragglers are known to remain in the cooler waters of the North Atlantic during the northern winter (Cramp & Simmons 1977).



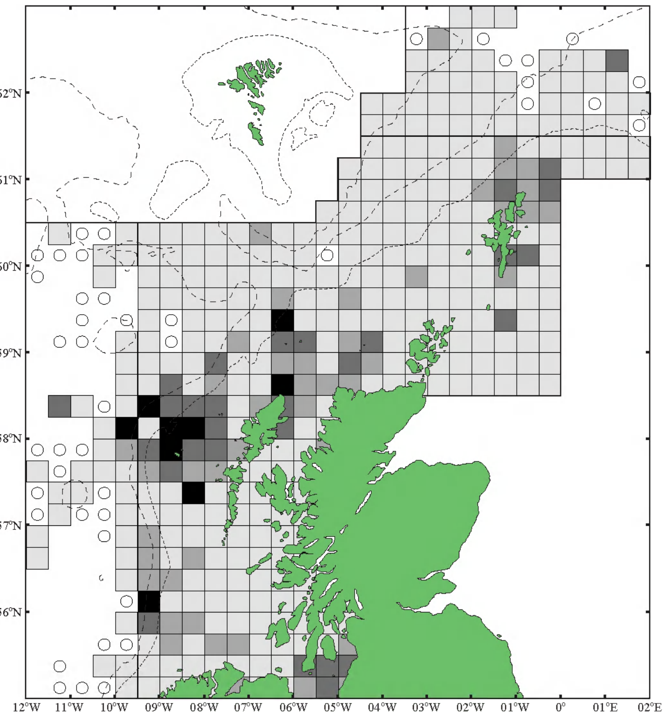
c) August

Figure 21 c). Leach's storm-petrel distribution

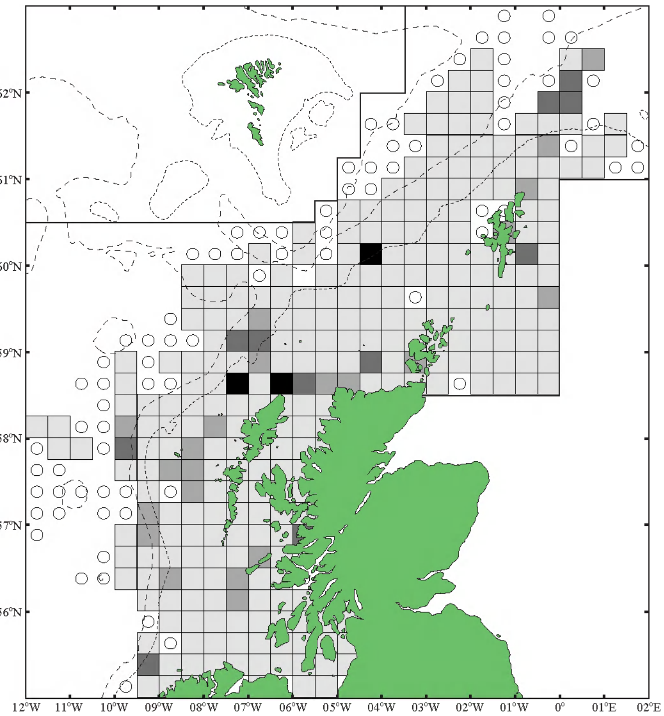
Density (birds/km^2): No birds; 0.01-0.49; 0.50-0.99; 1.00-1.99; 2.00+

5.9 Gannet *Morus bassanus*

March to August: Gannets are partial migrants, with some adults and most immature birds moving as far south as west Africa during the winter months (Nelson 1978). Adults began to return to the study area in March whereas immature birds tended to start arriving in May. This has also been noted for gannets in the North Sea (Tasker *et al.* 1985a). Between March and August, gannets were widely dispersed at low densities over most of the study area regardless of water depth (Figure 22a). Areas of high concentration were found near the breeding colonies at Shetland, Sula Sgeir, North Rona, Ailsa Craig and especially St. Kilda where birds were regularly observed



a) March to August



b) September to February

Figure 22 a) - b). Gannet distribution

Density (birds/km^2): No birds; 0.01-0.99; 1.00-1.99; 2.00-4.99; 5.00+

over the shelf edge. These concentrations consisted mostly of adults and may reflect the limited foraging range of breeding birds, as they are mostly within the estimated maximum foraging range of 150 km from the colony (Leaper *et al.* 1988; Tasker *et al.* 1985a). Immature birds were widely dispersed and tended not to associate with the colonies. The proportion of immature birds peaked in July at 16.5%. Gannets regularly scavenge around fishing vessels (Camphuysen *et al.* 1995; Hudson & Furness 1989); peak concentrations were found associating with boats along the slope north and west of the Western Isles in April.

September to February: Gannets leave the study area during September and October, resulting in lower densities during the winter months (Figure 22b). Between August and November, just over 9% of gannets recorded were immature but by January, this proportion had dropped to just over 1%. Although overall numbers were much reduced, concentrations remained around the colonies and along the continental shelf edge. Gannets were associated with fishing vessels off the north coast of Scotland and along the shelf break.

5.10 Cormorant *Phalacrocorax carbo*

January to December: Cormorants are resident in the study area and the largest colonies are located in the Northern Isles (Lloyd *et al.* 1991). This species was recorded in shallow inshore waters, along almost all of the coastlines surveyed (Figure 23). Although also found in freshwater and estuarine habitats, cormorants are rare at sea away from the coast (Stone *et al.* 1995a), as they usually feed in water less than 10 m deep (Skov *et al.* 1995b). The plumage of cormorants, which is less water repellent than that of ducks (Rijke 1968), may also limit their distribution, necessitating the need for nearby roost sites either on land or hard structures such as oil production platforms (Dunnet 1986).

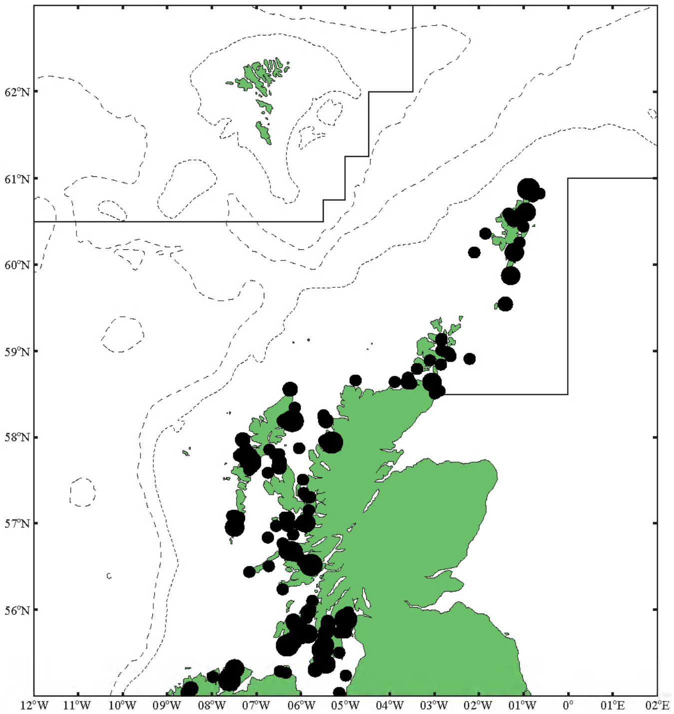


Figure 23. Cormorant sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

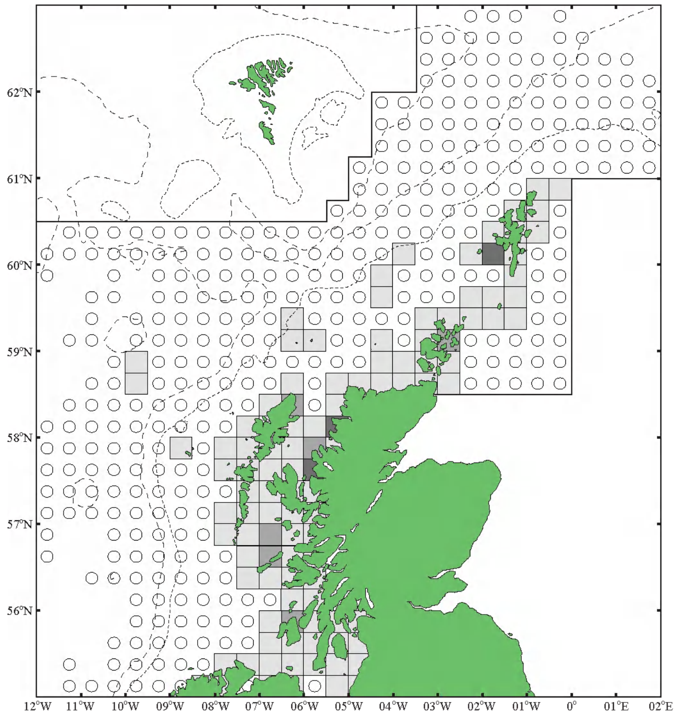


Figure 24. Shag distribution throughout the year

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

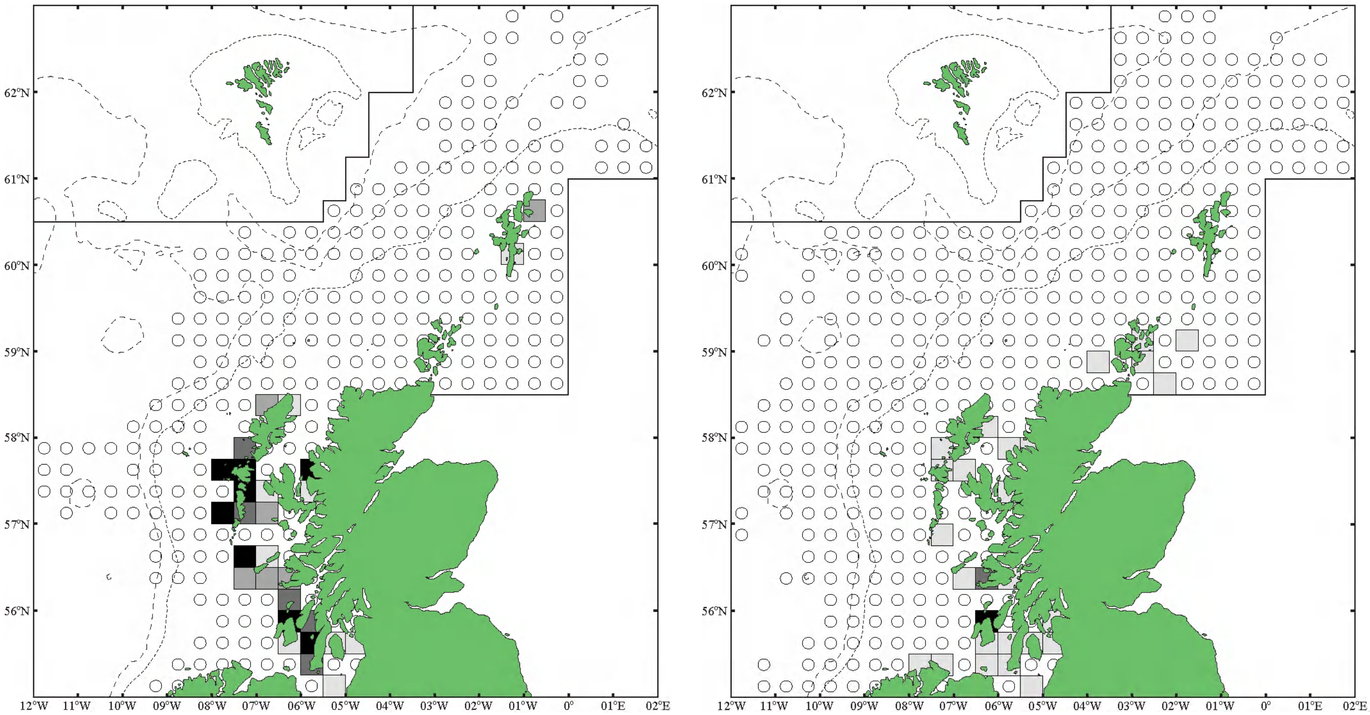
5.11 Shag *Phalacrocorax aristotelis*

January to December: Shags are another inshore species but, in contrast to cormorants, are found only in marine waters. In the study area, low densities of shags were recorded throughout the year (Figure 24). Shags rarely forage more than 10 km from their colonies during the breeding season and are usually found in waters less than 40 m deep (Wanless *et al.* 1991). Moderate concentrations were found in the sea lochs of north-west Scotland as well as near Foula in the Shetland Isles, which holds 2,400 pairs during the breeding season (Lloyd *et al.* 1991). The distribution of shags at sea may also be limited by the less water repellent properties of their plumage (Coulson 1986). The feathers of the Phalacrocoracidae are less water repellent than the feathers of ducks (Rijke 1968).

5.12 Common eider *Somateria molissima*

December and January: The common eider was the most numerous of the six seaduck species recorded. This species is very much an inshore one as it normally feeds in waters less than 4 m deep (Pethon 1967). During December and January, moderate to high densities of wintering common eiders were recorded around the Western Isles with low densities elsewhere (Figure 25a). There were no sightings in deep waters (>200 m). In the study area, the inshore waters of Orkney, Shetland and south-west Scotland are the most important areas for wintering eiders (Baillie 1986).

February to November: Lower densities of common eiders were recorded between February and November (Figure 25b). There was little change in the geographical spread of the distribution although the species now occurred around Orkney. Common eiders generally disperse only short distances between breeding grounds and wintering areas (Baillie 1993).



a) December to January　　b) February to November

Figure 25 a) - b). Common eider distribution

Density (birds/km^2): ○ No birds　□ 0.01-0.49　□ 0.50-0.99　□ 1.00-1.99　■ 2.00+

5.13 Long-tailed duck *Clangula hyemalis*

October to March: The long-tailed duck is a winter visitor to Britain probably from Fennoscandia and north-western Russia, though their exact origins are unknown (Campbell 1986a). The distribution was mainly inshore apart from a single bird over deep water in the Rockall Trough in November (Figure 26). Scapa Flow, Orkney held the only notable concentration. This site is the second most important wintering area for this species in Britain (Campbell 1986a). Although this duck appears to be thinly dispersed it may be under-recorded, as with other inshore species. Most birds were recorded in March.

May: Long-tailed ducks were also seen during May, again in Orkney. Small numbers of long-tailed ducks are frequently recorded during the summer in Britain (e.g. Gibbons *et al.* 1993; Sharrock 1976).

5.14 Pomarine skua *Stercorarius pomarinus*

May to November: Pomarine skuas migrate between wintering grounds off west Africa and breeding grounds in the high Arctic (Furness 1987b). Wynne-Edwards (1935) suggested that the passage of Pomarine skuas spanned the full width of the Atlantic. At-sea sightings between May and November show the species was widely distributed throughout the whole of the study area (Figure 27) over the continental shelf, shelf-edge and deep water. However, the numbers encountered are low compared with those sometimes seen from land (Davenport 1975, 1987; Fox & Aspinall 1987; Harrop *et al.* 1993). Spring passage occurred mostly in May when high numbers were recorded on the shelf-edge from 57°N north-eastwards to the Faroe-Shetland Channel suggesting its utilisation as a migration route. During autumn most sightings were made in October. This species occurs in British waters conspicuously later than Arctic skua and often in large numbers (e.g. Fox & Aspinall 1987).

December to April: Only five sightings of Pomarine skua were made between December and April. Singles were recorded in December, January and March with two in April. None was seen in February.

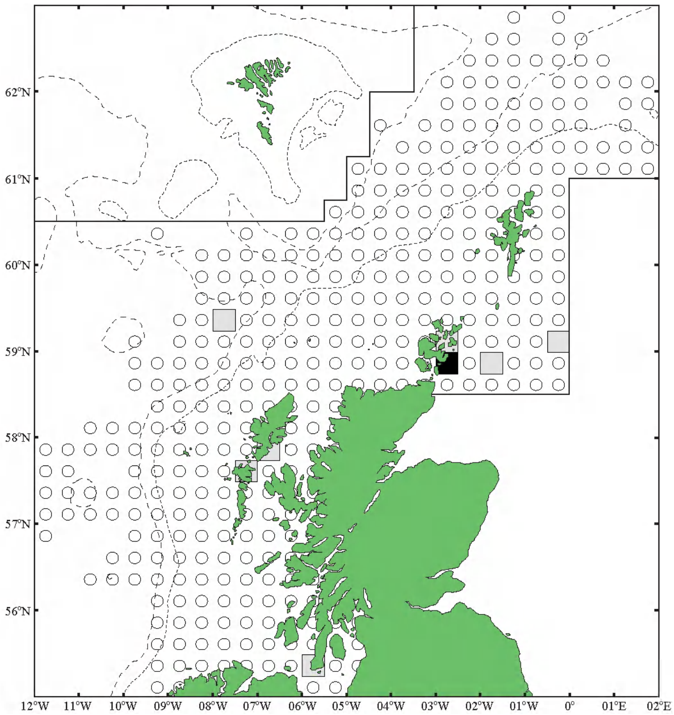


Figure 26. Long-tailed duck distribution throughout the year

Density (birds/km^2): No birds; 0.01-0.49; 0.50-0.99; 1.00-1.99; 2.00+

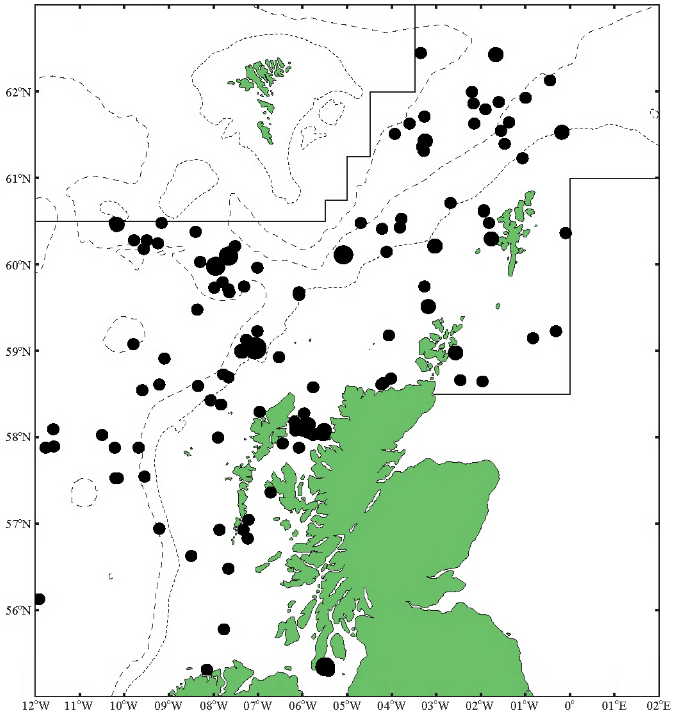


Figure 27. Pomarine skua sightings from May to November

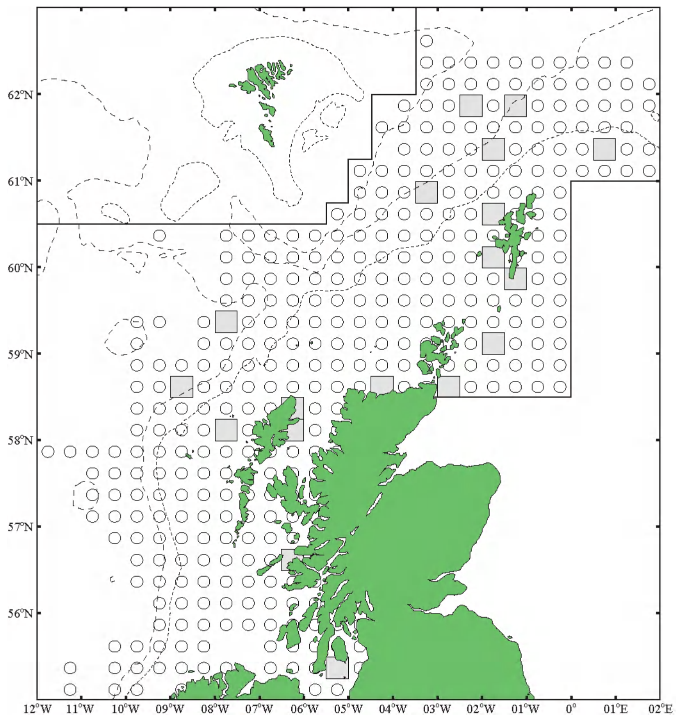
Number of individuals: 1; 2; 3-5; 6+

5.15 Arctic skua *Stercorarius parasiticus*

March to May: Arctic skuas return from their southern wintering grounds between March and May, to the main breeding areas on Shetland and Orkney. The at-sea distribution shows low numbers in the study area (Figure 28a). Records around Shetland and Orkney, and the north and west coasts of Scotland, closely mirror the locations of breeding colonies. It is possible that the continental shelf records are of birds returning to more northerly colonies in north-west Europe.

June to August: During the breeding season, between June and August, the species was widely distributed in low densities, mostly in inshore waters close to the colonies (Figure 28b). The largest colonies in the study area are in the Northern Isles and most birds were recorded in these waters. Only low densities were found over deep water.

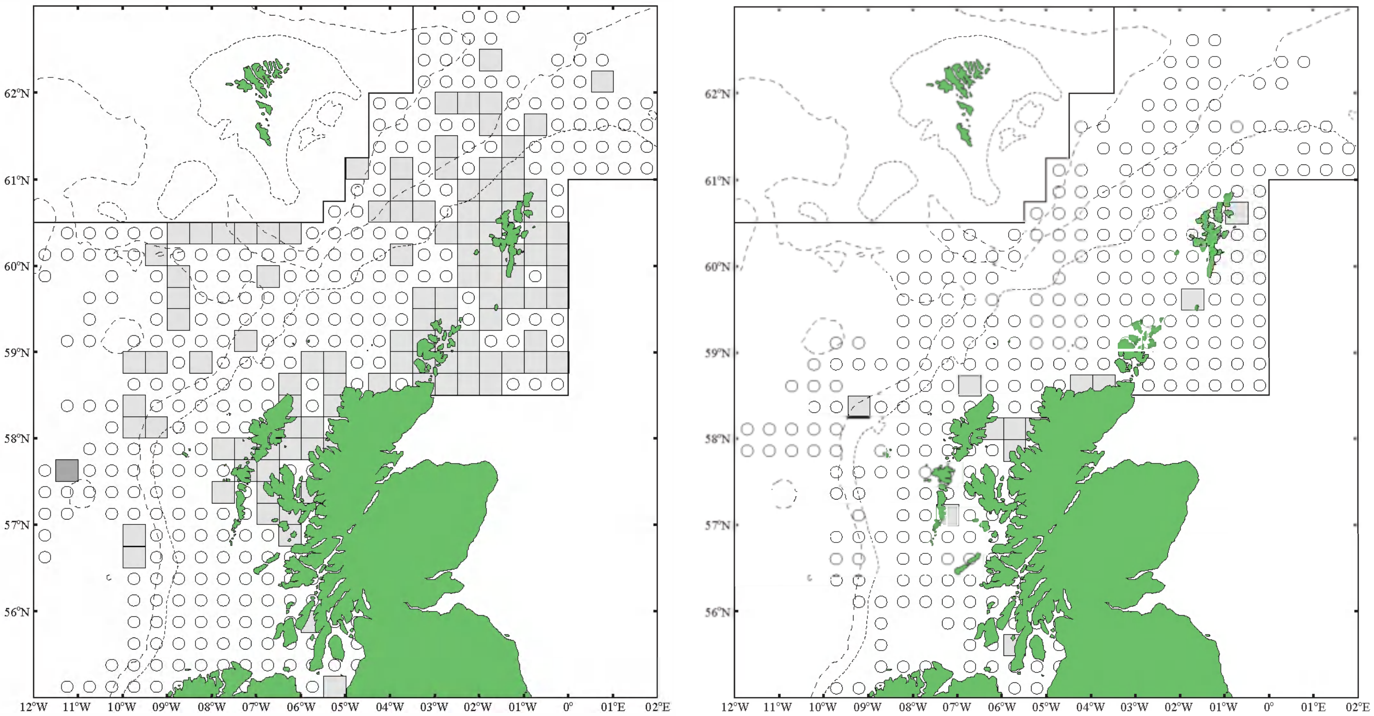
September and October: Arctic skuas begin to leave their breeding areas during August and migrate southwards largely via inshore waters on the east coast of Britain (Stone *et al.* 1995a). Consequently, few birds were recorded in the study area during this period; most records were from inshore waters (Figure 28c), which are thought to be favoured by Arctic skuas during the autumn so they can kleptoparasitise terns gathering at near-shore feeding sites (Wuorinen 1992).



a) March to May

Figure 28 a). Arctic skua distribution

Density (birds/km^2): No birds; 0.01-0.49; 0.50-0.99; 1.00-1.99; 2.00+



b) June to August

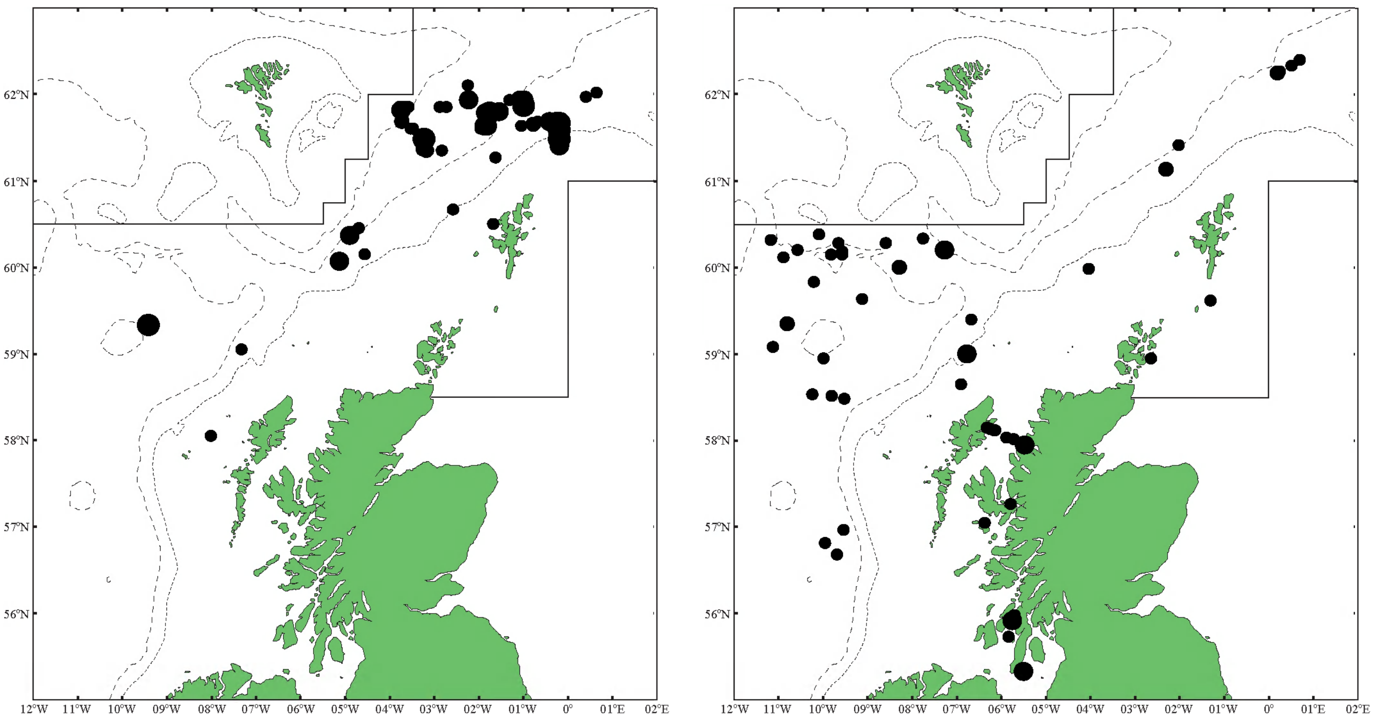
c) September and October

Figure 28 b) - c). Arctic skua distribution

Density (birds/km^2): ○ No birds ☐ 0.01-0.49 ☐ 0.50-0.99 ☐ 1.00-1.99 ■ 2.00+

5.16 Long-tailed skua *Stercorarius longicaudus*

May and June: Long-tailed skuas are uncommon migrants in British waters. In common with Pomarine skuas, they are Arctic breeders that pass through the Atlantic Frontier migrating to and from their wintering areas off West Africa. Some are thought to cross the Atlantic and winter off South America along with birds from Arctic Canada (Furness 1987b). Highest numbers in the Atlantic Frontier were recorded during May. This accords well with land-based observations of skua passage made from the Western Isles (Davenport 1987, 1991). Most sightings were from the



a) May and June

b) July to September

Figure 29 a) - b). Long-tailed skua distribution

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

north end of the Faroe-Shetland Channel with some also seen north-west of the Western Isles near to Rosemary Bank (Figure 29a). Relatively few sightings were made in June presumably because most birds had by then passed through on their way to the breeding grounds in Scandinavia and northern Russia.

