JOINT NATURE CONSERVATION COMMITTEE

The distribution of seabirds and marine mammals in Falkland Islands waters

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ISBN 1 86107 534 0

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Summary

Data collected on the distribution of seabirds and marine mammals in the waters around the Falkland Islands between February 1998 and January 2001 are presented. Following the completion of the first year of the project, a dispersion atlas *Seabird and marine mammal dispersion in the waters around the Falkland Islands 1998–1999* (White *et al*. 1999) was produced. The present updated atlas adds considerably to survey coverage achieved during the first year and is the first step towards investigating the inter-annual variability in seabird and marine mammal dispersion within Falkland Islands waters.

To date, 57 species of seabird and 17 species of marine mammal have been recorded. For the majority of species, the patterns of spatial and seasonal distribution are broadly similar to those identified after 12 months. Prions continued to be the most numerous 'species' recorded with particularly high densities encountered within the Special Co-operation Area during summer months.

Following a further two years of surveys, a number of patterns tentatively identified after the first year have proven to be consistent. The dramatic drop in numbers of prions in March and April, for example, was recorded in all three years of surveys and therefore is unlikely to be a result of variability in survey distribution.

A degree of inter-annual variation was identified for a number of species. Most notable amongst these was the influx of Antarctic petrels into the study area during the winter of 1999. Also, less spectacular variations, such as seabirds opportunistically feeding on jellyfish, have been recorded.

In view of the very little published information about marine mammals in Falkland Islands waters, surveys have added greatly to our knowledge on the occurrence and distribution of these animals within these waters.

Continuation of the project will fill existing gaps in survey coverage and also evaluate the possible threat to seabird populations of direct mortality from fishing operations within the Falkland Islands conservation zones.

Foreword

The Seabirds at Sea Team (SAST), first of the Nature Conservancy Council and now of the Joint Nature Conservation Committee (JNCC), was established in 1979 to study the distribution and abundance of seabirds in the seas around the United Kingdom. The project started as a consequence of seabird mortality caused by oil pollution from vessels at sea in the 1970s and concerns about the risk of oil spills associated with oil exploration and exploitation in the North Sea.

SAST has developed standardised methods for surveying seabirds at sea (Tasker *et al*. 1984; Webb and Durinck 1992) and has applied them since 1979 in most waters of north-west Europe. Survey results have been used to advise Government and the hydrocarbon industry on ways of minimising the effects of potentially damaging activities on seabirds, marine mammals and the marine environment in general. SAST has also co-ordinated data collection and storage with a number of European organisations to form the European Seabirds at Sea database.

In the Falkland Islands, hydrocarbon exploration licences were awarded in 1996 and activity culminated in 1998 with the drilling of six wells by the drilling rig *Borgny Dolphin*. The perceived threat to seabirds of potential surface pollution demanded that the location of important concentrations of seabirds in these waters be determined. In February 1998, JNCC, under contract to Falklands Conservation (FC), with funds from the exploration licence holders (Falklands Operators Sharing Agreement), commenced at-sea surveys of seabirds and marine mammals in Falkland Islands waters. The results of the first year of surveys were published as *Seabird and marine mammal dispersion in the waters around the Falkland Islands 1998–1999* (White *et al*. 1999).

The *Borgny Dolphin* left the islands at the end of 1998 and there has since been no further drilling in Falkland Islands waters. However, there has been some seismic work and it is expected that exploration will resume in the near future. In anticipation of this, the Falkland Islands Government (FIG) awarded funds to FC to retain JNCC under contract to continue the programme of at-sea surveys for a further two years. The results of the first two years of surveys were published as an atlas depicting vulnerability of seabird concentrations to surface pollution *Vulnerable concentrations of seabirds in Falkland Islands waters* (White *et al*. 2001). This highlighted the locations of seabird concentrations that were most highly vulnerable to the effects of surface pollution. This report summarises three years of survey work and updates and expands the distribution atlas published after the first year of the project.

1 Introduction

Background

This report outlines the results of an intensive three-year study into the at-sea distribution of seabirds and marine mammals in the waters of the Falkland Islands. It updates and adds much valuable new information to that contained in the report produced after the first year of surveys (White *et al*. 1999). The additional information gained in the second and third years of surveys has improved both the seasonal and spatial distribution of coverage and enabled an understanding of some of the inter-annual variation in the patterns of seabird and marine mammal dispersion that was not possible after one year of surveys. Where possible, factors that might influence these dispersion patterns, such as oceanography or fisheries, have been identified. The aim of this report is to present the results of the study in a way that will assist the assessment of the likely impact of human use of the marine environment on seabirds and marine mammal populations in the area.

Study area

The Falkland Islands lie between 51° and 53° S and 57° and 62° W on an outcrop at the southern end of the Patagonian Shelf. The archipelago comprises two main islands – East Falkland and West Falkland – and 778 smaller satellite islands (Woods 1986). The islands have a total land area of approximately 12,000 km^2.

The closest point of South America is about 500 km south-west of the Falkland Islands. South Georgia lies approximately 1,300 km to the east with the South Shetland Islands approximately 1,000 km to the south. Falkland Islands waters extend some 360 km to the north, south and east of the islands, while to the west they meet the boundary of the Argentine Exclusive Economic Zone (EEZ) some 110 km west of West Falkland. Thus, Falkland Islands waters cover approximately 400,000 km^2 (Richards 1997).

For the purposes of this report the study area was defined as a box with south-west co-ordinates 56° S 64° W and north-east co-ordinates 47° S 52° W. The majority of Falkland Islands waters are contained within this box. The exception is a small area south of 56° S that was only rarely covered by surveys.

Climate

At a similar latitude south as London, UK, is north, variation in seasonal day length in the Falkland Islands is similar to that in the UK. The climate is temperate, although the currents bathing the Falkland Islands are cold water rather than the warm waters of the Gulf Stream that influence the climate in the UK. Mean daily temperature ranges from 4.8 °C in winter to 9.6 °C in summer. Humidity ranges from 75% in November to 89% in July. The prevailing winds are in the westerly quadrant for 70% of the year and wind speeds average 17 knots. Rainfall is evenly distributed throughout the year, averaging 625 mm per year in Stanley but as little as 310 mm in the west of the islands (Richards 1997).

The marine environment

The Falkland Islands are in the southern cold-temperate zone of surface water. Offshore sea surface temperatures range from around 6 °C in winter to 13 °C in summer (Richards 1997). The Antarctic Convergence lies approximately 500 km to the south of the islands and 700 km to the east (Figure 1.1).

The coastline of the Falkland Islands is heavily indented with many sheltered natural harbours and bays. Most of the coast is rocky but there are many sandy beaches. In the east of the archipel-

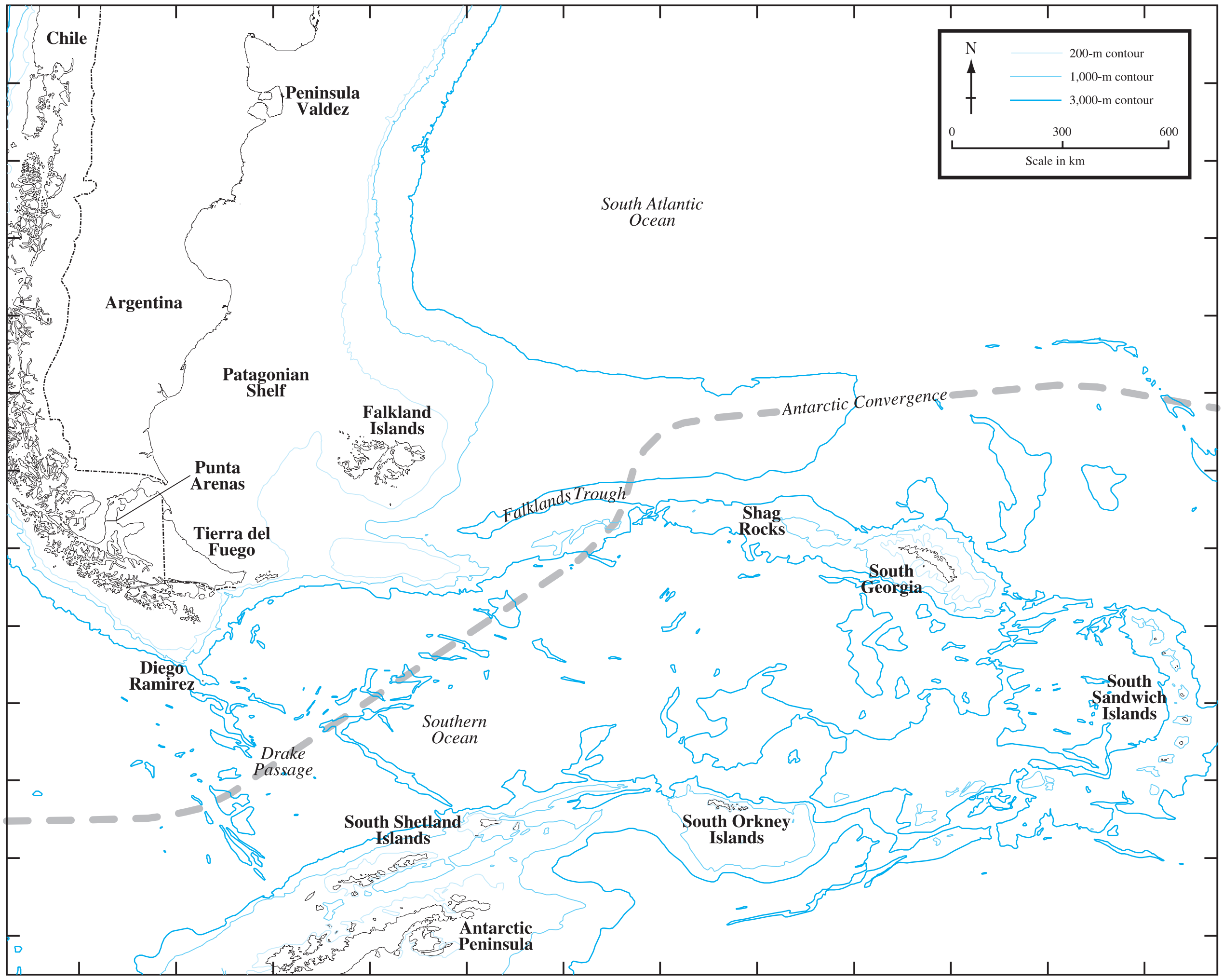

Figure 1.1 The position of the Falkland Islands in relation to South America and the islands of the Scotia Arc with approximate position of Antarctic Convergence.

ago the rocky coast is generally low, but in the west there are cliffs up to 200 m high.

Extensive beds of kelp (mostly giant kelp and tree kelp) grow in waters up to 30 m deep and may extend up to 1 km from the coast (Strange 1992). These kelp beds provide shelter and feeding grounds for a wide range of invertebrates, molluscs and fish (Castilla 1985), which in turn make the kelp beds a rich feeding ground for seabirds and marine mammals in inshore waters. During storms, patches of kelp are often dislodged from the rocks and float out to sea, becoming a focal point for a range of foraging seabird species, most notably grey-backed storm-petrels[1] (Gillon *et al.* 2001).

The shallow waters of the Patagonian Shelf extend some 100 km to the north, 25 km to the east and 40 km to the south of the islands. However, Beauchêne Island on the southern edge of the Patagonian Shelf lies within 5 km of the 200 m depth contour. To the west, between the Falkland Islands and South America, are Patagonian Shelf slope waters, gently sloping waters between 200 m and 300 m deep. To the north and north-east of the islands there is a gradual increase in depth from the 200 m to the 1000 m isobaths resulting in an extensive area of continental shelf slope waters. To the east and south of the islands the Patagonian Shelf slope is steeper, resulting in a limited area of continental shelf slope waters. The Falklands Trough, a deep water area that runs parallel to and north of the Scotia Ridge, extends into the study area to the south-east of the islands. These waters constitute some of the deepest within the study area, extending to a depth of over 3000 m.

To the east of the Drake Passage, a branch of the cold Antarctic Circumpolar Current flows north

1 Unless stated otherwise seabird nomenclature and taxonomy follows Harrison (1987). Marine mammal nomenclature and taxonomy follow Jefferson *et al.* (1993). The scientific names of all species mentioned in the text may be found in Appendix I.

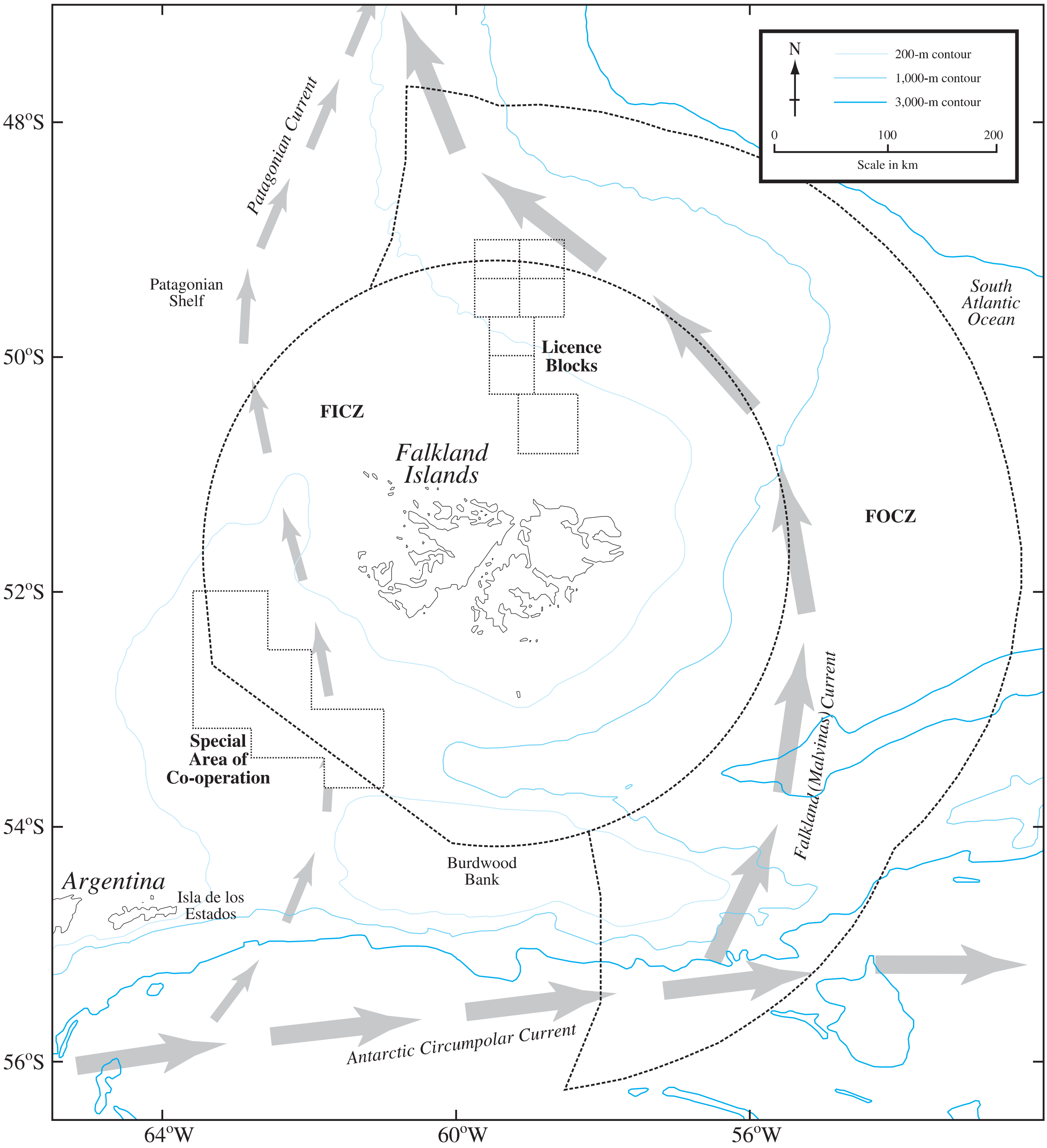

Figure 1.2 The study area, limit of territorial waters and areas licensed for hydrocarbon exploration.

and encircles the Falkland Islands. The Patagonian Current to the west of the islands is slacker than the Falklands/Malvinas Current to the east of the islands (Glorioso and Flather 1995). The Falklands/Malvinas Current flows north along the continental shelf slope as far as 35° S, where it meets the warm south flowing waters of the Brazil Current (Peterson *et al*. 1996). Where these currents are forced up onto the Patagonian Shelf, the resultant upwelling of nutrient-rich water produces rich feeding grounds for seabirds and marine mammals.

Fisheries

Since the mid-1970s there has been a well established multinational fishing fleet operating in Falkland Islands waters. Prior to 1986, there was no regulation of this fishery but in 1986 FIG declared an exclusive zone – the Falklands Islands Interim Fishery Conservation and Management Zone (FICZ) – and began regulating the fishery through the sale of licences. In 1990, FIG extended this zone to 200 nautical miles to the

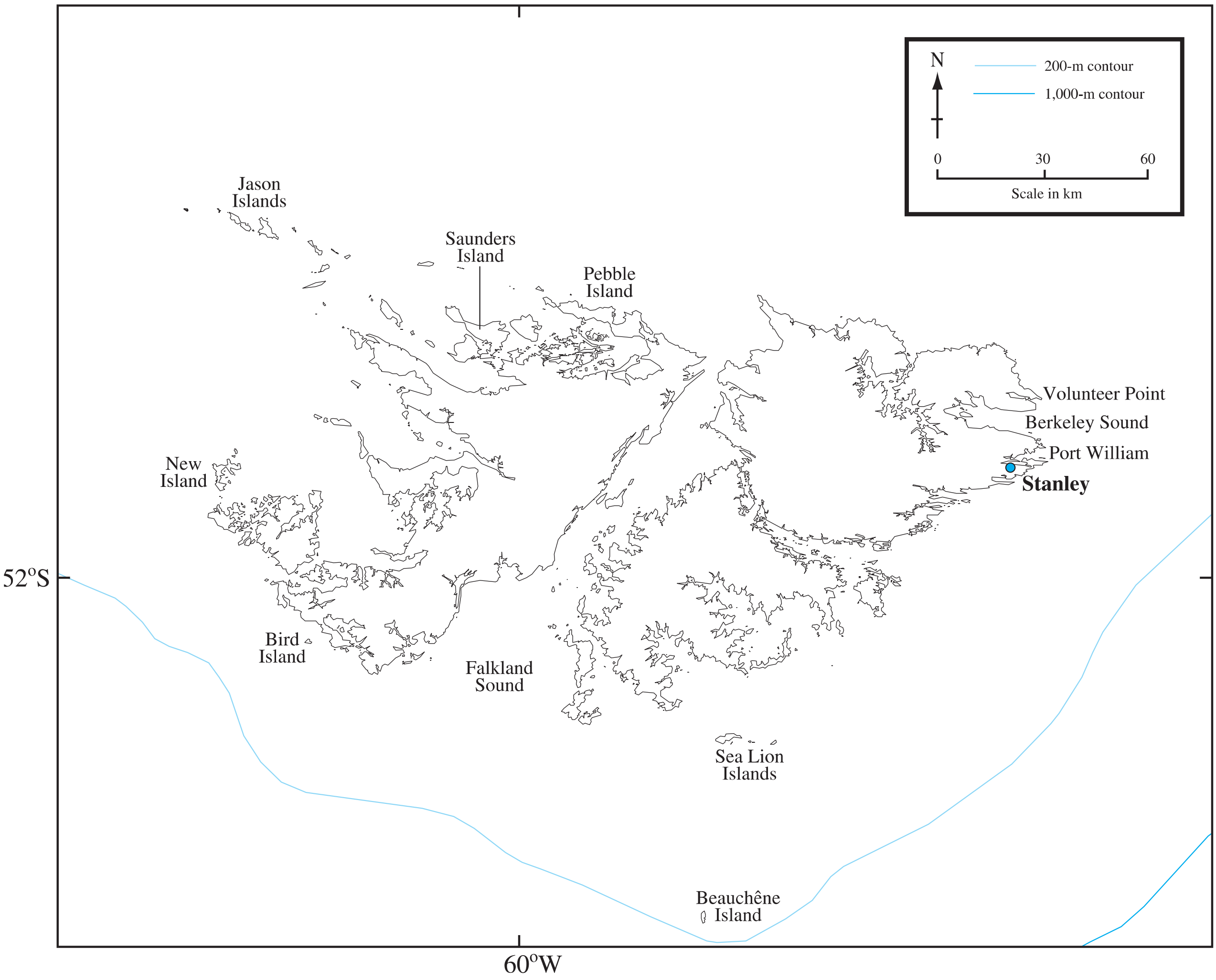

Figure 1.3 Location of places in the Falkland Islands mentioned in text.

north, east and south of the islands, thus creating the Falklands Outer Conservation Zone (FOCZ).

Fisheries within the conservation zones can be divided into four broad categories.

The largest fishery, in terms of number of vessels, catch and income to FIG, is the seasonal jigging fishery for *Illex* squid. The *Illex* fishery, which takes place between February and June, is concentrated over the Patagonian Shelf to the north and west of the islands. Jigging commences in international waters to the north of the FOCZ with the vessels following the southward migration of *Illex* into Falklands Islands waters. Jigging is very species-specific, with little bycatch (Nolan and Yau 1997). Consequently, this fishery does not provide scavenging seabirds with large quantities of food.

A trawl fishery for *Loligo* squid operates off the east coast of East Falkland, within the '*Loligo* box' (Figure 1.2). The fishery has two seasons, February to May and August to November. Approximately 4% of the catch is discarded by these vessels (Nolan and Yau 1997), which then become available to seabirds. As a result, large numbers of seabirds, especially black-browed albatrosses, giant petrels and Cape petrels, are often associated with these vessels.

A number of trawlers are licensed to fish for a variety of target species, primarily finfish. The levels of discards from these fisheries vary according to the species targeted, but are generally higher than those from jiggers (Nolan and Yau 1997) and attract large flocks of scavenging seabirds.

A longline fishery for Patagonian toothfish, consisting of two vessels, operates in the deeper waters of the FOCZ. Although operating in areas that generally support low densities of seabirds, these vessels attract large flocks of birds. Recent studies indicate that a high proportion of the South Georgian breeding population of wandering albatrosses attends these vessels during the course of the year (Croxall *et al*. 1999).

Hydrocarbon exploration

Seismic surveys were first shot in the region in the 1950s. There were further surveys in the late 1970s and again from 1993 (Richards 1997). FIG issued offshore production licences for licence blocks in the North Falklands Basin in October 1996. Seismic data were acquired between December 1996 and May 1997, with further seismic work conducted in 1998. Six exploratory wells were drilled between April and December 1998. Seismic work resumed in December 2000 but, at the time of writing, there is no prospect of a resumption of drilling. However, the northern blocks remain licensed and there is also interest in exploring new areas, notably the Special Co-operation Area (SCA) and other parts of Falkland Islands waters (Figure 1.2).

Seabird populations

Seabird populations in and around the Falkland Islands are of international importance (Croxall *et al*. 1984a; Woods and Woods 1997). In total, the Falkland Islands probably support more than two million pairs of breeding seabirds (Table 1.1). Of these, more than 1% of the world population of some 15 seabird species and as much as 85% of the world population of dolphin gull (Woods and Woods 1997; Yorio *et al*. 1998) and 74% of the world population of black-browed albatross breed in the islands (Huin 2001; Gales 1998). These populations and others feed in the productive waters of the Patagonian Shelf surrounding the islands, an area long recognised as being important for seabirds (Cooke and Mills 1972; Brown *et al*. 1975; Veit 1995).

Of 28 species of albatross and petrel that have recently been listed by the United Nations Convention on Migratory Species (CMS) and are now subject to a conservation agreement; eight occur regularly in Falkland Islands waters, of which three breed in the islands, and a further five occur occasionally (White *et al*. 1999). The Falkland Islands and any users of these waters have an international responsibility to protect these birds from harmful operations. These birds depend entirely upon the marine environment for their food and are consequently vulnerable to the impact of human activities such as fishing and hydrocarbon exploration and exploitation.

In recent years there has been a marked increase in the number of systematic studies of Falkland Islands seabirds. In 1986, the then Falkland Islands Foundation (now FC) initiated the Falkland Islands Seabird Monitoring Programme (Thompson 1989). This ongoing programme aims to monitor the population sizes and diets of a number of important seabird species whose diet potentially conflicts with commercial fisheries (Clausen 2000).

Several recent studies have deployed satellite tracking devices to monitor the at-sea movements of black-browed albatrosses (Huin 1999) and rockhopper, gentoo and Magellanic penguins (Stokes and Boersma 2000; Pütz *et al*. 1998) that

Table 1.1 Population sizes of seabird species breeding in the Falkland Islands.

Species	*Number of pairs*	*Source*
King penguin	500	K. Pütz (pers. comm.)
Magellanic penguin	76,000–142,000*	Woods and Woods (1997)
Macaroni penguin	50	Bingham (1998)
Gentoo penguin	113,000*	Clausen (2001)
Rockhopper penguin	272,000*	Clausen (2001)
Black-browed albatross	382,000*	Huin (2001)
Southern giant petrel	5,000–10,000*	Woods and Woods (1997)
Thin-billed prion	1,000,000*	Croxall *et al*. (1984a)
Fairy prion	10000	Woods and Woods (1997)
White-chinned petrel	1,000–5,000	Woods and Woods (1997)
Great shearwater	50–100	Woods and Woods (1997)
Sooty shearwater	10,000–20,000	Woods and Woods (1997)
Grey-backed storm-petrel	1,000–5,000*	Woods and Woods (1997)
Wilson's storm-petrel	5,000+	Woods and Woods (1997)
Common diving-petrel	5,000–10,000	Woods and Woods (1997)
Rock shag	32,000–59,000*	Woods and Woods (1997)
Imperial shag	45,000–84,000*	Woods and Woods (1997)
Falkland steamer duck	9,000–16,000*	Woods and Woods (1997)
Antarctic skua	5,000–9,000*	Woods and Woods (1997)
Brown-hooded gull	1,400–2,600*	Woods and Woods (1997)
Kelp gull	24,000–44,000*	Woods and Woods (1997)
Dolphin gull	3,000–6,000*	Woods and Woods (1997)
South American tern	6,000–12,000*	Woods and Woods (1997)

*exceeds 1% of the world population

breed in the Falkland Islands. In addition, a number of species have been satellite tracked to Falkland Islands waters from other breeding areas. For example, white-chinned petrels (Berrow *et al*. 2000), wandering albatrosses (Prince *et al*. 1998) and northern giant petrels (Gonzáles-Solís *et al*. 2000) from South Georgia and northern royal albatrosses from New Zealand (Robertson and Nicholls 2000).

These studies have provided much valuable information on the movements of individual birds, but due to the high cost of the transmitters, sample sizes are small and often limited to breeding adults in order to allow opportunities to retrieve the transmitter.

With the advent of exploration for hydrocarbons in the waters of the Falkland Islands and the likelihood of further exploration in the future, it was considered important to determine where the most important concentrations of seabirds are located. The only way of determining broad-scale seabird distribution is to undertake surveys at sea. Such surveys have been carried out off both coasts of North America and off north-west Europe (e.g. Stone *et al*. 1995) and the results successfully applied to manage oil industry activities in those areas (Webb *et al*. 1995). This project has made significant advances in locating areas within Falkland Islands waters that support important concentrations of seabirds (White *et al*. 2001).

Threats to seabird populations

Since human colonisation of the Falkland Islands, seabird populations have been impacted through direct mortality, reduced productivity and through habitat degradation. Introduction of cats, rats and foxes to parts of the islands has resulted in the distribution of many ground-nesting seabirds becoming restricted to offshore islands that are free of mammalian predators. Introduction of grazing animals has reduced the available area of tussac grass – a habitat used extensively by burrowing petrels and shearwaters. It has been estimated that 81% of the area previously covered by tussac grass has been lost to grazing and fires (Strange 1987).

It is likely that past exploitation of seabirds, coupled with habitat degradation, has resulted in a reduction in the size of present populations when compared with historical levels. Historical information is lacking for most species; however, there is evidence that the population of rockhopper penguins was once considerably larger than at present. Rockhopper penguins undoubtedly suffered from both the penguin oiling industry and excessive egg collection (Cott 1954; Strange 1992). While oiling has ceased and egg collection only continues at very low levels compared with historical levels, rockhopper penguin populations have not recovered. Recent events, such as a large scale die-off in the mid-1980s (Keymer 1988), which was linked to starvation caused by a food shortage in the crucial pre-moult period, have undoubtedly contributed to the lack of a recovery in numbers.

Interactions between seabirds and commercial fisheries are complex. Several studies have shown that food obtained by seabirds scavenging from fishing vessels can be beneficial to the population as a whole (Fisher 1952). Work carried out in Falkland Islands waters, however, has shown that the interactions between seabirds and fisheries are potentially detrimental to some seabird species through direct competition for a common, finite, resource (Thompson 1992; Thompson and Riddy 1995).

Of more immediate concern is the fact that interactions between seabirds and fishing vessels are known to directly cause incidental mortality of seabirds (Bartle 1991; Brothers 1991). Globally, the high levels of by-catch of some albatross and petrel species have raised concerns about the future of those species. These concerns have resulted in the listing of 28 species of albatross and petrels under the CMS. Over recent years, this has become a major conservation issue, particularly with regard to albatrosses. In the Falkland Islands, the black-browed albatross population has declined from 506,000 pairs in 1980/81 to 382,000 pairs in 2000/01 (Huin 2001). Weimerskirch and Jouventin (1998) linked changes in albatross population sizes with low levels of juvenile recruitment, which is tentatively linked with the distribution of longliner effort. Recent analysis by Schiavini *et al.* (1998) gives some background information into the problems of interactions between albatrosses and fisheries over Patagonian Shelf waters. While levels of by-catch in Falkland Islands waters are not thought to pose serious problems to albatross and petrel populations at present, there is a lack of quantitative data to support this.

Longline fisheries for Patagonian toothfish within the Falkland Islands conservation zones are maintained at a low level, with only two vessels licensed. The company involved, Consolidated Fisheries Ltd, has taken a responsible attitude towards the issue of seabird by-catch and has sought advice from scientists and implemented mitigation measures to reduce levels of incidental mortality. Of greater concern are the vessels that fish the high seas adjacent to the conservation zones. Fishing effort in this region is higher and the extent to which mitigation measures are used is unknown.

Although no research within Falkland Islands waters has yet been directed at seabird mortality

associated with trawl fisheries, there is anecdotal evidence that seabirds are killed during trawling operations as a consequence of collisions with trawl warps. The extent of the problem is not known, as such incidental mortality has not been recorded systematically. However, in view of the high level of fishing effort by trawlers within the conservation zones, the number of birds killed in this way could be significant.

To date, oil pollution has not been a chronic problem in Falkland Islands waters, as it is in some other parts of the worlds oceans. For example, oil pollution within the Argentine EEZ is estimated to cause the deaths of as many as 40,000 Magellanic penguins annually (Gandini *et al*. 1994). Some of these birds are likely to be of Falkland Islands origin, such as Magellanic penguins that breed in the Falkland Islands winter off the coast of Argentina (Pütz *et al*. 1998). In the Falkland Islands there have been a number of small-scale incidents in which low numbers of penguins and shags have been found onshore after becoming oiled (K. Thompson pers. comm.; Smith 1998).

Marine mammal populations

Prior to this study, knowledge of the cetacean fauna of the Falkland Islands was based largely on coastal observations and records of stranded animals. Hamilton (1952) recorded a total of 16 species within Falkland Islands waters, while Strange (1992) recorded a total of 23 species. More recently, observations from FIG Air Service pilots and fisheries observers of the FIG Fisheries Department (FIGFD) give an indication of some of the species present in offshore areas, but interpretation of these casual observations is difficult.

Two species of dolphin, Peale's and Commerson's, are commonly seen from land and are known to breed locally. However, there is nothing known about the population size of these species and for most other species little is known about their status in Falkland Islands waters. Long-finned pilot whales are probably the most regular and certainly the most abundant species found stranded, while several other small odontocetes are known to occur in Falkland Islands waters, primarily through stranding records. Of these, the beaked whales and the spectacled porpoise are particularly poorly known.

A limited amount of historical data on the relative abundance of baleen whales in Falkland Islands waters is available from the records of the New Island whaling station, which operated between 1908 and 1916. Records from the station are incomplete, and information on where the catches were made is not available, but Hamilton (1952) lists the catch for two seasons, 1912–13 and 1913–14 (Table 1.2).

Table 1.2 Numbers of whales caught by the New Island whaling station fleet in 1912–13 and 1913–14 (Hamilton 1952).

Species	*Number caught*
Southern right whale	1
Fin whale	99
Sei whale	148
Blue whale	3
Humpback whale	15

Three species of pinniped, South American sea lion, South American fur seal and southern elephant seal, breed in the Falkland Islands (Strange 1992). A further two species, Antarctic and subantarctic fur seals, have been recorded breeding (D. Thompson pers. comm.) and a further species, leopard seal, is recorded annually as a nonbreeding visitor to the islands.

Knowledge of the distribution and size of breeding pinniped populations indicates that the three species that regularly breed in the islands are currently at very low levels compared to historical populations (Strange 1992; Thompson *et al*. 1995). While these declines were probably linked with exploitation for skins and oil, which continued until the early 1960s, the populations have failed to recover since the cessation of hunting (Strange 1992; Thompson *et al*. 1995).

Little is known of the at-sea distribution of Falkland Islands pinnipeds. Prior to the start of a South American fur seal satellite tracking programme in 2000 (Thompson and Moss 2001), the only previous work was a satellite tracking study of South American sea lions (Thompson *et al.* 1995). In addition, satellite tracking of southern elephant seals from Patagonia (Campagna *et al*. 1995) and Antarctic fur seals from South Georgia (I. Boyd pers. comm.) have both tracked animals into Falkland Islands waters, but, in common with satellite tracking studies of seabirds, sample sizes are small.

This project, while primarily focused on identifying seabird dispersion patterns, has contributed significantly to the knowledge of marine mammal distribution in the waters around the Falkland Islands.

Threats to marine mammal populations

Hunting of pinnipeds for skins and oil in the 19th century resulted in the local extinction of southern elephant seals and serious reductions in the numbers of both sea lions and fur seals (Strange

1992), although it is unclear how large the pre-exploitation populations were. Although exploitation has now ceased, there is evidence that numbers of South American sea lions continued to decline after exploitation ended (Thompson *et al*. 1995), suggesting that other factors may be involved in the low levels of populations today.

The whaling industry between the 18th and 20th centuries has undoubtedly had a significant impact on the numbers of large whales present in Falkland Islands waters. However, while no data exist to assess whether populations have recovered to pre-whaling levels, there is evidence for some species that the cessation of commercial whaling has resulted in a recovery of some populations in the South-west Atlantic; e.g. southern right whales at Peninsula Valdez, Argentina, increased at 7% per annum from 1970 to 1990 (R. Payne in Harris 1998).

Habitat degradation has almost certainly had an impact on the distribution of South American sea lions in the Falkland Islands. Most South American sea lion populations are found on offshore islands with extensive stands of tussac grass.

Cetaceans in Falkland Islands waters are under little direct threat from fisheries, in contrast to the situation in southern South America, where there are a variety of fisheries impacts on small cetaceans (Hucke-Gaete 2000). However, trawl fisheries do pose a potential threat to some marine mammals, as elephant seals have been recorded in the trawls of fishing boats (K. Pütz pers. comm.). Interactions between longliners and cetaceans – primarily killer whales taking fish from the lines, but also sperm whales – have been observed in Falkland Islands waters (pers. obs.) but the exact nature and scale of the interactions has not been documented.

The effects of hydrocarbon exploration and exploitation may have an impact on marine mammal populations. The effects of oil pollution on marine mammals is poorly understood, but the effects do not appear to be as serious for cetaceans as for pinnipeds. Whales have smooth skins that do not become clogged with oil and lose their waterproofing ability, unlike seabirds and pinnipeds. The most likely immediate impact of an oil spill on cetaceans appears to the risk of inhalation of oil vapours, while in the longer term habitat degradation as the result of oil spills may result in population declines (Gubbay and Earll 2000)

Further threats to marine mammals, principally cetaceans, arise from the use of airguns during seismic surveys. The frequencies used by the airguns may interfere with communication, while avoidance of the noise may drive animals away from their feeding grounds. While seismic activity within the Falkland Islands has been limited, and there are no reports of cetaceans being affected, behavioural responses to the firing of airguns have been recorded elsewhere for a number of species (Richardson *et al*. 1995; Stone 2000).

2 Methods

Seabird and marine mammal surveys were primarily conducted from vessels of opportunity. After the withdrawal of the rig supply vessels from the Falkland Islands at the end of 1998, these were primarily the Fishery Protection Vessels (FPVs) of the FIGFD. The MV *Golden Fleece* was chartered for a two-week period during May/June 2000.

Survey methods were similar to those employed in the north-east Atlantic. All birds and mammals within a 300 m transect to one side of a survey vessel with known position, speed and heading were counted. In addition to this continuous strip transect, all flying birds were sampled using 'snapshot' counts, the frequency of which was determined by the speed of the vessel and the maximum distance ahead of the vessel at which all flying birds could be reliably detected.

Full details of the survey methods can be found in Tasker *et al*. (1984) and Webb and Durinck (1992).

Where possible, additional information regarding the birds' age, characteristic plumage, moult status and feeding behaviour was recorded. For example, where possible, wandering and southern royal albatrosses were assigned to a plumage stage based on the illustrations in Harrison (1983).

The presence of significant 'floating matter', and any influence this had on seabird behaviour, was recorded. This took two main forms: recording the presence or absence of other vessels (including the vessel type, activity and distance from the survey base) and the recording of patches of free-floating kelp.

Seabirds associating with the survey base and those obviously associating with fishing vessels were not counted. This may have led to under-recording of certain species, such as giant petrel species, Cape petrel and wandering albatross species, all of which exhibited a marked tendency to associate with the survey base.

In addition to counts of seabirds and information on the movements of the vessel, records were also kept of environmental conditions. Environmental data allow for comparisons to be made between the conditions under which observations were made and thereby assess one aspect of data quality.

In order to minimise the extent to which adverse weather conditions influenced the quality of survey data, surveys were usually conducted only in wind strengths of less than Beaufort Force 6. Occasionally it was possible to survey in wind speeds greater than Beaufort Force 6, for example, when in sheltered inshore waters. However, all subsequent analysis was carried out on data collected in sea states less than 7. This constraint aims to reduce the error caused by the difficulty in detecting marine mammals and seabirds on the sea surface in increasingly poor weather (see p. 20).

During each cruise survey data were recorded on a set of specially designed forms (see Appendix V).

3 Data handling

During and after each survey cruise all data were transcribed from data sheets onto computer using custom-built software. Several automatic checks are made for logical errors during the data transcription process. Data were checked manually by another member of the survey team for remaining errors before final storage on the South-west Atlantic Seabirds at Sea Database (SWASASD). Data storage is on a fully relational database that allows a full range of standard query-based manipulations.

Correction factors for assessing densities of South Atlantic seabirds

In general, it would be predicted that the detectability of birds on the surface of the sea would be less reliable for distant birds than for close birds. Also, the detectability of larger and more conspicuously coloured species should be more reliable than for smaller, cryptically coloured species. Additionally, detectability should decline as weather conditions deteriorate and sea state increases.

All of these predictions can be tested using survey data and, if required, relevant correction factors can be calculated and applied to the data collected.

During surveys, the perpendicular distance from the track of the vessel to birds on the sea surface was recorded in one of four distance bands within the 300 m transect. These four bands are from 0–50 m (Band A), 50–100 m (Band B), 100–200 m (Band C) and 200–300 m (Band D). Assuming that birds on the water do not alter their behaviour in response to the survey vessel, the numbers of birds encountered in each transect band should occur in the ratio of 1:1:2:2 (A:B:C:D). In order to compensate for lower detection rates of more distant birds on the water, densities of birds on the water were weighted by species-specific correction factors, calculated thus:

Table 3.1 Correction factors applied in estimating densities of South Atlantic seabird species.

Species	*Correction factor*
Gentoo penguin	1.6
Rockhopper penguin	1.7
Magellanic penguin	1.3
Royal albatross spp.	1.1
Black-browed albatross	1.0
Cape petrel	1.4
Antarctic fulmar	1.1
Prion spp.	1.2
White-chinned petrel	1.2
Great shearwater	1.1
Wilson’s storm-petrel	1.4
Grey-backed storm-petrel	1.5
Diving-petrel spp.	1.6
Imperial shag	1.2
Kelp gull	1.2

$$\text{Correction factor} = \frac{3(A+B)}{A+B+C+D}$$

where A, B, C and D represent the numbers of birds recorded in each transect band. This method of calculating correction factors assumes 100% detection in bands A and B.

Correction factors were applied only to records of birds on the water in transect, for those species where more than 1,500 birds were recorded on at least 10 occasions. Species-specific correction factors are presented in Table 3.1.

Data presentation

Four types of maps are presented.

The distribution of common species is represented by the use of density maps. Common bird species are defined as those with greater than 10 records totalling more than 1,500 birds in the three-year period. Bird density is calculated as the number of birds of a species recorded ‘in transect’ divided by the area of sea surveyed (in km^2). This can be calculated for any area and for any time. Usually, density maps are generated at a scale of a ¼ International Council for the Exploration of the Sea (ICES) rectangle (15' latitude by 30' longitude) and on a

monthly basis. Where appropriate, months can then be combined where similar patterns of distribution and/or abundance are exhibited. Correction factors have been applied to common species of seabird for the presentation of density maps.

The distribution of regular species is represented by the use of relative abundance maps. Regular bird species are defined as those with more than 10 records of between 200 and 1,500 birds during the three-year period. Relative abundance is calculated as the number of birds of a species recorded divided by the distance travelled. This can be calculated for any area and for any time. In common with density maps, abundance maps are usually generated at a scale of the ¼ ICES rectangle and on a monthly basis. Where appropriate, months can then be combined where similar patterns of distribution and/or abundance are exhibited.

The distribution of scarce bird species is represented by the use of dot distribution maps. Scarce bird species are defined as those with 10 or more records of fewer than 200 birds during the three-year period. The size and location of the dots indicates both the number of birds recorded and the area in which those birds were recorded. However, in contrast to the previous two methods of presenting the data, results presented using this method are not effort-related. In common with the previous two methods, the number of sightings is summarised per ¼ ICES rectangle in which the species was recorded.

The distribution of marine mammals is represented either by the use of abundance maps as outlined above or by the use of dot distribution maps, depending on the numbers recorded. Marine mammals with more than 10 records totalling more than 200 animals are represented by abundance maps. Those with more than 10 records of less than 200 animals are represented by dot distribution maps. However, for scarce marine mammals the dots are located at the position of the sighting (not summarised per ¼ ICES rectangle) and the dots are not size-scaled.

Those rare birds and mammals with fewer than 10 records have been listed on pp. 74–5 and 83–4 respectively.

For those species with a restricted, coastal distribution, maps were generated at a scale of 1⁄16 ICES rectangle (7.5' latitude by 15' longitude), within a rectangle bounded by south-west co-ordinates 53° 30' S 63° W and north-east co-ordinates 50° S 56° W.

A summary of the treatment applied to each species is given in Tables 3.2(a) and (b).

The maps were produced using DMAP for Windows Version 6.5b, produced by Alan Morton of Blackthorn Cottage, Chawridge Lane, Winkfield, Windsor, Berkshire SL4 4QR, United Kingdom.

In addition to the species distribution maps, histograms of the monthly totals of species are also presented. While the totals are not related to the levels of survey effort in each month, these histograms give a good indication of the broad patterns of seasonal presence and absence of species in Falkland Islands waters.

The distances of birds from the shore were calculated using an application written for Paradox by Andy Webb of the JNCC. This used coastal outlines taken from the GEBCO Digital Atlas produced by the British Oceanographic Data Centre, Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, Merseyside L43 7RA, United Kingdom. The accuracy of the measurements depends on the resolution of the coastal outline used. In all cases this has been consistent, so that it is possible to compare measurements within this report. Where possible cross-reference has been made to charts to check the accuracy of positions and distances, but this has not been possible in every case.

Table 3.2(a) Summary of data handling treatments – seabirds.

Common	*Regular*	*Scarce*	*Rare*
Gentoo penguin	Wandering albatross spp.	King penguin	Sooty albatross
Rockhopper penguin	Northern royal albatross	Chinstrap penguin	Broad-billed prion
Magellanic penguin	Grey-headed albatross	Macaroni penguin	Great-winged petrel
Southern royal albatross	Northern giant petrel	Shy albatross species	White-headed petrel
Black-browed albatross	Blue petrel	Light-mantled albatross	Spectacled petrel
Southern giant petrel	Fairy prion	Antarctic petrel	Cory's shearwater
Cape petrel	Atlantic petrel	Kerguelen petrel	Manx shearwater
Antarctic fulmar	Soft-plumaged petrel	Grey petrel	Chilean skua
Prion species	Black-bellied storm-petrel	Little shearwater	Cayenne tern
White-chinned petrel	Rock shag	White-bellied storm-petrel	Grey phalarope
Great shearwater	Falkland steamer duck	Magellan diving-petrel	
Sooty shearwater	*Catharacta* species	Arctic skua	
Wilson's storm-petrel	Long-tailed skua	Brown-hooded gull	
Grey-backed storm-petrel		Dolphin gull	
Diving-petrel species		*Sterna* species	
Imperial shag		Arctic tern	
Kelp gull			
South American tern			

Table 3.2(b) Summary of data handling treatments – marine mammals.

Regular	*Scarce*	*Rare*
Long-finned pilot whale	Fin whale	Southern right whale
Hourglass dolphin	Sei whale	Humpback whale
Peale's dolphin	Minke whale	*Mesoplodon* spp.
Commerson's dolphin	Sperm whale	Killer whale
Fur seal species	Southern bottlenose whale	Southern rightwhale dolphin
	South American sea lion	
	Southern elephant seal	

4 Results

At-sea surveys were carried out in every month between February 1998 and January 2001. Surveys have continued since then but are not considered here. Surveys were conducted throughout the south-west Atlantic – as far north as 35° S (Black 1999), south to 65° S (White and Gillon 2000), east to 28° W (White and Gillon 2000) and west to 70° W (Gillon *et al*. 2000). All data collected are held on the SWASASD. The majority, over 82%, of survey effort was conducted within Falkland Islands waters. This analysis includes all survey effort within a rectangle defined by south-west co-ordinates 56° S 64° W and north-east co-ordinates 47° S 52° W.

Survey effort

In total, 91 survey cruises were conducted during the three years. In most cases single observers were on board, with the remainder being conducted with two observers. These joint surveys were used to either standardise data collection between observers or to train new or inexperienced observers. A complete list of cruises including dates and survey effort is given in Appendix II.

A total of 20,907 km² of survey effort was conducted within the study area in the period under consideration. Monthly survey effort ranged from a low of 262.2 km² in November 2000 to a high of 1,546.7 km² in November 1998 (Table 4.1 and Figure 4.1), with an average monthly survey effort of 676.5 km².

Following the first year of survey work it was considered necessary to extend the project to improve survey coverage and investigate inter-annual variations in seabird and marine mammal distribution. In subsequent years, 'new' survey coverage has been achieved in all months (Table 4.1). However, in each successive year, significantly more effort is needed to achieve coverage in a 'new' ¼ ICES rectangle (Kruskal–Wallis $K = 17.3$, $p = 0.01$, $d.f. = 2$).

Although the FPVs have enabled good coverage over the past three years, in future the use of vessels specifically chartered to target areas and seasons with low survey coverage would be advantageous. This was highlighted in May and June 2000 when the MV *Golden Fleece* was chartered for a period of two weeks. During this period, effort was concentrated on the SCA, which had received very little survey coverage at this time during preceding years.

Over the three years monthly survey effort ranged from a low of 1,345 km² in February to a high of 2,356 km² in November with an average of 1,742 km². The combined monthly totals of survey effort are shown in Figure 4.2.

Figures 4.3–4.14 show the distribution of survey effort in each month.

The distribution of all the survey effort achieved in the period under review is shown in

Table 4.1 Summary of survey effort and the number of 'new' ¼ ICES rectangles per month.

	1998		*1999*		*2000*		*2001*	
Month	*Effort (km²)*	*'new' ¼ ICES*	*Effort (km²)*	*'new' ¼ ICES*	*Effort (km²)*	*'new' ¼ ICES*	*Effort (km²)*	*'new' ¼ ICES*
Jan			1159.4	154	472.8	39	820.7	47
Feb	363.7	56	508.8	82	472.4	25		
Mar	433.9	49	949.9	63	699.2	50		
Apr	403.9	37	371.1	28	704.1	40		
May	420.5	48	448.2	24	528.9	46		
Jun	881.2	116	504.2	30	390.3	27		
Jul	716.7	105	862.4	104	344.8	18		
Aug	922.6	104	609.9	81	592.3	41		
Sep	999.6	114	1278.8	119	457.7	39		
Oct	719.8	85	980.3	111	293.7	24		
Nov	1546.7	176	881.8	64	262.6	20		
Dec	1103.1	132	510.3	67	738.8	30		

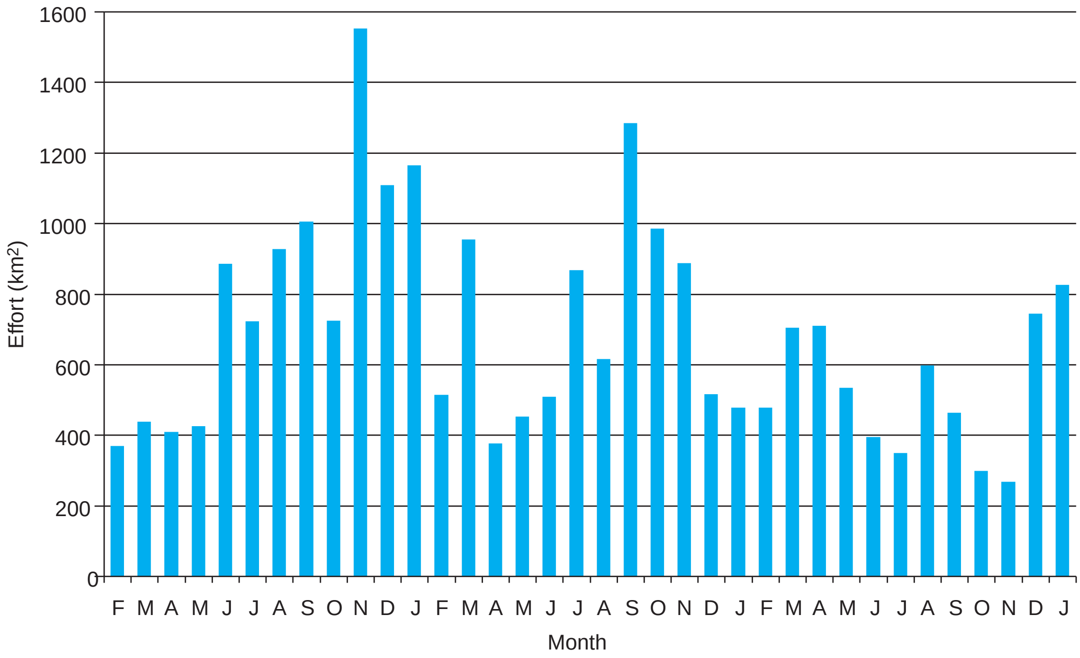

Figure 4.1 Survey effort (km²) achieved in each month, February 1998 to January 2001.

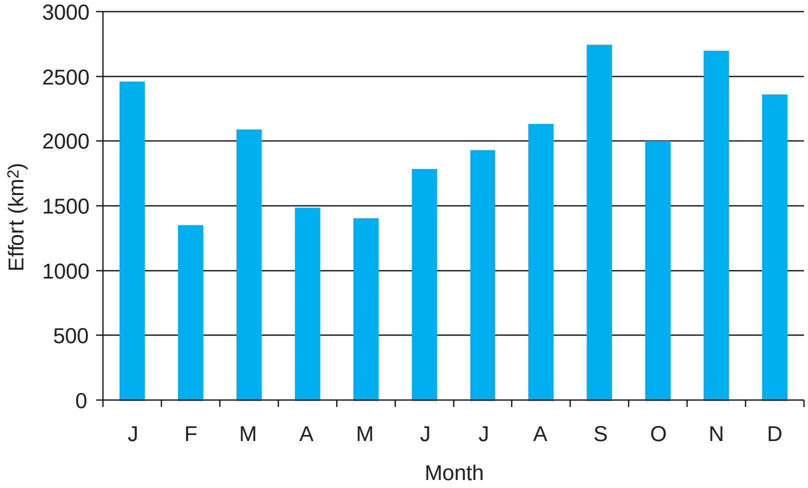

Figure 4.2 Survey effort (km²) by month over the three years of the project.

Figure 4.15. Highest levels of effort were concentrated over Patagonian Shelf waters, particularly waters around Stanley and in the west of the survey area. This reflects the fact that the FPVs are based in Stanley and their tendency to patrol the western borders of the conservation zones.

Species richness

The total survey effort achieved in each ¼ ICES rectangle (Figure 4.15) closely reflects the total number of species recorded (Figure 4.16). Highest species richness was found in Patagonian Shelf waters and in the vicinity of the 1,000 m isobath to the north-east of the islands; the areas with the highest levels of survey effort. It is therefore evident that increased survey coverage increases the number of seabird species recorded.

On a monthly basis, an increase in the level of survey effort also results in an increase in the number of species recorded. The rate of this increase is greatest between zero and 20 km² of survey effort. However, for levels of survey effort above 20 km² per month there is little increase in the number of species recorded (Figure 4.17).

The distribution of many species can be linked to water depth. Consequently, each ¼ ICES rectangle was assigned a depth class. Monthly survey effort within each depth class is shown in Figure 4.18. For operational reasons, the FPVs infre-

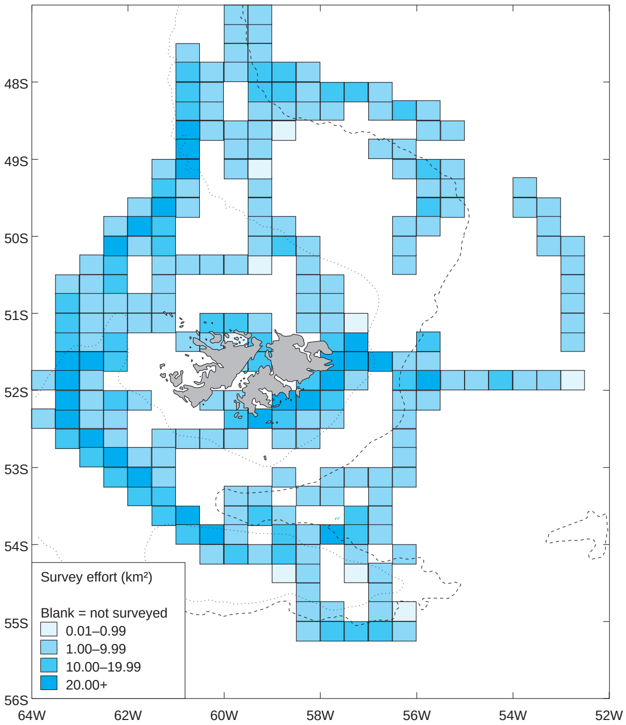

Figure 4.3 Distribution of survey effort, January.

