HAULOUT SITE USAGE BY SOUTHERN ELEPHANT SEALS, *MIROUNGA LEONINA*, AT MARION ISLAND.

By

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Department of Zoology and Entomology
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ABSTRACT

Data obtained from annual tagging and regular tag resightings of southern elephant seals at Marion Island has allowed the investigation of the patterns of terrestrial haulout site usage by this species. Southern elephant seals were found to prefer some sites while descriminating against other sites for the various haulout events, with different age and sex classes using different sites. The degree of preference showed signs of having intensified during the stage of population stabilisation, highlighting the influence of population density on site selection. Certain age classes seemed not to tolerate each other at the beaches, especially the adults and juveniles during their breeding and moulting haulouts respectively when an overlap in these events occur. Elephant seals prefer open beaches with smooth surfaces during the breeding season. Sites with access to moult wallows were prefered during the moulting season by adult seals. There is some indication that juvenile seals also preferred such sites during the moult haulout although this was not supported statistically. Wintering young animals did not show strong site

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selection. Overall, sites with low anthropogenic influence were prefered, especially during the breeding season. Some popular sites were simply used for all haulouts and by all age and sex groups, and apparently have all the requirements of a good site for terrestrial haulout by southern elephant seals.

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CHAPTER 1 GENERAL INTRODUCTION

1.1 Introduction

In animals, the choice of a place to live is called habitat selection, and is influenced by two types of factors, namely, the physiological tolerance limits and psychological factors (Miller & Harley 1996). While some animals are influenced in their choice for a place to live by the physical environment, some are influenced by the densities of conspecifics. According to Feldhamer *et al.* (1999), choosing a place to live does not necessarily imply a conscious choice or that individuals make a critical evaluation of the entire constellation of factors confronting them. Often the choice is an innate reaction to certain aspects of the environment.

It is very difficult to illustrate the concept of habitat selection for pinnipeds since they alternate between two totally different media, land and water (see section 1.2.2). In this case choosing where to feed (aquatic habitat) and where to haul out for breeding, moulting and resting are two entirely different matters.

Young southern elephant seals, *Mirounga leonina*, appear to haul out for the winter at sites that are not visited by older seals hauling out to breed (Hofmeyr 2000). These juveniles also seem to avoid sites that are used by breeding animals when there is an overlap in the timing of the haulouts. Observation also suggests that southern elephant seals prefer certain haulout sites to others for the different types of haulouts.

There is a perceived need to quantitatively address these hypotheses in order to describe terrestrial habitat selection with more certainty. This study aims to detect and describe the social factors (age, sex and status) and the topographical factors (physical characteristics of the sites) that are of importance in terrestrial habitat selection by southern elephant seals.

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This study will have two major implications. Food availability, predation of pups by killer whales (Pistorious *et al.* 1999), competition with the increasing fur seal populations and the impacts of the fishing industry (Bester 1988) have been highlighted as possible factors operating in the marine environment which could be responsible for the Marion Island population decline before stabilization from 1994 (Pistorius *et al.* 2004). Factors that operate on land have been alluded to (Condy 1979) but have never been rigorously investigated, although they have been discounted as playing a role in the decline of the southern elephant seal population at Marion Island (Bester 1988). The first implication of this study is therefore procurement of additional information towards the understanding of the former decline (Bester & Wilkinson 1994; Pistorius *et al.* 1999b) and recent stabilisation (Pistorius & Bester 2002; Pistorius *et al* 2004) of the Marion Island population. Secondly, the importance of different landing sites for this species will be assessed and recommendations will be made to the Prince Edward Islands Management Committee (PEIMC), as to which sites are vital for the survival of this population, their susceptibility to disturbance and the management regime that they should therefore fall under.

1.2 Study Animals

1.2.1 Biology.

The southern elephant seal, *Mirounga leonina,* is the largest of all the living pinnipeds (King 1983, Maxwell 1967). It is one of the most sexually dimorphic marine mammals, a trait that becomes more apparent with aging of the animals (Maxwell 1967; Le Boeuf & Laws 1994). Adult males weigh up to 3700 kg while adult females weigh up to 800kg with the mean recorded lengths of the species being 4.72m and 2.82m for adult males and adult females respectively (Le Boeuf & Laws 1994).

The onset of sexual maturity is condition dependent (Laws 1994), and at Marion Island, females give birth for the first time between the ages of three and six years (Bester & Wilkinson 1994; Pistorius *et al.* 2001). Bulls might mature sexually at the age of four

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years but they are socially mature and able to hold harems from the age of eight (Le Boeuf & Laws 1994), although bulls as young as six years old occasionally hold harems in the small Marion Island population (MRI, unpublished results).

Southern elephant seals forage at sea and come to land to breed, moult, and winter (rest). Participation and timing of the different haulouts depends on the age, sex and social status of the animals (Hofmeyr 2000; Kirkman *et al.* 2001, 2003, 2004).

1.2.2 Terrestrial phase.

The breeding season of southern elephant seals at Marion begins with the hauling out of bulls in mid August for the establishment of territories (Condy 1979). The pregnant cows follow early in September and they aggregate in groups called harems. The harems reach their maximum size around the 15^{th} of October, when the number of adult females is at peak with the maximum number of pups present about one week later (Condy 1979, Wilkinson 1992). After parturition and three weeks of lactation, individual mated females leave. The dominant male (beachmaster) in the harem is responsible for up to 98% of all the matings (Wilkinson 1992). Harems on Marion Island are small, allowing the beachmasters to control and defend entire harems, and therefore there seems to be no need for assistant beachmasters, and as such, they are rare (Wilkinson 1992). Bachelors and challengers are, however, very often at the periphery of the harems. The beachmaster remains on the beach until the last cow leaves, or until he is displaced by another bull.

The moult haulout is obligatory to all seals except pups of the year, which moult during suckling. Moulting entails the shedding of the skin and hair in patches (King 1983). Timing of this haulout depends on age and sex, with yearlings of both sexes hauling out first from mid-November and may be present until late January. Subadults of both sexes and adult females haul out from mid-December to mid-March, and the adult males moult from late December to mid-April (Condy 1979).

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The third and least understood haulout is the one that mostly juveniles of both sexes participate in, with occasional appearances by adults. It is called the resting or the winter haulout (Hofmeyr 2000; Kirkman *et al.* 2001). For underyearlings and yearlings, participation in this event is similar for both sexes. Participation of older animals depends more on sex than age, with males more likely to haul out in winter (Kirkman *et al.* 2001).

1.2.3 Pelagic Phase

Although they show a great degree of fidelity to natal rookeries for breeding, moulting and resting, southern elephant seals forage widely in the Southern Ocean (Bester 1988, 1989). They range as far south as the pack ice region and the Antarctic continent and north to the continents abutting the Southern Ocean (Bester 1989). Post-breeding females from Marion Island range up to 1460 km distant, feeding within the inter-frontal zones south of the Antarctic Polar Front and between the Sub-Tropical Convergence and the Sub-Antarctic Front, and at the oceanic frontal systems. Post-moulting females can go as far as 3133 km from the island into the pack-ice (Jonker & Bester 1998). Adult males remain relatively close to Marion Island during their post-breeding period probably pursuing pelagic prey species in very deep waters (Malherbe 1998), although during the post-moulting period they go further afield (unpublished data).

1.2.4 Distribution and present status.

Southern elephant seals breed and moult on many sub-Antarctic islands during the austral spring and summer (Bester 1988). They breed on both sides of the Antarctic Polar Front and comprise four stocks, namely, the Peninsula Valdés, the South Georgia, the Macquarie and the Kerguelen stocks (Slade 1998; Hoelzel 2001; McMahon *et al.* 2003). Each stock is comprised of several sub-populations (Fig. 1.1).

The South Georgia stock consists of South Georgia, King George Island, the South Orkney Islands, the South Shetland Islands, South Sandwich Islands, Gough Island and

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Fig 1.1. Map of the Southern Ocean, indicating the four southern elephant seal stocks (Modified from Condy 1979)

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Bouvet Island. The Falklands and the South American groups are separate from the South Georgia stock and constitute the Peninsula Valdés stock (Slade 1998).

The sub-populations of the Kerguelen stock are those at Iles Kerguelen, Heard Island, Ĭles Crozet, Amsterdam and St Paul Islands and the Prince Edward Islands (Bester 1988). The Prince Edward Island group comprises Marion Island (the larger of the two islands and the study area), and Prince Edward Island.

The Macquarie stock consists of the populations at Macquarie Island, Campbell Island, the Auckland Islands and Antipodes Islands. The total world population of southern elephant seals was estimated to be 664 000 during 1990, with percentage contributions of 60%, 28% and 12% for the South Georgia and Peninsula Valdés, Kerguelen and Macquarie stocks respectively (Laws 1994).

Populations of elephant seals have, at a number of sites, experienced an unexplained decline since the 1950s (Barrat & Moungin 1978; Pascal 1985; Burton 1986; Hindell & Burton 1987; Guinet *et al.* 1992). Included in these populations are those at the Prince Edward Islands (Condy 1979; Bester 1980; Pistorius *et al.* 1999a). The Marion Island population declined at an average rate of 4.9% per annum between 1974 and 1989. This decline slowed to 1.9% per annum between 1983 and 1989 (Bester & Wilkinson 1994) and recently the population appears to have stabilized (Pistorius & Bester 2002; Pistorious *et al.* 2004). Currently it is thought that the elephant seal populations at Marion Island and Macquarie Island were driven principally by resource limitations (Pistorius *et al.* 1999a; McMahon *et al.* 2003)

1.3. RESEARCH OBJECTIVES.

An extensive mark-recapture programme of elephant seals on Marion Island that started in 1983 (Bester 1988) has resulted in the accumulation of a large database on recapture records. Using this database, the following aspects of behaviour and population dynamics have been studied:

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1. The patterns of survival of southern elephant seals and factors influencing some of these patterns (Bester & Wilkinson 1994; Pistorius & Bester 2002; Pistorius *et al.* 1999a, b, 2001, 2002, 2004; McMahon *et al.* 2003),
2. The temporal patterns of southern elephant seal haulouts (Kirkman *et al.* 2001, 2003, 2004),
3. The dispersal of southern elephant seals to terrestrial haulout sites relative to natal and previous haulout sites (Bester 1989; Hofmeyr 2000),
4. The dispersion of the southern elephant seals at the island (Wilkinson & Bester 1990; Hofmeyr 2000).

A fifth aspect, the spatial use of the terrestrial environment is the subject of this study, and endeavours to assess the social and environmental factors that are of importance in determining the suitability of a site during the terrestrial haulout of southern elephant seals. It will address aspects of animal behaviour, i.e. their choice of the sites for different haulouts, and aspects of ecology, i.e. the topographical requirements of southern elephant seals in the terrestrial environment.

The main research question is:

What is the pattern of spatial use of the terrestrial habitat by southern elephant seals of different age and sex classes, during reproductive, moult and winter haulouts, and how does this relate to the onshore social and physical environment?

In Chapter 4 I test and establish the fact that southern elephant seals of different age and sex classes prefer different sites during the three different haulout seasons. This is to uncover the pattern of terrestrial use by southern elephant seals.

Chapter 5 determines whether the pattern of terrestrial use is the same for the period of population decline and the period after population stabilization i.e., to see if population density has an influence in terrestrial site utilization.

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The influence of age and sex groups on the haulout choice by other such groups will be investigated in Chapter 6, through examining haulout site selection during the periods of temporal overlap in haulouts between the different age and sex groups.

In Chapter 7, I assess if there are any topographical features that are of importance in haulout site choice by southern elephant seals, i.e. to assess which physical characteristics are important to southern elephant seals during the various haulouts.

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CHAPTER 2 GENERAL METHODS

2.1 The main study area

The leeward east coast of Marion Island (46°54`S, 37°45`E) is made up of beaches that are differentially accessible to elephant seals while the west coast present cliffs interspersed with rocky and inaccessible beaches that also experience high wave activity (See Chapter 3).

The main study area, on the east coast, was divided into 40 clearly demarcated sites. Each of these sites received a code, MM for Marion Island, followed by three-digit number ranging from 001 to 068. Some of these sites are single, large beaches while others are stretches of coastline with several small inlets as described in section 3.4, Chapter 3.

2.2 Mark-resighting program.

The seal marking and resighting techniques used in this study are reported in full in Pistorius *et al.* (1999a, 2000). Essentially elephant seal weanlings were double tagged since 1983 with colour coded Jumbo Rototags (Dalton Supplies Ltd, Henly-on-Thames, UK) at their sites of birth. Different colour combinations were used for each year in order to differentiate the cohorts. Each individual seal received one of a pair of exclusively three-digit numbered tags in the interdigital webbing of each hind flipper (Fig 2.2).

Tag resights during censuses were done every ten days during the winter and the moult haulout between Storm Petrel Beach (051) and Kildalkey Beach (020) (Fig 2.1). During the breeding season haulout, censuses and tag resights were done on a seven-day cycle on this section of the coast. The South coast sites at Watertunnel Stream and Goodhope Bay East and West were censused once every 10 to 20 days during the winter and moult

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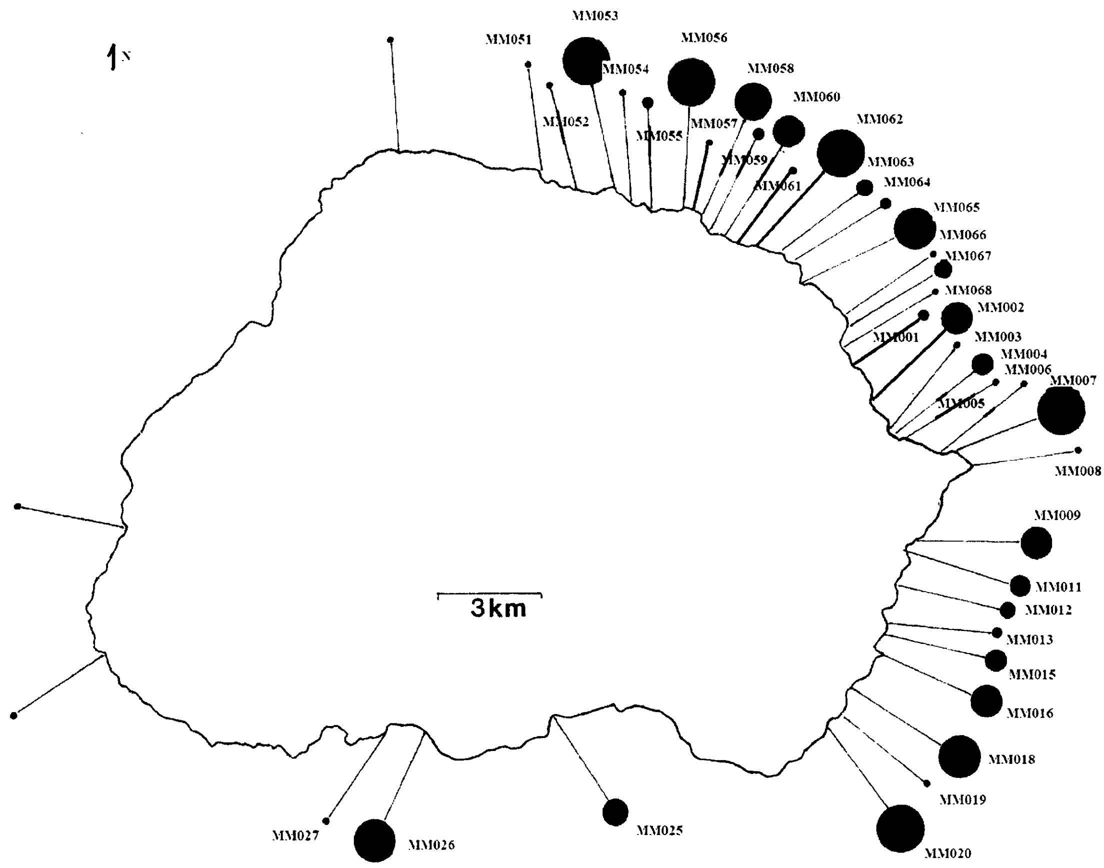

Fig 2.1. The coastline of Marion Island showing the study area and sites (MM051 in the North to MM026 in the South). The size of each dot corresponds with the number of pups born at each site and hence the popularity of the different sites.

haulout and during the breeding haulout, this stretch of the coastline was censused on a 7-14 day cycle.

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Fig 2.2. Immediately after weaning all pups were double tagged with Jumbo Rototags and their sex and site of birth were noted. (Picture: Wilna Wilkinson)

Over the past 18 years from 1983 to 2001 more than 9 000 animals had been marked and some 55 000 records of resights have been collected.

2.3 Data collection

Age and sex classification of elephant seals at Marion Island followed Condy (1979). Classes are given below with class codes in parentheses.

Pups = young of both sexes before the first pelagic expedition (00)
Underyearlings = animals of both sexes under the age of one year (10)
Yearlings = one-year-old animals of both sexes (20)
Subadults = males two years and older but younger than six years (30)
Females two years and older but below five years that have not been recorded with a pup during any breeding season (30)

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<u>Adults</u> = males six years and older (40)
Females five years and older and all those that have been recorded with a pup during any breeding season (40).

For each beach visited on each occasion, the following were recorded:

1. Total number of adults (males separate from females),
2. Total number of subadults,
3. Total number of yearlings,
4. Total number of underyearlings,
5. Pups (separated into live and dead ones, and preweaned and weaned ones),
6. Total number of animals on the beach.