July to September: Large scale departures from the breeding grounds occur in August, continuing through to September, with a much slower migration southwards than in spring (Cramp & Simmons 1983). In the period from July to September, again almost all sightings were over deep waters, except in August when there were several sightings in coastal waters west of Scotland (Figure 29b).

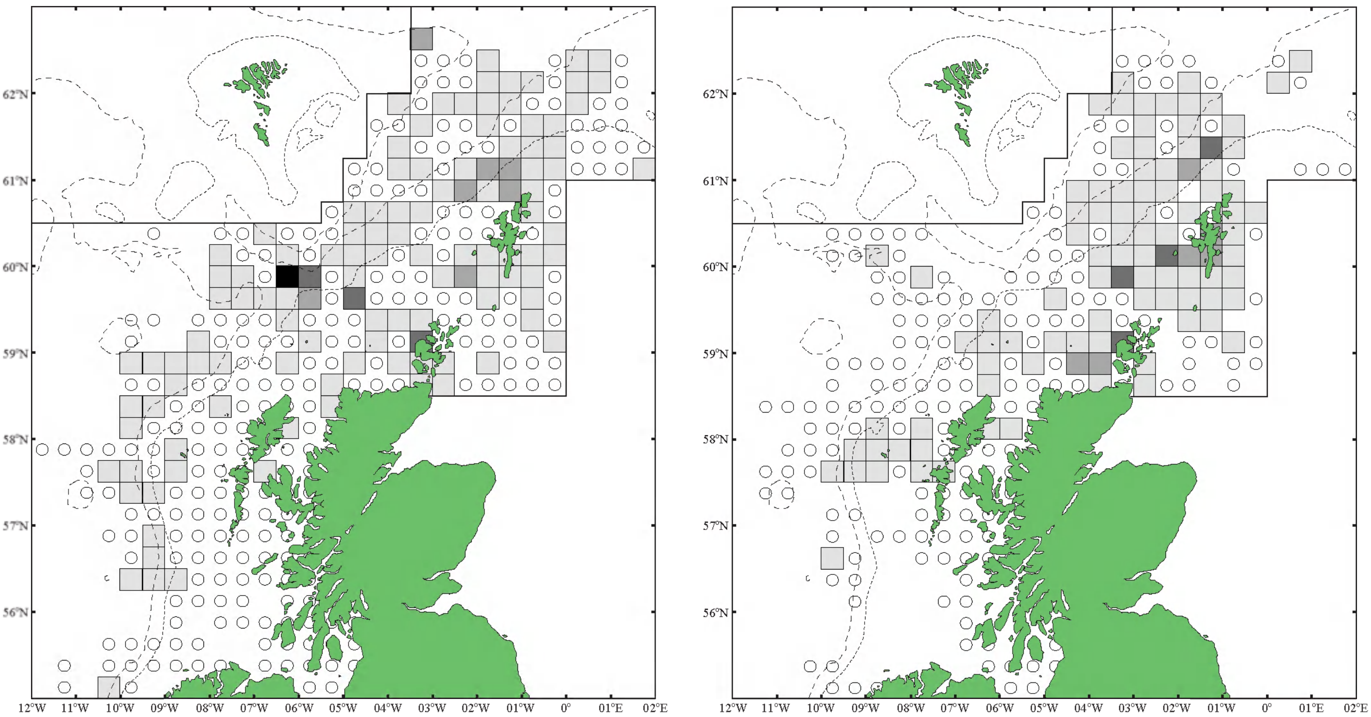
5.17 Great skua (Bonxie) *Stercorarius skua*

April and May: In April and May, the great skua was widespread, but mostly in low densities (Figure 30a). In shelf waters, the distribution centred on the main colonies in Orkney and Shetland. In offshore waters, low densities of birds were found along the shelf break. An area of higher concentration south-west of the Faroe-Shetland Channel occurred where great skuas associated with fishing vessels. Low numbers of birds were found associating with fishing vessels at other areas along the shelf-break.

June: In June, great skuas were widespread inshore around Orkney and Shetland in low to moderate densities (Figure 30b). Densities were still mostly low, although a moderate concentration was found around Foula, the site of the largest great skua colony in the world (Lloyd *et al.* 1991). The maximum foraging range of a great skua from its colony is estimated at 60 km (Furness & Hislop 1981). Great skuas were generally less widespread in deep waters although present at low densities in the Faroe-Shetland Channel. As most mature birds will have started nesting at this stage, these birds are probably mainly non-breeders. There were few records of great skuas attending fishing vessels in June.

July: In July, low densities of skuas were widespread over the continental shelf around the Northern Isles (Figure 30c). Moderate densities were recorded in waters near the colonies. Again the offshore distribution mainly consisted of low densities of birds in the waters closest to the Northern Isles. This is possibly due to influxes of immature birds, which visit club sites (a collection of non-breeders) within colonies during July before departing in August along with adults and fledged young (Tasker *et al.* 1985b). Associations with fishing vessels were widespread north of Scotland during July, although the densities recorded were low. Discards from fishing vessels form a major part of the diet of breeding great skuas on Foula from June onwards (Furness & Hislop 1981).

August to October: Between August and October, great skuas became more widely dispersed as birds began to leave the colonies and move into the surrounding seas (Figure 30d). Associations with fishing vessels were recorded in all three months. Low densities were encountered around fishing vessels mostly around Lewis, apart from one area of high density to the north-east of Shetland.



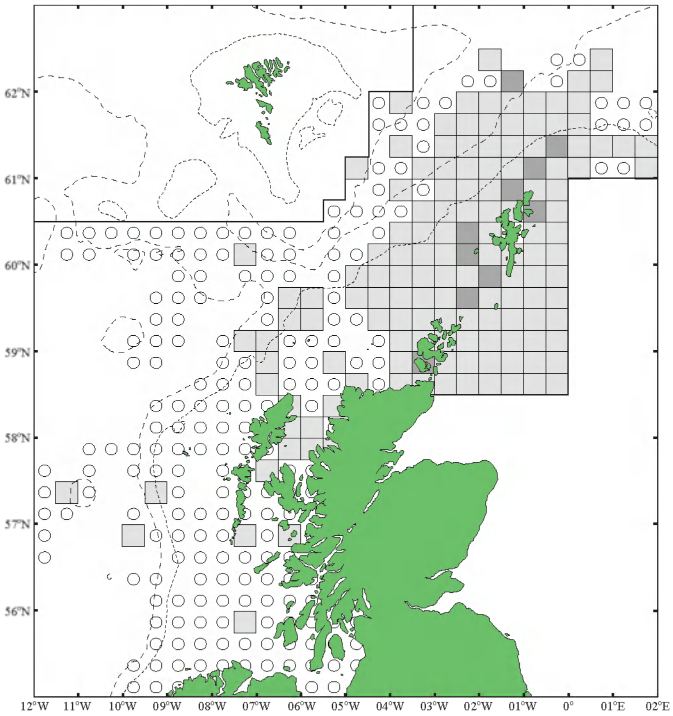
a) April and May

b) June

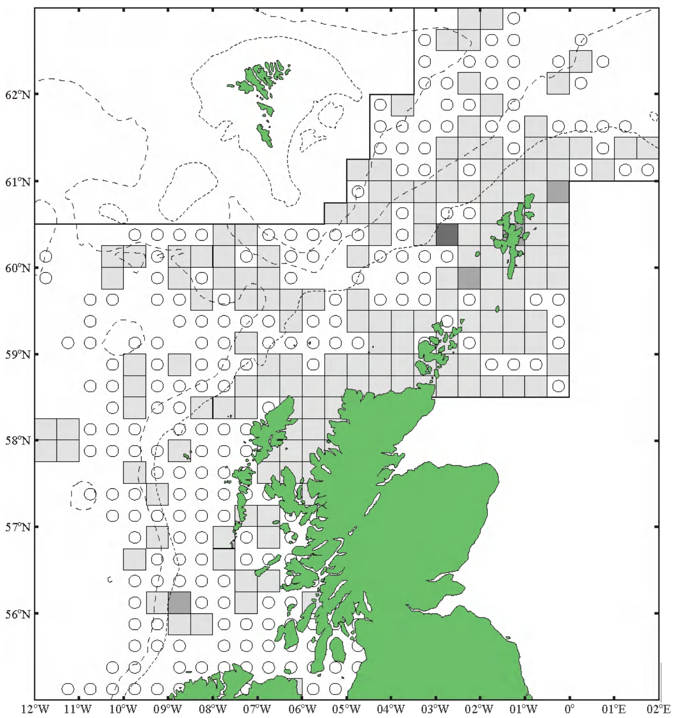
Figure 30 a) - b). Great skua (Bonxie) distribution

Density (birds/km^2): No birds 0.01-0.49 0.50-0.99 1.00-1.99 2.00+

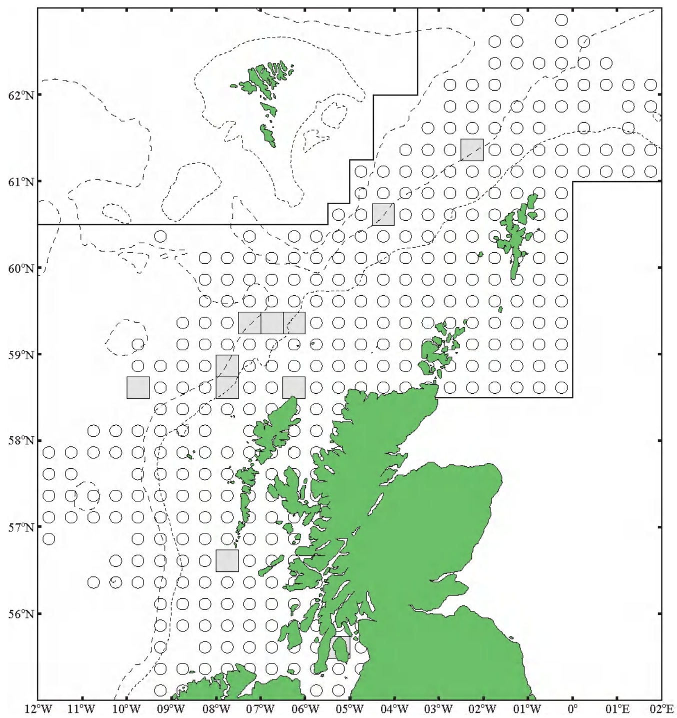
November to March: Few great skuas were recorded between November and March (Figure 30e). Birds encountered at this time of the year are likely to be adults. Although adults winter principally in the Eastern Atlantic south to Iberia, some stay in home waters and the North Sea which are deserted by younger birds during the winter months (Cramp & Simmons 1983).



c) July



d) August to October



e) November to March

Figure 30 c) - e). Great skua (Bonxie) distribution

Density (birds/km^2): ○ No birds 0.01-0.49 0.50-0.99 1.00-1.99 2.00+

5.18 Black-headed gull *Larus ridibundus*

January to December: The black-headed gull is a common resident in Britain (Flegg 1986). Low densities were found inshore, mainly off the west coast (Figure 31). Black-headed gulls were recorded sporadically in the Atlantic Frontier. During the autumn, small numbers were observed in deep waters (>200 m). These may be Icelandic birds, which are partially migratory, some wintering in Scotland and Ireland (Cramp & Simmons 1983; Horton *et al.* 1984).

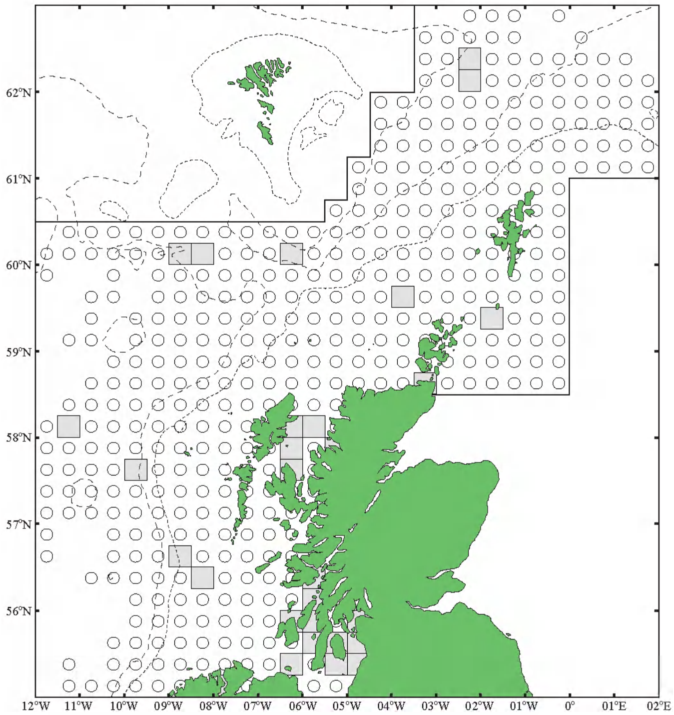


Figure 31. Black-headed gull distribution throughout the year

Density (birds/km^2): No birds; 0.01-0.49; 0.50-0.99; 1.00-1.99; 2.00+

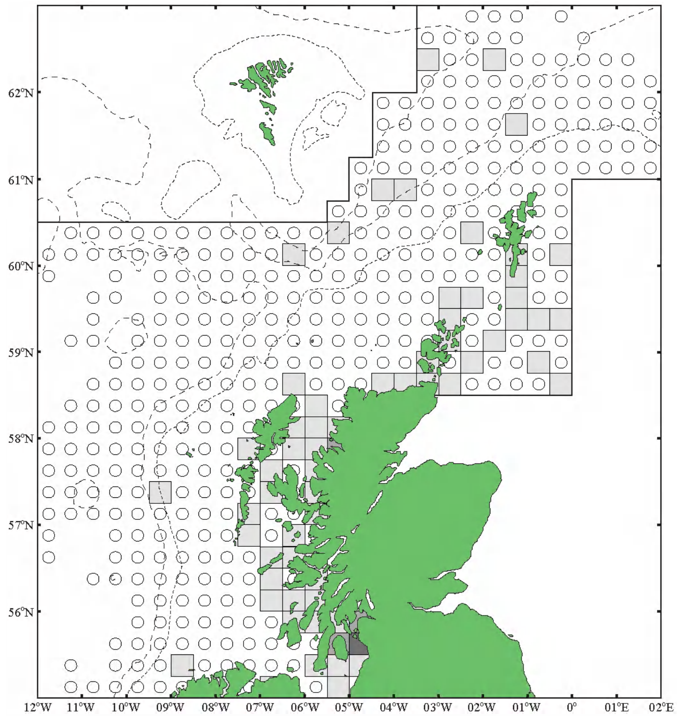


Figure 32. Common gull distribution throughout the year

Density (birds/km^2): No birds; 0.01-0.49; 0.50-0.99; 1.00-1.99; 2.00+

5.19 Common gull *Larus canus*

January to December: Common gulls were recorded in small numbers in all months. Records were largely from inshore waters, especially off the west coast of Scotland, though some were encountered over the deeper water of the Faroe-Shetland Channel (Figure 32). Most records over the Faroe-Shetland Channel occurred during the late summer and autumn and may reflect birds migrating from more northerly colonies in Norway (Radford 1960).

5.20 Lesser black-backed gull *Larus fuscus*

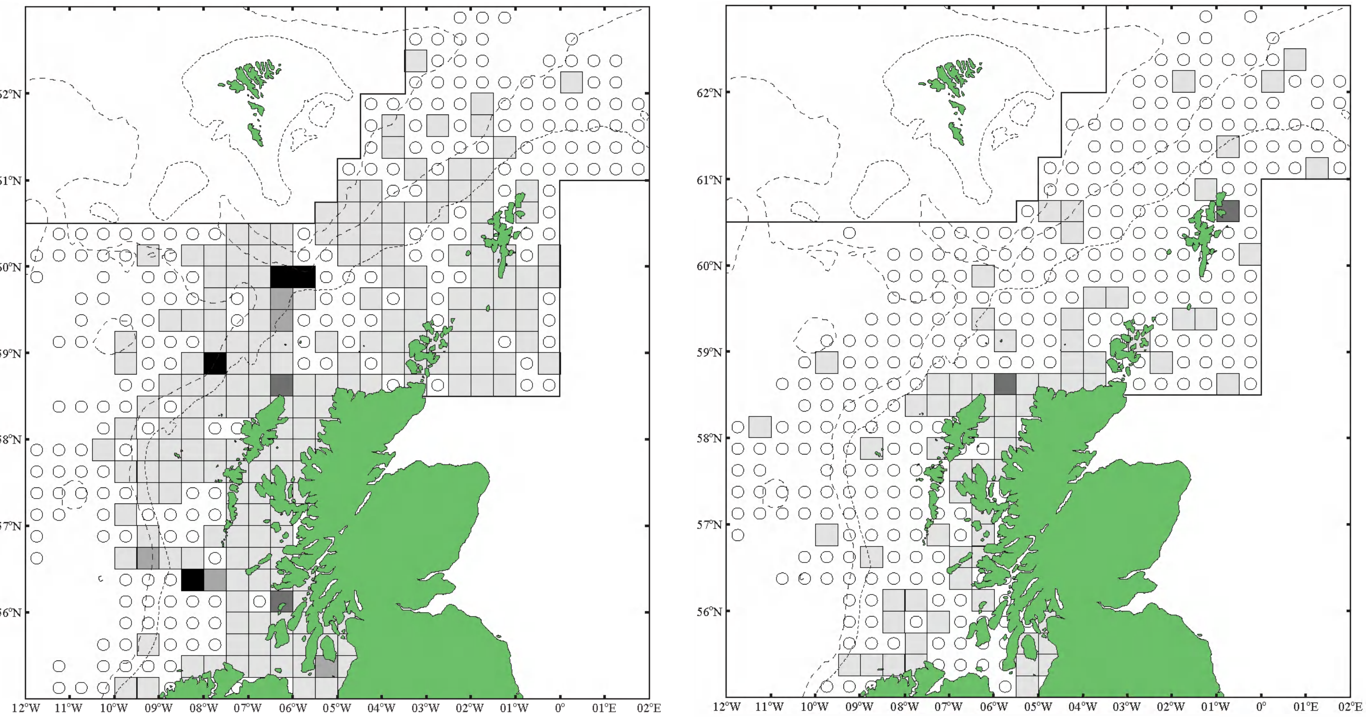
April to August: In Scotland, most lesser black-backed gulls migrate south for the winter, although some birds over-winter in the south of the country (Hickling 1986). Between April and August this species was widespread at low densities both over shelf and slope waters (Figure 33a). During this time, lesser black-backed gulls regularly associated with fishing vessels especially south of 60°N along the shelf-break. The areas of high density were accounted for by birds associated with fishing vessels in April and May.

September to March: Fewer birds were recorded between September and March and the majority were recorded in inshore waters (Figure 33b). There were occasional sightings in deep waters. In October, some birds were recorded associating with fishing vessels over shelf waters between Lewis and Shetland, and account for the moderate densities indicated on the map.

5.21 Herring gull *Larus argentatus*

May to September: Herring gulls were primarily recorded near the coast, with few birds further offshore over the Atlantic Frontier. Between May and September, during the breeding and post-breeding periods, the distribution was almost entirely coastal (Figure 34a) with concentrations along the west coast of Scotland south of Skye. This area is one of the main breeding centres of the herring gull in Scotland (Lloyd *et al.* 1991). Some herring gulls were associated with fishing vessels along the west coast.

October to April: From October to April, a larger component of the distribution was situated on the continental slope, although densities remained low. This wider distribution may be due to herring gulls from more northerly colonies moving into the study area for part of the winter. Migrants arrive during September and October, with many returning northwards during March and April (Coulson & Butterfield 1985; Cramp & Simmons 1983). Offshore areas favoured lay to the west and north of Shetland and to the west of Scotland south of

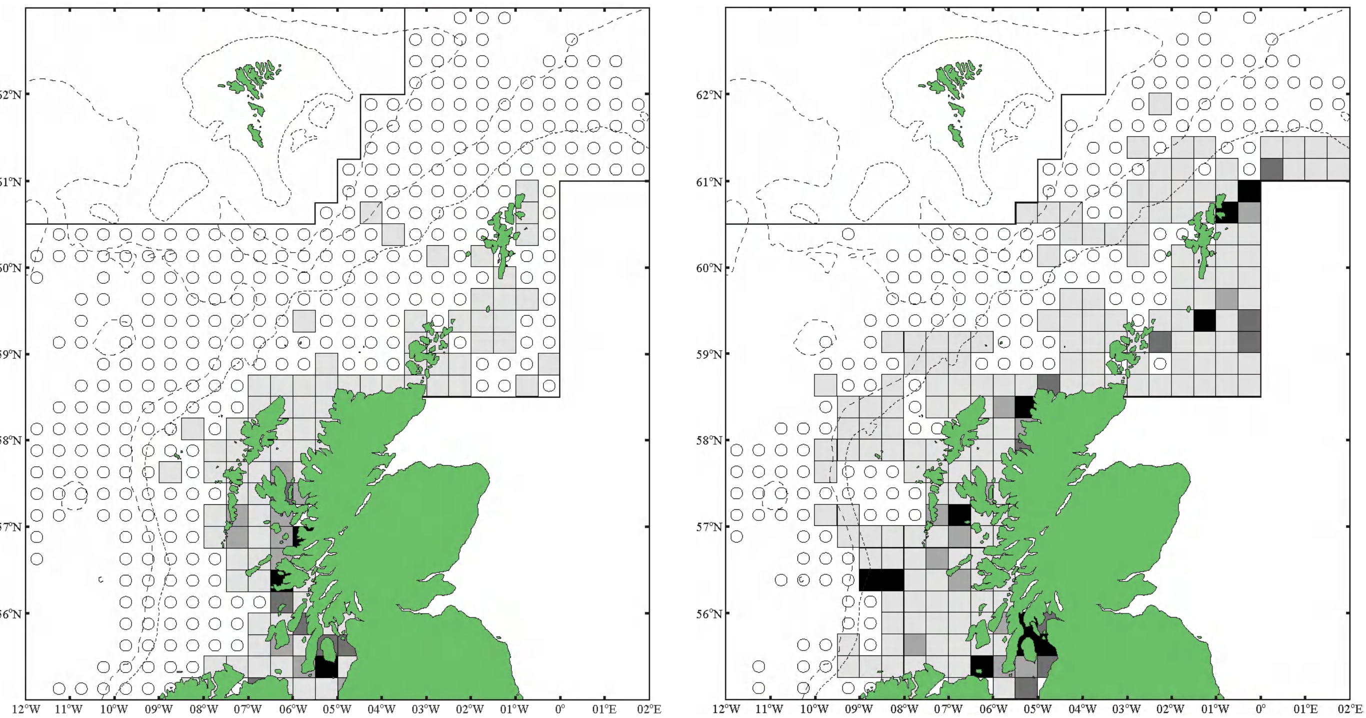


a) April to August

b) September to March

Figure 33 a) - b). Lesser black-backed gull distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+



a) May to September

b) October to April

Figure 34 a) - b). Herring gull distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

60°N (Figure 34b). An inshore concentration was noticeable in the Firth of Clyde. Herring gulls were associated with fishing vessels along the west coast and also over slope waters west of Scotland, mainly between February and April.

5.22 Iceland gull *Larus glaucoides*

November to March: The Iceland gull is a regular, but scarce, winter visitor from Greenland (Grant 1982), and was observed in small numbers between November and March. Most sightings were either along the continental slope or in inshore waters (Figure 35). Records in January accounted for 21 out of the total of 33 birds recorded. Immatures accounted for 63% of birds whose age was determined, half of which were juveniles.