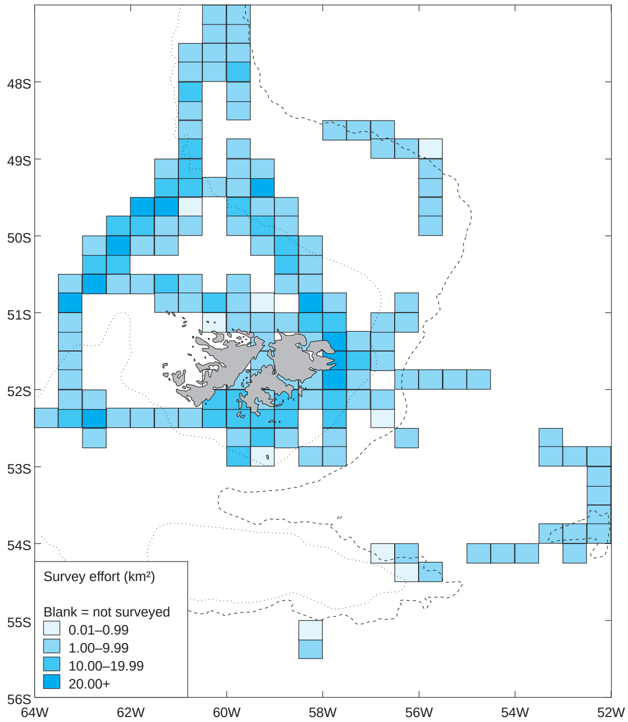

Figure 4.4 Distribution of survey effort, February.

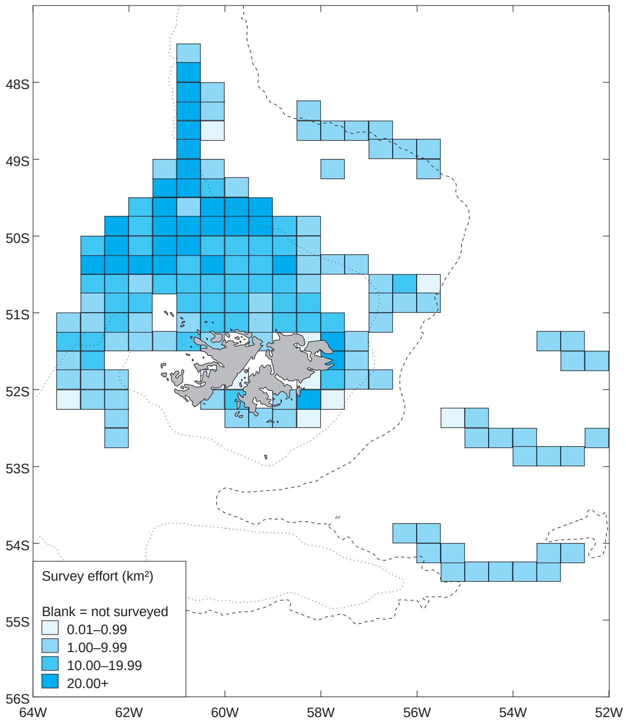

Figure 4.5 Distribution of survey effort, March.

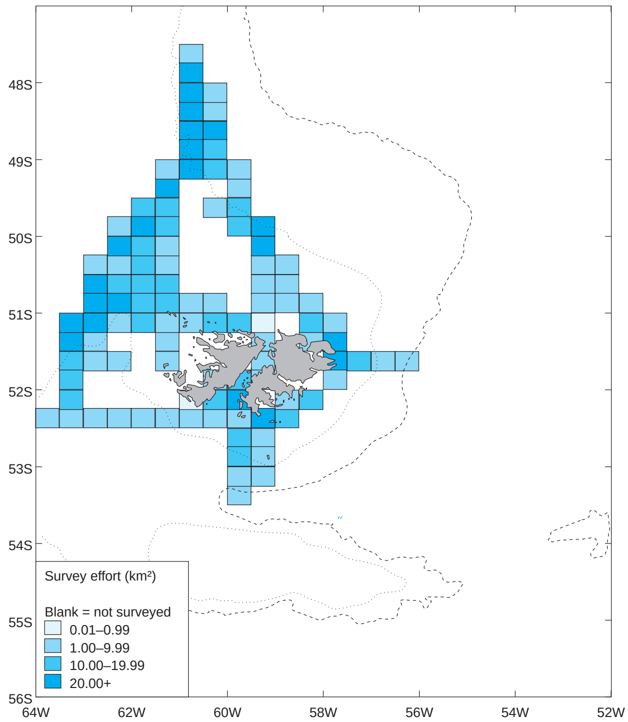

Figure 4.6 Distribution of survey effort, April.

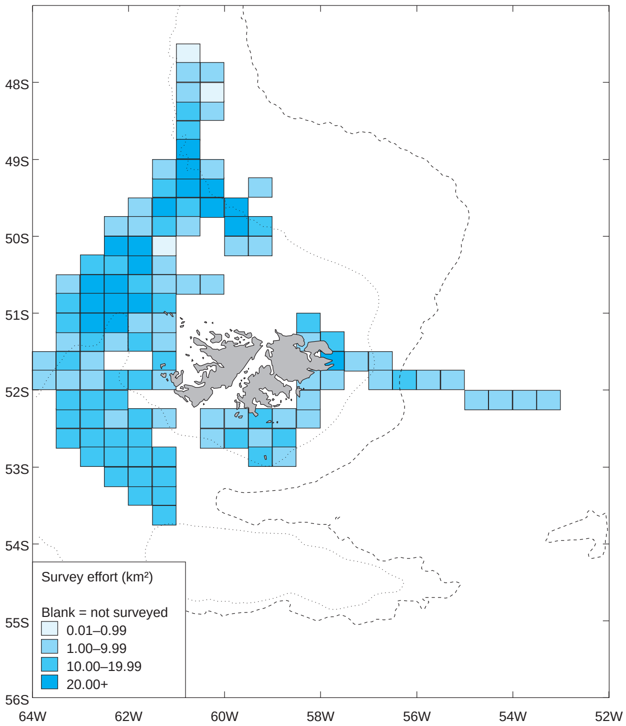

Figure 4.7 Distribution of survey effort, May.

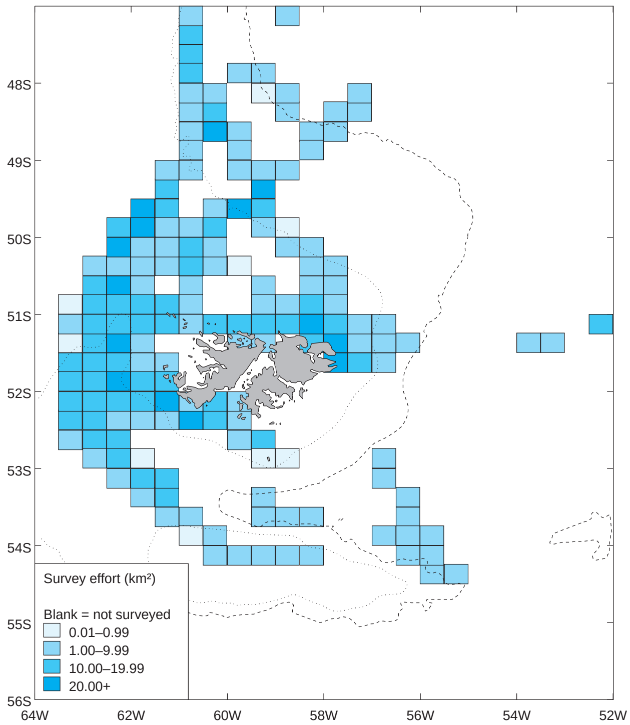

Figure 4.8 Distribution of survey effort, June.

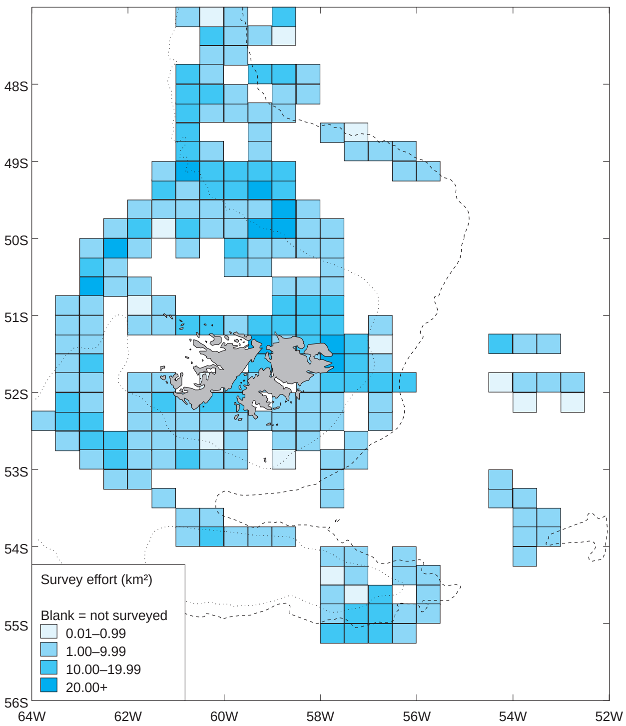

Figure 4.9 Distribution of survey effort, July.

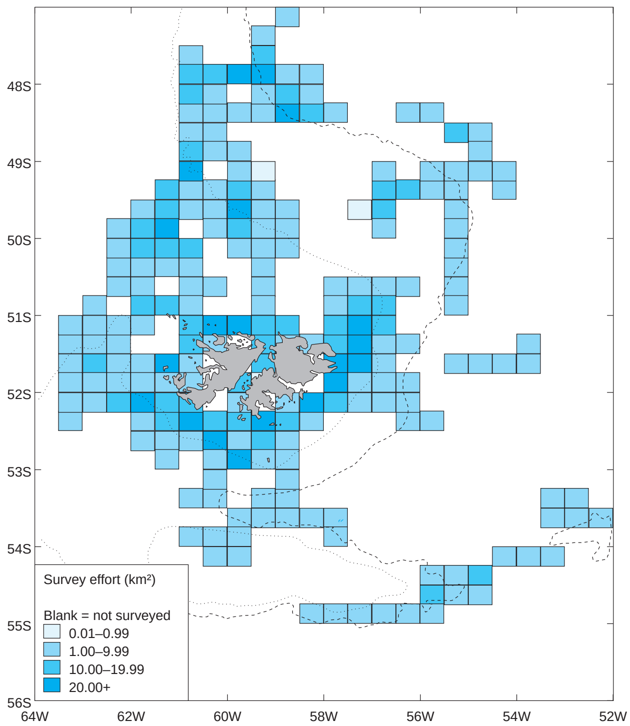

Figure 4.10 Distribution of survey effort, August.

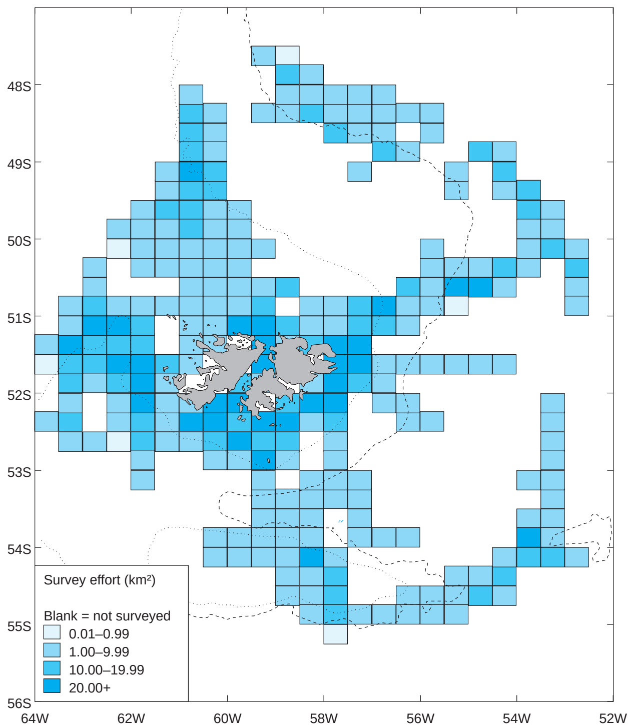

Figure 4.11 Distribution of survey effort, September.

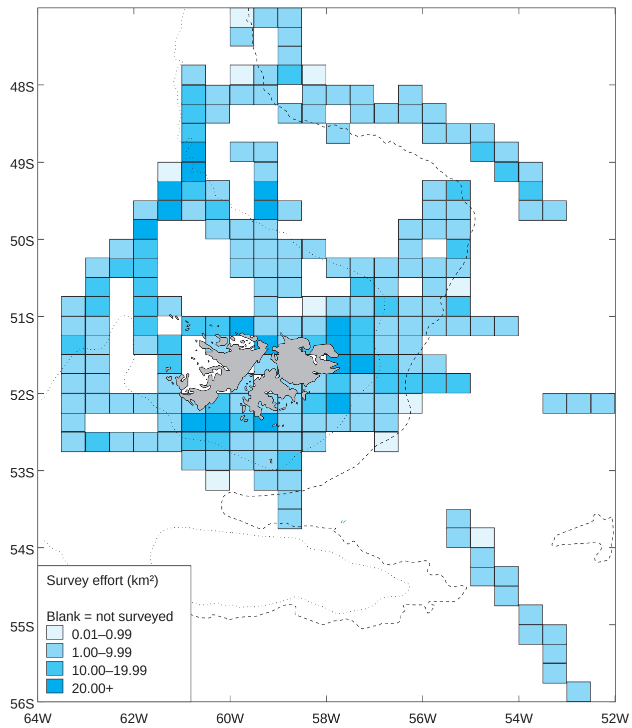

Figure 4.12 Distribution of survey effort, October.

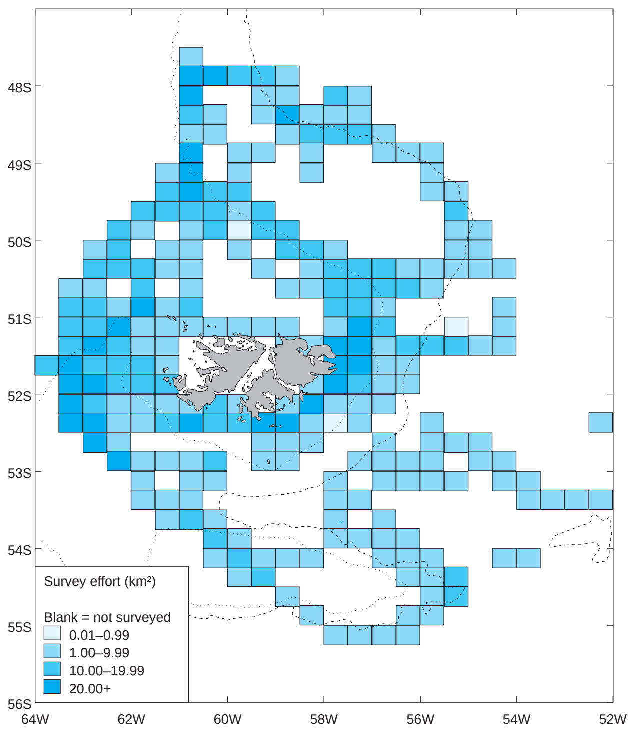

Figure 4.13 Distribution of survey effort, November.

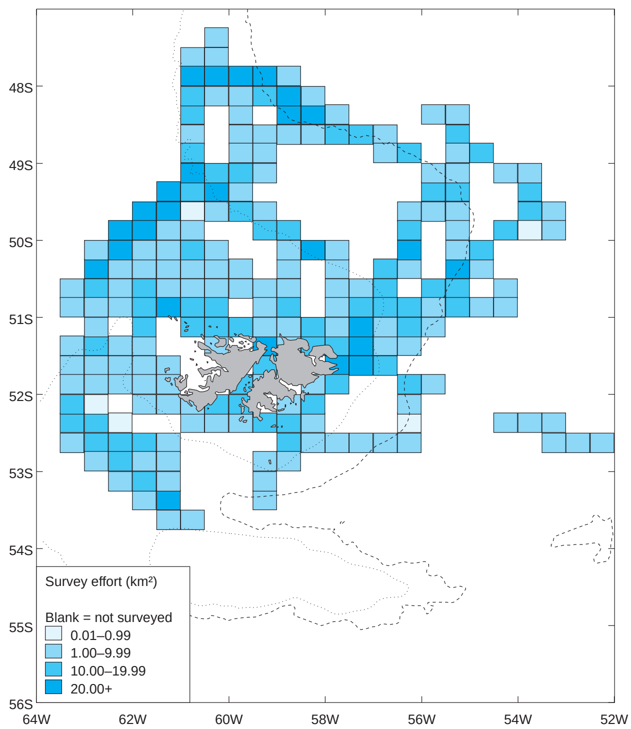

Figure 4.14 Distribution of survey effort, December.

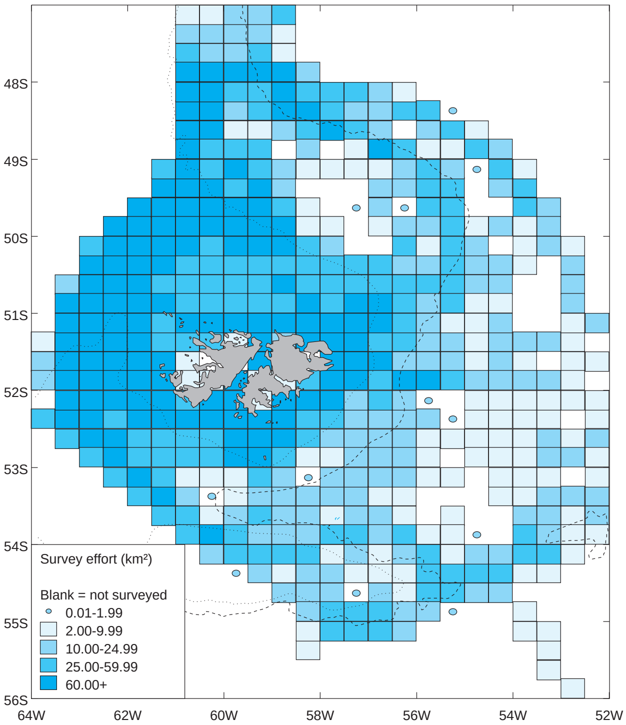

Figure 4.15 Total survey effort in all months.

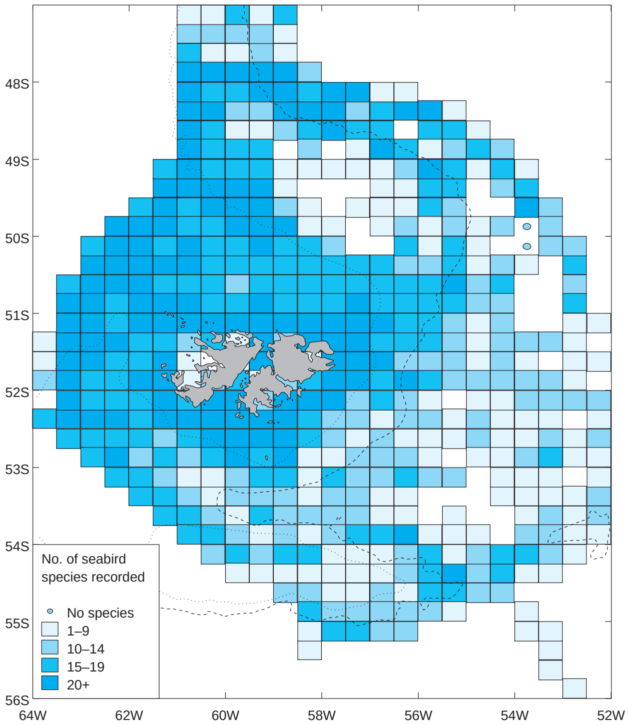

Figure 4.16 Total survey number of seabird species recorded in all months.

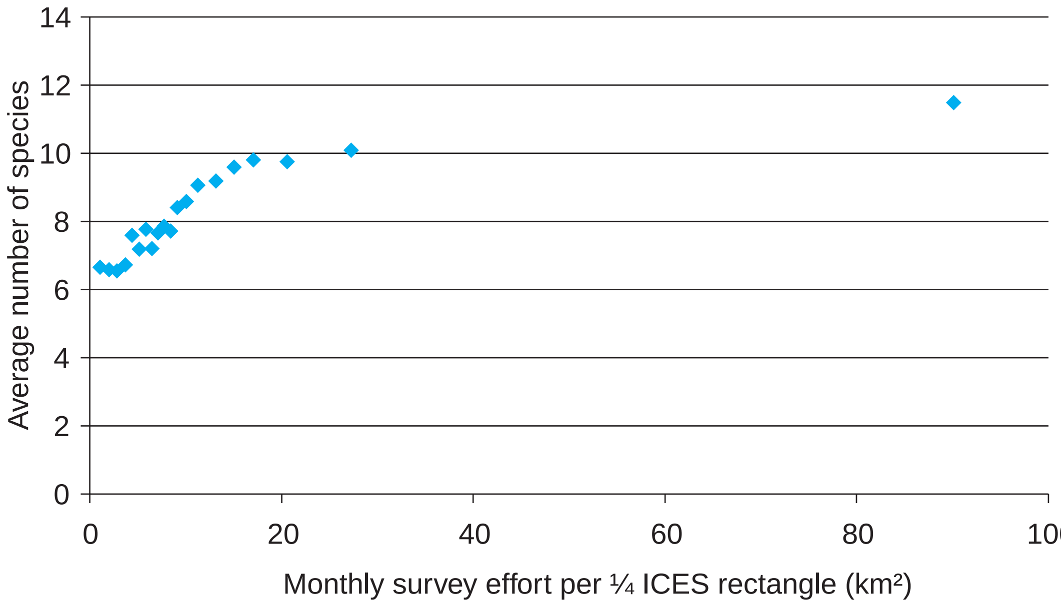

Figure 4.17 Species discovery curve – species richness (number of species per ¼ ICES rectangle per month) with respect to monthly survey effort (km² per ¼ ICES rectangle).

quently patrol oceanic waters (>1,000 m deep) between February and June; this is reflected in survey coverage.

During surveys, a ten minute period in which no birds were recorded were noted as a 'No Birds' period. The distribution of these periods, as a percentage of total effort within each ¼ ICES rectangle, is shown in Figure 4.19. It is clear that a greater proportion of survey effort in deep-water areas produced 'No Birds' records than that over Patagonian Shelf waters. This reflects the generally low densities of birds encountered in deep-water areas.

Survey conditions

The amount of survey effort achieved during each sea state is shown in Figure 4.20. It is evident that

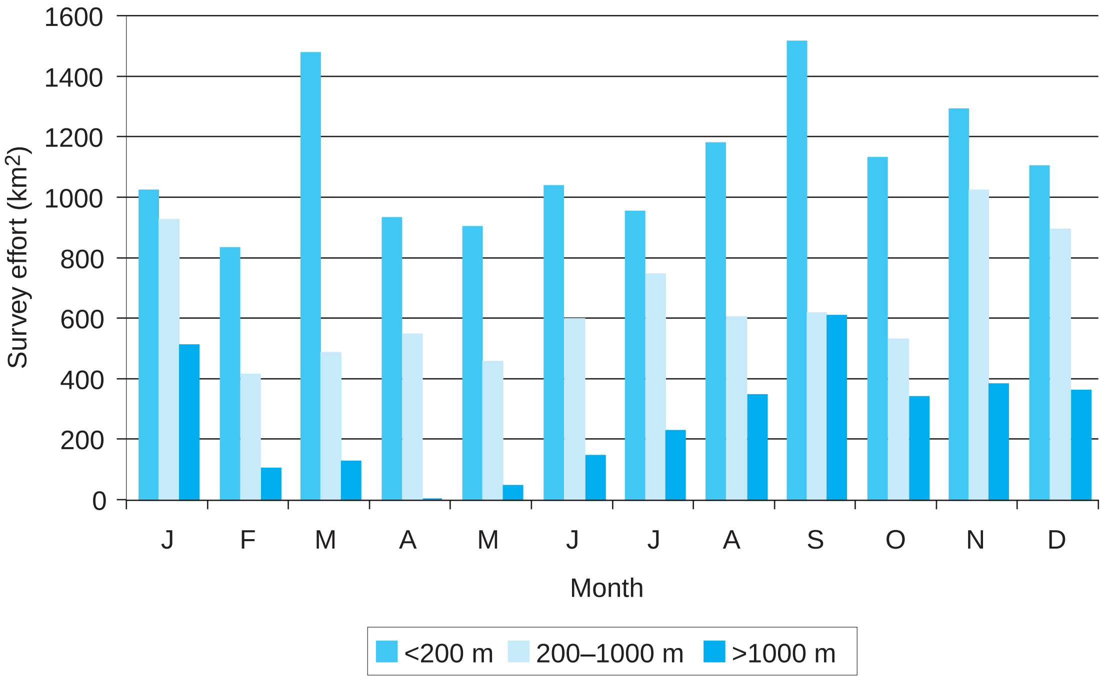

Figure 4.18 Monthly distribution of survey effort by depth.

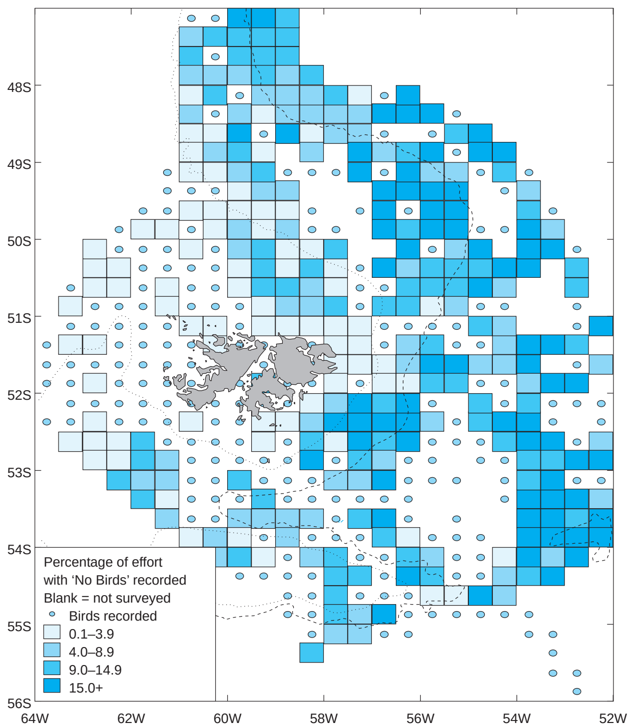

Figure 4.19 Distribution of survey effort with 'No Birds' recorded.

the majority of survey effort was conducted during sea states 3 and 4, reflecting the average wind speed in the Falklands of 17 knots (Richardson 1997). There is little variation in the average sea state during surveys throughout the year (Figure 4.21). The wind direction during surveys was predominantly from the western quadrant (Figure 4.22).

Floating matter

Fishing vessels

Fishing vessels regularly attract large numbers of scavenging seabirds. While this analysis excludes those birds and marine mammals that are directly associated with such vessels, their influence is likely to extend over several km², affecting seabird and marine mammal dispersion in a complex manner. The distribution of fishing vessels present during surveys is shown in Figures 4.23(a)–(d). Data are expressed as the percentage of survey effort conducted in the presence of fishing vessels.

Between February and June, large numbers of jiggers and trawlers, mostly targeting *Illex* squid, are present over the Patagonian Shelf (Figure 4.23(a)). During July, following the end of the *Illex* season, few vessels continue to fish within Falkland Islands waters (Figure 4.23(b)). The 'second' fishing season in Falkland Islands waters begins in August. At this time a number of trawlers are licensed to fish for finfish and *Loligo* squid over Patagonian Shelf waters (Figure 4.23(c)). During December and January, fishing effort within Falkland Islands waters is low (Figure 4.23(d)).

Throughout the year, two longliner vessels are licensed to fish for Patagonian toothfish in waters greater than 600 m in depth. These vessels are occasionally encountered while surveying the deeper waters of the FOCZ (Figures 4.23(a)–(d)).

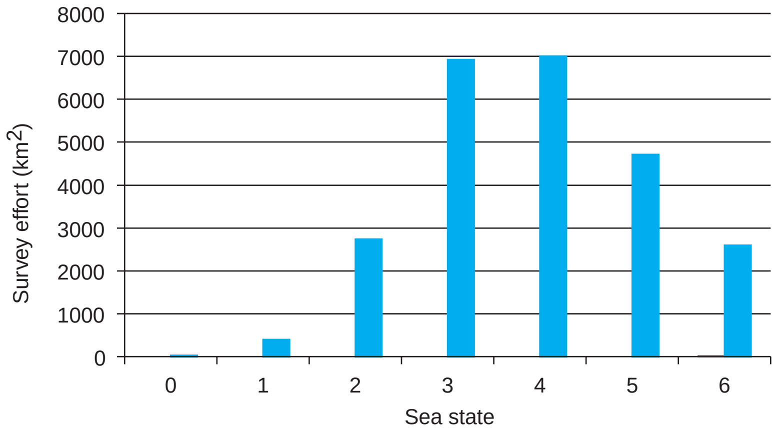

Figure 4.20 Distribution of survey effort relative to sea state.

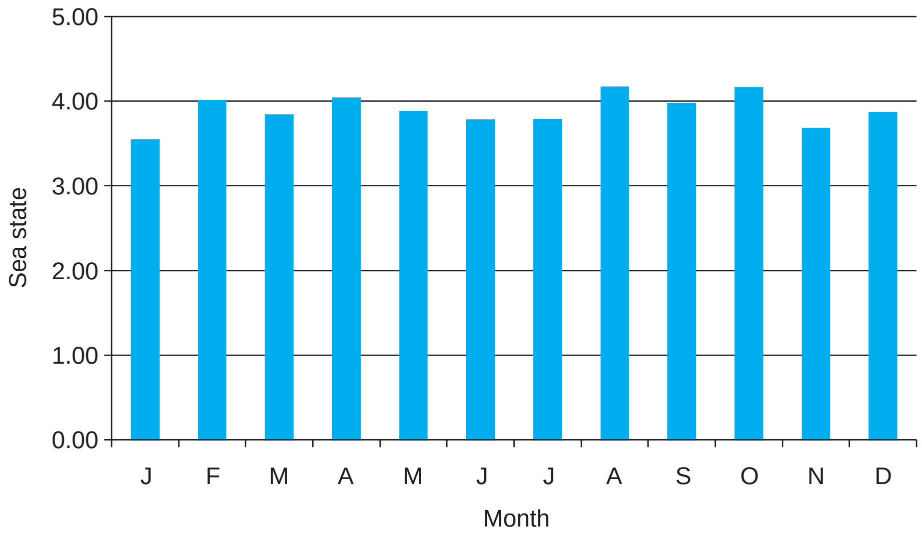

Figure 4.21 Monthly variation in sea state during surveys.

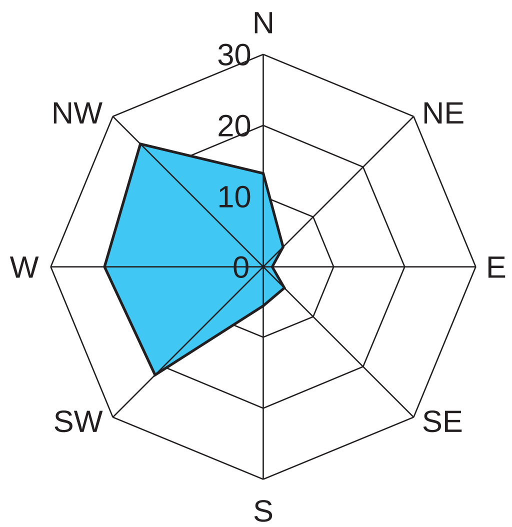

Figure 4.22 Wind rose showing percentage of survey conducted under different wind directions.

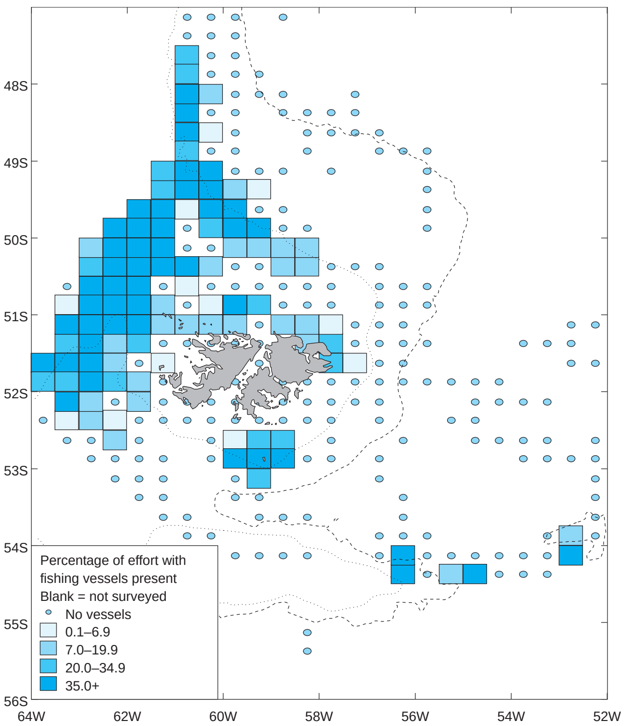

Figure 4.23(a) Distribution of fishing vessels during surveys, February to June.

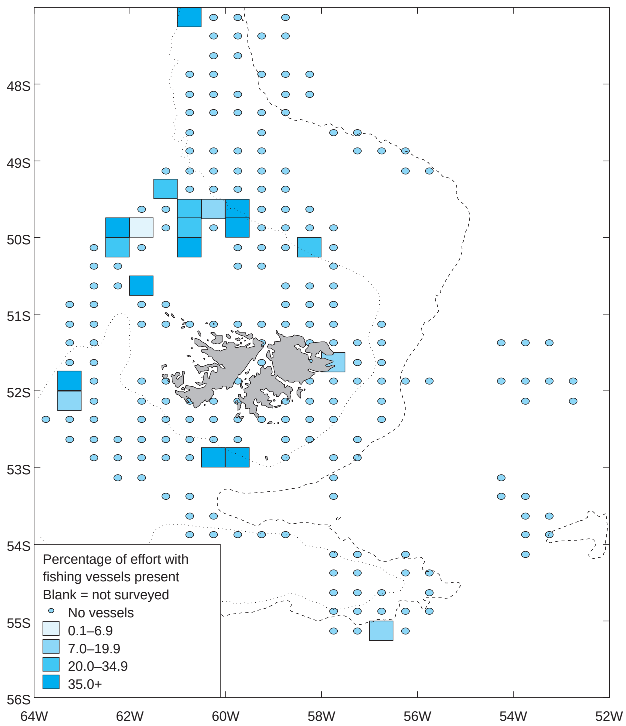

Figure 4.23(b) Distribution of fishing vessels during surveys, July.

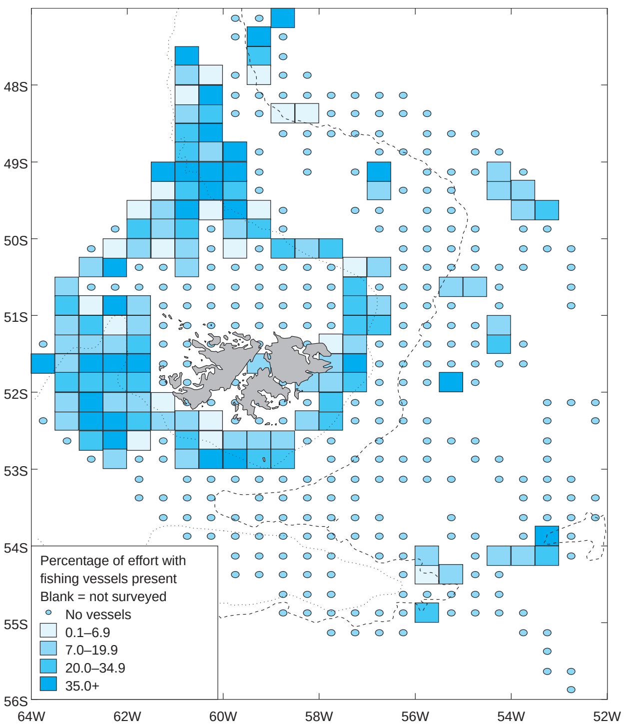

Figure 4.23(c) Distribution of fishing vessels during surveys, August to November.

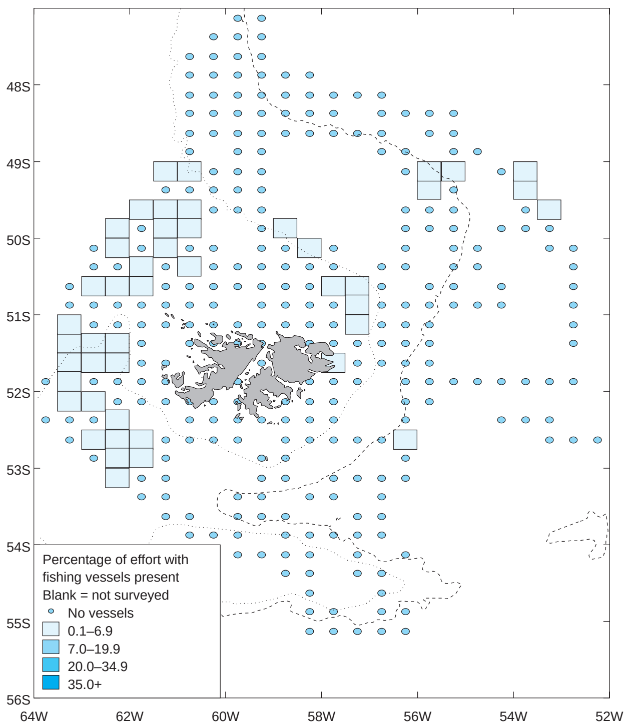

Figure 4.23(d) Distribution of fishing vessels during surveys, December to January.

Kelp

Patches of free-floating kelp were frequently encountered throughout the year (Figure 4.24(a)). The lower numbers encountered from February to June probably relate to survey coverage, which is concentrated over Patagonian Shelf waters where low densities of kelp were recorded throughout the year (Figure 4.24(b)). The low numbers of kelp recorded between February and May (Figure 4.24(a)) probably reflects the bias in survey coverage towards the north-west of the survey area in

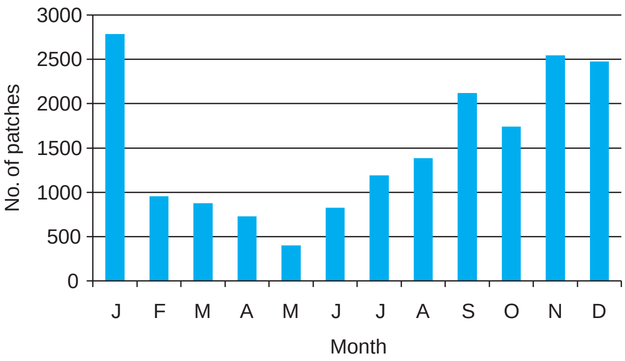

Figure 4.24(a) Number of patches of kelp recorded in each month.

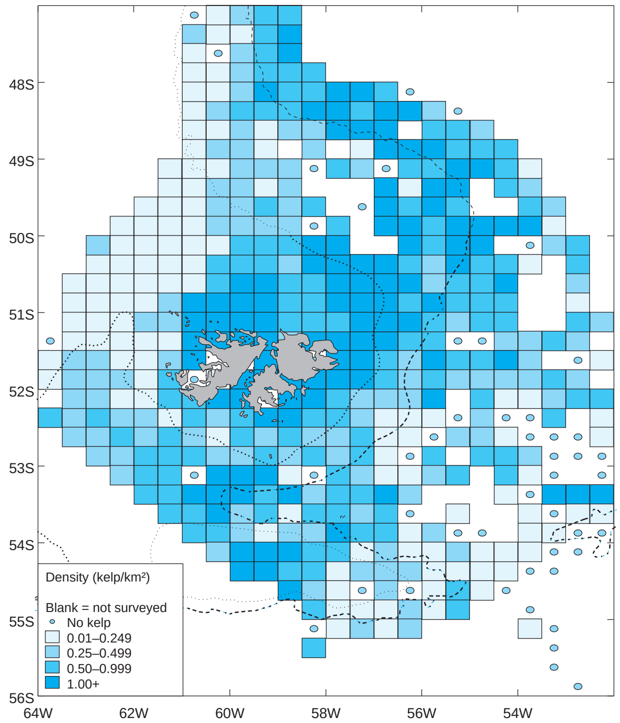

Figure 4.24(b) Distribution and abundance of kelp patches, all months.

these months; an area of low kelp densities. The distribution of free-floating kelp patches (Figure 4.24(b)) suggests that they drift to the north-east of the islands then along the 1,000 m isobath probably carried by the Falklands/Malvinas Current. As would be expected, high densities of kelp patches were encountered in inshore waters, near the extensive kelp beds around the coast of the Falkland Islands. Kelp patches recorded to the south of the islands were likely to originate from continental South America.

During surveys, 22 species of seabirds were recorded associating with free-floating patches of kelp. Of these, grey-backed storm-petrels were recorded most frequently and appeared to exploit the patches as sources of food (Gillon *et al.* 2001).

Seabirds

A total of 399,753 seabirds of 57 species was recorded during surveys. Five species not recorded in the study area during the first year of surveys (White *et al.* 1999) were recorded in subsequent years. The number of records and the total number of each species recorded is summarised in Appendix IVa.

Penguins Spheniscidae

Of the 17 species of penguin, five or six breed in the Falkland Islands while a further five or six have been recorded as vagrants (Woods 1988; Strange 1992). Three of the breeding species – rockhopper, gentoo and Magellanic penguins – are present in internationally important numbers. Six species of penguins were recorded during surveys – all five of the regularly breeding species and one vagrant.

The detection and identification of penguins at sea was one of the more significant challenges facing observers. However, with experience, this did not prove to be as daunting as originally anticipated. Penguins proved to be the most difficult seabirds to detect at ranges greater than 100 m from the survey base, in particular eudyptid penguins (see p. 20). In total, 1.4% of penguins were recorded as unidentified (excluding those penguins recorded as ‘rockhopper/macaroni’ penguin). Unidentified penguins were recorded in all months and throughout the survey area. There was some seasonal variation in the proportion of unidentified penguins, with monthly values ranging from a low of 0.4% in January to a peak of 7.1% in July. These birds have not been included in this analysis.

King penguin Aptenodytes patagonicus

The Falkland Islands support a small but growing population of king penguins, with approximately 300 chicks raised annually indicating a total population of about 500 pairs (K. Pütz pers. comm.).

A total of 151 king penguins was recorded on 81 occasions. With the exception of one record in March, all records were in the period May to November (Figure 4.25(a)) with the majority (88.9%) between June and September. In these months birds were recorded throughout the survey area, with most records from continental shelf slope waters to the north of the islands with 61.1% of records north of 50° S (Figure 4.25(b)). Between October and March there were only eight records of king penguins, all but one of which were south of 50° S (Figure 4.25(c)). Although the breeding pop-

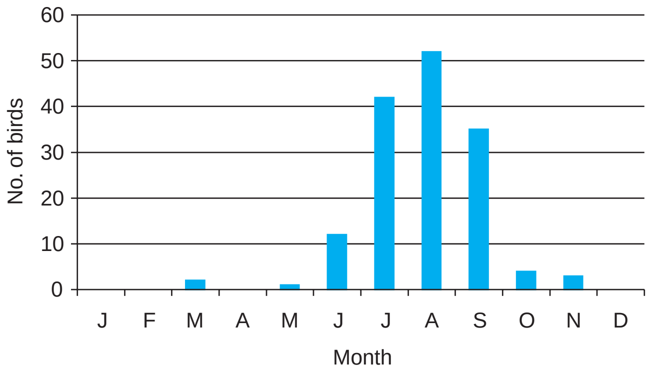

Figure 4.25(a) Number of king penguins recorded in each month.

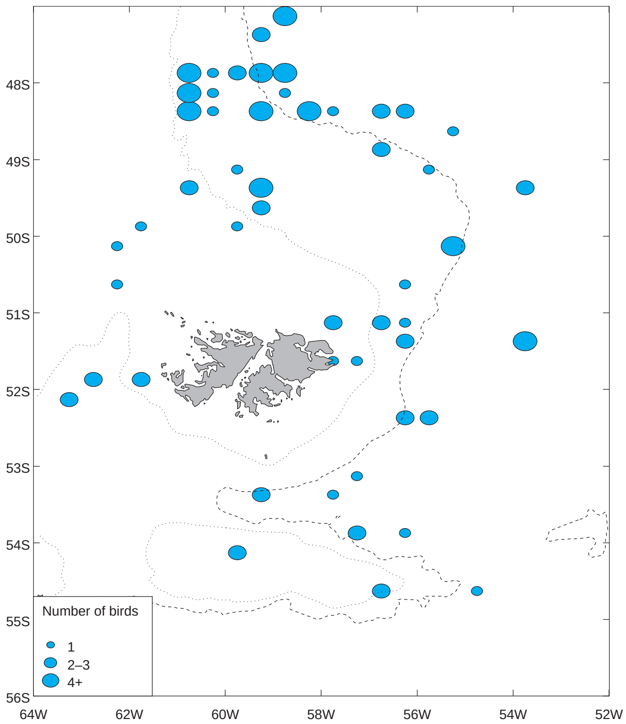

Figure 4.25(b) Distribution of king penguin sightings, June to September.

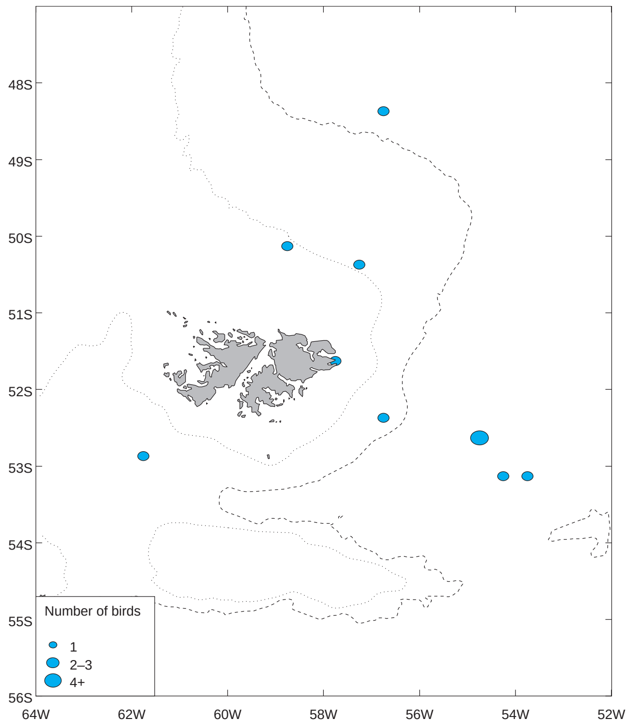

Figure 4.25(c) Distribution of king penguin sightings, October to May.

ulation is present year round, there were no records between December and February.

Gentoo penguin Pygoscelis papua

The gentoo penguin is a resident breeding species in the Falkland Islands. A census of the population in 2000/2001 produced an estimate of 113,000 breeding pairs (Clausen 2001), making the Falkland Islands the second most important location for this species after South Georgia (Ellis *et al*. 1998).

A total of 3,896 gentoo penguins was recorded, with records in all months (Figure 4.26(a)). While gentoo penguins are resident in the Falkland Islands, there was a distinct seasonal variation in the numbers recorded during surveys with a marked increase in the non-breeding season between April and September.

Between December and March, gentoo penguin dispersion is closely linked to inshore waters (Figure 4.26(b)). During this period, highest densities were recorded to the south of Falkland Sound with locally high densities in other coastal waters. At this time, all gentoo penguin records were less than 81 km from the coast.

From April to November, gentoo penguins dispersed widely over the Patagonian Shelf waters surrounding the Falkland Islands with records up 316 km from the coast. Inshore waters to the south of Falkland Sound supported the highest densities of gentoo penguins, with locally high densities recorded throughout other inshore areas. Densities in offshore areas were generally low and very few birds ventured into waters deeper than 200 m (Figure 4.26(c)). One unusual feature of gentoo penguin distribution at this time was the rela-

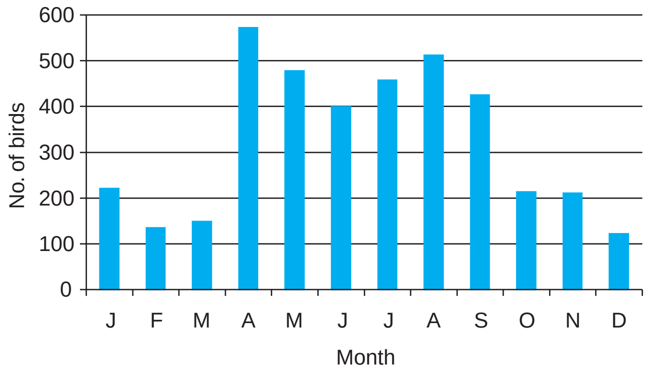

Figure 4.26(a) Number of gentoo penguins recorded in each month.

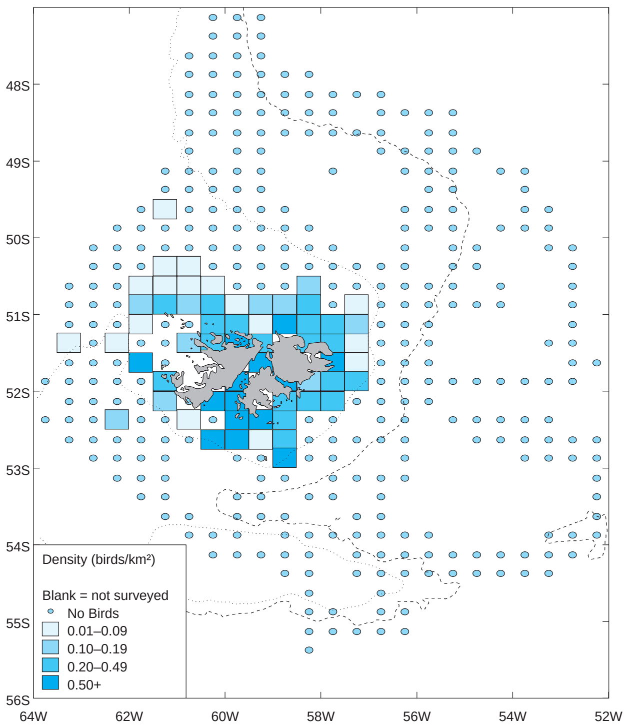

Figure 4.26(b) Gentoo penguin distribution and abundance, December to March.

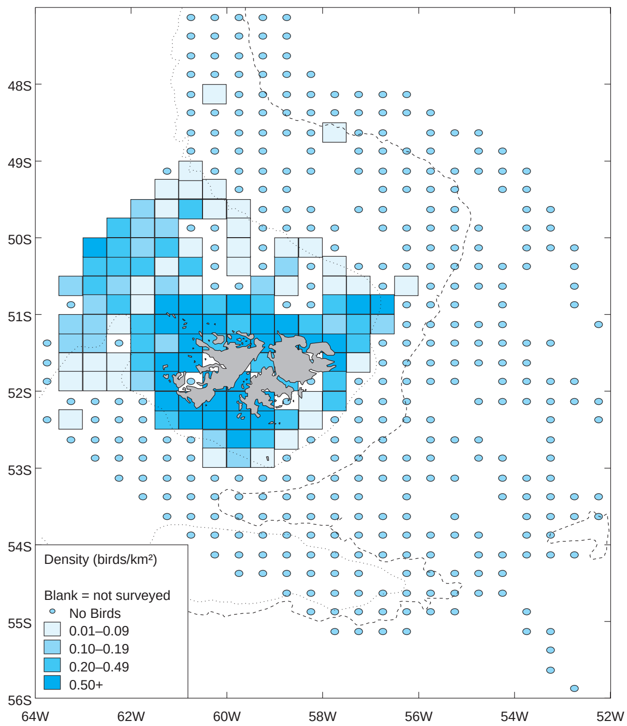

Figure 4.26(c) Gentoo penguin distribution and abundance, April to November.

tively low densities of birds in Patagonian Shelf waters to the north of West Falkland.

A significantly higher proportion of gentoo penguins was recorded in groups (>1 bird) from April to November than during the December to March period ($c^2 = 333.76$, *d.f.* = 1, $p = 0.01$).

Chinstrap penguin P. antarctica

Chinstrap penguins do not breed in the Falkland Islands, although occasional birds are recorded onshore. For example, for several years in the late 1990s one bird was recorded each summer in a gentoo penguin colony on Saunders Island. The nearest chinstrap penguin colony is 1,000 km to the south of the Falkland Islands in the South Shetland Islands.

A total of 24 chinstrap penguins was recorded, on 10 occasions. All records occurred between August and October (Figure 4.27(a)) and all were in the extreme south-east of the survey area (Figure 4.27(b)). The location and seasonality of records indicates that Falkland Islands waters lie at the northern limit of this species' winter range.

Rockhopper penguin Eudyptes chrysocome and macaroni E. chrysolophus penguin

It was not always possible to be certain of the specific identification of eudyptid penguins at sea, although with good views the two species were found to be readily separable. Consequently, over 53% of eudyptid penguins were recorded as 'rockhopper/macaroni' penguin. The vast majority of sightings probably relate to rockhopper pen-

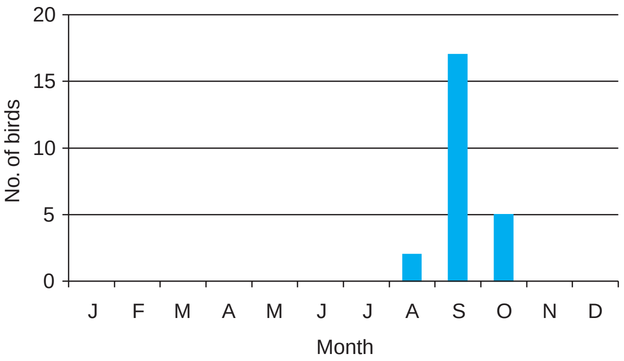

Figure 4.27(a) Number of chinstrap penguins recorded in each month.