For each of the five age classes above, the following was recorded:

1. Total number of seals of that age class,
2. Number of seals checked for tags,
3. Number of seals found with tags.

For each tagged animal found the following information was recorded:

1. Date,
2. Site code,
3. Tag colour combination (age),
4. Tag number,
5. Social status (the reason for the hauling out),
6. Moulting stage (moulting progress).

2.4 Site description

Each site was catergorised as to whether moult wallows or vegetated areas were accessible from it or not. Component sites are those made up of several small beaches or inlets while those noted as single beaches comprised one beach only. The beach

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type was broadly classified on the basis of the dominant material on it (sand, pebbles, boulders, rocks, vegetation), or a combination thereof following Van Aarde (1980) and Bester (1982).

2.5 Data manipulation

All the data files from the various years were pooled. Frequencies and percentages of records for each of the forty sites for each age class and each haulout season were determined using the SAS 8.2 statistical package.

2.6 Limitations and assumptions of the study

1). Male elephant seals attain sexual maturity at the age of five but attain social maturity at the age of eight (Laws & Le Boeuf 1994), but in the small Marion Island population they are able to hold harems as early as the age of six (Pistorius *et al.* 2001). Bulls of age six that have been recorded present during the breeding season were considered adults (40) but the rest of six-year-old males were still considered subadults (30) following Kirkman *et al.* (2003). The youngest females to give birth at Marion Island were three years old (Bester & Wilkinson 1994), but any female between ages three and six that had not at any time been observed with a pup was considered subadult (30), with those that have been observed with pups considered adults (40) together with females seven-years-old and above that are fully recruited to the breeding population (Bester & Wilkinson 1994, Pistorious *et al.* 2001).

2). It is assumed that the intensity and efficiency of search efforts during the study period was consistent (Hofmeyr 2000).

3). The exact times and dates of arrival and departure of elephant seals at the sites could not be recorded as the resights could not be done at daily intervals (Pistorius *et al.* 1999).

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4). It is assumed that each animal on a particular beach was aware of the presence of all others on that beach.

5). Once an animal hauled out for a particular season, it is assumed to have selected that site and has not been to other sites for that particular haulout.

6). Only the effects of social interactions during overlapping haulout events are considered in this study.

7). The mark-recapture programme at Marion Island was initiated primarily with the aim of obtaining demographic data (Bester & Wilkinson 1994), and the data is therefore not necessarily suited for a behavioural study. The data was edited for use in the present study using the SAS statistical package, which allowed the following:

(1) correcting records of individuals which were inconsistently age classed in such a way that animals are promoted in an ascending order of age class codes (see section 2.3) from underyearling to yearling, subadult and finally to adult,

(2) assigning breeding, moulting or winter haulout stage to each record based upon the status, sex and timing of the haulout of the animals,

(3) checking that periods of haulout were compatible with appropriate age and month of the year when resighted, and

(4) clearly erroneous records were deleted.

The moulting season extends from one calendar year to another. To enable the pooling of all the moulting data together, and to assign moulting animals to a particular year, the moulting data from January to May of each year were backdated by one year, e.g. animals moulting from January to May 1987 became the moulters of 1986.

Southern elephant seals at Marion Island are assumed to age a year on the 15th of October, the peak of the breeding season haulout (Wilkinson 1992). For ease of handling the data, a year was added to the age of all tagged seals at their first resighting during the breeding season, even if they were resighted before the median birth date (15th of

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October). This was done so that a breeding animal would have only one age during a particular breeding season.

From 1983 to 1989, censuses and hence tag resights, took place only from August of one year to May of the next year, which means that the winter haulout went largely unrecorded. Complete winter records are therefore only available from 1990 onwards.

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CHAPTER 3 STUDY AREA

3.1 Geographical description.

Marion Island and Prince Edward Island together constitute the Prince Edward Archipelago. The islands are situated in the southern Indian Ocean, where they were formed some 1.2 million years ago from a series of volcanic events. They lie some 2 180 km to the southeast of Cape Town, 2 300 km from Antarctica (Chown & Hänel 1998) and 950 km to the west of the nearest landmass, Îles Crozet (Fig. 1.1). Marion is the bigger of the two islands and is positioned at 46°54'S and 37°45'E (Chown & Hänel 1998).

3.2 Topography.

Marion Island is 290 km^2 in area, roughly oval in shape, with a maximum altitude of 1230 m (Jan Smuts [Mascarin] Peak). It measures 24 km from west to east and 14 km from north to south, and has a circumference of roughly 72 km (Wilkinson 1992).

The majority of the island's coastline is irregular in configuration and is composed of sea-pounded cliffs of up 15 m high. Initial irregularities in these areas have been smoothed over time to produce wide, open bays with stony beaches along the base of the cliffs (Wilkinson 1992). There are only two sandy beaches on the whole island, at Ship's Cove and Goodhope Bay East. Beaches of an extremely irregular nature are characteristic of the exposed west coast while the beaches on the leeward east coast are largely composed of pebbles, stones and rounded rocks (Wilkinson *et al.* 1987), which give elephant seals easy access to the terrestrial environment on that coast.

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3.3 Climate

Systematic observations have been consistently made since the annexation of the islands in 1948. The climate is basically oceanic with modifications due to the topography of the island itself. The main features, according to Wilkinson (1992) are:

- Strong, predominantly westerly winds, with highest velocities during the day and gales most frequent in the winter.
- Relatively low temperatures, with a mean annual temperature of 5.5°C, with little annual or diurnal variation.
- Abundant precipitation in the form of rain, snow or graupel (ice-rain) with the mean annual precipitation of 2576 mm.
- High relative humidity, with little annual or diurnal variation from 80%.
- A high degree of cloudiness, with only 20 to 33% of the possible amount of sunshine reaching the island surface. Daylight duration is 15 hours in summer and 9 hours in winter.

Sea surface temperatures measured at the station are low (annual mean = 5.0°C) with little annual variation. Recent observations show that sea and air temperatures at Marion Island are rising by 0.025°C per year (Prince Edward Islands Management Plan Working Group 1996), probably as result of global warming.

2.4 Marion Island beach descriptions

A grid based on fractions of degrees (30 seconds intervals) of latitude and longitude was superimposed on the map of Marion Island, each of the grid blocks being 0.67 km^2 in area. The description of beaches and status of elephant seals and includes the site code, beach name and grid block location:

MM001- TRANSVAAL COVE

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LOCATION: I34.

DESCRIPTION: Three separate areas:

1. Boulder Beach: the long boulder beach below Base, extending to just south of Paddy Rocks (the rock platform towards the southern end of the beach).
2. Gentoo Lake: The large lake behind the beach.
3. Southern Beaches: A few tiny beaches, partially hidden below low overhanging cliffs between Base and Marker Point.

ELEPHANT SEALS: Rest and moult on Boulder Beach, in and around Gentoo Lake, and on the vegetation to the south. Seals occasionally rest on the southern beaches.

MM002-TRYPOT COVE

LOCATION: J35.

DESCRIPTION: Five separate areas:

1. Trypot Beach: The rock rubble/pebble beach with the two tongues of vegetated rock extending out onto it, and the sealer's trypot on its main section.
2. Trypot North: Two very small boulder beaches at the heads of the two small gullies immediately to the north of Trypot Beach.
3. North Beaches: A few tiny beaches between Trypot North and Cormorant Pinnacle.
4. Trypot South: The first three tiny boulder beaches south of Trypot Beach. The first two give access directly to Trypot Wallow (the vegetated area immediately to the south of Trypot Beach), while the third, among the black lava on the southern headland of the cove, leads up to hummocky *Cotula* rises.
5. Southern Beaches: A few tiny beaches along the coast between Trypot Cove and The Fault.

ELEPHANT SEALS: Important breeding site on Trypot Beach. Major moulting site in Trypot Wallows and in and around the gulley entering on its south side. A few seals also moult and rest on Trypot North Beaches, and on Trypot South and Southern Beaches.

MM003- MACARONI BAY-NORTH

LOCATION: K35-K36.

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DESCRIPTION: Three large rock platforms jutting out from the base of steep grassy cliffs, and a long beach between the southernmost of the rock platforms and Macaroni Waterfall (the waterfall at the mouth of the river that drains the lakes and mires above the bay).

ELEPHANT SEALS: A few breed, moult or rest on the beach and occasionally on the rock platforms.

MM004- MACARONI BAY-SOUTH BEACH

LOCATION: K36

DESCRIPTION: A long, predominantly boulder and pebble beach at the base of steep grassy and crumbly cliffs.

ELEPHANT SEALS: Breed, moult and rest on the beach.

MM005- MACARONI ROCKS BEACH

LOCATION: K36

DESCRIPTION: A very long, boulder and rockfall beach at the base of steep crumbly cliffs, mostly vegetated with grass. A group of rock stacks (Macaroni Rocks) lie off the southern point of Macaroni Bay.

ELEPHANT SEALS: A few moult and rest on the beach.

MM006- ARCHWAY BAY - ARCHWAY BEACH

LOCATION: K37.

DESCRIPTION: A rock fall and boulder beach divided in two by a vegetated (*Cotula*) black lava outcrop. A number of sloping and vegetated cliffs of various heights surround the beach, the highest being a *Blechnum* slope behind the middle of the beach.

ELEPHANT SEALS: A few moult and rest on the beach.

MM007- ARCHWAY BAY - MAIN AND SOUTHERN BEACHES

LOCATION: K38.

DESCRIPTION: Several distinct sections:

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1. Main Beach: a very long wide rock rubble beach with a king penguin breeding colony on it.
2. A long stretch of boulder beach to the southeast of the main beach.
3. A very small rock rubble beach next to the cliffs of East Cape.
4. A long narrow stretch of boulder beach immediately to the northwest of the main beach.
5. A tiny rock rubble beach in a small gulley to the northwest of section 4. (above), and separated from it by a black lava headland.

ELEPHANT SEALS: Main breeding site on the main beach. Major moulting site on the beach and vegetation southeast of main beach (2).

MM008- EAST CAPE BEACHES

LOCATION: K38-M38.

DESCRIPTION: The coast can be divided into two sections:

1. A number of tiny, inaccessible beaches at the bases of the vertical cliffs around the vegetated black lava plateau of East Cape proper.
2. A series of very small coves and beaches between the flat miry black lava plateau of East Cape and Hansen Point. The beaches are surrounded by high sloping rocky cliffs with low undulating hillocks behind.

ELEPHANT SEALS: A few moult and rest on these beaches.

MM009- HANSEN POINT

LOCATION: M38.

DESCRIPTION: A very tiny pebble beach (the river virtually flows straight into the sea) surrounded by the branched river delta and an area of *Cotula*, grasses and grey lava boulders.

ELEPHANT SEALS: Important resting and moulting site in vegetation around delta and well up the river.

MM010- TINY BEACH

LOCATION: N37.

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DESCRIPTION: A tiny boulder beach with a small waterfall at its rear.
ELEPHANT SEALS: Occasionally a few resting.

MM011- BULLARD BAY - NORTH BEACHES

LOCATION: N36.

DESCRIPTION: Three separate beaches: the main beach is a short but very wide rock rubble and boulder beach with a river running across it. A 5 m waterfall with a pool at its base marks the rear of the beach and a trypot sits on the beach's south side. Immediately to the north of the main beach is a small boulder beach and north of that an even smaller rock fall beach. Its three beaches are separated by small rock falls.

ELEPHANT SEALS: Breed, moult and rest on the main beach, right back to the waterfall. A few moult and rest on the middle beach.

MM012- BULLARD BAY- SOUTH BEACH

LOCATION: O36.

DESCRIPTION: Two distinct areas:

1. The short but very wide pebble beach, which forms the mouth of the broad, shallow rivers.
2. The large, grey lava rock platform immediately to the south of the river mouth.

ELEPHANT SEALS: Breed, moult, and rest on the beach. Moult and rest up to 0,5 km up river, on northern section of rock platform, and on the grassy slopes behind it.

MM013- KILLER WHALE COVE

LOCATION: P36.

DESCRIPTION: A short but very wide boulder and rock rubble beach in the mouth of the river. The beach gradually merges with the steep sided, flat-bottomed river valley, becoming narrower and grassier with distance from the sea. The cove, just an extension of the river valley, is rectangular in shape, though the southern headland is considerably longer than the northern one.

ELEPHANT SEALS: A number breed, moult and rest on the beach and well up the river (>0,5 km).

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MM014- WATERFALL BEACH

LOCATION: P35.

DESCRIPTION: A small rock rubble and rock fall beach surrounded by steep cliffs, vegetated where the slope allows. Soft Plume River falls onto the southern margin of the beach, between a small rock platform and a sea cave at the base of the cliff. A second, smaller stream falls onto a ledge just above the centre of the beach.

ELEPHANT SEALS: A few breed and rest on the beach.

MM015- LANDFALL BEACH

LOCATION: Q35.

DESCRIPTION: Two beaches, separated by the river mouth: -

1. Main beach. A long, straight, rock rubble and boulder beach on the northern side of the river, bounded by a low, slopping, grassy cliff behind.
2. South of the river mouth and just beyond a very small headland, a long rock fall and boulder beach with vertical, grassy, basalt cliffs behind.

ELEPHANT SEALS: Breed, rest, and moult o the main beach and well up the river (>0,5 km).

MM016- SEALER'S CAVE

LOCATION: Q35.

DESCRIPTION: A long curved beach on the western shore of the cove. It is a boulder beach at its northern end and rock rubble toward the south. A large rock platform with many pools lies at about the middle of the beach and two others occur on the cove's southern shore. High, grassy, basalt cliffs surround the whole cove and the sealer's cave is in the most south-western corner of the cliffs.

ELEPHANT SEALS: Significant breeding, moulting, and resting beach.

MM017- SEALER`S CAVE TO WHALE-BIRD POINT.

LOCATION: Q35-R35

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DESCRIPTION: A short stretch of coastline with a number of small beaches and rock platforms along it.

ELEPHANT SEALS: Occasional resting and moulting seals.

MM018- FUNK BAY

LOCATION: R35-S34.

DESCRIPTION: A long stretch of coastline comprising one very long beach (toward the southern end of the bay) and numerous smaller ones. South of the main beach the smaller beaches are separated from each other by small points, rock falls, and outcrops. North of the main beach the small beaches are interspersed with stretches of sea cliffs.

ELEPHANT SEALS: Breed and rest on the main beach. Moult on the vegetated areas upstream of the river.

MM019-KILDALKEY POINT

LOCATION: S33/34.

DESCRIPTION: Several small boulder/rock fall beaches separated by small points (the most northerly beach has pebble and rock rubble areas also). Each beach is surrounded by high, crumbly cliffs.

ELEPHANT SEALS: A few breed, moult and rest on the beaches and in the tidal pools on the points.

MM020- KILDALKEY BAY

LOCATION: S33–T33.

DESCRIPTION: The main beach is a very large, unbroken, sweeping beach, rock rubble on its northern side and boulders on the south. Immediately to the south, but still within Kildalkey Bay, are two tiny rock rubble beaches.

ELEPHANT SEALS: Major breeding site on the main beach. Major moulting area on vegetation south of the main beach and at the base of Green Hill. Moulting and resting seals on main and tiny beaches also.

MM025- WATERTUNNEL STREAM

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LOCATION: S21.

DESCRIPTION: A series of very small to tiny beaches extending from the mouth of the stream running down the eastern side of Santa Rosa Valley (Sphinx Creek) around to, and including, the most north-western corner of Crawford Bay.

ELEPHANT SEALS: Major breeding, moulting and resting site on beaches, in creek, and all over nearby vegetation.

MM026- GOODHOPE BAY – EAST BEACHES

LOCATION: S/T15.

DESCRIPTION: A very course sandy beach, surrounded by rock falls under the escarpment and boulders elsewhere.

ELEPHANT SEALS: Major breeding, moulting and resting site.

MM027- GOODHOPE BAY – WEST BEACHES

LOCATION: S/T13/14.

DESCRIPTION A number of beaches at the base of the escarpment on the western side of Goodhope Bay and on the eastern side of the Rook's Peninsula (the large peninsula between Goodhope Bay and Rook's Bay).

ELEPHANT SEALS: A few breed, moult and rest on the peninsula beaches and surrounding vegetation.

MM051- STORM PETREL BAY AND COVE

LOCATION: C20–C21.

DESCRIPTION: A large bay with high, vegetated cliffs along it's south western shore and a flat *Cotula* plain, separated from the sea by a margin of rugged, bare, black lava, on it's south eastern side. Storm Petrel Cove is on the eastern side of the *Cotula* plain.

There are three beaches: -

1. Main beach. A small rock rubble beach at the back of the cove surrounded by high, black lava cliffs with hummocky *Cotula* slopes rising above them.

2. Just to the west of the main beach, also in the cove. A tiny gulley leading to a *Cotula* hummock area and, west of that, the *Cotula* plain.

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3. The tiny pebble beach in the gulley at the mouth of Repetto's stream (the stream running down both sides of Repetto's hill) on the eastern side of Storm Petrel Bay.
ELEPHANT SEALS: Moult and rest on the all beaches and among the *Cotula* hummocks near beach 2.

MM052- STORM PETREL BAY TO GONEY BAY

LOCATION: C21–D24.
DESCRIPTION: A long stretch of coastline with few, small beaches along it. The most easterly of these, *Cotula* beach, at the mouth of the first stream west of Goney Bay and at the back of a small cove, is a very small sand/boulder beach that leads up to a boulder and *Cotula* moulting area.
ELEPHANT SEALS: A few moult and rest on *Cotula* beach and the nearby moulting are, rarely elsewhere.