5.23 Glaucous gull *Larus hyperboreus*

October to April: The glaucous gull is another regular but scarce winter visitor from eastern Greenland and Arctic Europe (Harris *et al.* 1989), but is more common than the Iceland gull. Glaucous gulls arrived earlier, and departed later, than Iceland gulls. Low densities were recorded between October and April (Figure 36), although few were encountered after February. Birds were concentrated over the Faroe-Shetland Channel and the Rockall Trough with some in shelf waters. Few birds were seen in the south of the study area. Over half of the sightings were made in January. Immatures accounted for 66% of birds that were aged, over half of which were juveniles.

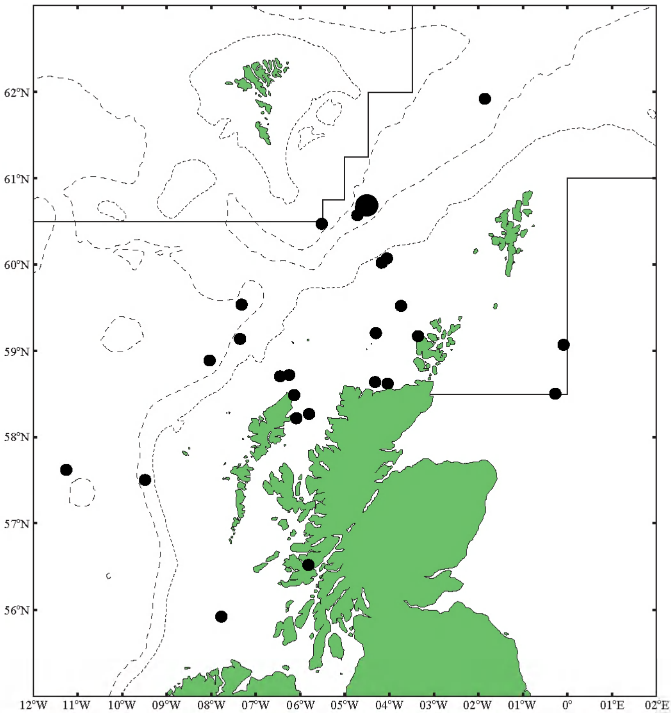


Figure 35. Iceland gull sightings from November to March

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

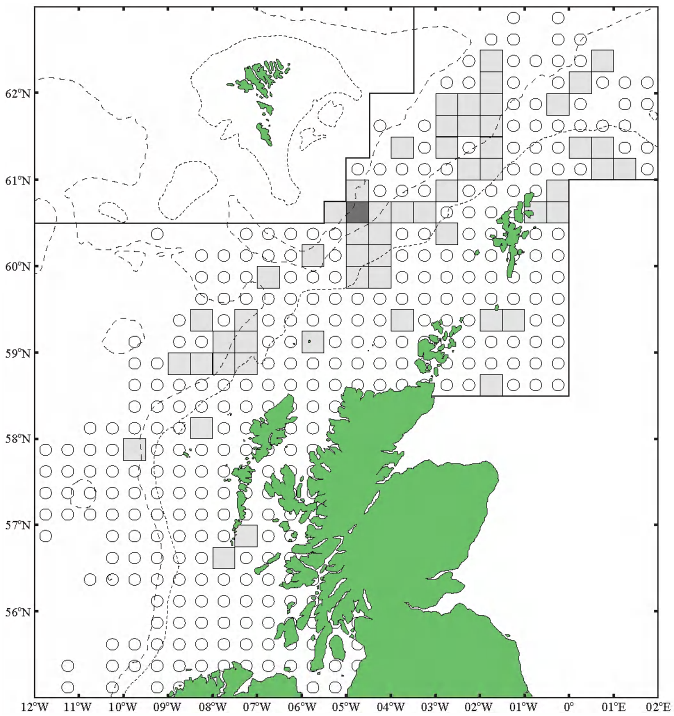


Figure 36. Glaucous gull distribution from October to April

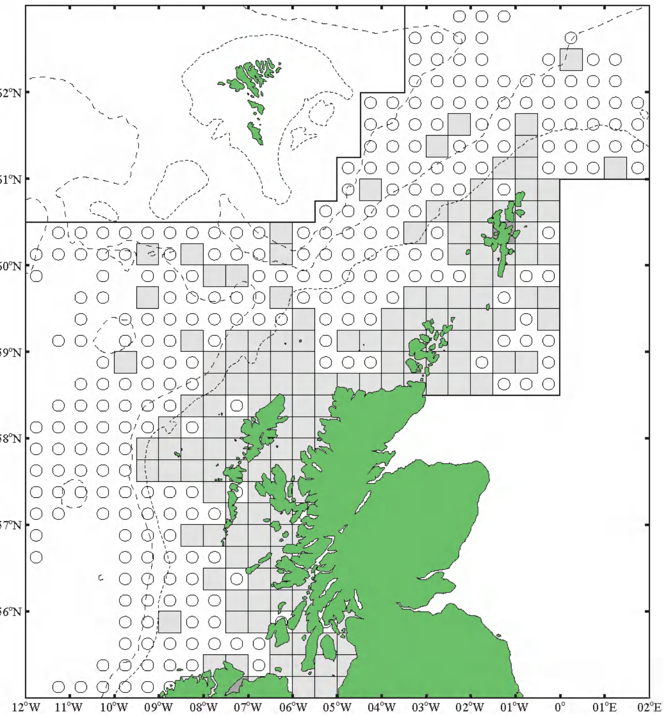
Density (birds/km^2): ○ No birds □ 0.01-0.49 □ 0.50-0.99 □ 1.00-1.99 ■ 2.00+

5.24 Great black-backed gull *Larus marinus*

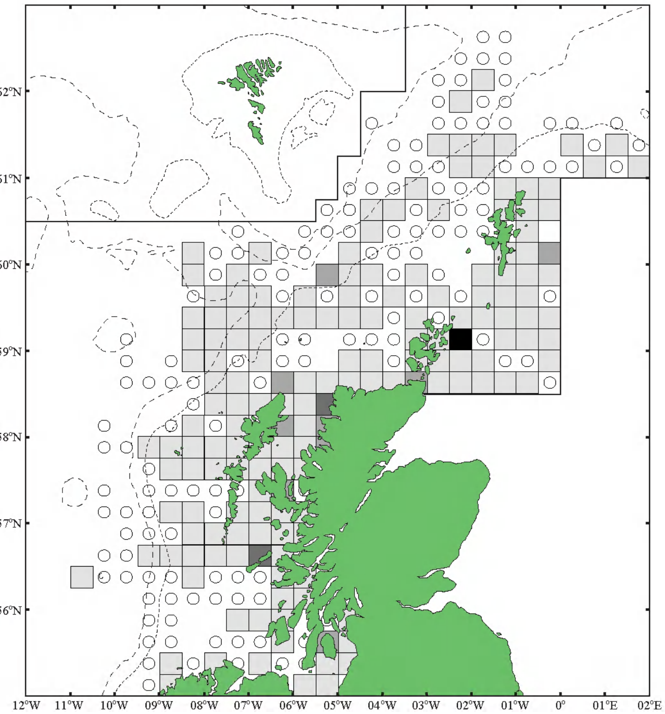
The great black-backed gull occurs only in the North Atlantic and Arctic and is the least common of the *Larus* species breeding regularly in the study area. Great black-back gulls are opportunistic feeders known to scavenge around fishing vessels, (Camphuysen *et al.* 1995; Furness *et al.* 1992) as well as around land-fill sites during the winter (Monaghan 1986).

May to September: During the breeding and post-breeding seasons, between May and September, great black-backed gulls were widespread at low density over waters within 50 km of the colonies (Figure 37a). Almost no birds were observed beyond this distance to the west of the Northern Isles. Their overall distribution was more widespread than that of the herring gull, especially around Orkney, Shetland and the Western Isles. These islands hold the majority of the breeding population of great black-backed gulls in Britain and Ireland, as well as the largest colonies (Lloyd *et al.* 1991). Few birds were recorded in waters deeper than 200 m, and it is likely that these birds were non-breeders.

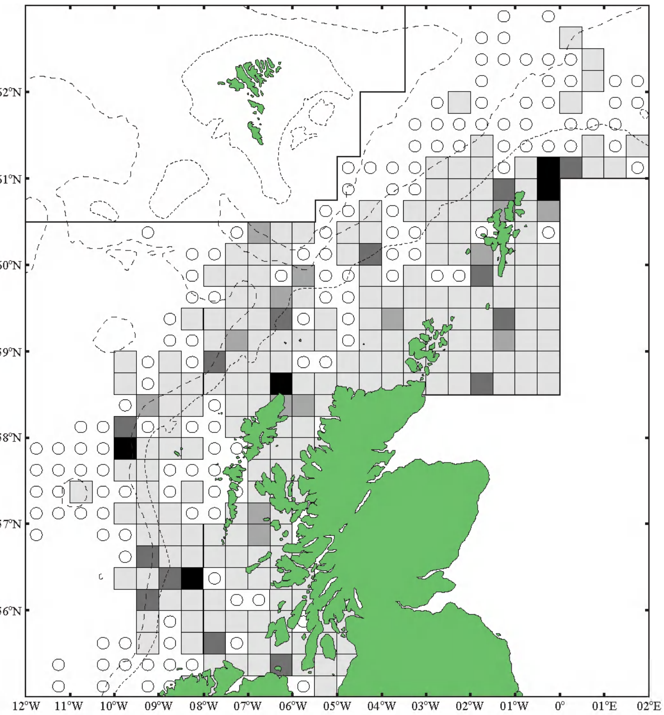
October to December: Between October and December, the distribution was patchier with lower densities around the colonies. Great black-backed gulls were widely dispersed along the shelf-break and in deeper waters particularly to the north-west of the Western Isles (Figure 37b). Patches of higher density were observed inshore due to birds associating with fishing vessels. Outside the breeding



a) May to September



b) October to December



c) January to April

season, British birds are mostly sedentary remaining within 300 km of their colonies (Harris 1962). During winter, small numbers of Icelandic great black-backed gulls are found to the west of Scotland (Harris 1962).

January to April: Great black-backed gulls were most widespread and abundant during this period (Figure 37c). In March and April the study area holds the highest densities of great black-backed gulls in north-western Europe (Stone *et al.* 1995a). Numbers at sea may be swollen by wintering birds moving back toward their northern breeding areas. Areas of moderate to high density, found along the slope as well as over shelf waters, were mostly caused by birds associating with fishing vessels. In this study, most associations with fishing vessels were recorded between January and April, with a peak in April, when highest densities were recorded in waters around Shetland and north of the Western Isles.

Figure 37 a) - c). Great black-backed gull distribution

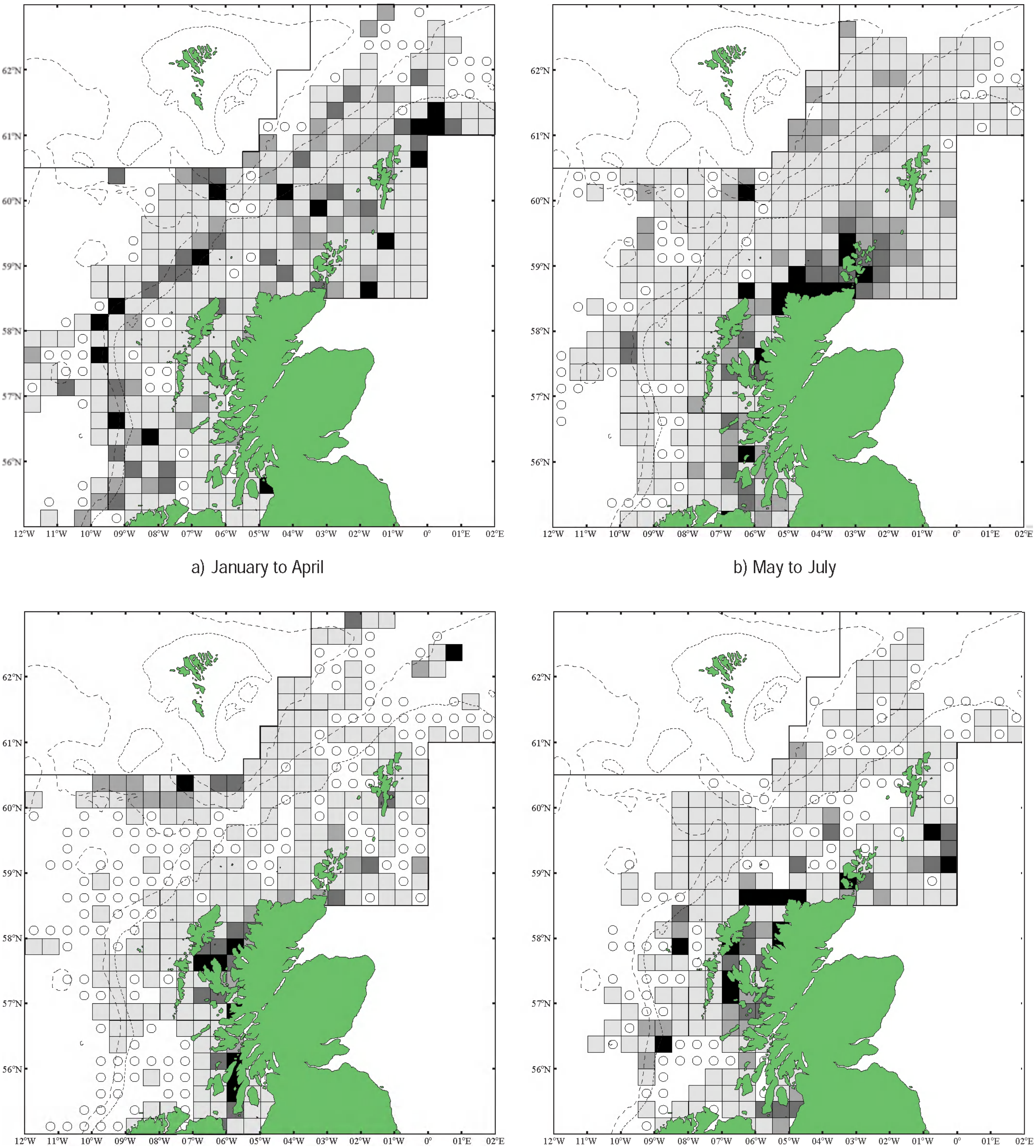
Density (birds/km^2): ○ No birds; 0.01-0.99; 1.00-1.99; 2.00-4.99; 5.00+

5.25 Kittiwake *Rissa tridactyla*

The kittiwake was the most abundant and widespread gull species recorded in the study area.

January to April: Between January and April, kittiwakes were widespread throughout the study area (Figure 38a), with highest densities of kittiwakes over the continental slope recorded at this time. This was most prevalent along the length of the Rockall Trough slope and less obvious on the slope adjacent to the Faroe-Shetland Channel. Kittiwakes are well known scavengers (Camphuysen *et al.* 1995) and in this area were often associated with fishing vessels, particularly in April. Kittiwakes have also been recorded along the continental slope south-west of Ireland at this time of year (Pollock *et al.* 1997). On the shelf, moderate to high densities were present north of Scotland with highest densities to the north-east of Shetland, where kittiwakes were associated with fishing vessels. Shelf waters west of Scotland, held mainly low densities of kittiwakes with isolated patches of moderate to high density.

May to July: From May to July, while still widespread, kittiwakes were concentrated in coastal waters close to the colonies (Figure 38b). This was particularly noticeable around Orkney and the northern coasts of Caithness and Sutherland, which hold the majority of Scotland's breeding kittiwakes (Lloyd *et al.* 1991). During the breeding season the foraging range varies from less than 5 km to 160 km, depending on feeding conditions (Coulson 1966; Hamer *et al.* 1993). In the study area, most birds were recorded within c. 25 km of the nearest colony.



a) January to April

b) May to July

c) August and September

d) October to December

Figure 38 a) - d). Kittiwake distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

Generally low densities were recorded offshore, although there were areas with moderate concentrations in the Faroe-Shetland Channel, probably comprising Faroese birds (Figure 38b). A small patch of high density in the Faroe-Shetland Channel, and similarly an area of moderate density along the continental slope west of Scotland, were due to kittiwakes congregating around fishing boats.

August and September: In August and September, the distribution was patchier than the previous seven months. There appeared to be movement away from the colonies on the north coast and around Orkney. Concentrations were now found in the Minch and other inshore waters off the west coast of Scotland. Kittiwakes often occur in mixed species flocks with auks and Manx shearwaters in autumn, commonly feeding on clupeid fish which are unavailable at other times of year (Bourne & Harris 1979; Burton *et al.*1987; Tasker *et al.* 1987). Low densities of kittiwakes prevailed in offshore waters although moderate densities were found south of the Faroes around 60°N (Figure 38c). No birds were recorded associating with fishing vessels in August and September. By August, most kittiwakes have finished breeding, and disperse from the colonies, some young birds even crossing the Atlantic (Coulson 1966).

October to December: Highest numbers of kittiwakes were still recorded in inshore waters west of Scotland, although there were high densities once again north of Scotland, around Orkney and to the east of Fair Isle (Figure 38d). Kittiwakes associating with fishing vessels accounted for some of the high densities in the Minch and directly to the north. Kittiwakes are easily out-competed at trawlers by the larger gull species and so depend more on naturally occurring food sources compared with some other scavenging species (Camphuysen *et al.* 1995; Galbraith 1983; Harris & Wanless 1990). Lowest numbers were recorded in offshore waters at this time. Further dispersal occurs as the species moves out into the North Atlantic.

5.26 Common tern *Sterna hirundo*

April to October: Common terns visit the British Isles in summer. They were recorded predominantly between the months of May and August, with single sightings in April and October. Their distribution was generally coastal and concentrated near colonies (Figure 39). In June there were several records of common terns feeding over deeper water along the continental slope. These may have been migrating birds from more northerly colonies. By August, the number of sightings had declined considerably as most common terns migrate south to winter off the coast of West Africa (Langham 1971; Radford 1961).

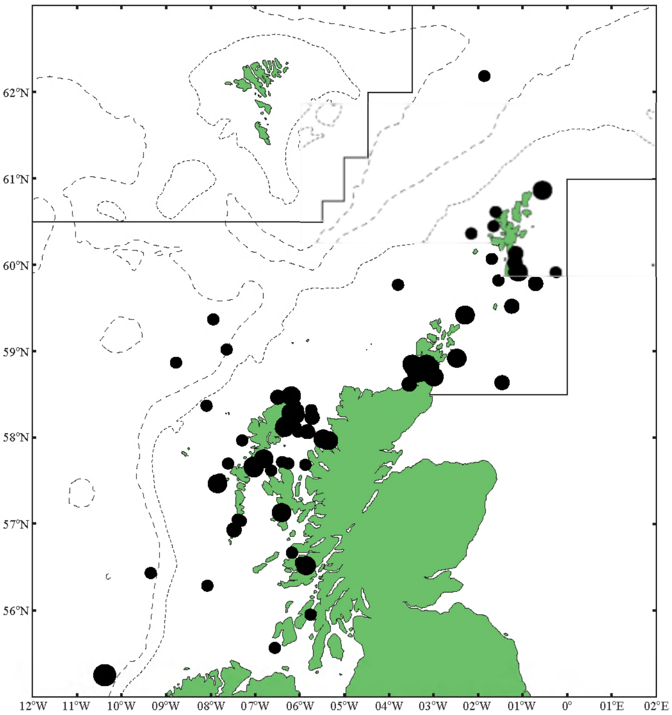


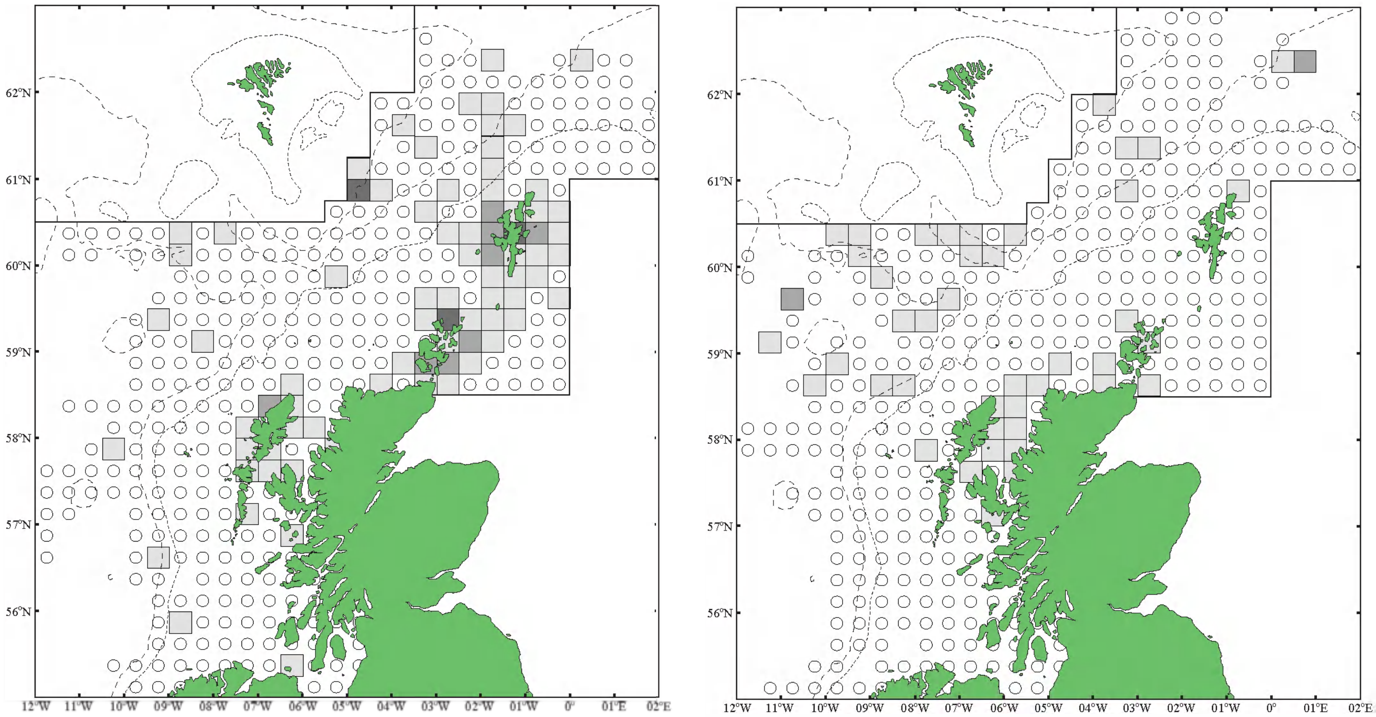
Figure 39. Common tern sightings from May to August

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

5.27 Arctic tern *Sterna paradisaea*

May to July: Arctic terns were recorded in the study area between May and October. During the breeding season, from May to July, Arctic terns were found mainly in inshore waters around the Northern and Western Isles (Figure 40a). The highest densities were concentrated in inshore waters around Orkney and Shetland, which hold over 80% of the British breeding population (Lloyd *et al.* 1991). The distribution was patchy in deep waters. These records presumably relate to adults returning to more northerly colonies during May, or to failed and non-breeders later.

August to October: In August, Arctic terns began to disperse from the main breeding sites. Low densities were observed in the Minch and again in deep waters particularly around the shelf break south of the Faroes (Figure 40b). By late autumn Arctic terns migrate south, down the coast of West Africa, some wintering as far south as the Antarctic, before returning north in May (Cramp & Simmons 1983).



a) May to July

b) August to October

Figure 40 a) - b). Arctic tern distribution

Density (birds/km^2): No birds 0.01-0.49 0.50-0.99 1.00-1.99 2.00+

5.28 Common guillemot *Uria aalge*

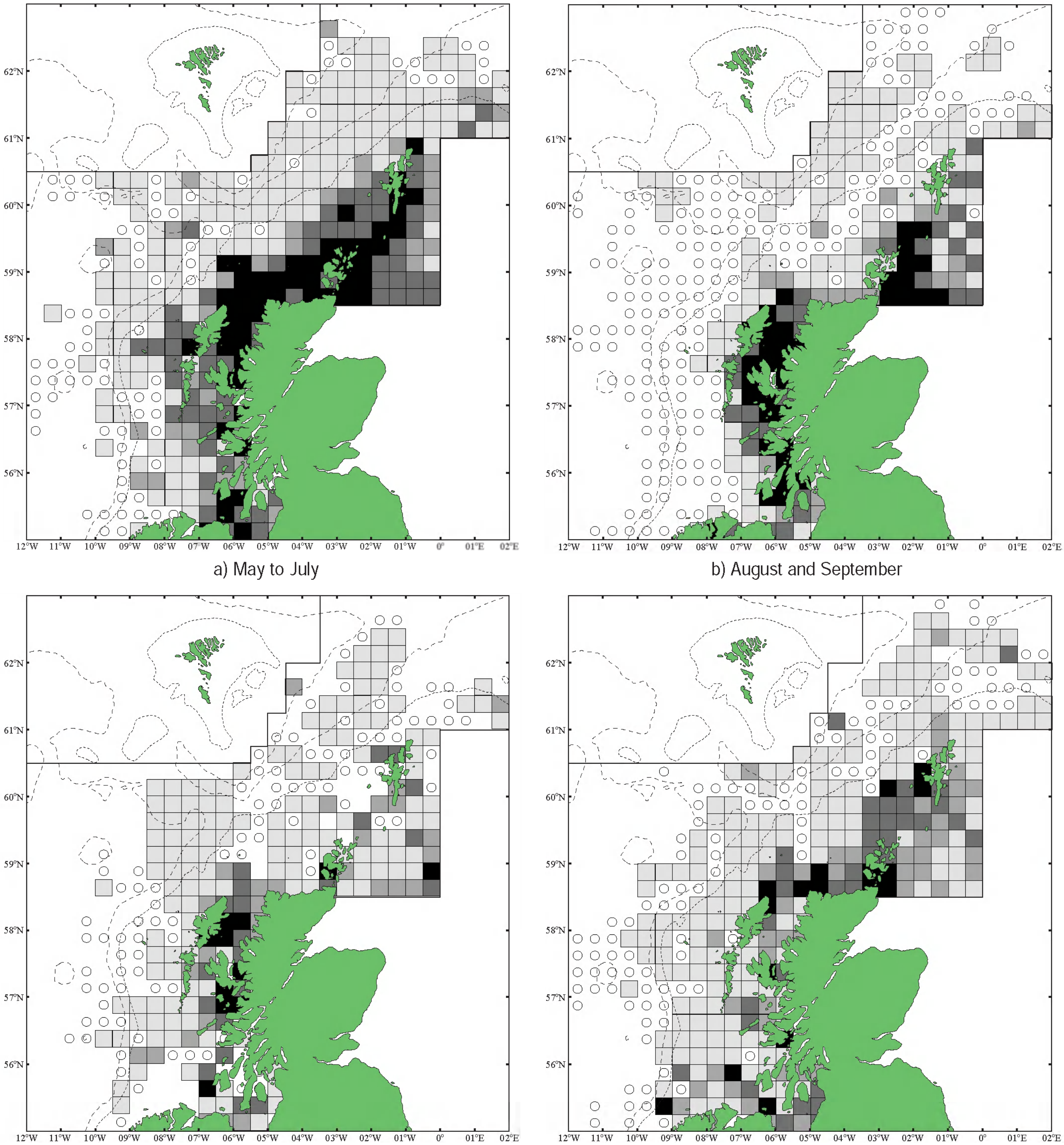
Common guillemots were the most abundant and widespread of the auk species recorded. They are primarily a shelf species preferring waters less than 100 m deep (Stone *et al.* 1995b), but were recorded along the shelf break at low densities throughout the year.