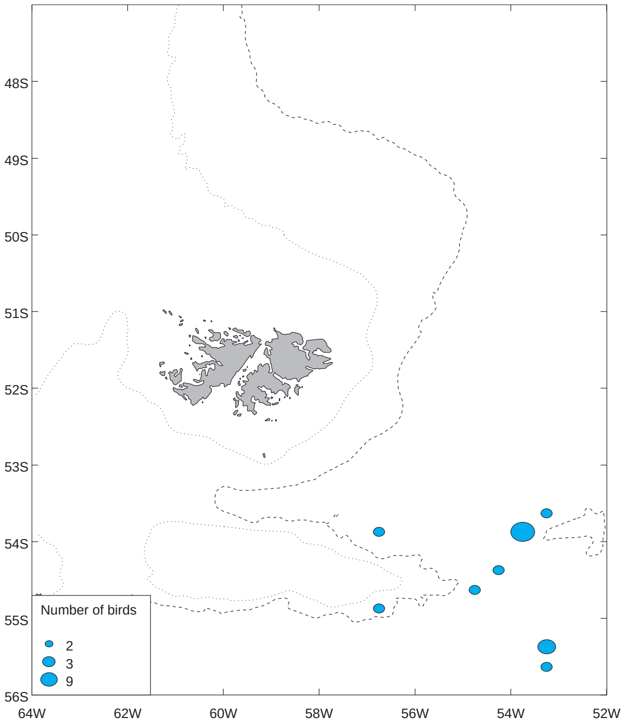

Figure 4.27(b) Distribution of chinstrap penguin sightings, August to October.

guins, the commoner breeding species in the Falkland Islands by a factor of about 10,000 pairs to one (Woods and Woods 1997).

Rockhopper penguins are primarily breeding season visitors to Falkland Islands waters. Numbers of rockhopper penguins breeding in the Falkland Islands declined dramatically during the latter part of the 20th century (Clausen 2001). The reasons for this are unknown, but a large die-off in 1985/86 was linked to a shortage of food in the pre-moult period (Keymer 1988). As a result of this decline and the discovery of a much larger population of rockhopper penguins on Isla de los Estados, Argentina, than was previously suspected (Schiavini 2000), the Falkland Islands now supports about 40% of the world population of southern rockhopper penguins (Clausen 2001).

A total of 2,980 eudyptid penguins was recorded. Of these, 1,357 were identified as rockhopper penguins, 45 as macaroni penguins and 1,578 as 'rockhopper/macaroni' penguin.

As it is considered that most 'rockhopper/macaroni' penguin records relate to rockhopper penguins, these records have been combined with rockhopper penguin records for this analysis. Macaroni penguin records have been analysed separately.

Most rockhopper penguin records were between September and April with lower numbers between May and August (Figure 4.28(a)). From these figures, it appears that rockhopper penguin numbers decrease by approximately 89% during the non-breeding season (May to August) when compared with the breeding season (November to February) (*cf.* Magellanic penguin below).

At the start of the breeding season, between September and November, rockhopper penguins were recorded throughout the conservation zones, with locally very high densities encountered over Patagonian Shelf slope waters and the Burdwood Bank (Figure 4.28(b)). From December to March, the highest densities of rockhopper penguins were largely restricted to coastal and Patagonian Shelf waters (Figure 4.28(c)). During the non-breeding season, April to August, rockhopper penguins were recorded in low to locally high densities throughout the conservation zones with widespread records from the west of the survey area (Figure 4.28(d)). Some of the records from deep waters to the north-east of the survey area at this time may relate to macaroni penguins.

A total of 45 macaroni penguins was recorded on 13 occasions between June and October (Figure 4.28(e)). In addition, some macaroni penguins may have been recorded as unidentified 'rockhopper/macaroni' penguins (see above). All the sightings occurred near the 1,000 m isobath to the north and east of the islands (Figure 4.28(f)).

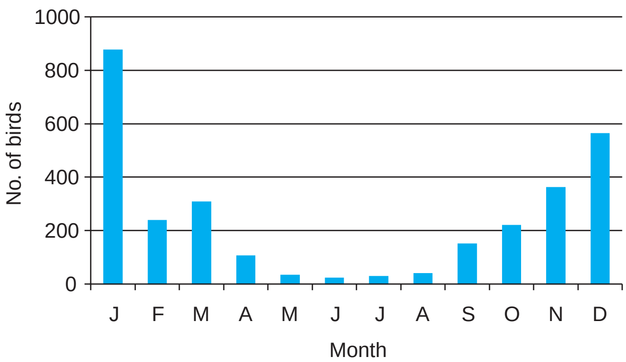

Figure 4.28(a) Number of rockhopper penguins recorded in each month.

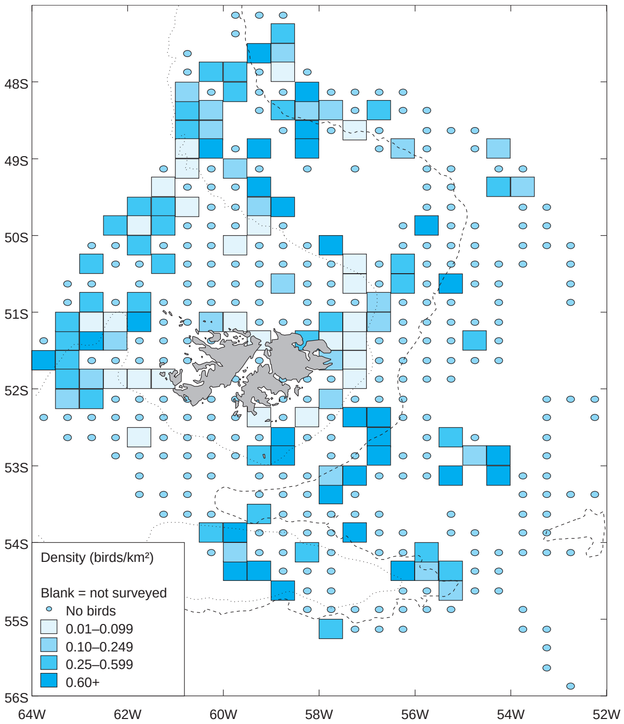

Figure 4.28(b) Rockhopper penguin distribution and abundance, September to November.

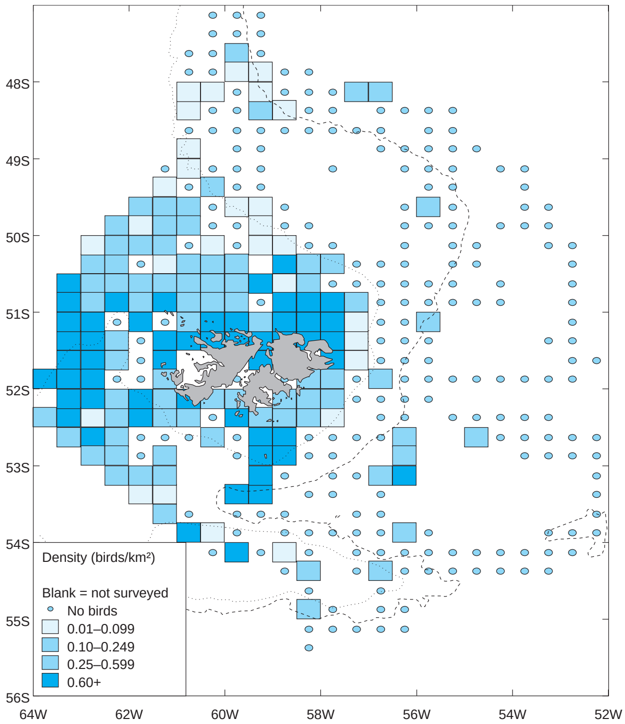

Figure 4.28(c) Rockhopper penguin distribution and abundance, December to March.

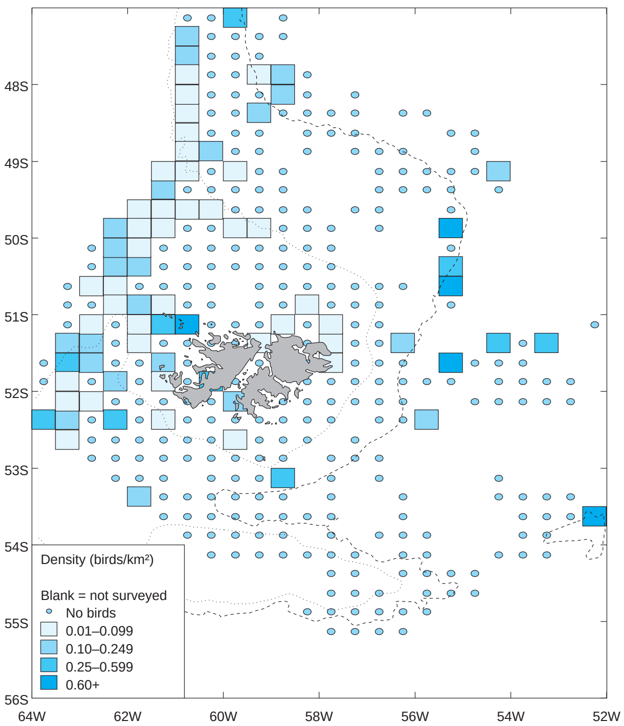

Figure 4.28(d) Rockhopper penguin distribution and abundance, April to August.

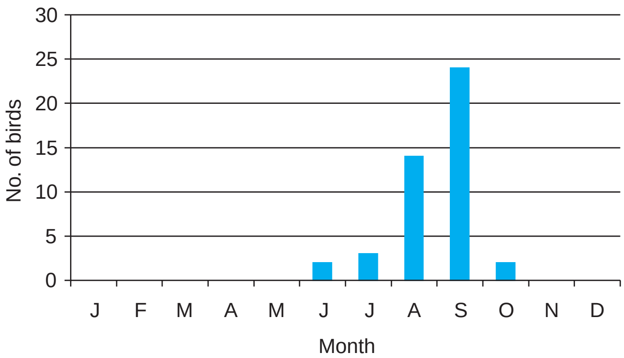

Figure 4.28(e) Number of macaroni penguins recorded in each month.

The highly seasonal nature of macaroni penguin records, combined with the very small breeding population within the islands (Table 1.1), suggests that these birds come from the much larger South Georgian population which numbers about 2.75 million pairs (Prince and Poncet in Woehler and Croxall 1997) (*cf.* king penguin, fur seal species).

Magellanic penguin Spheniscus magellanicus

The Magellanic penguin is a summer breeding visitor to the Falkland Islands. The population is estimated to be between 76,000 and 142,000 pairs (Woods and Woods 1997), although this species' burrow-nesting habits make it extremely difficult to census accurately.

Magellanic penguins were the commonest penguin species recorded during surveys. The majority of the 12,033 birds were encountered between November and April (Figure 4.29(a)). Magellanic

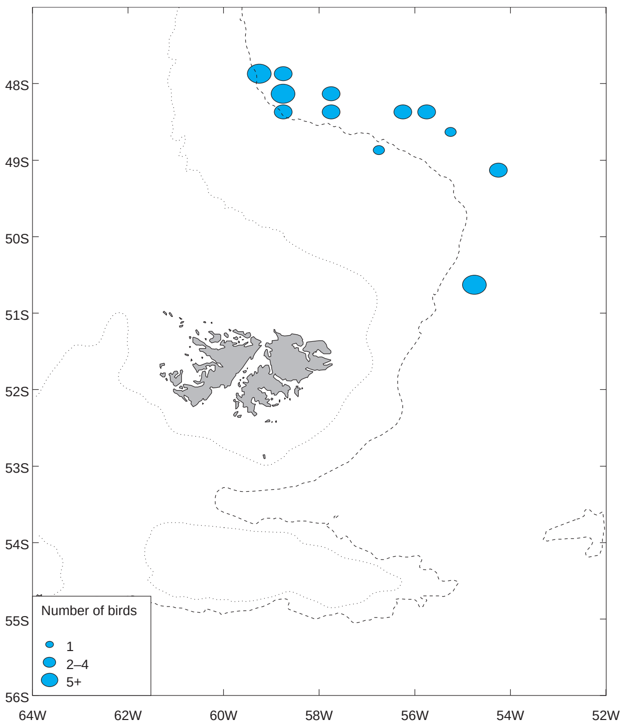

Figure 4.28(f) Distribution of macaroni penguin sightings, June to October.

penguins were recorded in all months, although there were very few records between May and August. From these figures, the number of Magellanic penguins in the study area decrease by 99.6% during the winter period (May to August) when compared with the summer period (November to February) (*cf.* rockhopper penguin).

Between November and April highest densities of Magellanic penguins were recorded in inshore waters (Figure 4.29(b)). Moderate, locally high, densities of Magellanic penguins were recorded over Patagonian Shelf waters and continental shelf slope waters to the north of the islands at this time while lowest densities of Magellanic penguins were recorded in deep waters to the south-east of the Falkland Islands, as far south as the Burdwood Bank. Magellanic penguins were absent from deep waters in the east of the survey area.

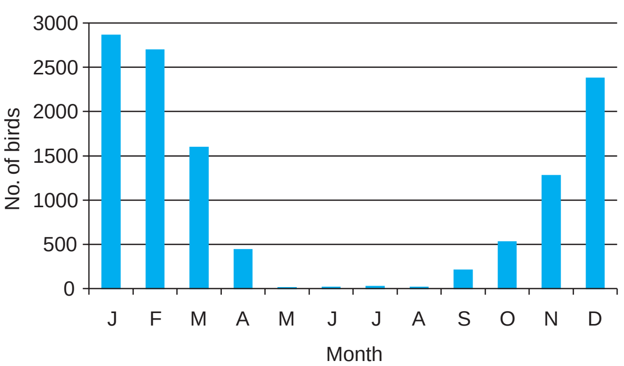

Figure 4.29(a) Number of Magellanic penguins recorded in each month.

Between May and August, Magellanic penguins were present in low densities in coastal and Patagonian Shelf waters to the north and west of the islands (Figure 4.29(c)). Numbers of returning birds increased in September and October when there were moderate and locally high densities of Magellanic penguins recorded in coastal waters, with few records away from these areas (Figure 4.29(d)).

In contrast to other penguin species, Magellanic and king penguins could be aged at sea. However, it was not always possible to age every bird, for example, when dealing with large flocks. The proportion of aged Magellanic penguins ranged from 41% of the 2,689 birds recorded in February to all of the eight birds recorded in May.

Immature Magellanic penguins exhibited a seasonal pattern of occurrence that was distinct from the adults (Figure 4.29(e)) although their spatial distribution was similar. In common with adults, the number of immature Magellanic penguins present in the survey area between May and August was low. In contrast with adults, the majority of immature birds did not return to the survey area until December. The fledging of juvenile birds in April was not detected by at-sea surveys suggesting that the majority of these birds do not linger in Falkland Islands waters but rapidly move north-west out of the study area.

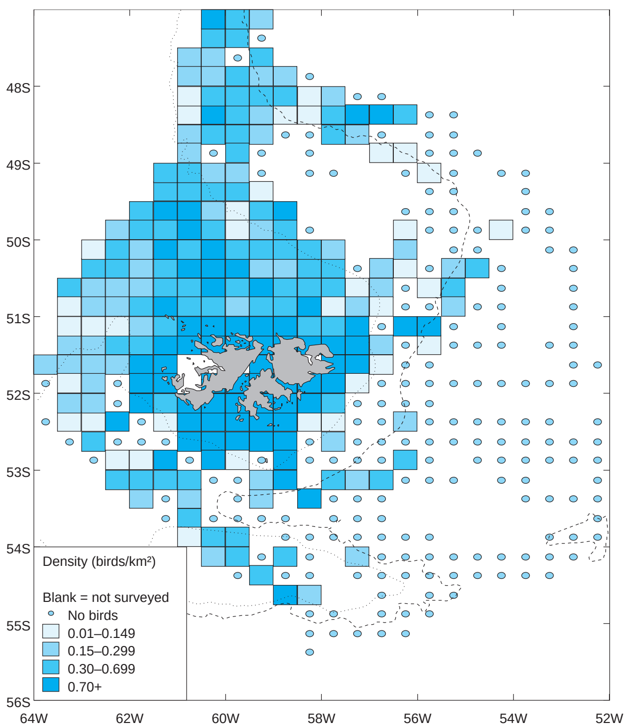

Figure 4.29(b) Magellanic penguin distribution and abundance, November to April.

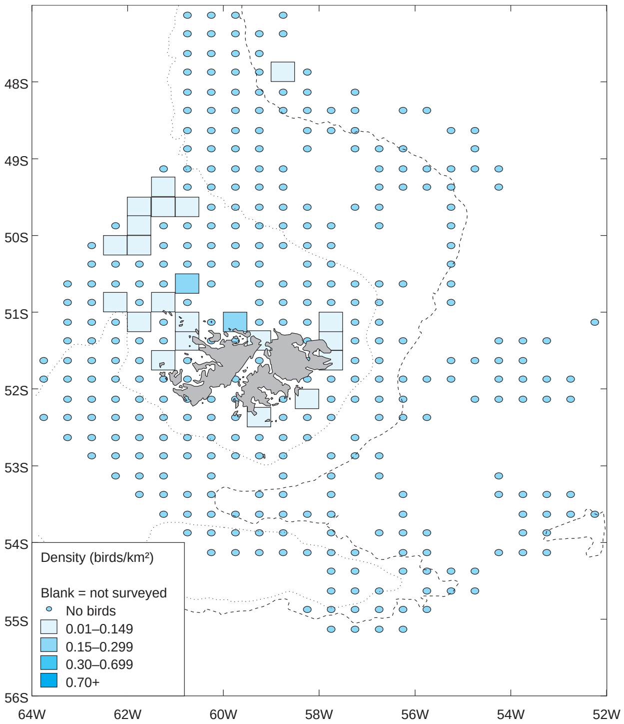

Figure 4.29(c) Magellanic penguin distribution and abundance, May to August.

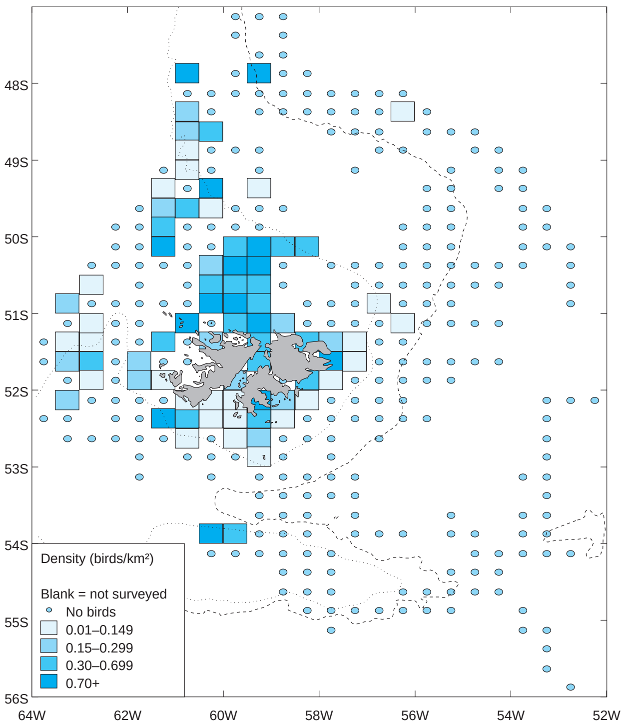

Figure 4.29(d) Magellanic penguin distribution and abundance, September to October.

Albatrosses Diomedeidae

Albatross taxonomy here follows Gales (1998).

At least 11 species of albatross have been recorded in Falkland Islands waters (Woods 1988),

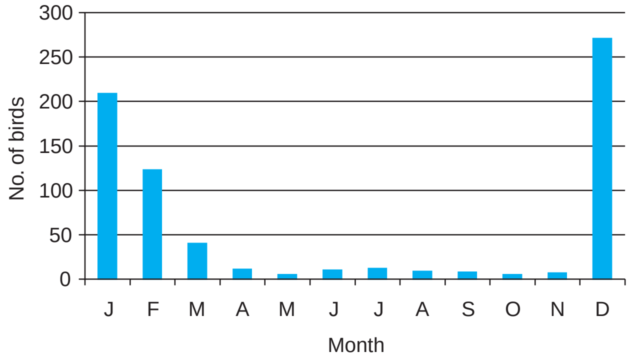

Figure 4.29(e) Number of immature Magellanic penguins recorded in each month.

of which one, the black-browed albatross, breeds in internationally important numbers. Nine species of albatross were recorded during surveys, five of them regularly and four others occasionally.

Wandering albatross species Diomedea exulans spp.

The wandering albatross is a non-breeding visitor to the waters of the Falkland Islands. The nearest breeding location of this species is at South Georgia, 1,300 km to the east of the Falkland Islands (Figure 1.1). Evidence from satellite tracking (Prince *et al*. 1998), observations from longliners (Croxall *et al*. 1999) and SAST surveys (White *et al*. 1999) all support the assumption that wandering albatrosses in Falkland Islands waters are usually, if not always, from the South Georgia population *D. exulans* (*sensu stricto*). This population numbers about 2,200 annual breeding pairs (Gales 1998).

Wandering albatrosses were recorded in all months, with a peak in November and high numbers also recorded between January and April (Figure 4.30(a)). In all months, wandering albatrosses were locally abundant in all deep water areas surveyed, with an area of high abundance recorded at the east end of the Burdwood Bank (Figures 4.30(b) and 4.30(c)). Between October and June, wandering albatrosses were also recorded at low densities in shallower Patagonian Shelf waters (Figure 4.30(b)).

A plumage stage (following Harrison 1983) was recorded for 91.8% of wandering albatrosses. The commonest plumage stage recorded was stage 4 (*cf*. southern royal albatross). Stage 1 birds were recorded from December, with a peak in March and April and no records after June. This indicates that a small proportion of juvenile wandering albatrosses from South Georgia visit Falkland Islands waters immediately after fledging, which peaks in December. It also suggests that wandering albatrosses undergo a post-juvenile body moult to Stage 2 in June (*cf*. Marchant and Higgins

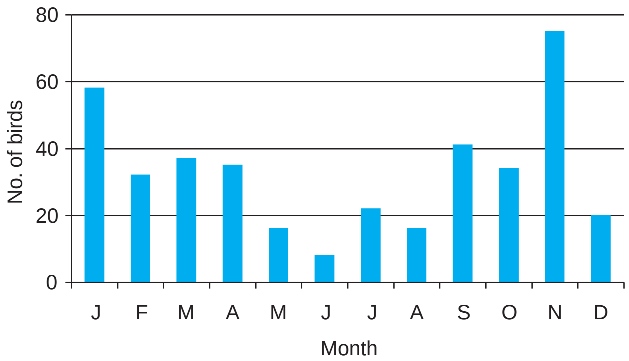

Figure 4.30(a) Number of wandering albatrosses recorded in each month.

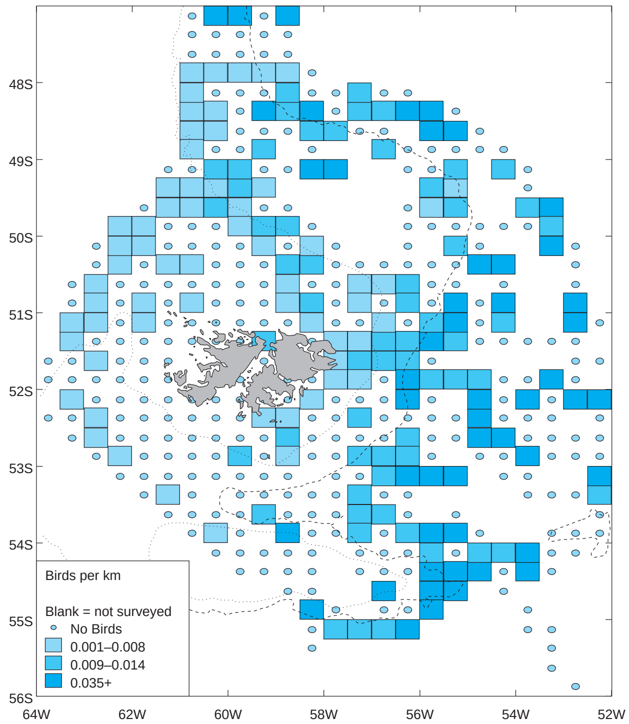

Figure 4.30(b) Wandering albatross distribution and abundance, October to June.

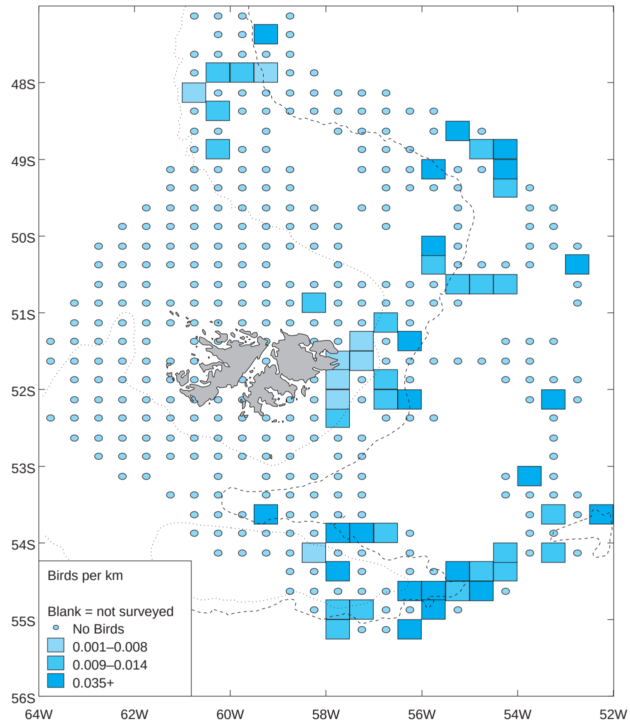

Figure 4.30(c) Wandering albatross distribution and abundance, July to September.

1990). Six birds, in a variety of plumage stages, were recorded in primary moult between January and April.

Wandering albatross was one of the species most likely to be under-recorded due to their habit of associating with the survey base (*cf.* giant petrels, Cape petrel and kelp gull). One bird was observed to remain with the survey base for at least 26 hours.

Northern D. sanfordi and southern D. epomophora royal albatrosses

Northern and southern royal albatrosses breed in New Zealand, where their annual breeding populations are 5,200 and 7,870 pairs respectively (Gales 1998). Outside the breeding season, royal albatrosses range across the South Pacific and into Patagonian Shelf waters in the south-west Atlantic. The importance of the Patagonian Shelf for royal albatrosses has long been recognised (Robertson and Kinsky 1972; Enticott 1986).

Both royal albatross species were recorded during surveys. In most cases, the separation of the two species was relatively straightforward. However, stage 1 southern royal albatrosses could not always be separated with certainty from northern royal albatrosses. As a result, of the 4,114 royal albatrosses recorded, 3,252 were identified as southern royal albatross, 447 as northern royal albatross and 415 were not specifically identified. Therefore, during surveys, southern royal albatrosses outnumbered northern royal albatrosses by a factor of approximately 7:1.

A plumage stage (following Harrison 1983) was recorded for 75.7% of southern royal albatrosses.

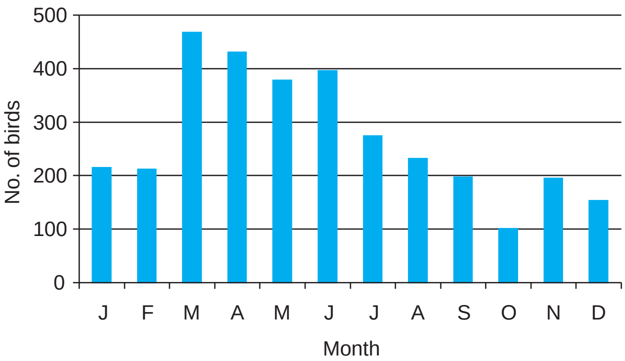

Figure 4.31(a) Number of southern royal albatrosses recorded in each month.

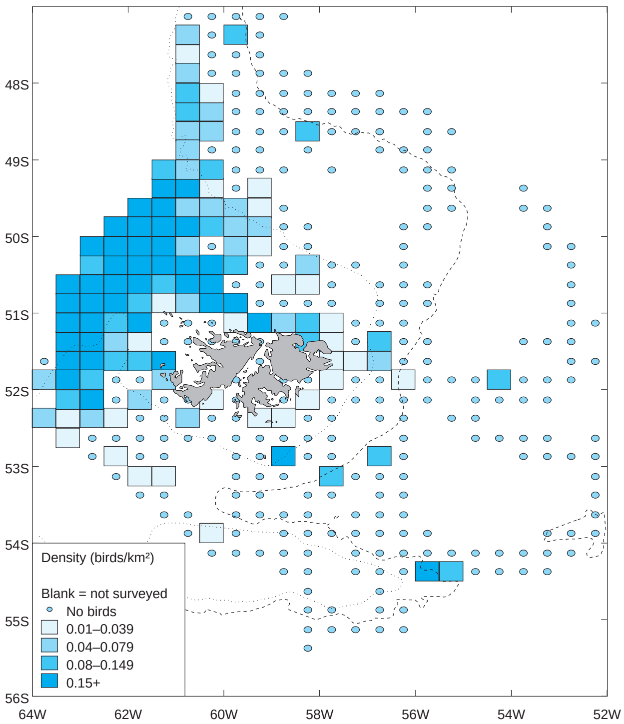

Figure 4.31(b) Southern royal albatross distribution and abundance, January to June.

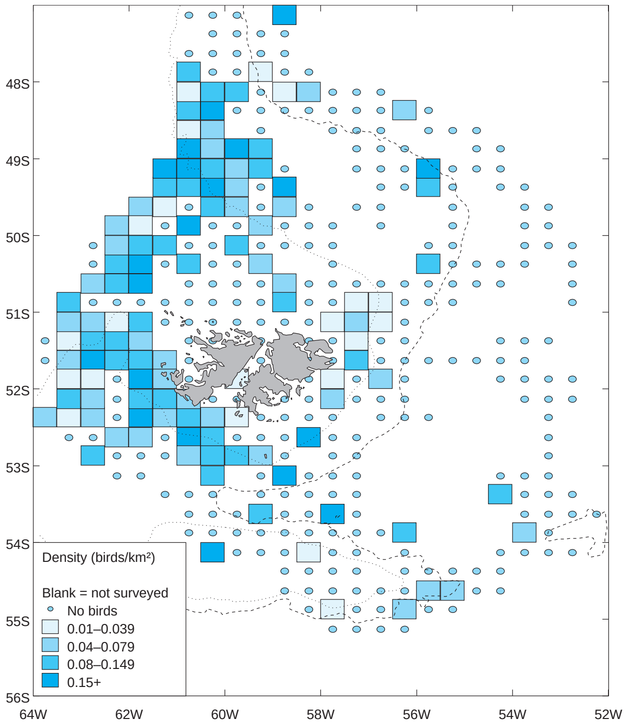

Figure 4.31(c) Southern royal albatross distribution and abundance, July to September.

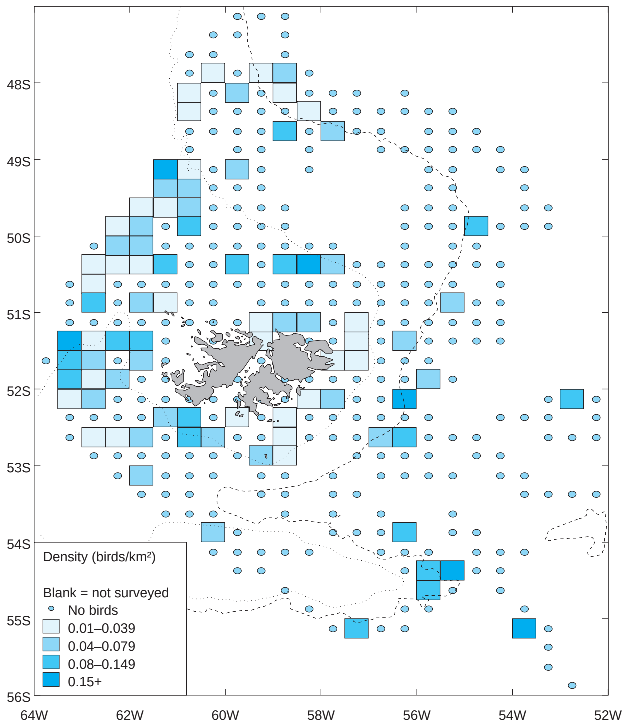

Figure 4.31(d) Southern royal albatross distribution and abundance, October to December.

The commonest plumage stage recorded was stage 2 (*cf.* wandering albatross). Stage 1 birds may have been more numerous, but an unknown number went unrecorded as 'royal albatross species'.

Southern royal albatrosses were most numerous in the waters of the Falkland Islands between March and June (Figure 4.31(a)), when very high densities were recorded in Patagonian Shelf waters to the north-west of the islands (Figure 4.31(b)) coinciding with the presence of the *Illex* squid jigging fleet in this area. Between July and September, after the end of the *Illex* season, this concentration of birds began to disperse with locally high densities present in Patagonian Shelf waters to the north and west of the islands (Figure 4.31(c)). Between October and December birds were present at low or moderate densities throughout Patagonian Shelf waters (Figure 4.31(d)). In all months, southern royal albatrosses were less numerous in deep-water areas (*cf.* wandering albatross).

Northern royal albatrosses were most frequently recorded between March and July (Figure

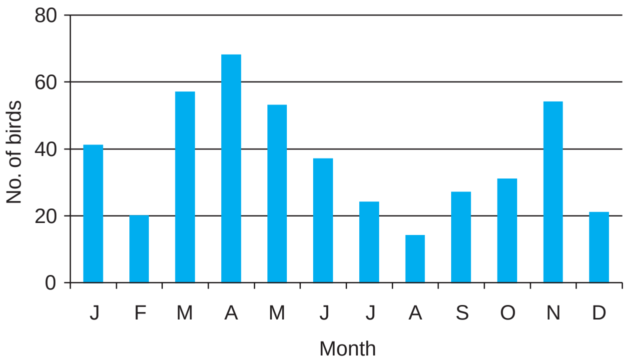

Figure 4.31(e) Number of northern royal albatrosses recorded in each month.

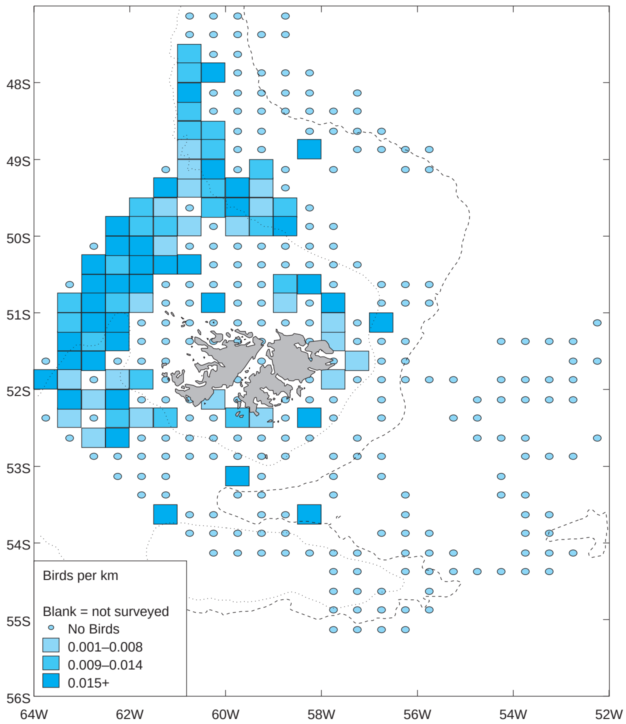

Figure 4.31(f) Northern royal albatross distribution and abundance, March to July.

4.31(e)), in areas similar to those occupied by high densities of southern royal albatrosses in roughly the same months (Figure 4.31(f)). At this time, northern royal albatrosses were generally absent from deep-water areas to the east of the islands. Very few northern royal albatrosses were recorded in August but numbers increased thereafter and peaked in November. Between September and February, northern royal albatrosses were recorded in low numbers throughout the survey area, including deep-water areas (Figure 4.31(g)).

A significant number of both southern and northern royal albatrosses were recorded in primary moult during the early months of the year, with a peak during February when 12% of southern and 25% of northern royal albatrosses were recorded in primary moult.

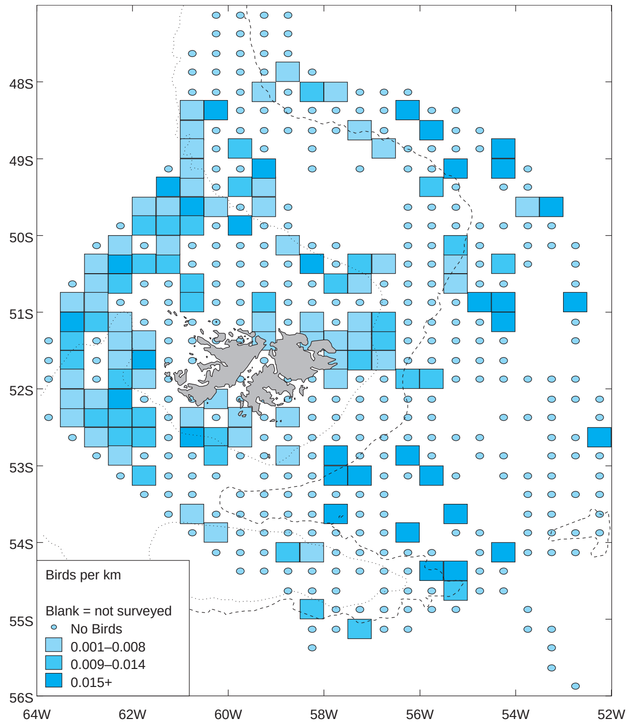

Figure 4.31(g) Northern royal albatross distribution and abundance, September to February.

Black-browed albatross Thalassarche melanophris

The Falkland Islands are the most important breeding location for black-browed albatrosses in the world, supporting 74% of the world population (Huin 2001, Gales 1998). The Falkland Islands population is in decline, with the breeding population of 2000/2001 estimated at 382,000 pairs (Huin 2001). The species also breeds on the islands of South Georgia and Diego Ramirez, Chile.

The total of 84,614 birds rendered black-browed albatross the second most abundant seabird recorded during surveys after prion species. Birds were recorded in all months with a peak in March (Figure 4.32(a)).

Between November and January, highest densities of black-browed albatrosses occurred in inshore waters to the west of the islands (Figure 4.32(b)). At this time, locally high densities of black-browed albatrosses were also recorded in deep (>200 m) waters to the south of the islands while birds were present at low densities or absent from deep-water areas to the east of the islands throughout the year.

Between February and June, black-browed albatrosses were present at very high densities throughout Patagonian Shelf waters to the northwest of the islands (Figure 4.32(c)). This coincided with the presence of the *Illex* squid jigging fleet in the area and also high densities of other al-

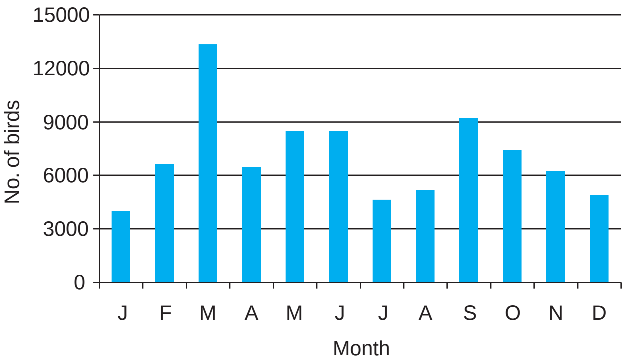

Figure 4.32(a) Number of black-browed albatrosses recorded in each month.

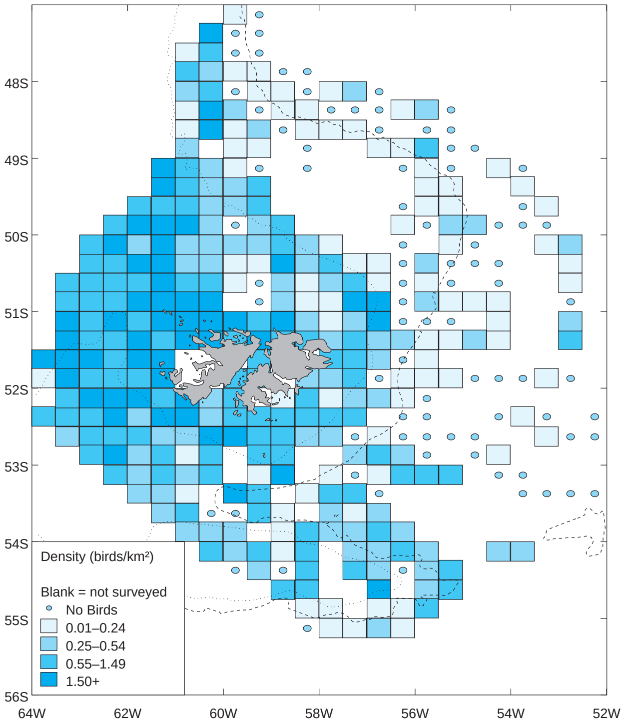

Figure 4.32(b) Black-browed albatross distribution and abundance, November to January.

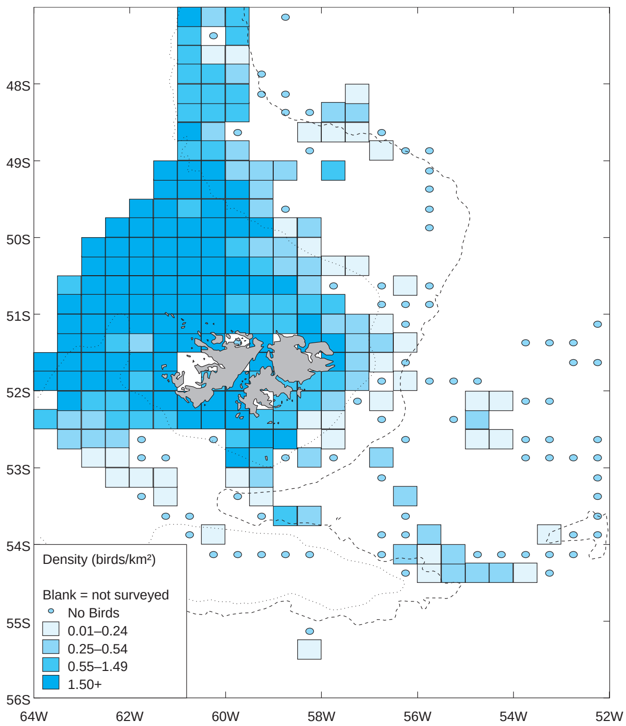

Figure 4.32(c) Black-browed albatross distribution and abundance, February to June.

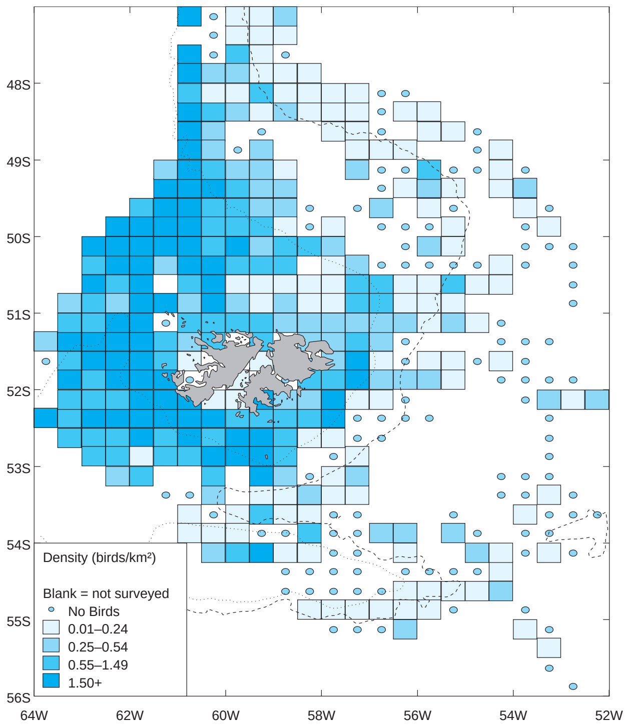

Figure 4.32(d) Black-browed albatross distribution and abundance, July to October.

batross species, *e.g.* southern royal albatross and grey-headed albatross.

Between July and October the concentrations of black-browed albatrosses over Patagonian Shelf waters were more localised than between February and June. There was a shift in the distribution of high densities of black-browed albatrosses to the south-west of the islands (Figure 4.32(d)). At this time there were few black-browed albatrosses in Patagonian Shelf waters to the north-east of the islands.

Black-browed albatrosses were recorded in primary moult between October and May. Primary moult was recorded in immature birds between October and April and in adults between December and May. However, less than 2% of the birds recorded during these months were recorded in moult.

Shy albatross species *T. cauta* spp.

'Shy' albatrosses are non-breeding visitors to Falkland Islands waters. All four species of 'shy' albatross breed in Australia or New Zealand and their dispersal into the South Atlantic is poorly understood. Both Salvin's albatross *T. salvini* and shy albatross *T. cauta* have been recorded in the south-west Atlantic (Prince and Croxall 1983; Petry *et al*. 1991).

Prior to this study, a total of eight 'shy' albatrosses had been recorded in Falkland Islands waters. All records were between March and August and none were subspecifically identified (Woods 1988).

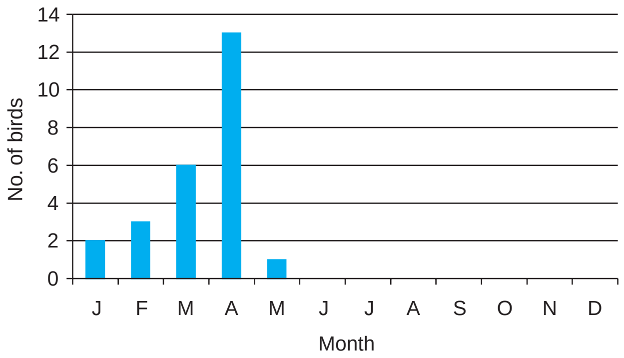

Figure 4.33(a) Number of shy albatrosses recorded in each month.

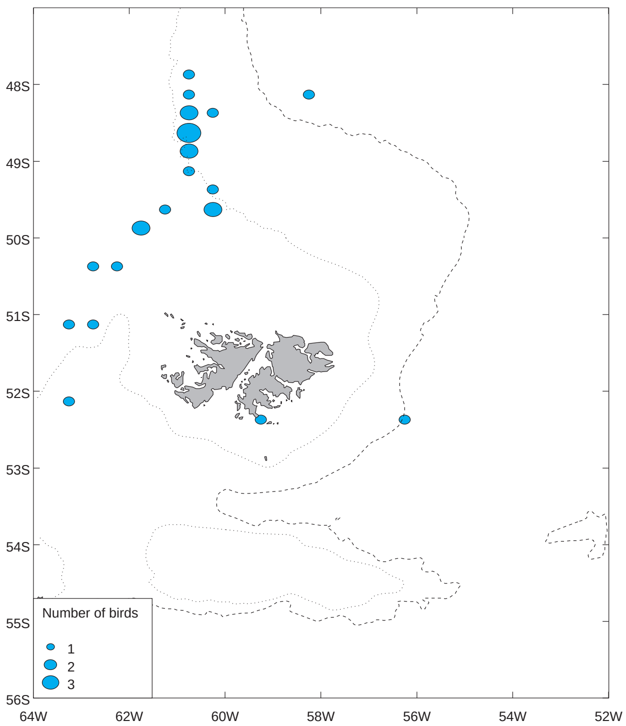

Figure 4.33(b) Distribution of shy albatross sightings, January to May.

A total of 25 'shy' albatrosses was recorded. The majority of records were of immature birds, the specific identification of which has not been attempted. There have been two records of adult *cauta* or *steadi* types (probably the former) and one adult *salvini* type. All records were in the period January to May with a peak in April (Figure 4.33(a)) and the majority were from waters to the north or west of the islands (Figure 4.33(b)).

Grey-headed albatross T. chrysostoma

Grey-headed albatrosses breed at both Diego Ramirez, to the south of Cape Horn, and at South Georgia (Figure 1.1). While most satellite tracking has been done during the breeding season, when grey-headed albatrosses are least frequent in Falkland Islands waters, the results suggest that it is birds from Diego Ramirez, rather than South Georgia, that are recorded in Falkland Islands waters (Prince *et al*. 1998; K. Reid pers. comm.; Robertson *et al*. 2000).

A total of 1,321 grey-headed albatrosses was recorded. Birds were recorded in all months, with a distinct peak in numbers between May and September (Figure 4.34(a)).

Between February and June grey-headed albatrosses were recorded at low densities throughout Patagonian Shelf waters to the north and west of the islands (Figure 4.34(b)). This timing broadly coincides with the presence of the *Illex* squid jigging fleet in the same general area. Also at this time, locally high densities of grey-headed albatrosses were recorded in deep water areas to the south and east of the islands. Outside this period, grey-headed albatrosses were only rarely recorded in Patagonian Shelf waters, with the exception of waters to the south-east of East Falkland (Figure 4.34(c)). Grey-headed albatrosses were commonest in the study area between July and September when they were present at locally high densities in deep waters to

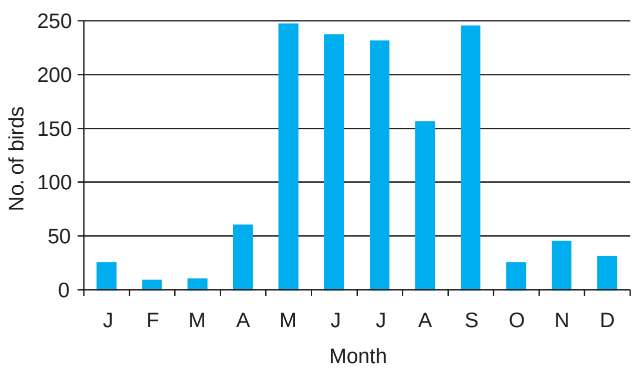

Figure 4.34(a) Number of grey-headed albatrosses recorded in each month.

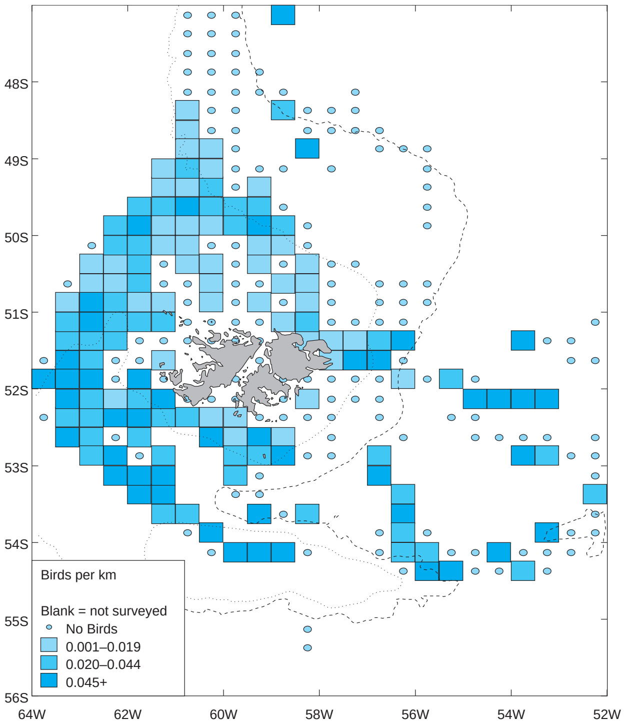

Figure 4.34(b) Grey-headed albatross distribution and abundance, February to June.

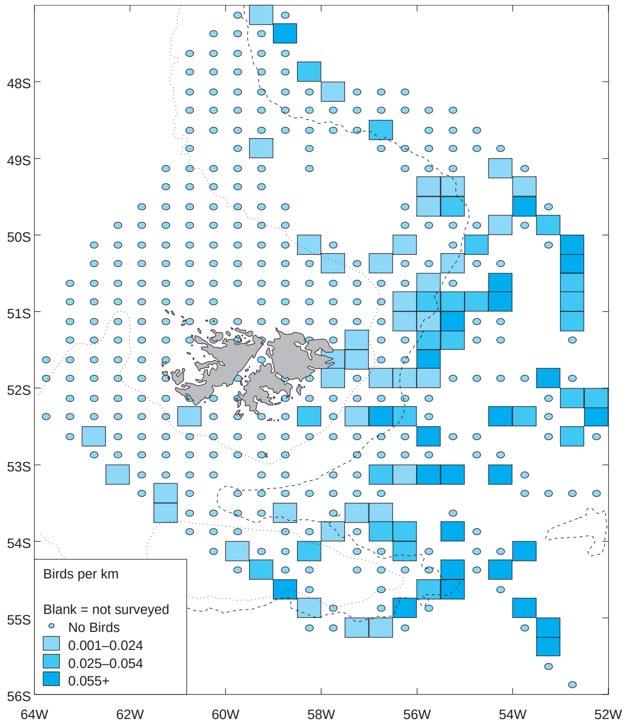

Figure 4.34(d) Grey-headed albatross distribution and abundance, October to January.

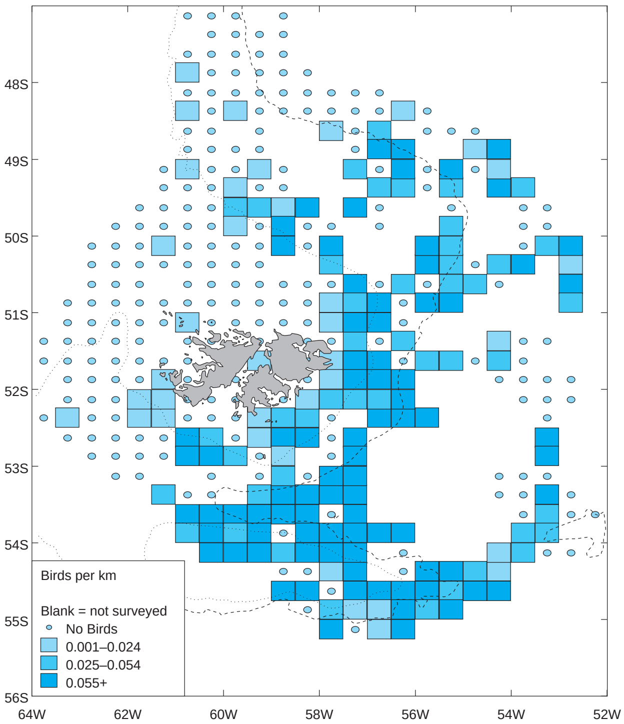

Figure 4.34(c) Grey-headed albatross distribution and abundance, July to September.

the north, east and south of the islands (Figure 4.34(c)). Between October and January, grey-headed albatrosses exhibited a similar deep water distribution, but were notably less numerous than in the July to September period (Figure 4.34(d)).

Light-mantled albatross Phoebetria palpebrata

Light-mantled albatrosses are non-breeding visitors to Falkland Islands waters. The nearest breeding population is found on South Georgia, which supports an annual breeding population of between 5,000 and 7,000 pairs (Gales 1998).

All 24 light-mantled albatrosses were recorded as single birds. Most records were in the August to November period with fewer records between January and May and none in June or July (Figure 4.35(a)). The majority of records were in waters deeper than 200 m to the east of the islands (Figure 4.35(b)).