MM053- GONEY BAY

LOCATION: D24/25.
DESCRIPTION: A rectangular bay with a large, vegetated rock stack dividing it into two, almost equal, halves. The beach area is also divided in half by a large, vegetated, ridge with several vegetated outcrops lying off it`s end and extending out into the bay toward the rock stack. The westerly beach is very wide and flat, the eastern one much narrower, with a low, sparsely vegetated rise behind it.
ELEPHANT SEALS: Important breeding, moulting and resting area. Seals moult on the vegetated areas around and behind the eastern beach.

MM054- GONEY BAY TO LOG BEACH COVE

LOCATION: D25
DESCRIPTION: A few very small beaches and rock fall stretches, including 'Toothpick Beach', a tiny beach in the gulley at the mouth of the first stream west of Log Beach Cove.
ELEPHANT SEALS: Occasionally rest and moult on Toothpick beach, rarely elsewhere.

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MM055- LOG BEACH COVE AND PRINSLOOMEER

LOCATION: D25, D26, & E25.

DESCRIPTION: Five distinct areas: -

1. Log Beach. The rock rubble/boulder beach in the southwestern corner of the cove, that slopes up to the vegetated plain north of Prinsloomeer. The sides of the beach, also vegetated, rise more steeply.
2. Prinsloomeer. The largest lake on the island due south of Log Beach.
3. Prinsloomeer River and mouth. The river that drains the lake into the cove, with the mouth being about 80 m east of Log Beach.
4. Feather Beach. The tiny, steep, rock rubble beach with many black lava intrusions into it, about 30 m east of Log Beach and near where large quantities of king penguin feathers accumulate on the black lava splash zone between the sea and the *Cotula* Hummocks.

ELEPHANT SEALS: Seals moult and rest on all beaches, around Prinsloomeer, and on vegetation through out the whole area.

MM056- KING PENGUIN BAY AND POINT

LOCATION: D26–D27.

DESCRIPTION: Three separate beaches: -

1.West Beach. The pebble/boulder beach on the western side of King Penguin point, with the *Cotula* covered, black lava ridge on its eastern side. It is the first beach east of Prinsloomeer mouth that provides a direct access from the sea to the king penguin colony.

2. Middle Beach. Another pebble/boulder beach, also on King Penguin Point, and only separated from West Beach by the *Cotula* covered, black lava ridge.

3. Long Beach. The very long pebble /boulder beach running right along the southern shore of King Penguin Bay, with two putrid lakes behind. The tiny rock rubble beach in the south-eastern corner of King Penguin Bay marks the edge of this beach.

ELEPHANT SEALS. Breed, moult and rest on all the beaches. Seals also moult on the islands and vegetation in and around the lakes behind Long Beach.

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MM057- KING PENGUIN BAY TO SEA ELEPHANT BAY

LOCATION: D27.

DESCRIPTION: A number of very small to tiny beaches, interspersed by small, rugged, black lava headlands. Includes the tiny rock rubble beach in the south-western corner of King Penguin Bay and the most northerly beach on the north-western shore of Sea Elephant Bay.

ELEPHANT SEALS: Rest and moult on the beaches and surrounding vegetation.

MM058- SEA ELEPHANT BAY – PINNACLE BEACH

LOCATION: D/E27.

DESCRIPTION: A long beach with many upright rock outcrops on its southern end, which give the beach its name.

ELEPHANT SEALS: Important breeding, moulting, and resting beach. Seals also moult on the vegetation above the southern end of the beach.

MM059- SEA ELEPHANT BAY – SOUTH BEACHES

LOCATION: E 28.

DESCRIPTION: A number of mostly tiny beaches along the southern shore of Sea Elephant Bay. The main beach is a small rock rubble and boulder beach near the cave at the foot of Long Ridge.

ELEPHANT SEALS: A few moult and rest on the beaches and nearby vegetation.

MM060- BLUE PETREL BAY

LOCATION: E28.

DESCRIPTION: A large beach with rock outcrops and rock platforms on both sides of it. On the west side these enclose a lagoon, or the extreme western side of which is another tiny beach. West of that, over a small headland, is a second tiny beach.

ELEPHANT SEALS: Breed, moult, and rest on the main beach. Occasionally moult and rest on the first tiny beach to the west (at the end of the lagoon).

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MM061- BLUE PETREL BAY TO SEALER'S BEACHES

LOCATION: E29.

DESCRIPTION: A number of small to tiny beaches, along the base of Long Ridge East and at the base of the black lava cliffs along the coast of Fairy Prion Valley.

ELEPHANT SEALS: Occasionally haul out to moult or rest.

MM062- SEALER`S BEACHES

LOCATION: E30.

DESCRIPTION: Two beaches, separated by a group of *Cotula* covered rock outcrops.

1. West Beach: A rock rubble/boulder beach, with a few outcrops toward its eastern side that leads up to a *Cotula* rise behind.
2. East beach: A large, flat, rock rubble/pebble beach with breeding king penguins on it.

BOUNDARIES: To the west: - See 061-062.

To the east: - The eastern side of East Beach.

ELEPHANT SEALS: Breed on East Beach. Moult and rest on both beaches, among the outcrops between the two, and on the vegetation east of East Beach and behind west Beach.

MM063- SEALER'S SOUTH

LOCATION: E30.

DESCRIPTION: A small rock rubble and pebble beach with many small rock outcrops on it. Rock falls occur on sides of the beach and *Cotula* slopes surround it to the rear. A very large, submerged reef lies just offshore and extends well out to sea.

ELEPHANT SEALS: A small number breed, moult, and rest on the beach. Moulting seals also climb up the steep, vegetated gulley at the rear of the beach to the vegetation behind.

MM064- SEALER'S SOUTH TO SHIP`S COVE

LOCATION: E30–F32.

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DESCRIPTION: Several mostly small beaches, usually at the base of steep *Cotula* or basalt cliffs.

ELEPHANT SEALS: A few rest and moult on many of the beaches.

MM065- SHIP'S COVE

LOCATION: F32.

DESCRIPTION: A large cove, surrounded by very high, grassy cliffs, except for a short break on the northwestern side. Dragon rock, a high, long, narrow rock stack, forms the northern side of the cove. A very long, flat, sandy beach lines the innermost shore of the cove. On the southern shore is a steep, narrow, rock fall beach and north of the sandy beach is a long, narrow, boulder beach. Another very small boulder beach on the northwestern side of the cove leads up to a vegetated moulting area in the break in the cliffs.

ELEPHANT SEALS: Major breeding site on the sandy beach. Seals moult and rest on all beaches, except the southern rock fall beach, and many also moult on the vegetation in the break in the cliffs.

MM066- SHIP'S COVE TO DUIKER'S POINT

LOCATION: F32–G34.

DESCRIPTION: Two distinct stretches of coast:-

1. Around King Bird Head (Ship's Cove to Skua Ridge). Several small to tiny beaches, mostly hidden by overhangs of very high, basalt cliffs. Two beaches, each in its own small cove, are visible from above, one just south of Ship's Cove and the other just north of Skua ridge.
2. Skua Ridge to Duiker's point. A series of small to tiny beaches, interspersed with black lava headlands.

ELEPHANT SEALS: A few moult and rest on some of the beaches.

MM067- DUIKER'S POINT TO AND INCLUDING VAN DEN BOOGAARD BEACH

LOCATION: G34–H33.

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DESCRIPTION: Two distinct sections of coastline.

1. Duiker's Point Peninsula. A number of very small and tiny beaches between Duiker's Point and Van den Boogaard River.
2. Van den Boogaard Beach. The long, narrow, irregular beach on either side of Van den Boogaard River.

ELEPHANT SEALS: A few breed on Van den Boogaard Beach and several rest and moult on the beach and nearby vegetation. A few rest and moult on Duiker's Point Peninsula beaches and nearby vegetation.

MM068- VAN DEN BOOGAARD BEACH TO BASE INCLUDING ROCKHOPPER BAY.

LOCATION: H33–I34.

DESCRIPTION: A few very small and tiny beaches and a couple of grey lava rock platforms. The main beach is at the mouth of Prion Valley.

ELEPHANT SEALS: A few moult and rest on Prion Valley Beach, rarely elsewhere.

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CHAPTER 4 THE PATTERN OF TERRESTRIAL HABITAT SELECTION BY SOUTHERN ELEPHANT SEALS

4.1 Introduction

Information on habit use is of crucial importance for population control, habitat management and conservation of both the species and the habitat (Babaasa 2000). The habitat of an animal varies with season and age of the animal (Callot 1978) and animals of different age groups might be found using different habitat during different seasons. For example, harbour seals (*Phoca vitulina*) are known to switch haulout sites in order to move closer to alternative foraging sites (Thompson *et al.* 2001) and also show some intraspecific variation in foraging range. The foraging range correlates with body size, with larger animals travelling further away from haulout sites (Thompson *et al.* 2001). Local availability of food therefore does not necessarily affect where the larger animals haul out, unlike in smaller animals that have lesser diving and foraging abilities. Nevertheless, harbour seals prefer haulout sites sheltered from the wind and waves (Bjorge *et al.* 2002). On the other hand, breeding colonies of the Subantarctic fur seal (*Arctocephalus tropicalis)* occur on all accessible habitat types at Gough Island as long as they have protection from high seas (windward coasts) and high environmental temperatures and solar radiation (leeward coasts) (Bester 1982a,b). Such information on terrestrial habitat requirements of seals would allow conservation authorities to identify potential areas of conflict between humans and the seal populations (Bradshaw *et al.* 2001).

For southern elephant seals, Hofmeyr (2000) suggested that different age and sex classes prefer certain sites to others during the different haulouts (Condy 1979) at Marion Island. Elephant seals hauling out to moult and for the winter may be seeking sites on the basis of characteristics that are not important for breeding seals (Hofmeyr 2000).

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Van Aarde (1980) distinguished four breeding area types (beach substrates) for southern elephant seals at Iles Kerguelen as (in decreasing order of preference) sandy, pebble and cobble beaches and vegetated humps. Low profile boulder beaches are also utilized (Bester 1980; Condy 1979). Beach substrate also relates to the social status of the bulls that haul out, with more experienced beachmasters hauling out on the more favoured sites (van Aarde 1980), which in turn influence the harem size because cows apparently choose sites with mature bulls for protection against harassment by immature bulls (Galimberti *et al.* 1999).

Investigating dispersion and dispersal of southern elephant seals at Macquarie Island, Nichols (1970) found that some beaches and tussock grass areas were frequented more than others while at the same time other areas were almost devoid of seals. The seals showed a tendency of dispersing away from their birthsite for the moult because of lack of vegetation on most of the breeding colony beaches (Nichols 1970) while at Marion Island they show some degree of site fidelity during the moult haulout because most beaches have associated vegetated areas (Hofmeyr 2000). At Marion Island moulting elephant seals prefer vegetated areas with smooth and gently sloping access areas (Panagis 1984; Bester 1979) while wintering juveniles apparently only need an accessible beach with suitable topography (Bester & van Niekerk 1984).

In this Chapter I attempt to quantitatively demonstrate that the well established assumption that elephant seals prefer certain sites to others during the various haulouts are indeed true/false. Further, I wish to determine if animals use different sites for the different haulouts and whether the pattern of site use is the same for different age and sex groups.

4.2 METHODS

For each age class and particular haulout, frequencies of individual records for each of the forty sites in the study area were calculated using the SAS 8.2 statistical package. To test for statistical significance in site preference, and for difference between male and

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female site choice, the standardized Log-Linear Coefficient (z), was computed for each site from the frequency of records for that site. The Log-Linear Coefficient (z) is significant outside /z/ = 2.58. Where the Log-Linear coefficient was $z \geq 2.58$, the site was preferred, and where $z \leq -2.58$, the site was discriminated against. Where the z score was $z \geq 2.58$ for males and $z \leq -2.58$ for females and vice versa, then there is a difference between males and females in the use of the site, with a positive value indicating increased usage of the site over the others (Agresti 1990). In the Tables 4.1 to 4.7. (below) are results of the Log-Linear model applied to the contingency table for beach and sex for all the age groups and all the haulouts. The numbers in brackets are the /z/-score, the standardized estimated Log-Linear coefficients, and are significant if /z/≥2.58.

4.3 RESULTS

(a) Underyearlings.

During the winter haulout, underyearling elephant seals showed preference for seventeen sites scattered all over the main study area and discriminated against seven sites (Table 4.1). There was no significant difference in site preference between male and female underyearlings during the winter haulout (P = 0.91) and between the numbers of males and females used in this sample (M = -2.418, F = 2.418, P = 0.64).

(b) Yearlings

During the moult haulout, yearling elephant seals showed some selection of sites, with eighteen sites being preferred and twelve being disfavoured ($P < 0.0001$) (Table 4.2). There was no significant difference in site preference between male and female yearlings during the moult haulout (P = 0.97) but a significant difference between the numbers of males and females used in this sample (M = -3.308, F = 3.308). The yearlings preferred nineteen sites during the winter haulout while eight sites were disfavoured ($P < 0.0001$) (Table 4.3). Males and females preferred the same sites during the winter haulout (P =

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0.49), with a significant difference between the numbers of males and females during the winter with more females than males (M = -3.051, F = 3.051) at P = 0.02).

(c) Subadults

During the moult haulout, subadult elephant seals preferred twenty-three sites and ten others were selected against (P < 0.0001) (Table 4.4). There was a significant difference in site preference between male and female subadults during the moult haulout, with males showing interest in two sites for which females showed no interest (P = 0.0080). There was no significant difference between the numbers of subadult males and females in this sample (M = 1.272, F = -1.272) at P = 0.0003. Eighteen sites were favoured and ten sites selected against during the winter haulout by subadult elephant seals (P < 0.0001) (Table 4.5), but no difference in site preference between male and female subadults during the winter haulout (P = 0.44). There was a significant difference between the numbers of males and females in this sample with more males than females (M = 11.872, F = -11.872) (P<0.0001)

(d) Adults

During the breeding haulout, adult elephant seals showed preference for certain sites over others, with sixteen sites being favoured and twelve being selected against (P<0.0001) (Table 4.6). There was a significant difference in site preference between male and female adults during the breeding season haulout, with females showing interest for seven sites that males showed no preference for (P<0.0001). There was a significant difference between the numbers of males and females used in this sample (M = -10.622, F = 10.622, P<0.0001). Fourteen sites were favoured versus five sites being avoided during the moult haulout by adult elephant seals (P < 0.0001) (Table 4.7). There was a significant difference in site preference between male and female adults during the moult haulout, with males showing interest for two sites that females showed no preference for (P < 0.0001). There was a significant difference between the numbers of males and females used in this sample (M = -16.431, F = 16.431) (P < 0.0001).

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Table 4.1 Selection (green) and avoidance (red) of beaches by underyearlings during the winter haulout.

Site	Sex				Total	
	Females n=1000		Male n=919		n=1919	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	31(-1.089)	3.06	34(1.089)	3.67	65(5.178)	3.35
MM002	48(-1.451)	4.78	54(1.451)	5.87	102(10.604)	5.30
MM003	10(0.061)	0.97	8(-0.061)	0.84	18(-2.621)	0.90
MM004	43(0.206)	4.30	34(-0.206)	3.71	77(6.929)	4.02
MM006	13(0.644)	1.31	8(-0.644)	0.87	21(-2.178)	1.10
MM007	37(-0.036)	3.71	31(0.036)	3.33	68(5.607)	3.53
MM008	2(0.324)	0.15	1(-0.324)	0.05	3(-4.324)	0.10
MM009	23(0.896)	2.31	14(-0.896)	1.49	37(0.432)	1.92
MM010	18(0.572)	1.85	12(-0.572)	1.36	30(-0.667)	1.62
MM011	63(0.035)	6.30	52(-0.035)	5.69	115(12.31)	6.01
MM012	21(1.215)	2.09	11(-1.215)	1.23	32(-0.484)	1.68
MM013	22(-1.199)	2.21	26(1.199)	2.81	48(2.431)	2.50
MM014	17(1.219)	1.80	9(-1.219)	0.96	26(-1.306)	1.40
MM015	41(-1.026)	4.08	43(1.026)	4.64	84(8.063)	4.35
MM016	20(-0.585)	2.02	20(0.585)	2.14	40(1.129)	2.08
MM017	5(0.810)	0.50	2(-0.810)	0.18	7(-4.102)	0.35
MM018	66(-1.640)	6.64	74(1.640)	8.01	140(15.58)	7.29
MM019	11(0.018)	1.07	9(-0.018)	1.00	20(-2.288)	1.03
MM020	43(-1.445)	4.32	49(1.445)	5.32	92(9.191)	4.80
MM025	35(-0.273)	3.60	32(0.273)	3.54	67(5.635)	3.57
MM026	12(0.214)	1.17	9(-0.214)	0.93	21(-2.134)	1.05
MM027	1(-0.574)	0.05	0(0.574)	0.00	1(-3.749)	0.03
MM051	10(-0.862)	1.01	12(0.862)	1.25	22(-1.951)	1.13
MM052	4(-0.280)	0.38	4(0.280)	0.47	8(-4.095)	0.43
MM053	45(-0.841)	4.52	45(0.841)	4.87	90(8.94)	4.68
MM054	6(1.059)	0.61	2(-1.059)	0.20	8(-3.975)	0.41
MM055	14(-1.219)	1.41	18(1.219)	1.95	32(-0.271)	1.67
MM056	54(1.098)	5.36	35(-1.098)	3.85	89(8.417)	4.64
MM057	10(-1.789)	0.99	17(1.789)	1.82	27(-1.22)	1.39
MM058	30(-1.447)	3.04	36(1.447)	3.90	66(5.295)	3.45
MM059	13(-0.677)	1.28	14(0.677)	1.55	27(-1.089)	1.41
MM060	13(-1.050)	1.31	16(1.050)	1.76	9(-0.768)	1.52
MM061	5(0.028)	0.50	4(-0.028)	0.47	63(-3.97)	0.49
MM062	31(-0.724)	3.20	32(0.724)	3.53	49(5.034)	3.36
MM063	26(-0.221)	2.64	23(0.221)	2.49	49(2.610)	2.57
MM064	34(-0.744)	3.42	34(0.744)	3.73	68(5.657)	3.57
MM065	48(0.445)	4.82	36(-0.445)	3.95	84(7.907)	4.40
MM066	13(0.898)	1.26	7(-0.898)	0.80	20(-2.3740	1.04
MM067	48(-0.343)	4.81	43(0.343)	4.73	91(9.058)	4.77
MM068	12(-0.214)	1.18	9(0.214)	1.03	21(-2.134)	1.11
Total	1000(-2.418)	100.03	919(2.418)	99.99		
Total					1919	100.02

Significance of Factors	
Factor	P-value
Sex	0.6400
Beach	<0.0001
Sex and Beach	0.9065

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Fig 4.2 Selection (green) and avoidance (red) of beaches by yearlings during the moult haulout.