May to July: From May to July very high concentrations of common guillemots were found in near-shore waters with low densities further offshore and extending to waters deeper than 200 m (Figure 41a). The highest densities were found around Shetland, Orkney, along the northern coast of Caithness and Sutherland, and off the west coast of Scotland – an area that holds most of the breeding birds in Scotland (Lloyd *et al.* 1991). Most breeding birds feed within 55 km of their colony (Leaper *et al.* 1988).

August and September: After the breeding season, common guillemots disperse from the colonies and gather in large flocks in inshore waters (Blake *et al.* 1984). At this time, they undergo a complete body moult rendering them flightless for several weeks (Birkhead & Taylor 1977). The highest concentrations were found to the east of Orkney and off the west coast of Scotland over the shallow inshore waters of the Minch and the Sea of Hebrides southwards to Islay. Although these areas are very important for moulting auks (Burton *et al.* 1987), overall numbers are lower than expected given the size of the breeding population. Some common guillemots from the west coast probably move into the Irish Sea (Harrison *et al.* 1989; Pollock *et al.* 1997), while those from the Shetland colonies move both east and south into the North Sea, an estimated one third of which move into the Moray Firth (Tasker *et al.* 1986). Beyond the shelf break common guillemots were widespread at low densities over the Faroe-Shetland Channel and an area to the south of the Faroe Bank (Figure 43b).

October and November: By October and November the moulting flocks had dispersed further offshore. Low densities were found along the shelf-edge over the Ymir and Wyville-Thomson Ridges and the Faroe-Shetland Channel (Figure 41c). High to moderate densities were still found inshore off the west coast particularly in the Minch. Fewer birds were present in the study area and some may winter in the North and Irish Seas (Pollock *et al.* 1997; Stone *et al.* 1995a).

December to April: Between December and April, common guillemots were more widely distributed than in previous months (Figure 41d). Highest densities remained over the continental shelf but the Minch was less important. Instead the inshore waters around Orkney and the southern half of Shetland held the highest concentrations. Although adult birds visit the colonies during the autumn and winter months (Harris & Wanless 1989a) most of the high densities around the colonies were observed in April, when colony attendance increases (Birkhead & del Nevo 1987; Wanless & Harris 1986). Low densities of common guillemots were observed over the deep waters along the continental slope.



a) May to July

b) August and September

c) October and November

d) December to April

Figure 41 a) - d). Common guillemot distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

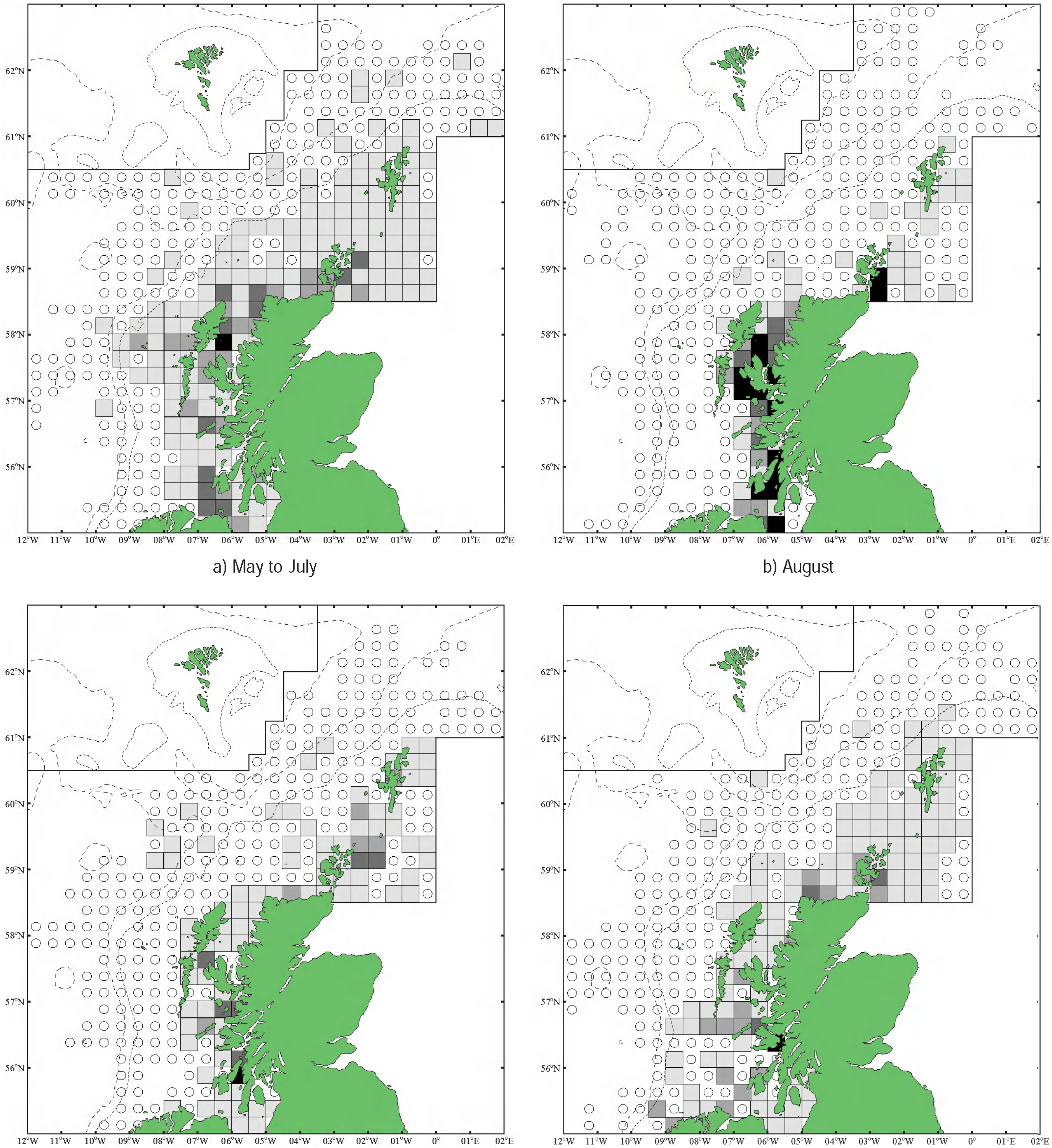
5.29 Razorbill *Alca torda*

Razorbills breed only in the North Atlantic with Iceland holding most of the world population. About 20% of the world population breeds in Britain, mostly around Scotland (Lloyd *et al.* 1991; Skov *et al.* 1995b). The razorbill is primarily a shelf species (Stone *et al.* 1995b), but is less widespread than the common guillemot, with few birds recorded beyond the 200 m isobath.

May to July: During the breeding season, highest densities were found inshore off the west coast of Scotland. Low densities were observed over the continental shelf especially to the west of the Western Isles (Figure 42a). Localised areas of low density were recorded beyond the shelf-break. In common with guillemots, razorbills leave the colonies in late June and July and become flightless during the moult (Birkhead & Taylor 1977).

August: During August, highest densities of razorbills occurred inshore off the west coast of Scotland (Figure 42b). The Minch is an important area for moulting auks and an estimated two-thirds of the west coast population congregates there with the remainder thought to move south into the Irish Sea (Burton *et al.* 1987; Harrison *et al.* 1989). Another area of high density was observed to the south of Orkney in the Pentland Firth; this area is known to be an important gathering area for moulting razorbills from Orkney and Shetland (Tasker *et al.* 1986). As with other months, very few records of razorbills were in deep waters (>200 m). In August west of Scotland, most birds were found inshore with a preference for shallow water with strong tidal currents (Harrison *et al.* 1994). Other studies show highest densities within 10 km of the coast at this time of year (Tasker *et al.* 1985c, 1986).

September to December: During the months of September to December, razorbills were recorded in low densities over shallow shelf-waters, with some distributed



a) May to July

b) August

c) September to December

d) January to April

Figure 42 a) - d). Razorbill distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.99 ▢ 1.00-1.99 ▢ 2.00-4.99 ■ 5.00+

along the shelf-edge and over the Wyville-Thomson and Ymir Ridges (Figure 42c). Moderate densities occurred inshore off the west coast of Scotland and north-east of Orkney. The pattern of distribution at this time was similar to that recorded between January and April although no birds were observed near the shelf-edge south of 57°N.

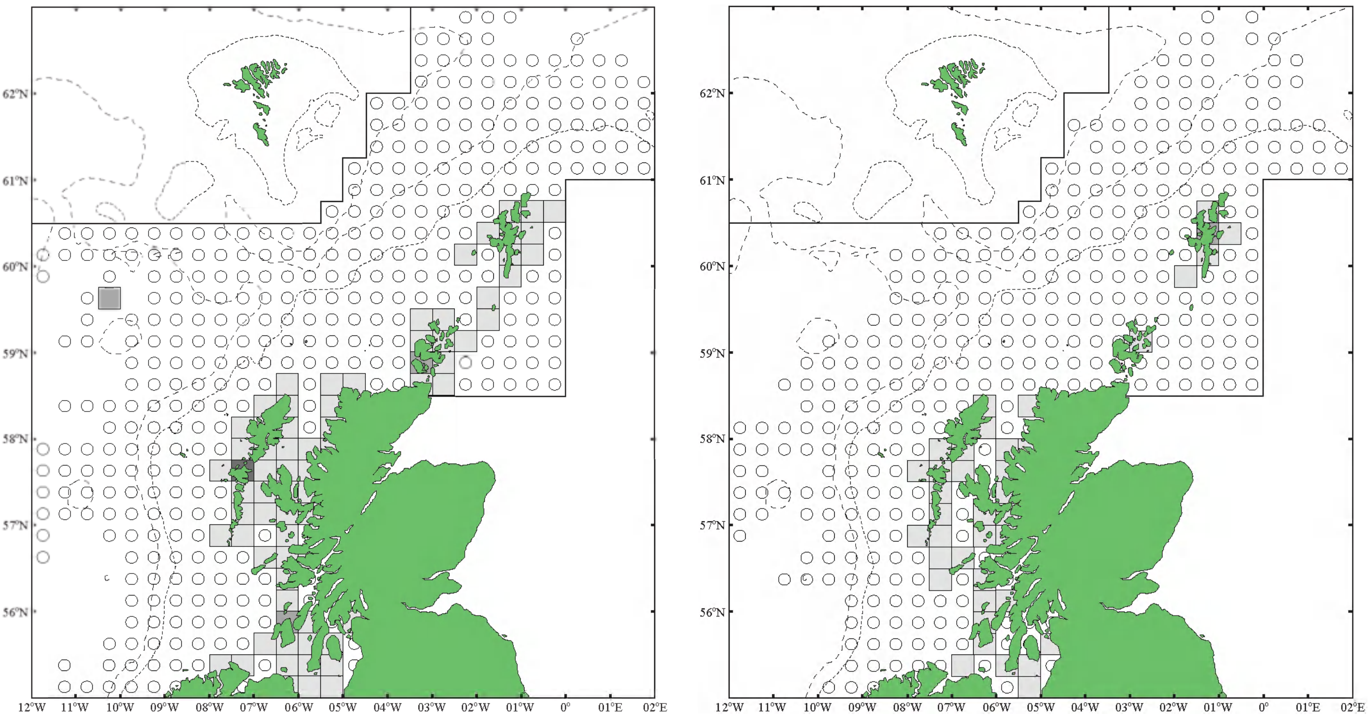
January to April: During winter, razorbills disperse widely; some birds winter in the North and Irish Seas and there is also immigration into the area from the north (Harris 1986; Harrison *et al.* 1989; Hudson & Mead 1984; Stone *et al.* 1995a; Tasker *et al.* 1987). Prior to the breeding season, from January to April, the razorbill was evenly dispersed in low densities over much of the continental shelf (Figure 42d). Adult birds visit the colonies during the winter with visits becoming longer by March (Harris & Wanless 1989b). Slightly higher densities were recorded near Orkney, Cape Wrath and around and to the north-west of Mull. These moderately high densities do not occur near the locations of the largest known razorbill colonies, possibly indicating the greater foraging range of razorbills at this time (Webb *et al.* 1990).

5.30 Black guillemot (Tystie) *Cepphus grylle*

In Europe the breeding distribution of the black guillemot stretches north-east from Scotland and Ireland (with a few pairs in northern England and Wales) encompassing Scandinavia, Spitsbergen and northern Russia (Cramp 1985). Within this area it is usually found inshore, occurring offshore less often than other auks (Cramp 1985; Stone *et al.* 1995b).

March to August: Black guillemots were widespread in low densities in coastal waters (Figure 43a). Black guillemots usually feed within 5 km of their nests during the breeding season (Cramp 1985) so the distribution closely matches that of the breeding colonies (Lloyd *et al.* 1991; Webb *et al.* 1990). A single bird observed near the Rosemary Bank in August was the only record beyond the shelf-edge.

September to February: The distribution pattern in winter was very similar to that of the previous period, reflecting the sedentary nature of the species, though fewer birds were recorded (Figure 43b). Most Shetland birds remain within 15 km of their colonies while ringing recoveries of Orkney birds suggest most move less than 50 km (Ewins 1988; Ewins & Kirk 1988). Black guillemots from Foula and Fair Isle have been found to move further than birds from other colonies, possibly because the coastlines of these islands provide limited shelter (Ewins & Kirk 1988). In contrast to these relatively small-scale movements two immature birds from southern Scandinavian colonies have been recovered in eastern England (Ewins & Kirk 1988). The sheltered, shallow inshore waters of Shetland provide an important gathering area for flocks of moulting black guillemots during autumn and winter (Ewins & Kirk 1988).



a) March to August

b) September to February

Figure 43 a) - b). Black Guillemot (Tystie) distribution

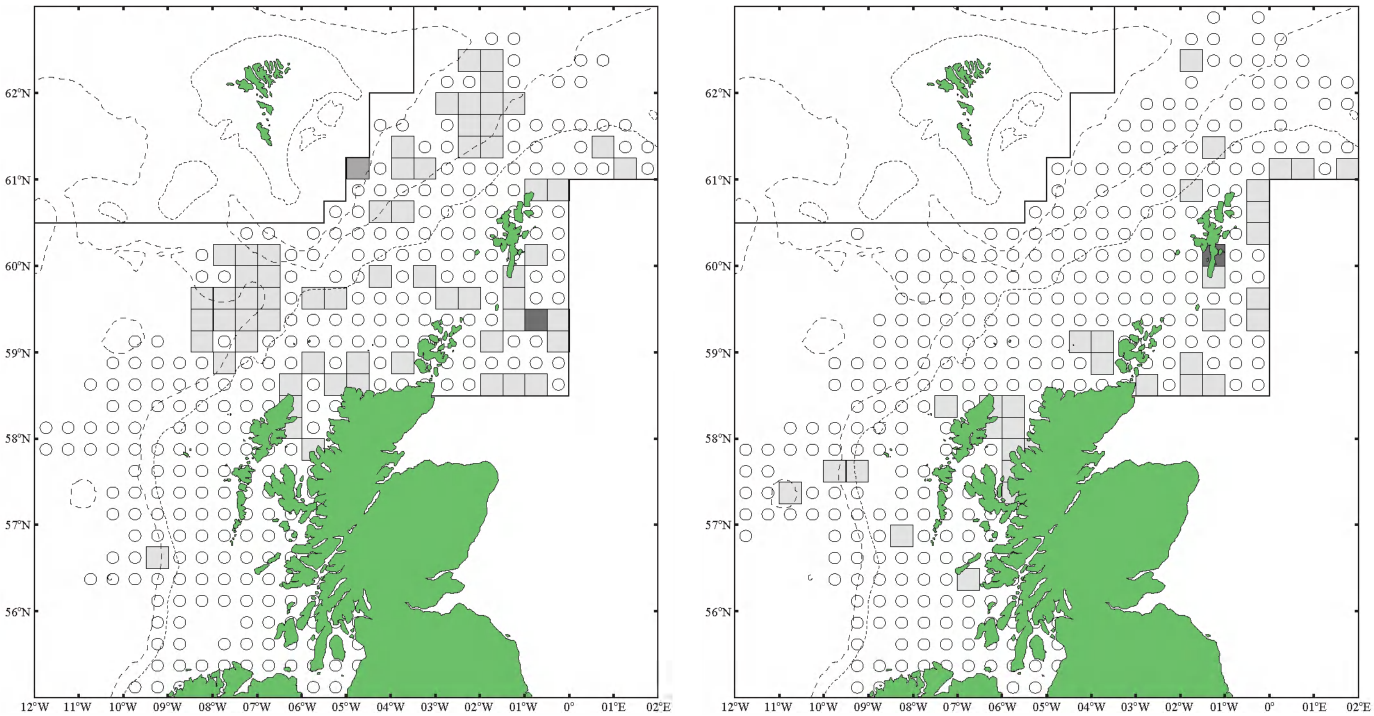
Density (birds/km^2): No birds 0.01-0.49 0.50-0.99 1.00-1.99 2.00+

5.31 Little auk *Alle alle*

September to December: The little auk is a winter visitor to Britain from the islands of Arctic Europe, and although generally uncommon, in some years large wrecks (birds driven inland and stranded in atypical habitats) can occur involving several thousand birds (Platteeuw 1996). Little auks were generally scarce in the study area. Low densities were observed in the Faroe-Shetland Channel from September to December and over the continental shelf edge north-west of the Western Isles in November (Figure 44a). Although recorded between September and May, little auks were most abundant in November. A major wintering ground for little auks is the relatively shallow northern North Sea which may hold up to 31% of the North-east Atlantic population (Skov *et al.* 1995b). During this period, 40% of the birds were recorded over the deep waters of the Atlantic Frontier.

January to March: From January through to March numbers of sightings were reduced with very few little auks recorded beyond the shelf edge (Figure 44b).

April and May: By April and May most little auks had migrated north to their breeding grounds leaving only a few scattered birds.



a) September to December

b) January to March

Figure 44 a) - b). Little auk distribution

Density (birds/km^2): ○ No birds ▢ 0.01-0.49 ▢ 0.50-0.99 ▢ 1.00-1.99 ■ 2.00+

5.32 Puffin *Fratercula arctica*

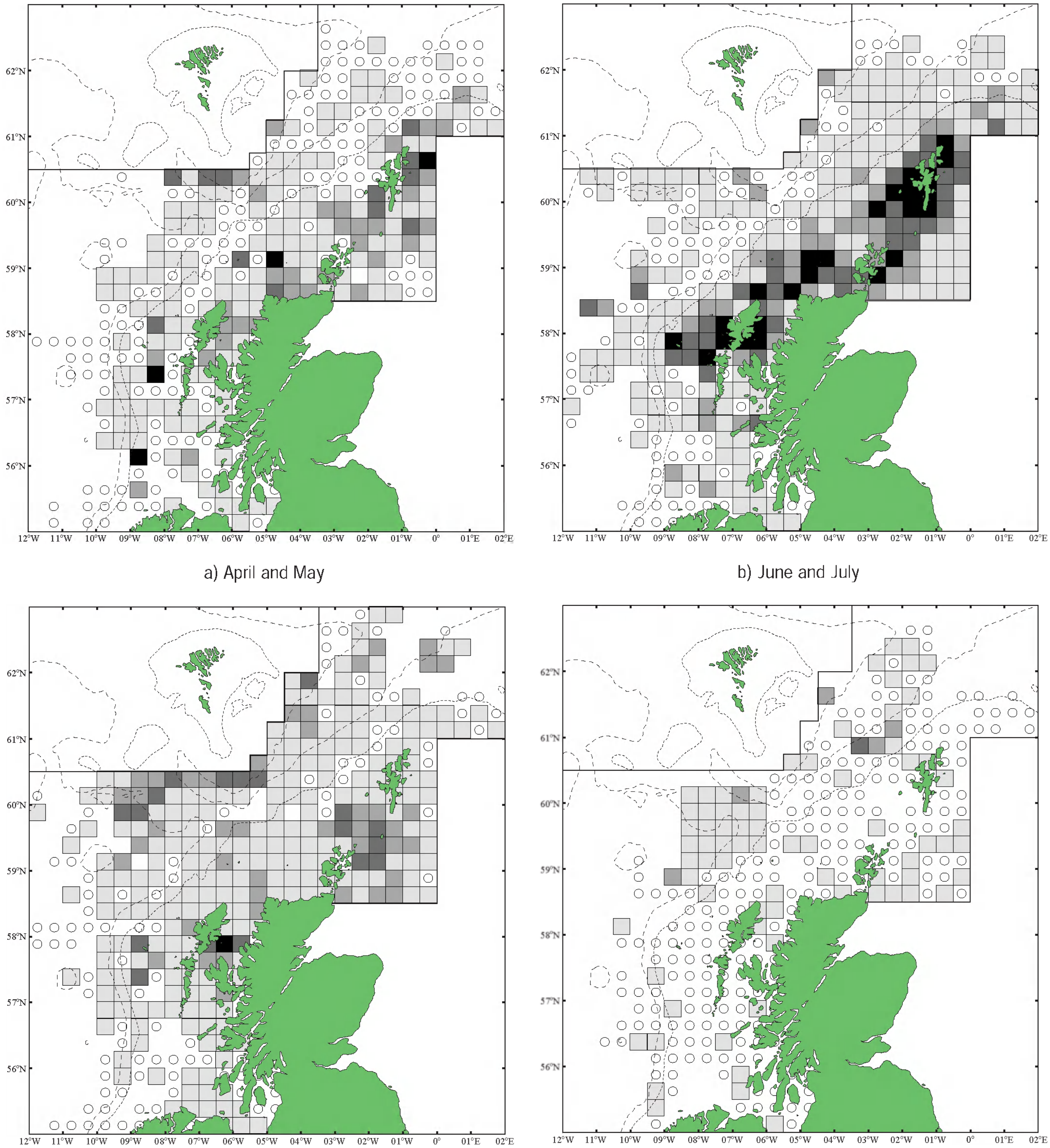
Puffins had a more widespread distribution than common guillemots or razorbills and were common in the deep waters of the Atlantic Frontier during the summer. Puffins are often more abundant in oceanic waters than inshore waters (Harrison *et al.* 1994), and appear to prefer deeper waters than common guillemots or razorbills (Stone *et al.* 1995b).

April and May: During April and May with the onset of the breeding season, puffins were widespread and numerous within the study area, with the majority over the shelf waters (Figure 45a). Eggs are laid mostly in April (Harris 1984). Moderate to high densities were observed around Shetland but remained low around other known colonies. Low to moderate concentrations of probable non-breeders or Faroese breeders were observed over the Faroe shelf break and the Faroe-Shetland Channel.

June and July: From June to late July, highest densities of puffins occurred, with concentrations around the main breeding sites of Shetland, Orkney, North Rona, the Shiants and St. Kilda (Lloyd *et al.* 1991), (Figure 45b). Low to moderate densities were observed beyond the shelf edge and over deep water as far west as the Rockall Trough and north to the Norwegian Sea. These are most likely non-breeders as breeding birds are generally thought to feed near the colony (Benn *et al.* 1987; Harris 1984; Wanless *et al.* 1990) although a maximum foraging range of 40 km has been recorded for St. Kilda puffins (Leaper *et al.* 1988). Foraging ranges of 50 km and 137 km from the nearest breeding site have been recorded during periods of low food availability (Anker-Nilsen & Lorentsen 1990; Joiris 1978). At this time there is a considerable influx of non-breeding birds around the colonies (Harris 1984).

August to September: Puffins were most widespread in deep waters at this time, possibly due to movement away from the colonies once chicks have fledged (Stone *et al.* 1995b). Moderate densities were recorded in deep waters south and west of the Faroes (Figure 45c). In shelf waters moderate densities were found between Orkney and Shetland and in the Minch.