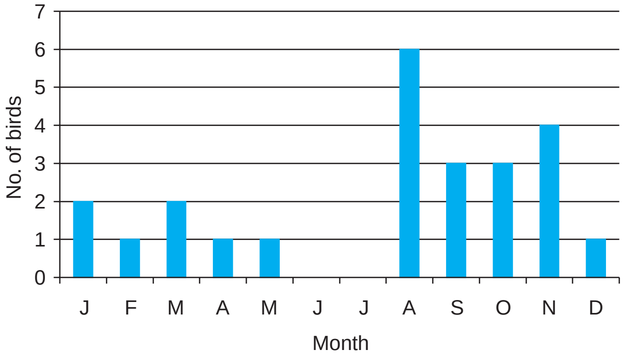

Figure 4.35(a) Number of light-mantled albatrosses recorded in each month.

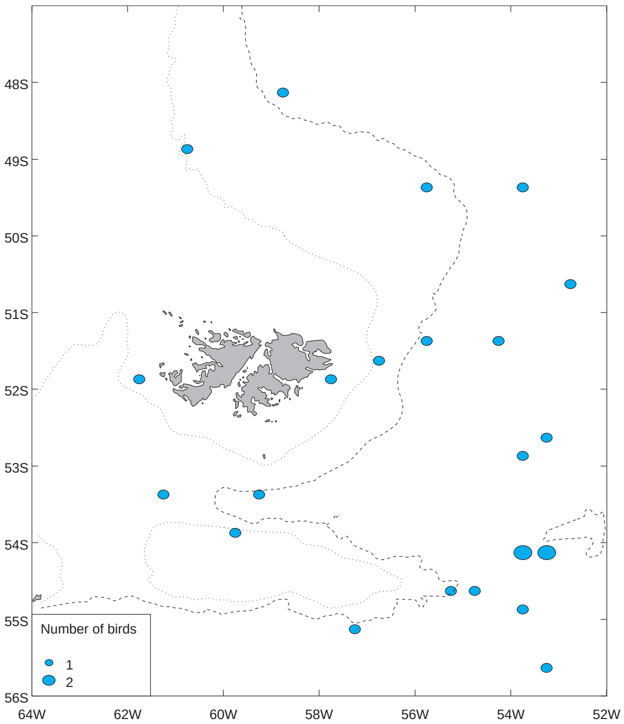

Figure 4.35(b) Distribution of light-mantled albatross sightings, all months.

Petrels and shearwaters Procellariidae

Prior to this study, 26 species of Procellariidae had been recorded in the waters of the Falkland Islands (Woods 1988; Bourne and Curtis 1997; A. Black pers. obs), nine of which breed in the islands (Woods and Woods 1997). During SAST surveys, 23 species were recorded, of which 17 species were either common or regular and six were regarded as vagrants.

Northern giant petrel Macronectes halli and southern giant petrel M. giganteus

Giant petrels were split into two distinct species, northern and southern, following the work of Bourne and Warham (1966). Although both species were regularly recorded at sea, only the southern giant petrel breeds regularly within the Falkland Islands, which support a population between 5,000 and 10,000 pairs (Woods and Woods 1997). None of these birds are of the white morph of this species, which breeds in South Georgia and the Antarctic Peninsula, where up to 10% of the breeding population are white morph birds (Hudson 1963). Devillers and Terschuren (1980) proposed that both northern and southern giant petrels breed in the Falkland Islands; however, despite two records of single breeding pairs of northern giant petrel on Beauchêne Island (Strange 1992), they have not been found breeding at this location in recent years (pers. obs.). The nearest breeding population of northern giant petrels, at South Georgia, numbers approximately 3,000 pairs (Croxall *et al.* 1984b). Dye-marked birds from this population have been observed during surveys and satellite tracking data have shown that female southern and northern giant petrels breeding in South Georgia visit Falkland Islands waters during November (Gonzáles-Solís *et al.* 2000).

With good views the two species are readily separable at sea. In total, 6,672 giant petrels were recorded. Of these, 3,535 (53.0%) were positively identified as southern giant petrel, 751 (11.3%) as northern giant petrel and 2,386 (35.7%) were recorded as unidentified giant petrels. The distribution of unidentified giant petrels show a similar distribution to southern giant petrel records (Figures 4.36(b)–(d)), and as a result these records have not been mapped here.

Giant petrels are one of the most conspicuous species to associate with the survey base and fishing vessels (*cf.* wandering albatross, Cape petrel and kelp gull). These birds fall outwith the survey methodology and thus the number of giant petrels recorded is likely to underestimate the true densities present within Falkland Islands waters.

Southern giant petrels were recorded in all months with peak numbers in June (Figure 4.36(a)). Between March and June highest densities of southern giant petrels were recorded over

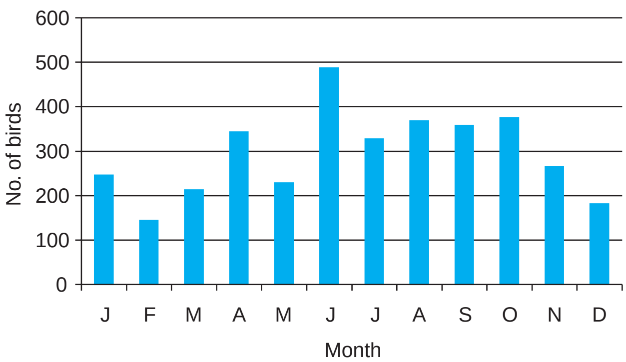

Figure 4.36(a) Number of southern giant petrels recorded in each month.

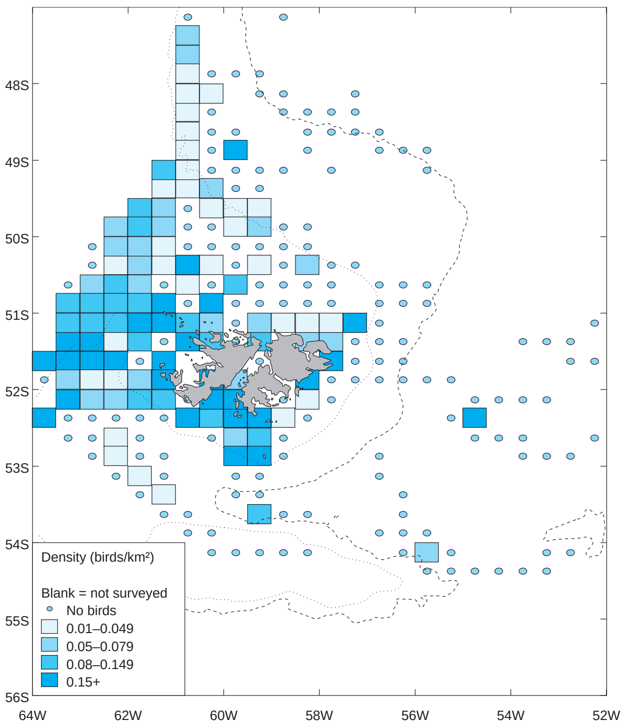

Figure 4.36(b) Southern giant petrel distribution and abundance, March to June.

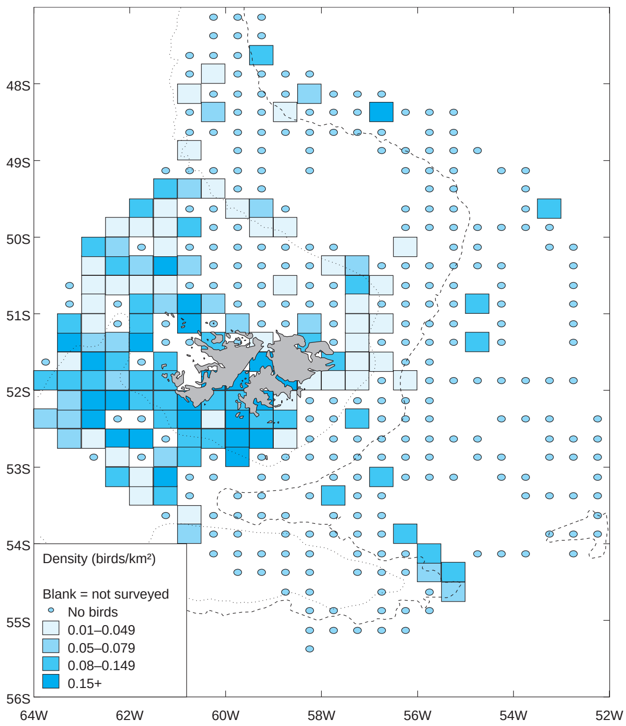

Figure 4.36(d) Southern giant petrel dispersion, November to February.

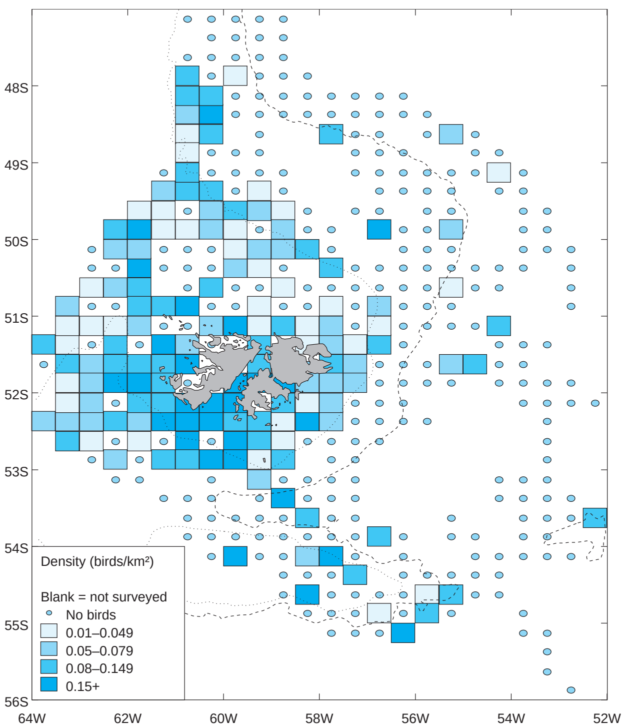

Figure 4.36(c) Southern giant petrel distribution and abundance, July to October.

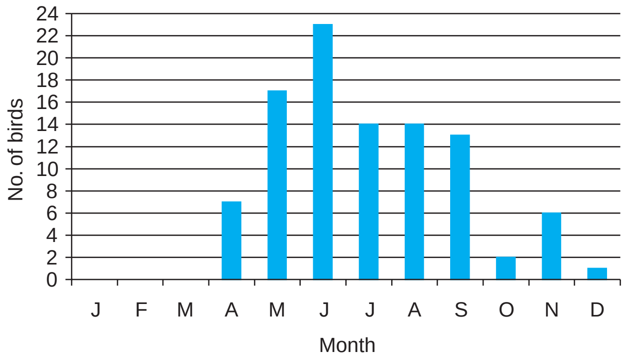

Figure 4.36(e) Number of white morph southern giant petrels recorded in each month.

Patagonian Shelf waters to the west and south of the islands (Figure 4.36(b)). Few birds were recorded from Patagonian Shelf waters to the north of the islands. From July to October southern giant petrels were recorded in similar numbers, but the areas of highest density were associated with waters to the south of the islands, particularly to the south of Falkland Sound (Figure 4.36(c)). This shift in dispersion mirrors a change in the distribution of fishing vessels recorded while surveying (see p. 29). Between November and February, lower numbers of southern giant petrels were recorded. During this period, areas of locally very high density were recorded throughout coastal waters and Patagonian Shelf and Patagonian Shelf slope waters to the south and west of the islands (Figure 4.36(d)).

White morph southern giant petrels are non-breeding visitors to the waters of the Falkland Islands. In total, 98 were recorded between April and December with the majority (84%) recorded between May and September (Figure 4.36(e)). These birds exhibited a similar distribution to

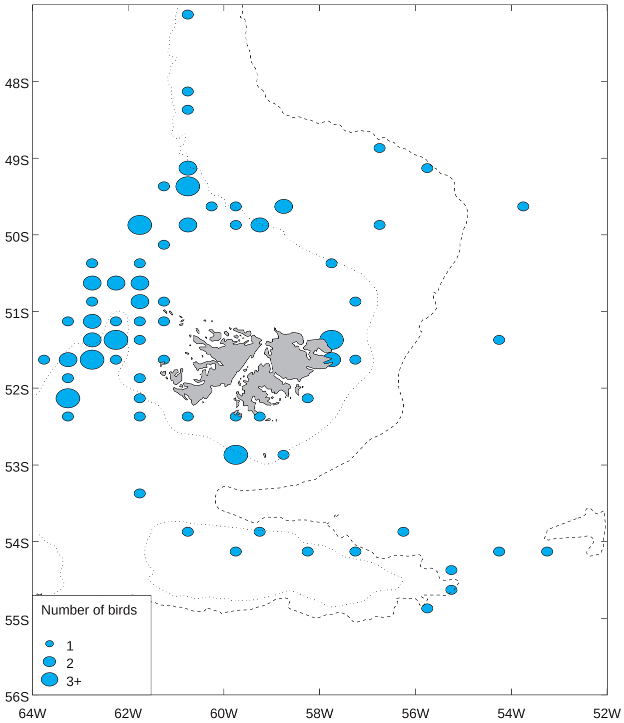

Figure 4.36(f) White morph southern giant petrel distribution of sightings, all months.

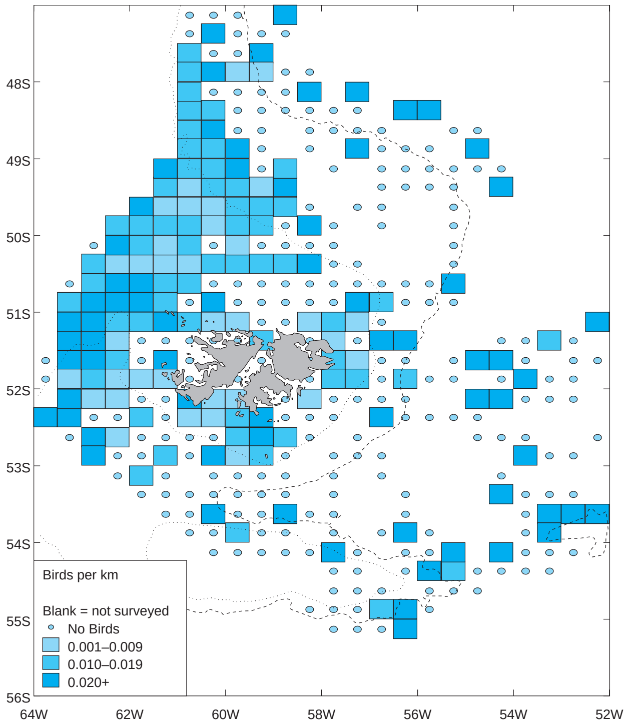

Figure 4.36(h) Northern giant petrel distribution of sightings, March to August.

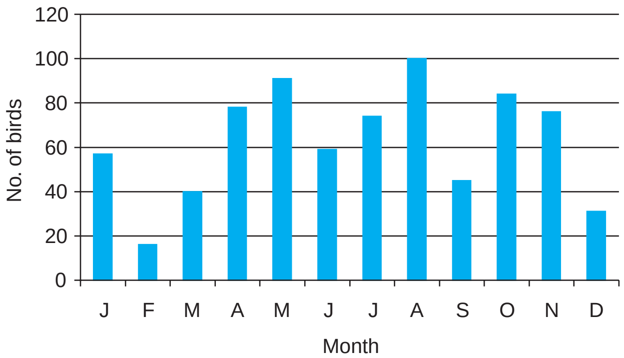

Figure 4.36(g) Number of northern giant petrels recorded in each month.

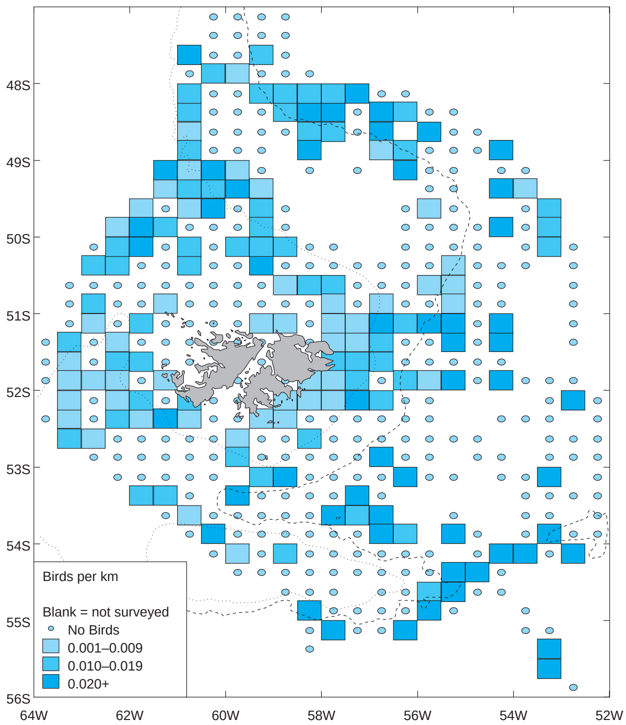

Figure 4.36(i) Northern giant petrel distribution of sightings, September to February.

other southern giant petrels recorded, with the majority over Patagonian Shelf waters to the west of the islands and lower numbers encountered over deeper shelf slope and oceanic waters (Figure 4.36(f)). The seasonality of white morph southern giant petrels within Falkland Islands waters is consistent with that recorded for several other species with breeding populations associated with the Antarctic Peninsula (e.g. Antarctic fulmar, Cape petrel).

Northern giant petrels were recorded throughout the year with a slight tendency for higher numbers during the winter (Figure 4.36(g)). From March to August, northern giant petrels were widespread and locally abundant in Patagonian Shelf waters to the north-west of the islands and in oceanic waters (Figure 4.36(h)). From September to February fewer northern giant petrels were recorded over Patagonian Shelf waters to the north-west of the islands, while remaining locally abundant over Patagonian Shelf slope and oceanic waters at this time (Figure 4.36(i)). Throughout the year northern giant petrels were less likely

than southern giant petrels to be recorded in coastal or inshore waters.

Both giant petrel species were recorded in primary moult between October and May. Both species showed a peak in December when 29% of southern and 28% of northern giant petrels recorded were in moult.

Antarctic petrel Thalassoica antarctica

Antarctic petrels are winter visitors to Falkland Island waters from their Antarctic breeding grounds. Prior to this study, there were four records of eight birds in Falkland Islands waters (Woods 1988).

A total of 56 Antarctic petrels was recorded. All records were in the period July to September (Figure 4.37(a)) and all were in waters to the south and east of the islands (Figure 4.37(b)). The majority of birds were in deep water areas, although there were three records in shallower Patagonian Shelf waters to the south and east of East Falkland following a period of southerly gales.

This species exhibited marked inter-annual variation in numbers. Only one bird was recorded during winter 1998, 55 were recorded in winter 1999 and none during winter 2000.

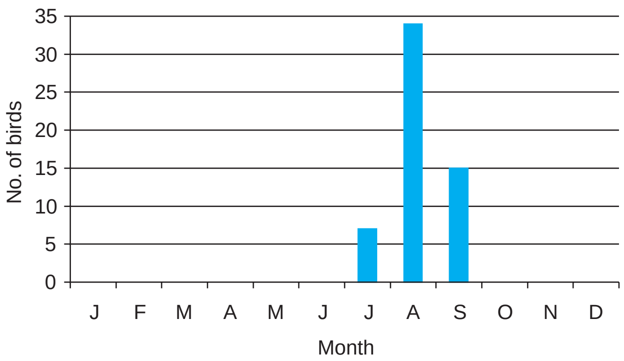

Figure 4.37(a) Number of Antarctic petrels recorded in each month.

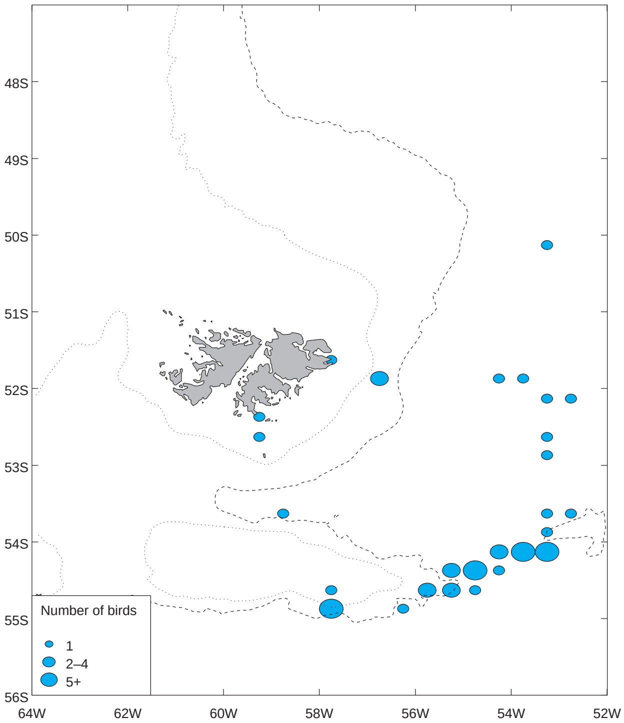

Figure 4.37(b) Distribution of Antarctic petrel sightings, July to September.

Cape petrel Daption capense

Cape petrels are non-breeding visitors to Falkland Islands waters from their Antarctic breeding grounds.

A total of 15,199 Cape petrels was recorded. Although recorded in every month, February and March produced very few records. Numbers of Cape petrel began increasing in April, with a significant increase in numbers during May. Numbers then remained high throughout the winter, with a gradual decrease from September onwards and few birds remaining after November (Figure 4.38(a)).

Cape petrels were very scarce in the survey area in the period December to March, with low densities encountered throughout Patagonian Shelf waters (Figure 4.38(b)). Thirty-eight per cent of the birds recorded during January and February were in active primary moult. These birds were either pre-/non-breeders or failed breeders making an early return to wintering areas. Numbers increased in April with locally high densities recorded in Patagonian Shelf waters to the west of the islands but few to the north of the islands (Figure 4.38(c)). Cape petrels were widespread throughout the survey area from May until September with highest densities recorded in Patagonian Shelf waters to the west and northwest of the islands (Figure 4.38(d)), the area occupied by the majority of the fishing fleet at this time. Densities in Patagonian Shelf waters to the east of the islands were much lower, with the waters to the south-east of East Falkland in particular supporting very few birds. Cape petrels were recorded in shelf-slope and oceanic waters to the

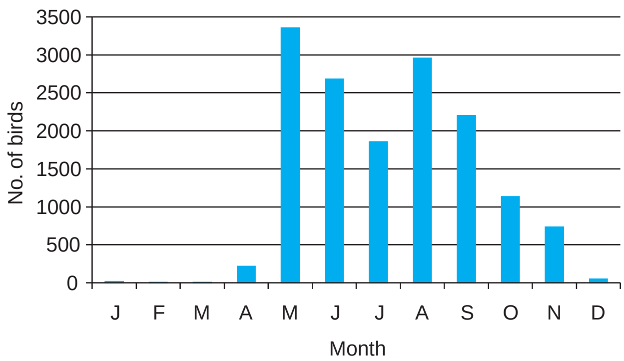

Figure 4.38(a) Number of Cape petrels recorded in each month.

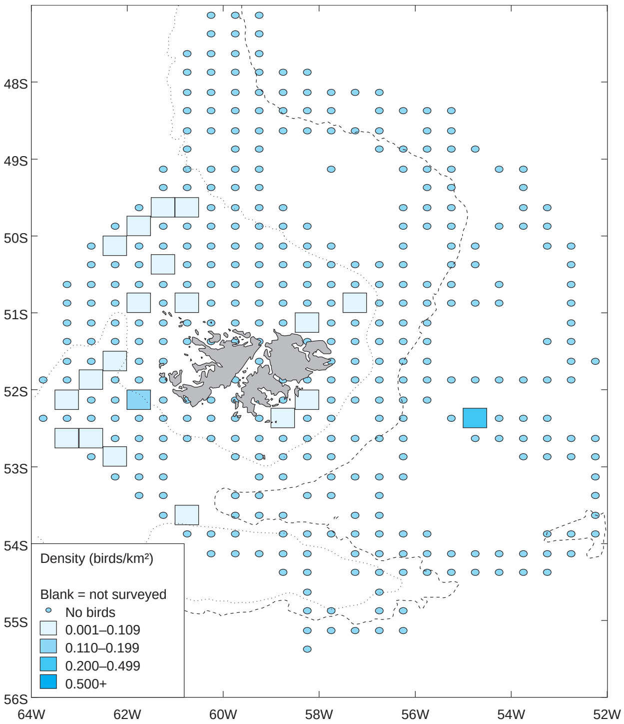

Figure 4.38(b) Cape petrel distribution and abundance, December to March.

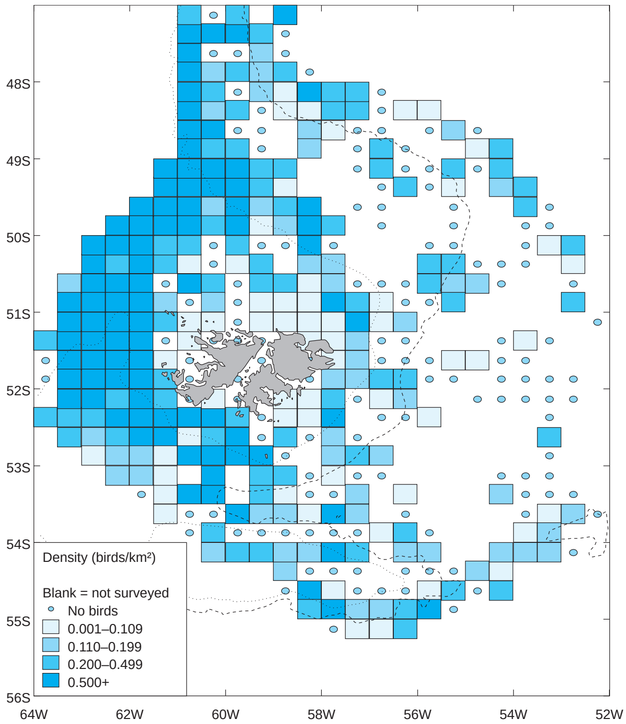

Figure 4.38(d) Cape petrel distribution and abundance, May to September.

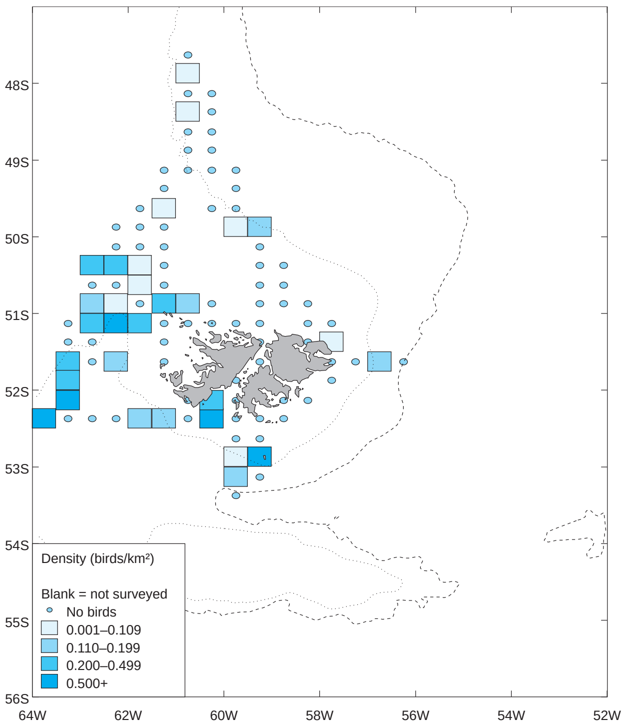

Figure 4.38(c) Cape petrel distribution and abundance, April.

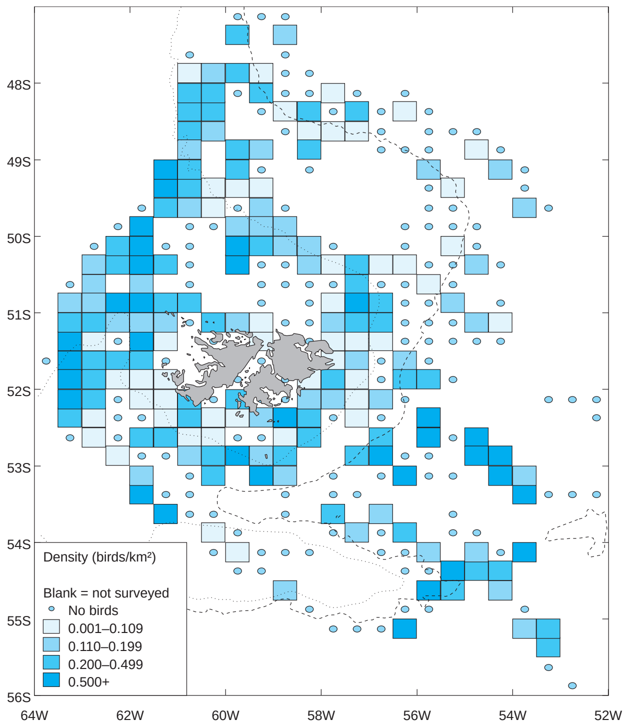

Figure 4.38(e) Cape petrel distribution and abundance, October to November.

north and south of the islands at this time, but densities were generally moderate or low. In October and November, only locally high densities of Cape petrels remained in Patagonian Shelf waters with only locally high densities remaining in Falkland Islands waters (Figure 4.38(e)).

Cape petrels were regular ship associates (*cf.* wandering albatross, giant petrels and kelp gull) and were frequently observed scavenging behind fishing vessels. Such birds fell outwith the survey. As a result, Cape petrel densities may have been underestimated.

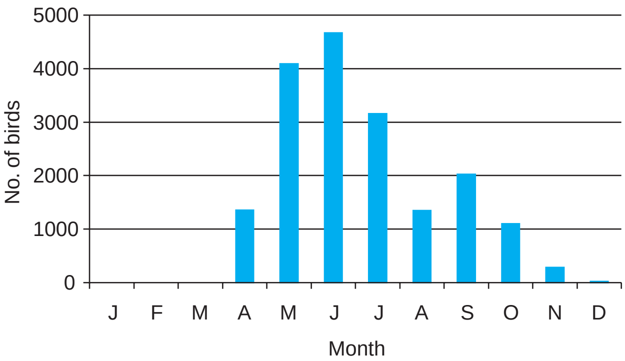

Figure 4.39(a) Number of Antarctic fulmars recorded in each month.

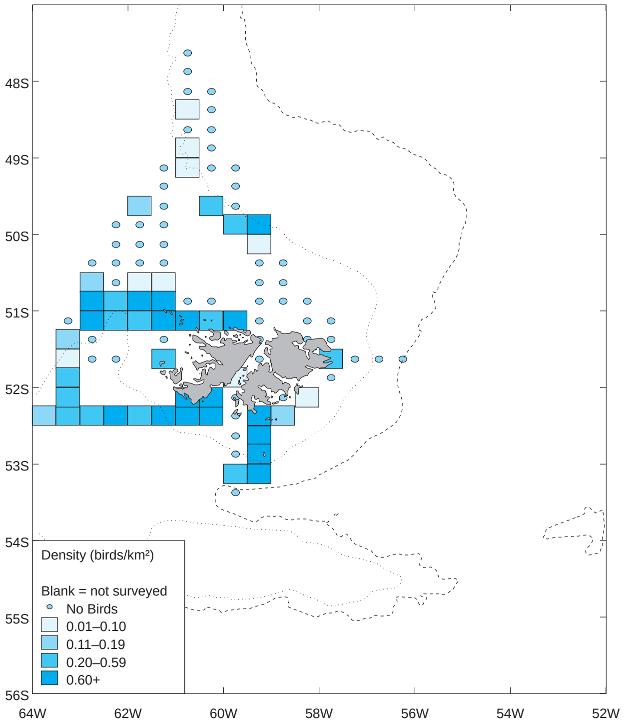

Figure 4.39(b) Antarctic fulmar distribution and abundance, April.

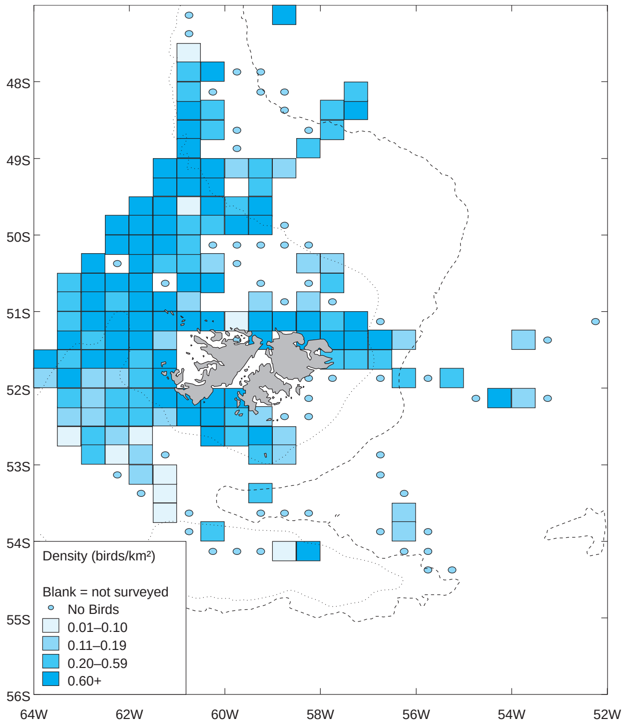

Figure 4.39(c) Antarctic fulmar distribution and abundance, May to June.

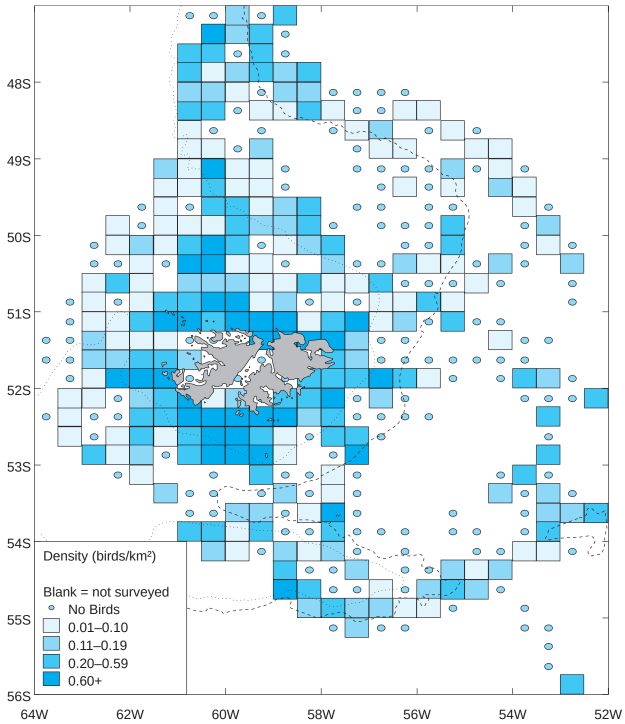

Figure 4.39(d) Antarctic fulmar distribution and abundance, July to October.

Antarctic fulmar Fulmarus glacialoides

In common with Cape petrels, Antarctic fulmars are non-breeding visitors to Falkland Islands waters from their Antarctic breeding grounds.

A total of 18,061 Antarctic fulmars was recorded, with all records in the period April to December (Figure 4.39(a)). This species exhibited a marked seasonal presence in Falkland Islands waters which was very similar to two other Antarctic breeding Procellariiforms – Cape petrel and white morph southern giant petrel.

Upon arrival in Falkland Islands waters in April Antarctic fulmars were found at highest densities in Patagonian Shelf waters off the north and south coasts of West Falkland and to the south of East Falkland (Figure 4.39(b)). In May and June, Antarctic fulmars were widespread at high densities throughout Patagonian Shelf waters to the west and north-west of the islands (Figure 4.39(c)). At this time Antarctic fulmars were virtually absent from Patagonian Shelf waters to the south-east of East Falkland. In the period July to October, highest densities were found in inshore waters, while Patagonian Shelf waters generally supported

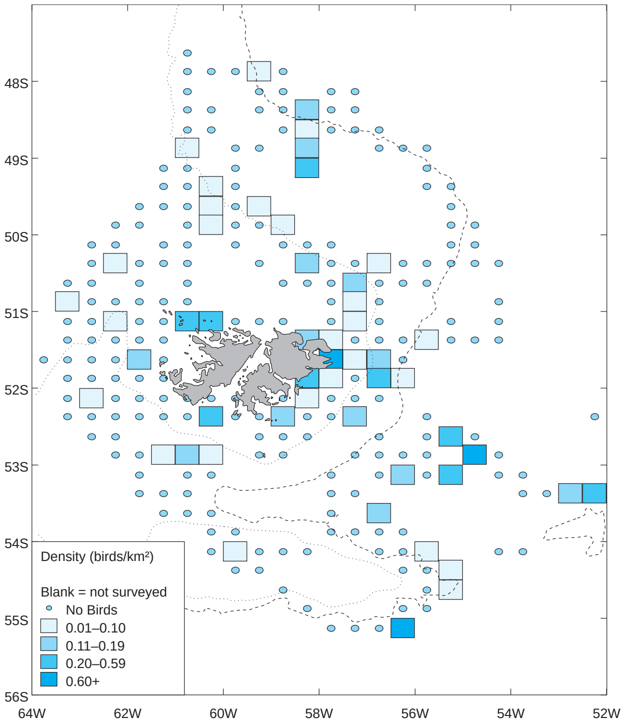

Figure 4.39(e) Antarctic fulmar distribution and abundance, November.

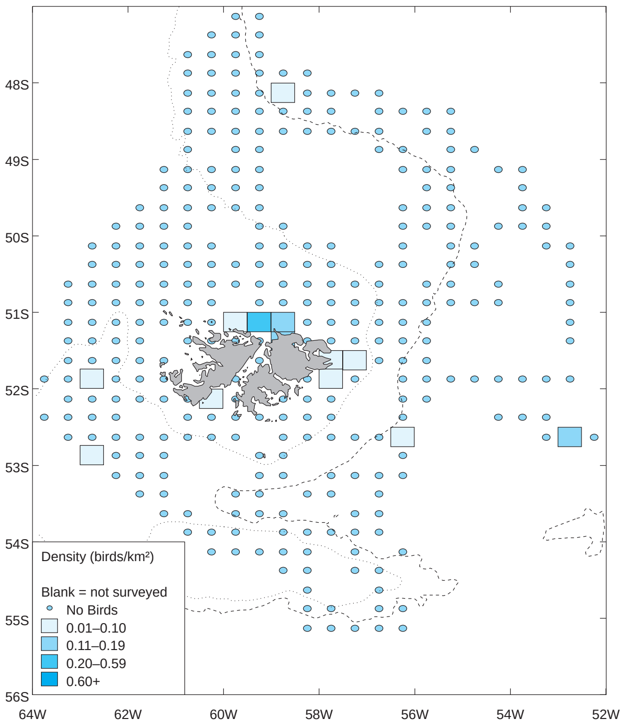

Figure 4.39(f) Antarctic fulmar distribution and abundance, December to January.

moderate or low densities. The area to the south of Falkland Sound consistently held high densities of Antarctic fulmars at this time (Figure 4.39(d)). By November, numbers of Antarctic fulmars had greatly reduced (Figure 4.39(e)) and very few were recorded in December (Figure 4.39(f)).

Blue petrel Halobaena caerulea

Blue petrels are non-breeding visitors to Falkland Islands waters. The nearest colonies are on the islands of South Georgia and Diego Ramirez, Chile (Harrison 1983), although it is not known to which population birds seen in Falkland Islands waters belong. Woods (1988) describes this species as widespread in offshore waters east of the Falklands, apparently more common in winter.

A total of 573 blue petrels was recorded. In all three years this species exhibited a clear seasonality in Falkland Islands waters, with all records in the period May to November, peaking in September (Figure 4.40(a)) *cf.* Kerguelen petrel.

The majority of records were in deep waters to the east and south-east of the islands, with relatively few from Patagonian Shelf waters, mostly to the south-east of East Falkland (Figure 4.40(b)).

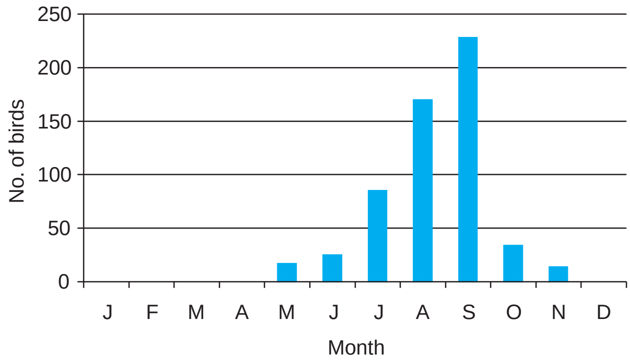

Figure 4.40(a) Number of blue petrels recorded in each month.

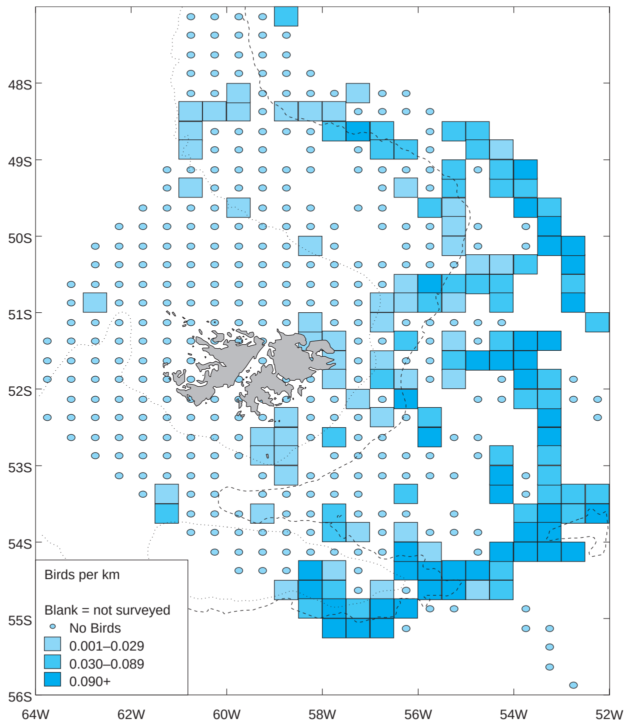

Figure 4.40(b) Blue petrel distribution and abundance, May to November.

Kerguelen petrel Aphrodroma brevirostris

Kerguelen petrels are non-breeding visitors to Falkland Islands waters. Their nearest breeding location is on the Tristan da Cunha group and Gough Island (Enticott and Tipling 1997). Kerguelen petrels were recorded by Bourne and Curtis (1985) as 'occurring occasionally around the Falkland Islands'.

A total of 152 Kerguelen petrels was recorded. With the exception of one record in March, all records were within the period May to November, with peak numbers in August (Figure 4.41(a)) *cf.* blue petrel. Kerguelen petrels return to colonies in August/September (Harrison 1983), so birds recorded in Falkland Islands waters at this time were presumably pre-/non-breeders. Over half of all Kerguelen petrel records occurred between July and September 1999.

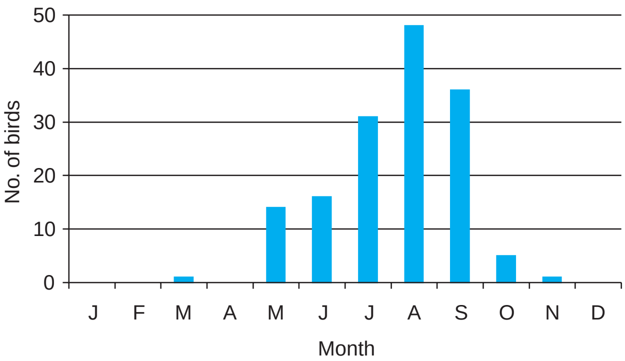

Figure 4.41(a) Number of Kerguelen petrels recorded in each month.

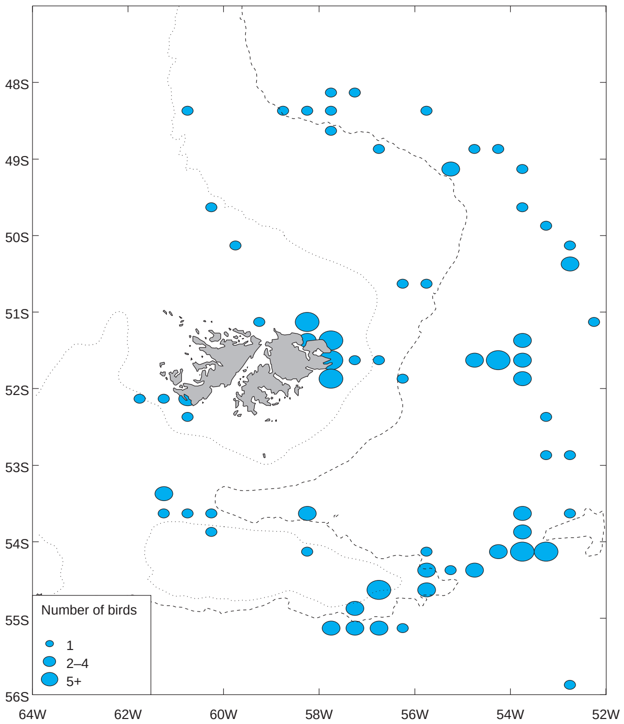

Figure 4.41(b) Distribution of Kerguelen petrel sightings, March to November.

Kerguelen petrels were primarily recorded in deep waters to the east of the islands. However, they were also recorded from shallow Patagonian Shelf waters off the north-east coast of East Falkland and south-west coast of West Falkland (Figure 4.41(b)).

The seasonal and spatial occurrence of this species closely matched that of blue petrel. However, Kerguelen petrels were more likely to be recorded in shallow Patagonian Shelf waters than blue petrel. While Kerguelen petrels exhibited a similar oceanic distribution to other species breeding in the Tristan da Cunha group and Gough Island (*e.g.* soft-plumaged petrel, Atlantic petrel, black-bellied storm-petrel), Kerguelen petrels were more likely to be recorded to the south and east of the islands in late winter than north and east of the islands in late summer.

Soft-plumaged petrel Pterodroma mollis

Soft-plumaged petrels are non-breeding late summer visitors to Falkland Islands waters. The nearest breeding locations to the Falkland Islands are on the Tristan da Cunha group and Gough Island.

A total of 861 soft-plumaged petrels was recorded. All records were within the period November to April, with a peak in January (Figure 4.42(a)) (*cf.* black-bellied storm-petrel). There was considerable inter-annual variation in the numbers of soft-plumaged petrels recorded. No soft-plumaged petrels were recorded in January 2001, yet 122 were recorded in January 1999 and 181 in January 2000.

Most soft-plumaged petrels were recorded in deep waters to the north-east of the islands (Figure 4.42(b)) *cf.* Atlantic petrel and black-bellied storm-petrel. Lower numbers of birds were also recorded to the south-east of the islands and in Patagonian Shelf waters, particularly to the south-east of East Falkland.

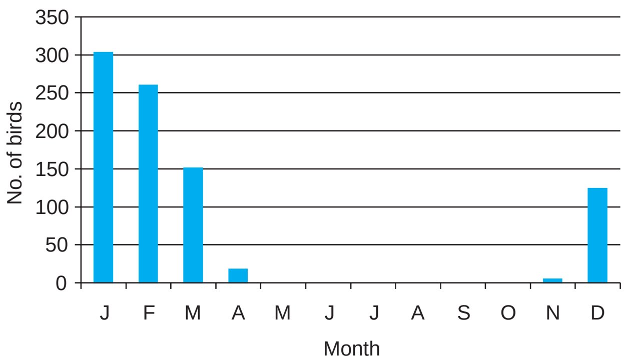

Figure 4.42(a) Number of soft-plumaged petrels recorded in each month.

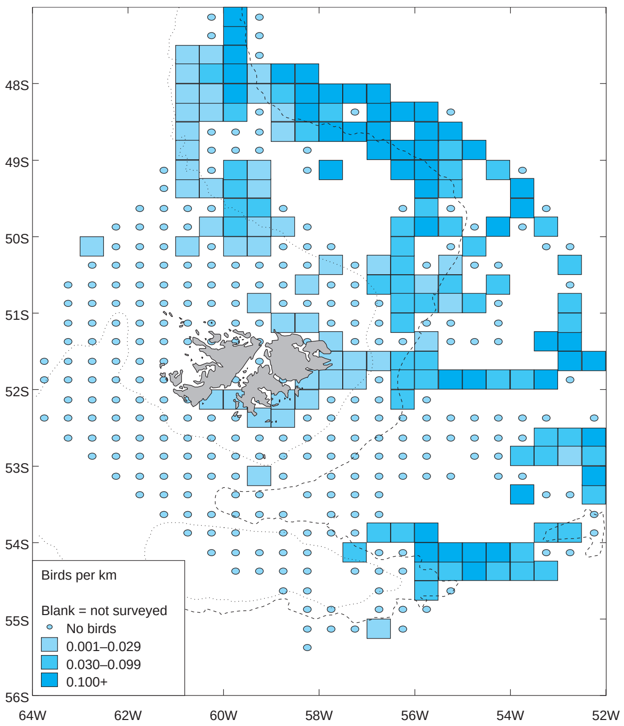

Figure 4.42(b) Soft-plumaged petrel distribution and abundance, November to April.

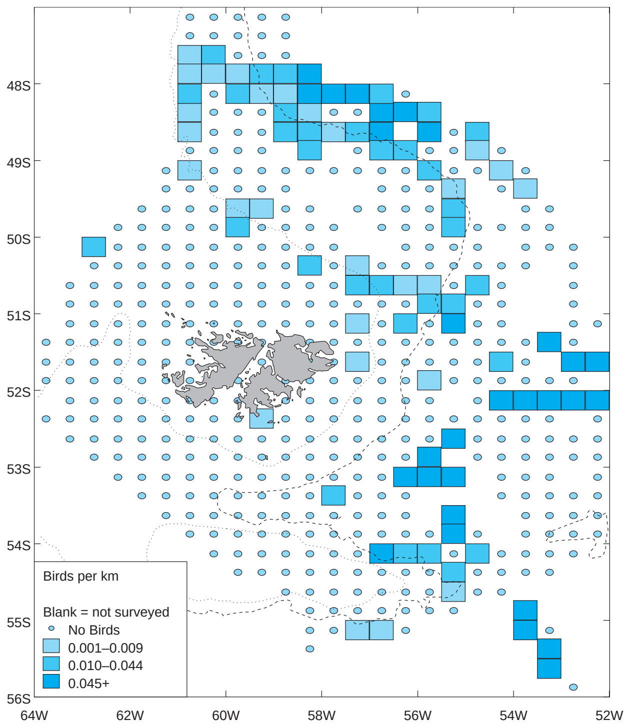

Figure 4.43(b) Atlantic petrel distribution and abundance, all months.

Atlantic petrel P. incerta

Atlantic petrels are non-breeding visitors to Falkland Islands waters. The nearest breeding locations to the Falkland Islands in the Tristan da Cunha group and Gough Island. Atlantic petrels and grey petrels are unusual among the seabird species that visit Falkland Islands waters from the Tristan da Cunha group and Gough Island in that they breed in the austral winter *cf.* grey petrel (Harrison 1983).

A total of 252 Atlantic petrels was recorded with records in all months, the majority between October and March (Figure 4.43(a)) with a pronounced October–November peak, earlier than for several other species that visit Falkland Islands waters from the Tristan da Cunha group and Gough Island. This is probably due to the fact that this species breeds during the winter, with birds arriving in Falkland Islands waters during post-breeding dispersal. This is supported by the observation of 25% of Atlantic petrels recorded between November and January in primary moult. However, the seasonal pattern of distribution does not match that of grey petrel, the other winter breeding species.

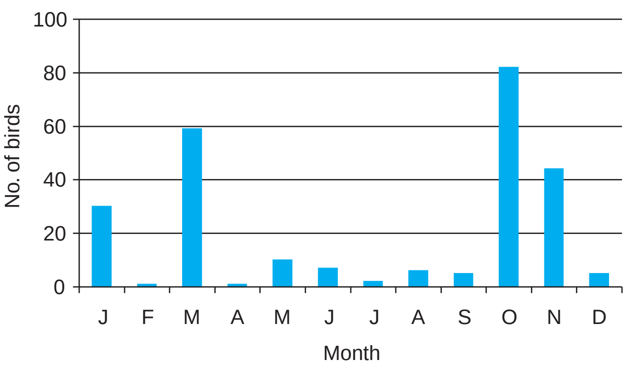

Figure 4.43(a) Number of Atlantic petrels recorded in each month.

This species exhibited a similar spatial distribution to other species breeding on the Tristan da Cunha group and Gough Island (*cf.* soft-plumaged petrel and black-bellied storm-petrel), with most records from deep waters to the north-east and south-east of the islands, and few birds venturing into the relatively shallow Patagonian Shelf waters (Figure 4.43(b)).

Prion species Pachyptila spp.

Prions are notoriously difficult to identify at sea to species level. The majority of birds encountered during surveys were thought to have been thin-billed prions from the large population that breeds in the Falkland Islands. Estimates of the size of this population vary from 100,000 pairs (Woods and Woods 1997) to one million pairs (Croxall *et al.* 1984a). However, the similar Antarctic prion may also be a regular visitor to Falklands Islands waters. A population of approximately 22 million pairs of this species breeds on South Georgia (Croxall *et al.* 1984b). Consequently, the vast majority of prions recorded during surveys were simply recorded as 'prion species'. Fairy prions proved easier to identify and

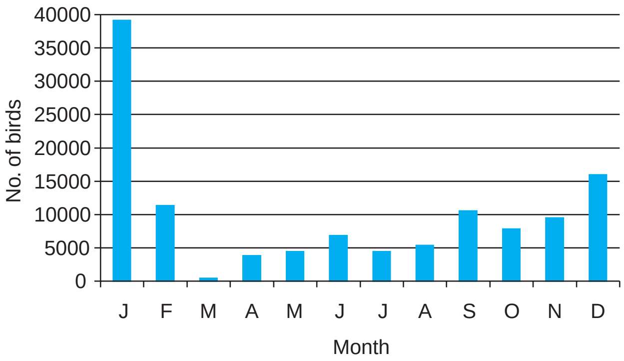

Figure 4.44(a) Number of prions species recorded in each month.