Sites	Sex				Total	
	Females n=1690		Males n=1510		n=3200	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	46(-0.046)	2.75	39(0.046)	2.59	85(3.300)	2.68
MM002	84(0.662)	4.95	63(-0.662)	4.21	147(10.516)	4.60
MM003	33(0.095)	1.93	27(-0.095)	1.76	60(0.105)	1.85
MM004	65(-0.701)	3.85	62(0.700)	4.13	127(8.431)	3.98
MM006	19(-0.8750	1.10	21(0.875)	1.42	40(-2.458)	1.25
MM007	73(-1.353)	4.34	77(1.353)	5.10	150(11.064)	4.70
MM008	7(0.249)	0.39	5(-0.249)	0.33	12(-5.602)	0.36
MM009	33(-0.836)	1.93	34(0.836)	2.28	67(1.048)	2.09
MM010	25(0.154)	1.48	20(-0.154)	1.34	45(-1.837)	1.41
MM011	87(0.092)	5.15	72(-0.092)	4.80	159(11.974)	4.98
MM012	15(0.327)	0.88	11(-0.328)	0.74	26(-4.219)	0.81
MM013	42(-0.906)	2.47	43(0.906)	2.88	85(3.340)	2.66
MM014	18(0.402)	1.08	13(-0.403)	0.86	31(-3.623)	0.97
MM015	97(0.359)	5.72	77(-0.359)	5.08	174(13.551)	5.42
MM016	36(-1.097)	2.13	39(1.097)	2.56	75(2.066)	2.34
MM017	6(0.324)	0.38	4(-0.324)	0.25	10(-5.705)	0.32
MM018	108(-0.806)	6.39	102(0.806)	6.75	210(17.474)	6.56
MM019	15(0.327)	0.88	11(-0.328)	0.74	26(-4.219)	0.81
MM020	69(-1.905)	4.07	80(1.905)	5.27	149(10.901)	4.64
MM025	64(-0.025)	3.78	54(0.025)	3.55	118(7.313)	3.67
MM026	51(-0.021)	3.04	43(0.020)	2.85	94(4.414)	2.95
MM027	8(1.806)	0.46	1(-1.806)	0.07	9(-4.918)	0.28
MM051	22(0.612)	1.28	15(-0.612)	1.01	37(-2.879)	1.15
MM052	16(-0.504)	0.95	16(0.504)	1.07	32(-3.472)	1.01
MM053	82(0.252)	4.84	66(-0.252)	4.35	148(10.722)	4.61
MM054	9(0.414)	0.56	6(-0.414)	0.41	15(-5.363)	0.49
MM055	28(-0.374)	1.64	26(0.374)	1.71	54(-0.640)	1.67
MM056	64(-1.490)	3.79	70(1.489)	4.61	134(9.230)	4.18
MM057	35(-0.605)	2.07	34(0.605)	2.25	69(1.305)	2.15
MM058	37(0.005)	2.20	31(-0.005)	2.07	68(1.142)	2.14
MM059	28(-1.191)	1.67	32(1.191)	2.12	60(0.127)	1.89
MM060	30(-0.679)	1.77	30(0.679)	1.96	60(0.144)	1.86
MM061	14(1.359)	0.83	6(-1.359)	0.40	20(-4.865)	0.63
MM062	41(-1.65)	2.44	49(1.650)	3.21	90(3.915)	2.80
MM063	47(0.654)	2.79	34(-0.654)	2.25	81(2.689)	2.54
MM064	61(-0.078)	3.60	52(-0.078)	3.47	113(6.726)	3.54
MM065	75(0.275)	4.41	60(0.275)	4.00	135(9.243)	4.22
MM066	19(-0.200)	1.13	17(-0.200)	1.11	36(-2.971)	1.12
MM067	77(0.242)	4.58	62(0.242)	4.08	139(9.707)	4.35
MM068	4(-0.901)	0.27	6(-0.901)	0.37	10(-5.705)	0.32
Total	1690(-3.308)	99.97	1510(3.308)	100.01		
Total					3200	100.00

Significance of factors	
Factor	P-value
Sex	0.0016
Beach	<0.0001
Sex and Beach	0.9669

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Table 4.3. Selection (green) and avoidance (red) of beaches by yearlings during the winter haulout.

Sites	Sex				Total	
	Females n=1050		Males n=944		n=1994	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	27(-1.019)	2.57	28(1.019)	2.97	55(3.327)	2.76
MM002	54(-0.702)	5.11	49(0.072)	5.14	103(10.342)	5.13
MM003	17(-0.693)	1.57	10(-0.693)	1.09	27(1.401)	1.35
MM004	40(-1.379)	3.84	43(1.379)	4.57	83(7.556)	4.19
MM006	9(-0.996)	0.89	11(0.996)	1.12	20(-2.449)	1.00
MM007	48(-2.444)	4.59	62(2.444)	6.60	110(11.146)	5.54
MM008	3(-1.155)	0.27	0(-1.155)	0.04	3(-3.523)	0.16
MM009	15(-0.279)	1.42	13(0.279)	1.42	28(-1.116)	1.42
MM010	24(1.043)	2.26	13(-1.043)	1.38	37(0.127)	1.84
MM011	49(-0.408)	4.68	42(0.043)	4.43	91(8.658)	4.56
MM012	11(-0.800)	1.09	12(0.800)	1.24	23(-1.946)	1.16
MM013	30(-0.654)	2.90	28(0.654)	3.02	58(3.795)	2.95
MM014	16(2.261)	1.51	3(-2.261)	0.37	19(-2.939)	0.97
MM015	41(-1.278)	3.93	43(1.278)	4.55	84(7.706)	4.22
MM016	28(-0.470)	2.67	25(0.470)	2.61	53(2.995)	2.64
MM017	4(0.014)	0.38	3(-0.014)	0.33	7(-4.293)	0.36
MM018	73(-0.858)	6.98	67(0.858)	7.13	140(15.083)	7.05
MM019	11(0.970)	1.08	5(-0.970)	0.55	16(-3.150)	0.83
MM020	50(-2.522)	4.78	65(2.522)	6.88	115(11.79)	5.77
MM025	31(-0.112)	2.91	25(0.112)	2.65	56(3.428)	2.79
MM026	18(-0.902)	1.69	19(0.902)	2.02	37(0.399)	1.85
MM027	1(0.538)	0.05	0(-0.538)	0.00	1(-3.794)	0.03
MM051	11(-0.356)	1.03	10(0.356)	1.04	21(-2.277)	1.03
MM052	14(-0.025)	1.30	11(0.025)	1.16	25(-1.633)	1.24
MM053	50(-0.952)	4.72	48(0.952)	5.08	98(9.677)	4.89
MM054	5(-0.066)	0.46	4(0.066)	0.40	9(-4.082)	0.43
MM055	14(-1.031)	1.32	16(1.031)	1.67	30(-0.780)	1.49
MM056	55(1.036)	5.26	34(-1.036)	3.65	89(7.973)	4.50
MM057	18(-0.375)	1.73	16(0.375)	1.67	34(-0.109)	1.70
MM058	34(-0.195)	3.28	28(0.195)	2.97	62(4.371)	3.13
MM059	20(1.350)	1.85	9(-1.350)	0.96	29(-1.245)	1.43
MM060	18(0.411)	1.69	12(-0.411)	1.28	30(-0.861)	1.49
MM061	7(0.459)	0.70	4(-0.459)	0.38	11(-3.818)	0.55
MM062	38(0.510)	3.61	26(-0.510)	2.79	64(4.525)	3.22
MM063	27(-1.912)	2.61	35(1.912)	3.70	62(4.330)	3.13
MM064	41(0.140)	3.90	31(-0.140)	3.27	72(5.820)	3.60
MM065	47(-0.369)	4.46	40(0.369)	4.19	87(8.089)	4.33
MM066	13(-0.204)	1.26	11(0.204)	1.17	24(-1.787)	1.21
MM067	33(-1.209)	3.16	35(1.209)	3.67	68(5.339)	3.40
MM068	5(-1.255)	0.50	8(1.255)	0.88	13(-3.548)	0.68
Total	1050(-3.051)	100.01	944(3.051)	100.04		
Total					1994	100.02

Significance of Factors	
Factor	P-value
Sex	0.0187
Beach	<0.0001
Sex and Beach	0.4894

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Table 4.4 Selection (green) and avoidance (red) of beaches by subadults during the moult haulout.

Sites	Sex				Total	
	Females n=3170		Males n=3465		n=6635	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	89(-2.109)	2.82	114(2.109)	3.30	203(8.784)	3.07
MM002	127(-1.568)	4.01	146(1.586)	4.22	273(14.755)	4.12
MM003	52(0.512)	1.65	44(-0.512)	1.28	96(-0.978)	1.45
MM004	116(-0.573)	3.66	118(0.573)	3.40	234(11.607)	3.52
MM006	16(-0.853)	0.51	20(0.853)	0.58	36(6.543)	0.55
MM007	188(-0.691)	5.92	191(0.691)	5.51	379(22.901)	5.71
MM008	5(0.188)	0.19	5(-0.188)	0.15	10(-7.728)	0.17
MM009	81(-0.534)	2.54	83(0.534)	2.40	164(5.464)	2.47
MM010	35(1.629)	1.11	21(-1.629)	0.59	56(-4.873)	0.84
MM011	120(-0.823)	3.78	126(0.823)	3.63	246(12.605)	3.70
MM012	29(-0.235)	0.93	29(0.235)	0.85	58(-4.598)	0.89
MM013	87(1.0638)	2.74	62(-1.064)	1.80	149(3.865)	2.25
MM014	15(2.006)	0.47	5(-2.006)	0.15	20(-7.222)	0.30
MM015	162(-1.234)	5.11	176(1.234)	5.07	338(19.856)	5.09
MM016	79(0.441)	2.51	69(-0.441)	1.99	148(3.957)	2.23
MM017	6(1.231)	0.18	2(-1.231)	0.07	8(-7.109)	0.12
MM018	202(-2.392)	6.38	244(2.392)	7.04	446(27.388)	6.72
MM019	25(0.699)	0.78	19(-0.699)	0.54	44(-5.881)	0.66
MM020	154(-3.164)	4.85	208(3.164)	6.01	362(21.272)	5.45
MM025	162(-1.133)	5.10	174(1.133)	5.02	336(19.713)	5.06
MM026	72(-2.183)	2.26	96(2.183)	2.77	168(5.647)	2.53
MM027	8(1.936)	0.24	1(-1.936)	0.01	9(-6.259)	0.12
MM051	42(-0.710)	1.34	46(0.710)	1.32	88(-1.730)	1.33
MM052	44(-0.808)	1.39	49(-0.808)	1.43	93(-1.250)	1.41
MM053	144(-1.150)	4.54	156(1.150)	4.49	300(16.945)	4.51
MM054	14(0.231)	0.43	12(-0.231)	0.34	26(-7.269)	0.38
MM055	66(-1.950)	2.07	86(1.950)	2.47	152(4.225)	2.28
MM056	154(-2.044)	4.86	184(2.044)	5.30	338(19.753)	5.09
MM057	66(-1.259)	2.10	77(1.259)	2.23	143(3.483)	2.17
MM058	60(-1.205)	1.89	70(1.205)	2.02	130(2.267)	1.95
MM059	52(-1.681)	1.63	67(1.681)	1.93	119(1.168)	1.79
MM060	73(-1.001)	2.32	81(1.001)	2.34	154(4.526)	2.33
MM061	6(0.188)	0.18	5(-0.188)	0.16	11(-7.728)	0.17
MM062	113(-2.358)	3.57	145(2.358)	4.20	258(13.396)	3.90
MM063	85(1.263)	2.68	97(-1.263)	2.79	182(7.049)	2.74
MM064	121(2.07)	3.82	84(-2.070)	2.42	205(8.765)	3.09
MM065	136(-3.583)	4.29	196(3.583)	5.66	332(18.888)	5.01
MM066	59(-0.048)	1.85	56(0.048)	1.61	115(0.876)	1.72
MM067	97(-0.199)	3.07	94(0.199)	2.71	191(0.890)	2.88
MM068	8(0.131)	0.25	7(-0.131)	0.20	15(-7.749)	0.22
Total	3170(-1.272)	100.02	3465(1.272)	100.00		
Total					6635	99.99

Significance of factors	
Factor	P-value
Sex	0.0003
Beach	0.0000
Sex and Beach	0.0080

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4.5 Selection (green) and avoidance (red) of beaches by subadults during the winter haulout.

Sites	Sex				Total	
	Females n=614		Males n=1576		n=2191	
	Freq(z)	%	Freq (z)	%	Freq (z)	%
MM001	18(-1.001)	3.09	57(1.001)	3.68	76(4.976)	3.07
MM002	20(-0.256)	3.28	50(0.256)	3.17	70(4.602)	4.12
MM003	7(-1.021)	1.30	12(1.021)	0.77	19(-2.411)	1.45
MM004	27(-0.831)	4.35	76(0.831)	4.80	103(8.461)	3.52
MM006	2(0.061)	0.33	5(-0.061)	0.29	7(-4.155)	0.55
MM007	28(-1.404)	4.58	89(1.404)	5.63	117(9.589)	5.71
MM008	1(0.320)	0.16	2(-0.320)	0.10	3(-4.363)	0.17
MM009	6(-1.322)	0.96	26(1.322)	1.63	32(-1.330)	2.47
MM010	12(0.824)	1.90	21(-0.824)	1.31	33(-0.368)	0.84
MM011	34(0.754)	5.51	67(-0.754)	4.26	101(9.405)	3.70
MM012	3(-0.437)	0.57	10(0.437)	0.65	13(-3.500)	0.89
MM013	15(0.821)	2.52	27(-0.821)	1.74	42(1.403)	2.25
MM014	5(1.409)	0.73	5(-1.409)	0.33	10(-3.910)	0.30
MM015	30(0.39)	5.04	66(-0.390)	4.19	96(8.655)	5.09
MM016	17(-0.103)	2.82	41(0.103)	2.57	58(3.015)	2.23
MM017	3(0.834)	0.51	4(-0.834)	0.23	7(-4.250)	0.12
MM018	37(-0.863)	5.97	102(0.863)	6.47	139(12.725)	6.72
MM019	3(-0.437)	0.41	10(0.437)	0.64	13(-3.500)	0.66
MM020	38(0.354)	6.21	82(-0.354)	5.18	120(11.536)	5.45
MM025	21(-1.81)	3.47	77(1.810)	4.91	98(6.839)	5.06
MM026	8(-1.154)	1.36	30(1.154)	1.89	38(-0.432)	2.53
MM027	2(0.953)	0.33	2(-0.953)	0.10	4(-4.449)	0.12
MM051	4(-1.008)	0.65	17(1.008)	1.06	21(-2.611)	1.33
MM052	8(-0.570)	1.27	24(0.570)	1.55	32(-0.977)	1.41
MM053	34(-0.521)	5.59	88(0.521)	5.59	122(11.065)	4.51
MM054	5(-0.546)	0.79	16(0.546)	1.02	21(-2.507)	0.38
MM055	10(-1.100)	1.69	35(1.100)	2.22	45(0.563)	2.28
MM056	31(-1.924)	4.99	108(1.924)	6.86	139(11.522)	5.09
MM057	9(0.166)	1.48	20(-0.166)	1.26	29(-1.163)	2.17
MM058	14(-1.781)	2.31	56(1.781)	3.57	70(3.332)	1.95
MM059	4(-0.908)	0.81	19(0.908)	1.20	23(-2.205)	1.79
MM060	11(0.828)	1.76	18(-0.828)	1.21	29(-0.843)	2.33
MM061	5(0.545)	0.85	9(-0.545)	0.56	14(-3.355)	0.17
MM062	21(-0.301)	3.39	53(0.301)	3.35	74(5.119)	3.90
MM063	16(-1.344)	2.67	55(1.344)	3.51	71(3.883)	2.74
MM064	24(-0.423)	3.88	62(0.423)	3.95	86(6.633)	3.09
MM065	23(-0.315)	3.71	58(0.315)	3.71	81(6.052)	5.01
MM066	12(1.791)	1.88	14(-1.791)	0.89	26(-1.370)	1.72
MM067	36(1.892)	5.79	55(-1.892)	3.50	91(8.618)	2.88
MM068	7(1.641)	1.10	7(-1.641)	0.45	14(-3.334)	0.22
Total	615(-11.872)	100.01	1576(11.872)	100.00		
Total					2191	99.99

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.4354

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Table 4.6 Selection (green) and avoidance (red) of beaches by adults during the breeding haulout.