October and November: By October and November overall numbers had decreased considerably and the distribution became very scattered (Figure 45d). Many of the birds from the Shetland and Orkney colonies move south



a) April and May

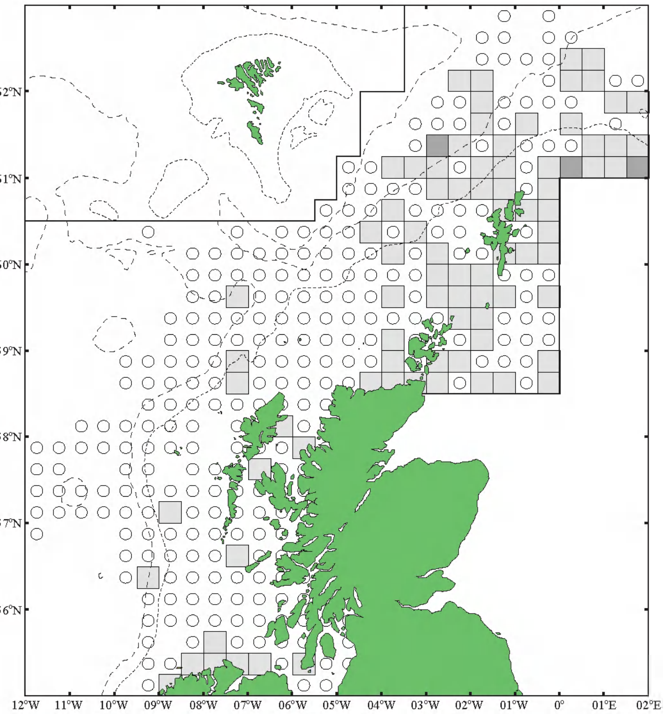
b) June and July

c) August and September

d) October and November

Figure 45 a) - d). Puffin distribution

Density (birds/km^2): No birds 0.01-0.99 1.00-1.99 2.00-4.99 5.00+



e) December to March

and winter in the North Sea (Stone *et al.* 1995b; Tasker *et al.* 1987). Low to moderate concentrations were recorded over and beyond the shelf break north-west of Shetland and over the deeper waters of the Faroe Bank Channel, the Wyville-Thomson Ridge and the Rockall Trough.

December to March: From December to March there was a further decrease in overall numbers of puffins in the study area. Most puffins were distributed east of 4°W and they were very scarce west of Scotland. Low densities were recorded in waters beyond the shelf edge, the majority of which were north and west of Shetland over the Faroe-Shetland Channel and over the shelf break (Figure 45e). During the winter, puffins from the west coast are thought to disperse widely, moving west into the Atlantic as well as south as far as the Mediterranean Sea (Harris 1984).

Figure 45 e). Puffin distribution

Density (birds/km^2): No birds; 0.01-0.99; 1.00-1.99; 2.00-4.99; 5.00+

5.33 Rare species

The following 16 species were recorded on fewer than 20 occasions between 1979 and 1999.

5.33.1 Black-throated diver *Gavia arctica*

In Britain the black-throated diver breeds only in Scotland, the current population numbering between 155-189 pairs (Ogilvie *et al.* 1999). There were ten records in the study area totalling 15 birds. All were found inshore in late winter and early spring, mostly west of Scotland where Webb *et al.* (1990) also recorded the highest densities. Most were single birds although one group of five was recorded off the Mull of Kintyre. Over 100 birds spend part of the winter along this coastline (Moser *et al.* 1986).

5.33.2 Great crested grebe *Podiceps cristatus*

Although a common grebe throughout most of Britain and continental Europe, this species was recorded on surveys only once. A single bird in winter plumage was recorded off the Mull of Kintyre in November 1994. North of Argyll, this species is rarely found off the west coast (Moser *et al.* 1986), although larger numbers are found to the south off Ayrshire and in Loch Ryan (Webb *et al.* 1990).

5.33.3 Soft-plumaged petrel sp. *Pterodroma* sp.

A single soft-plumaged petrel was recorded approximately 130 km north-west of Lerwick, on 25 June 1996. This was the first occurrence of this species in Scottish waters and establishes a new northerly latitude record for the species group (White 1998). The bird was thought most likely to be a Fea's petrel *Pterodroma feae*, which breeds on the Desertas and Cape Verde Islands off north-west Africa.

5.33.4 Cory's shearwater *Calonectris diomedea*

Four Cory's shearwaters were recorded between July and October. Single birds were seen in the Minch, west of North Uist, west of Islay and off Arran. Cory's shearwaters breed on many islands and coastal stretches of the Mediterranean. In autumn they undergo post-breeding dispersal with the bulk of the population passing through the Straits of Gibraltar into the Atlantic where they winter (Telleria 1980).

5.33.5 Mediterranean shearwater *Puffinus yelkouan*

On the 20 August 1997 a single Mediterranean shearwater was observed flying north-east in the Minch at 58°07′N, 06°08′W. In recent years, small numbers (c. 50) have been seen annually in Scottish waters, mostly by land-based bird-watchers (e.g. Murray 1999). The species originates from the Mediterranean Sea where the breeding colonies are situated. After breeding, birds disperse into the Atlantic, via the Straits of Gibraltar, before moving north and south (Cramp & Simmons 1977).

5.33.6 Wilson's storm-petrel *Oceanites oceanicus*

The only record of this species was of a single bird on 1 June 1997 at 61°37′N, 02°48′W, north-west of Shetland. This is only the fourth occasion that this species has been recorded in Scottish waters (Murray 1999). Although rarely encountered in British waters, Wilson's storm-petrel is numerous in its breeding range in the Southern Hemisphere, where the total population is estimated at several million pairs. During the non-breeding season, this species migrates north into the Atlantic, Pacific and Indian Oceans (Cramp & Simmons 1977).

5.33.7 Common scoter *Melanitta nigra*

Ten sightings of common scoters, comprising 50 birds, were made inshore off the west coast and around the Northern and Western Isles. There were two sightings over deep water: a group of five birds in August and a single bird in November. The British and Irish breeding population of this duck numbers less than 200 pairs (Underhill *et al.* 1998) but the winter population is far greater. Immigrants from breeding grounds in Fenno-Scandia and Russia augment UK numbers to 25,000 (Campbell 1986b), although only low numbers are recorded on the west coast of Scotland (Moser *et al.* 1986; Webb *et al.* 1990).

5.33.8 Velvet scoter *Melanitta fusca*

Two velvet scoters were recorded at 60°58′N, 00°57′W on 11 November 1994 to the north of Unst in the Shetland Isles. This species is a winter visitor to Britain from its breeding grounds in Fenno-Scandia and northern Russia. In common with the previous species it prefers coastal waters although fewer are recorded annually. The wintering population of the UK may number as many as 10,000, although 2,500-5,000 is more usual (Campbell 1986c). Most of these are on the east coast of Scotland (Cranswick *et al.* 1999).

5.33.9 Red-breasted merganser *Mergus serrator*

This seaduck was recorded between February and November mostly in inshore waters. Of a total of 27 birds, over half were recorded in February. About 2,000 pairs of red-breasted merganser breed in Britain, mostly in the north and west; immigrants from Iceland and Scandinavia bring the winter population up to 11,000 (Chandler 1986; Gibbons *et al.* 1993). The species is commonly found inshore on the north and west coasts of Scotland during the winter (Moser *et al.* 1986).

5.33.10 Red-necked phalarope *Phalaropus lobatus*

A group of three red-necked phalaropes in breeding plumage on 13 August 1994 was the only record. They were seen at 60°05′N, 00°04′W just east of the Shetland Isles. This island group is the main breeding area of the species in Britain, where the population currently numbers almost 40 breeding males (Ogilvie *et al.* 1999).

5.33.11 Grey phalarope *Phalaropus fulicarius*

Nine observations totalling ten birds were recorded. Apart from a single bird in June, most sightings were between August and October. Eight birds were recorded in inshore waters north and west of Scotland, and the other two were observed over waters greater than 1,000 m deep, west of Scotland. The grey phalarope has a circumpolar breeding distribution on the Arctic tundra but outside the breeding season it is entirely pelagic, wintering off the coast of Africa (Griffiths & Sinclair 1982). The majority of these sightings relate to birds moving south for the winter.

5.33.12 Little gull *Larus minutus*

Twenty-three little gulls were recorded in inshore waters off west Scotland in May. Single birds were recorded in July and November. These may relate to birds that dispersed northwards from Liverpool Bay or the Irish Sea where this species is common during spring (Webb *et al.* 1990).

5.33.13 Sabine's gull *Larus sabini*

During the course of the survey, six single Sabine's gulls were recorded. Five records were in August or September with one in May. Five were adults and two were juveniles. The sightings were in the inshore waters of the Minch and Pentland Firth, as well as further offshore to the north and west of the Western Isles. Autumn records of Sabine's gull are not unusual on the western coasts of Europe. The breeding populations of Canada and Greenland migrate on a diagonal route across the north Atlantic to wintering areas off south-west Africa (Grant 1982). Occurrences are usually the result of westerly gales in autumn.

5.33.14 Sandwich tern *Sterna sandvicensis*

A total of 12 Sandwich terns was recorded between May and August. Records came from inshore waters near the Irish coast (2) the Orkney Isles (4) and the Shetland Isles (1). This distribution of records corresponds with the species breeding colonies on the northern Irish coast and in Orkney. The species does not breed in Shetland (Lloyd *et al.* 1991).

5.33.15 Little tern *Sterna albifrons*

Seven little terns were recorded inshore around North Uist and Orkney, six in June and one in September. The main breeding areas for the species on the west coast are Argyll and Bute and the Western Isles (Lloyd *et al.* 1991). Small numbers have bred in Orkney in recent years (Thompson *et al.* 1999).

5.33.16 Brünnich's guillemot *Uria lomvia*

A single bird was recorded over the deep water of the Faroe-Shetland Channel on 23 January 1995. In Europe this species breeds mainly on Iceland with a small number in Norway and north-west Russia (Cramp 1985). In autumn, some birds (notably immatures) disperse from their colonies to winter offshore in low-Arctic waters. There are occasional records from the inshore waters of Shetland (Johnston 1999).

6. Cetacean distribution

Between June 1979 and March 1999, surveys by SAST and European colleagues within ESAS have recorded a total of fifteen species (12,482 individuals) of cetacean within the study area (Table 8). A further 1,011 individuals were not identified to species level.

Table 8. Total number of each cetacean species recorded in the study area since 1979

Cetacean Species	Total number of animals recorded	Total number of sightings	Average group size
Fin whale *Balaenoptera physalus*	29	17	1.7
Sei whale *Balaenoptera borealis*	42	19	2.2
Minke whale *Balaenoptera acutorostrata*	158	143	1.1
Humpback whale *Megaptera novaeangliae*	5	4	1.3
Sperm whale *Physeter macrocephalus*	80	68	1.2
Northern bottlenose whale *Hyperoodon ampullatus*	17	7	2.4
Sowerby's beaked whale *Mesoplodon bidens*	1	1	1.0
Killer whale *Orcinus orca*	241	52	4.6
Long-finned pilot whale *Globicephala melas*	2,018	175	11.5
Atlantic white-sided dolphin *Lagenorhynchus acutus*	4,925	341	14.4
White-beaked dolphin *Lagenorhynchus albirostris*	1,859	531	3.5
Risso's dolphin *Grampus griseus*	292	78	3.7
Bottlenose dolphin *Tursiops truncatus*	131	21	6.2
Common dolphin *Delphinus delphis*	1,210	101	12.0
Harbour porpoise *Phocoena phocoena*	1,474	754	2.0
Unidentified Cetaceans			
Cetacean sp.	66	30	2.2
Whale sp.	192	104	1.8
Beaked whale sp.	62	21	3.0
Dolphin sp.	691	252	2.7

6.1 Fin whale *Balaenoptera physalus*

A total of 29 fin whales was recorded between May and October, with a peak number of 11 animals occurring during August. A single immature was recorded during August in the Faroe-Shetland Channel. Although average group size for this species was 1.7 animals, one sighting at the Anton Dohrn Seamount in July 1995 involved five animals. A single fin whale was also observed associating with six white-sided dolphins in the Faroe Bank Channel. The distribution of fin whales was centred north of 60°N to the south and south-east of the Faroe Islands, and all sightings occurred near or beyond the 1,000 m isobath (Figure 46). It is possible that fin whales utilise the shelf edge as a migration channel (Evans 1987), spending the summer months at high latitudes before returning to the southern wintering grounds. Most sightings of fin whales in UK waters occur between May and October (Evans 1992; Pollock *et al.* 1997), suggesting that whales utilise the area during the summer. However, acoustic detection of fin whales to the north and west of Scotland suggests that at least some animals may be resident in Atlantic Frontier waters throughout the year (Clark & Charif 1998). Also sightings of adults with calves off south-west England and Ireland during the winter may indicate that some animals remain within UK waters to breed (Evans 1992) or use the region as a nursery ground.

6.2 Sei whale *Balaenoptera borealis*

Sei whales are generally considered to be pelagic animals, and none had been recorded prior to the commencement of dedicated deep-water surveys. Seventy-four percent of the 42 animals recorded were observed in August. Sightings were concentrated in deep water to the south-east of the Faroe Islands (Figure 46). Sei whales tended to form slightly larger groups than fin whales, with aggregations occurring particularly in the Faroe-Shetland Channel. Whaling records suggest that numbers of sei whales in the north-east Atlantic fluctuate between years, with peak numbers occurring during 'invasion years' (Christensen *et al.* 1992). Compared with fin or minke whales, sei whales are specialist feeders (Sigurjónsson 1995) and the variation in their annual occurrence may result from fluctuations in food supply, particularly of the copepod *Calanus finmarchicus* (Ingebrigtsen 1929; Jonsgård & Darling 1977). However, in the North Atlantic, sei whales will also feed on euphausiids and small schooling fish (Mizroch *et al.* 1984). Sei whales migrate between high latitude summer feeding areas and low latitude wintering areas, and they are thought to reach Scottish waters between April and July, leaving during late August and September (Jonsgård & Darling 1977). Within the study area, sei whales were sighted only between May and October, despite coverage in suitable waters at other times of year. Sei whale records occurred south of 59°N during June and July and north of 60°N during all other months. Although small groups of animals may remain at high latitudes over the winter (Evans 1992), none were recorded there during this study.

6.3 Minke whale *Balaenoptera acutorostrata*

Minke whales were the most common baleen whale species recorded in the study area, with a total of 158 individuals (Figure 47). Only 12 sightings occurred in water deeper than 200 m, indicating the inshore nature of this species. Sightings were most frequent along the east coast of Lewis in the north Minch, and to the south of the Isle of Skye. Minke whales were recorded only between May and October, with over 74% of the total number of animals recorded between June and August. The seasonal pattern in minke whale sightings suggests migration of animals into British waters to feed during the summer months, before movement south to breed during the winter (Evans 1980). Juvenile minke whales were recorded on the east and west coasts of Lewis during June and July, with two immature animals south of Skye in August and October. Minke whales have twice been recorded in association with harbour porpoises; it is possible that the two species occur in the same area to exploit similar food supplies (Camphuysen & Webb in press).

6.4 Humpback whale *Megaptera novaeangliae*

The humpback whale is uncommon in Atlantic Frontier waters, with only four records since 1979. Sightings occurred in the summer months between May and September, corresponding with seasonal migration to high latitude feeding areas in the north-west Atlantic (Martin *et al.* 1984). Three sightings were of single animals, while one sighting of two animals was made in the Faroe-Shetland Channel during July 1988. A single humpback whale was recorded with three white-sided dolphins in less than 200 m depth of water to the west of Lewis during September 1996. All other sightings have occurred in over 1,000 m depth of water (Figure 46). Five sightings from seismic vessels during 1996 and 1997 also occurred near the 1,000 m isobath (Stone 1997, 1998). Although records of humpbacks from both SAST and seismic observations occurred during the summer months only, acoustic surveys to the north and west of Scotland have detected humpbacks between November and March (Clark & Charif 1998), indicating that some animals may utilise the Atlantic Frontier during the winter months. The north-east Atlantic humpback whale population is only slowly recovering from heavy exploitation, although the species may never have been particularly numerous in the area (Winn & Reichley 1985). All four of the SAST sightings within the study area have occurred since 1988, suggesting a potential return of some animals to the region. This is also indicated by the annual return of up to three humpback whales to the inshore waters around the Shetland Islands between March and September since 1992 (P. Fisher pers. comm.) and by other sightings around the coast of Scotland (Gibson 1995).

6.5 Sperm whale *Physeter macrocephalus*

Sperm whales are the most frequently encountered species of large whale within the study area, with a total of 80 animals recorded. Sightings occurred in all months of the year except for February and March, and peaked in June. Low effort during February and March may explain the lack of records, though other months with low effort (November and December) did produce sperm whale sightings. Almost all sperm whale sightings occurred along the 1,000 m isobath, with animals either on or beyond the continental slope. Acoustic detection rates have also been found to be highest in offshore waters (Lewis *et al.* 1998). Concentrations of sperm whales occur particularly along the Ymir Ridge and north of Shetland in the Faroe-Shetland Channel (Figure 48). Sperm whales feed on squid, octopus and fish, particularly cephalopod populations that occur in intermediate and deep waters (Clarke 1980; Gaskin 1982). An increased primary productivity and subsequent increase in prey species where water currents converge along the continental slope may therefore explain the relationship of sperm whales with the shelf edge (Waring *et al.* 1993; Jaquet 1996). All aged animals were adults and the average group size of 1.2 animals suggests that most animals were adult males, since females tend to form gregarious breeding pods (Best 1979). In the North Atlantic, adult females were not taken by whaling stations in the British Isles (Rice 1989), and the majority of sighted or stranded sperm whales around Britain and Ireland are sub-adult or mature males (Berrow *et al.* 1993).

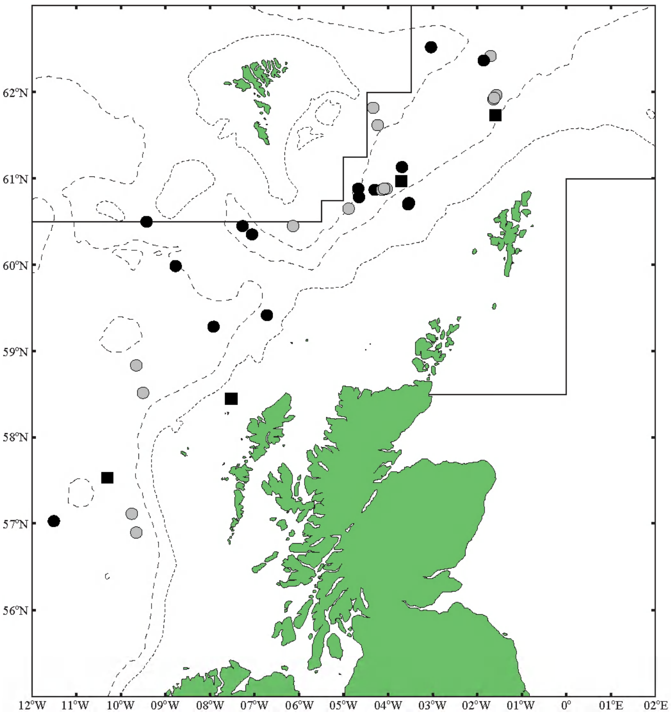


Figure 46. Distribution of fin, sei and humpback whale sightings throughout the year

● Fin whale ○ Sei whale ■ Humpback whale

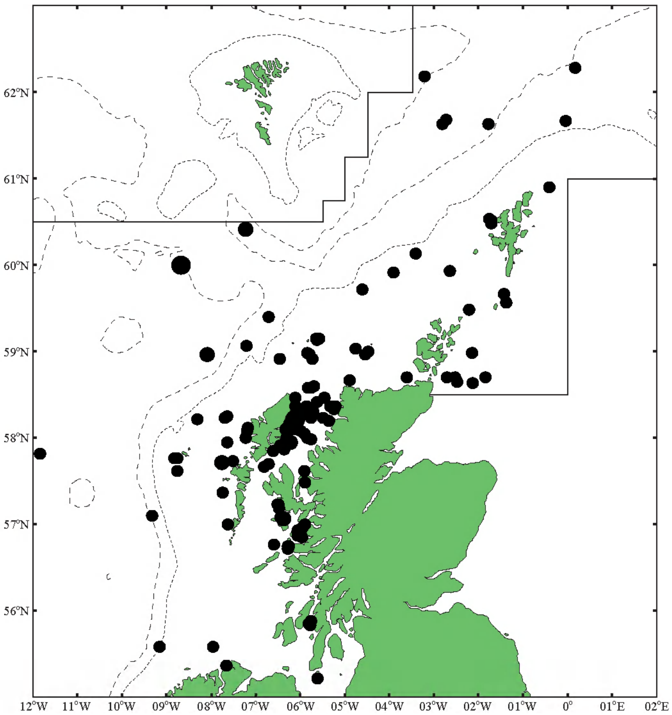


Figure 47. Distribution of minke whale sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3+

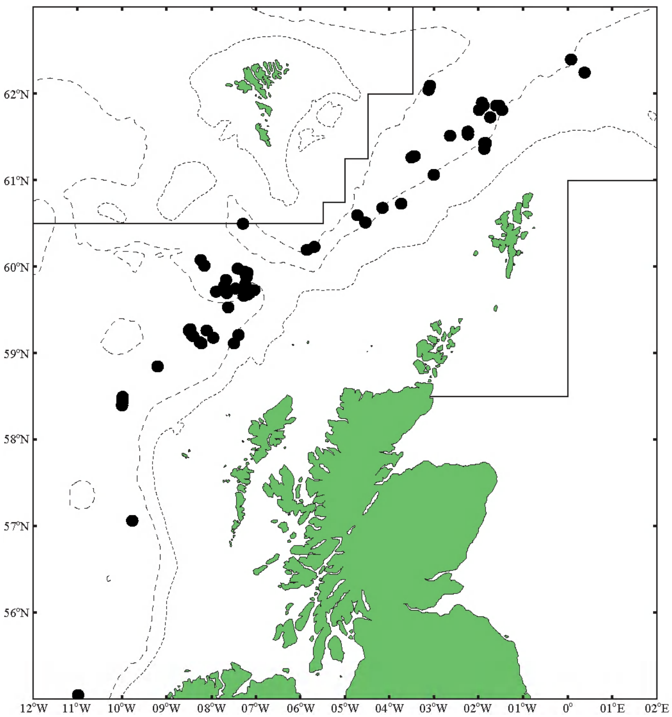


Figure 48. Distribution of sperm whale sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3+

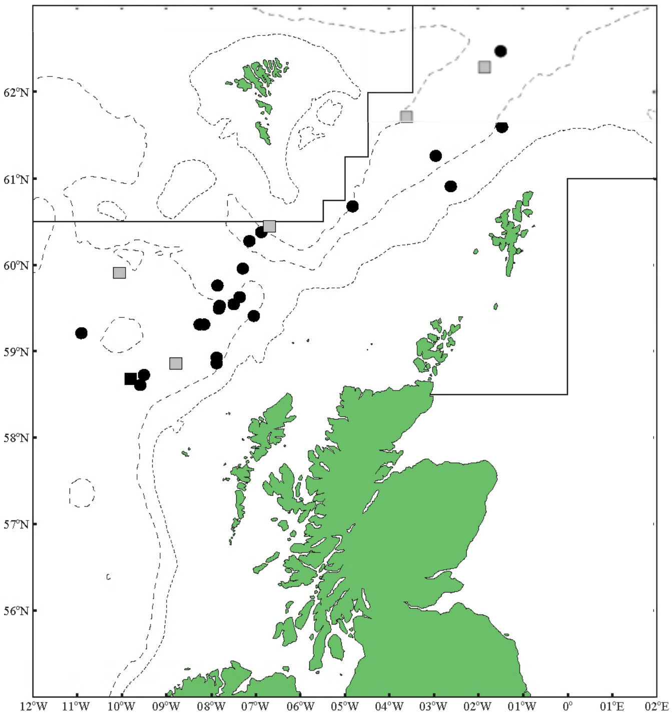


Figure 49. Distribution of beaked whale sightings throughout the year

□ Northern bottlenose whale

■ Sowerby's beaked whale

● Unidentified beaked whale

6.6 Unidentified beaked whales *Mesoplodon* spp.

The distribution and occurrence of beaked whales in the waters to the north and west of Scotland is poorly understood. Beaked whales tend to inhabit deep, offshore waters, and their long dive duration and inconspicuous surfacing behaviour may explain the limited number of sightings at sea. A total of 62 unidentified beaked whales have been recorded in the study area, with no sightings at all prior to the commencement of deep water surveys in 1995. The majority of animals observed were thought to belong to the genus *Mesoplodon*, which includes 14 species of small, taxonomically similar beaked whales. Beaked whales were observed throughout the year, but have not been recorded between February and April or during July. In February, there was no coverage in the waters in which beaked whales have been recorded in, but suitable survey coverage was achieved during April and July. A distinct peak in the number of whales recorded occurred during August (68% of all individuals sighted). Their distribution is similar, but slightly more southerly than that of the sperm whale, with almost all sightings occurring in water deeper than 1,000 m, particularly south of the Ymir Ridge (Figure 49). The diet of beaked whales is mostly squid and pelagic fish, which explains their occurrence in deep-water areas, although this is largely based on the stomach contents of stranded animals (Mead 1989). Whereas the average group size over the year was 2.95 animals, sightings were most frequently of single animals, and groups of up to ten have been recorded in the study area. A sighting of three juvenile animals occurred during August.