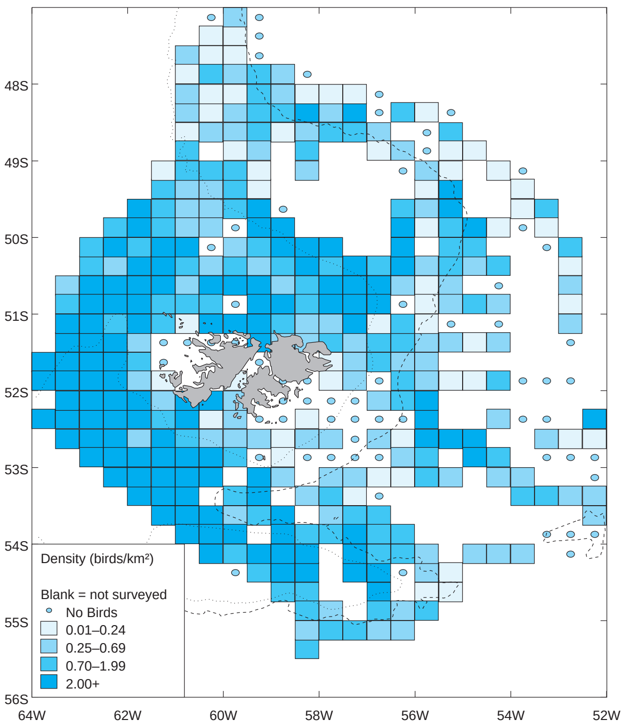

Figure 4.44(b) Prion species distribution and abundance, November to February.

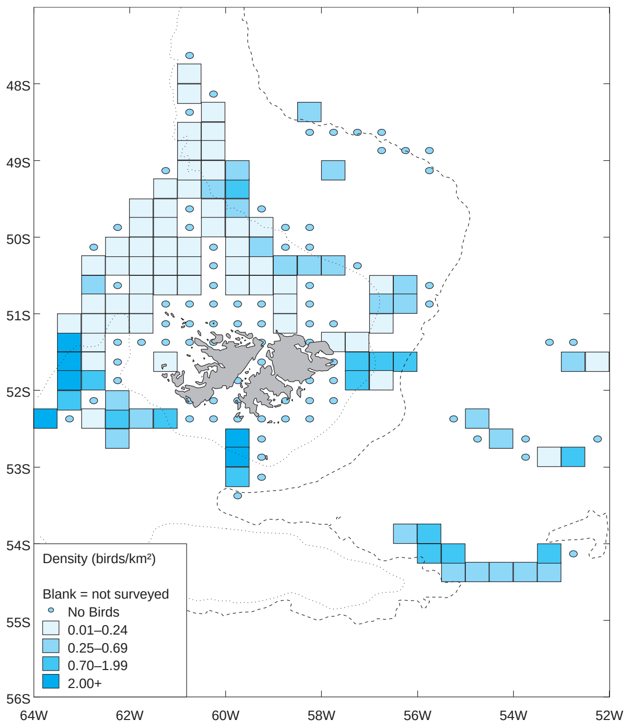

Figure 4.44(c) Prion species distribution and abundance, March to April.

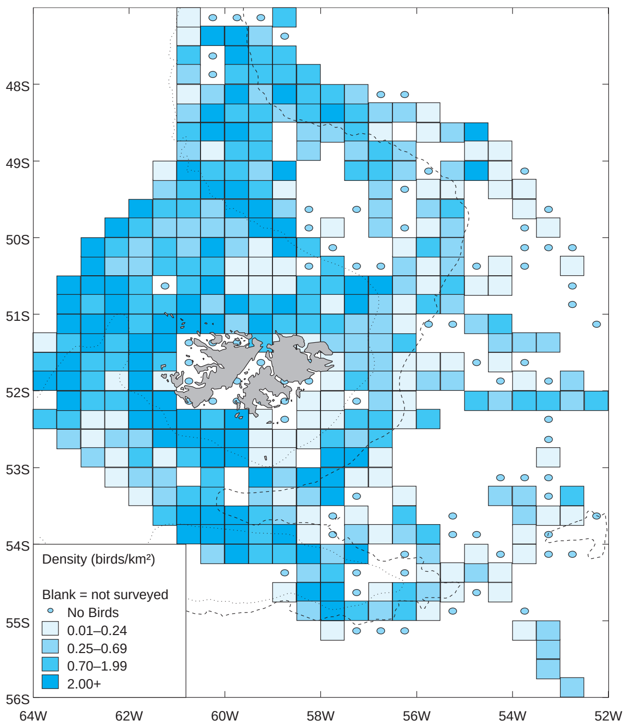

Figure 4.44(d) Prion species distribution and abundance, May to October.

are treated separately. Prions proved to be the most numerous seabirds encountered during surveys with a total of 119,610 recorded. Highest numbers were recorded in the period September to February with a peak in January (Figure 4.44(a)). A marked decline in numbers was evident in March, with relatively low numbers present throughout the winter months.

Between November and February highest densities were found throughout the Patagonian Shelf waters to the west and north-west of the islands. The shelf-slope waters within the SCA, relatively close to large colonies on New and Bird Islands, were also found to hold high densities at this time (Figure 4.44(b)) *cf.* Wilson's storm-petrels and diving-petrels. High densities were also found to the north of West Falkland and along the shelf-break to the north of East Falkland. Prions were absent from or present at low densities in Patagonian Shelf waters to the south-east of East Falkland at this time and throughout the year. Oceanic waters held low or moderate, locally high, densities of birds.

Although coverage in March and April was more restricted, a large decline in the number and densities of prions was observed. This decline was noted in White *et al*. (1999) and has proven to be the case in the subsequent two years of surveys. At this time, although locally high densities were still found to the south-west of the islands, densities over the rest of the Patagonian Shelf waters were greatly reduced (Figure 4.44(c)).

Between May and October, densities in Patagonian Shelf waters to the west of the islands were moderate or high; however, in comparison to the period November to February, densities within the SCA were greatly reduced. Continental shelf slope waters to the north of the islands, in the vicinity of the 200 m isobath and the Burdwood Bank, also held moderate to high densities at this time (Figure 4.44(d)).

Fairy prion P. turtur

The Falkland Islands population of fairy prions is estimated to be perhaps as high as 10,000 pairs, all on Beauchêne Island (Woods and Woods 1997).

In common with other difficult to identify species, such as Magellan diving-petrel, it is necessary to adopt a cautious approach to the interpretation of the figures for fairy prion. Although fairy prion is the easiest of the prions to identify at sea, on many occasions it was not possible to specifically identify all prions seen; for example, when dealing with large flocks of prions. As a result, the records of this species may not reflect their true seasonal and spatial distribution pattern.

A total of 288 fairy prions was recorded. There were records in all months except February, with pronounced peaks in April, August and October (Figure 4.45(a)). The lack of any seasonal pattern is probably a reflection of the difficulty encountered in identifying this species. From the presence of high numbers in both April and August it appears that the species may be resident in the survey area and that the species can be found in waters in the vicinity of the colony year-round.

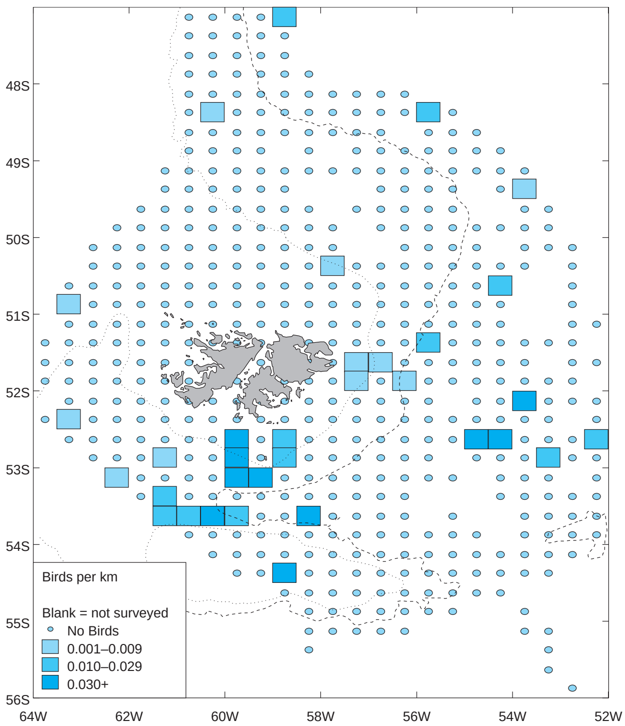

Figure 4.45(b) Fairy prion distribution and abundance, all months.

Fairy prions were recorded primarily in continental shelf slope and oceanic waters. There were very few records from Patagonian Shelf waters, with the exception of waters to the south of the islands near the known colony on Beauchêne Island (Figure 4.45(b)). As such, it is perhaps unsurprising that there should be a high number of sightings in this area.

Grey petrel Procellaria cinerea

Grey petrels are non-breeding visitors to Falkland Islands waters. The nearest breeding locations are on the Tristan da Cunha group and Gough Island where they are winter breeders *cf*. Atlantic petrel (Harrison 1983). Records in Woods (1988) indicate that the species has been recorded ‘at least between February and June’.

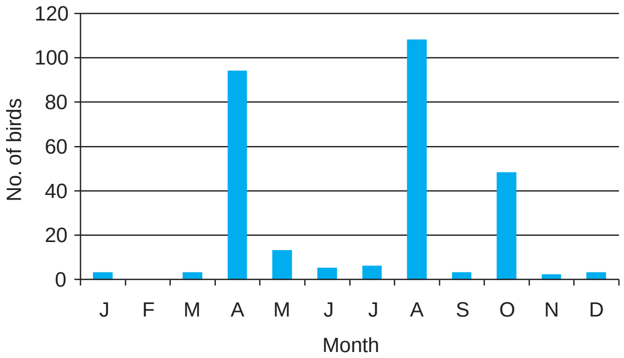

Figure 4.45(a) Number of fairy prions recorded in each month.

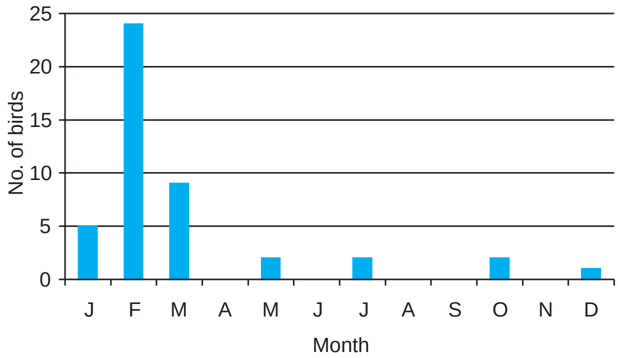

Figure 4.46(a) Number of grey petrels recorded in each month.

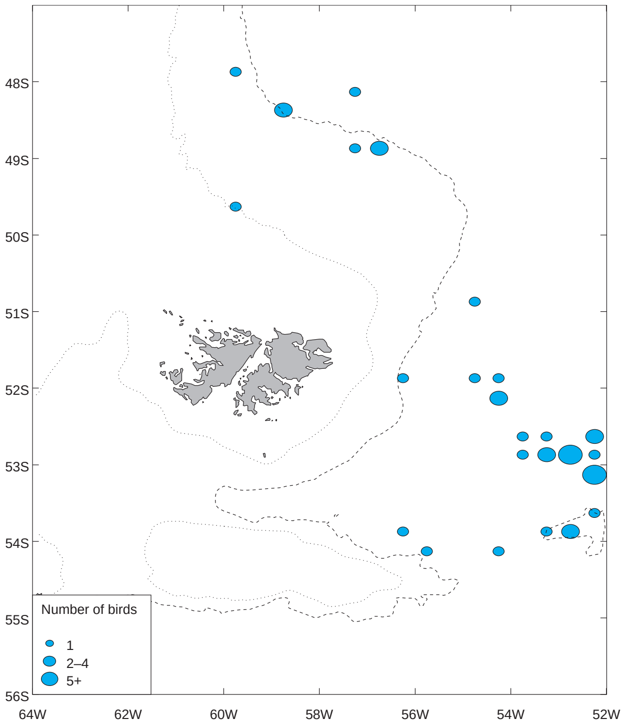

Figure 4.46(b) Distribution of grey petrel sightings, all months.

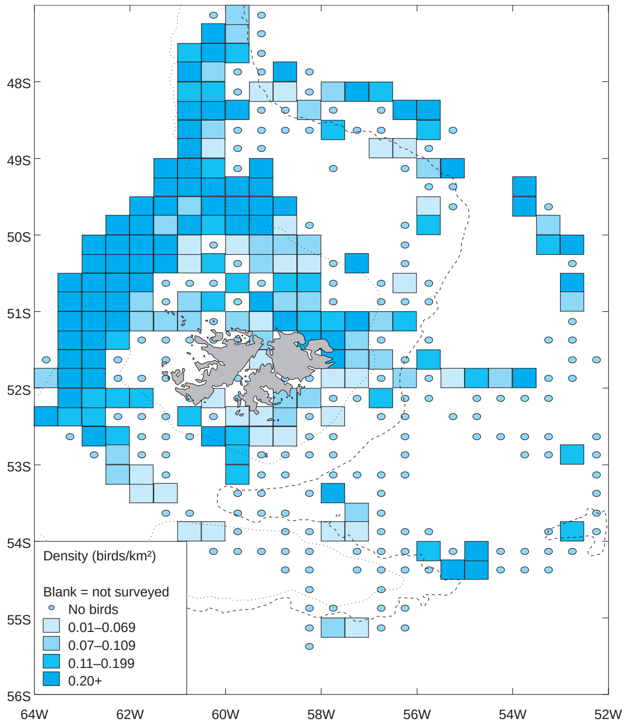

Figure 4.47(b) White-chinned petrel distribution and abundance, January to May.

A total of 45 grey petrels was recorded. The majority of records fell between December and March, with a peak in numbers in February. Further single birds were recorded in May, July and October (Figure 4.46(a)). All records were from deep waters to the north and east of the islands (Figure 4.46(b)).

White-chinned petrel P. aequinoctialis

The Falkland Islands support a breeding population of white-chinned petrels estimated to be between 1,000 and 5,000 pairs (Woods and Woods 1997). A much larger population, 2 million pairs, breeds at South Georgia and birds from this population are known to visit Falkland Islands waters during the breeding season (Berrow *et al*. 2000).

A total of 8,044 white-chinned petrels was recorded. Records occurred in all months, but with lower numbers present during winter. Highest numbers were found in late summer with a peak in March and lowest numbers in July (Figure 4.47(a)). A total of 245 white-chinned petrels was recorded in primary moult. Of these, 232 were in the period February to April with 9% of all white-

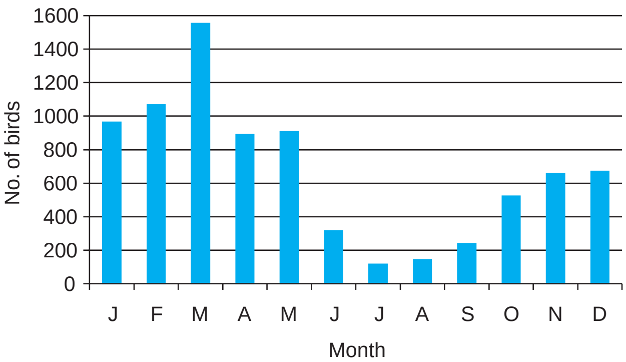

Figure 4.47(a) Number of white-chinned petrels recorded in each month.

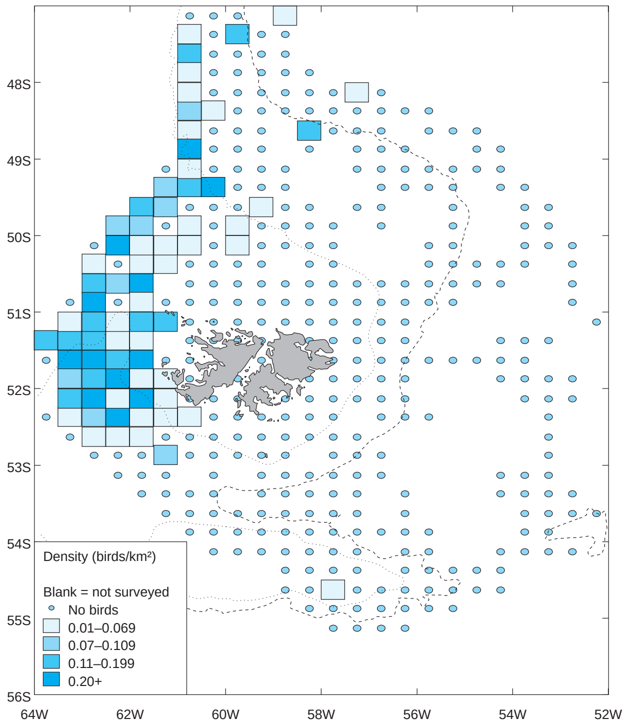

Figure 4.47(c) White-chinned petrel distribution and abundance, June to September.

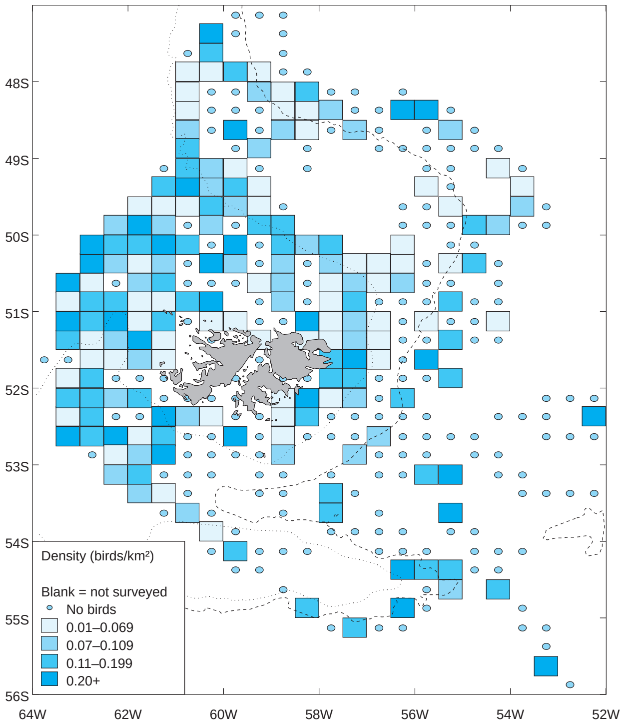

Figure 4.47(d) White-chinned petrel distribution and abundance, October to December.

chinned petrels recorded during March in primary moult.

White-chinned petrels showed a highly seasonal distribution with birds present throughout the Patagonian Shelf waters during the summer months, but restricted to the west of the survey area during winter months. Between January and May, very high densities of white-chinned petrels were encountered over Patagonian Shelf waters to the west and north-west of West Falkland, broadly corresponding with the area occupied by the *Illex* jigging fleet. Lower densities were recorded to the south and east of the islands at this time (Figure 4.47(b)). Between June and September, there were very few records of white-chinned petrels to the east or south-east of the islands, while densities to the west of the islands were generally low or moderate with locally high or very high densities (Figure 4.47(c)). By October white-chinned petrels were widespread, with locally high densities recorded throughout the survey area (Figure 4.47(d)).

Great shearwater Puffinus gravis

Great shearwaters are summer visitors to Falkland Islands waters, with a breeding population estimated to be between 50 and 100 pairs (Woods and Woods 1997). This represents a tiny proportion of the South Atlantic population with some 4 million pairs breeding in the Tristan da Cunha group and Gough Island (Williams 1984).

A total of 6,468 great shearwaters was recorded with the majority in the period December to April

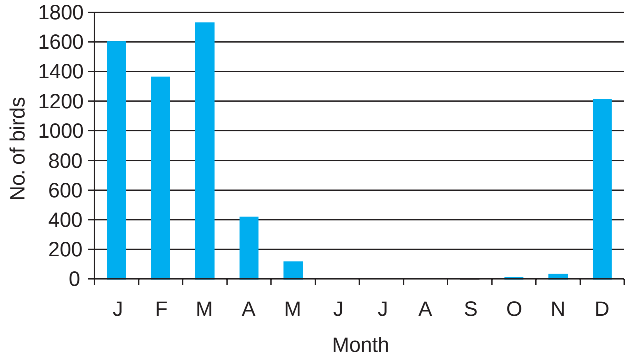

Figure 4.48(a) Number of great shearwaters recorded in each month.

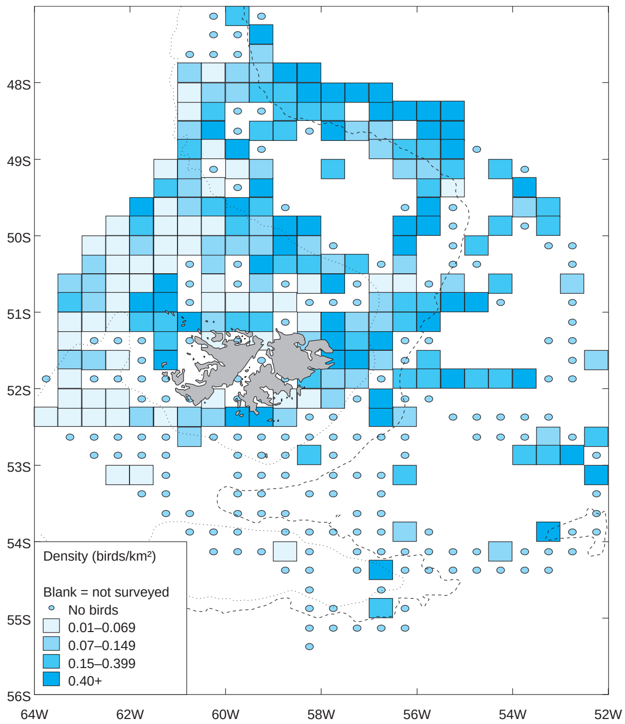

Figure 4.48(b) Great shearwater distribution and abundance, December to April.

(Figure 4.48(a)). Approximately 5% of birds were recorded in primary moult during March and April. Great shearwaters were the species most frequently recorded associating with cetaceans, most notably hourglass dolphins.

Between December and April, great shearwaters were recorded at highest densities over shelf slope and oceanic waters to the east and north of the islands, with locally high densities also recorded over Patagonian Shelf waters (Figure 4.48(b)). By May, very few great shearwaters remained in Falkland Islands waters (Figure 4.48(c)) and none were recorded between June and August. Great shearwaters were recorded again in September; however, they remained very scarce until December (Figure 4.48(d)).

The majority of great shearwaters recorded were presumably from the larger Tristan da

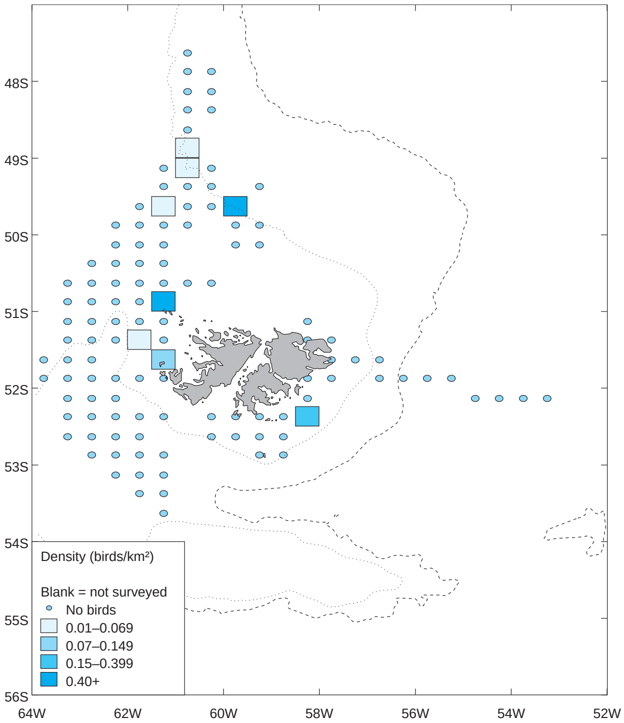

Figure 4.48(c) Great shearwater distribution and abundance, May.

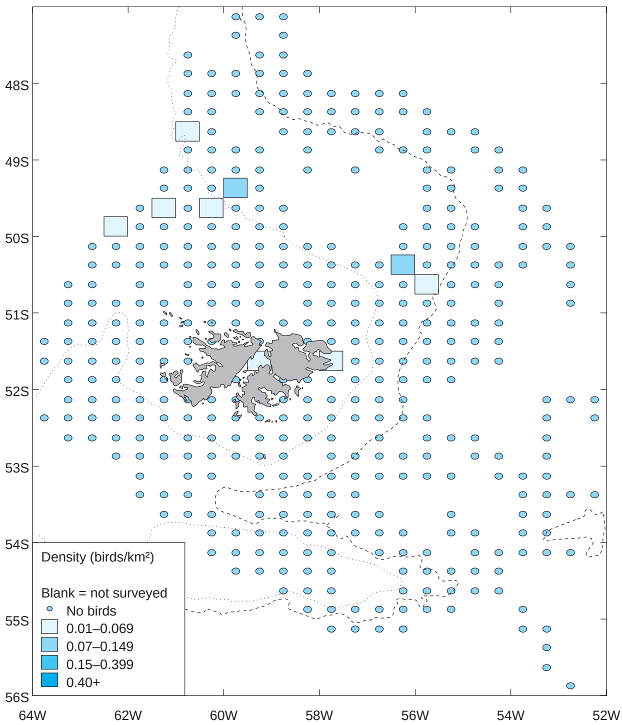

Figure 4.48(d) Great shearwater distribution and abundance, September to November.

Cunha group and Gough Island population rather than local breeding birds. At least 1.7% of birds recorded were in primary moult, presumably pre- or non-breeders (Watson 1971; Streseman and Streseman 1970).

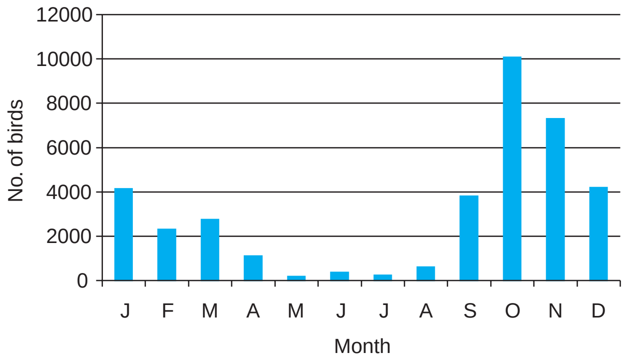

Figure 4.49(a) Number of sooty shearwaters recorded in each month.

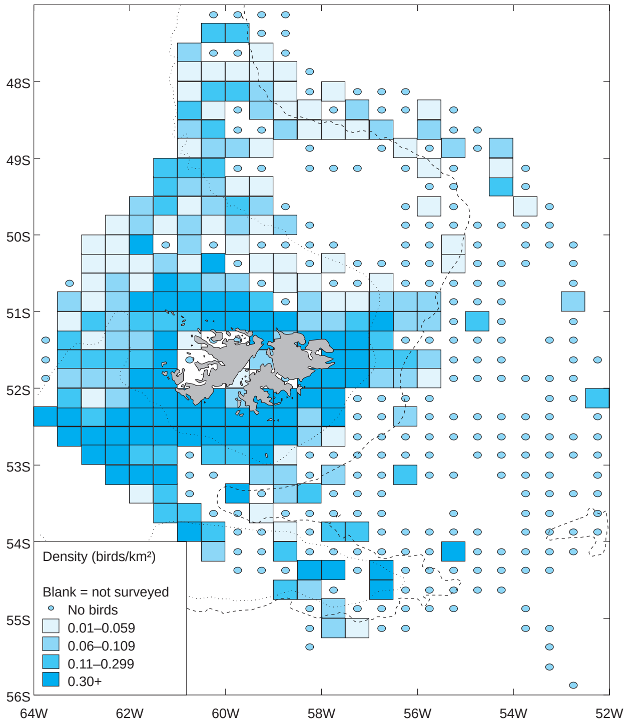

Figure 4.49(b) Sooty shearwater distribution and abundance, September to March.

Sooty shearwater P. griseus

The Falkland Islands breeding population of sooty shearwaters is thought to be in the order of 10,000 to 20,000 pairs (Woods and Woods 1997). Prior to this study, sooty shearwaters were regarded as a breeding season visitor to Falkland Islands waters; for example, Bourne and Curtis (1985) described sooty shearwaters leaving Falkland Islands waters in April.

A total of 37,109 sooty shearwaters was recorded. Birds were recorded in every month, although by far the highest numbers were encountered in the period September to March, with a peak in October (Figure 4.49(a)).

Between September and March, highest densities of sooty shearwaters were recorded throughout the inshore waters around the islands and

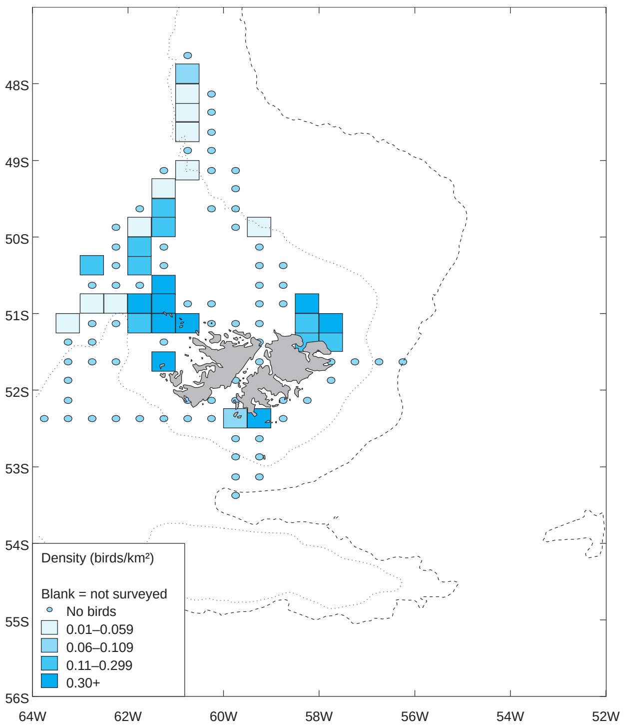

Figure 4.49(c) Sooty shearwater distribution and abundance, April.

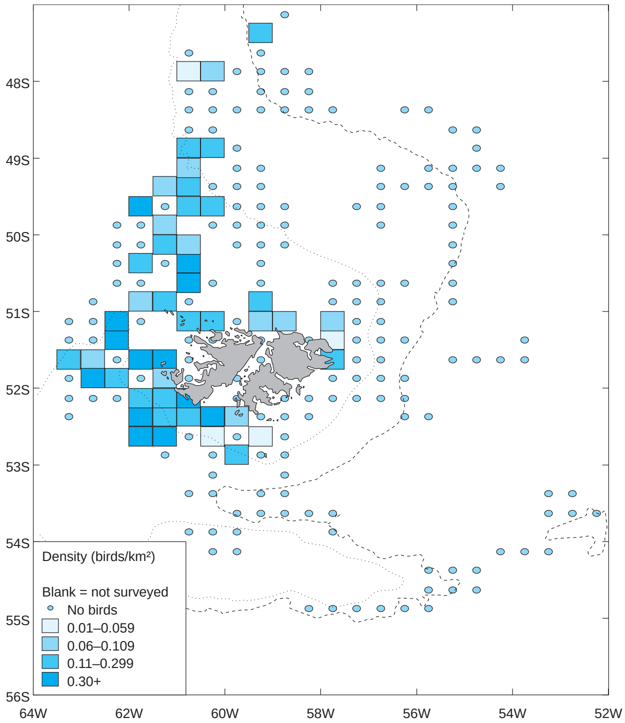

Figure 4.49(e) Sooty shearwater distribution and abundance, August.

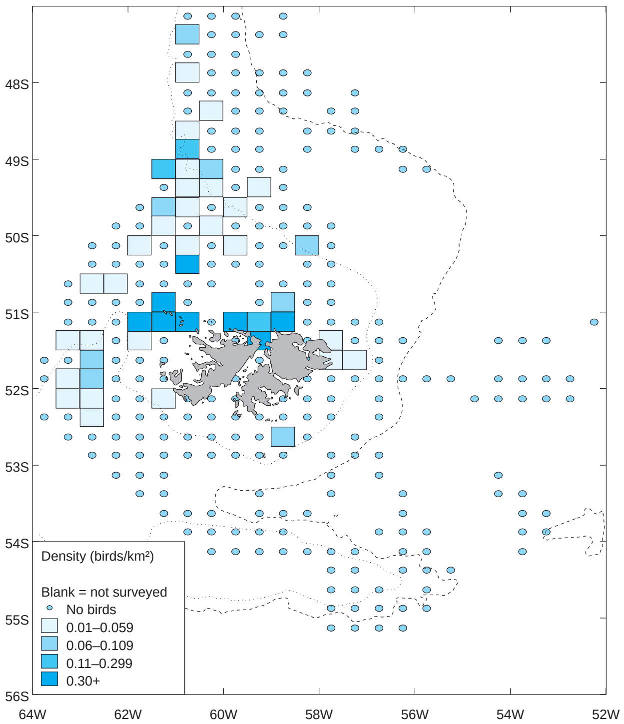

Figure 4.49(d) Sooty shearwater distribution and abundance, May to July.

Patagonian Shelf waters to the east and south-west of the islands. Sooty shearwaters were generally absent from oceanic waters, but locally low or moderate densities were encountered to the north of the islands (Figure 4.49(b)). In April, locally very high densities were encountered in coastal and Patagonian Shelf waters but numbers were lower than during the preceding period (Figure 4.49(c)). In winter months, May to July, high densities however were encountered in inshore waters off the north coast of West Falkland, in particular in the vicinity of the Jason Islands and the northern entrance to Falkland Sound. Low densities of sooty shearwaters were encountered in Patagonian Shelf waters to the north-west of the islands. (Figure 4.49(d)). Sooty shearwaters started returning to Falkland Islands waters from the northern hemisphere in August, with highest densities encountered on Patagonian Shelf waters to the south-west of the islands (Figure 4.49(e)).

Little shearwater P. assimilis

Although it is not known which subspecies of little shearwater occurs in Falkland Islands waters, the most likely is the race *elegans*, which breeds in the Tristan da Cunha group and Gough Island (Marchant and Higgins 1990; Williams 1984). However, observers noted that there were some marked differences in the appearance of individual birds, most notably in the extent of white feathering around the eye, suggesting that perhaps more than one subspecies occurs in Falkland Islands waters. Prior to this study there had been three records of little shearwater in Falkland Islands waters (Bourne and Curtis 1986; Gregory 1994).

A total of 24 little shearwaters was recorded. All records were in the December to April period with a peak in March (Figure 4.50(a)). Two birds were

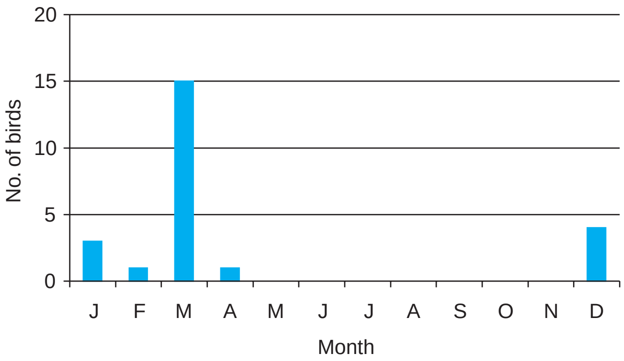

Figure 4.50(a) Number of little shearwaters recorded in each month.

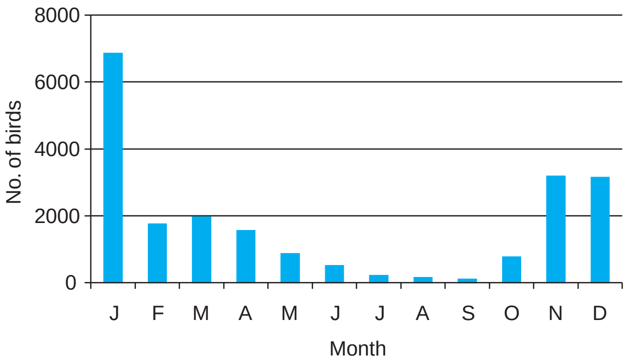

Figure 4.51(a) Number of Wilson's storm-petrels recorded in each month.

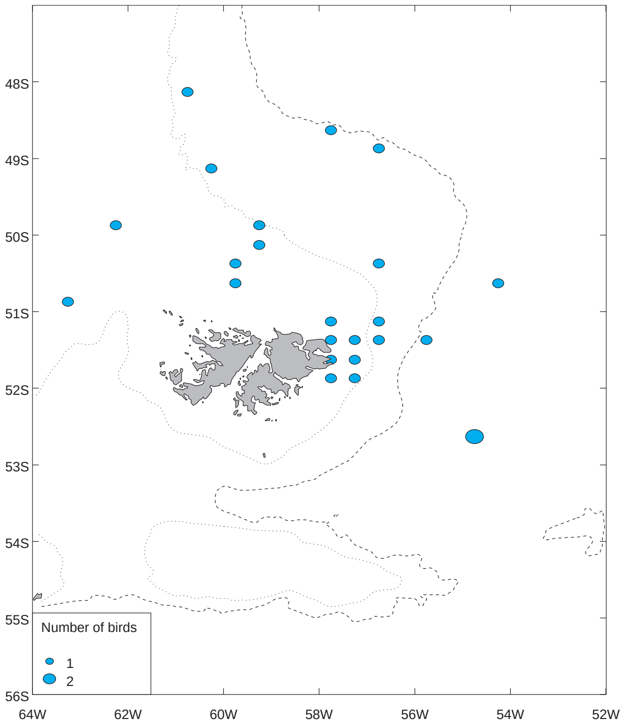

Figure 4.50(b) Distribution of little shearwater sightings, December to April.

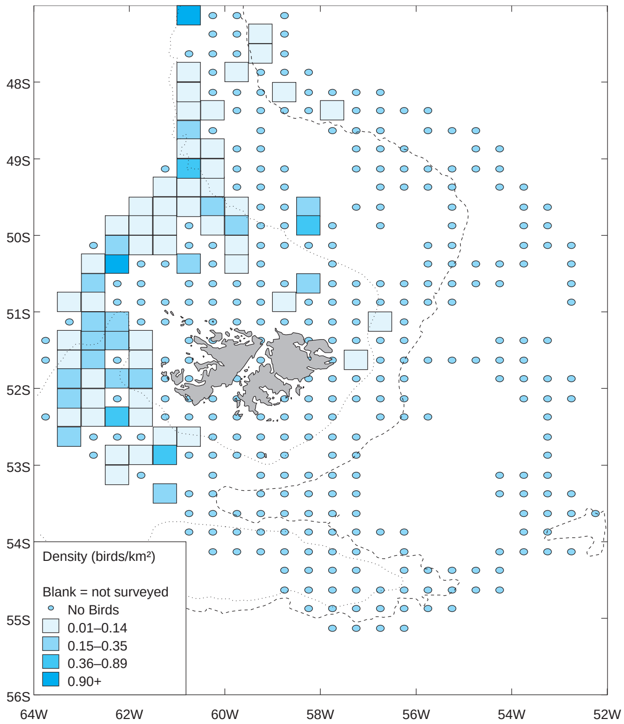

Figure 4.51(b) Wilson's storm-petrel distribution and abundance, July to September.

recorded in primary moult in December and January.

All records came from waters to the north and east of the islands. Little shearwaters were recorded both in deep-water areas and Patagonian Shelf waters, with a concentration of records in the waters east of East Falkland (Figure 4.50(b)).

Storm-petrels Oceanitidae

Six species of storm-petrel have previously been recorded within Falkland Islands waters (Woods 1988; Bourne and Curtis 1997). Two species, Wilson's and grey-backed storm-petrels, definitely breed, and black-bellied storm-petrels possibly do so (I. Strange pers. comm.). Four species were recorded during surveys in Falkland Islands waters.

Wilson's storm-petrel Oceanites oceanicus

The Falkland Islands support a breeding population of Wilson's storm-petrels estimated to be in excess of 5,000 pairs (Woods and Woods 1997). Prior to this study Wilson's storm-petrels were regarded as summer visitors to Falkland Islands waters.

A total of 21,019 Wilson's storm-petrels was recorded. Most birds were present in the period October to June, with a marked peak in numbers between November and January (Figure 4.51(a)). Eighty-eight Wilson's storm-petrels were recorded in active primary moult between December and April, with 91% of records in February and March. Breeding adult Wilson's storm-petrels moult on their wintering grounds from May onwards (Marchant and Higgins 1990). This suggests that those birds moulting in Falkland Islands

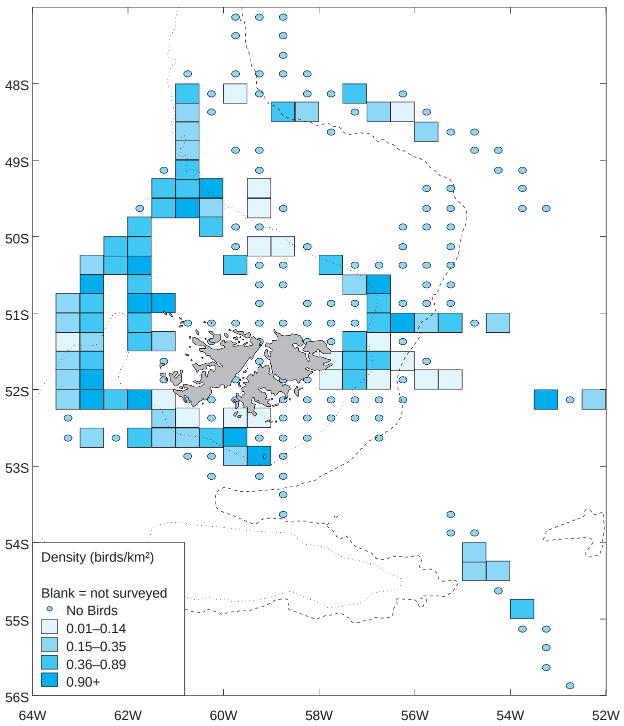

Figure 4.51(c) Wilson's storm-petrel distribution and abundance, October.

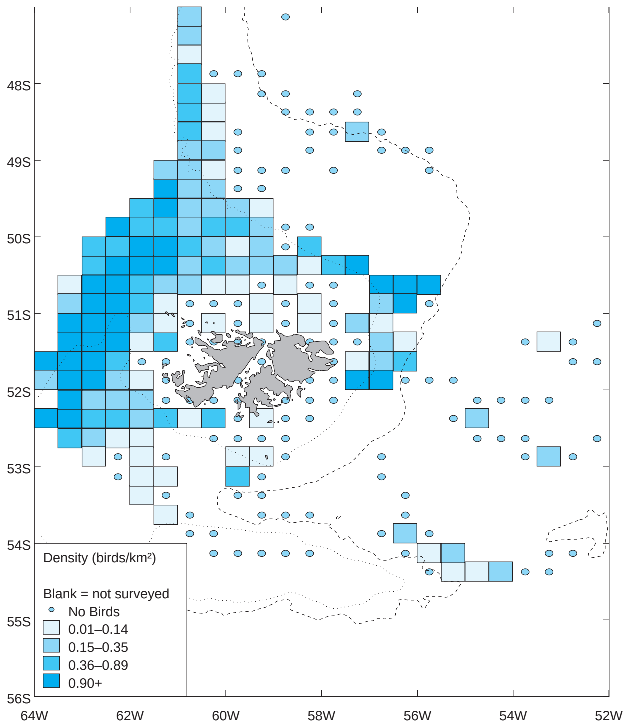

Figure 4.51(e) Wilson's storm-petrel distribution and abundance, March to June.

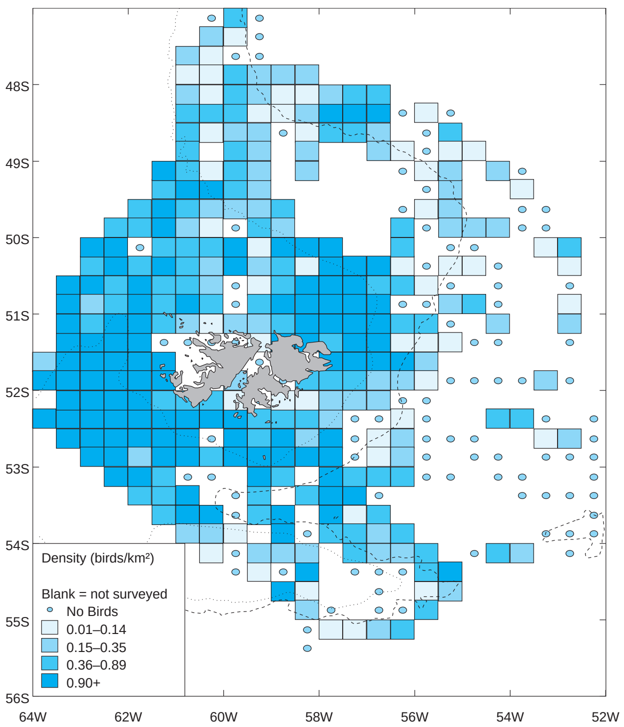

Figure 4.51(d) Wilson's storm-petrel distribution and abundance, November to February.

waters were failed breeders or pre-breeders and that those birds present during the winter were not breeding adults.

Between July and September, Wilson's storm-petrels were encountered at low to moderate densities in Patagonian Shelf waters to the north-west of the islands (Figure 4.51b) *cf.* white-chinned petrel. Very few birds were recorded to the east or north-east of the islands at this time. During October Wilson's storm-petrels returned to Falkland Islands waters in low numbers with highest densities to the west and north-east of the islands (Figure 4.5(c)). Between November and February Wilson's storm-petrels were widespread throughout Falkland Islands waters. At this time highest densities were found over Patagonian Shelf waters, particularly to the west of the islands, and also from the shelf-slope waters within the SCA to the south-west of the islands (*cf.* prions and diving-petrels). High densities were also found at this time to the north-east of East Falkland in the vicinity of the 200 m isobath (Figure 4.51(d)). Although Wilson's storm-petrels were still present at high densities in Patagonian Shelf waters to the west of the islands in the period March to June, densities were greatly reduced within the SCA and from the waters to the north-east of East Falkland (Figure 4.51(e)). There also appeared to be a movement away from inshore waters around the islands.

Grey-backed storm-petrel Garrodia nereis

The Falkland Islands support between 1,000 and 5,000 breeding pairs of grey-backed storm-petrels (Woods and Woods 1997). Prior to this study, grey-backed storm-petrels were thought to be summer visitors to Falkland Islands waters (*cf.* Wilson's storm-petrels).

A total of 2,758 grey-backed storm-petrels was recorded, with the majority in the period Septem-

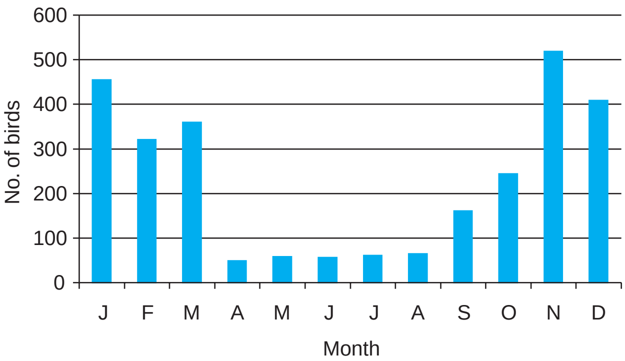

Figure 4.52(a) Number of grey-backed storm-petrels recorded in each month.

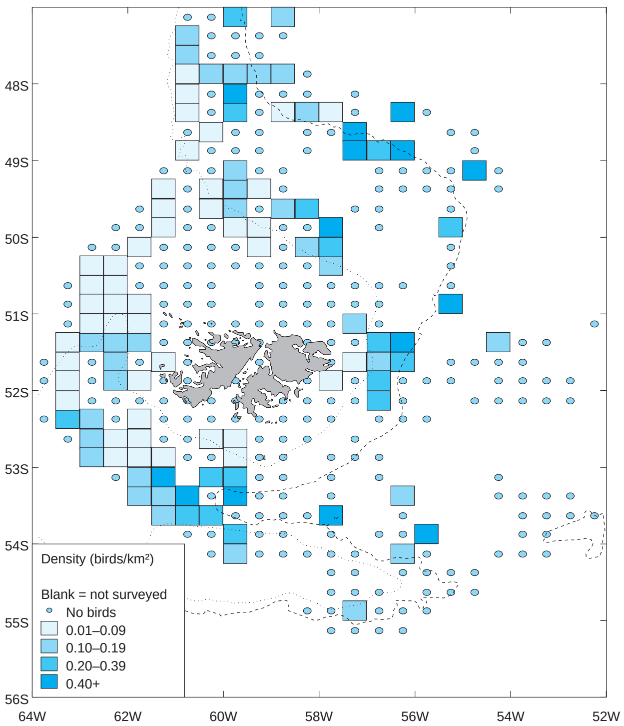

Figure 4.52(b) Grey-backed storm-petrel distribution and abundance, April to August.

ber to March (Figure 4.52(a)). Forty-nine grey-backed storm-petrels were recorded in primary moult in the period December to March, with a peak in December, when 7% of all grey-backed storm-petrels recorded exhibited primary moult. Breeding adult grey-backed storm-petrels moult after breeding between February and May (Marchant and Higgins 1990). Therefore, it seems likely that most of the birds observed moulting in Falkland Islands waters were either failed or pre-breeders. The fact that no birds were recorded in moult during the winter months suggests that those birds wintering in Falkland Islands waters were either failed or pre-breeders (*cf.* Wilson's storm-petrel).

Between April and August, low densities of grey-backed storm-petrels were encountered at

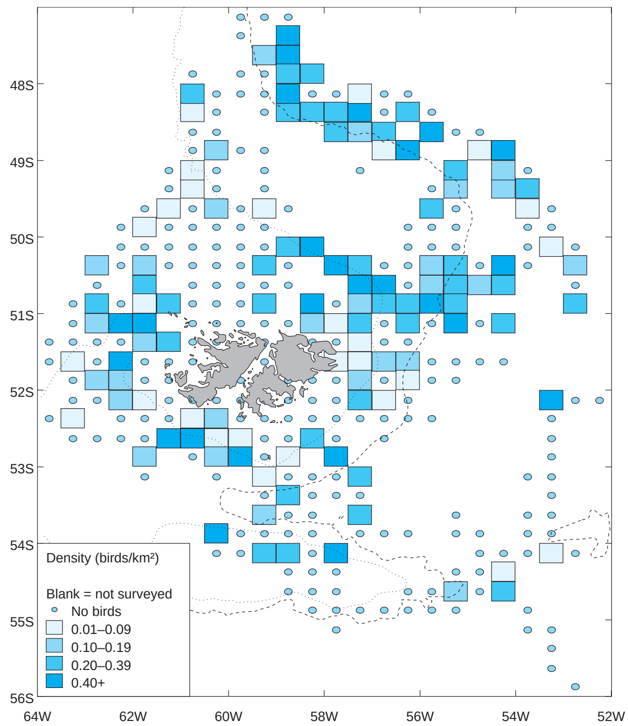

Figure 4.52(c) Grey-backed storm-petrel distribution and abundance, September to October.

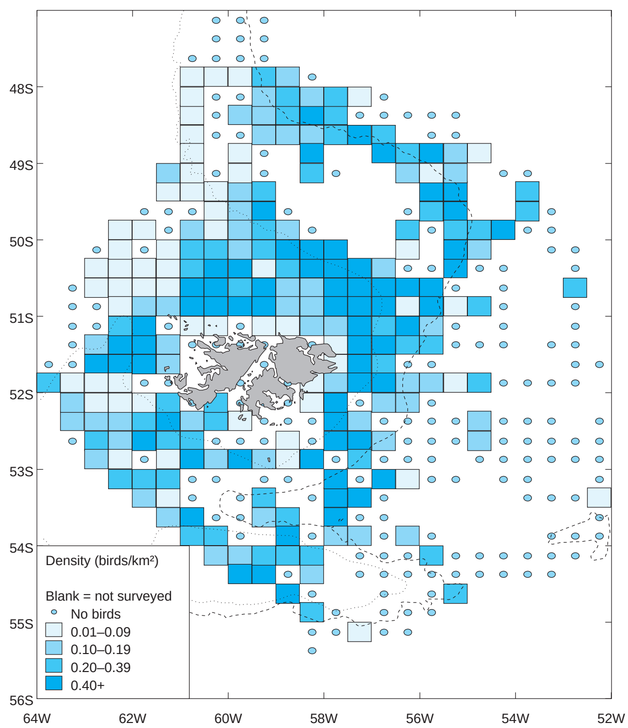

Figure 4.52(d) Grey-backed storm-petrel distribution and abundance, November to March.

locally high densities recorded in continental shelf slope and oceanic waters with lower densities on the Patagonian Shelf (Figure 4.52(b)). In September and October, numbers of grey-backed storm-petrels in Falkland Islands waters increased, with locally high densities recorded in

the vicinity of the 200 m isobath to the west of the islands and around the 1,000 m isobath to the south and north-east. At this time, densities in Patagonian Shelf waters remained low (Figure 4.52(c)). Between November and March, locally high densities were encountered in Patagonian Shelf waters to the north-west of the islands, with highest densities remaining in the vicinity of the 200 m and 1,000 m isobaths, most notably to the north-east of the islands (Figure 4.52(d)).

Grey-backed storm-petrel was the species most frequently involved in associations with free-floating kelp-patches. A significant correlation was found between the density of grey-backed storm-petrels and the density of kelp (Gillon *et al*. 2001). Studies of the diet of grey-backed storm-petrels have recorded them feeding almost exclusively on a goose barnacle which develops on free-floating debris, such as kelp patches (Imber 1981). In turn, the distribution of free-floating kelp is determined by the direction of the Falklands/Malvinas Current (Figures 1.2 and 4.24(b)).

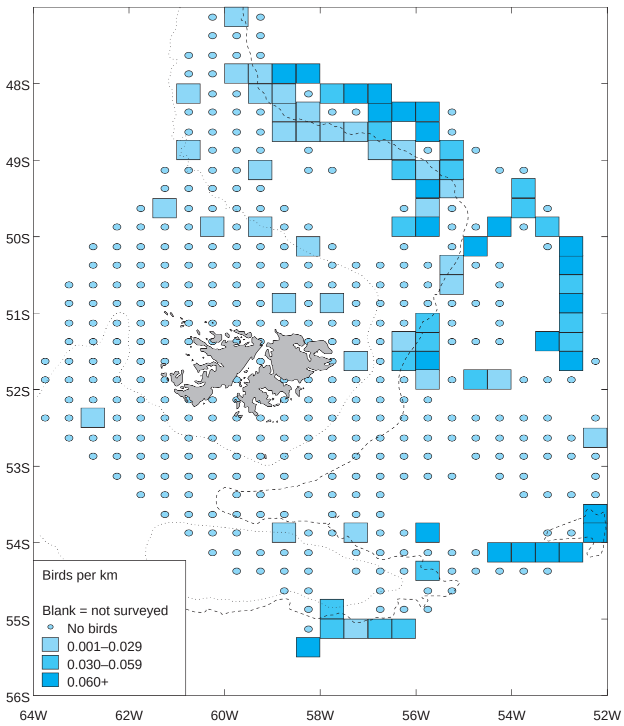

Figure 4.53(b) Black-bellied storm-petrel distribution and abundance, October to April.

Black-bellied Fregetta tropica and White-bellied F. grallaria storm-petrels

Of the two species of *Fregetta* storm-petrel, black-bellied storm-petrels are known to occur in Falkland Islands waters, while white-bellied storm-petrels may do so, but their status remains unclear (Woods 1998). Most previous records of black-bellied storm-petrel in Falkland Islands waters have been between November and February (Woods 1988).