Sites	Sex				Total	
	Females n=2327		Males n=316		n=2643	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	25(-0.650)	1.08	8(0.650)	2.54	33(2.245)	1.25
MM002	114(2.000)	4.91	16(-2.000)	5.05	130(10.728)	4.93
MM003	1(-2.303)	0.03	3(2.303)	0.87	4(-2.925)	0.13
MM004	93(2.026)	4.01	12(-2.026)	3.86	105(8.110)	3.99
MM006	2(0.162)	0.07	0(-0.162)	0.00	2(-2.799)	0.06
MM007	204(4.704)	8.78	11(-4.704)	3.61	215(10.238)	8.17
MM008	1(-0.166)	0.02	0(0.166)	0.06	1(-2.977)	0.03
MM009	11(-0.150)	0.52	3(0.150)	0.96	14(-1.139)	0.57
MM010	2(0.162)	0.08	0(-0.162)	0.03	2(-2.799)	0.07
MM011	117(3.101)	5.05	10(-3.101)	3.06	127(7.820)	4.81
MM012	38(2.133)	1.65	2(-2.113)	0.71	40(0.156)	1.53
MM013	28(0.945)	1.19	4(-0.945)	1.14	32(0.761)	1.18
MM014	1(-0.166)	0.05	0(0.166)	0.15	1(-2.977)	0.06
MM015	73(2.113)	3.14	8(-2.113)	2.49	81(5.248)	3.06
MM016	72(1.859)	3.10	9(-1.859)	2.79	81(5.749)	3.06
MM017	1(-0.166)	0.05	0(0.166)	0.00	1(-2.977)	0.05
MM018	180(3.313)	7.74	20(-3.113)	6.48	200(14.375)	7.59
MM019	3(-2.286)	0.12	4(2.286)	1.29	7(-2.419)	0.26
MM020	231(4.101)	9.92	20(-4.101)	6.39	251(15.4610	9.50
MM025	36(-0.589)	1.54	11(0.589)	3.42	47(4.450)	1.76
MM026	110(1.354)	4.71	18(-1.534)	5.59	128(11.421)	4.82
MM027	2(-1.547)	0.06	2(1.547)	0.54	4(-2.988)	0.12
MM051	3(-1.256)	0.11	2(1.256)	0.63	5(-2.810)	0.17
MM052	2(-1.547)	0.09	2(1.547)	0.62	4(-2.988)	0.16
MM053	196(1.244)	8.41	38(-1.244)	12.18	234(20.826)	8.86
MM054	2(-1.547)	0.10	2(1.547)	0.61	4(-2.988)	0.16
MM055	11(-0.763)	0.46	4(0.763)	1.32	15(-0.932)	0.56
MM056	197(2.450)	8.47	28(-2.450)	8.75	225(17.844)	8.50
MM057	9(-0.586)	0.37	3(0.586)	1.05	12(-1.544)	0.45
MM058	113(-3.162)	4.84	9(-3.162)	2.77	122(7.125)	4.59
MM059	12(-2.163)	0.52	8(2.163)	2.57	20(0.443)	0.76
MM060	70(1.127)	3.01	12(-1.127)	3.78	82(7.115)	3.11
MM061	1(-1.203)	0.04	1(1.203)	0.36	2(-3.226)	0.08
MM062	160(2.650)	6.87	20(-2.650)	6.33	180(13.858)	6.81
MM063	53(2.246)	2.30	4(-2.246)	1.16	57(2.056)	2.16
MM064	21(0.385)	0.89	4(-0.385)	1.26	25(0.205)	0.94
MM065	112(2.625)	4.81	12(-2.625)	3.75	124(8.761)	4.69
MM066	2(-1.547)	0.10	2(1.547)	0.65	4(-2.988)	0.16
MM067	17(-0.010)	0.74	4(0.010)	1.17	21(-0.1870	0.79
MM068	1(-0.166)	0.04	0(0.166)	0.03	1(-2.977)	0.04
Total	2327(10.622)	99.99	316(-10.622)	100.02		
Total					2643	99.99

Significance of factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	<0.0001

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Table 4.7 Selection (green) and avoidance (red) of beaches by adults during the moult haulout.

Sites	Sex				Total	
	Females n=2351		Males =325		n=2677	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	61(-2.190)	2.59	14(2.190)	4.32	75(5.727)	2.80
MM002	70(-4.282)	2.97	25(4.282)	7.75	95(9.589)	3.55
MM003	29(1.028)	1.25	1(-1.028)	0.30	30(-1.468)	1.14
MM004	47(0.861)	2.02	3(-0.861)	0.86	50(0.200)	1.88
MM006	11(0.711)	0.45	0(-0.711)	0.00	11(-2.301)	0.39
MM007	129(0.243)	5.49	16(0.243)	4.75	145(9.322)	5.40
MM009	56(0.440)	2.40	5(-0.440)	1.63	61(1.621)	2.30
MM010	12(0.772)	0.52	0(-0.772)	0.08	12(-2.245)	0.46
MM011	68(1.206)	2.88	4(-1.206)	1.30	72(1.482)	2.69
MM012	36(-0.072)	1.55	4(0.072)	1.37	40(0.196)	1.53
MM013	51(1.390)	2.15	2(-1.390)	0.46	53(-0.224)	1.94
MM014	3(-0.124)	0.11	0(0.124)	0.00	3(-3.003)	0.10
MM015	95(0.777)	4.02	8(-0.777)	2.52	103(4.559)	3.84
MM016	43(0.701)	1.82	3(-0.701)	0.76	46(0.041)	1.69
MM017	2(-0.343)	0.07	0(0.343)	0.00	2(-3.154)	0.07
MM018	212(0.291)	9.02	23(-0.291)	7.16	235(14.145)	8.80
MM019	11(-0.108)	0.45	1(0.108)	0.26	12(-2.517)	0.43
MM020	148(-1.672)	6.30	26(1.672)	7.87	174(13.479)	6.49
MM025	139(-3.392)	5.91	35(3.392)	10.82	174(15.618)	6.51
MM026	76(-2.265)	3.22	16(2.265)	5.18	92(7.603)	3.46
MM027	3(-0.124)	0.14	0(0.124)	0.00	3(-3.003)	0.12
MM051	39(1.608)	1.64	0(-1.608)	0.00	39(-1.449)	1.44
MM052	41(1.049)	1.73	2(-1.049)	0.56	43(-0.556)	1.59
MM053	123(-2.404)	5.24	26(2.404)	8.00	149(12.583)	5.58
MM054	9(-0.328)	0.40	1(0.328)	0.25	10(-2.708)	0.39
MM055	56(-2.165)	2.40	13(2.165)	3.99	69(5.069)	2.59
MM056	119(-1.376)	5.07	20(1.376)	6.13	139(10.506)	5.20
MM057	71(-0.901)	3.04	11(0.901)	3.50	82(5.093)	3.09
MM058	32(-1.985)	1.37	8(1.985)	2.33	40(1.558)	1.49
MM059	38(-1.519)	1.66	8(1.519)	2.48	46(2.083)	1.76
MM060	44(-0.085)	1.86	5(0.085)	1.65	49(1.084)	1.83
MM061	4(0.046)	0.15	0(-0.046)	0.05	4(-2.873)	0.14
MM062	91(-1.666)	3.85	16(1.666)	5.18	107(8.325)	4.01
MM063	59(0.916)	2.52	4(0.916)	1.15	63(1.190)	2.35
MM064	80(1.836)	3.41	3(-1.836)	1.00	83(1.166)	3.12
MM065	116(0.322)	4.94	12(-0.322)	3.64	128(7.180)	4.78
MM066	41(1.049)	1.75	2(-1.049)	0.63	43(-0.556)	1.61
MM067	75(1.089)	3.18	5(-1.089)	1.55	80(2.283)	2.98
MM068	11(-0.872)	0.46	2(0.872)	0.51	13(-2.374)	0.46
Total	2351(16.431)	100.00	325(-16.431)	99.99		
Total					2677	100.00

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	<0.0001

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4.4. Discussion

Hofmeyr (2000), suggested that young elephant seals (underyearlings and yearlings) hauling out for the winter and the moult do not seek sites on the same basis as adult animals hauling out to breed. All that young seals need is a beach that is accessible and flat (Hofmeyr 2000) but older animals (subadults and adults) are expected to be more selective because of previous haulout experience.

There is almost no overlap between preferred sites and non-preferred sites for the different haulouts. Only one site that appeared among the favoured sites appeared again among the non-preferred sites. About 50% of all the preferred sites were selected by all age groups and for all the haulouts, and about 50% of all non-preferred sites were discriminated against by all age groups and for all the haulouts. There is therefore a difference in site quality detectable to elephant seals intent on hauling out.

Young animals appeared to be more generalists, using almost all the preferred sites for all the haulouts. Preference becomes more apparent with age. For adults, there are sites that are used significantly more for breeding and significantly less for moulting (MM004, MM011, MM016 and MM058). Another two sites are only used for moulting by adults (MM057 & MM055).

Difference in site use between males and females was apparent in adult elephant seals only during the moulting season. Two sites (MM020 & MM065) were preferred significantly more by males than by females during the subadult moult. During the adult moulting season, again two sites (MM002 & MM025) were preferred significantly more by males than by females. By contrast, during the breeding season, seven sites were preferred significantly more by females than by males. This difference can be explained by the elephant seal's polygynous breeding system because the beaches where the difference in site selection was apparent were all main breeding beaches.

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It can be concluded that there is a differential site usage by southern elephant seals of different age and sex classes during the three different haulouts. This seems to depend on experience, and thus age and hence familiarity with the island haulout sites. Pistorius *et al.* (2002) suggested that animals participating in the winter haulout have higher natal site fidelity during all haulouts as opposed to those that do not.

The reason why some sites are not used for hauling out might be related to factors other than beach topography and substrate. For example, inshore obstacles below the low tide mark such as rocky platforms that are not readily observed from the shore and/or currents may hinder the hauling out of seals at some beaches that may seem favourable in all other respects. This is supported by the findings of Carrick *et al.* (1962) at Macquarie Island. These issues will be pursued in Chapter 7.

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Chapter 5 THE INFLUENCE OF POPULATION DENSITY ON SITE SELECTION

5.1 Introduction.

During the late 1800s and the early 1900s, elephant seals and fur seals at the Prince Edward Islands were exploited to near extermination by man for oil and pelts respectively (Condy 1977; Kerley 1987). The last ship to undertake sealing at the islands was the *Kildalkey* of the company Irving and Johnson of Cape Town in 1931 (Kerley 1987). Condy (1977) regarded this date as the start of the elephant seal population recovery, assuming that the population had not been disturbed since then.

Since recovery, fur seals (*Arctocephalus tropicalis* and *A. gazella)* mainly bred in large colonies on the western coast of Marion Island (Kerley 1987; Condy 1978), but more recently both species of fur seals extended their breeding colonies to the eastern coast as well (Hofmeyr *et al.* 1997) concomitant with the population increase. Currently there are more new small breeding colonies and fairly large non-breeding colonies all over the island (Hofmeyr *et al.* 1997). Campagna & Lewis (1992) found that elephant seals showed a tendency of redistribution as the population increased at the Falkland Islands. The opposite of this observation might be true as well, in a decreasing population, animals can become restricted to certain parts of the available habitat.

Populations of elephant seals have, at a number of sites in the southern ocean, until recently, experienced an unexplained decline since the 1950s (Barrat & Moungin 1978; Pascal 1986; Hindell & Burton 1987; Guinet *et al.* 1992). Included in these declining populations are those of the Prince Edward Islands (Condy 1977; Pistorius *et al.* 1999b). The Marion Island population declined by 4.9% per annum between 1974 and 1989, but the decline slowed to 1.9% per annum between 1983 and 1989 (Bester & Wilkinson 1994) and the population has apparently stabilized since about 1994 (Pistorius & Bester 2002; Pistorius *et al.* 2004).

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Sites used for breeding and moulting were distributed sparsely along the western and southern coast and densely along the eastern and northern coast during the early state of decline (1950s) until the 1970s (Condy 1977). During the later stages of population decline, most elephant seals activities were restricted to the southern, leeward eastern and northern coast, with the use of moulting sites having decreased by 13.9% from 1974 to 1984 (Panagis 1985).

This chapter aims at determining the possible influence of population density on haulout site preference by southern elephant seals at Marion Island. This will be attained by comparing the terrestrial site usage of elephant seals during the late stages of decline (1984 to 1994) and after stabilization (1995 to 2001).

5.2 Methods

The data collected was analyzed separately for the period of population decline (1983 – 1994) and the period after population stabilization (1995 – 2001) (Pistorius & Bester 2002). Analysis on terrestrial haulout site usage was identical for both the time periods.

For each age class and haulout type (period), frequencies and percentages of records for each of the forty sites in the study area were calculated using the SAS Version 8.2 statistical package. To test for statistical significance of site preference and possible difference between males and females, the standardized Log-Linear Coefficient (z), was computed for each site from the frequency of records for that site. Log-Linear Coefficient (z) is significant outside $/z/=2.58$. Where the Log-Linear coefficient z was ≥ 2.58, the site was preferred, and with $z \leq -2.58$, the site was discriminated against. Where the z score is $z \geq 2.58$ for males and $z \leq -2.58$ for females and vice versa, then there is a difference between males and females in the use of the site, with the one having a positive value using the site more than the other (Agresti 1990). In the Tables 5.1 to 5.14 are the results of the Log-Linear model applied to the contingency table for beach and sex for all the age groups and all the haulouts during the state of population decline and after population

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stabilization. The numbers in brackets are the /z/-score, the standardized estimated Log-Linear coefficients, and are significant if $/z/ \geq 2.58$

5.3 Results

5.3.1 Winter Haulout

During the winter haulout at the stage of population decrease, underyearling elephant seals favoured fifteen sites but did not show any significant discrimination against any sites (Table 5.1). The numbers of males and females used in this sample were not significantly different (M=-0.665, F=0.655 at P=0.0468) and there was not any significant difference in sites preferred between males and females. During the winter haulout after population stabilisation, underyearling elephant seals showed preference for sixteen sites and significant discrimination against six sites (Table 5.8). The numbers of males and females used in this sample were not different (P = 0.3731), and there was not any significant difference in site preference between males and females.

During the winter haulout at the stage of population decrease, site selection was not as pronounced as during the moult and there were no sites that were significantly discriminated against (Table 5.3). However, there were twelve sites that yearling elephant seals preferred. There was no significant difference in the numbers of males and females used in this sample (P = 0.3857) and sexes preferred similar sites. During the winter haulout after population stabilisation , seventeen sites were selected over five other sites (Table 5.10). There was a significant difference in the numbers of males and females used in this sample (P = 0.0189, M =-2.754; F = 2.754) and sexes significantly preferred similar sites.

The numbers of males and females taking part in the winter haulout of subadults were significantly different (P < 0.0001, M= 6.039, F= -6.039), but no significant difference in site preference between males and females (P = 0.7808) was detected. No sites were

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significantly selected against during the stage of population decrease (Table 5.5). The numbers of males and females used for the winter haulout of the subadults were significantly different after the population stabilisation (P < 0.0001, M= 9.394, F= 9.394) and without significant difference in site preference between sexes (P = 0.1889). There were fourteen sites that were significantly favoured and eight sites that were significantly selected against (Table 5.12).

5.3.2 Moult Haulout.

During the moult haulout at the stage of population decrease, yearling elephant seals preferred fifteen sites over nine other sites (Table 5.2). There was no significant difference in the numbers of males and females used in this sample (P = 0.0446, M= -1.623, F=1.623) and the different sexes sought similar sites. After population stabilisation, during the moult haulout, yearling elephant seals preferred seventeen sites and avoided six sites (Table 5.9). There was a significant difference in the numbers of males and females used in this sample (P = 0.0151, M=-2.774, F=2.774) and sexes significantly preferred similar sites.

Twenty sites were favoured over eleven other sites during the moult haulout of subadults during the stage of population decrease (P < 0.0001) (Table 5.4). The numbers of males and females used for this sample were not significantly different (P = 0.0193, M= 0.218, F= -0.218) and there was no significant difference in site preference between males and females (P = 0.3674). Twenty-one sites were favoured over ten other sites during the subadult moult haulout after population stabilisation (P < 0.0001) (Table 5.11). The numbers of males and females compared in this sample were not significantly different (P = 0.0048, M= -1.423, F= 1.432) and there was no significant difference in site preference between males and females (P = 0.0553).

During the moult haulout, no sites were discriminated against, but ten sites were favoured during the population decrease by adult southern elephant seals (Table 5.7). There was a significant difference between the numbers of males and female used in this sample (P <

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0.0001, M= -9.689, F= 9.689), but there was no significant difference in site preference between males and females. During the moult haulout fifteen sites were favoured and four sites were discriminated against after population stabilisation (Table 5.14). There was a significant difference between the numbers of males and females used in this sample (P < 0.0001, M= -14.311, F= 14.311), and one site was preferred significantly more by males than females.