6.7 Northern bottlenose whale *Hyperoodon ampullatus*

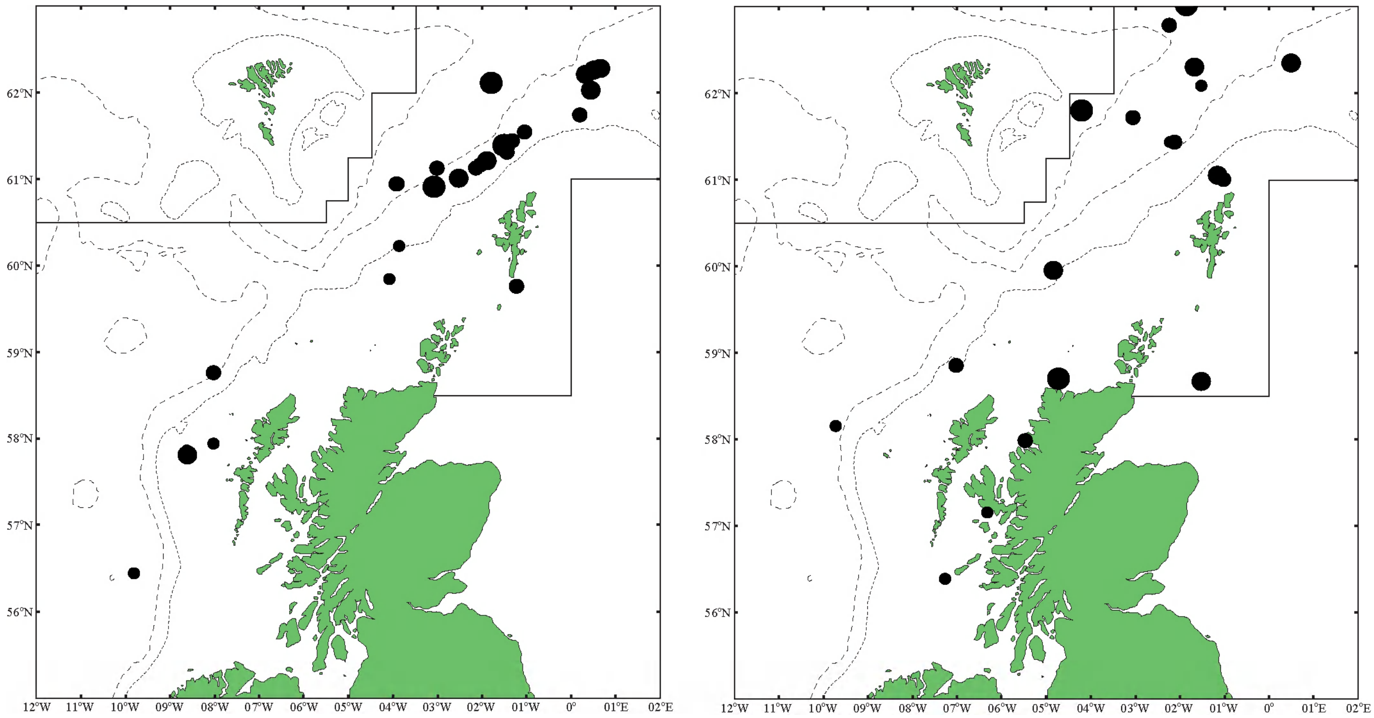
There have been seven sightings of northern bottlenose whales since 1979, involving a total of 17 animals. The distribution of northern bottlenose whales in the North Atlantic is centred in cold, deep waters near or seaward of the 1,000 m isobath (Reeves *et al.* 1993). This is definitely the case to the north and west of Scotland where all SAST records have occurred over deep water (Figure 49). Northern bottlenose whales are thought to migrate northwards from low latitudes in the spring, returning south from polar waters in the autumn (Benjaminsen & Christensen 1979). Peak numbers of animals during April and August, suggests that spring and autumn movements do occur within the region. Three northern bottlenose whales recorded to the north-west of Lewis during August 1998 appeared to be associating with large numbers of migrating long-finned pilot whales. Catches of bottlenose whales in the Faroe Islands peak during the autumn (Bloch *et al.* 1996), but they do occur throughout the year suggesting that some individuals within the study area may be non-migratory as has been found in the north-west Atlantic (Whitehead *et al.* 1997). There was only one winter record (in November). The average group size of bottlenose whales observed in the study area was 2.4 animals. Frequent sightings of two animals in both British (Evans 1980; Weir 1999) and Faroese waters (Bloch *et al.* 1996) suggests that animals may travel together in pairs.

6.8 Sowerby's beaked whale *Mesoplodon bidens*

Sowerby's beaked whale was positively identified once, when a single individual surfaced in deep water south of the Rosemary Bank in June 1998 (Figure 49). The close proximity of the animal to the vessel enabled identification to be made from the position of the teeth halfway along the lower jaw. It is likely that many of the unidentified *Mesoplodon* spp. were also of this species. Although Moore (1966) considered the centre of distribution of Sowerby's beaked whale to be the North Sea, stomach contents from stranded animals indicate an offshore pelagic distribution (Ostrom *et al.* 1993). This is also suggested by sightings at sea that occur in deep, offshore water (Carlström *et al.* 1997; Hooker & Baird 1999).

6.9 Killer whale *Orcinus orca*

Killer whales were distributed over both the continental shelf and in deep offshore waters, with the main concentration of sightings occurring over the slope to the north and north-west of Shetland. They were recorded on 52 occasions, and were observed in every month of the year except February and September. Of the total number of animals recorded, 43% were observed during June. Throughout May and June, sightings were distributed predominantly along the continental slope to the north of Shetland (Figure 50a). During the rest of the year sightings were widespread over the region (Figure 50b). Based on two sightings of an identifiable animal recorded over 100 km apart in the space of two weeks, Evans (1988) suggested that individual pods of this species may range over comparatively large distances in British waters. The average group size within the study area was 4.6 individuals, which accords with the mean group size recorded in the rest of British and Irish waters (Evans 1988). However, group size increased between June and August. Juvenile killer whales are generally sighted only in summer (Hammond & Lockyer 1988), and calves were observed in the study area in July and August.



a) May and June

b) July to April

Figure 50 a) - b). Distribution of killer whale sightings Number of individuals: ● 1 ● 2-4 ● 5-8 ● 9+

6.10 Long-finned pilot whale *Globicephala melaena*

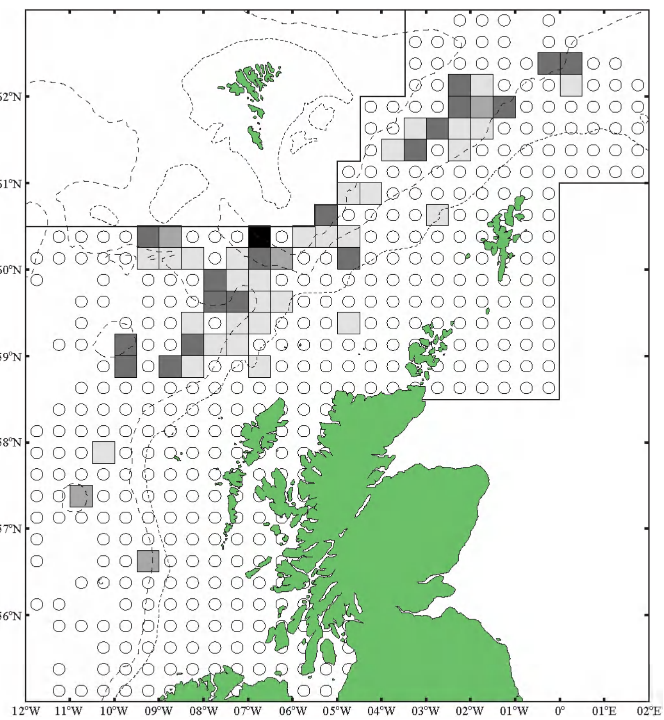


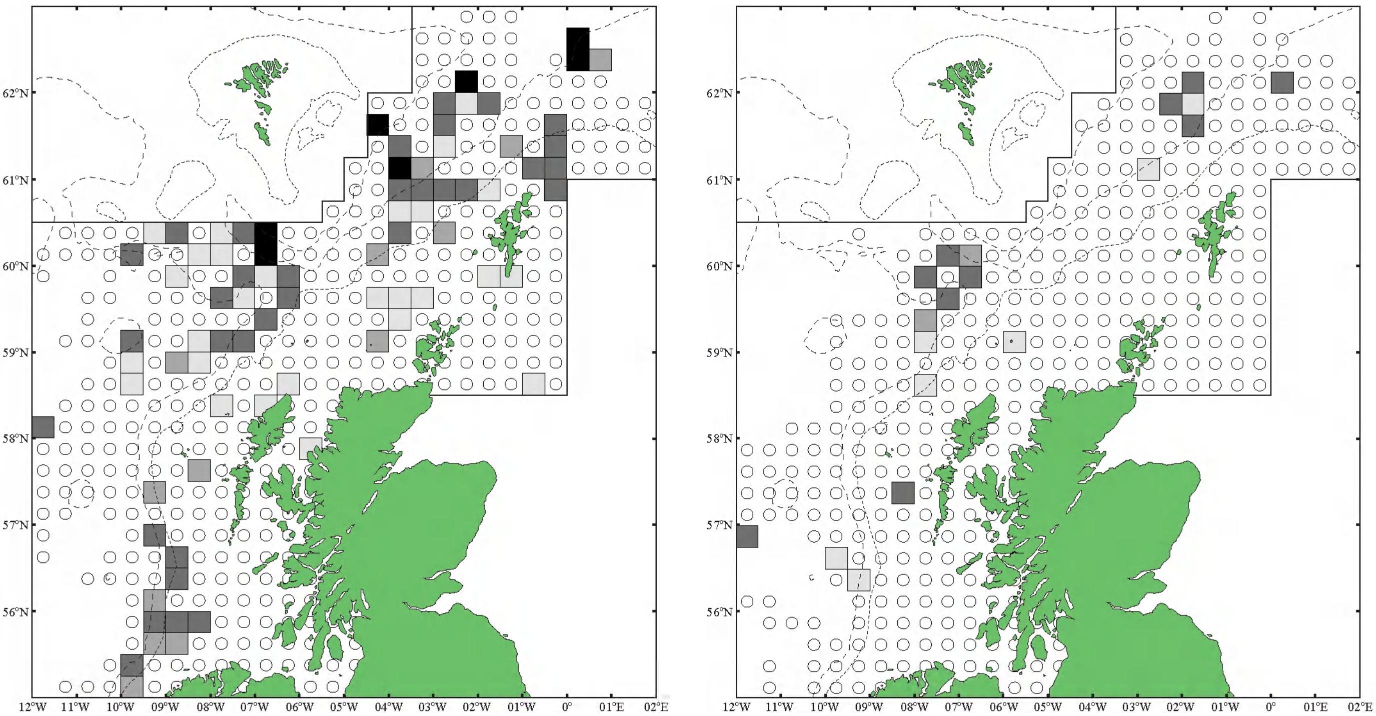
Figure 51. Abundance of long-finned pilot whales throughout the year

Abundance (individuals/km): ○ No whales □ 0.01-0.03 □ 0.04-0.06 □ 0.07-0.99 ■ 1.00+

Long-finned pilot whales were the second most abundant species of cetacean with 2,018 animals recorded (Table 8). Their distribution was concentrated along the continental slope north of Scotland, particularly in waters around 1,000 m deep (Figure 51). The highest abundance occurred in the Faroe-Shetland Channel and the Faroe Bank Channel. Within the study area, long-finned pilot whales feed principally on deep water squid (Desportes & Mouritsen 1993), and their occurrence in deep water channels appears to be related to the distribution of squid (Bloch *et al.* 1993). Concentrations of long-finned pilot whales along the United States shelf edge have also been related to the presence of squid (Payne & Heinemann 1993). Long-finned pilot whales are a gregarious species, the average group size recorded was 11.5 animals, although a pod of 400 individuals was encountered in the Faroe Bank Channel in August 1997. The average group size peaked between June and September, and 67 % of recorded calves occurred in August. Associations were recorded with white-sided dolphins on 37 occasions, bottlenose dolphins twice, and once each with common dolphins and northern bottlenose whales.

6.11 Atlantic white-sided dolphin *Lagenorhynchus acutus*

The Atlantic white-sided dolphin was the most abundant species observed in the study area, with a total of 4,925 animals recorded (Table 8). The distribution of this species is centred mostly in deep water along the shelf edge and in water deeper than 1,000 m. Atlantic white-sided dolphins were recorded in all months of the year, but were more widespread and abundant between June and November (Figure 52a), when animals occurred in high abundance over the Faroe-Shetland Channel and the Faroe Bank Channel. Groups were more frequently recorded in continental shelf waters (<200 m depth) during the summer, particularly in July. This may correspond with the calving period (Evans 1992) although other data suggests an extended breeding period (Reeves *et al.* 1999a). Juvenile animals were recorded between June and August, and peaked in July. An inshore movement of this species during the summer has also been recorded in areas of the western Atlantic (Northridge *et al.* 1997). During August there was a large increase in numbers of white-sided dolphins. The average group size of 14.4 animals indicates that the white-sided dolphin was the most gregarious species of those recorded. Groups of dolphins were often split into several sub-groups when both feeding and travelling, as has been found elsewhere in the North Atlantic (Leopold & Couperus 1995). Groups of over 100 animals were recorded on six occasions. Between December and May, there was a reduction in the number of animals, and most sightings occurred in deep, offshore water (Figure 52b). The distribution of white-sided dolphins in the north-west Atlantic is centred on areas of high seabed relief (Selzer & Payne 1988), which seems also to be the case in the Atlantic Frontier where dolphins were concentrated over the shelf edge and deep water channels. Atlantic white-sided dolphins are regularly recorded in association with long-finned pilot whales, and have also been observed with fin and humpback whales, and bottlenose, white-beaked and common dolphins.



a) June to November

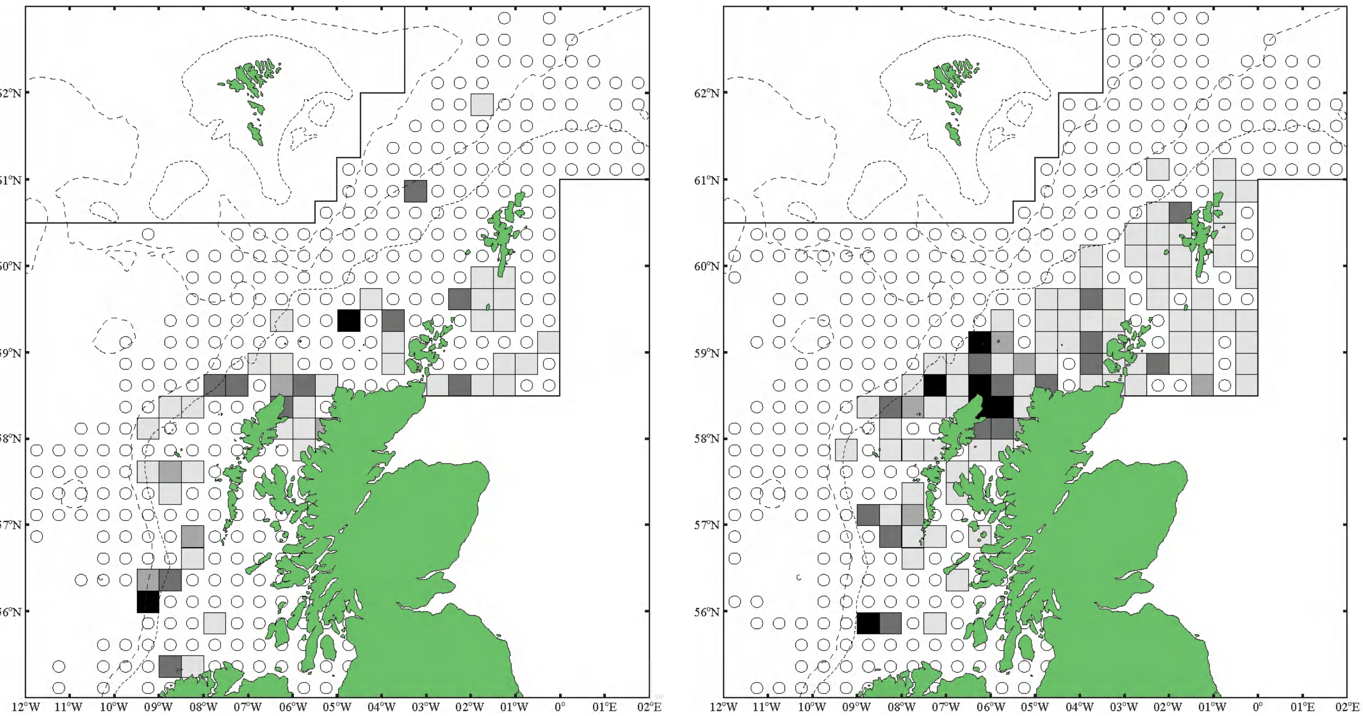
b) December to May

Figure 52 a) - b). Abundance of Atlantic white-sided dolphins

Abundance (individuals/km): No animals; 0.01-0.03; 0.04-0.06; 0.07-0.99; 1.00+

6.12 White-beaked dolphin *Lagenorhynchus albirostris*

The white-beaked dolphin was the most commonly recorded species in shelf waters to the north and west of Scotland, to where its distribution was almost entirely confined. White-beaked dolphins were recorded in every month of the year, with an increase in number between May and October, peaking during July. Between November and April, white-beaked dolphins were distributed at low abundance in the Minch, south of Shetland and along slope waters (Figure 53a). White-beaked dolphins showed a much more widespread pattern of distribution between May and October, with low abundance throughout most of the shelf waters, and high abundance in the northern portion of the Minch (Figure 53b). The white-beaked dolphin generally feeds on clupeids (e.g. herring), gadids (e.g. cod, haddock and whiting) and hake (Reeves *et al.* 1999b). It has been suggested that the peak in the number of white-beaked dolphins during July may be related to concentrations of herring, which spawn during the spring and autumn off north-west Scotland and in the autumn off north Scotland (Coull *et al.* 1998; Evans 1980). The white-beaked dolphin was the only cetacean to be recorded in every year since 1979, indicating its common occurrence. Although white-beaked dolphin schools comprised an average of only 3.5 animals, the high frequency with which they were observed rendered this species the third most numerous cetacean recorded. Juvenile white-beaked dolphins were seen in January, March and between July and October, with August providing the highest numbers of juvenile and immature animals. White-beaked dolphins have been recorded in association with white-sided dolphins and harbour porpoises.



a) November to April

b) May to October

Figure 53 a) - b). Abundance of white-beaked dolphins

Abundance (individuals/km): ○ No animals ▢ 0.01-0.02 ▢ 0.03-0.04 ▢ 0.05-0.09 ■ 0.10+

6.13 Risso's dolphin *Grampus griseus*

Risso's dolphin is not as abundant as many other dolphin species in the study area, but is widely distributed throughout the shelf waters of north Scotland, the Orkney and Shetland Islands, and particularly around the Western Isles (Figure 54). Although they are generally considered to be a species found beyond the continental slope (Kruse *et al.* 1999), most sightings occurred in shelf waters shallower than 200 m, with records along the shelf edge between July and December. Numbers show a clear peak in August and September, when animals were particularly concentrated around the north-east coast of Lewis. Juvenile Risso's dolphins were sighted between March and November. Risso's dolphins are probably resident in certain areas of the study area, in particular the waters east of Lewis where recognisable individuals are seen repeatedly (Atkinson *et al.* 1997).

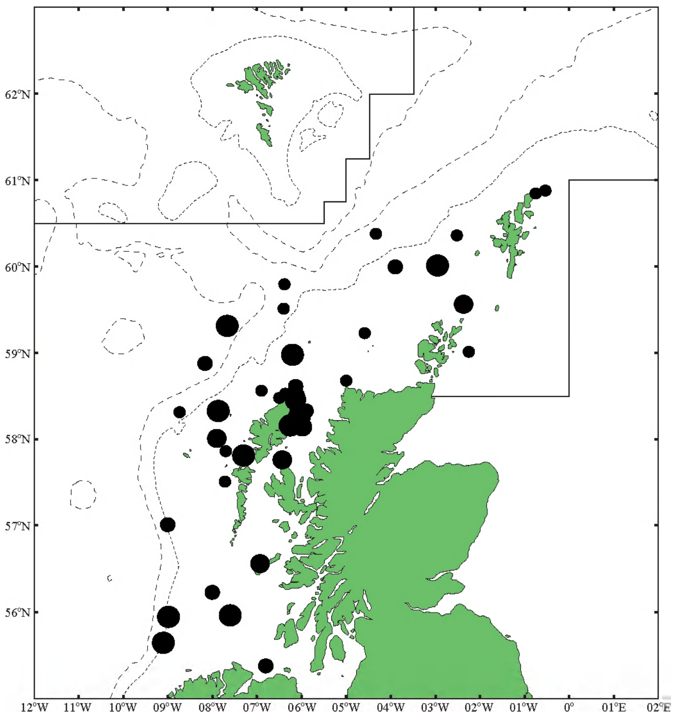
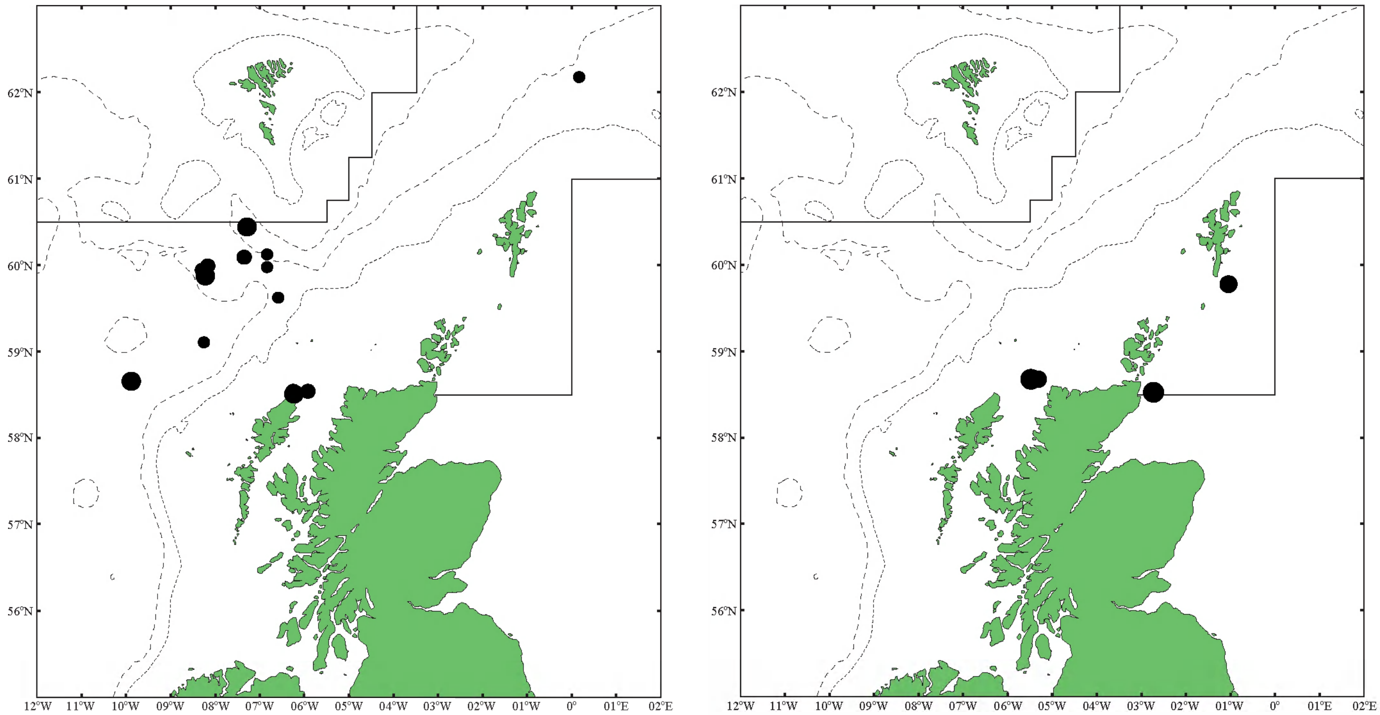


Figure 52. Distribution of Risso's dolphin sightings throughout the year

Number of individuals: ● 1-2 ● 3-4 ● 5-7 ● 8+

6.14 Bottlenose dolphin *Tursiops truncatus*

Bottlenose dolphins were infrequently recorded, with a total of 21 sightings (131 animals) since 1979. Between April and August, bottlenose dolphins were found in coastal shelf waters to the north-east of the Western Isles, south of Shetland and off north-east Scotland (Figure 55a). Bottlenose dolphins were generally uncommon during these months with only five sightings. The bottlenose dolphin also occurred in offshore groups that were recorded along the continental shelf edge close to the 1,000 m isobath. Bottlenose dolphins were sighted offshore between September and March (Figure 55b), with deep-water sightings concentrated along the Wyville-Thomson and Ymir Ridges. The water depth at these ridges is similar to the mean depth for offshore bottlenose dolphin sightings in the north-west Atlantic (Kenney 1990). School size ranged from one to 30 animals, with an average of 6.23 animals. School size increased to an average of 13.0 animals during September and October when animals were mostly offshore. Bottlenose dolphins in offshore waters have been recorded with pilot whales and white-sided dolphins. Sightings of bottlenose dolphins recorded on other UK surveys (Evans 1981), and in other areas of the world (Scott & Chivers 1990) indicate ecological separation into inshore and offshore populations, but the number of sightings is low in our data-set and more research and survey work would be required to establish this.



a) September to March

b) April to August

Figure 55 a) - b). Distribution of bottlenose dolphin sightings throughout the year Number of individuals ● 1-3 ● 4-8 ● 9+

6.15 Common dolphin *Delphinus delphis*

There have been 101 sightings of common dolphins in the Atlantic Frontier, where they occur towards the northern extremity of their distribution. There were only three records north of 60°N latitude, with most sightings concentrated at about 59°N on the shelf west of the Western Isles (Figure 56). The majority of common dolphin sightings were recorded in deep water over or beyond the 1,000 m isobath. Common dolphins were found in every month of the year, with numbers peaking in July, September and November. Notable concentrations of animals occurred on the shelf to the north-west of the Western Isles during October and November. Juvenile common dolphins were recorded between July and November, with a peak in August. Common dolphins were more gregarious than many species, with an average group size of 12.0 animals and five records of schools containing over fifty animals. Associations of common dolphins with long-finned pilot whales and white-sided dolphins were recorded, each on one occasion. Common dolphins occur more frequently over areas of high seabed relief and in warmer, more saline waters off the north-eastern United States (Selzer & Payne 1988). The seasonal variation in abundance and distribution of common dolphins may be related to prey distribution, with aggregations of dolphins occurring over upwellings (Hui 1979) and at frontal systems (Goold 1998) where prey species may concentrate.