Black-bellied storm-petrels breed on both South Georgia and the Tristan da Cunha group and Gough Island. This species may also breed on Beauchêne Island in the Falklands archipelago (I. Strange pers. comm.), although firm evidence of this is lacking. In the South Atlantic, white-bellied storm-petrels breed only in the Tristan da Cunha group and Gough Island. However, the status of the white-bellied storm-petrel in the Tristan da Cunha group and Gough Island is uncertain, with some reports of black-bellied storm-petrels with white-bellies (see account in Marchant and Higgins 1990).

It is not known to which population black-bellied storm-petrels in Falkland Islands waters belong. However, their seasonal presence matches other seabird species from the Tristan da Cunha group and Gough Island (e.g. great shearwater and soft-plumaged petrel) and the presence of white-bellied birds further supports this location as the origin of the majority of *Fregetta* storm-petrels in Falkland Islands waters. The alternative source of black-bellied storm-petrels in Falkland Islands waters is South Georgia, where there is an estimated population of 10,000 pairs (Prince and Croxall 1983). The species is a summer visitor to South Georgia, with no birds recorded below the Antarctic Convergence during at-sea surveys in the winter (Black *et al*. 2000). Where these birds go in the winter is unknown, but from the lack of

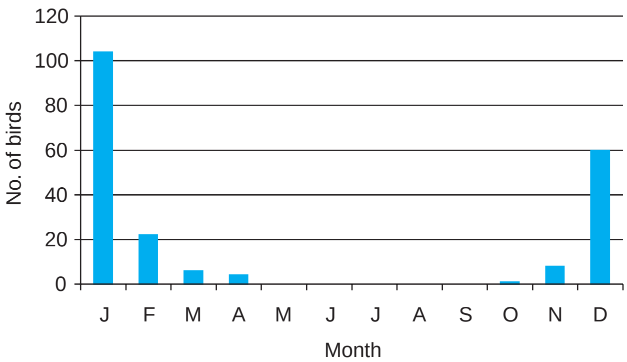

Figure 4.53(a) Number of black-bellied storm-petrels recorded in each month.

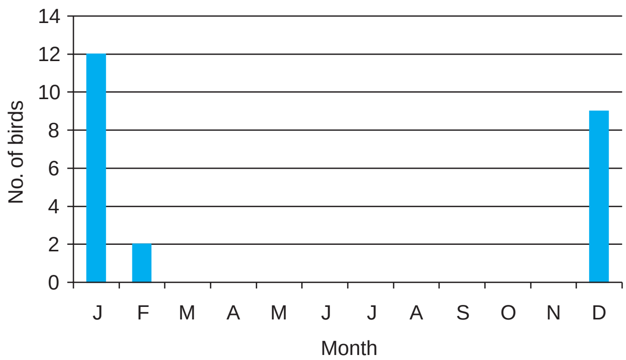

Figure 4.53(c) Number of white-bellied storm-petrels recorded in each month.

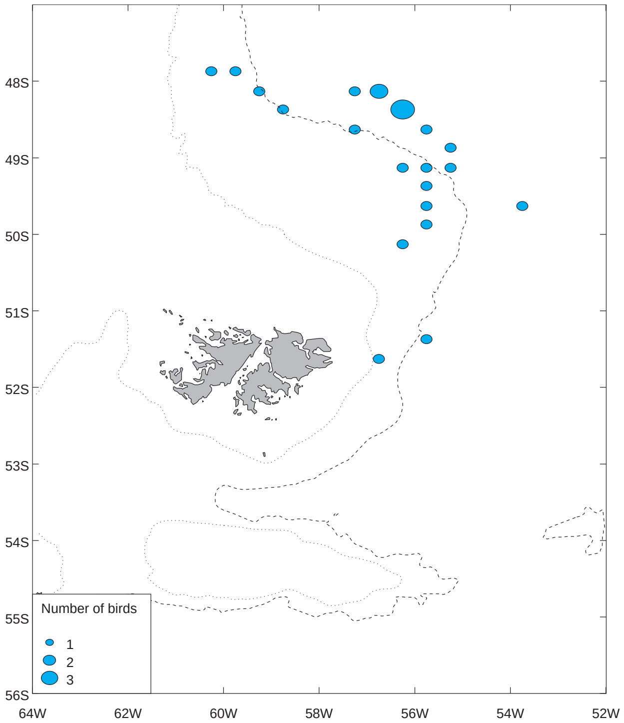

Figure 4.53(d) Distribution of white-bellied storm-petrel sightings, December to February.

winter records of black-bellied storm-petrel during this study it is apparent that they do not move into Falkland Islands waters.

During surveys, *Fregetta* storm-petrels with both black and white bellies were observed. These have been kept separate in this analysis and the white-bellied birds tentatively identified as *F. grallaria*, although they may be a white-bellied form of *F. tropica*.

A total of 228 *Fregetta* storm-petrels was recorded. Of these, 205 were identified as black-bellied storm-petrels and 23 as white-bellied storm-petrels. All records of both species were in the period October to April, with white-bellied records restricted to December to February (Figures 4.53(a) and (c)). Numbers of both species peaked in January *cf.* soft-plumaged petrel.

The majority of black-bellied storm-petrel records were in deep waters to the north-east of the islands, with a few records to the south-east of the islands and occasional records in Patagonian Shelf waters to the north of the islands (Figure 4.53(b)). All records of white-bellied storm-petrel were in deep waters to the north and east of the islands (Figure 4.53(d)).

Diving-petrels Pelecanoididae

Of the four species of diving-petrel, three have been recorded in Falkland Islands waters (Woods 1988; Bourne and Curtis 1997). One species, common diving-petrel, breeds in the islands, while the Magellan diving-petrel is a regular visitor in low numbers and may breed; the status of Georgian diving-petrel is poorly known, but it is probably a rare visitor.

Diving-petrel species Pelecanoides spp.

Diving-petrel identification at sea is not straightforward. Most Magellan diving-petrels can be confidently identified given reasonable views. The separation of common diving-petrel from Georgian diving-petrel is not so straightforward, and while common diving-petrel is believed to be the common species in Falkland Islands waters, this assumption was not made during surveys.

A total of 6,078 diving-petrels were recorded. Of these, 133 were recorded as Magellan diving-petrel, 753 as common diving-petrel with 5,192 not specifically identified. In the following analysis, numbers of common diving-petrels and unidentified diving-petrels have been combined.

Diving-petrels were recorded in all months, with the majority (84%) recorded between September and February (Figure 4.54(a)). No diving-petrels were recorded in moult. It is not known whether this is because they do not moult in Falkland Islands waters or because they become flightless during moult and therefore difficult to detect (Watson 1968).

Between September and October, diving-petrels were encountered at highest densities in Patagonian Shelf waters to the west and south of the islands (Figure 4.54(b)). Elsewhere in the survey area, diving-petrels were present at low or moderate densities in Patagonian Shelf waters with occasional birds in deep-water areas. From November to February, highest densities of diving-petrels were concentrated in Patagonian Shelf and continental shelf slope waters to the west and south-west of the islands *cf.* prions and Wilson's storm-petrel. Moderate densities were recorded throughout Patagonian Shelf waters with occasional birds recorded in deep water areas and over the Burdwood Bank (Figure 4.54(c)). Between March and August, diving-petrels were present at reduced densities in most parts of the study area. The exception to this was waters in the vicinity of

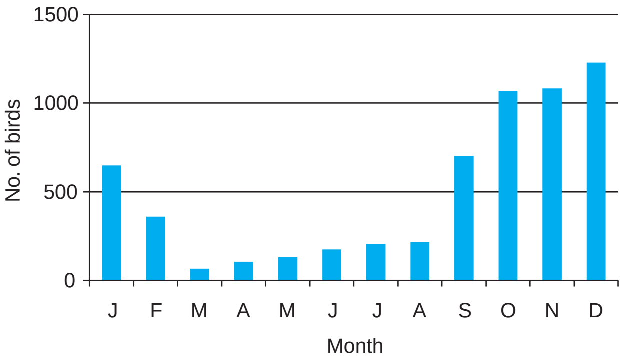

Figure 4.54(a) Number of diving-petrels recorded in each month.

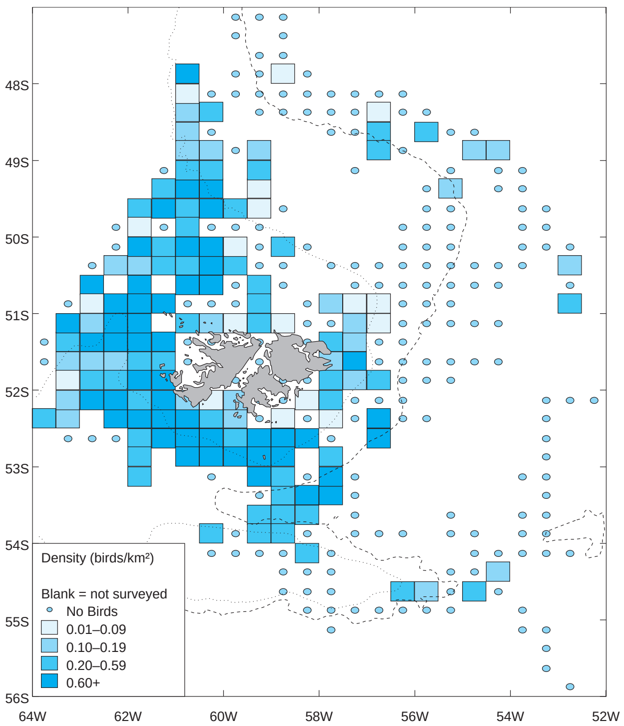

Figure 4.54(b) Diving-petrel distribution and abundance, September to October.

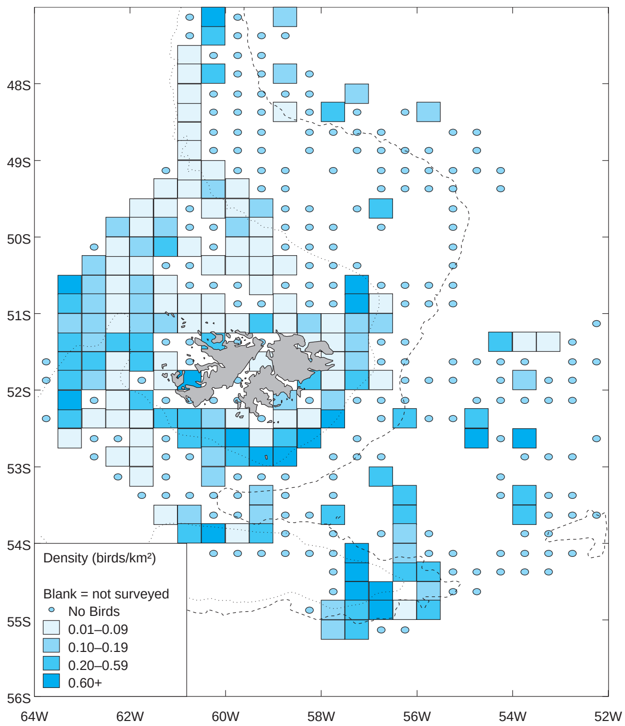

Figure 4.54(d) Diving-petrel distribution and abundance, March to August.

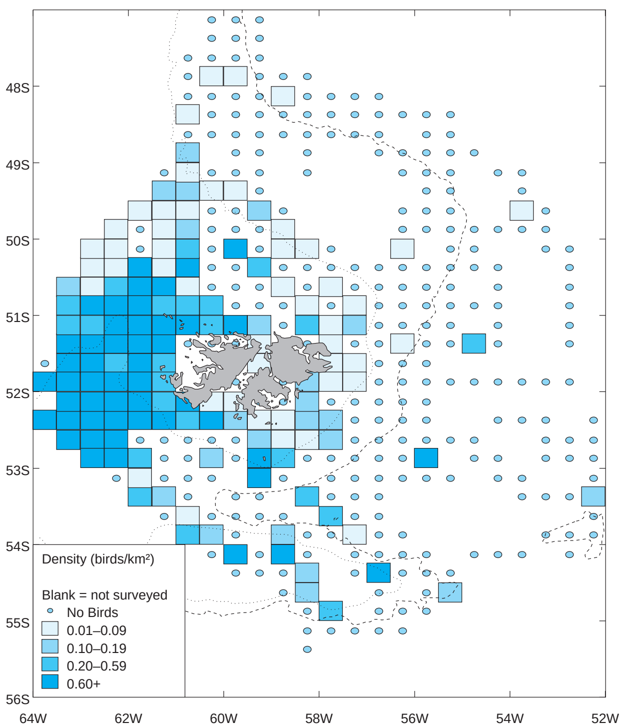

Figure 4.54(c) Diving-petrel distribution and abundance, November to February.

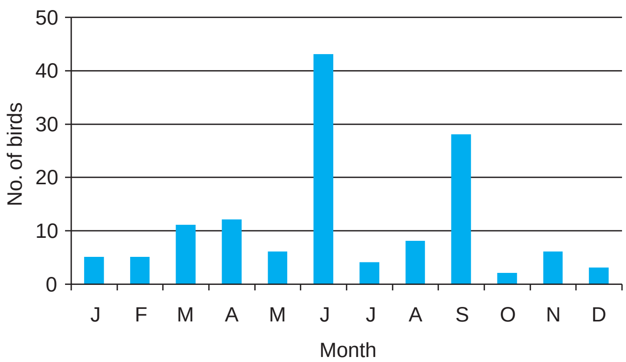

Figure 4.54(e) Number of Magellan diving-petrels recorded in each month.

Beauchêne Island and the Burdwood Bank, where locally very high densities of diving-petrels were recorded (Figure 4.54(d)).

Magellan diving-petrels were recorded in all months with apparent peaks in June and September (Figure 4.54(e)). In common with fairy prion, this lack of any clear seasonal pattern is probably a reflection of the difficulties encountered in identifying this species.

Magellan diving-petrels were recorded primarily to the west of the survey area (Figure 4.54(f)). This was not unexpected, as the southern part of mainland South America is the main breeding range of this species. There was also a relatively high proportion of records from coastal and partially enclosed waters such as Falkland Sound and Berkeley Sound. In these areas Magellan diving-petrels were recorded within 2 km of the coast while there were no records of common diving-petrel within 2 km of the coast. The presence of birds close inshore during the summer adds weight to speculation that the species breeds in the Falkland Islands, although this has not been proven (Woods and Woods 1997).

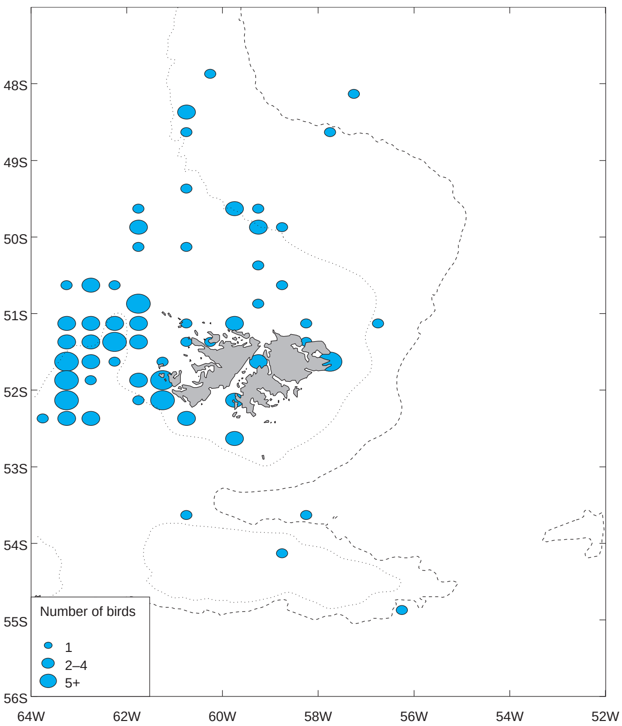

Figure 4.54(f) Distribution of Magellan diving-petrel sightings, all months.

There were relatively few Magellan diving-petrels among the locally high densities of diving-petrels recorded over the Burdwood Bank in the winter months. It is likely that Georgian diving-petrels were present but undetected in these concentrations, as observers on board longliners in this area have recorded this species (B. Sullivan pers. comm.).

Shags Phalacrocoracidae

Three species of shag have been recorded in the waters surrounding the Falkland Islands (Woods 1988). Two of these are resident breeding species and were commonly recorded during our surveys. The third, red-legged shag, is a vagrant and was not recorded during surveys.

Rock shag Phalacrocorax magellanicus

Rock shags are a resident breeding species in the Falkland Islands. The population is estimated to be between 32,000 and 59,000 pairs (Woods and Woods 1997). Globally, rock shags are only found in the Falkland Islands and South America.

A total of 796 rock shags was recorded, with records in all months and a peak in July (Figure 4.55(a)). The decline in the number of birds recorded in May is not easily explained, but is probably linked to low levels of inshore survey effort in this month (*cf*. Commerson's dolphin). Highest densities were typically encountered in enclosed or partially enclosed waters, most notably within Falkland Sound (Figures 4.55(b) and 4.55(c)).

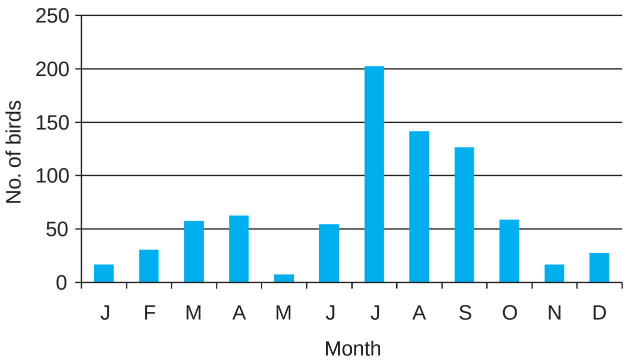

Figure 4.55(a) Number of rock shags recorded in each month.

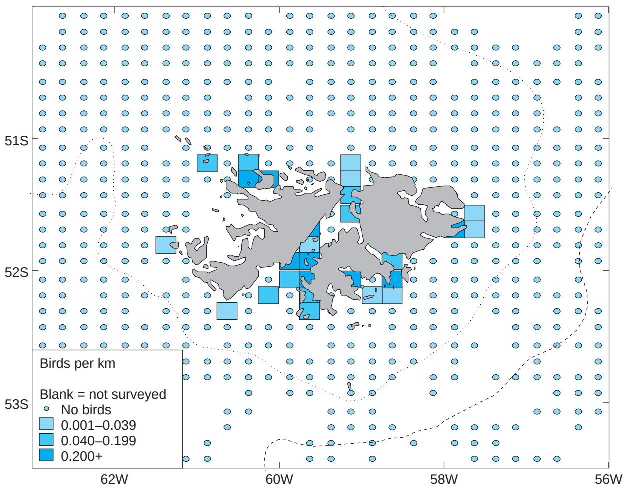

Figure 4.55(b) Rock shag distribution and abundance, October to March.

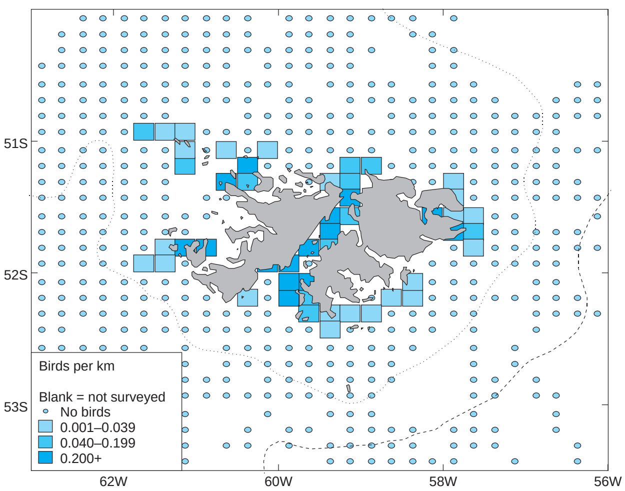

Figure 4.55(c) Rock shag distribution and abundance, April to September.

Rock shags were typically recorded closer inshore than imperial shags, with all rock shag records within 27 km of the coast. In common with imperial shag, there was evidence of birds moving further offshore in winter. In December and January there were no records of rock shags more than

5 km from the coast, while in June and July rock shags were recorded up to 27 km from the coast. There were no records of adult rock shags more than 16 km from the coast, as all six birds recorded between 16 and 27 km offshore were immatures in the post-fledging period (April to July).

Imperial shag P. atriceps

An endemic race of imperial shag *P. a. albiventer* is resident in the Falkland Islands, with a population of between 45,000 and 84,000 breeding pairs (Woods and Woods 1997). Other races of imperial shag are found in areas adjacent to the study area at South Georgia, the Antarctic Peninsula and in southern South America.

A total of 39,264 imperial shags was recorded during surveys. Birds were recorded in all months with a peak in numbers between June and September (Figure 4.56(a)). The majority of records came from inshore waters, with a movement of birds further offshore during winter months. Between November and May the average imperial shag record was 12 km from the coast, increasing to 37 km between June and October.

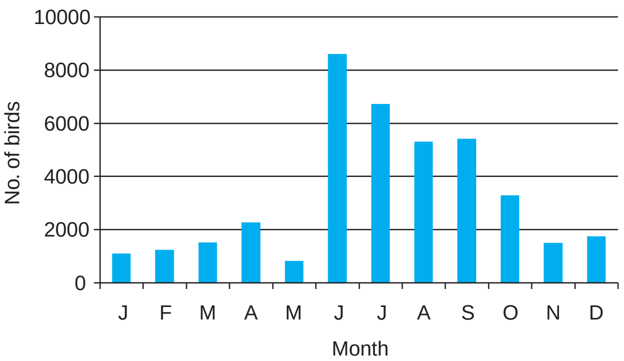

Figure 4.56(a) Number of imperial shags recorded in each month.

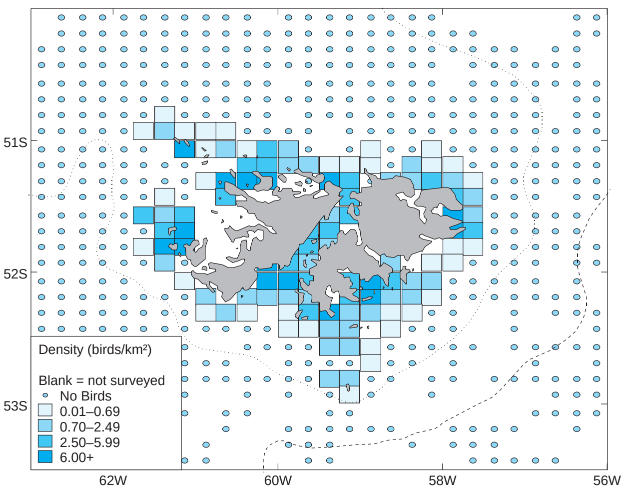

Figure 4.56(b) Imperial shag distribution and abundance, November to May.

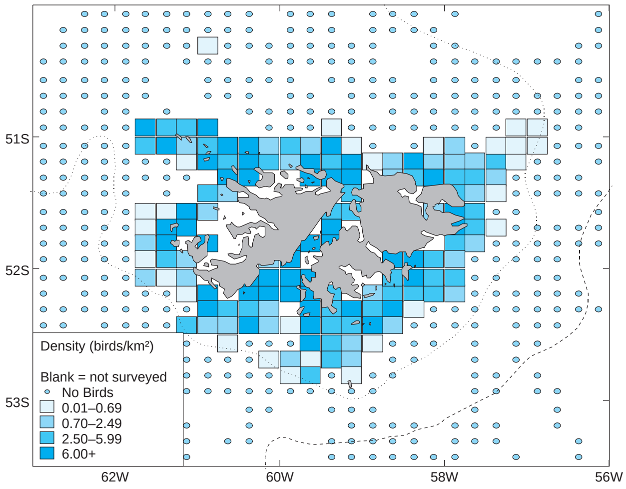

Figure 4.56(c) Imperial shag distribution and abundance, June to October.

Between November and May, imperial shag densities in inshore waters were generally low or moderate, with locally high or very high densities (Figure 4.56(b)). Between June and October, imperial shag densities were higher throughout inshore waters, with low or moderate densities recorded further offshore (Figure 4.56(c)). This offshore movement was most noticeable to the south and west of the islands and to the north-east of East Falkland. At all times of year, birds were restricted to Patagonian Shelf waters (<200 m deep).

Ducks Anatidae

Only one species of duck was recorded during surveys. There are several other species of wildfowl that are primarily coastal in their distribution, e.g. kelp goose, Patagonian crested duck, and would thus be vulnerable to any surface pollution reaching the shore. However, these species are unlikely to venture far from the shore and did not occur within the areas surveyed.

Falkland steamer duck Tachyeres brachydactyla

The Falkland steamer duck is endemic to the Falkland Islands with a population estimated to be between 9,000 and 16,000 pairs (Woods and Woods 1997).

A total of 699 Falkland steamer ducks was recorded during surveys. Peak numbers were recorded in April after which numbers progressively fell with no birds recorded in December (Figure 4.57(a)). It is likely that during the breeding season Falkland steamer ducks remain even closer to the shore than at other seasons, resulting in the decrease in the number of birds observed during surveys in the breeding season.

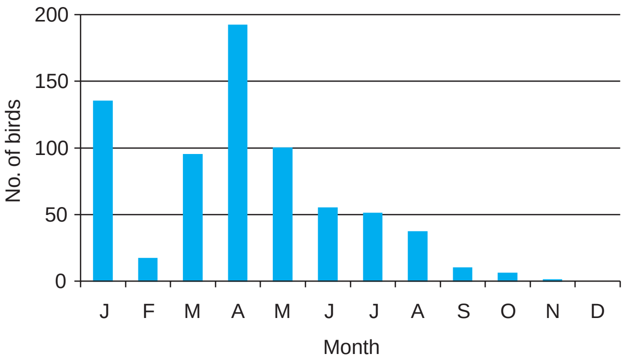

Figure 4.57(a) Number of Falkland steamer ducks recorded in each month.

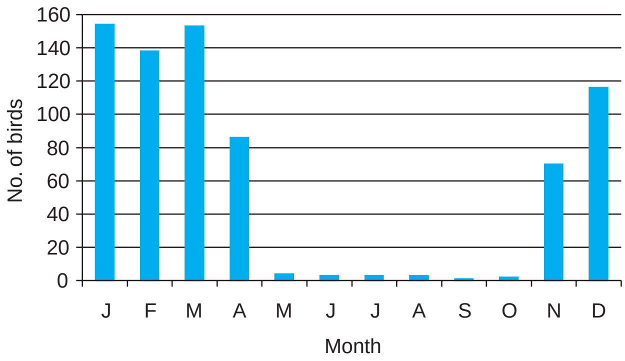

Figure 4.58(a) Number of *Catharacta* skuas recorded in each month.

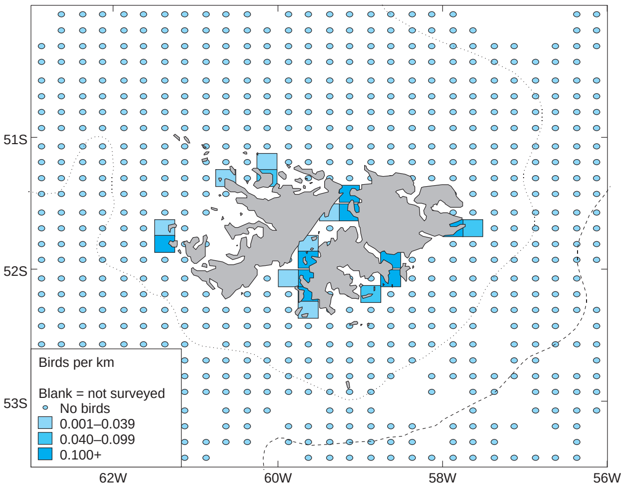

Figure 4.57(b) Falkland steamer duck distribution and abundance, all months.

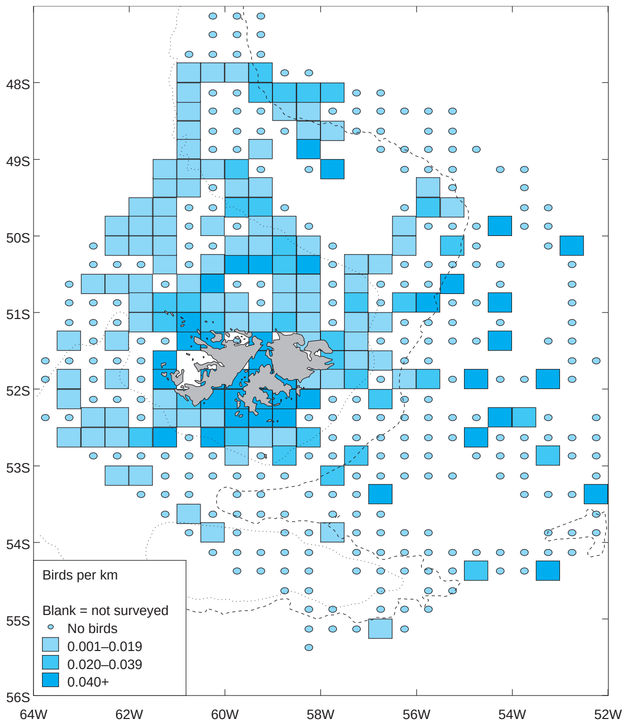

Figure 4.58(b) *Catharacta* skua distribution and abundance, November to April.

All records came from coastal waters (Figure 4.57(b)), with no records more than eight km from land. Relatively little survey effort is directed at these waters and it is likely that this species is present throughout the coastal waters of the Falkland Islands (Woods and Woods 1997).

Skuas Stercorariidae

Of the five species of skua that have been recorded in the waters of the Falkland Islands (Woods 1988), just one breeds in the islands (Woods and Woods 1997). Four species of skua were recorded during SAST surveys, two were recorded regularly and two were regarded as vagrants.

Antarctic skua Catharacta antarctica

The nominate race of the three subspecies of Antarctic skua, *C. a. antarctica*, breeds in the Falkland Islands. The Falkland Islands support between 5,000 and 9,000 breeding pairs, the majority of the world population of this subspecies. There is also a small population in South America (Woods and Woods 1997). In addition, two closely related species of *Catharacta* skua, Chilean and South Polar skuas, have been recorded in Falkland Islands waters (Woods 1988).

Due to the difficulties of identifying *Catharacta* skuas at sea, a number of birds remained unidentified. It is thought probable that most of these records referred to Antarctic skua, but neither Chilean skua nor South Polar skua could be ruled out in all cases. As a result, all unidentified *Catharacta* skuas have been combined with Antarctic skuas for this analysis. Of the total of 737 *Catharacta* skuas recorded, 573 (77.7%) were identified as Antarctic skuas, four as Chilean skuas and the remainder were recorded as unidentified *Catharacta* skua. There were no confirmed records of South Polar skua within the study area.

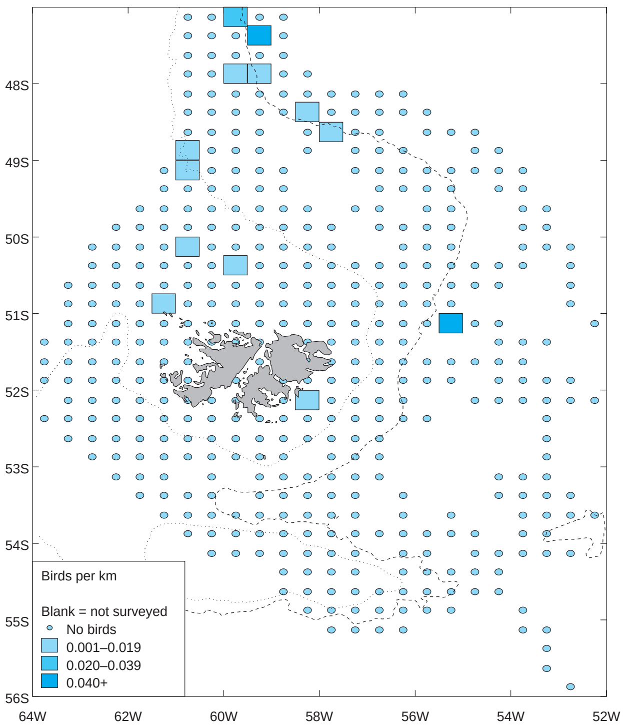

Figure 4.58(c) *Catharacta* skua distribution and abundance, May to October.

Catharacta skuas were strongly seasonal in their presence in Falkland Islands waters.

The majority of records (97.9%) occurred between November and April (Figure 4.58(a)) when *Catharacta* skuas were most commonly encountered in inshore waters with local concentrations of birds found throughout the rest of the study area (Figure 4.58(b)). The few birds recorded between May and October were mostly in offshore areas to the north and west of the islands (Figure 4.58(c)). Where Antarctic skuas go when they leave Falkland Islands waters for the winter is unknown, although it is thought that they move north to about 20° S (Olsen and Larsson 1997).

Catharacta skuas were recorded kleptoparasitising imperial shags, rock shags, Magellanic penguins and sooty shearwaters.

Arctic skua Stercorarius parasiticus

Arctic skuas are summer visitors to Falkland Islands waters from their breeding areas in the northern hemisphere. Prior to this study there were only three records of Arctic skuas in Falkland Islands waters (Woods 1988).

A total of 35 Arctic skuas was recorded. All records fell in the period between January and April (Figure 4.59(a)). Most birds were recorded in an exceptional influx in January 2000 when 26 birds were recorded in waters to the north of the islands. All other records came from inshore waters with one over the continental shelf slope to the north of the islands (Figure 4.59(b)).

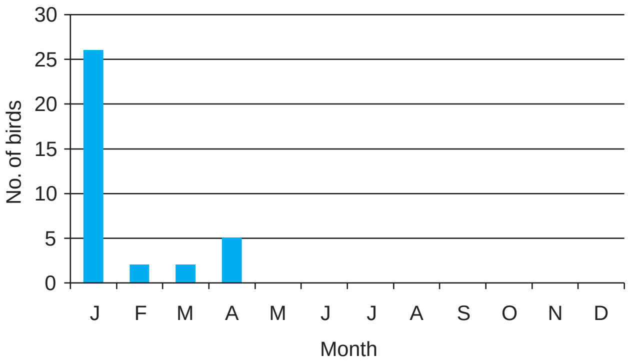

Figure 4.59(a) Number of Arctic skuas recorded in each month.

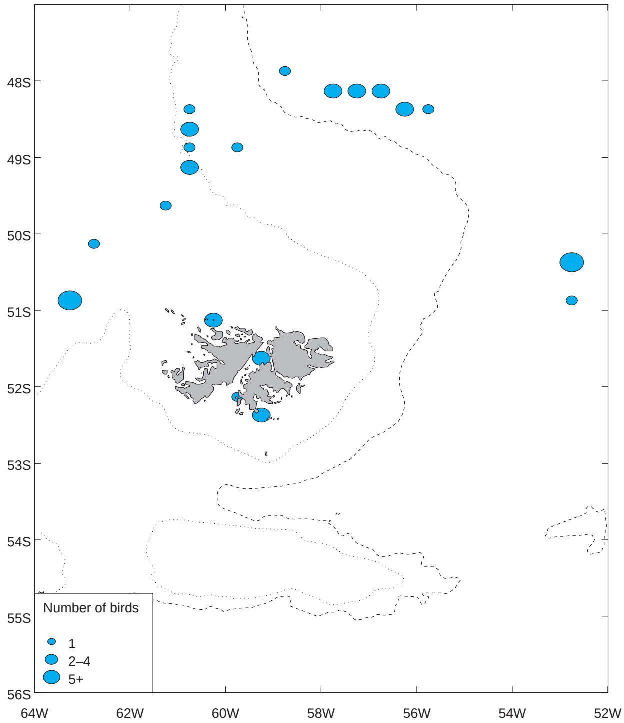

Figure 4.59(b) Distribution of Arctic skua sightings, January to April.

Long-tailed skua S. longicaudus

Long-tailed skuas breed during the boreal summer in the high Arctic and spend the non-breeding season in the South Atlantic and South Pacific Oceans (Olsen and Larsson 1997). This species was known to occur in Falkland Islands waters, in particular within the Falklands/Malvinas Current (Veit 1985).

A total of 239 long-tailed skuas was recorded during surveys. Long-tailed skuas exhibited clear seasonality in their presence in Falkland Islands waters. The first birds arrived in the study area in November, numbers then increased in December and were relatively constant until March, after which numbers decreased during April with no records from May to October (Figure 4.60(a)). This pattern would be expected given this species'

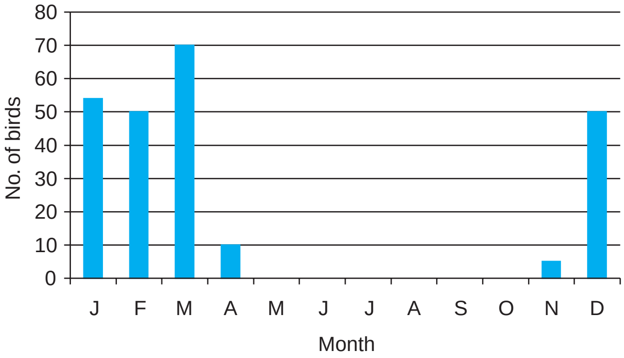

Figure 4.60(a) Number of long-tailed skuas recorded in each month.

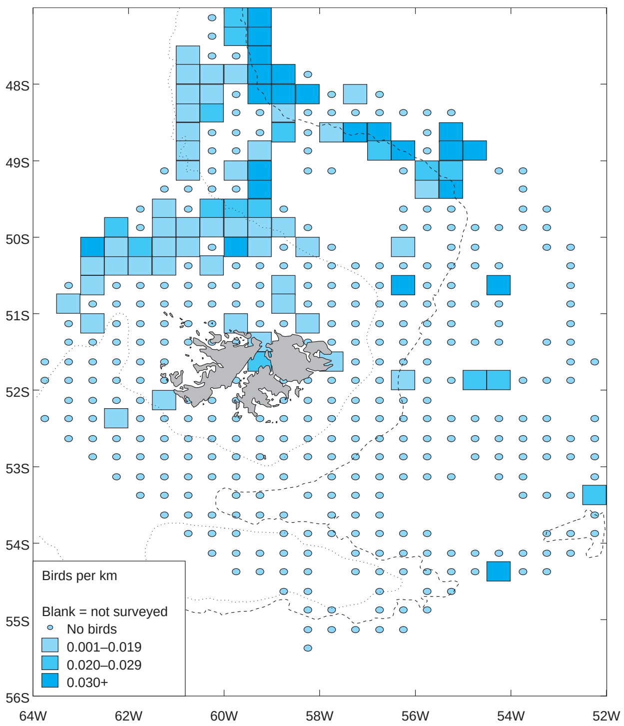

Figure 4.60(b) Long-tailed skua distribution and abundance, November to April.

breeding season in the northern hemisphere. However, it is notable that immature birds do not appear to spend the breeding season in this part of their wintering grounds.

December 2000 and January 2001 produced far fewer records of long-tailed skuas than in previous years. A similar pattern was observed for other non-breeding summer visitors typically associated with the Falklands/Malvinas Current (e.g. soft-plumaged petrel and black-bellied storm-petrel).

The majority of long-tailed skua records were in deep waters to the north and the east of the islands associated with the Falklands/Malvinas Current (Figure 4.60(b)). Lower densities were recorded over Patagonian Shelf waters with only four birds recorded south of 52° S.

Very few birds were recorded feeding, but on one occasion a bird was seen kleptoparasitising a Wilson's storm-petrel, behaviour also noted by Brady (1994). Several birds were noted in primary moult in December and January.

Gulls Laridae

Seven species of gull have been recorded in the Falkland Islands (Woods 1988; Curtis 1993), three of which breed (Woods and Woods 1997). Only the three species that breed in the islands were recorded during surveys.

Dolphin gull Larus scoresbii

Dolphin gulls are resident breeders in the Falkland Islands. Their global distribution is restricted to the Falkland Islands and southern South America. The Falkland Islands population is estimated to be between 3,000 and 6,000 pairs (Woods and Woods 1997) while the South American population is estimated to be less than 1,000 pairs (Yorio *et al.* 1998), making the Falkland Islands the most important location in the world for this species with potentially as much as 85% of the world population.

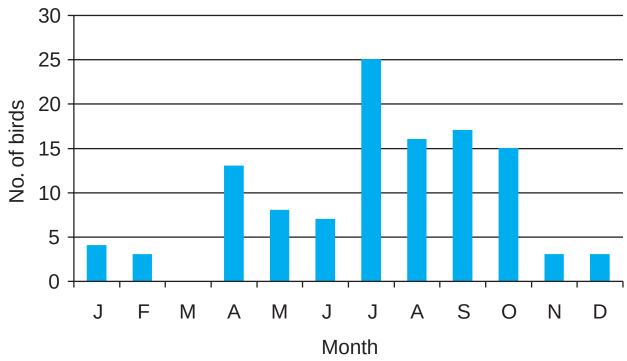

Figure 4.61(a) Number of dolphin gulls recorded in each month.

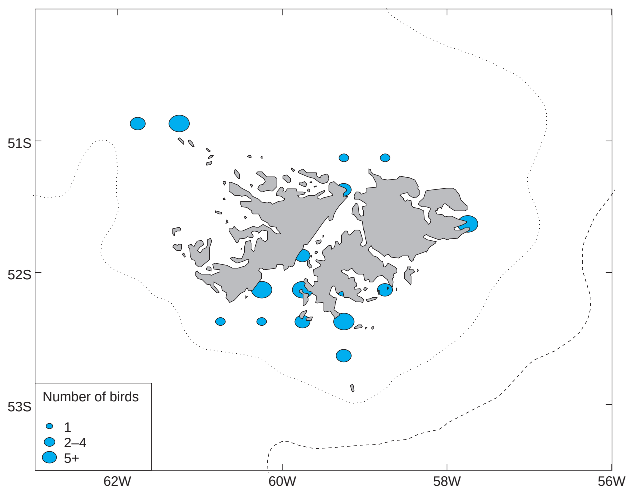

Figure 4.61(b) Distribution of dolphin gull sightings, all months.

A total of 114 dolphin gulls was recorded on 60 occasions. Dolphin gulls were recorded in all months except March, with a peak in July (Figure 4.61(a)).

Dolphin gulls exhibited a coastal distribution, with most records coming from partially enclosed waters (Figure 4.61(b)). No birds were recorded more than 20 km from the coast. There was a notable concentration of records in waters around the south of Falkland Sound and the south coast of East Falkland (*cf.* South American tern).

Kelp gull L. dominicanus

Kelp gull is a resident breeder in the Falkland Islands. The population is estimated to be between 24,000 and 44,000 pairs (Woods and Woods 1997). This species has a circumpolar distribution in the southern hemisphere and is found in Antarctica and on subantarctic islands. It is likely that the local Falkland Islands population is swelled during the winter by an influx of Antarctic birds.

A total of 2,288 kelp gulls was recorded during surveys. Birds were recorded in all months with highest numbers between June and September and a peak in June (Figure 4.62(a)).

Between November and April the majority of kelp gulls were recorded in inshore waters, including the waters around Beauchêne Island (Figure 4.62(b)). Between May and October there was a distinct increase in the number of kelp gulls in Patagonian Shelf and continental shelf slope waters, with widespread records at low to locally high densities (Figure 4.62(c)). It is not known whether these were local birds moving offshore or birds moving into the study area from Antarctica or South Georgia. There were relatively few records in deep water areas in any season.

Kelp gulls were one of the species most likely to be under-recorded during surveys due to their habitat of associating with the survey base.

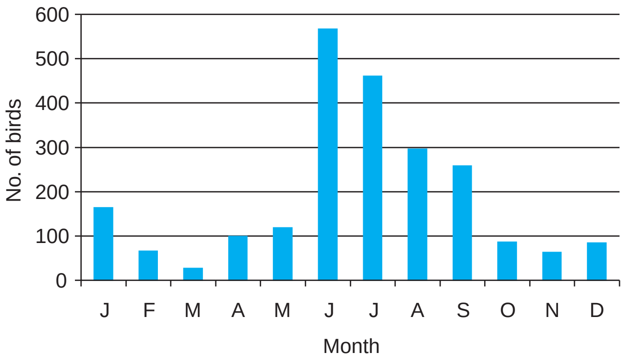

Figure 4.62(a) Number of kelp gulls recorded in each month.

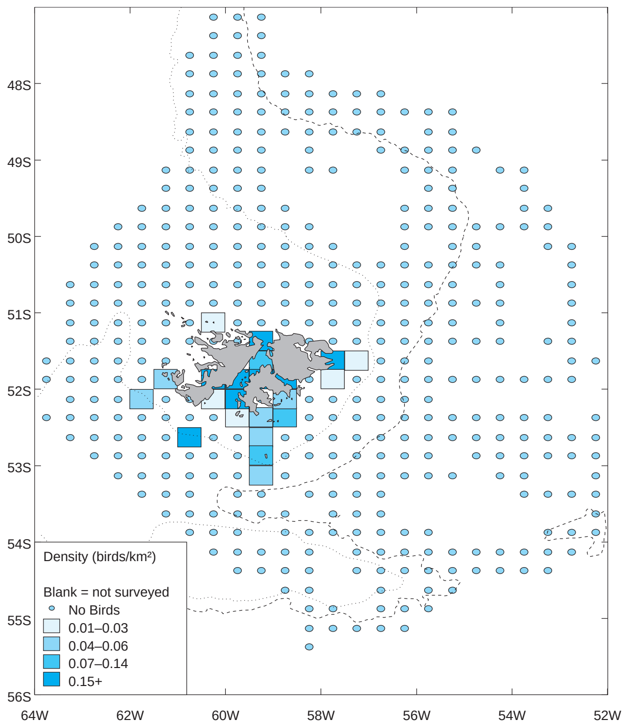

Figure 4.62(b) Kelp gull distribution and abundance, November to April.

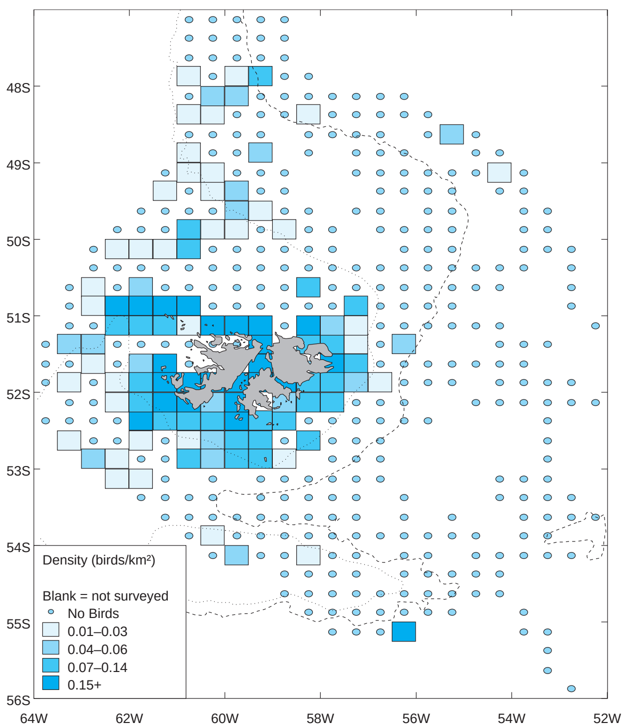

Figure 4.62(c) Kelp gull distribution and abundance, May to October.

Brown-hooded gull L. maculipennis

In common with dolphin gulls, brown-hooded gulls are restricted to southern South America and the Falkland Islands. However, unlike that species, they are notably commoner in South America than they are in the Falkland Islands. The world population is estimated at 50,000 pairs (Enticott and Tipling 1997), while the Falkland Islands population numbers between 1,400 and 2,600 pairs (Woods and Woods 1997).

A total of 134 brown-hooded gulls was recorded, on 69 occasions. Brown-hooded gulls were recorded in all months with a peak in January (Figure 4.63(a)). Brown-hooded gulls exhibited a coastal distribution, but were more often recorded on open coastlines than dolphin gulls (Figure 4.63(b)). The majority of brown-hooded gull records were within 10 km of the coast, but one adventurous (or lost) bird was recorded 53 km from the coast to the north-west of the islands in November.

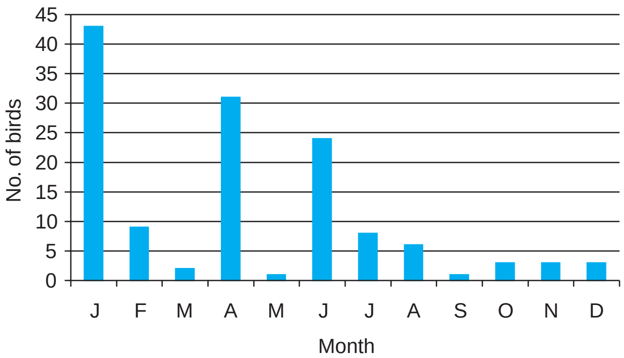

Figure 4.63(a) Number of brown-hooded gulls recorded in each month.

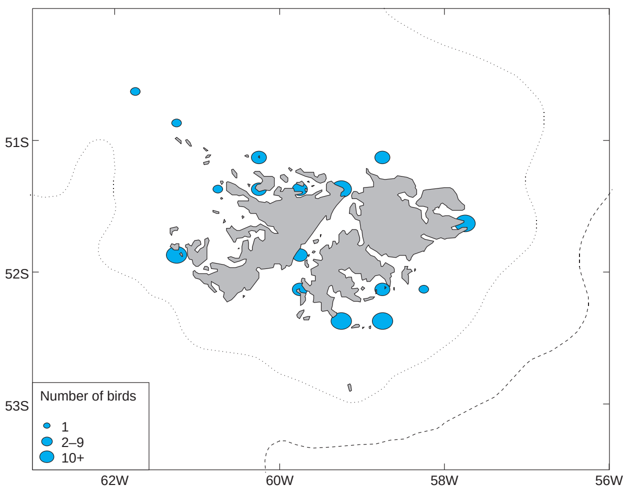

Figure 4.63(b) Distribution of brown-hooded gull sightings, all months.

Terns Sternidae

Of the six species of tern previously recorded in Falklands Islands waters (Woods 1988; Bourne and Curtis 1997), just one, the South American tern, breeds in the islands (Woods and Woods 1997). During SAST surveys, three species were recorded. The high number of *Sterna* spp. records could obscure the true pattern of South American tern dispersion and the occurrence of other rarer species, particularly Antarctic tern.

South American tern Sterna hirundinacea

South American tern is the only tern species to breed in the Falkland Islands. Terns were often difficult to identify at sea, and as a result 7.7% (160 birds) of all tern records were not specifically identified. For the purposes of this analysis, South American terns have been treated separately from the unidentified terns, as the two groups showed distinct seasonal and spatial distribution patterns.

A total of 1,894 South American terns was recorded. South American terns were recorded in all months, with an autumn peak in March and April. Numbers were generally high during the summer breeding season, but the species was also present throughout the winter (Figure 4.64(a)).

Between October and April, highest densities of South American terns were recorded in coastal waters (Figure 4.64(b)), in particular within Falkland Sound and around the south of East Falkland (*cf.* dolphin gull). Between May and September, South American terns exhibited a similar distribution to the October to April period, but at lower densities (Figure 4.64(c)), except off the north coast of West Falkland where locally high densities were recorded (*cf.* sooty shearwater).

South American terns were frequently recorded resting on patches of free-floating kelp. Relatively few South American terns were recorded resting

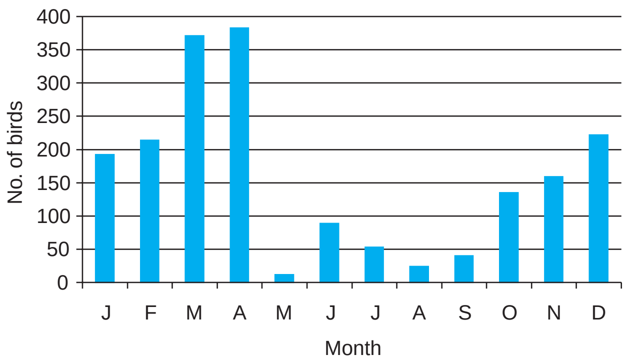

Figure 4.64(a) Number of South American terns recorded in each month.

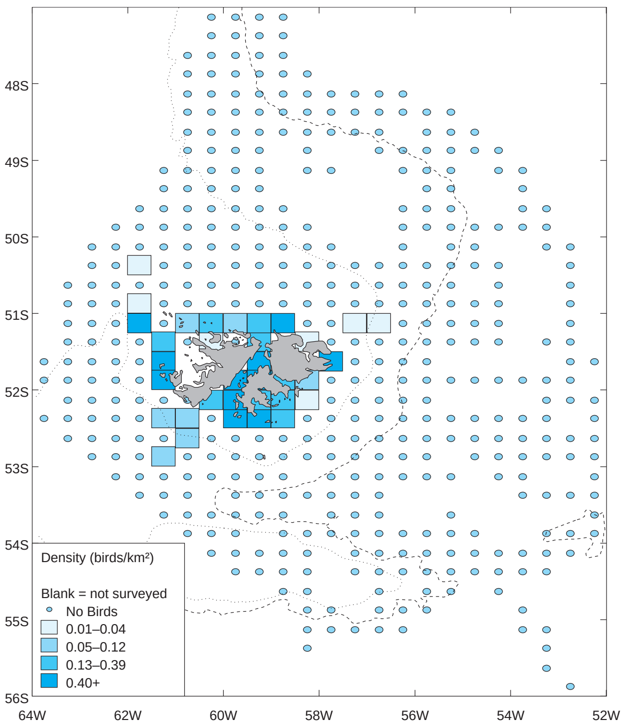

Figure 4.64(b) South American tern distribution and abundance, October to April.

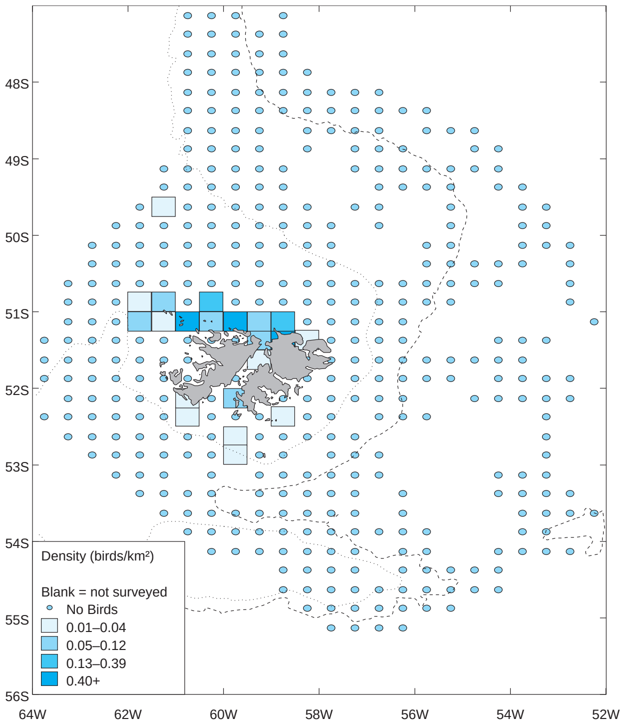

Figure 4.64(c) South American tern distribution and abundance, May to September.

on the open sea. South American terns were often observed in multi-species feeding associations centred on groups of penguins, primarily gentoo and Magellanic penguins.