5.3.3 Breeding haulout

Selection of sites during the breeding haulout of adult southern elephant seals was not pronounced during the population decrease, thirteen sites were significantly favoured (Table 5.6) but no sites were discriminated against. There was a significant difference between the numbers of males and females compared in this sample (P < 0.0001, M= -7.434, F= 7.434). Two sites (MM007 and MM065) were preferred significantly more by females than by males. During the breeding haulout of adult southern elephant seals, thirteen sites were significantly favoured and four sites were discriminated against (Table 5.13). There was a significant difference between the numbers of males and females used in this sample (P < 0.0001, M= -7.895; F= 7.895). Six sites were preferred significantly more by females than by males (P = 0.0002).

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Table 5.1. Site selection by underyearlings in the winter haulout during the population decline.

Site	Sex				Total	
	Females n=361		Males n=308		n=669	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	14(0.776)	3.97	9(-0.776)	3.04	23(3.392)	3.54
MM002	19(-0.109)_	5.22	18(0.109)	5.96	37(7.023)	5.56
MM003	1(-0.592)	0.28	2(0.592)	0.54	3(-2.116)	0.40
MM004	15(0.725)	4.25	10(-0.725)	3.20	25(3.930)	3.77
MM006	5(0.924)	1.39	2(-0.924)	0.65	7(-1.125)	1.05
MM007	17(1.924)	4.59	6(-1.924)	1.91	23(2.700)	3.36
MM008	0(-0.046)	0.00	0(0.046)	0.00	0(-2.486)	0.00
MM009	8(0.627)	2.17	4(-0.627)	1.63	12(0.679)	1.92
MM010	6(0.453)	1.57	4(-0.453)	1.47	10(-0.155)	1.52
MM011	19(0.389)	5.17	15(-0.389)	4.94	34(6.252)	5.06
MM012	7(1.041)	1.87	3(-1.041)	0.92	10(-0.315)	1.43
MM013	7(-0.183)	2.22	8(0.183)	2.63	15(1.645)	2.41
MM014	10(1.635)	2.72	2(-1.635)	0.98	12(0.216)	1.92
MM015	15(0.517)	4.25	11(-0.517)	3.50	26(4.250)	3.90
MM016	9(0.044)	2.40	7(-0.044)	2.61	16(1.919)	2.50
MM017	0(-0.460)	0.00	0(0.046)	0.11	0(-2.486)	0.05
MM018	27(0.084)	7.36	24(-0.084)	7.72	51(10.044)	7.53
MM019	2(-0.521)	0.65	3(0.521)	0.98	5(-1.591)	0.80
MM020	15(-0.326)	4.65	22(1.326)	7.03	37(6.826)	5.53
MM025	9(-0.193)	2.49	9(0.193)	2.77	18(2.208)	2.62
MM026	1(-0.976)	0.28	3(0.976)	0.81	4(-1.887)	0.52
MM027	0(-0.046)	0.00	0(0.046)	0.00	0(-2.486)	0.00
MM051	0(-1.568)	0.07	4(1.568)	1.14	4(-1.823)	0.56
MM052	1(-0.080)	0.28	1(0.080)	0.33	2(-2.346)	0.30
MM053	10(-1.787)	2.77	19(1.787)	6.06	29(4.662)	4.28
MM054	4(1.444)	1.13	0(-1.444)	0.00	4(-1.823)	0.61
MM055	2(-1.163)	0.60	5(1.163)	1.69	7(-1.125)	1.10
MM056	23(0.608)	6.28	17(-0.608)	5.39	40(7.577)	5.87
MM057	3(-1.321)	0.83	7(1.321)	2.28	10(-0.315)	1.50
MM058	15(-0.240)	4.11	15(0.240)	5.02	30(5.355)	4.53
MM059	4(-0.459)	1.20	4(0.459)	1.63	8(-0.413)	1.40
MM060	4(-0.747)	1.18	6(0.747)	1.85	10(-0.155)	1.48
MM061	2(-0.102)	0.42	2(0.102)	0.65	4(-1.857)	0.52
MM062	14(1.003)	3.74	8(-1.003)	2.61	22(3.037)	3.22
MM063	7(-0.879)	2.03	10(0.879)	3.15	17(1.845)	2.54
MM064	15(-0.412)	4.22	15(0.412)	5.21	30(5.596)	4.68
MM065	23(1.852)	6.26	10(-1.852)	3.20	33(5.273)	4.85
MM066	5(0.924)	1.48	2(-0.924)	0.65	7(-1.125)	1.10
MM067	21(0.672)	5.91	15(-0.672)	4.99	36(6.643)	5.49
MM068	2(-0.102)	0.42	2(0.102)	0.76	4(-1.857)	0.57
Total	361(0.665)	100.43	308(-0.665)	100.01		
Total					669	99.99

Significance of Factors	
Factor	P-value
Sex	0.0468
Beach	<0.0001
Sex and Beach	0.5199

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Table 5.2. Site selection by yearlings in the moult haulout during the population decline.

Site	Sex				Total	
	Females n=984		Males n=895		n=1879	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	22(-0.367)	2.27	22(0.367)	2.41	44(1.720)	2.34
MM002	48(0.214)	4.86	41(-0.214)	4.53	89(8.730)	4.70
MM003	18(-0.664)	1.80	20(0.664)	2.21	38(0.702)	2.00
MM004	41(-0.598)	4.21	42(0.598)	4.70	83(7.893)	4.44
MM006	14(-0.486)	1.45	15(0.486)	1.67	29(-0.825)	1.55
MM007	47(-0.721)	4.82	49(0.721)	5.50	96(9.796)	5.14
MM008	4(-0.168)	0.37	4(0.168)	0.46	8(-4.142)	0.41
MM009	21(0.129)	2.08	18(-0.129)	1.96	39(0.860)	2.02
MM010	12(-0.065)	1.19	11(0.065)	1.21	23(-1.846)	1.20
MM011	56(0.213)	5.67	48(-0.213)	5.38	104(10.88)	5.53
MM012	3(-1.121)	0.33	6(1.121)	0.70	9(-3.985)	0.51
MM013	21(-0.955)	2.13	25(0.995)	2.83	46(2.022)	2.46
MM014	8(-0.706)	0.80	10(0.706)	1.14	18(-2.688)	0.96
MM015	68(0.535)	6.92	55(-0.535)	6.12	123(13.416)	6.54
MM016	22(0.446)	2.22	17(-0.446)	1.89	39(0.824)	2.06
MM017	3(0.280)	0.30	2(-0.280)	0.19	5(-4.377)	0.25
MM018	64(-0.243)	6.51	60(0.243)	6.66	124(13.662)	6.58
MM019	5(-1.013)	0.56	8(1.013)	0.94	13(-3.476)	0.74
MM020	38(-2.116)	3.89	54(2.116)	6.02	92(8.958)	4.91
MM025	28(0.448)	2.85	21(-0.448)	2.44	49(2.648)	2.65
MM026	28(1.246)	2.89	17(-1.246)	1.90	45(1.641)	2.42
MM027	7(1.715)	0.66	1(-1.715)	0.11	8(-3.767)	0.40
MM051	9(-0.695)	0.93	11(0.695)	1.24	20(-2.358)	1.08
MM052	10(-0.476)	1.05	11(0.276)	1.25	21(-2.183)	1.15
MM053	47(0.802)	4.76	35(-0.802)	3.84	82(7.577)	4.32
MM054	6(0.429)	0.63	4(-0.429)	0.46	10(-3.887)	0.55
MM055	16(0.661)	1.60	11(-0.661)	1.28	27(-1.23)	1.45
MM056	35(-0.806)	3.58	38(0.806)	4.25	73(6.366)	3.90
MM057	24(0.391)	2.40	18(-0.391)	2.11	42(1.501)	2.26
MM058	18(0.983)	1.83	11(-0.983)	1.28	29(-0.950)	1.57
MM059	20(-0.189)	1.99	19(0.189)	2.17	39(0.878)	2.08
MM060	20(0.508)	2.01	15(-0.508)	1.68	35(0.142)	1.85
MM061	5(0.909)	0.55	2(-0.909)	0.18	7(-4.143)	0.37
MM062	27(-0.540)	2.76	28(0.54)	3.14	55(3.531)	2.94
MM063	31(0.818)	3.17	22(-0.818)	2.40	53(3.063)	2.80
MM064	32(-0.436)	3.22	32(0.436)	3.61	64(4.974)	3.40
MM065	44(0.043)	4.47	39(-0.043)	4.39	83(7.865)	4.43
MM066	11(-0.874)	1.08	14(0.874)	1.52	25(-1.529)	1.29
MM067	49(0.992)	5.00	35(-0.992)	3.94	84(7.8210	4.50
MM068	2(-0.551)	0.19	3(0.551)	0.29	5(-4.377)	0.23
Total	984(1.623)	100.00	895(-1.623)	100.00		
Total					1897	99.98

Significant of Factors	
Factor	P-value
Sex	0.0446
Beach	<0.0001
Sex and Beach	0.9652

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Table 5.3. Site selection by yearlings in the winter hauout during the population decline.

Site	Sex				Total	
	Females n=342		Males n=319		n=662	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	15(0.216)	4.27	12(-0.216)	3.06	27(4.351)	4.02
MM002	22(-0.266)	6.58	21(0.266)	6.61	43(8.18)	6.59
MM003	2(0.252)	0.88	2(-0.252)	0.70	4(-1.705)	0.79
MM004	14(0.463)	4.02	10(-0.463)	2.98	24(3.527)	3.51
MM006	3(-0.859)	0.95	5(0.859)	1.55	8(-0.891)	1.24
MM007	9(-1.638)	2.68	16(1.638)	4.98	25(3.581)	3.79
MM009	6(1.120)	1.75	2(-1.120)	0.73	8(-1.051)	1.26
MM010	2(-0.922)	0.54	4(0.922)	1.19	6(-1.465)	0.85
MM011	20(1.377)	5.77	10(-1.377)	3.24	30(4.627)	4.55
MM012	3(-0.859)	0.73	5(0.859)	1.68	8(-0.891)	1.19
MM013	6(-1.214)	1.61	10(1.214)	3.01	16(1.315)	2.29
MM014	5(1.289)	1.32	1(-1.289)	0.31	6(-1.601)	0.83
MM015	12(-1.055)	3.56	16(1.055)	4.83	28(4.567)	4.18
MM016	9(-0.721)	2.70	11(0.721)	3.34	20(2.538)	3.01
MM017	2(0.375)	0.58	1(-0.375)	0.31	3(-2.208)	0.45
MM018	22(-0.827)	6.42	25(0.827)	7.67	47(9.024)	7.03
MM019	3(0.252)	1.02	2(-0.252)	0.70	5(-1.705)	0.87
MM020	21(-1.704)	6.25	31(1.704)	9.66	52(9.827)	7.90
MM025	8(0.556)	2.31	5(-0.556)	1.60	13(0.515)	1.97
MM026	4(-0.197)	1.20	3(0.197)	1.24	7(-0.837)	1.22
MM051	3(0.252)	0.78	2(-0.252)	0.67	5(-1.705)	0.73
MM052	5(0.474)	1.51	3(-0.474)	0.94	8(-0.891)	1.23
MM053	18(0.310)	5.35	14(-0.310)	4.47	32(5.566)	4.93
MM054	4(0.587)	1.12	2(-0.587)	0.58	6(-1.465)	0.86
MM055	6(0.388)	1.66	4(-0.388)	1.39	10(-0.305)	1.53
MM056	21(0.926)	6.19	13(-0.956)	4.06	34(5.833)	5.16
MM057	6(-0.762)	1.68	8(0.762)	2.42	14(0.859)	2.04
MM058	10(0.173)	2.88	8(-0.173)	2.41	18(1.989)	2.65
MM059	8(1.534)	2.44	2(-1.534)	0.67	10(-0.710)	1.58
MM060	6(-0.762)	1.66	8(0.762)	2.54	14(0.859)	2.08
MM061	1(0.606)	0.15	0(-0.606)	0.00	1(-2.411)	0.08
MM062	11(0.625)	3.25	7(-0.625)	2.22	18(1.885)	2.75
MM063	9(-0.721)	2.75	11(0.721)	3.56	20(2.538)	3.15
MM064	9(-0.721)	2.50	11(0.721)	3.52	20(2.538)	2.99
MM065	20(0.979)	5.75	12(-0.979)	3.71	32(5.332)	4.76
MM066	6(-0.235)	1.85	6(0.235)	1.91	12(0.327)	1.88
MM067	11(-1.072)	3.35	15(1.072)	4.67	26(4.052)	3.99
MM068	0(-0.770)	0.00	1(0.77)	0.16	1(-2.411)	0.08
Total	342(1.028)	100.01	319(-1.028)	99.29		
Total					662	100.01

Significance of Factors	
Factor	P-value
Sex	0.3857
Beach	<0.0001
Beach and Sex	0.8756

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Table 5.4 Site selection by subadults in the moult haulout during the population decline.

Site	Sex				Total	
	Females n=1552		Males n=1686		n=3238	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	54(-0.462)	3.47	60(0.462)	3.57	114(8.111)	3.53
MM002	67(-0.998)	4.28	81(0.998)	4.79	148(11.989)	4.54
MM003	28(-0.599)	1.83	24(0.599)	1.44	52(0.081)	1.63
MM004	67(-0.777)	4.32	78(0.777)	4.63	145(11.687)	4.48
MM006	12(0.457)	0.77	10(-0.457)	0.58	22(-3.987)	0.67
MM007	82(-0.682)	5.29	93(0.682)	5.53	175(14.969)	5.41
MM008	3(0.020)	0.18	3(-0.02)	0.17	6(-5.434)	0.18
MM009	37(-0.483)	2.41	42(0.483)	2.46	29(3.709)	2.44
MM010	15(0.610)	0.98	12(-0.610)	0.71	27(-3.344)	0.84
MM011	46(-0.79)	2.97	55(0.790)	3.45	101(6.480)	3.14
MM012	9(0.271)	0.61	8(-0.271)	0.50	17(-4.590)	0.55
MM013	46(2.213)	2.98	27(-2.213)	1.62	73(2.572)	2.27
MM014	7(1.224)	0.45	3(-1.224)	0.16	10(-5.135)	0.30
MM015	96(0.709)	6.19	87(-0.709)	5.13	183(15.823)	5.64
MM016	37(0.772)	2.41	31(-0.772)	1.87	68(2.237)	2.12
MM017	1(0.013)	0.04	1(-0.013)	0.07	2(-5.069)	0.06
MM018	101(-0.031)	6.49	103(0.031)	6.08	204(17.985)	6.28
MM019	11(0.251)	0.69	10(-0.251)	0.58	21(-4.110)	0.64
MM020	70(-1.254)	4.53	88(1.254)	5.24	158(13.043)	4.90
MM025	71(-0.379)	4.58	77(0.379)	4.55	148(12.067)	4.56
MM026	31(-0.651)	1.98	37(0.651)	2.21	68(2.237)	2.10
MM027	5(1.459)	0.32	1(-1.459)	0.03	8(-4.905)	0.17
MM051	15(-1.089)	0.94	22(1.089)	1.32	37(-2.043)	1.14
MM052	22(0.511)	1.41	19(-0.511)	1.13	41(-1.431)	1.26
MM053	69(0.244)	4.42	67(0.244)	4.00	136(10.723)	4.20
MM054	10(0.034)	0.65	10(-0.034)	0.58	20(-4.233)	0.61
MM055	26(-2.124)	1.68	45(2.124)	2.69	71(2.297)	2.21
MM056	69(-1.606)	4.44	92(1.606)	5.47	161(13.282)	4.97
MM057	40(0.397)	2.60	37(-0.397)	2.17	77(3.461)	2.38
MM058	23(-2.226)	1.47	42(2.226)	2.50	65(1.466)	2.01
MM059	20(-0.954)	1.31	27(0.954)	1.58	47(-0.655)	1.45
MM060	45(-0.708)	2.89	53(0.708)	3.12	98(6.116)	3.01
MM061	1(-0.492)	0.06	2(0.492)	0.13	3(-5.158)	0.10
MM062	61(-0.506)	3.94	68(0.506)	4.05	129(9.887)	4.00
MM063	38(-0.880)	2.42	47(0.880)	2.79	85(4.440)	2.61
MM064	64(2.116)	4.13	42(-2.116)	2.47	106(6.812)	3.27
MM065	62(-2.111)	4.00	91(2.111)	5.41	153(12.241)	4.73
MM066	34(-0.286)	2.17	37(0.286)	2.21	71(2.667)	2.19
MM067	55(0.353)	3.56	52(-0.353)	3.09	107(7.276)	3.32
MM068	2(0.017)	0.13	2(-0.017)	0.09	4(-5.368)	0.11
Total	1552(-0.218)	99.99	1686(0.218)	100.17		
Total					3238	100.02

Significance of Factors	
Factor	P-value
Sex	0.0193
Beach	<0.0001
Sex and Beach	0.3674

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Table 5.5 Site selection by subadults in the winter haulout during the population decline.