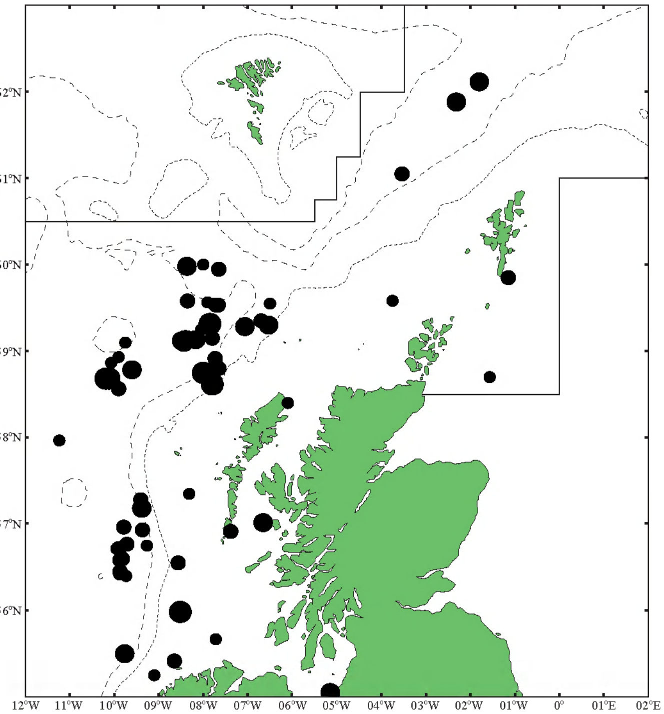
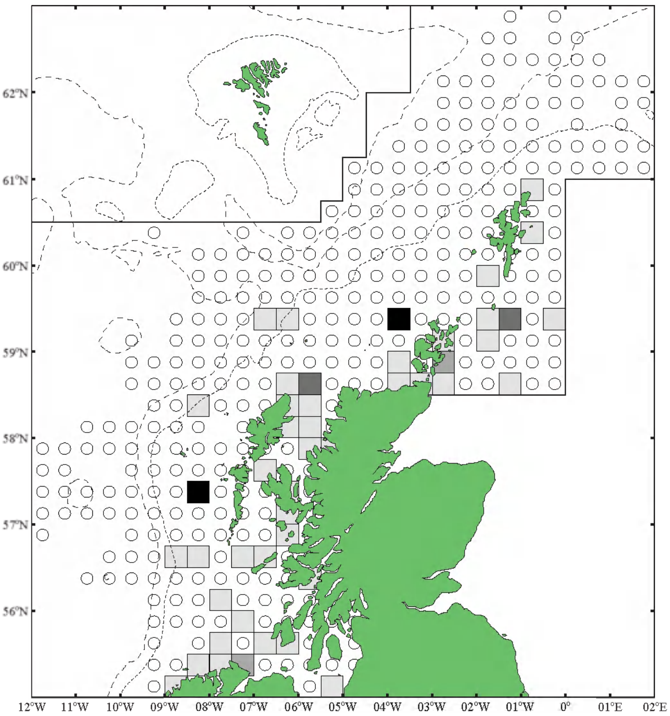


Figure 56. Distribution of common dolphin sightings throughout the year

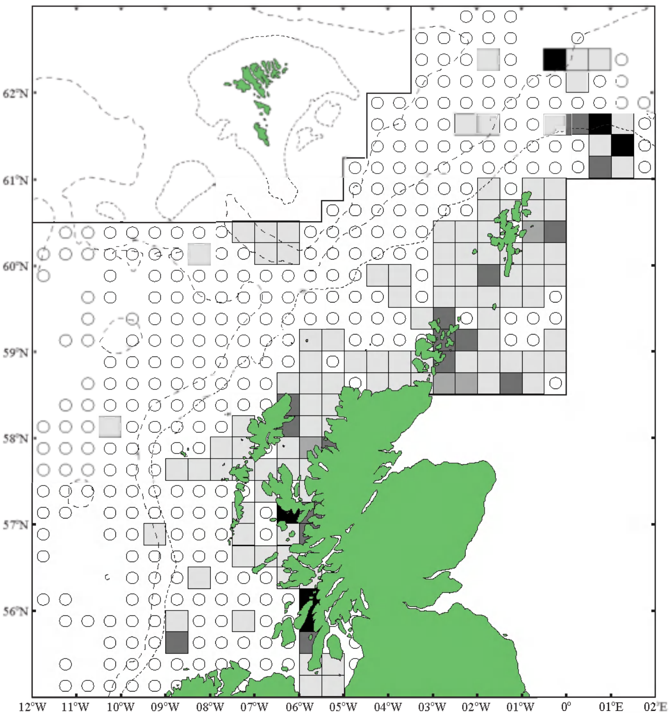
Number of individuals: 1-3 4-9 10-39 40+

6.16 Harbour porpoise *Phocoena phocoena*

The harbour porpoise was the most frequently sighted cetacean species (Table 8) and was widely distributed in shelf waters, shallower than the 200 m isobath. Acoustic monitoring techniques have also shown the harbour porpoise to be more frequent in inshore waters (Lewis *et al.* 1998). Between November and March, harbour porpoises were sighted at low abundance over the shelf, with higher concentrations to the north-west of the Orkney Islands and west of South Uist (Figure 57a). Over the summer months between April and October, they were much more widely sighted over the shelf with moderate concentrations on the north-east coast of Lewis, around



a) November to March



b) April to October

Figure 57 a) - b). Distribution of harbour porpoise throughout the year

Abundance (individuals/km): No animals 0.01-0.02 0.03-0.04 0.05-0.09 0.10+

Orkney and Shetland, and on the west Scottish mainland (Figure 57b). Also during this period, a small number were found in deep water off the shelf edge, particularly within the Faroe Bank Channel. School size varied between one and 20 animals, but with an average of 2.0 individuals. The average observed group size increased from 1.9 during May to September, to 2.4 over the winter months from October to April. Sightings increased between June and September, and reached a marked peak during July and August. Calves were recorded in the study area between June and August. Harbour porpoises were recorded in the vicinity of minke whales and white-beaked dolphins in the Minch. The diet of harbour porpoises varies regionally but is dominated by clupeids supplemented with gadids and other demersal fish (Martin 1995; Read 1999).

7. Pinniped distribution

Three species of pinniped have been recorded during surveys (Table 9). The common (harbour) seal *Phoca vitulina* and the grey seal *Halichoerus grypus* both breed in the survey area, whereas the hooded seal *Crystophora cristata* has been recorded as a non-breeding visitor.

Table 9. Distribution by month of pinniped sightings (number of animals)

Species	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Common (Harbour) seal	6	4	11	10	2	19	7	13	4	4	0	4
Grey seal	51	16	22	16	88	67	64	45	28	10	6	6
Hooded seal	1	0	0	0	1	1	2	0	1	1	0	0
Unidentified pinniped	19	8	12	3	18	23	32	26	4	1	5	4

7.1 Common (Harbour) seal *Phoca vitulina*

The common seal is a resident breeder within the survey area. It is distributed around all the coasts of north-west Scotland and the offshore islands. There are no common seals breeding in the Faroe Islands (Mikkelsen & Haug 1999). The total population in the UK is estimated to be 28,980, 85% of these within the survey area (Bleakley 1997; Duck 1996, 1997a-d).

Common seals were recorded in inshore waters throughout the survey area (Figure 58). There were few records further offshore and only one in waters deeper than 200 m, an animal on the edge of the Faroe-Shetland Channel in October.

Common seals were recorded during surveys in all months except November (Table 9). Peak numbers of common seals were recorded in the months of June to August. This may be a reflection of a larger proportion of the common seal population at sea in these months but it is probably also linked to the higher levels of survey effort in these months and/or better weather conditions. Low numbers of animals were recorded in May prior to the breeding season. Low numbers were also recorded during the winter months. This is more likely to be linked to low levels of survey effort at this time.

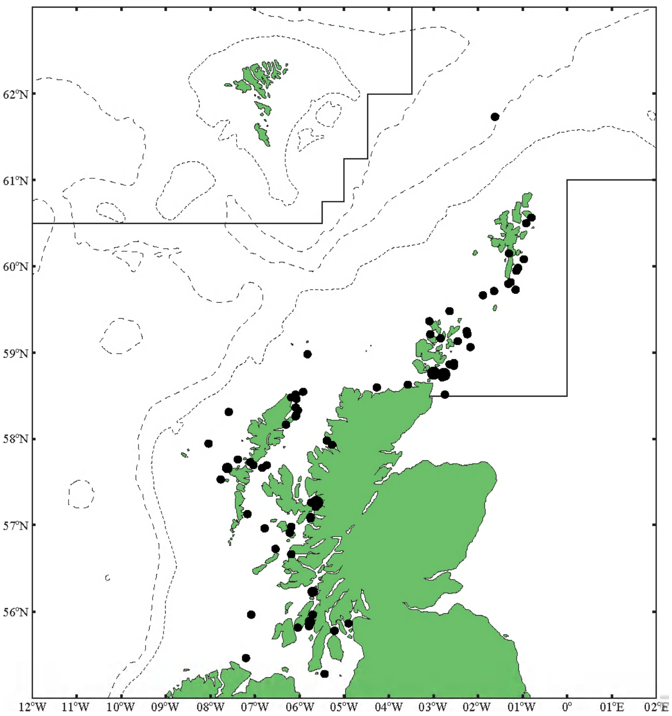


Figure 58. Common (harbour) seal sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

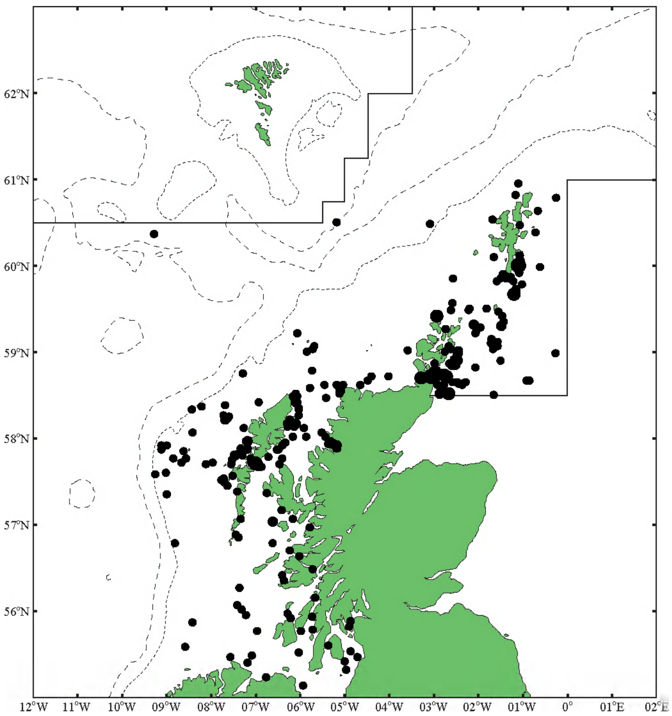


Figure 59. Grey seal sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

7.2 Grey seal *Halichoerus grypus*

The grey seal is a resident breeder within the survey area. It is widely distributed around the coasts of north-west Scotland and the offshore islands. The UK population of grey seals is of international importance; estimated to be about 40% of the world population (Thompson 1992). The survey area produces 86% of grey seal pups born in the UK and is therefore of national importance (Bleakley 1997; Duck 1996, 1997a-d). The Faroe Islands previously supported significant numbers of grey seals but there is no up-to-date information (Mikkelsen & Haug 1999).

Grey seals were recorded during surveys in all months (Table 9). Peak numbers of grey seals were recorded in the months of June to August, which may be partly a reflection on the high levels of survey effort in these months combined with better viewing conditions. Lowest numbers were recorded between October and December, which may be a factor of reduced levels of survey effort and is also due to the fact that animals are ashore to pup and mate at this time.

As with the common seal, grey seals were most frequently encountered in shelf waters (Figure 59). Grey seals were regularly encountered further offshore than common seals but they were only rarely recorded in waters deeper than 200 m. This corresponds with research showing that grey seals make longer distance foraging trips from haul-out sites than common seals (Bjørge 1995; Thompson *et al.* 1996). However, grey seals are also known to make long distance trips from the UK to the Faroes (McConnell *et al.* 1999).

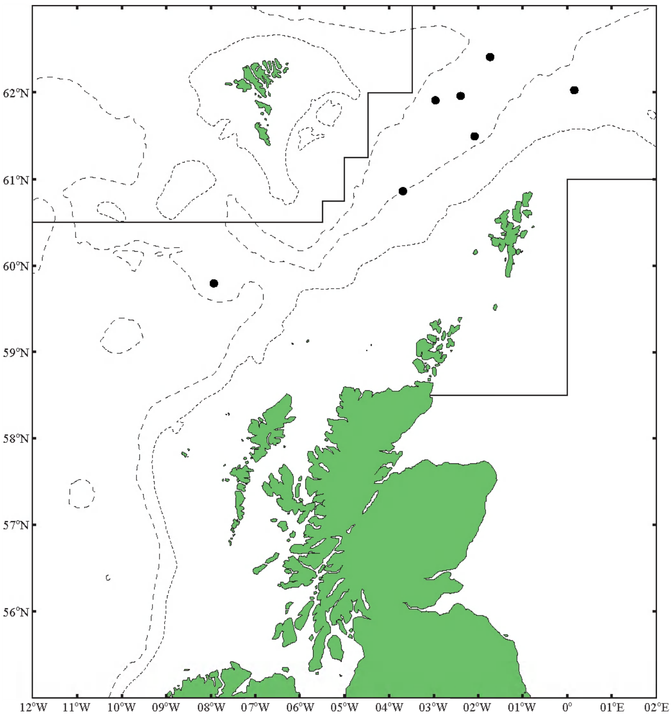


Figure 60. Hooded seal sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

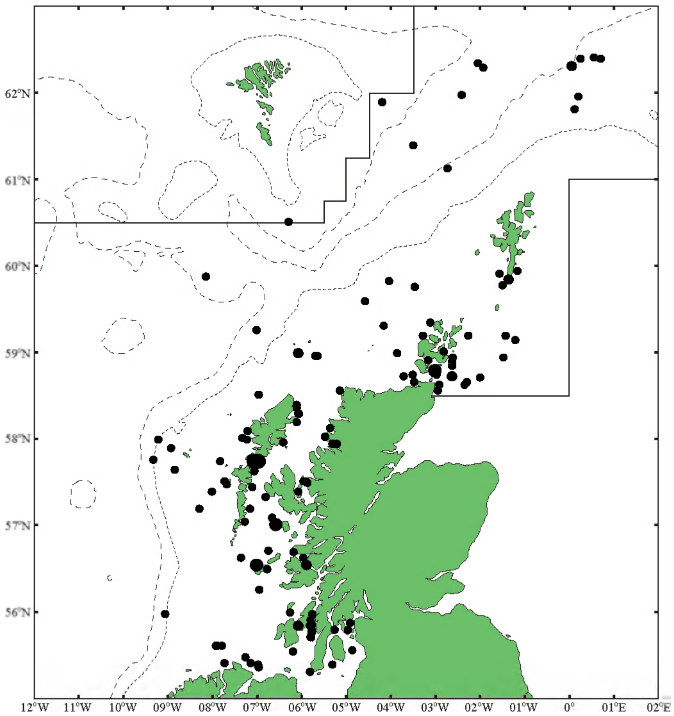


Figure 61. Unidentified seal sightings throughout the year

Number of individuals: ● 1 ● 2 ● 3-5 ● 6+

7.3 Hooded seal *Cystophora cristata*

Hooded seals do not breed in the survey area and have been observed only rarely on land in the region. The nearest breeding population of hooded seals is around Jan Mayen (71ºN, 8º30'W), where there is a population of perhaps 250,000 animals (Reeves *et al.* 1992).

Hooded seals were recorded only in deep waters and most sightings were in the Faroe-Shetland Channel (Figure 60). There were no records of hooded seal from SAST surveys until two were observed in deep water to the north of the Shetland Islands in May and June 1997 (White & Leaper 1997). In addition, five unidentified seals in the vicinity of the Shetland-Faroe Channel on the same survey were also likely to have been hooded seals. Following these observations there have been sightings in all seasons. Although it is tempting to speculate that the other unidentified seals in deep waters (Figure 61) may have been hooded, grey seals have been known to make long distance foraging trips from the North Sea to the Faroes (McConnell *et al.* 1999). Hooded seals were not recorded in waters shallower than 200 m.

These observations accord with the movements of satellite tagged hooded seals from Jan Mayen, which have been recorded in waters around the Faroes in all months except May, June and July (Folkow *et al.* 1996). Movements of seals were not synchronised; different seals were recorded at different times of year. During their time at sea, most of their time was spent in deep waters along the shelf break, submarine ridges or sea mounts, where they made repeated dives of greater than 1,000 m.

The numbers of hooded seals using the survey area is undoubtedly small, but the at-sea observations and results of satellite tracking suggest that the area is used regularly by a small proportion of the hooded seal population, rather than by lost or vagrant individuals.

8. Discussion

The primary aims of this project were to gain information on seabird and marine mammal dispersion along the continental slope, particularly in the offshore blocks licensed in the 17th and earlier offshore oil licensing rounds and to census several important seabird colonies on islands nearest the licensed areas.

8.1 Survey coverage

Since dedicated surveys began, total survey coverage has increased from 36,381 km^2 before May 1997 to 48,220 km^2 in March 1999. Over deeper waters coverage has more than doubled from 7,629 km^2 to 15,773 km^2 (Table 6). Monthly survey effort is less intensive and extensive during September to April compared with the summer months (Table 5, Figures 5 and 6). Inadequate coverage during parts of the year could result in the yearly distribution of a species being misrepresented. Outwith summer, surveying is constrained by poor weather and decreased daylight hours, especially when surveying remote water.

8.2 Seabird distribution: Atlantic Frontier and continental shelf

The main focus of the study was seabird distribution in the deep waters of the Atlantic Frontier i.e. the continental slope and oceanic waters (depth 200-2,500 m). The study area also included shelf waters in order to place the offshore observations into context. More importantly, a pollution incident in the deep waters of the Atlantic Frontier could also affect seabirds in shelf waters. Oil spills can be very mobile; prevailing weather systems and water currents of the Atlantic could push an oil spill inshore where it may affect a larger number of seabirds. The deep water of the Atlantic Frontier generally had lower species diversity than shelf waters, and most species occurring there were found in lower abundance than over the shelf. The shelf was characterised mainly by diving fish-eating species e.g. auks and Manx shearwaters, some of which occurred in important numbers, whereas surface feeders e.g. fulmars and storm-petrels were mainly encountered over deep water.

8.2.1 Importance of Atlantic Frontier for seabirds

The most abundant species over deep water were fulmar, gannet, and kittiwake, with fulmar occurring in the highest average densities. These species are highly pelagic, and capable of travelling long distances to forage. Furthermore, they are adaptable, opportunistic feeders, so high densities of all three species along the shelf edge prior to the breeding season may be associated with scavenging around fishing vessels (Hudson & Furness 1989; Camphuysen *et al.* 1993). High densities of gannets were recorded over the shelf edge near St. Kilda during the breeding season, suggesting the area was being used by birds nesting on the large gannetries on the islands. The study area supports almost 50% of the gannets found in the north-east Atlantic, almost half of these nesting at St. Kilda (Murray & Wanless 1997).

The Atlantic Frontier was found to be especially important for summer visitors such as Leach's storm-petrel and European storm-petrel. Of the two, Leach's storm-petrel is a true Atlantic Frontier species and was found only beyond the continental shelf and at most times of year. Some 97% of Leach's storm-petrels recorded were over the deep waters along the Atlantic Frontier. The European storm-petrel frequents both offshore and shelf waters (Bourne 1986; Harrison *et al.* 1994). High numbers of European storm-petrels were also found, and occur at higher densities off south-west Ireland (Pollock *et al.* 1997). Both these species breed in the study area in internationally important numbers (>1% of biogeographic population, Table 1). The pelagic habits of Leach's storm-petrel probably restricts its breeding distribution to sites closest to the continental shelf edge, such as St. Kilda and North Rona.

Almost 65% of the world's great skuas breed in the study area and they also utilised the deep waters, particularly in April and May. Moderate to high densities of lesser black-backed gulls were recorded along the shelf edge before the breeding season. These may have been associating with fishing vessels in the area (Camphuysen *et al.* 1995). Great black-backed gulls and puffins were recorded throughout the year and were abundant at times. Great black-backed gulls also forage around fishing vessels for discards (Furness *et al.* 1992), and high numbers were recorded in late winter. Puffins were most abundant in offshore waters during the summer months as they disperse widely during the winter.

Although the shelf break is of importance for species such as fulmars, kittiwakes, gannets and great black-backed gulls, densities are reduced during the late spring and summer when birds move into shelf waters to return to their breeding colonies (Webb *et al.* 1990).

Few of the species deemed most vulnerable to oil pollution, such as divers, auks, Manx shearwater, cormorant and shag (Webb *et al.* 1995), were present in offshore waters. Guillemot, razorbill and herring gull were present in Atlantic Frontier waters throughout the year, but only at low densities. These species are primarily found in waters less than 200 m deep and lack the pelagic characteristics of the more abundant species in offshore waters.

8.2.2 Importance of shelf waters north and west of Scotland for seabirds

Shelf waters are important for Atlantic Frontier species at certain times of year, especially during the breeding season. During the summer, Manx shearwaters were most common in shelf waters and often formed large rafts on the water. The relative abundance of Manx shearwaters, when compared solely with the numbers of other species found on the shelf (Figure 11), was quite low. However, when one considers that the study area holds an estimated 22% of the biogeographic breeding population then it can be argued that inshore waters are very important for this species. The same argument applies to the shag, which was almost entirely confined to the shelf and was recorded only in low numbers, yet the study area supports 29% of the biogeographic breeding population.

The Orkney and Shetland Isles are the main north-west European stronghold for great and Arctic skuas; shelf waters are particularly important for them. Herring gull, lesser black-backed gull and great black-backed gull were other important members of the shelf seabird community.

Large concentrations of guillemots and razorbills occur in inshore waters, particularly in July and August when they moult and are flightless for several weeks. High densities of puffins occurred between April and September, the shelf waters around Scotland being among the most important for this species in north-west Europe (Stone *et al.* 1995b). The distribution of the black guillemot was found to be almost entirely inshore, although it was one of the least numerous of the auks to be recorded. This species occurs too close to land to be detected in SAST type surveys. With the study area holding an estimated 45% of the biogeographic breeding population of this species, it is clear that this is one of the most important species found in shelf waters.

Shelf waters were also important for divers, cormorant, seaduck, black-headed and common gulls, and common terns although all were recorded in low numbers. Inshore waters west of Scotland are especially important for great northern divers between November and April, and may hold a substantial proportion of those spending the winter in European waters (Webb *et al.* 1990).

8.3 Marine mammal distribution

The proximity of the shelf edge to the Scottish islands, and the influence of the Gulf Stream, results in a diversity of habitats and a particularly rich number of species. A total of 27 species of cetacean have been recorded in UK waters (Evans 1995), and we recorded 15 species in this study.

The distribution of cetacean species within an area may be related to oceanographical features such as sea temperature, salinity, sea-floor relief and depth (e.g. Selzer & Payne 1988; Evans 1990; Skov *et al.* 1995a). Certainly different species show a tendency towards shelf, slope or deep-water habitats (Evans 1990; Davis *et al.* 1998). Some cetaceans also favour areas of high seabed relief where varied water currents may increase food availability (Hui 1979; Selzer & Payne 1988). It is probable that the observed relationships are a feature of prey distribution and abundance rather than a direct relationship between cetaceans and environmental features (Gaskin 1982; Kenney & Winn 1986; Evans 1987; Selzer & Payne 1988; Gowans & Whitehead 1995). A strong correlation exists between the abundance of fin, humpback and minke whales with that of their prey species in the north-west Atlantic, and these species may segregate by depth to avoid competing directly with one another for food (Piatt *et al.* 1989).

Species of cetacean that feed on squid, such as sperm, beaked and long-finned pilot whales, tend to occur in deeper waters along and seaward of the shelf edge where their prey is more abundant (Kenney & Winn 1987). Shelf edge habitats have been shown to be important for individual cetacean species (e.g. Waring *et al.* 1993), diversity of species (Kenney & Winn 1986), and overall biomass of cetaceans (Kenney & Winn 1987). Some largely piscivorous species such as white-beaked dolphins and harbour porpoises take a wide range of prey species and have their centre of distribution on the shelf and oceanic banks (Skov *et al.* 1995a). Large baleen whales may also use the shelf edge as a migration channel between feeding and breeding grounds (Evans 1987).

As stated earlier, surveys are inherently restricted by weather conditions during the year. During the winter, high swell heights and rough seas result in reduced sighting rates particularly for inconspicuous species such as beaked and minke whales, and small species such as harbour porpoises (Palka 1996), though large whales may still be relatively detectable in choppy seas (Stone 1998).

Sightings of cetaceans were found to peak during summer months with areas to the west of Shetland, and west of the Western Isles being important. Although this may be an artefact of improved weather conditions, there were marked seasonal patterns for some species. Few large whales were seen outside the summer months, though they generally inhabit deep waters where coverage is difficult to achieve during the winter. However, sightings of other deep-water species such as sperm and long-finned pilot whales and white-sided dolphins occurred throughout the year, and beaked whales were sighted between August and January, when coverage in deep-water regions was reduced. Although it is not easy to correct for variations in observer ability, survey vessel, weather conditions, and uneven levels of survey coverage, overall trends in species distribution and occurrence may still be revealed (Evans 1980).

8.3.1 Importance of Atlantic Frontier for marine mammals

Whereas previous cetacean surveys focused on several areas of the Scottish continental shelf (see section 1.2), the distribution and abundance of cetaceans in deep water along the slope and off the shelf edge was poorly known.

Eight species of cetacean (fin whale, sei whale, humpback whale, sperm whale, beaked whales, killer whale, pilot whale, and white-sided dolphin) were primarily recorded in the Atlantic Frontier waters, although inshore movements of some of these species appeared to occur during the summer.

Almost all sightings of fin, sei, humpback and sperm whale were beyond the 200 m isobath, either over the shelf break or in deep water. The increase in sperm whale sightings corresponds to increased survey work over deep water. Prior to 1997, nine animals had been recorded in the study area by JNCC surveys, but since then a further 71 animals have been seen, particularly around the 1,000 m isobath. Stone (1997, 1998), reporting on sightings of cetaceans from seismic vessels, found that large whales (fin, blue, sperm and humpback) were distributed along or beyond the 1,000 m isobath. This corresponds with whaling records that show that most catches of these species occurred in deep waters just off the edge of the continental shelf (Thompson 1928). 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 this study as baleen whales were sighted only between May and October. However, the area in the southern Faroe-Shetland Channel where the majority of fin whales are sighted receives little survey coverage during winter, and although some seasonal migration may occur, inadequate survey coverage obscures this. Individual fin whales, tracked by hydrophone arrays, have shown no consistent direction of movement (Clark & Charif 1998). In the Atlantic Frontier region, some fin whales may remain in deep water at high latitudes throughout the year, as the species has been detected by hydrophone arrays in considerable numbers in all months (Clark & Charif 1998). Humpback whales were rarely sighted during our survey work. However, individual humpback whales tracked using passive acoustic arrays that detect vocalisations seem to exhibit a late winter/early spring southward migration into and through the study area (Clark & Charif 1998).