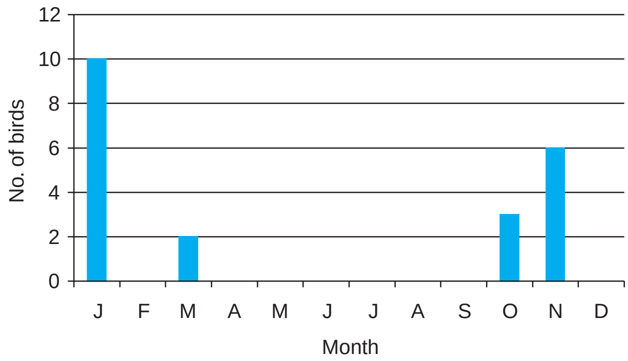

Figure 4.65(a) Number of Arctic terns recorded in each month.

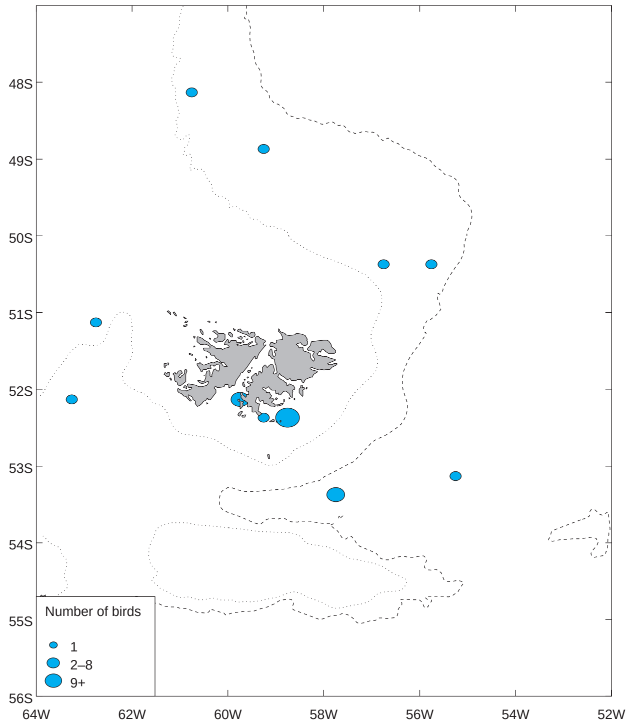

Figure 4.65(b) Distribution of Arctic tern sightings, all months.

Arctic tern S. paradisea

Arctic terns are summer visitors to Falkland Islands waters from their breeding grounds in the northern hemisphere. Bourne and Curtis (1985) recorded this species as a ‘scarce non-breeding visitor’.

A total of 21 Arctic terns was recorded. This species was undoubtedly under-recorded due to the unsatisfactory views of many terns at sea. Some of the birds recorded as *Sterna* species (see below) may have been Arctic terns. All records were in the period October to March, although there were no records in either December or February (Figure 4.65(a)). Records occurred throughout the survey area with most records in offshore areas (Figure 4.65(b)).

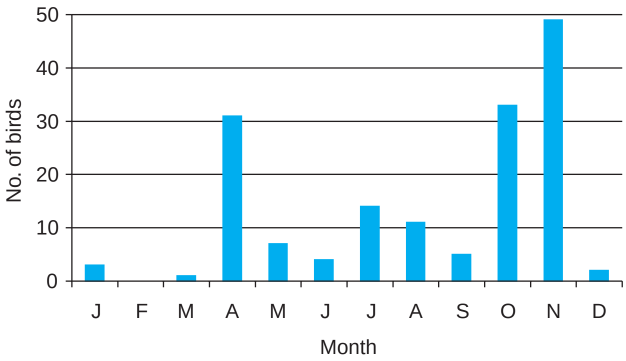

Figure 4.66(a) Number of unidentified *Sterna* terns recorded in each month.

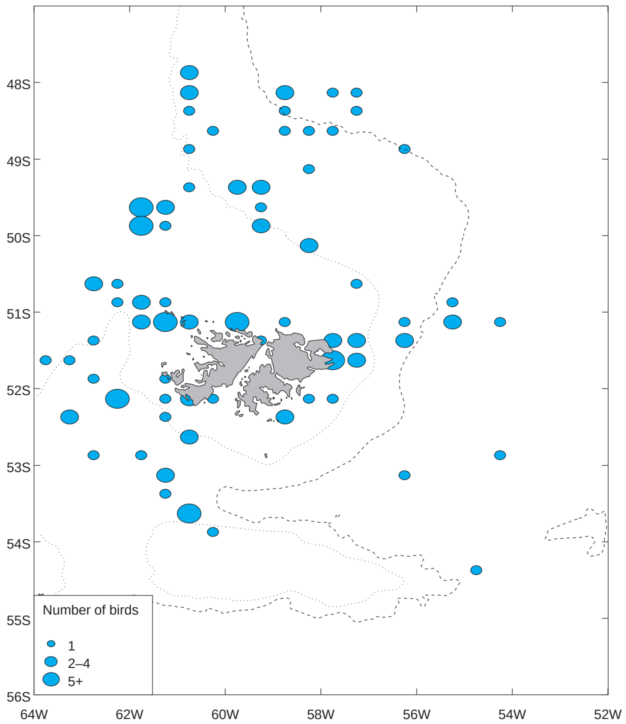

Figure 4.66(b) Distribution of unidentified *Sterna* terns sightings, all months.

Unidentified Sterna tern Sterna spp.

The majority of the 160 unidentified terns were recorded between April and November (Figure 4.66(a)) and in offshore waters (Figure 4.66(b)). It remains possible that these birds were South American terns, but in many cases the observers considered this unlikely.

Rare seabirds

There were fewer than ten records of the following species:

Sooty albatross *Phoebetria fusca*
There was a total of six records of sooty albatrosses, all of single birds between December and March. Two were recorded in January 1999 at 49° 06' S 56° 04' W and 49° 11' S 55° 51' W, one in December 1999 at 50° 50' S 54° 47' W and three in March 2000 at 49° 54' S 59° 40' W, 50° 27' S 57° 09' W and 51° 22' S 53° 14' W.

Broad-billed prion *Pachyptila vittata*
Given good views, broad-billed prions proved to be readily identifiable; however, many may have gone undetected among the hordes of unidentified prions. Single broad-billed prions were identified in November 1998 at 52° 46' S 62° 29' W and in October 1999 at 50° 20' S 56° 00' W.

White-headed petrel *Pterodroma lessonii*
Single white-headed petrels were recorded in January 1999 at 49° 01' S 56° 17' W, in September 1999 at 54° 00' S 52° 59' W and in November 1999 at 51° 51' S 57° 14' W.

Great-winged petrel *P. macroptera*
Two great-winged petrels were recorded during surveys. Both birds were recorded within three days of each other by independent observers on vessels approximately 830 km apart. One was recorded in February 1999 at 53° 05' S 52° 28' W and the other was recorded in March 1999 at 47° 52' S 60° 41' W.

Spectacled petrel *Procellaria conspicillata*
A single spectacled petrel was recorded in March 2000 at 50° 20' S 57° 41' W. This is the second record for the Falkland Islands, following one seen from a fishing vessel at approximately 54° 23' S 55° 45' W in December 1996 (A. Black pers. obs.).

Cory's shearwater *Calonectris diomedea*
A single Cory's shearwater was recorded in November 1999 at 52° 46' S 60° 36' W. This is the second record for the Falkland Islands (Woods 1988).

Manx shearwater *Puffinus puffinus*
Single Manx shearwaters were recorded in November 1998 at 50° 36' S 57° 21' W, in January 1999 at 47° 60' S 60° 28' W, in February 2000 at 50° 50' S 63° 09' W and in January 2001 at 48° 38' S 60° 40' W.

Grey phalarope *Phalaropus fulicarius*
Single grey phalaropes were recorded on two occasions in December 1998 at 48° 29' S 57° 53' W and 51° 28' S 57° 21' W.

Chilean skua *Catharacta chilensis*
A total of four Chilean skuas was recorded. Single birds were recorded in November 1998 at 52° 00' S 62° 22' W, in January 1999 at 49° 04' S 55° 47' W, and in March 2000 at 48° 43' S 60° 49' W and 50° 11' S 58° 37' W.

The difficulty of separating this species from Antarctic skua may have resulted in this species being under-recorded.

Cayenne tern *Sterna (sandvicensis) eurygnatha*
Two Cayenne terns were recorded in April 1999 at 48° 38' S 60° 40' W, probably the second record for the Falkland Islands (Gregory 1994).

Marine mammals

A total of 6,550 marine mammals of 17 species was recorded during surveys. Of these, 5,463 were cetaceans of at least 14 species and 1,087 were pinnipeds of at least three species. No new species of cetacean or pinniped were recorded within the survey area after the first 12 months of survey. The number of records and the total number of each species recorded is summarised in Appendix IVb.

Cetaceans

Fin whale Balaenoptera physalus

A total of 57 fin whales was recorded, on 27 occasions. Group size varied from one to 12 animals. The majority (93%) were recorded between November and January with only four records of single animals outside this period (Figure 4.67(a)).

Fin whales were recorded throughout the survey area, typically in deep water areas (>200 m) although there were several records from the edge of the Patagonian Shelf. There was a small concentration of records in the vicinity of the Burdwood Bank with two records from shallow (<200 m) waters over the Bank (Figure 4.67(b)).

Fin whales were not recorded associating with any other cetaceans and were recorded with associated seabirds on only one occasion, when several Wilson's storm-petrels and unidentified

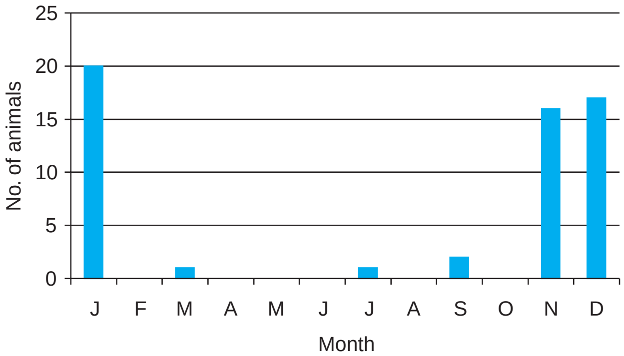

Figure 4.67(a) Number of fin whales recorded in each month.

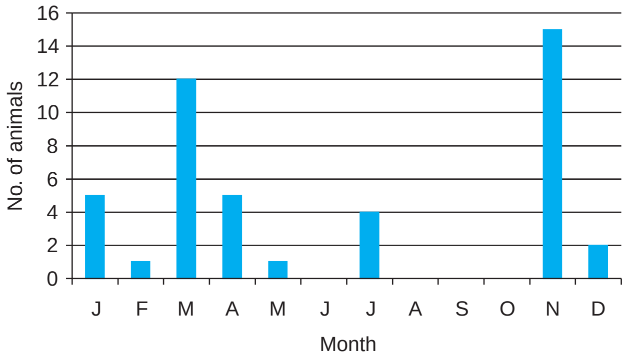

Figure 4.68(a) Number of sei whales recorded in each month.

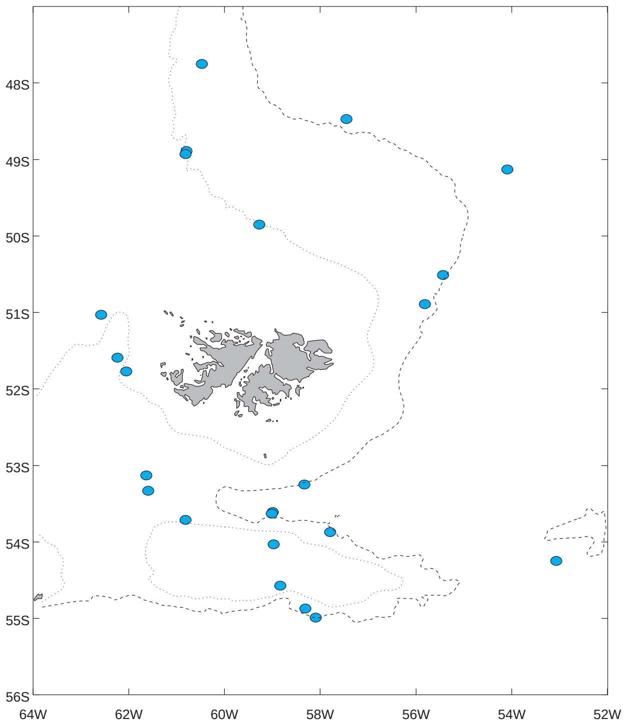

Figure 4.67(b) Distribution of fin whale sightings, all months.

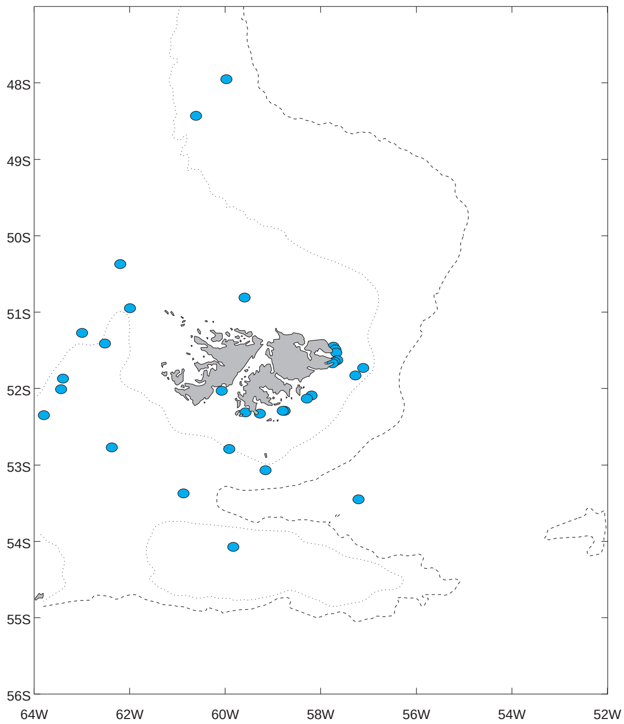

Figure 4.68(b) Distribution of sei whale sightings, all months.

prions were observed associating with a single fin whale.

Sei whale B. borealis

There were 31 records of sei whales totalling 45 animals. Group size ranged from one to three animals. The numbers of sei whales recorded increased in November and remained high until April, with only three records outside this period and no records between August and October (Figure 4.68(a)).

The majority of records were from Patagonian Shelf waters around East Falkland, with a notable concentration in waters between MacBride Head and the Sea Lion Islands (Figure 4.68(b)). Elsewhere, most of the records were from relatively shallow waters with only one record in waters deeper than 1,000 m.

Sei whales were not recorded associating with any other cetacean species and were not recorded with associating seabirds.

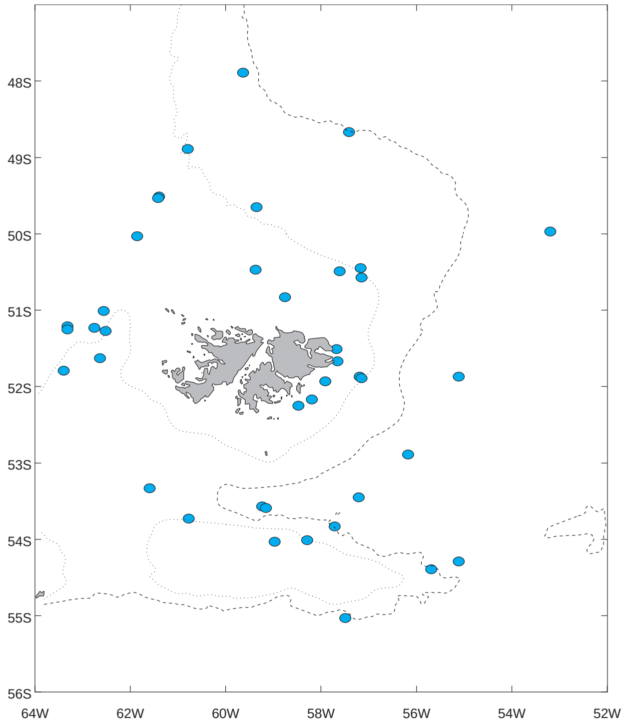

Figure 4.69(b) Distribution of unidentified large whale sightings, all months.

Unidentified large whales

On a number of occasions, large whales were seen that could not be specifically identified, either because only the blow was seen or because views were too poor to distinguish between fin and sei whales. A total of 44 unidentified large whales was recorded, on 40 occasions. Of these, 18 animals were recorded as 'fin or sei', while the remaining 26 could relate to other large whale species.

Unidentified large whales were recorded in all months except April, May and September (Figure 4.69(a)). Peak numbers occurred between November and March – a similar seasonal distribution to that recorded for fin (Figure 4.67(a)) and sei whales (Figure 4.68(a)).

Unidentified large whales were recorded throughout the survey area (Figure 4.69(b)). It is possible to infer the probable identity of some of these animals from the observed distributions of those large whales that were identified. For example, those recorded on the Patagonian Shelf to the south-east of East Falkland are likely to have been sei whales, whereas those in deep waters to the east and south-east of the islands more likely to have been fin whales. However, all records are uncertain and it is difficult to draw any firm conclusions.

Minke whale B. acutorostrata

A total of 68 minke whales was recorded, on 60 occasions. Group size varied from one to eight animals, although only two records were of more than one animal. Minke whales were recorded in all months except August, with peaks in April (six records totalling 13 animals) and December (17 records totalling 17 animals). The majority of minke whale records occurred between September and April, with only three records outside this period (Figure 4.70(a)).

Most records were from Patagonian Shelf waters around East Falkland and in the north-west of

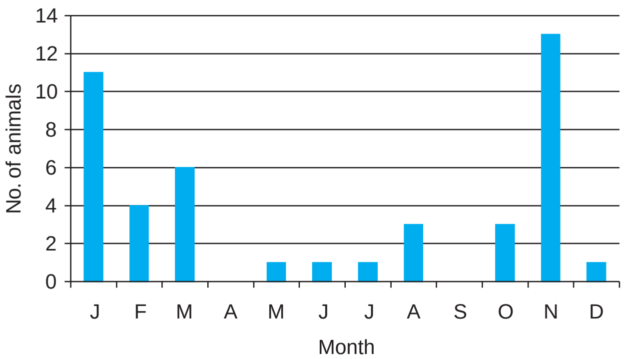

Figure 4.69(a) Number of unidentified large whales recorded in each month.

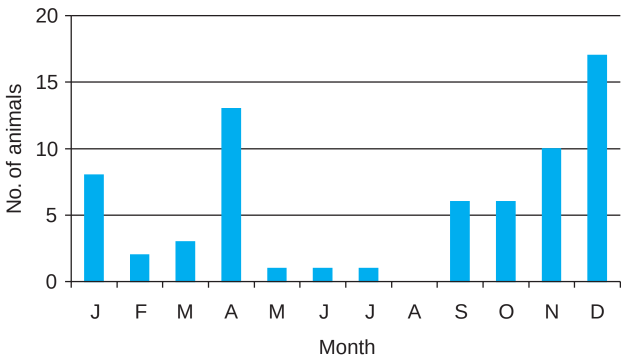

Figure 4.70(a) Number of minke whales recorded in each month.

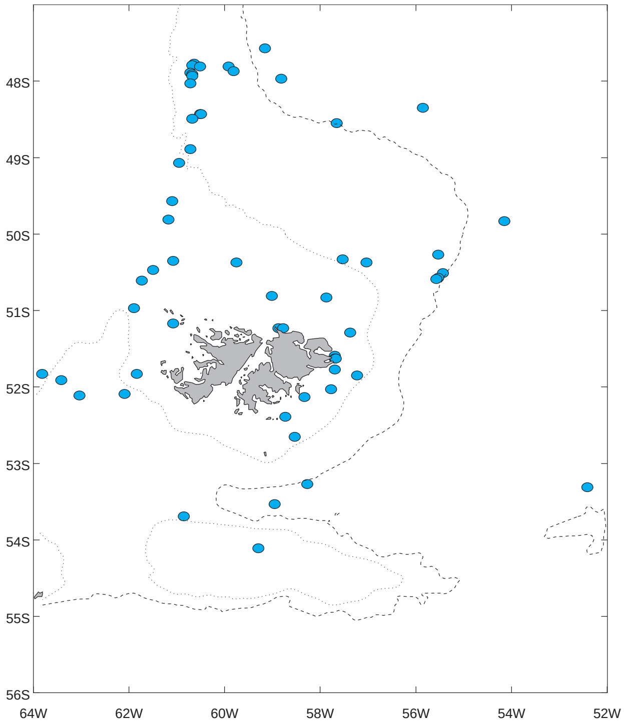

Figure 4.70(b) Distribution of minke whale sightings, all months.

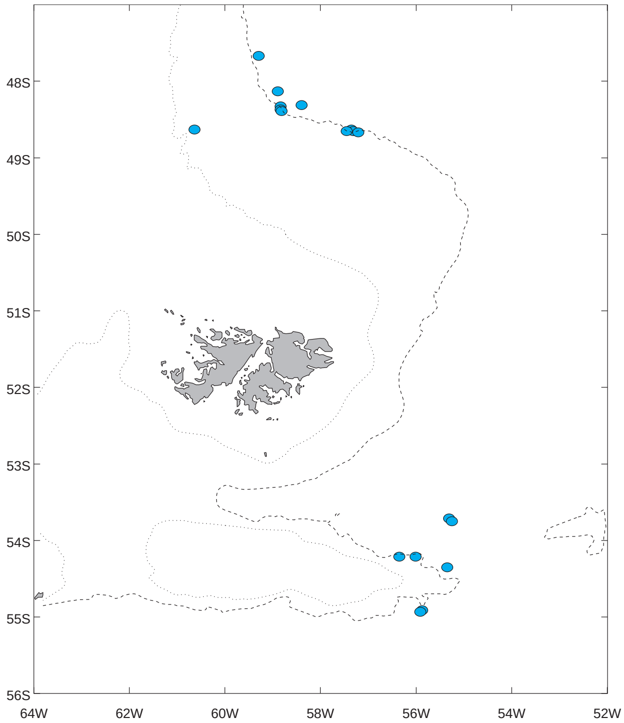

Figure 4.71(b) Distribution of sperm whale sightings, all months.

the survey area, although there were records throughout the survey area (Figure 4.70(b)).

There was one record of a group of hourglass dolphins associating with a minke whale, but no records of seabirds associating with minke whales.

Sperm whale Physeter macrocephalus

Sperm whales were encountered on 21 occasions with a total of 28 animals recorded. Group size varied from one to four animals. July and December both produced four records of five animals and October produced two records of six animals. Records occurred in all seasons, but there were no records in March or May (Figure 4.71(a)). This was probably related to the low levels of survey effort in deep water areas during these months (Figure 4.18).

All sperm whale records came from waters deeper than 200 m (Figure 4.71(b)). Animals were recorded from two distinct areas; the east end of the Burdwood Bank and the continental shelf slope and 1,000 m isobath to the north of the islands; both areas where longliners fish for Patagonian toothfish (FIGFD 2000). On a number of occasions, sperm whales were observed in the vicinity of longliners, an association that has been observed elsewhere (Ashford *et al*. 1996).

Southern bottlenose whale Hyperoodon planifrons

A total of 34 southern bottlenose whales was recorded, on 18 occasions. Group size varied from one to five animals. All records were in the period September to February (Figure 4.72(a)) and all

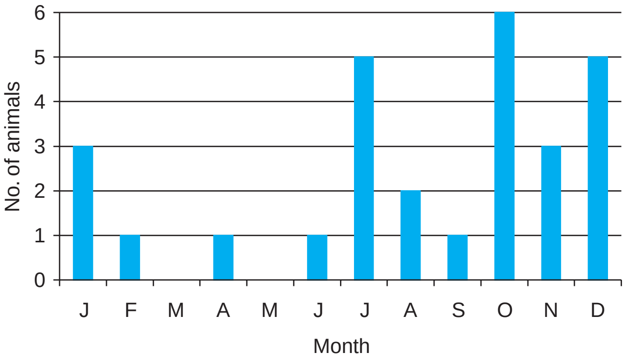

Figure 4.71(a) Number of sperm whales recorded in each month.

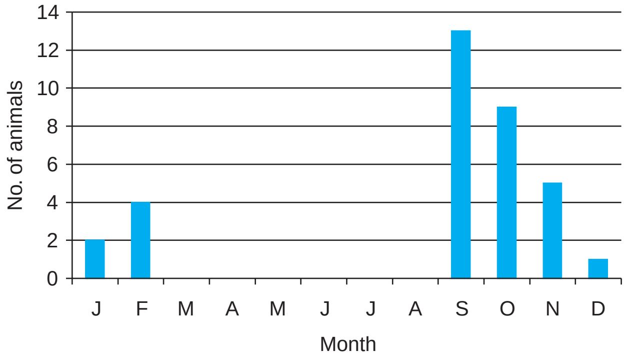

Figure 4.72(a) Number of southern bottlenose whales recorded in each month.

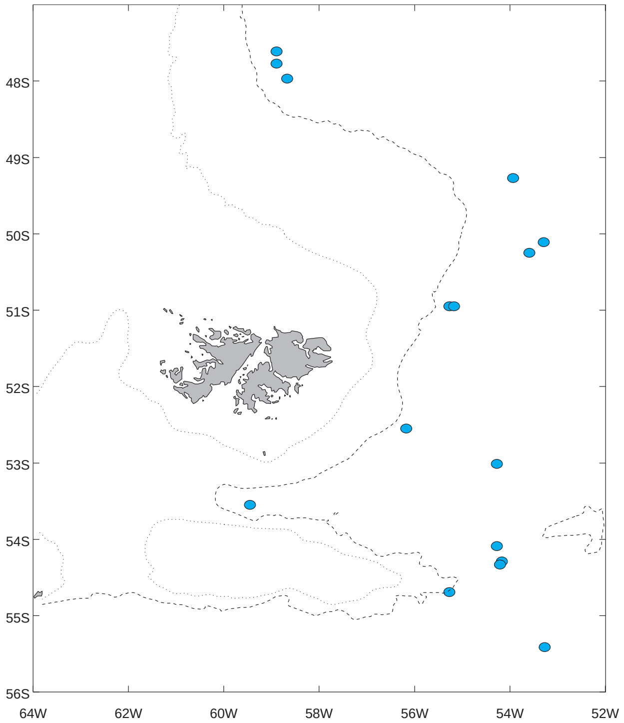

Figure 4.72(b) Distribution of southern bottlenose whale sightings, September to February.

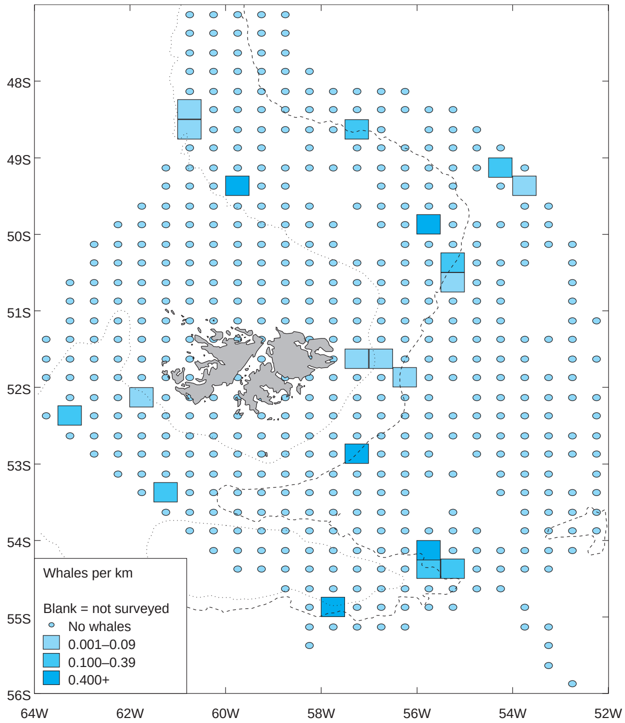

Figure 4.73(b) Long-finned pilot whale distribution and abundance, all months.

were in waters deeper than 1,000 m (Figure 4.72(b)).

The lack of records between March and August may be due, in part, to the reduced levels of survey effort in deep water areas in these months (Figure 4.18). Despite this, it appears that there is an element of seasonality to the presence of this species in Falkland Islands waters. In common with many of the other cetacean species recorded, this species is more numerous in Falkland Islands waters in the summer months than in the winter.

Long-finned pilot whale Globicephala melas

A total of 872 long-finned pilot whales was recorded on a total of 27 occasions. The majority of long-finned pilot whale sightings occurred during 1999 when 15 of the 24 sightings were recorded. Group size varied from two to 200 animals. The latter, in May 2000, was the largest group of cetaceans recorded during surveys.

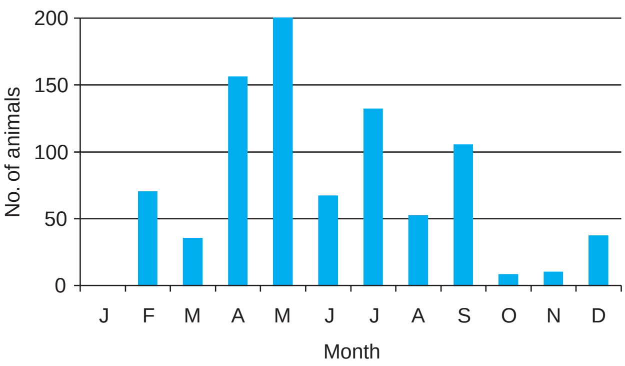

Figure 4.73(a) Number of long-finned pilot whales recorded in each month.

Long-finned pilot whales were recorded in all months except January. The number of records in a month varied from one in March, May and October to four in July, August and September. There was no clear seasonality to the records, although it appears that there was a greater likelihood of recording long-finned pilot whales in winter than in summer (Figure 4.73(a)). This is particularly apparent when the lower winter levels of survey effort are taken into account. Sightings were more frequent later in the winter, while group size was larger earlier in the winter.

Long-finned pilot whales were generally recorded in waters deeper than 200 m (Figure 4.73(b)). The only records from waters of less than 200 m depth were from Patagonian Shelf waters to the east of the islands. There were no records from Patagonian Shelf waters to the north-west of the islands.

Long-finned pilot whales were regularly seen in association with other cetacean species. Notably, all five records of southern rightwhale dolphin were in the company of long-finned pilot whales. Hourglass dolphins were also recorded associating with long-finned pilot whales on three occasions. In total, 11 seabird species were recorded associating with long-finned pilot whales.

Hourglass dolphin Lagenorhynchus cruciger

A total of 886 hourglass dolphins was recorded, on 177 occasions. Group size varied from one to

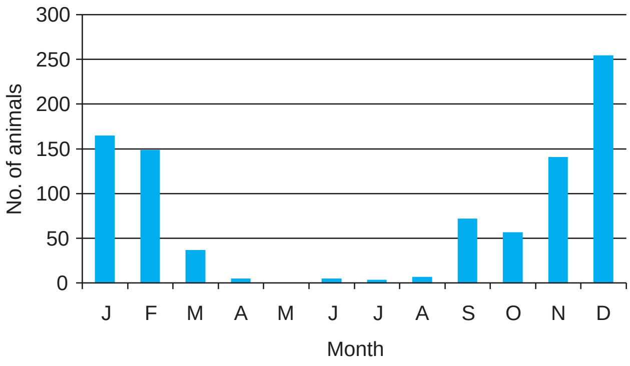

Figure 4.74(a) Number of hourglass dolphins recorded in each month.

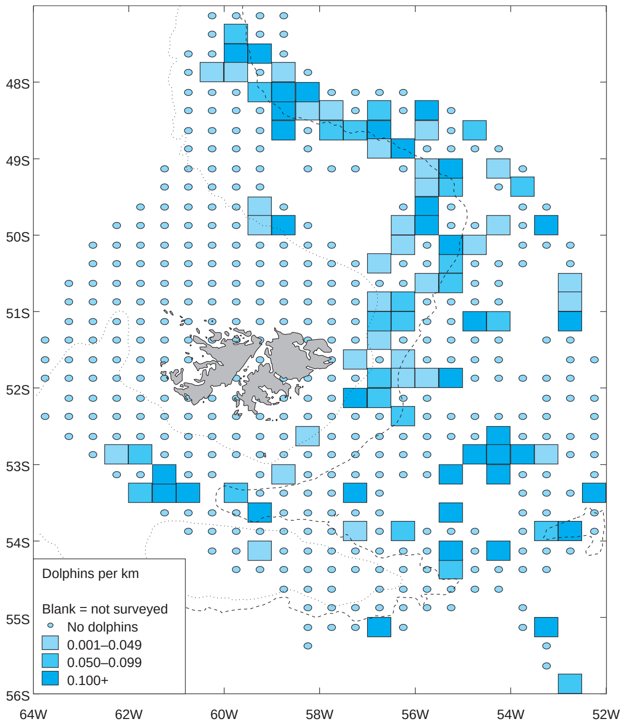

Figure 4.74(b) Hourglass dolphin distribution and abundance, September to March.

50 animals with an average of 5.3. Hourglass dolphins exhibit clear seasonality in Falkland Islands waters, with the majority of records (96.6%) between September and March (Figure 4.74(a)) and only six records outside this period.

The majority of hourglass dolphin records in both periods involved animals in waters deeper than 200 m (Figures 4.74(b) and (c)). There was little overlap in range between this species and Peale's dolphin (Figure 4.75(b)). The areas where hourglass dolphins typically occurred were within the cold, northward flowing waters of the Falkland/Malvinas current.

Hourglass dolphins were recorded associating with long-finned pilot whales, southern rightwhale dolphins and minke whales. On only one occasion was an hourglass dolphin recorded associating with Peale's dolphins – in waters be-

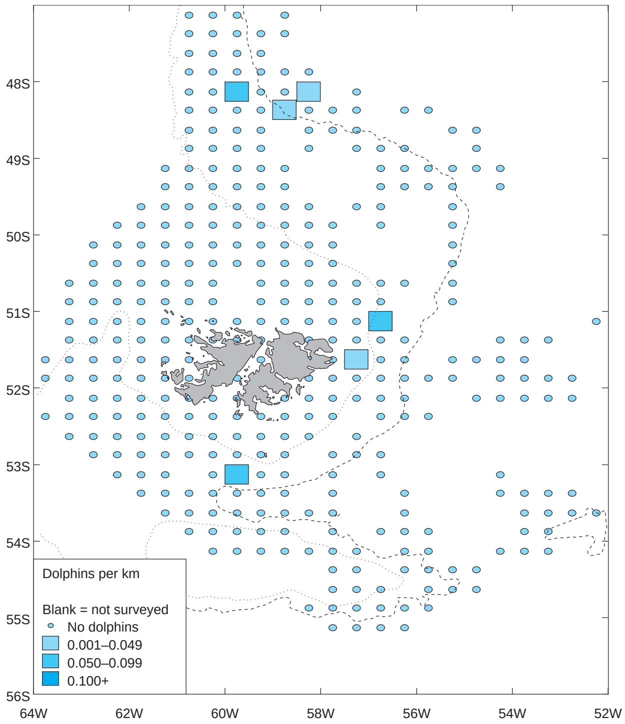

Figure 4.74(c) Hourglass dolphin distribution and abundance, April to August.

yond the 200 m isobath to the south-west of the islands. Seabirds, particularly great shearwaters, were frequently observed associating with hourglass dolphins. Great shearwaters were present on 15 of the 21 occasions when seabirds were recorded associating with hourglass dolphins.

Peale's dolphin L. australis

Peale's dolphin was the most numerous and most frequently recorded cetacean encountered during surveys. A total of 2,617 animals was recorded, on 864 occasions. Group size varied from one to 15 animals, with an average of 3.0. Peale's dolphins were recorded in all months, with a peak of 104 records of 358 animals in August (Figure 4.75(a)).

Peale's dolphins were generally found only in waters less than 200 m deep (Figure 4.75(b)). There was no discernible seasonal pattern in the distribution of animals, although there was a tendency for a greater number of records in the winter months and for animals to be in larger groups in the winter than in the summer.

Peale's dolphins were occasionally recorded in waters over the Burdwood Bank. To reach the Burdwood Bank animals would have to travel through waters greater than 200 m deep. It seems probable that the Peale's dolphin recorded over the Burdwood Bank were from the Argentine population rather than from the Falkland Islands (*cf.* South American sea lion). Peale's dolphins were recorded continuously from the coast of the Falkland Islands to the western boundary of the

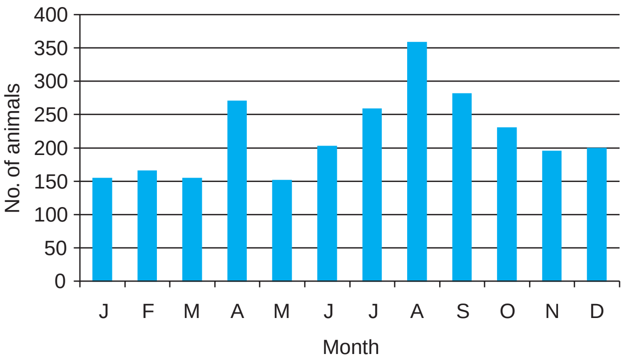

Figure 4.75(a) Number of Peale's dolphins recorded in each month.

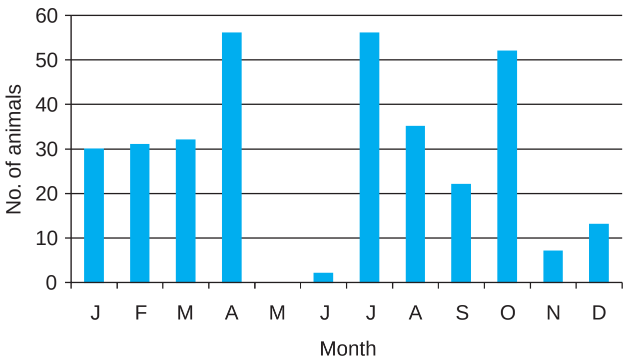

Figure 4.76(a) Number of Commerson's dolphins recorded in each month.

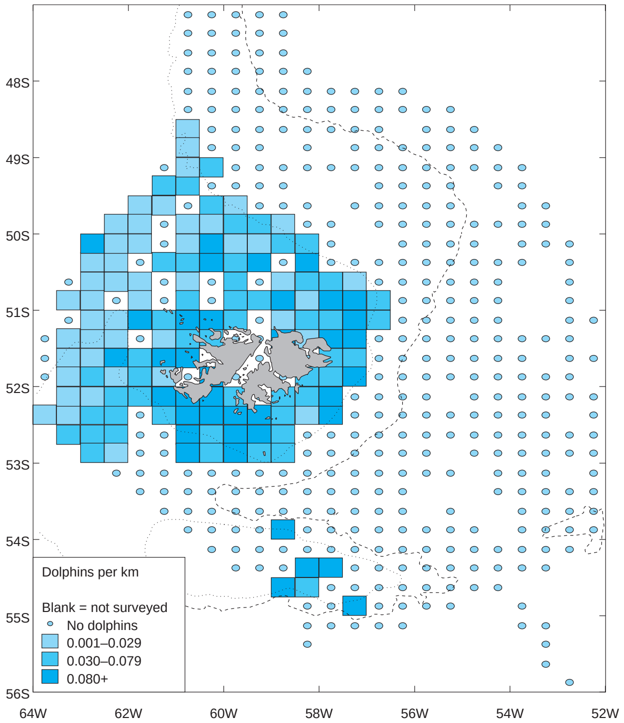

Figure 4.75(b) Peale's dolphin distribution and abundance, all months.

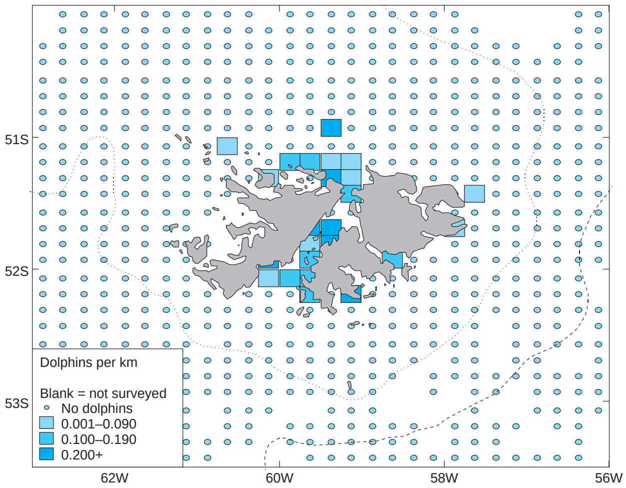

Figure 4.76(b) Commerson's dolphin distribution and abundance, all months.

FICZ, suggesting that this species has a continuous distribution between the Falkland Islands and southern South America. This is supported by observations during transects between the Falkland Islands and Punta Arenas, Chile, which recorded Peale's dolphin throughout the Patagonian Shelf (Gillon *et al*. 2000).

Peale's dolphins were only rarely observed with associating seabirds. Both Commerson's and hourglass dolphins were recorded associating with Peale's dolphins on only one occasion. Peale's dolphins were not recorded with any other cetacean species, although on one occasion an animal was recorded in the vicinity of a South American sea lion.

Commerson's dolphin Cephalorhynchus commersonii

A total of 336 Commerson's dolphins was recorded, on 100 occasions. Group size varied from one to 11 animals with an average of 3.3. Commerson's dolphins were recorded in all months except May (Figure 4.76(a)) with a peak of 18 records of 56 animals in April. The decline in the number of Commerson's dolphins recorded in May and June cannot be easily explained but is probably due to variation in the level of survey effort in inshore waters rather than genuine seasonal variation in the number of animals present in the survey area.

The species was found to have a highly coastal distribution, with the majority of records from partially enclosed waters, e.g. the north end of Falkland Sound (Figure 4.76(b)). Of the 100 records of this species, 98.8% were within 10 km of the coast and there were no records further than 25 km offshore.

It is difficult to interpret any seasonality in either the distribution or numbers of this species in Falkland Islands waters. However, the fact that the species was recorded in all seasons and the absence of records away from the coast suggest that the species is resident in the Falkland Islands and that there is little mixing, if any, between the populations in the Falkland Islands and southern South America.

A Commerson's dolphin was recorded in association with Peale's dolphins on only one occasion despite Peale's and Commerson's dolphins having been observed associating from land on the landward side of kelp beds on numerous occasions (pers. obs.). Commerson's dolphins were not recorded associating with other cetacean species and were not observed with associated seabirds.

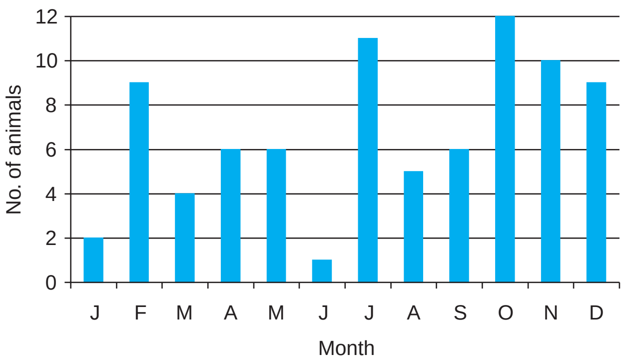

Figure 4.77(a) Number of South American sea lions recorded in each month.

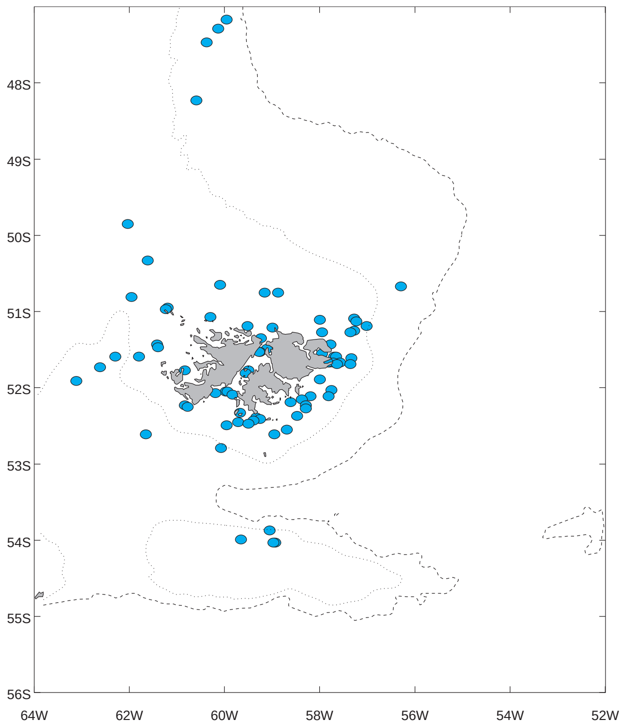

Figure 4.77(b) Distribution of South American sea lion sightings, all months.

Pinnipeds

South American sea lion Otaria byronia

South American sea lions are widely distributed around the coasts of southern South America and the Falkland Islands. The population in Patagonia is estimated to be 60,000 animals (E. Crespo in Harris 1998), considerably larger than the Falkland Islands population estimated to be 3,385 animals (Strange 1990).

A total of 81 South American sea lions was recorded, on 77 occasions. The majority of animals were recorded singly although there were six records of two animals. South American sea lions were recorded in every month. The number of animals recorded in each month varied, although there was no clear pattern to this variation. A peak of 12 animals were recorded in October with a low of one animal in June (Figure 4.77(a)).

Most South American sea lions were recorded from coastal waters or Patagonian Shelf waters (Figure 4.77(b)). There were three records in the vicinity of the Burdwood Bank and four records in the extreme north of the survey area. These animals may have been from the Argentine population rather than animals from the Falkland Islands (*cf*. Peale's dolphin).

Fur seal species Arctocephalus spp.

In the Falkland Islands, the South American fur seal population is estimated to be between 18,000 and 20,000 animals (Strange 1992). On rare occasions, both subantarctic and Antarctic fur seals have been recorded with pups in the Falkland Islands (D. Thompson pers. comm.).

A conservative approach to the identification of fur seals at sea was adopted, with the result that most were recorded as 'fur seal species'. While most records probably refer to South American fur seals, some will undoubtedly refer to Antarctic fur seals. Satellite tracking of the latter species has shown that animals from South Georgia visit Falkland Islands waters during the winter period (I. Boyd pers. comm.).

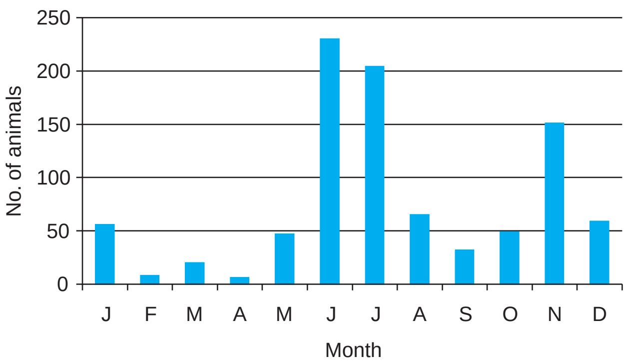

Figure 4.78(a) Number of fur seals recorded in each month.

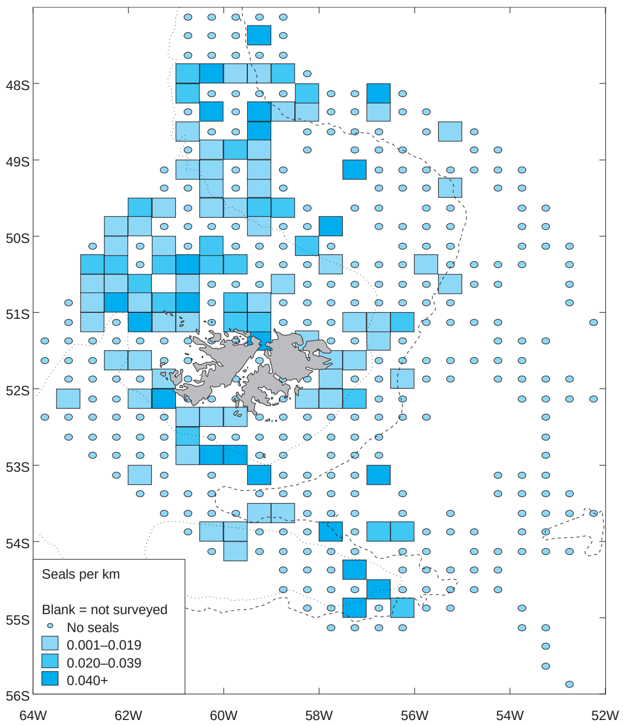

Figure 4.78(b) Fur seal distribution and abundance, June to October.

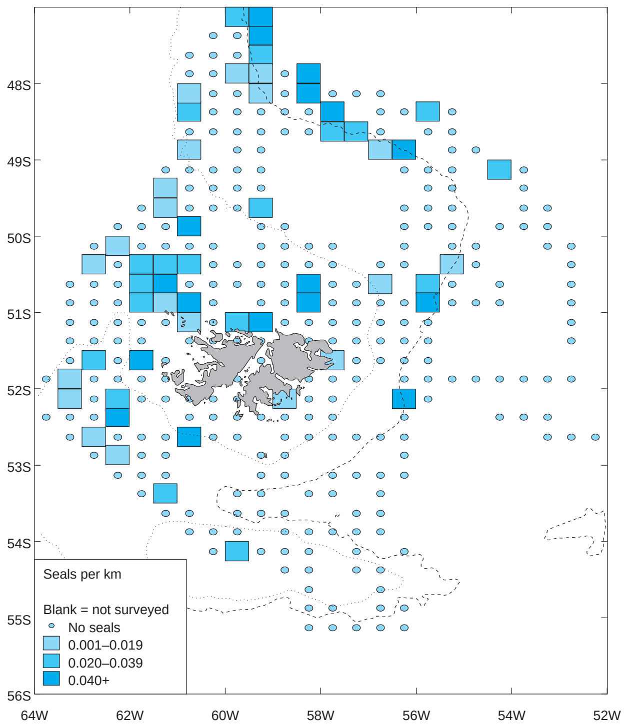

Figure 4.78(d) Fur seal distribution and abundance, December to January.

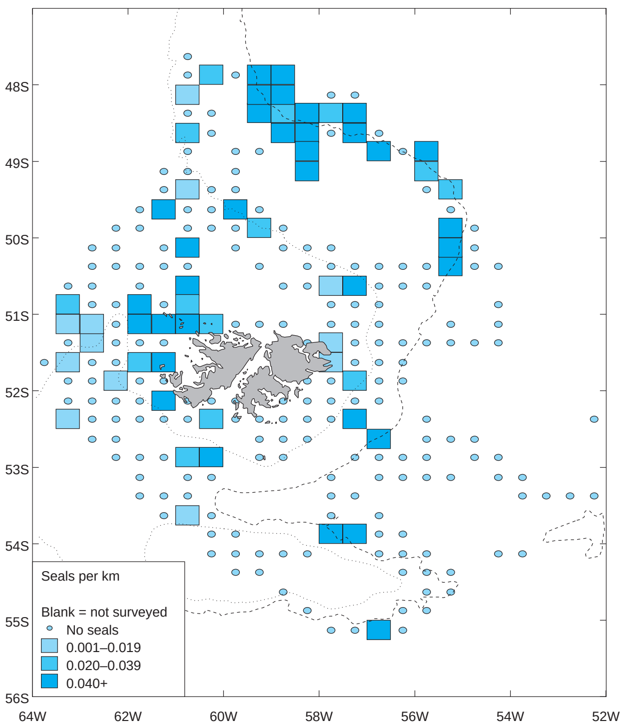

Figure 4.78(c) Fur seal distribution and abundance, November.

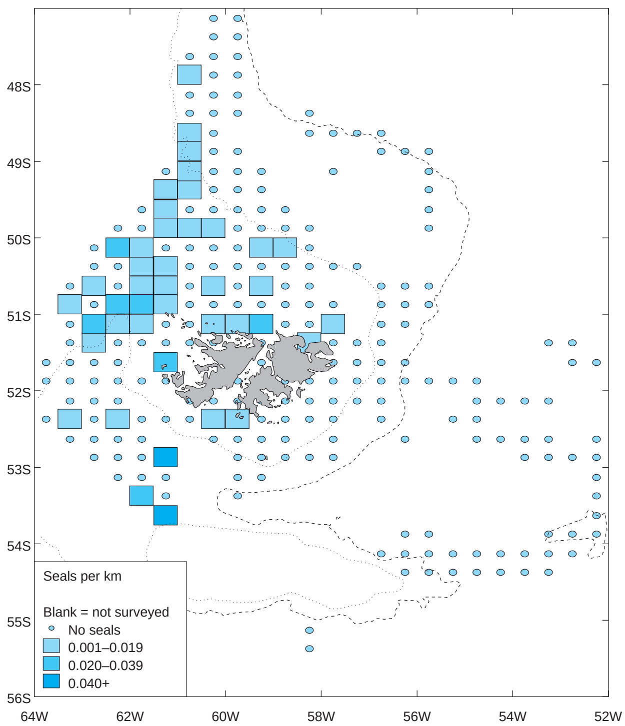

Figure 4.78(e) Fur seal distribution and abundance, February to May.

A total of 937 fur seals was recorded, on 442 occasions. Fur seals were recorded in all months with a distinct midwinter peak in June and July and a further peak in November (Figure 4.78(a)).

The peak in June and July was largely a result of the locally high numbers of animals recorded in coastal and Patagonian Shelf waters (Figure 4.78(b)). The November peak was a result of a

marked increase in the number of records in deep waters to the north-east of the islands (Figure 4.78(c)). Outside these months, fur seals were encountered in lower numbers throughout the survey area (Figures 4.78(d) and (e)).

Fur seals in the Falkland Islands pup in December and moult is completed by May. There is no evidence of a clear migration of Falkland Islands fur seals, although there is some movement away from breeding colonies from midwinter (Strange 1990). It seems likely that this movement away from colonies was detected during surveys in coastal and Patagonian Shelf waters during June and July. The offshore peak in November remains unexplained, although there is a possibility that these animals were not South American fur seals from the Falkland Islands population, but were in fact Antarctic fur seals from South Georgia.