Site	Sex				Total	
	Females n=240		Males n=606		n=846	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	9(-0.257)	4.17	26(0.257)	4.36	35(5.206)	4.30
MM002	12(0.211)	5.07	26(-0.211)	4.27	38(5.969)	4.50
MM003	0(-1.209)	0.00	6(1.209)	1.07	6(-1.717)	0.77
MM004	11(0.413)	4.48	22(-0.413)	3.65	33(5.041)	3.89
MM006	1(0.730)	0.42	1(-0.730)	0.08	2(-2.500)	0.18
MM007	9(-1.137)	4.17	36(1.137)	5.94	45(6.262)	5.44
MM008	1(1.206)	0.21	0(-1.206)	0.00	1(-2.462)	0.06
MM009	4(-0.034)	1.67	10(0.034)	1.64	14(0.371)	1.65
MM010	2(0.052)	0.83	5(-0.052)	0.87	7(-1.355)	0.86
MM011	18(1.030)	7.57	30(-1.030)	4.92	48(8.452)	5.67
MM012	2(0.600)	0.76	3(-0.600)	0.54	5(-1.803)	0.60
MM013	3(0.102)	1.46	7(-0.102)	1.19	10(-0.585)	1.27
MM014	1(1.206)	0.42	0(-1.206)	0.00	1(-2.462)	0.12
MM015	12(0.316)	5.00	25(-0.316)	4.09	37(5.831)	4.35
MM016	7(-0.044)	2.85	17(0.044)	2.87	24(2.756)	2.87
MM017	0(-0.169)	0.00	1(0.169)	0.17	1(-2.462)	0.12
MM018	18(0.835)	7.92	34(-0.835)	5.61	52(9.296)	6.27
MM019	2(0.600)	0.83	3(-0.600)	0.44	5(-1.803)	0.55
MM020	16(0.280)	6.53	34(-0.280)	5.69	50(8.373)	5.93
MM025	7(0.517)	2.92	13(-0.517)	2.10	20(2.092)	2.33
MM026	0(-1.750)	0.00	13(1.750)	2.07	13(-1.231)	1.48
MM051	1(-1.297)	0.42	10(1.297)	1.61	11(-1.031)	1.27
MM052	5(0.713)	2.08	8(-0.713)	1.34	13(0.362)	1.55
MM053	13(-1.235)	5.61	46(1.235)	7.55	59(8.448)	7.00
MM054	1(-1.037)	0.56	8(1.037)	1.32	9(-1.259)	1.10
MM055	4(-0.630)	1.84	14(0.630)	2.29	18(0.980)	2.16
MM056	11(-1.362)	4.38	42(1.362)	6.92	53(7.238)	6.19
MM057	5(0.918)	1.91	7(-0.918)	1.13	12(0.131)	1.35
MM058	8(-0.240)	3.23	21(0.240)	3.43	29(3.738)	3.37
MM059	2(-0.868)	0.83	10(0.868)	1.72	12(-0.54)	1.47
MM060	3(0.552)	1.18	5(-0.552)	0.87	8(-1.011)	0.96
MM061	1(-0.020)	0.21	3(0.020)	0.57	4(-2.068)	0.47
MM062	9(0.403)	4.17	20(-0.403)	3.26	29(4.376)	3.52
MM063	5(-1.000)	2.05	20(1.000)	3.34	25(2.214)	2.97
MM064	7(-0.758)	3.33	26(0.758)	4.28	33(4.343)	4.01
MM065	10(-0.356)	3.96	27(0.356)	4.44	37(5.327)	4.30
MM066	5(1.137)	2.17	6(-1.137)	0.94	11(-0.119)	1.29
MM067	11(0.65)	4.72	20(-0.650)	3.24	31(4.728)	3.66
MM068	0(-0.169)	0.10	1(0.169)	0.17	1(-2.462)	0.15
Total	240(-6.039)	100.03	606(6.039)	99.99		
Total					846	100.00

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.7808

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Table 5.6 Site selection by adults in the breeding haulout during the population decline.

Site	Sex				Total	
	Females n=826		Males n=81		n=908	
	Freq(z)	%	Freq (z)	%	Freq (z)	%
MM001	5(-0.108)	0.58	1(0.108)	1.55	6(-0.378)	0.67
MM002	52(1.545)	6.29	6(-1.545)	6.88	58(7.555)	6.34
MM003	0(-1.977)	0.00	2(1.977)	2.81	2(-1.468)	0.26
MM004	42(2.168)	5.09	2(-2.168)	2.85	44(3.338)	4.89
MM006	1(-0.187)	0.16	0(0.187)	0.00	1(-1.713)	0.15
MM007	75(3.071)	9.08	2(-3.071)	2.26	77(4.254)	8.46
MM010	1(-0.187)	0.16	0(0.187)	0.00	1(-1.713)	0.15
MM011	37 (1.688)	4.51	3(-1.688)	3.94	40(4.199)	4.46
MM012	18 (1.312)	2.18	1(-1.312)	1.59	19(1.021)	2.13
MM013	9(0.510)	1.09	1(-0.510)	1.52	10(0.228)	1.13
MM014	1(-0.187)	0.09	0(0.187)	0.45	1(-1.713)	0.12
MM015	25(1.001)	3.02	2(-1.001)	3.61	27(3.468)	3.07
MM016	19(1.377)	2.32	1(-1.377)	1.36	20(1.085)	2.23
MM018	54(2.365)	6.47	3(-2.365)	3.51	57(4.906)	6.20
MM019	0(-1.558)	0.00	1(1.558)	0.60	1(-1.713)	0.05
MM020	67(2.352)	8.14	5(-2.352)	6.43	72(7.34)	7.98
MM025	16(-0.18)	1.91	3(0.18)	4.82	19(3.355)	2.17
MM026	26(0.352)	3.20	5(-0.352)	6.02	31(5.112)	3.46
MM051	1(-1.226)	0.12	1(1.226)	1.20	2(-1.443)	0.22
MM052	1(-1.226)	0.10	1(1.226)	0.60	2(-1.443)	0.15
MM053	76(1.374)	9.16	11(-1.374)	13.47	87(11.969)	9.55
MM055	4(-1.024)	0.50	2(1.024)	2.29	6(-0.046)	0.67
MM056	61(1.025)	7.49	10(-1.025)	12.32	71(10.728)	7.93
MM057	3(-1.282)	0.40	2(1.282)	2.14	5(-0.348)	0.56
MM058	40(2.280)	4.80	1(-2.28)	1.51	41(1.983)	4.50
MM059	5(-1.367)	0.65	3(1.367)	3.51	8(0.723)	0.91
MM060	34(1.538)	4.06	3(-1.538)	3.12	37(4.041)	3.97
MM062	50(1.979)	6.01	4(-1.979)	4.62	54(5.764)	5.89
MM063	23(1.607)	2.77	1(-1.607)	1.20	24(1.313)	2.63
MM064	13(1.340)	1.57	0(-1.340)	0.00	13(-0.387)	1.43
MM065	53(2.626)	6.36	1(-2.626)	1.61	54(2.327)	5.93
MM066	2(-0.867)	0.27	1(0.867)	0.64	3(-1.109)	0.31
MM067	11(0.736)	1.28	1(-0.736)	1.20	12(0.451)	1.27
Total	826(7.434)	99.83	81(-7.434)	99.63		
Total					908	99.84

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.0043

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Table 5.7 Site selection by adults in the moult haulout during the population decline.

Site	Sex				Total	
	Females n=583		Males n=63		n=646	
	Freq (z)	%	Freq (z)	%	Freq (z)	%
MM001	21(-1.545)	3.58	6(1.545)	10.32	27(5.396)	4.24
MM002	14(-0.841)	2.43	3(0.841)	5.56	17(2.568)	4.74
MM003	15(1.058)	2.51	0(-1.058)	0.00	15(-0.214)	2.27
MM004	16(1.103)	2.66	0(-1.103)	0.53	16(-0.170)	2.45
MM006	2(-0.216)	0.26	0(0.216)	0.00	2(1.397)	0.23
MM007	41(1.310)	6.97	2(-1.310)	3.97	43(3.443)	6.67
MM009	8(0.625)	1.34	0(-0.625)	0.00	8(-0.631)	1.21
MM010	3(0.005)	0.51	0(-0.005)	0.00	3(-1.204)	0.46
MM011	17(0.608)	2.91	1(-0.608)	1.59	17(1.075)	2.78
MM012	6(0.434)	1.06	0(-0.434)	0.00	6(-0.811)	0.95
MM013	15(1.058)	2.61	0(-1.058)	0.00	15(-0.214)	2.35
MM015	25(1.418)	4.33	0(-1.418)	0.00	25(0.139)	3.91
MM016	8(0.625)	1.46	0(-0.625)	0.00	8(-0.631)	1.31
MM018	44(-0.031)	7.48	6(0.031)	8.81	50(7.282)	7.61
MM019	5(-0.694)	0.91	1(0.694)	1.03	6(-0.261)	6.47
MM020	38(0.398)	6.56	4(-0.398)	5.63	42(5.340)	5.73
MM025	31(-0.773)	5.32	5(0.773)	9.52	36(6.389)	3.44
MM026	16(-2.038)	2.78	5(2.038)	9.52	21(4.709)	0.46
MM051	3(0.005)	0.51	0(-0.005)	0.00	3(-1.204)	2.06
MM052	13(0.958)	2.28	0(-0.958)	0.00	13(-0.311)	2.06
MM053	24(-1.288)	4.18	6(1.288)	8.99	30(5.735)	4.65
MM054	4(-0.892)	0.77	1(0.892)	1.32	5(-0.469)	0.82
MM055	17(0.608)	2.95	1(-0.608)	0.79	18(1.075)	2.74
MM056	24(-0.885)	4.11	5(0.885)	7.57	29(5.091)	4.45
MM057	18(-0.453)	3.05	3(0.453)	4.81	21(3.002)	3.23
MM058	11(-1.192)	1.97	3(1.192)	3.97	14(2.142)	2.16
MM059	5(0.317)	0.77	0(-0.317)	0.00	5(-0.921)	0.70
MM060	13(0.301)	2.25	1(-0.301)	1.59	14(0.763)	2.18
MM062	17(0.012)	2.96	2(-0.012)	2.65	19(2.074)	2.93
MM063	12(-0.466)	1.99	2(0.466)	2.65	14(1.550)	2.05
MM064	22(1.327)	3.73	0(-1.327)	0.71	22(0.050)	3.43
MM065	37(-0.037)	6.33	5(0.037)	8.15	42(6.105)	6.50
MM066	21(1.294)	3.56	0(-1.294)	0.32	21(0.017)	3.25
MM067	17(1.145)	2.90	0(-1.145)	0.00	17(-0.128)	2.62
Total	583(9.689)	99.99	63(-9.689)	100.00		
Total					646	103.11

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.3313

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Table 5.8. Site selection by underyearlings in the winter haulout during the population stabilization

Sites	Sex				Total	
	Females n=640		Males n=608		n=1249	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	16(-1.742)	3.98	24(1.742)	2.54	40(3.322)	3.24
MM002	28(-1.478)	5.82	36(1.478)	4.53	64(8.006)	5.16
MM003	9(0.425)	0.98	5(-0.425)	1.35	14(-1.608)	1.17
MM004	28(-0.050)	3.96	24(0.050)	4.34	52(5.736)	4.15
MM006	8(0.200)	0.98	6(-0.200)	1.26	14(-1.788)	1.13
MM007	21(-1.128)	4.05	25(1.128)	3.22	46(4.614)	3.62
MM008	2(0.342)	0.08	1(-0.342)	0.23	3(-3.574)	0.16
MM009	15(0.789)	1.42	9(-0.789)	2.40	24(0.145)	1.92
MM010	13(0.683)	1.31	8(-0.683)	2.01	21(-0.436)	1.67
MM011	44(0.025)	6.07	37(-0.025)	6.94	81(10.707)	6.51
MM012	14(0.858)	1.39	8(-0.858)	2.21	22(-0.275)	1.81
MM013	14(-1.161)	2.89	18(1.161)	2.21	32(1.871)	2.55
MM014	8(0.200)	0.95	6(-0.200)	1.28	14(-1.788)	1.12
MM015	25(-1.502)	5.21	32(1.502)	3.98	57(6.581)	4.58
MM016	12(-0.415)	1.90	12(0.415)	1.81	24(0.298)	1.85
MM017	5(1.257)	0.22	1(-1.257)	0.78	6(-3.129)	0.51
MM018	40(-1.735)	8.16	50(0.735)	6.22	90(12.088)	7.17
MM019	8(0.200)	1.01	6(-0.200)	1.30	14(-1.788)	1.16
MM020	28(-0.473)	4.47	27(0.473)	4.36	55(6.316)	4.41
MM025	26(-0.176)	3.92	24(0.176)	4.22	50(5.566)	4.07
MM026	11(0.834)	0.99	6(-0.834)	1.67	17(-1.273)	1.33
MM027	1(0.585)	0.00	0(-0.585)	0.08	1(-3.275)	0.04
MM051	10(0.100)	1.31	8(-0.100)	1.54	18(-0.964)	1.43
MM052	3(-0.223)	0.55	3(0.223)	0.44	6(-3.272)	0.49
MM053	35(0.480)	4.27	26(-0.480)	5.50	61(7.241)	4.90
MM054	2(-0.189)	0.30	2(0.189)	0.31	4(-3.539)	0.31
MM055	12(-0.618)	2.08	13(0.618)	1.86	25(0.500)	1.97
MM056	30(1.070)	3.09	19(-1.070)	4.84	49(5.069)	3.98
MM057	7(-1.059)	1.59	10(1.059)	1.08	17(-1.195)	1.33
MM058	16(-1.147)	3.33	20(1.147)	2.43	36(2.673)	2.87
MM059	8(-0.591)	1.51	9(0.591)	1.33	17(-1.156)	1.42
MM060	9(-0.597)	1.72	10(0.597)	1.38	19(-0.742)	1.55
MM061	4(0.546)	0.38	2(-0.546)	0.55	6(-3.247)	0.47
MM062	18(-1.430)	3.99	24(1.430)	2.89	42(3.793)	3.43
MM063	19(0.569)	2.15	13(-0.569)	2.98	32(1.802)	2.58
MM064	19(-0.344)	2.99	18(0.3440	2.96	37(2.917)	2.98
MM065	26(-0.589)	4.32	26(0.589)	4.01	52(5.771)	4.16
MM066	7(0.261)	0.87	5(-0.261)	1.13	12(-2.190)	1.01
MM067	27(-0.734)	4.60	28(0.734)	4.19	55(6.316)	4.39
MM068	10(0.361)	1.17	7(-0.361)	1.61	17(-1.195)	1.40
Total	640(1.939)	99.98	608(-1.939)	99.97		
Total					1249	100.00

Significance of Factors	
Factor	P-value
Sex	0.3731
Beach	<0.0001
Sex and Beach	0.9676

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Table 5.9 Site selection by yearlings in the moult haulout during the population stabilization.

Sites	Sex				Total	
	Females n=695		Males n=606		n=1302	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	23(0.193)	3.32	17(-0.193)	2.88	40(3.120)	3.11
MM002	35(0.658)	4.99	23(-0.658)	3.75	58(6.248)	4.41
MM003	15(1.116)	2.14	7(-1.116)	1.09	22(-0.607)	1.65
MM004	24(-0.1481)	3.39	20(0.148)	3.31	44(3.936)	3.36
MM006	4(-0.995)	0.62	6(0.995)	1.06	10(-2.730)	0.83
MM007	26(-1.108)	3.70	28(1.108)	4.54	54(5.806)	4.10
MM008	2(0.643)	0.43	1(-0.643)	0.12	3(-3.525)	0.29
MM009	12(-1.362)	1.74	16(1.362)	2.59	28(0.814)	2.14
MM010	13(0.281)	1.92	9(-0.281)	1.52	22(-0.404)	1.74
MM011	31(0.066)	4.47	23(-0.066)	3.95	54(5.894)	4.23
MM012	12(1.162)	1.67	5(-1.162)	0.80	17(-1.569)	1.27
MM013	21(-0.259)	2.98	18(0.259)	2.95	39(3.003)	2.97
MM014	10(1.425)	1.48	3(-1.425)	0.44	13(-2.337)	1.00
MM015	29(0.132)	4.10	22(-0.132)	3.55	51(5.163)	3.84
MM016	14(-1.985)	2.04	22(0.985)	3.57	36(2.254)	2.75
MM017	3(0.127)	0.49	2(-0.127)	0.33	5(-3.815)	0.42
MM018	44(-0.721)	6.30	41(0.721)	6.75	85(11.025)	6.51
MM019	9(1.244)	1.35	3(-1.244)	0.45	12(-2.471)	0.93
MM020	28(-0.437)	4.09	25(0.437)	4.18	53(5.615)	4.13
MM025	34(-0.686)	4.85	32(0.686)	5.22	66(7.909)	5.02
MM026	23(-1.224)	3.28	25(1.224)	4.28	48(4.885)	3.75
MM027	1(0.543)	0.19	0(-0.543)	0.00	1(-3.333)	0.10
MM051	13(1.611)	1.80	4(-1.611)	0.67	17(-1.708)	1.28
MM052	6(-0.116)	0.83	5(0.116)	0.80	11(-2.535)	0.81
MM053	35(-0.449)	5.01	31(0.449)	5.12	66(7.889)	5.06
MM054	2(-0.266)	0.34	2(0.266)	0.34	4(-3.644)	0.34
MM055	11(-0.990)	1.72	14(0.990)	2.35	25(0.456)	2.02
MM056	29(-1.134)	4.15	31(1.134)	5.18	60(6.871)	4.63
MM057	11(-1.368)	1.62	15(0.368)	2.45	26(0.410)	2.01
MM058	18(-1.037)	2.60	20(1.037)	3.26	38(2.825)	2.91
MM059	9(-1.186)	1.23	12(0.186)	1.91	21(-0.577)	1.55
MM060	9(-1.377)	1.44	14(0.377)	2.39	23(0.004)	1.88
MM061	9(0.911)	1.23	4(-0.911)	0.74	13(-2.249)	1.00
MM062	14(-1.680)	2.01	20(0.680)	3.34	34(1.945)	2.63
MM063	16(0.119)	2.27	12(-0.119)	2.05	28(0.814)	2.17
MM064	29(0.447)	4.19	20(-0.447)	2.28	49(4.719)	3.76
MM065	30(0.406)	4.37	21(-0.406)	3.44	51(5.093)	3.94
MM066	8(1.047)	1.22	3(-1.047)	0.51	11(-0.611)	0.89
MM067	28(-0.581)	4.04	26(0.581)	4.31	51(5.806)	4.17
MM068	3(-0.314)	0.38	3(0.314)	0.49	6(-3.396)	0.43
Total	695(2.774)	99.99	606(-2.774)	98.96		
Total					1302	100.03

Significance of Factors	
Factor	P-value
Sex	0.0151
Beach	<0.0001
Sex and Beach	0.7268

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Table 5.10. Site selection by yearlings in the winter during the population stabilization.