The beaked whales, a poorly known group of cetaceans that favour deep submarine canyons, have also been increasingly recorded as increased survey coverage has been achieved in suitable habitats. The waters of the Atlantic Frontier may be of particular significance for beaked whales, whose distribution in the North Atlantic is poorly understood. Northern bottlenose whales were the most frequently sighted species of beaked whale, although 62 unidentified beaked whale individuals were thought to belong to the genus *Mesoplodon*. Almost all of these have been seen in waters over 1,000 m deep. Sightings of *Mesoplodon* species at sea are rare, partly as a result of their behaviour and habitat requirements. *Mesoplodon* species are rarely sighted in some areas where northern bottlenose whales are frequently observed, such as the Gully off Nova Scotia (Hooker & Baird 1999), suggesting that species of *Mesoplodon* may be generally uncommon throughout much of their range. Only one individual was positively identified to species: a single Sowerby's beaked whale seen near the Rosemary Bank. The genus *Mesoplodon* includes 14 species of small, taxonomically similar beaked whales, which are difficult to identify at sea. It is probable that most of the unidentified beaked whale sightings also refer to Sowerby's beaked whale. Further work may help to clarify the specific identity of the animals seen in the Atlantic Frontier.

Killer whales, long-finned pilot whales and Atlantic white-sided dolphins occurred in high numbers in the Atlantic Frontier throughout the year, according with observations made by Stone (1997, 1998). Killer whales were also frequently found close inshore. Bottlenose and common dolphins were found in all water depths, although the latter was most abundant along the shelf edge. Common dolphins were replaced by white-sided dolphins at latitudes greater than 60°N, although both species inhabited deep pelagic waters. Selzer and Payne (1988) suggest that the differences in distribution between these two species may be related to environmental factors such as temperature, with common dolphins occurring in warmer waters and white-sided dolphins in colder waters further north. Occasional sightings of minke whales also occurred.

The few records of hooded seals also came from deep water areas. A study of satellite-tagged hooded seals at Jan Mayen (Folkow *et al.* 1996) has indicated that these animals undergo long distance migrations and appear to favour the deep waters of the Faroe-Shetland Channel. Since increased survey effort began in these waters, we have also recorded hooded seal sightings in this area and further survey work may record more.

8.3.2 Importance of shelf waters north and west of Scotland for marine mammals

Minke whale, white-beaked dolphin and harbour porpoise were found widely distributed in shelf waters. Previous surveys have found the distributions of each entirely confined within the 200 m isobath (Northridge *et al.* 1995; Stone 1997, 1998). Numbers of all three species peaked in summer, and the minke whale was not sighted at all between November and April. This suggests that seasonal variation in sighting rates and numbers for some species is not necessarily a result of bias in survey effort. The harbour porpoise was the most frequently sighted species, although white-beaked dolphins were more numerous (Table 8). Minke whales were the commonest baleen whale within the study area, and also in shelf waters, the Minch being especially important for this species. The distribution of white-beaked and white-sided dolphins showed an allopatric pattern; white-beaked dolphins appear to replace white-sided dolphins in waters less than 200 m deep. Although 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. Both the white-beaked dolphin and the Atlantic white-sided dolphin occur on both sides of the North Atlantic. Survey data from the European shelf and North American shelf indicate the former species to be more numerous in the east, and the latter more numerous in the west (Northridge *et al.* 1997). Though the white-beaked dolphin was more often sighted during our study, the white-sided dolphin was the more numerous species. However, differences in skull measurements indicate that the white-beaked dolphins found in Europe may be a separate population to those in North America, whereas the white-sided dolphins are similar (Mikkelsen & Lund 1994). Northridge *et al.* (1997), based on the observed distribution of white-beaked dolphins throughout the north-east Atlantic, has further suggested that the white-beaked dolphins in Scottish and north-east English waters may even be isolated to some extent from those further north or west in Norwegian and Icelandic waters. In this case the Atlantic Frontier may hold a very significant proportion of, and consequently may be very important for, this local population.

Risso's and bottlenose dolphins were found in moderate numbers throughout the study area. Risso's dolphins were widely dispersed in shelf waters, particularly around the Western Isles. Each inhabits both deep offshore waters and shallow shelf waters throughout their geographical range (Evans 1987).

Common and grey seals were found mostly in shelf waters. Grey seals were the most numerous species, and were occasionally found in offshore waters. It is possible that the few grey seals recorded in the Faroe-Shetland Channel and near to the Faroe Bank originate from the Faroe Islands. The grey seal was the most numerous species. As with seabirds that occur inshore, both species are probably under recorded due to constraints and objectives of the survey methodology.

8.4 The threat of surface and noise pollution to seabirds and marine mammals in the Atlantic Frontier

Seabirds are affected by oil pollution in several ways: oiling of their plumage results in waterlogging, whereas oil ingested during preening may result in liver and kidney damage (Furness & Monaghan 1987). The impact of surface pollution on seabirds varies considerably with the geographic location of the spill, the season during which it occurs, and the ecology of the species affected. Species that spend a lot of time on the water, with small biogeographic populations and low reproductive output, are most vulnerable (Williams *et al.* 1994). The vulnerability of a species to surface pollution may also change over the year. Auks become more vulnerable after the breeding season when they gather in concentrations to moult, rendering them flightless and restricting their mobility.

Clearly the offshore waters of the Atlantic Frontier are important for seabirds. Although they host lower species diversity and numbers of seabirds than shelf waters, it would be erroneous to suggest that a pollution incident occurring there would be of little importance. For instance, oil spills can be highly mobile and disperse over large distances, and an offshore spill could possibly move inshore where it would have a greater effect. Also, seabird distribution patterns change over the year. An oil spill offshore during summer, when more species and higher numbers of birds are present, would have a greater impact than during winter. Fulmar, gannet, and European and Leach's storm-petrels were all recorded in high densities offshore during the breeding season, and this area was also important for kittiwake and puffin, prior to, and after the breeding season respectively. Of these species, gannet and puffin are considered to be the most vulnerable to oil pollution due to their ecology (Webb *et al.* 1995). Both are heavily reliant on the marine environment, have low breeding output with a long period of immaturity before breeding, and the study area contains a large percentage of the biogeographic population of each. Puffins also spend much time on the water. Results from beached bird surveys show that over 47% of puffins and 29% of gannets washed up dead on beaches are contaminated with oil (Stowe 1982). The aerial habits of the fulmar, together with its large population and widespread distribution, reduce its vulnerability.

As inshore waters contain greater species diversity and a higher number of seabirds, a pollution event on the shelf would have a greater potential impact on seabirds. In contrast to offshore waters, shelf waters held important concentrations of seabirds throughout the year, and a high number of species utilised only this habitat. An oil spill over the shelf would be especially serious during summer. Most seabirds forage close to their colonies when breeding, so a pollution event near the major assemblages of seabirds, such as those found on Shetland, Orkney, North Rona or St. Kilda, could have important consequences for breeding populations. High adult mortality during the breeding season would reduce productivity, resulting in population declines in successive years. The main species with a significant shelf component to their distributions include fulmar, Manx shearwater, gannet, great skua, Arctic skua, lesser black-backed gull, herring gull, great black-backed gull, kittiwake, Arctic tern, common guillemot, razorbill and puffin. Of these the three auk species, Manx shearwater and great skua are rated most vulnerable to oil pollution (Webb *et al.* 1995). The study area contains a large proportion of the biogeographic population of each. Furthermore, as stated above, auks spend much time on the water, gather in concentrations at certain times of the year, and moult while at sea, which renders them less mobile. In

Britain, almost 60% of all auks recovered dead on beaches during the autumn and winter are contaminated with oil (Stowe 1982). When at sea the Manx shearwater also spends much time in flight although, because they are sub-surface feeders, they sometimes gather in large rafts on the sea when feeding rendering them more at risk. Great skuas also spend much time in flight and occasionally gather in rafts to feed, but less frequently than the shearwaters. Nevertheless, with such a high percentage of the biogeographic breeding population contained in the study area, the species must be considered as one of those most at risk from an oil spill, especially when occurring close to a colony. Of the gull species, kittiwake is the most vulnerable as it is the only one which relies on the marine environment throughout the year.

Of the remaining species, red-throated diver, great northern diver, cormorant, shag and black guillemot are considered the most vulnerable to oil pollution. All spend a large amount of time on the surface of the water and the study area holds large percentages of the biogeographic breeding populations of shag and black guillemot, and high numbers of great northern divers in winter. Divers especially are very susceptible to oiling; 64% of those recovered dead on beaches show signs of oil pollution compared with 16% of cormorants and shags (Stowe 1982).

Marine mammals are less directly affected by oil pollution than seabirds due to a combination of factors. Compared with seabirds they are (usually) more mobile, more sensitive to disturbance and less abundant, but the main reason that they are less affected by oil pollution is because they rely on blubber for insulation, rather than feathers. Feathers contaminated with oil lose their insulating properties and consequent seabird mortality results from hypothermia and/or oil ingested through preening. Marine mammals are not affected in this way though death through ingestion of oil may still occur. As with seabirds, the effects of oil pollution can only be measured directly if stranded or dead animals are found. However, dead cetaceans are rarely found after major oil spills have occurred (Kingston 1995; SEEEC 1998), so the immediate affects from a pollution event are difficult to ascertain. The cetacean populations of the Atlantic Frontier are obviously highly important. However, it is impossible to say just how vulnerable they are without further data on their susceptibility to oil pollution. The seal populations of the Atlantic Frontier may be more at risk, but again data from previous large oil spills indicates low mortality due to such events (Kingston 1995; SEEEC 1998). Inshore concentrations of grey and common seals would be most vulnerable, especially if an incident occurred during the pupping season.

The vulnerability of different seabird species to surface pollutants may be indicated by vulnerability indices (Seip *et al.* 1991; Williams *et al.* 1994). When combined with known densities of seabirds in an area at a given time of year, vulnerability scores for different sea areas may be computed (e.g. Carter *et al.* 1993; Webb *et al.* 1995). Subsequent vulnerability mapping is a useful tool that has been used when advising on offshore activities in the oil and gas industry. The strategic timing of activities can greatly reduce the threat of surface pollution to seabirds. Vulnerability atlases may be incorporated into oil spill contingency plans in addition to providing conservation advice in the event of spillage. For areas containing vulnerable concentrations of seabirds within the Atlantic Frontier study area, readers are advised to consult Webb *et al.* (1995) or the latest version of UKDMAP (NERC 1998) on CD-ROM. Development of the vulnerability index currently used by JNCC is underway, with the aim of rendering it globally applicable.

While it is accepted that oil spillage from production platforms is a rare event, an increase in oil production inevitably leads to increased shipping. This sector accounts for the majority of spillage events and consequent degradation of the marine environment, particularly with respect to seabirds. The oil spill off south Shetland in 1993 that resulted from the wreck of the '*Braer*' was responsible for the deaths of at least 1,542 seabirds, mostly from locally important inshore concentrations of wintering seabirds such as shags, black guillemots, kittiwakes and duck species (Ritchie & O'Sullivan 1994). This oil spill occurred in an area where several seabird species breed in large colonies during the summer, but the timing of the spill, in January, avoided large-scale reductions to summer auk populations.

In addition to the toxic effect of oil spills on cetaceans, acoustic disturbance from the airguns used during seismic exploration for hydrocarbon reserves may have an effect on marine mammal species. The gun arrays towed by seismic vessels operate at low frequencies, generally below 200 Hz, although some high frequency noise may also be emitted (Goold 1996). Low frequency noise may overlap directly with the sounds used by baleen whales (10 Hz–l kHz) for communication, and incidental, high frequency noise produced may affect porpoises, dolphins and toothed whales, whose frequency range is most sensitive at 10-150 kHz (Evans & Nice 1996). Seismic vessels operate throughout UK waters, and are present in Atlantic Frontier waters particularly during the summer months. Although JNCC Guidelines have been issued to minimise the potential disturbance to cetacean species from seismic exploration, neither the short- nor long-term effects of the emitted sound on cetaceans have been studied. Potential effects include direct physical damage, changes in behaviour and interference in communication. Avoidance of loud noise by cetaceans may result in a shift in distribution away from feeding and breeding grounds, and this may also result indirectly if potential prey species are displaced by seismic activity. Although clear evidence for a reaction of marine mammals to seismic activity is limited, behavioural responses to the firing of airguns have been recorded for a number of species (Richardson *et al.*, 1995; Stone 1997, 1998, 2000).

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Appendix I. Scientific names of seabirds, cetaceans, pinnipeds and fish mentioned in the text

Seabirds

Red-throated diver	*Gavia stellata*
Black-throated diver	*Gavia arctica*
Great northern diver	*Gavia immer*
Great crested grebe	*Podiceps cristatus*
Fulmar	*Fulmarus glacialis*
Soft-plumaged petrel sp.	*Pterodroma* sp.
Cory's shearwater	*Calonectris diomedea*
Great shearwater	*Puffinus gravis*
Sooty shearwater	*Puffinus griseus*
Manx shearwater	*Puffinus puffinus*
Mediterranean shearwater	*Puffinus mauretanicus*
European storm-petrel	*Hydrobates pelagicus*
Leach's storm-petrel	*Oceanodroma leucorhoa*
Wilson's storm-petrel	*Oceanites oceanicus*
Gannet	*Morus bassanus*
Cormorant	*Phalacrocorax carbo*
Shag	*Phalacrocorax aristotelis*
Common eider	*Somateria mollissima*
Long-tailed duck	*Clangula hyemalis*
Common scoter	*Melanitta nigra*
Velvet scoter	*Melanitta fusca*
Red-breasted merganser	*Mergus serrator*
Red-necked phalarope	*Phalaropus lobatus*
Grey phalarope	*Phalaropus fulicarius*
Pomarine skua	*Stercorarius pomarinus*
Arctic skua	*Stercorarius parasiticus*
Long-tailed skua	*Stercorarius longicaudus*
Great skua	*Stercorarius skua*
Little gull	*Larus minutus*
Sabine's gull	*Larus sabini*
Black-headed gull	*Larus ridibundus*
Common gull	*Larus canus*
Lesser black-backed gull	*Larus fuscus*
Herring gull	*Larus argentatus*
Iceland gull	*Larus glaucoides*
Glaucous gull	*Larus hyperboreus*
Great black-backed gull	*Larus marinus*
Kittiwake	*Rissa tridactyla*
Sandwich tern	*Sterna sandvicensis*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sterna albifrons*
Common guillemot	*Uria aalge*
Brünnich's guillemot	*Uria lomvia*
Razorbill	*Alca torda*
Black guillemot	*Cepphus grylle*
Little auk	*Alle alle*
Puffin	*Fratercula arctica*

Cetaceans

Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Minke whale	*Balaenoptera 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 melaena*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*
White-beaked dolphin	*Lagenorhynchus albirostris*
Risso's dolphin	*Grampus griseus*
Bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Harbour porpoise	*Phocoena phocoena*

Pinnipeds

Common (harbour) seal	*Phoca vitulina*
Grey seal	*Halichoerus grypus*
Hooded seal	*Cystophora cristata*

Fish

Herring	*Clupea harengus*
Sprat	*Sprattus sprattus*
Greater silver smelt	*Argentina silus*
Cod	*Gadhus morhua*
Haddock	*Melanogrammus aeglifinus*
Whiting	*Merlangius merlangus*
Blue whiting	*Micromesistius poutassou*
Poor cod	*Trisopteris minutus*
Norway pout	*Trisopterus esmarkii*
Pollack	*Pollachius pollachius*
Saithe	*Pollachius virens*
Torsk	*Brosme brosme*
Ling	*Molva molva*
Blue ling	*Molva dypterygia*
Hake	*Merluccius merluccius*
Redfish spp.	*Sebastes* spp.
Sandeel spp.	*Ammodytes* spp.
Goby spp.	*Gobius* spp.
Mackerel	*Scomber scrombus*
Greenland halibut	*Reinhardtius hippoglossoides*

Appendix II. Survey coverage (km^2) obtained in licensed rectangles located in Atlantic Frontier (June1979-March 1999)

Licensed rectangle	1/4 ICES Rectangle (see Figure 4.)	Lat/ Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
West of Hebrides														
132 NW	1	5645 0930			6.41	10.10	21.49	22.31	11.05	24.17	22.91		7.60	
NE	2	5645 0900	14.43	6.99	3.95	27.02	11.15		11.43	21.04	12.04	8.25		
CNW	3	5630 0930			22.50	21.02	20.48	26.80		24.03	22.67		1.40	
CNE	4	5630 0900	10.88	2.15		16.54	1.15	4.88		12.67	8.66		8.70	
CSW	5	5615 0930			23.24	22.78	23.23	23.03	3.60			22.61	3.60	
CSE	6	5615 0900	14.73	6.00	11.25	0.82	10.25	22.76	9.25	7.50	8.40	21.57		
142 SW	7	5700 0930	9.45		5.05	6.65	10.61	7.65	14.76	32.28			2.85	
SE	8	5700 0900	18.29	16.60	9.25	14.60	2.20	6.97		23.80	23.04	4.60		1.90
152 NW	9	5845 0930		22.56	21.38	20.93	1.83	22.08	3.06	24.60	18.90		20.60	
CNW	10	5830 0930		21.89	28.03	3.76	23.42	23.27		23.40	34.00		19.57	
153 NW	11	5845 0830		12.57	22.64	21.59	2.36	11.78		23.35	3.21	12.57	0.88	
NE	12	5845 0800	22.48			25.03	13.40	8.40		23.42	4.08	11.82	26.19	22.22
CNW	13	5830 0830	5.40			17.10	20.40	4.15		12.27			23.40	
CNE	14	5830 0800		7.20	1.25	2.45	11.86	17.92	11.95	6.95	3.84	3.45		0.91

Appendix II. continued

Licensed rectangle	1/4 ICES Rectangle (see Figure 4.)	Lat/ Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
154 NW	15	5845 0730	20.59	20.05	9.60	6.10	15.22		22.65	3.60	2.55	11.20	25.40	25.19
CNW	16	5830 0730	25.81	30.63	3.60	2.50	12.16	16.86	18.90	26.80	6.17	13.95	24.58	20.93
163 CSE	17	5915 0800	32.59		5.25	8.86	22.40	18.05		22.69		15.83	25.47	23.64
SE	18	5900 0800	33.26			22.03	5.84	12.12		11.55	25.01	18.25	26.52	24.40
164 NW	19	5945 0730	22.63	18.34	23.52	23.21		23.15		35.90	3.17	26.01	25.13	12.81
NE	20	5945 0700	23.49		8.22	22.32	23.43	23.37	3.75	15.48	2.28	23.19	25.33	16.94
CNW	21	5930 0730	29.58	23.00		22.43	23.81	23.35		31.61	12.41	23.73	26.33	24.67
CNE	22	5930 0700	28.16		21.63	23.82	22.26	3.80		22.25	9.00	22.76	27.93	22.69
CSW	23	5915 0730	25.48		2.10	3.95	21.57	23.52		27.56	21.55	23.23	23.63	1.50
CSE	24	5915 0700	23.37	4.98	2.05	8.63	5.80	5.50		10.77	10.08	25.97	27.47	23.92
SW	25	5900 0730	24.42		4.35	6.65	22.22	6.42	1.05	7.50		19.69	25.39	19.94
SE	26	5900 0700	21.58	6.60	23.75	13.30	35.85	7.10	29.15	15.35	8.25	23.24	26.40	7.51
165 NW	27	5945 0630	15.27		22.33	6.86	21.70		17.08	12.77	16.50	22.83	23.23	1.92
CNW	28	5930 0630	12.77	5.25		19.17		1.37	12.53	5.20		22.14	24.25	
West of Shetland														
202 NW	29	5945 0430	9.94		6.65		20.25	7.14	10.05	3.30	21.90		20.91	2.10
NE	30	5945 0400	3.61			8.00	23.45	8.85	43.01				21.85	6.00
CNW	31	5930 0430		4.00	7.60	1.10	4.10	7.92	15.15	16.55	15.61	12.65		8.40
CNE	32	5930 0400	21.95	9.00		7.60	1.20	8.54	39.43	18.75		4.55		6.90
CSW	33	5915 0430	2.55		4.17	1.00	10.85	12.23	6.20	11.10	1.70	2.40	18.90	
204 CNE	34	6030 0400	21.80		8.05	1.00	22.55	24.62	2.10	21.68	10.85	8.85	0.78	
CSW	35	6015 0430	20.69		6.96	2.00	22.99	1.85			4.56		1.22	23.83
CSE	36	6015 0400	3.34	10.41	10.15	8.00	32.88	21.30	12.65	23.66	10.00	18.08	8.17	10.91
SW	37	6000 0430	21.32		6.45	7.00	20.63	9.18	1.30	9.90	36.07		8.51	
SE	38	6000 0400	10.74	7.44	4.75	5.19	12.02	5.37	18.06	4.00	4.28		2.10	
205 NW	39	6045 0330	23.37			4.20	6.68	22.88	28.30	29.18	3.89			2.14
NE	40	6045 0300				4.20	14.85	20.88	13.55	15.90	16.24	3.81		10.93
CNW	41	6030 0330			11.54	8.40	22.07	22.60	7.31	42.16	9.55		8.45	9.65
CNE	42	6030 0300	6.40	10.95	1.62		5.90	21.22	38.62	8.41	6.76	0.99	8.00	
CSW	43	6015 0330	10.74	1.05	2.73		17.88	14.59	38.84	0.89	1.31	8.60	1.04	1.07
CSE	44	6015 0300	3.31	9.45			1.15	9.02	35.90	8.28	10.31	8.11	8.52	1.15
SW	45	6000 0330	10.11	8.44	1.52	3.14	24.91	28.36	39.96	4.58	14.74		8.40	9.29
SE	46	6000 0300	12.73				14.90	14.32	31.77	3.00	7.28		2.69	10.87
206 NW	47	6045 0230		4.20	3.95	9.05	13.55	18.05	9.79	25.11	1.90	8.36		
NE	48	6045 0200		16.63	10.45	4.35	7.15	8.47	48.20	16.62	9.35	1.84		
CNW	49	6030 0230	6.18	5.25	10.65		9.21	8.04	37.63	6.95	7.60	7.91		
CNE	50	6030 0200	8.07		10.15	13.15	11.06	17.20	67.18	6.25	2.10	1.98	7.35	2.40
CSW	51	6015 0230	9.68		24.15	1.70	1.20	13.13	68.43	4.90	0.95		8.05	3.80
207 NW	52	6045 0130	3.60	17.43	19.50	18.00	18.93		53.87	4.75	4.53	7.20		
213 CSW	53	6115 0330					7.62	5.93	6.32	7.72	2.05		8.54	
CSE	54	6115 0300		1.40	8.36	3.15	15.31	11.69	18.25	9.00	22.59		5.93	
SW	55	6100 0330	5.69				7.18	7.81	7.41	13.17			8.79	
SE	56	6100 0300	24.81			4.20	16.25	11.28	15.06	13.04	22.62		7.73	
North of Shetland														
214 CSW	57	6115 0230	0.79	3.50	0.98	4.05	8.19	13.20	24.15	23.53	21.58	4.06	13.43	
CSE	58	6115 0200	21.42		0.93		16.75	13.55	19.71	20.27	7.70		15.28	0.62
SW	59	6100 0230	21.78				8.45	15.87	12.85	22.61	22.80	2.91	2.96	
SE	60	6100 0200	0.74	2.10	10.08		18.53	20.99	10.87	15.39	8.19	14.93	4.60	2.99
208 CNE	61	6130 0100			1.50	2.85	21.00	5.00	20.30		3.80	1.35		
CSW	62	6115 0130			3.05		17.12	22.93	13.55	11.10			11.93	16.22
CSE	63	6115 0100	3.30		13.90	2.85	2.40	22.65	28.43		6.00	10.35		6.56
SW	64	6100 0130		5.80	23.17	1.90	25.53	20.23	27.52		10.70	7.51	1.06	5.22
209 CNW	65	6130 0030	9.80		13.13		16.67	9.98	6.59	1.50	21.36			
CSW	66	6115 0030	1.10		3.30		10.50	9.47	19.20	4.50	22.94			
214 NW	67	6145 0230			9.10		8.14	18.34	20.14		22.60		16.47	9.24
NE	68	6145 0200	22.61	7.80	5.87		24.72	24.13	21.36		10.70	22.87	24.38	22.52
CNW	69	6130 0230	1.51	4.90	4.95	2.00	10.96	33.04	21.57	12.75	25.05		14.40	8.94
CNE	70	6130 0200		12.30		7.00	28.60	34.25	29.96	13.98	5.70	23.03	24.82	23.28
208 NW	71	6145 0130	22.87	6.15	9.13	8.40	53.98	26.63	24.52	12.18		23.69	21.65	22.95
CNW	72	6130 0130	21.86		7.51	4.10	47.08	43.56	23.65	3.75		21.63	23.22	20.91
217 CSW	73	6215 0130	1.10		21.18		23.05	8.27	14.08	1.60		21.53	22.59	12.91
SW	74	6200 0130	22.61		21.79		16.50	9.26	15.92	20.39	23.68	23.83	22.18	22.86
219 CSW	75	6215 0000E	22.59		27.74		24.57	23.75	23.01	47.53	10.47			
CSE	76	6215 0030E	21.93		21.86		17.90	26.09	22.64	5.48	1.45			
SW	77	6200 0000E	25.23		20.65		39.10	25.22	21.94	8.29	13.13			
SE	78	6200 0030E	1.44		20.76		25.60	25.03	24.52					

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- to provide advice and knowledge to anyone on nature conservation issues affecting Great Britain and internationally;
- to establish common standards throughout Great Britain for the monitoring of nature conservation and for research into nature conservation and the analysis of the results;
- to commission or support research which the Committee deems relevant to the special functions.

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COVER PHOTOGRAPHS
Long-finned pilot whale *Globicephala melaena*, Peter Hope Jones/JNCC
Gannet *Morus bassanus*, Andy Webb/JNCC

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