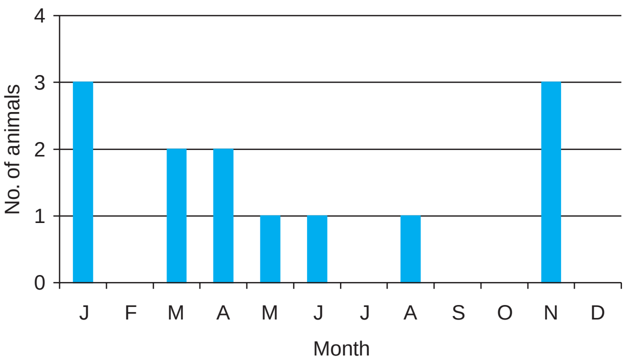

Figure 4.79(a) Number of southern elephant seals recorded in each month.

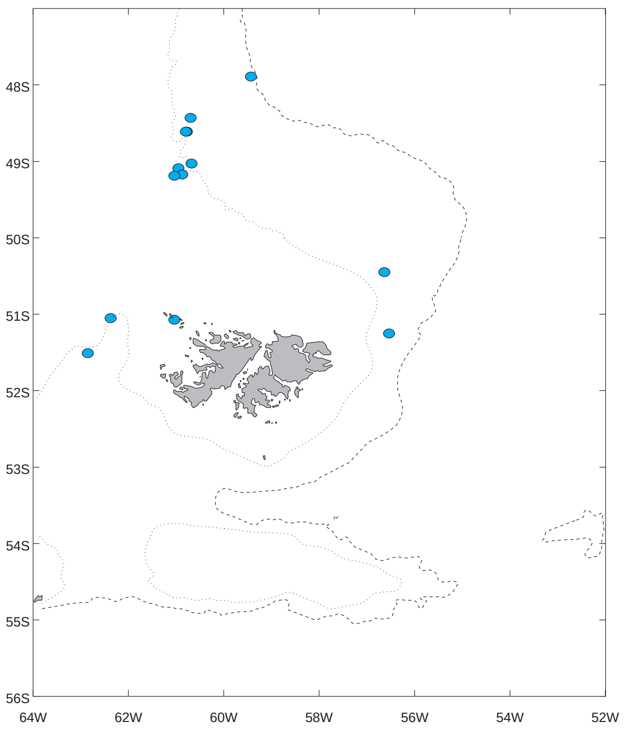

Figure 4.79(b) Distribution of southern elephant seal sightings, all months.

Southern elephant seal Mirounga leonina

Although southern elephant seals breed in the Falkland Islands, there is presently no population estimate for the islands, although numbers are thought to be in the low thousands (Strange 1992; Galimberti and Boitani 1999). Larger populations exist on the South American mainland estimated to be about 33,000 animals (Laws 1994), as well as about 110,000 breeding females at South Georgia (Boyd *et al.* 1996).

A total of 13 southern elephant seals was recorded, with animals recorded in every season (Figure 4.79(a)). All records north of 50° S occurred between January and May whereas all those south of 50° S were in June, August and November.

All records involved animals in waters to the north of the Falkland Islands with the majority in the vicinity of the 200 m isobath. There was only one record of an animal in coastal waters (Figure 4.79(b)). There was a distinct cluster of records at the edge of the Patagonian Shelf around 49° S 61° W. These animals may have been from the Argentine population rather than the Falkland Islands.

Rare marine mammals

The following marine mammal species were recorded on fewer than 10 occasions.

Southern right whale *Eubalaena australis*
In 1998, there were two records of southern right whales during surveys. Two animals were recorded in November at 48° 36' S 56° 57' W and two were recorded in December at 50° 00' S 62° 06' W. In 2000, a single animal was recorded in June at 52° 12' S 61° 57' W. In January 2001 single animals were recorded at 48° 21' S 60° 41' W and at 50° 53' S 62° 27' W.

Humpback whale *Megaptera novaeangliae*
A total of seven humpback whales was recorded on five occasions. All records were in the period October to March and all were in Patagonian Shelf waters; one to the east of the islands and four to the north-west of the islands. In 1998, two humpback whales were observed in December at 51° 29' S 57° 33' W. In 1999, two were recorded in February at 50° 55' S 63° 13' W and one was recorded at 50° 19' S 62° 09' W in October. In 2000, singles were recorded in January at 50° 48' S 63° 09' W and in March at 49° 40' S 61° 32' W.

Unidentified beaked whale species *Mesoplodon* spp.
There were seven records of Ziphiid whales totalling 15 animals. Beaked whales are notoriously difficult to identify at sea, and as a result none of the animals seen during these surveys were specifically identified, although at least one of the re-

cords probably referred to Gray's beaked whale. Group size ranged from one to six animals and all records were in waters deeper than 1,000 m to the east of the islands, with six of the seven records to the south-east and just one to the north-east.

In 1998, six animals were recorded in November at 53° 26' S 54° 35' W and a further three animals at 54° 18' S 55° 24' W. In 1999, two were recorded in July at 53° 14' S 57° 48' W, two groups of two were recorded in September at 48° 50' S 54° 39' W and 54° 26' S 55° 02' W with a further single at 53° 09' S 57° 44' W and one was recorded in October at 53° 43' S 58° 59' W.

Killer whale *Orcinus orca*
During surveys, there were seven records of killer whales totalling 18 animals. Most records were from coastal and Patagonian Shelf waters with one record from waters deeper than 1,000 m to the north of the islands. In September 1998, there were three animals at 52° 04' S 58° 14' W. In 1999, four were recorded in January at 48° 09' S 58° 41' W; a single was recorded in March at 51° 59' S 59° 49' W; two were recorded in April at 49° 25' S 61° 11' W and singles were recorded in June at 50° 19' S 61° 02' W and in September at 53° 01' S 59° 24' W. In 2000, a single male was recorded in June at 51° 51' S 62° 29' W and six were recorded at 49° 19' S 60° 15' W in December.

Southern rightwhale dolphin *Lissodelphis peronii*
There were five records of southern rightwhale dolphins totalling 231 animals. All records involved animals in deep waters to the east of the islands and all were in the company of long-finned pilot whales. Two of the sightings were also associated with hourglass dolphins. Associated seabirds were recorded on four out of the five sightings. In September 1998 a group of 120 southern right whale dolphins was seen at 48° 40' S 57° 12' W. In 1999, a group of six was seen in February at 49° 50' S 55° 34' W; 60 were seen in July at 52° 49' S 57° 20' W and a further 25 were recorded at 52° 52' S 57° 23' W and 20 were seen in September at 50° 34' S 55° 07' W.

5 Discussion

This project is the first of its kind in the waters of the Falkland Islands. The report produced at the end of the first year of surveys (White *et al*. 1999) described for the first time the dispersion patterns of seabirds and marine mammals in the area. The vulnerability atlas published at the end of the second year of surveys related the patterns of seabird dispersion to the potential threat of surface pollution (White *et al*. 2001).

The results of the first year of surveys were published with the caveat that caution should be exercised when interpreting the results of just 12 months of surveys as these may not have been representative. This report, based on three years of surveys describes the patterns of seabird and marine mammal dispersion in the waters of the Falkland Islands with a greater degree of confidence than was possible at the end of the first 12 months of survey work.

It should be stressed that while the distribution of seabirds and marine mammals is often described in relation to water depth or the distance of sightings from the coast; neither water depth nor the distance from the coast are being suggested as the primary factor in influencing the distribution of seabirds and marine mammals in the waters of the Falkland Islands. They are used here as proxies for unknown variables. Whether these are food availability, water temperature, depth or a combination of these and other factors is unknown and would repay further investigation. For example, with the exception of penguin species covered by the Falkland Islands Seabird Monitoring Programme and black-browed albatross, little is known of the diet of seabird and marine mammal species in the waters of the Falkland Islands. Consequently, it is impossible to relate the observed distributions of seabirds to the distributions of prey species, which may themselves be unknown.

Survey

Most surveys, over 90% of all survey effort, were conducted from FPVs of FIGFD. This resulted in the distribution of survey effort being closely linked to the activity of the patrol vessels which in turn is dictated by the seasonal changes in fishing activity within the conservation zones. For example, there exists a bias towards coverage in the north-west of the survey area in April and May at the height of the *Illex* squid jigging season. This may have introduced biases to over-emphasising the importance of this area compared to others, especially for species attracted by jiggers.

Surveys were also conducted from the rig supply vessels travelling between Stanley and the drilling rig *Borgny Dolphin* between April and October 1998. However, these surveys finished when the drilling rig and supply vessels were withdrawn from Falkland Islands waters at the end of 1998.

Other surveys were conducted from the MV *Tamar FI* between Falkland Islands and Punta Arenas, Chile, and to the east and south of the survey area on the FPVs of the Government of South Georgia and South Sandwich Islands and on the British Antarctic Survey vessel RRS *James Clark Ross*. These trips provided valuable opportunities to place the observations made in Falkland Islands waters in a regional context.

The available vessels of opportunity only rarely visited the core study areas of the licence blocks and the SCA. As a result, coverage in these areas was not as high as had been hoped at the outset of the project. Due to the limited availability of vessels of opportunity, other than the FPVs, it seems likely that a dedicated survey vessel is required to obtain adequate levels of survey coverage in waters away from the main fishing grounds. In May and June 2000 the MV *Golden Fleece* was chartered to conduct dedicated seabird and marine mammal surveys within the SCA and successfully increased survey coverage in the area at a time when only limited coverage had been achieved from vessels of opportunity (Gillon and Black 2000).

Inshore waters were consistently under-sampled during these surveys. There are several reasons for this: first, the primary objective was to survey offshore areas licensed for hydrocarbon

exploration and exploitation; second, the FPVs spend most of their time more than 3 nautical miles from the coast, as most commercial fishing vessels are prohibited from fishing any closer to shore than 3 nautical miles; and third, extensive beds of kelp which are a hazard to shipping extend up to a kilometre from the coast in some areas. These areas are avoided by the FPVs and consequently species with a preference for feeding in or around kelp beds, in particular on the landward side of kelp beds, will be under-recorded.

In general, the biases introduced by the variation in seasonal and spatial coverage are understood and it is possible to allow for them when interpreting the results. However, there are times when seasonal and spatial biases work together making it difficult to interpret the results of the survey. For example, transects through Falkland Sound were made in seven months in 1998, three months in 1999 and two months in 2000. Only one month, April, received coverage in more than one year.

The methods used in the north-east Atlantic were successfully adapted to the south-west Atlantic. As evidenced by the correction factors for south-west Atlantic seabirds, the detection of seabirds within the 300 m band transect is generally comparable to the detection rates in the north-east Atlantic (Stone *et al*. 1995). Rockhopper penguins and diving-petrels proved to be the most difficult species to detect, the former probably due to their relatively small size for a penguin and cryptic colouration, while the low detectability of the latter is probably a result of its small size.

There was considerable variation in the levels of survey effort achieved each month. Attempts were made to ensure that survey effort in each month was broadly comparable over the three years, but this did not always prove to be possible. The main factor influencing levels of survey effort was day length. During the summer months only the observer's need to sleep and eat limited the amount of survey effort, while in winter the amount of available daylight was the limiting factor. To a lesser extent, other factors such as vessel and observer availability also had some influence on the level of survey effort achieved each month.

Three observers collected more than 99% of survey coverage. This undoubtedly resulted in lower variability in the quality of survey data than if a wide variety of observers had been used. This consistency of data quality further increases confidence when interpreting the results of this study.

Use of the study area by seabirds

The results of the project broadly agree with existing information regarding seabird occurrence in Falkland Islands waters (e.g. Bourne and Curtis 1985, Woods 1988). For example, no seabird species new to the Falkland Islands were recorded during this study. Similarly, there were no cases where previously rare species were found to be common or vice versa. In some cases the status of species was clarified. For example, little shearwaters were shown to be regular in low numbers whereas they were previously regarded as a vagrant (Woods 1988).

Prior to this study, information detailing the relative abundance of seabirds in Falkland Islands waters was scant. Information was available regarding the population size of those species breeding in the islands (Woods and Woods 1997), but little data was available on the abundance of these species at-sea or of the abundance of those species that do not breed in the islands.

Broadly consistent patterns of seasonal and spatial distribution can be detected between years for the majority of species, while several species exhibited clear inter-annual variation. For example, Antarctic petrels were relatively numerous in winter 1999, but were rarely recorded in winter 1998 or winter 2000. This variation could be due to a range of factors. For example, an abundance of food in Falkland Islands waters in winter 1999 and/or a lack of food supply within their usual range at the same time. In turn, this is driven by oceanographic factors such as sea surface temperature. However, at present it is not possible to identify the exact cause of the influx of this species into Falkland Islands waters.

The two commonest species recorded during surveys were found to be those with the largest breeding populations in the islands – prions and black-browed albatrosses (Croxall *et al*., 1984, Huin 2001). Other species recorded commonly were typically either abundant Antarctic breeding species, such as Antarctic fulmar or Cape petrel, which spend the non-breeding season in the survey area, or locally common Falkland Islands breeding species.

However, the abundance of species as breeding birds in the Falkland Islands was not always reflected in their abundance at-sea. For example, sooty shearwaters were the fourth commonest species recorded during surveys, but are only about the ninth commonest breeding seabird species in the islands (Woods and Woods 1997). The largest known colony in the islands is on Kidney Island at the entrance to Berkeley Sound. The reg-

ular passage of FPVs through this area to and from Stanley resulted in this ¼ ICES rectangle having the highest survey effort, 3% of the total survey effort, while producing 31% of all sooty shearwaters. Therefore, it can be seen that it is crucial to consider the level and distribution of survey effort when interpreting seabird abundance and dispersion patterns.

From the relative abundance of penguin species during surveys, Magellanic penguins outnumber gentoo penguins by about 3:1 and rockhopper penguins by about 4:1. However, when effort is taken into account Magellanic penguins were still recorded at highest densities (very high densities >0.7 birds per km^2) followed by rockhopper penguins (very high densities >0.6 birds per km^2) and then gentoo penguins (very high densities >0.5 birds per km^2). This more closely reflects the size of the populations of these species in the Falkland Islands (Woods and Woods 1997), but Magellanic penguins appear commoner from at-sea surveys than estimates of the breeding population would suggest. The burrow-nesting habits of Magellanic penguins make this species notoriously difficult to census and the high numbers recorded at sea suggests that the Falkland Islands population may be larger than published figures.

Many species exhibited marked seasonal variation in their occurrence in Falkland Islands waters. Where information on seabird seasonality exists, the results of this study broadly agreed with existing knowledge. However, differences were found for some species. For example, Bourne and Curtis (1985) recorded the presence of Kerguelen petrels 'year-round'. In the first 12 months of surveys, the species was only recorded between June and November. At the time of our first report (White *et al*. 1999), it was uncertain whether 1998 might have been anomalous and the species would subsequently be found year-round. This has not occurred and Kerguelen petrels have been recorded in all three years with all records in the period between March and November.

Seasonal variation was typically linked to the species' breeding season. However, given the wide range of life history strategies exhibited by the seabird species utilising Falkland Islands waters it is not appropriate to generalise seabird assemblages as 'breeding' or 'non-breeding'. So, while it is more useful to use terms such as 'summer' and 'winter' when describing the seasonal presence of species in Falkland Islands waters, it should not be assumed that summer is the breeding season or that winter is the non-breeding season. For example, both royal and wandering albatrosses take about 12 months to rear one chick. While both species are present in Falkland Islands waters year-round, all royal albatrosses present in Falkland Islands waters are believed to be non-breeders or pre-breeders (Robertson and Nicholls 2000), whereas wandering albatrosses are a mixture of breeders and non-/pre-breeders in all months (Croxall *et al*. 1999). Long-tailed skuas breed in the boreal summer and visit Falkland Islands waters in their non-breeding 'winter' season during the austral summer. In addition, seabirds typically have large populations of immature or pre-breeders and non-breeders which further confuse the issue of the seasonal presence or absence of species, and this goes some way towards explaining some of the unexpected seasonal patterns of distribution recorded during this study.

Wilson's storm-petrels were recorded in Falkland Islands waters in all months, whereas prior to this study they were generally regarded as being summer visitors to Falkland Islands waters, spending the winter in tropical waters (Woods 1988, Marchant and Higgins 1990). It is not possible to age Wilson's storm-petrels at sea, but it is possible to infer the age of birds from the state of moult. Wilson's storm-petrel were only recorded in moult between November and April, i.e. during the breeding season. Breeding adult Wilson's storm-petrels moult on their wintering grounds post-breeding, i.e. between April and September. Therefore, since no birds were recorded in moult in Falkland Islands waters in these months it is reasonable to assume that birds observed moulting in Falkland Islands waters were non- or pre-breeders and those observed during the winter were birds that did not breed in the previous season. Likewise, sooty shearwaters and grey-backed storm-petrels were found in Falkland Islands waters in all months, with probably only non- or pre-breeders present during the winter.

Rather less information existed regarding species' spatial distribution. Where this did exist, the results of recent surveys have confirmed earlier observations while increasing the detailed knowledge of the distribution of these species. For example, this study confirmed the observation that royal albatrosses are more common in Patagonian Shelf waters while wandering albatrosses are commoner in deep water areas (Bourne and Curtis 1985). However, this study was also able to provide a more detailed picture of wandering albatross distribution in Falkland Islands waters and identified that while wandering albatrosses occurred in oceanic waters year-round, they were only found in Patagonian Shelf waters between October and June. Likewise, Thompson's (1989) observation that imperial shags feed further offshore than rock shags was confirmed by this study. In addition, this study has been able to quantify these distances and identify seasonal variation in the distance offshore that these species feed.

The at-sea distribution of some species did provide some surprises. Gentoo penguins, typically regarded as an inshore species, were recorded throughout Patagonian Shelf waters, particularly during the winter months. This is only a part of the picture, since gentoo penguins were regularly recorded as far west as the limit of Falkland Islands territorial waters. It is not known how far the range of gentoo penguins extends over the Patagonian Shelf towards the Argentine coast, but the species is regarded as a vagrant on the coast of Patagonia (Harris 1998), showing that the gentoo penguins from the Falkland Islands do not regularly reach Argentina.

The observed changes in at-sea distribution of a number of species can be compared with the results of satellite tracking of those species. For example, the observed changes in the at-sea distribution of king penguins is reflected in the satellite tracking results (K. Pütz pers. comm.), and as such it is probable that a proportion of the king penguins recorded in winter to the north of the islands are of Falkland Islands origin. However, the frequency of encounters with king penguins during the winter months was higher than would be expected given the small size of the Falkland Islands breeding population. The gentoo penguin population in the islands outnumbers the king penguin population by a factor of about 220:1 (Clausen 2001). Both species are resident in the islands, and, since gentoo penguin distribution is centred in coastal waters with high levels of survey effort, as expected gentoo penguin was the commoner species recorded. However, the highest densities of gentoo penguins (>0.5 birds per km^2) were only ten times greater than the highest densities of king penguins (>0.05 birds per km^2).

Even taking into account their more restricted at-sea range, the number of king penguins recorded between June and September is still unexpectedly high. King penguins may be more readily detectable than gentoo penguins, or alternatively birds in Falkland Islands waters may not be exclusively from the small Falkland Islands population. It seems likely that at least some of the birds are from the much larger South Georgia population, estimated to be 400,000 pairs (Woehler and Croxall 1997). The largest deep-water concentration of fur seals and all macaroni penguins recorded were both located in a similar area and at a similar season to the king penguins, suggesting that these may also have been from the larger South Georgia populations of macaroni penguin and Antarctic fur seals.

At-sea observations indicate that Magellanic penguins are almost absent during the non-breeding season, while rockhopper penguins are recorded at about 10% of their frequency during the breeding season. These observations are supported by satellite tracking of Magellanic penguins during the non-breeding season has shown that birds depart from Falkland Islands waters after moulting onshore in March and swim northwest as far as 35° S (Pütz *et al*. 2000). In contrast, rockhopper penguins do not move as far north as Magellanic penguins and remain in Falkland Islands waters for longer during the winter than Magellanic penguins (Pütz 1999).

Whenever possible the moult status of birds was recorded. Other than inshore resident species, such as shags, and penguins, which moult onshore, the majority of the other seabird species within Falkland Islands waters are Procellariiformes. Primary moult in Procellariiformes around the Falkland Islands seems largely confined to prebreeders or failed breeders, as evident from its chronology. The majority of birds in moult were recorded between November and April, with a peak in March. For most species breeding in the Falkland Islands this is within their breeding season and, in general, seabirds do not moult while breeding (Warham 1996).

Hence, species seen in primary moult, such as great shearwater and Wilson's storm-petrel, were most likely to have been non- or pre-breeders. Several exceptions to this are known within seabird species found in Falkland Islands waters, such as black-browed albatrosses which may start moulting towards the end of chick rearing (Huin 2000) and giant petrels which moult during the breeding season (Hunter 1984). The absence of moulting Antarctic fulmars in Falkland Islands waters is a result of this species moulting while incubating (Barbraud and Chastel 1998).

These observations suggest that, due to the concentration of birds on the Patagonian Shelf, local breeders and non-breeding visitors choose not to moult there but rather move to less congested areas. These surveys only detected six prions in moult from a total of nearly 120,000 birds. Evidence that thin-billed prions undertake a post-breeding migration to the Bellingshausen Sea is presented by Harper (1972). However, several species associated with the deeper waters of the continental shelf slope and the Falklands/Malvinas Current were recorded in moult during their non-breeding season. For example, 33 of the 239 long-tailed skuas (13.8%) and 20 of the 252 Atlantic petrels (7.9%) recorded were in primary moult.

Use of the study area by marine mammals

The paucity of existing information regarding the status of cetaceans in Falkland Islands waters

makes it difficult to place the results of this study in context. What is clear is that this study has added greatly to knowledge in an area where little was known.

The three commonest dolphin species recorded exhibited clear spatial habitat partitioning. Peale's dolphins were found to be widespread throughout Patagonian Shelf waters, while Commerson's dolphins were restricted to coastal waters and hourglass dolphins were found in oceanic waters, primarily during the summer months (White *et al.* in prep.). The absence of dusky dolphins, which are common further north on the Patagonian Shelf (Jefferson *et al.* 1993), from the study area may also be due to habitat partitioning, but further survey work to the north of the present study area would be required to establish whether this is the case. Two of the large baleen whale species also exhibited a degree of habitat partitioning. Fin whales were primarily found in deep water areas while sei whales were commoner in Patagonian Shelf waters. In both cases, habitat partitioning may be driven by a need to reduce competition for food (Roughgarden 1976). However, little is known about the diets of these species in Falkland Islands waters.

Peale's dolphins were found throughout Patagonian Shelf waters within the study area and were also recorded throughout Patagonian Shelf waters during transects between the Falkland Islands and Punta Arenas, Chile (Gillon *et al.* 2000). The continuous distribution of this species between Falkland Islands and South America will likely result in some degree of mixing of populations. In contrast, Commerson's dolphins were only recorded in coastal waters of both the Falkland Islands and southern South America. As a result, it appears from this study that the populations of this species rarely, if ever, mix and can probably be regarded as distinct populations.

Several species exhibited marked seasonality in their presence in Falkland Islands waters. The majority of hourglass dolphins occurred between September and March, while all southern bottlenose whale records were between September and February. Both species were typically recorded in deep water areas, which received a higher level of survey coverage during the summer months than in the winter, but this alone cannot explain the difference in the sightings. For example, long-finned pilot whales, another species with a predominantly offshore distribution, were recorded most frequently between April and September.

It is not known why hourglass dolphins and southern bottlenose whales exhibit this seasonality, although it seems likely to be linked to a seasonal movement of prey species into the study area.

Sperm whales were primarily found in deep water areas, with a distribution closely linked to the distribution of longline fishing effort. Sperm whales have been recorded associating with longline fishing vessels in the Falkland Islands (pers. obs.) and elsewhere (*e.g.* Ashford *et al.* 1996). The nature of the association in Falkland Islands waters is unclear, but it seems likely that both sperm and killer whales take fish from the longlines.

Spectacled porpoises had been listed as 'frequent' in Falkland Islands waters (Bingham in Hucke-Gaete 2000). This species was not recorded during this study. It is possible that the species is extremely ship-shy, or that its distribution is restricted to inshore waters rarely covered by this study (particularly in West Falkland). However, what seems more likely is that spectacled porpoises are rarer in Falkland Islands waters than was previously considered.

Some inter-annual variation in the occurrence of cetaceans was recorded. There was a marked decrease in baleen whales, mainly fin, sei and minke whales, recorded in summer 2000/01 when compared with 1998/99 and 1999/2000. This can be explained in part by the reduction in survey effort in 2000/01 but this alone does not explain the size of the decrease. The distribution of survey effort is unlikely to be a factor, since species such as minke whales were recorded throughout the survey area while fin and sei whales were typically either deep water (fin) or shallow water (sei) species. It seems more likely that the occurrence of these species is linked to the local availability of food, which was perhaps relatively less in 2000/01 than in preceding years. Whether this decline could be linked to the reduction in the number of several seabird species, e.g. soft-plumaged petrel and black-bellied storm-petrel, recorded in 2000/01 is unknown.

Importance of sea areas and vulnerability to surface pollution

Analysis of the SWASASD allowed the identification of a number of distinct communities of seabirds, often with common origins (Harding *et al.* unpublished MS). For example, in late summer the Patagonian Shelf slope and oceanic waters to the north of the islands supported a community of seabirds that can broadly be described as being of Tristan da Cunha and Gough Island origin. Those species seen regularly in this area, such as soft-plumaged petrels, black-bellied storm-petrels and great shearwaters, together with rarities such as sooty albatross, white-bellied storm-petrel and

spectacled petrel, are all likely to be from Tristan da Cunha and Gough Island.

These communities were neither exclusive nor discrete and there is considerable overlap between areas. In addition, several species that were found to be typical of an area were frequently of diverse origins. For example, long-tailed skuas were also a regular feature of the same area during the summer, but these were of Arctic origin rather than Tristan da Cunha and Gough Island. The reasons underlying the distribution of these seabird communities are poorly understood, but are likely to be a combination of oceanographic features giving rise to productive feeding grounds. In this area, these productive feeding grounds are linked to upwellings of the cold, northward-flowing, Falklands/Malvinas Current.

The vulnerability atlas published using two years of survey data highlighted those areas supporting important concentrations of seabirds that would be vulnerable to a surface pollution incident (White *et al*. 2001). Inshore waters were found to be important in all months, largely due to the presence of resident species with a predominantly coastal distribution such as the endemic Falkland steamer duck, imperial shag and gentoo penguin.

The other areas of importance to seabirds were Patagonian Shelf waters to the north and west of the islands. These areas support high densities of black-browed albatrosses and royal albatrosses year-round, with high densities of prions and storm-petrels during the breeding season and high densities of Cape petrel and Antarctic fulmars during the non-breeding season. In addition, low to moderate densities of rockhopper and Magellanic penguins occur throughout these areas during the breeding season and are replaced by gentoo penguins during the non-breeding season. The low densities of seabirds encountered in deep water areas results in these areas being of generally low to moderate vulnerability for seabirds in all months.

During surveys a total of 44 birds, 0.011% of all birds, of seven species were recorded as having plumage contaminated with oil, with black-browed albatrosses accounting for over half of the total. This figure is similar to the 0.014% of all seabirds recorded as oiled in the North-east Atlantic SAST database (A. Webb pers. comm.). Oiled seabirds were recorded in all three years of surveys and were mostly recorded between March and October, coinciding with the period of highest shipping activities within Falkland Islands waters.

To date, there have been no incidents in Falkland Islands waters resulting in significant numbers of oiled Procellariiformes. This may be due in part to their primarily aerial lifestyle and also to their highly developed sense of smell, which may allow them to better detect and avoid surface pollution than other seabirds. In one incident, following the sinking of a trawler, several hundred albatrosses (mostly black-browed albatross) and other Procellariiformes (mostly Cape petrels) were observed on the water in the vicinity of the resultant bunker fuel slick. However, on that occasion, no birds were observed within the area of the slick or with contaminated plumage (pers. obs.). In the Falkland Islands small numbers of penguins are observed annually onshore with plumage contaminated by oil (e.g. Smith 1998). Similarly, on Bird Island, South Georgia, low numbers of penguins have also been recorded returning to colonies with plumage contaminated by oil; this has yet to be recorded in the large albatross populations there (Reid 1994).

At present, surface pollution is not a significant threat to seabirds within Falkland Islands waters. However, oil spills can be very mobile and may be pushed into the waters of the Falkland Islands by weather systems and water currents. In addition, many seabird species range throughout the Patagonian Shelf waters. For example, Magellanic penguins breeding in the Falkland Islands winter on the Patagonian Shelf as far north as 35° S (Pütz *et al*. 2000), so surface pollution in Argentine waters may affect seabird populations in the Falkland Islands. An estimated 40,000 penguins die from oil pollution on the coast of Argentina annually (Gandini *et al*. 1994). It is likely that at least some of these birds will be of Falkland Islands origin. This is not a result of disasters, such as the sinking of the MV *Treasure* off the coast of South Africa, which resulted in about 22,000 jackass penguins becoming oiled (Cheney 2000), but a result of chronic oil pollution such as the discharge of oily waste from ballast tanks.

It is unlikely that further survey work will produce results that will dramatically alter the distribution of vulnerable concentrations of seabirds in Falkland Islands waters. However, the current vulnerability of seabirds in Falkland Islands waters relates solely to the potential threat of surface pollution. It is possible that a future assessment of vulnerability will seek to include a component of vulnerability to the activities of the fishing industry in Falkland Islands waters, either through competition for a common resource or by direct mortality through the fishing operations. For example, the black-browed albatross population in the Falkland Islands has declined from 468,000 pairs in 1995 to 382,000 pairs in 2001 (Huin 2001). The cause of this decline is thought to be seabird by-catch in longline fisheries in the south-west Atlantic (Schiavini *et al*. 1998).

The survey work conducted in Falkland Islands waters over the past three years was initiated by

concerns about the potential impact of hydrocarbon exploration on seabird populations in the area. Hydrocarbon exploration is just one of a range of threats facing seabird populations at sea. There is also a growing awareness of the problems faced by albatross and petrel populations as a result of interactions with fisheries in the Southern Oceans. A considerable amount of information on the foraging ranges of seabirds can be obtained by satellite tracking of adult (breeding) birds. However, survival rates of pre- or non-breeders may also have long-term effects on population decline and it is the distribution of these birds that is very difficult to determine without direct observations. Therefore, surveys such as these, conducted in a rigorous and consistent fashion, represent the best data available on the distribution and relative abundance of seabirds in this important region of the southern ocean. The results of these surveys are crucial to determining the patterns of use of marine habitats by seabirds and marine mammals, a thorough understanding of which is essential to effective management of both fishing and hydrocarbon exploitation of those areas.

Acknowledgements

The project was sponsored by FC with funding from FIG and, in the first year, from FOSA (Shell Exploration and Production South west Atlantic B.V., Amerada Hess (Falkland Islands) Limited, LASMO International Limited and IPC Falklands Limited).

We thank Tom Eggeling, Director of FIG Environmental Planning Department and Rebecca Ingham of FC for their continued enthusiastic support and for their valued contributions to the steering group of the project.

We also thank FC staff in Stanley and the UK for their support throughout the project. We are also grateful for the assistance provided by JNCC staff in Aberdeen and Peterborough – Sharon Robertson for administrative support, Andy Webb for computing and technical advice and Trudi Harris and Kirsty Meadows who organised the report production.

We would like to acknowledge the FIGFD for allowing us access to the FPVs for use as survey bases. We thank John Barton (Director of Fisheries), Jon Clark (Marine Officer) and Fisheries Officers John Adams, John Addinall, Emma Jones, Richard McKee, Roy Summers and Steve Waugh.

Thanks to all the captains and crews of the vessels used for their support and hospitality – MV *Cordella*, MV *Criscilla*, MV *Dorada*, MV *L'Espoir*, MV *Golden Fleece*, RRS *James Clark Ross*, MV *Mærsk Mariner*, MV *Mærsk Puncher*, MV *Sigma* and MV *Tamar FI*.

Comments from Keith Reid (British Antarctic Survey), Mark Tasker (JNCC) and Jim Enticott improved an earlier draft of this report.

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Appendix I

English and scientific names of species mentioned in text

Table I.1 English and scientific names of birds mentioned in text.

English	*Scientific*	*English*	*Scientific*
King penguin	*Aptenodytes patagonicus*	Spectacled petrel	*P. conspicillata*
Gentoo penguin	*Pygoscelis papua*	Cory's shearwater	*Calonectris diomedea*
Chinstrap penguin	*P. antarctica*	Great shearwater	*Puffinus gravis*
Rockhopper penguin	*Eudyptes chrysocome*	Sooty shearwater	*P. griseus*
Macaroni penguin	*E. chrysolophus*	Manx shearwater	*P. puffinus*
Magellanic penguin	*Spheniscus magellanicus*	Little shearwater	*P. assimilis*
Jackass penguin	*S. demersus*	Wilson's storm-petrel	*Oceanites oceanicus*
Wandering albatross species	*Diomedea exulans* spp.	Black-bellied storm-petrel	*Fregetta tropica*
		White-bellied storm-petrel	*F. grallaria*
Southern royal albatross	*D. epomophora*	Grey-backed storm-petrel	*Garrodia nereis*
Northern royal albatross	*D. sanfordi*	Common diving-petrel	*Pelecanoides urinatrix*
Black-browed albatross	*Thalassarche melanophris*	Georgian diving-petrel	*P. georgicus*
Shy albatross species	*T. cauta* spp.	Magellan diving-petrel	*P. magellani*
Grey-headed albatross	*T. chrysostoma*	Imperial shag	*Phalacrocorax atriceps*
Sooty albatross	*Phoebetria fusca*	Rock shag	*P. magellanicus*
Light-mantled albatross	*P. palpebrata*	Red-legged shag	*P. gaimardi*
Southern giant petrel	*Macronectes giganteus*	Kelp goose	*Chloephaga hybrida*
Northern giant petrel	*M. halli*	Patagonian crested duck	*Lophonetta specularoides*
Antarctic petrel	*Thalassoica antarctica*	Falkland steamer duck	*Tachyeres brachydactyla*
Cape petrel	*Daption capense*	Grey phalarope	*Phalaropus fulicarius*
Antarctic fulmar	*Fulmarus glacialoides*	Antarctic skua	*Catharacta antarctica*
Snow petrel	*Pagodroma nivea*	Chilean skua	*C. chilensis*
Blue petrel	*Halobaena caerulea*	South Polar skua	*C. maccormicki*
Broad-billed prion	*Pachyptila vittata*	Arctic skua	*Stercorarius parasiticus*
Antarctic prion	*P. desolata*	Long-tailed skua	*S. longicaudus*
Fairy prion	*P. turtur*	Brown-hooded gull	*Larus maculipennis*
Thin-billed prion	*P. belcheri*	Kelp gull	*L. dominicanus*
Kerguelen petrel	*Aphrodroma brevirostris**	Dolphin gull	*L. scoresbii*
Soft-plumaged petrel	*Pterodroma mollis*	Arctic tern	*Sterna paradisaea*
White-headed petrel	*P. lessonii*	Antarctic tern	*S. vittata*
Atlantic petrel	*P. incerta*	South American tern	*S. hirundinacea*
Great-winged petrel	*P. macroptera*	Cayenne tern	*S. (sandvicensis) eurygnatha*
Grey petrel	*Procellaria cinerea*		
White-chinned petrel	*P. aequinoctialis*		

Until recently *Pterodroma brevirostris* (Olson 2000)

Table I.2 English and scientific names of marine mammals mentioned in the text.

English	*Scientific*
Southern right whale	*Eubalaena australis*
Pygmy right whale	*Caperea marginata*
Blue whale	*Balaenoptera musculus*
Fin whale	*B. physalus*
Sei whale	*B. borealis*
Minke whale	*B. acutorostrata*
Humpback whale	*Megaptera novaeangliae*
Sperm whale	*Physeter macrocephalus*
Southern bottlenose whale	*Hyperoodon planifrons*
Gray's beaked whale	*Mesoplodon grayi*
Killer whale	*Orcinus orca*
Long-finned pilot whale	*Globicephala melas*
Dusky dolphin	*Lagenorhynchus obscurus*
Hourglass dolphin	*L. cruciger*
Peale's dolphin	*L. australis*
Southern rightwhale dolphin	*Lissodelphis peronii*
Commerson's dolphin	*Cephalorhynchus commersonii*
Spectacled porpoise	*Australophocaena dioptrica*
South American sea-lion	*Otaria byronia*
South American fur seal	*Arctocephalus australis*
Subantarctic fur seal	*A. tropicalis*
Antarctic fur seal	*A. gazella*
Southern elephant seal	*Mirounga leonina*
Leopard seal	*Hydrurga leptonyx*
Weddell seal	*Leptonychotes weddellii*

Table I.3 English and scientific names of terrestrial mammals mentioned in the text.

English	*Scientific*
Rat	*Rattus* spp.
Cat	*Felis domesticus*
Fox	*Dusicyon griseus*

Table I.4 English and scientific names of fish mentioned in the text.

English	*Scientific*
Southern blue whiting	*Micromesistius australis*
Hoki	*Macruronus magellanicus*
Red Cod	*Salilota australis*
Hake species	*Merluccius* spp.
Kingclip	*Genypterus blacodes*
Patagonian toothfish	*Dissostichus eleginoides*
Skate	*Bathyraja* and *Raja* spp.

Table I.5 English and scientific names of marine invertebrates mentioned in the text.

English	*Scientific*
Barnacle	*Lepas australis*
Lobster krill	*Munida gregaria*
Argentine shortfin squid	*Illex argentinus*
Patagonian squid	*Loligo gahi*

Table I.6 English and scientific names of plant species mentioned in the text.

English	*Scientific*
Tussac grass	*Poa flabellata*
Giant kelp	*Macrocystis pyrifera*
Tree kelp	*Lessonia flavicans*

Appendix II

List of survey cruises, February 1998–January 2001

Vessel	*Dates*	*Effort in survey area (km²)*	*Vessel*	*Dates*	*Effort in survey area (km²)*
MV *Cordella*	06.02–17.02.98	319	MV *Tamar FI*	23.03–26.03.99	40
MV *L'Espoir*	21.02–04.03.98	63	MV *Criscilla*	31.03–16.04.99	355
MV *Cordella*	20.03–31.03.98	416	MV *Criscilla*	29.04–10.05.99	211
MV *Dorada*	12.04–22.04.98	391	MV *Dorada*	19.05–01.06.99	278
MV *Mærsk Mariner*	30.04–02.05.98	20	MV *Tamar FI*	31.05–08.06.99	53
MV *Dorada*	10.05–13.05.98	59	MV *Dorada*	02.06–15.06.99	236
MV *Criscilla*	14.05–25.05.98	355	MV *Criscilla*	09.06–22.06.99	93
MV *Criscilla*	02.06–09.06.98	194	MV *Criscilla*	24.06–02.07.99	161
MV *Mærsk Mariner*	10.06–12.06.98	25	MV *Dorada*	03.07–13.07.99	254
MV *Criscilla*	10.06–23.06.98	293	MV *Dorada*	15.07–27.07.99	325
MV *Dorada*	22.06–04.07.98	299	MV *Criscilla*	22.07–03.08.99	315
MV *Criscilla*	24.06–07.07.98	206	MV *Dorada*	30.07–10.08.99	47
MV *Dorada*	05.07–15.07.98	146	MV *Dorada*	11.08–24.08.99	255
MV *Criscilla*	08.07–21.07.98	229	MV *Dorada*	25.08-07.09.99	437
MV *Dorada*	19.07–01.08.98	163	MV *Dorada*	08.09–19.09.99	356
MV *Mærsk Puncher*	22.07–24.07.98	34	MV *Tamar FI*	11.09–18.09.99	104
MV *Mærsk Mariner*	25.07–27.07.98	29	MV *Criscilla*	16.09–28.09.99	373
MV *Dorada*	03.08–15.08.98	484	MV *Dorada*	24.09–05.10.99	412
MV *Criscilla*	19.08–01.09.98	358	MV *Criscilla*	29.09–12.10.99	517
MV *Mærsk Puncher*	26.08–29.08.98	38	MV *Dorada*	06.10–22.10.99	80
MV *Dorada*	30.08–11.09.98	314	MV *Dorada*	24.10–30.10.99	201
MV *Criscilla*	02.09–15.09.98	218	RRS *James Clark Ross*	23.10–07.11.99	100
MV *Criscilla*	16.09–29.09.98	465	MV *Criscilla*	11.11–23.11.99	426
MV *Dorada*	27.09–11.10.98	377	MV *Dorada*	24.11–30.11.99	356
MV *Criscilla*	15.10–27.10.98	295	MV *Criscilla*	25.11–07.12.99	205
MV *Mærsk Puncher*	19.10–21.10.98	59	MV *Dorada*	15.12–24.12.99	378
MV *Dorada*	28.10–08.11.98	112	MV *Dorada*	02.01–10.01.00	457
MV *Criscilla*	28.10–10.11.98	453	RRS *James Clark Ross*	13.01–17.02.00	56
MV *Dorada*	11.11–21.11.98	434	MV *Tamar FI*	31.01–07.02.00	129
MV *Criscilla*	11.11–24.11.98	452	MV *Criscilla*	16.02–29.02.00	305
MV *Dorada*	22.11–05.12.98	423	MV *Criscilla*	01.03–14.03.00	317
MV *Criscilla*	09.12–23.12.98	598	MV *Dorada*	07.03–19.03.00	316
MV *Dorada*	27.12.98–09.01.99	873	RRS *James Clark Ross*	27.03–01.04.00	71
MV *Dorada*	10.01–15.01.99	312	MV *Dorada*	09.04–18.04.00	266
MV *Criscilla*	20.01–02.02.99	441	MV *Criscilla*	12.04–25.04.00	280
MV *Dorada*	07.02–14.02.99	255	MV *Tamar FI*	16.04–23.04.00	79
MV *Criscilla*	17.02–02.03.99	176	MV *Criscilla*	26.04–09.05.00	305
MV *Dorada*	27.02–06.03.99	190	MV *Dorada*	03.05–15.05.00	64
MV *Criscilla*	03.03–15.03.99	436	MV *Golden Fleece*	24.05–07.06.00	381
MV *Dorada*	07.03–19.03.99	308	MV *Dorada*	18.06–27.06.00	250

Vessel	*Dates*	*Effort in survey area (km²)*	*Vessel*	*Dates*	*Effort in survey area (km²)*
MV *Dorada*	12.07–24.07.00	281	MV *Dorada*	21.10–30.10.00	294
MV *Tamar FI*	24.07–31.07.00	80	MV *Sigma*	12.11–21.11.00	263
MV *Dorada*	04.08–08.08.00	95	MV *Dorada*	14.12–23.12.00	607
MV *Dorada*	09.08–24.08.00	245	MV *Dorada*	27.12.00-08.01.01	554
MV *Dorada*	24.08-04.09.00	373	MV *Tamar FI*	02.01-09.01.01	331
MV *Dorada*	21.09-01.10.00	336	MV *Dorada*	10.01–23.01.01	455

Appendix III

Summary of monthly survey effort

Summary of monthly survey effort (km²) in each ¼ ICES rectangle either wholly or partly within the core study areas – the Licence Blocks to the north of the islands and the Special Co-operation Area (SCA) to the south-west of the islands (Figure 1.2). For the SCA, only ¼ ICES rectangles wholly or partly within Falkland Islands waters are considered.

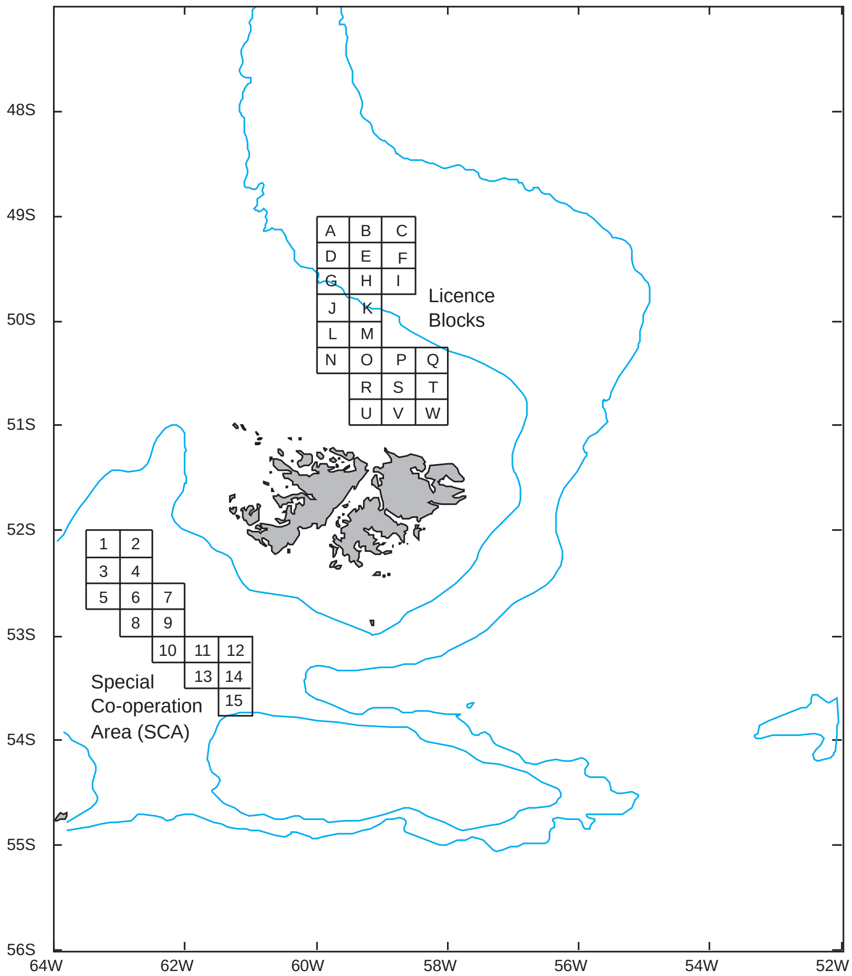

Figure III.1 Position of ¼ ICES rectangles either wholly or partly within the core study areas.

Table III.1 Monthly survey effort in ¼ ICES rectangles either wholly or partially within Licence Blocks.

	Code	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
49;07.50S+59;45.00W	A	7.8	9.1		2.7		8.0	10.7	7.5			17.8	10.5
49;07.50S+59;15.00W	B	1.0	6.0				3.4	21.7	0.9		6.1		6.1
49;07.50S+58;45.00W	C						5.4	12.5					
49;22.50S+59;45.00W	D		4.9	1.0	4.5			10.4	10.8			14.3	5.2
49;22.50S+59;15.00W	E	7.0	20.5			1.3	30.8	27.7	7.1		28.5		
49;22.50S+58;45.00W	F							14.2					
49;37.50S+59;45.00W	G		10.1	23.8	14.2	21.4	22.9	9.2	20.1	4.6		7.0	13.4
49;37.50S+59;15.00W	H	5.5	5.7	22.4			18.4	4.6	5.0		29.5	10.6	8.4
49;37.50S+58;45.00W	I		4.7					26.2	7.0		2.1		
49;52.50S+59;45.00W	J		4.0	43.1	17.9	22.8		4.1	19.2	9.7	8.1	1.0	
49;52.50S+59;15.00W	K	4.4	13.1	27.3	20.5	11.1	9.4	21.1	2.9		8.7	13.8	13.8
50;07.50S+59;45.00W	L			18.4		5.6		12.9	8.8	13.1	6.4	10.0	
50;07.50S+59;15.00W	M	7.7	5.8	16.0	26.3	3.3		3.3	1.1	1.9	7.1		
50;22.50S+59;45.00W	N	9.4		12.4			0.8	6.1		9.3	6.1		5.8
50;22.50S+59;15.00W	O	0.9	0.0	16.1	6.0			9.7	8.2	2.4	7.3	5.7	
50;22.50S+58;45.00W	P		16.1	20.6	1.9						7.1		4.3
50;22.50S+58;15.00W	Q	6.4	4.8	7.2			12.4	3.6				6.1	
50;37.50S+59;15.00W	R			14.4	5.0		5.9		8.8	11.6	6.5		8.0
50;37.50S+58;45.00W	S		9.1	12.1	9.4			8.4		12.8	6.2	9.5	7.4
50;37.50S+58;15.00W	T	8.1	9.0	8.8			5.4	7.5				4.8	
50;52.50S+59;15.00W	U		0.9	9.2	7.0		7.3		8.7	16.8	7.8		2.3
50;52.50S+58;45.00W	V			17.7	4.2		2.1	10.6					13.7
50;52.50S+58;15.00W	W	8.5	22.0	16.7	2.1		13.0	11.9		6.2	1.0		
Total effort (km²)		66.7	145.8	287.2	121.7	65.5	145.2	236.4	116.1	88.4	138.5	100.6	98.9
No. with any coverage		11	16	17	13	6	14	20	14	10	15	11	12
No. with >10km²		0	5	13	4	3	5	11	3	4	2	5	4

Table III.2 Monthly survey effort in ¼ ICES rectangles either wholly or partially within SCA.

	Code	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
52;07.50S+63;15.00W	1	28.8	3.5	0.9	10.8	11.9	10.3	22.2	8.9	6.1	7.6	30.6	15.2
52;07.50S+62;45.00W	2	9.8	5.3	7.4		11.1	10.0	9.3	8.7		4.9	12.6	0.9
52;22.50S+63;15.00W	3	44.6	19.8		2.1	10.6	10.6	16.2	3.5	13.6	6.5	20.9	14.5
52;22.50S+62;45.00W	4	9.6	30.9		9.7	10.6	10.8	15.0				23.2	10.1
52;37.50S+63;15.00W	5	16.5				10.3	7.9	7.1		2.3	2.8		1.6
52;37.50S+62;45.00W	6	36.5	1.8			12.0	12.7	17.2		7.9	13.6	21.9	17.0
52;37.50S+62;15.00W	7	2.1		5.5		10.3	10.4	12.2		0.8	3.8	3.4	18.8
52;52.50S+62;45.00W	8	13.5				11.0	5.5	7.2					1.0
52;52.50S+62;15.00W	9	35.0				11.5	11.5	16.5				21.5	13.8
53;07.50S+62;15.00W	10	14.2				11.2	6.8	7.6					9.4
53;07.50S+61;45.00W	11	40.3				12.5	15.8	1.6		8.5		7.9	15.7
53;07.50S+61;15.00W	12	2.0				13.6	10.8						8.5
53;22.50S+61;45.00W	13	14.2				11.0	9.0					2.5	8.5
53;22.50S+61;15.00W	14	14.8				14.1	18.3	6.7				7.6	21.5
53;37.50S+61;15.00W	15	12.3				10.2	6.1					1.7	2.0
Total effort (km²)		294.2	61.3	13.8	22.6	171.9	156.5	138.8	21.1	39.2	39.2	153.8	158.5
No. with any coverage		15	5	3	3	15	15	12	3	6	6	11	15
No. with >10km²		11	2	0	1	15	10	6	0	1	1	6	8

Appendix IV

Species totals recorded during surveys

Table IV.1 Total number of each species of seabird recorded during surveys

Species	*No. of birds*	*No. of records*
Prion species	119,623	24,416
Black-browed albatross	84,614	36,972
Imperial shag	39,264	11,865
Sooty shearwater	37,109	9,800
Wilson's storm-petrel	21,019	10,925
Antarctic fulmar	18,061	7,314
Cape petrel	15,199	5,418
Magellanic penguin	12,033	4,511
White-chinned petrel	8,044	5,769
Great shearwater	6,468	2,738
Diving-petrel species	5,192	3,304
Gentoo penguin	3,896	2,040
Southern giant petrel	3,535	3,188
Southern royal albatross	3,252	3,123
Grey-backed storm-petrel	2,758	2,204
Giant petrel species	2,386	1,099
Kelp gull	2,288	1,224
South American tern	1,894	670
Eudyptid penguin species	1,578	739
Rockhopper penguin	1,357	670
Grey-headed albatross	1,321	1,140
Soft-plumaged petrel	861	730
Rock shag	796	486
Common diving-petrel	753	654
Northern giant petrel	751	716
Falkland steamer duck	699	140
Blue petrel	573	532
Antarctic skua	573	492
Northern royal albatross	447	447
Royal albatross species	415	309
Wandering albatross species	394	394
Fairy prion	288	103
Penguin species	263	196
Atlantic petrel	252	245
Long-tailed skua	239	212
Black-bellied storm-petrel	205	196
Catharacta skua species	160	135
Sterna species	160	104
Kerguelen petrel	152	145
King penguin	151	81
Brown-hooded gull	134	69
Magellan diving-petrel	133	127
Dolphin gull	114	60
Antarctic petrel	56	54
Macaroni penguin	45	13
Grey petrel	45	34
Arctic skua	35	30
Shy albatross species	25	25
Chinstrap penguin	24	10
Light-mantled albatross	24	24
Little shearwater	24	24
White-bellied storm-petrel	23	23
Arctic tern	21	14
Sooty albatross	6	6
Manx shearwater	4	4
Chilean skua	4	4
White-headed petrel	3	3
Great-winged petrel	2	2
Broad-billed prion	2	2
Cayenne tern	2	1
Grey phalarope	2	2
Spectacled petrel	1	1
Cory's shearwater	1	1

Table IV.2 Total number of each species of marine mammal recorded during surveys

Species	*No of animals*	*No of records*	*Species*	*No of animals*	*No of records*
Peale's dolphin	2617	864	Sei whale	45	31
Fur seal species	937	442	Large whale species	44	40
Hourglass dolphin	886	177	Southern bottlenose whale	34	18
Long-finned pilot whale	872	27	Sperm whale	28	21
Commerson's dolphin	336	100	Killer whale	18	7
Southern rightwhale dolphin	231	5	Mesoplodon species	17	7
Dolphin species	184	57	Southern elephant seal	13	13
South American sea lion	81	77	Medium/small whale species	12	10
Minke whale	68	60	Humpback whale	7	5
Fin whale	57	27	Southern right whale	7	6
Unidentified pinniped	56	46			

Appendix V

Examples of survey forms

JNCC SEABIRDS AT SEA TEAM RECORDING SHEET
BASE DATA

Ship . . . .   Sheet . . . . . of . . . . .
Observer(s) . . . .
Date . . . . . / . . . . . / . . . . .

Time (UT)	Start/Mid/End	Latitude (S)	Longitude (W)	Speed (knots)	Course

JNCC SEABIRDS AT SEA TEAM RECORDING SHEET
TRIP DATA

Date . . . . . / . . . . . / . . . . . Sheet . . . . . of . . . . .

Trip key	Start time (UT)	Observer	Method	Angle of view	Species counted	Base activity	Notes

Base name . . . . Height of eye . . . .
Transect width . . . . Duration . . . . No. observers . . . .

ENVIRONMENT DATA

Time (UT)	Wind dir^n	Wind force	Sea state	Swell height	Vis	Cloud	Rain	Sun strength	Sun dir^n	Notes

Joint Nature Conservation Committee

SEABIRDS AT SEA TEAM RECORD SHEET

SHIP . . . . OBSERVER . . . .
DATE . . . . PAGE . . . . . OF . . . . . NEXT ASSOC. . . . .

	TIME	SPECIES	AGE	PLU	NO	DIST	DIR	FLY	SEA	TR	ASS	NOTES
1												
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