Sites	Sex				Total	
	Females n=695		Males n=606		n=1302	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	11(-1.406)	1.72	15(1.406)	2.63	26(0.789)	2.14
MM002	30(-0.111)	4.47	24(0.111)	4.19	54(6.226)	4.34
MM003	12(0.568)	1.75	7(-0.568)	1.21	19(-0.729)	1.50
MM004	23(-1.934)	3.43	31(1.934)	5.37	54(6.167)	4.33
MM006	6(-0.145)	0.92	5(0.145)	0.87	11(-2.271)	0.90
MM007	35(-1.579)	5.32	40(1.579)	6.96	75(9.906)	6.08
MM008	3(1.149)	0.43	0(-1.149)	0.07	3(-2.923)	0.26
MM009	8(-1.006)	1.17	10(1.006)	1.78	18(-0.837)	1.45
MM010	20(1.320)	3.01	9(-1.320)	1.59	29(1.008)	2.35
MM011	28(-1.048)	4.21	29(1.048)	4.99	57(6.843)	4.57
MM012	6(-0.145)	0.89	5(0.145)	0.88	11(-2.271)	0.89
MM013	22(0.004)	3.39	17(-0.004)	2.90	39(3.399)	3.16
MM014	9(1.553)	1.43	2(-1.553)	0.42	11(-2.444)	0.96
MM015	29(-0.374)	4.40	25(0.374)	4.39	54(6.269)	4.39
MM016	18(0.598)	2.70	11(-0.598)	1.92	29(1.285)	2.34
MM017	2(-0.285)	0.30	2(0.285)	0.37	4(-3.472)	0.33
MM018	45(-0.693)	6.86	41(0.693)	7.07	86(11.697)	6.96
MM019	8(1.0180)	1.18	3(-1.0180)	0.50	11(-2.370)	0.86
MM020	26(-1.800)	3.92	33(1.800)	5.67	59(7.107)	4.74
MM025	20(-0.453)	2.98	18(0.453)	3.08	38(3.2650	3.03
MM026	11(-1.022)	1.67	13(1.022)	2.25	24(0.422)	1.94
MM027	1(0.532)	0.08	0(-0.532)	0.00	1(-3.239)	0.04
MM051	8(-0.519)	1.23	8(0.519)	1.32	16(-1.237)	1.27
MM052	9(-0.296)	1.29	8(0.296)	1.37	17(-1.032)	1.33
MM053	30(-1.443)	4.59	34(1.443)	5.80	64(8.052)	5.15
MM054	1(-0.753)	0.15	2(0.753)	0.33	3(-3.516)	0.23
MM055	8(-1.006)	1.24	10(1.006)	1.66	18(-0.837)	1.44
MM056	33(0.680)	4.94	21(-0.680)	3.63	54(5.995)	4.33
MM057	12(0.306)	1.88	8(-0.306)	1.39	20(-0.474)	1.65
MM058	24(-0.235)	3.57	20(0.235)	3.45	44(4.397)	3.51
MM059	11(0.950)	1.69	5(-0.950)	0.78	16(-1.419)	1.27
MM060	10(1.073)	1.52	4(-1.073)	0.67	14(-1.833)	1.12
MM061	7(0.443)	1.03	4(-0.443)	0.62	11(-2.306)	0.84
MM062	27(0.648)	4.05	17(-0.648)	2.90	44(4.175)	3.52
MM063	18(-1.243)	2.73	21(1.243)	3.71	39(3.446)	3.19
MM064	33(0.996)	4.91	19(-0.996)	3.37	52(5.499)	4.19
MM065	26(-1.024)	3.96	27(1.024)	4.68	53(6.118)	4.30
MM066	7(0.108)	1.04	5(-0.108)	0.84	12(-2.084)	0.95
MM067	21(-0.310)	3.13	18(0.310)	3.05	39(3.446)	3.09
MM068	5(-1.267)	0.79	8(1.267)	1.35	13(-1.905)	1.05
Total	663(2.754)	99.97	579(-2.754)	100.03		
Total					1242.000	99.99

Significance of Factors	
Factor	P-value
Sex	0.0189
Beach	<0.0001
Sex and Beach	0.7082

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Table 5.11 Site selection by subadults in the moult haulout during the population stabilization.

Sites	Sex				Total	
	Females n=695		Males n=606		n=1302	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	11(-1.406)	1.72	15(1.406)	2.63	26(0.789)	2.14
MM002	30(-0.111)	4.47	24(0.111)	4.19	54(6.226)	4.34
MM003	12(0.568)	1.75	7(-0.568)	1.21	19(-0.729)	1.50
MM004	23(-1.934)	3.43	31(1.934)	5.37	54(6.167)	4.33
MM006	6(-0.145)	0.92	5(0.145)	0.87	11(-2.271)	0.90
MM007	35(-1.579)	5.32	40(1.579)	6.96	75(9.906)	6.08
MM008	3(1.149)	0.43	0(-1.149)	0.07	3(-2.923)	0.26
MM009	8(-1.006)	1.17	10(1.006)	1.78	18(-0.837)	1.45
MM010	20(1.320)	3.01	9(-1.320)	1.59	29(1.008)	2.35
MM011	28(-1.048)	4.21	29(1.048)	4.99	57(6.843)	4.57
MM012	6(-0.145)	0.89	5(0.145)	0.88	11(-2.271)	0.89
MM013	22(0.004)	3.39	17(-0.004)	2.90	39(3.399)	3.16
MM014	9(1.553)	1.43	2(-1.553)	0.42	11(-2.444)	0.96
MM015	29(-0.374)	4.40	25(0.374)	4.39	54(6.269)	4.39
MM016	18(0.598)	2.70	11(-0.598)	1.92	29(1.285)	2.34
MM017	2(-0.285)	0.30	2(0.285)	0.37	4(-3.472)	0.33
MM018	45(-0.693)	6.86	41(0.693)	7.07	86(11.697)	6.96
MM019	8(1.0180)	1.18	3(-1.0180)	0.50	11(-2.370)	0.86
MM020	26(-1.800)	3.92	33(1.800)	5.67	59(7.107)	4.74
MM025	20(-0.453)	2.98	18(0.453)	3.08	38(3.2650	3.03
MM026	11(-1.022)	1.67	13(1.022)	2.25	24(0.422)	1.94
MM027	1(0.532)	0.08	0(-0.532)	0.00	1(-3.239)	0.04
MM051	8(-0.519)	1.23	8(0.519)	1.32	16(-1.237)	1.27
MM052	9(-0.296)	1.29	8(0.296)	1.37	17(-1.032)	1.33
MM053	30(-1.443)	4.59	34(1.443)	5.80	64(8.052)	5.15
MM054	1(-0.753)	0.15	2(0.753)	0.33	3(-3.516)	0.23
MM055	8(-1.006)	1.24	10(1.006)	1.66	18(-0.837)	1.44
MM056	33(0.680)	4.94	21(-0.680)	3.63	54(5.995)	4.33
MM057	12(0.306)	1.88	8(-0.306)	1.39	20(-0.474)	1.65
MM058	24(-0.235)	3.57	20(0.235)	3.45	44(4.397)	3.51
MM059	11(0.950)	1.69	5(-0.950)	0.78	16(-1.419)	1.27
MM060	10(1.073)	1.52	4(-1.073)	0.67	14(-1.833)	1.12
MM061	7(0.443)	1.03	4(-0.443)	0.62	11(-2.306)	0.84
MM062	27(0.648)	4.05	17(-0.648)	2.90	44(4.175)	3.52
MM063	18(-1.243)	2.73	21(1.243)	3.71	39(3.446)	3.19
MM064	33(0.996)	4.91	19(-0.996)	3.37	52(5.499)	4.19
MM065	26(-1.024)	3.96	27(1.024)	4.68	53(6.118)	4.30
MM066	7(0.108)	1.04	5(-0.108)	0.84	12(-2.084)	0.95
MM067	21(-0.310)	3.13	18(0.310)	3.05	39(3.446)	3.09
MM068	5(-1.267)	0.79	8(1.267)	1.35	13(-1.905)	1.05
Total	663(2.754)	99.97	579(-2.754)	100.03		
Total					1242.000	99.99

Significance of Factors	
Factor	P-value
Sex	0.0189
Beach	<0.0001
Sex and Beach	0.7082

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Table 5.12 Site selection by subadults in the winter haulout during the population stabilization.

Sites	Sex				Total	
	Females n=374		Males n=945		n=1320	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	8(-1.109)	2.41	31(1.109)	3.24	39(2.364)	3.01
MM002	8(-0.574)	2.14	23(0.574)	2.45	31(1.181)	2.36
MM003	7(2.266)	2.14	5(-2.266)	0.49	12(-1.817)	0.96
MM004	15(-1.215)	4.29	51(1.215)	5.34	66(6.659)	5.04
MM006	1(-0.062)	0.27	3(0.062)	0.32	4(-3.317)	0.30
MM007	18(-0.778)	4.87	50(0.778)	5.26	68(7.248)	5.15
MM008	1(0.274)	0.13	2(-0.274)	0.16	3(-3.469)	0.15
MM009	2(-1.648)	0.51	16(1.648)	1.66	18(-1.659)	1.34
MM010	10(1.000)	2.59	15(-1.000)	1.62	25(0.669)	1.89
MM011	16(-0.110)	4.22	37(0.110)	3.95	53(5.341)	4.03
MM012	2(-0.433)	0.45	6(0.433)	0.74	8(-2.643)	0.66
MM013	11(0.964)	3.22	19(-0.964)	2.03	30(1.847)	2.37
MM014	4(0.940)	0.94	5(-0.940)	0.55	9(-2.586)	0.66
MM015	18(0.117)	5.09	41(-0.117)	4.36	59(6.669)	4.57
MM016	10(0.190)	2.82	21(-0.190)	2.24	31(1.577)	2.40
MM017	3(1.063)	0.85	3(-1.063)	0.28	6(-3.129)	0.44
MM018	18(-1.938)	4.75	68(1.938)	7.18	86(8.626)	6.50
MM019	1(-0.765)	0.13	6(0.765)	0.68	7(-2.874)	0.52
MM020	23(0.325)	6.04	47(-0.325)	4.99	70(8.439)	5.29
MM025	14(-2.214)	3.84	61(2.214)	6.40	75(6.632)	5.68
MM026	8(0.592)	2.23	14(-0.592)	1.50	22(-0.027)	1.71
MM027	2(0.900)	0.54	2(-0.900)	0.16	4(-3.418)	0.26
MM051	3(0.259)	0.80	5(-0.259)	0.63	8(-2.611)	0.68
MM052	3(-0.315)	0.76	16(0.315)	1.71	19(-1.328)	1.44
MM053	21(0.393)	5.61	42(-0.393)	4.48	63(7.343)	4.80
MM054	4(0.265)	0.94	8(-0.265)	0.85	12(-2.057)	0.88
MM055	6(-0.919)	1.61	21(0.919)	2.24	27(0.257)	2.06
MM056	20(-1.434)	5.42	65(1.434)	6.89	85(9.122)	6.47
MM057	5(-0.220)	1.22	13(0.220)	1.37	18(-1.036)	1.32
MM058	6(-2.144)	1.72	35(2.144)	3.74	41(1.451)	3.17
MM059	2(-0.342)	0.80	9(0.342)	0.91	11(-2.148)	0.88
MM060	8(0.592)	2.14	14(-0.592)	1.45	22(-0.027)	1.65
MM061	5(1.327)	1.27	5(-1.327)	0.56	10(-2.385)	0.76
MM062	10(-1.049)	2.64	33(1.049)	3.50	43(2.923)	3.25
MM063	11(-0.994)	3.08	35(0.994)	3.71	46(3.477)	3.53
MM064	16(-0.020)	4.24	36(0.020)	3.84	52(5.231)	3.95
MM065	13(-0.277)	3.57	32(0.277)	3.35	45(3.853)	3.41
MM066	3(1.010)	1.70	8(-1.010)	0.88	14(-1.581)	1.11
MM067	23(1.378)	6.23	35(-1.378)	3.65	58(6.977)	4.38
MM068	7(1.760)	1.74	6(-1.760)	0.65	13(-1.775)	0.96
Total	374(-9.394)	99.96	945(9.394)	100.01		
Total					1320	99.99

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.1889

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Table 5.13 Site selection by adults in the breeding haulout during the population stabilization.

Sites	Sex				Total	
	Females n=1499		Males n=231		n=1730	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	20(-0.391)	1.35	7(0.391)	2.89	27(2.930)	1.56
MM002	62(1.693)	4.15	10(-1.693)	4.39	72(7.677)	4.18
MM003	1(-0.050)	0.04	0(0.050)	0.17	1(-2.520)	0.06
MM004	51(1.137)	3.41	10(-1.137)	4.22	61(7.047)	3.52
MM006	0(-0.603)	0.02	0(0.603)	0.00	0(-2.622)	0.02
MM007	129(3.983)	8.62	9(-3.983)	4.09	138(9.373)	8.01
MM008	1(-0.050)	0.03	0(0.050)	0.08	1(-2.520)	0.04
MM009	11(0.018)	0.73	3(-0.018)	1.21	14(-0.074)	0.80
MM010	1(-0.050)	0.04	0(0.050)	0.04	1(-2.520)	0.04
MM011	80(3.152)	5.35	6(-3.152)	2.75	86(5.935)	5.00
MM012	20(1.715)	1.35	1(-1.715)	0.39	21(-0.375)	1.22
MM013	19(1.304)	1.24	2(-1.304)	1.01	21(0.218)	1.21
MM014	0(-0.603)	0.03	0(0.603)	0.04	0(-2.622)	0.03
MM015	48(2.155)	3.21	5(-2.155)	2.09	53(3.985)	3.06
MM016	53(1.697)	3.53	8(-1.697)	3.30	61(6.107)	3.50
MM017	1(-0.050)	0.08	0(0.050)	0.00	0(-2.520)	0.07
MM018	127(2.786)	8.45	17(-2.786)	7.53	144(13.696)	8.33
MM019	3(-2.012)	0.18	4(2.012)	1.54	7(-1.384)	0.37
MM020	163(3.939)	10.91	15(-3.939)	6.38	178(13.705)	10.30
MM025	20(-0.391)	1.33	7(0.391)	2.92	27(2.930)	1.54
MM026	83(1.996)	5.55	13(-1.996)	5.43	96(10.192)	5.53
MM027	2(-1.332)	0.10	2(1.332)	0.73	4(-2.157)	0.18
MM051	2(-0.656)	0.11	1(0.656)	0.43	3(-2.377)	0.15
MM052	1(-1.038)	0.09	1(1.038)	0.63	2(-2.58)	0.16
MM053	120(1.176)	7.99	27(-1.176)	11.72	147(17.161)	8.49
MM054	2(-1.332)	0.16	2(1.332)	0.83	4(-2.157)	0.25
MM055	6(-0.301)	0.43	2(0.301)	0.98	8(-1.286)	0.50
MM056	135(3.004)	9.01	17(-3.004)	7.47	152(13.943)	8.80
MM057	5(-0.514)	0.35	2(0.514)	0.66	7(-1.476)	0.39
MM058	73(2.744)	4.86	7(-2.744)	3.23	80(6.392)	4.64
MM059	7(-1.351)	0.44	5(1.531)	2.24	12(-0.037)	0.68
MM060	36(0.435)	2.44	9(-0.435)	4.02	45(5.474)	2.65
MM061	1(-1.038)	0.05	1(1.038)	0.48	2(-2.580)	0.11
MM062	110(2.432)	7.35	16(-2.432)	6.94	126(12.669)	7.29
MM063	31(1.790)	2.04	3(-1.79)	1.14	34(1.691)	1.92
MM064	8(-0.923)	0.52	4(0.923)	1.72	12(-0.164)	0.68
MM065	59(1.550)	3.96	10(-1.55)	4.52	69(7.517)	4.03
MM066	0(-1.837)	0.00	2(1.837)	0.65	2(-2.318)	0.09
MM067	7(-0.642)	0.44	3(0.642)	1.16	10(-0.729)	0.54
MM068	1(-0.05)	0.07	0(0.050)	0.00	1(-2.520)	0.06
Total	1499(7.895)	100.01	231(-7.895)	100.02		
Total					1730	100.00

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.0002

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Table 5.14 Site selection by adults in the moult haulout during the population stabilization

	Sex				Total	
	Females n=1599		Males n=248		n=1847	
	Freq (z)	(%)	Freq (z)	(%)	Freq (z)	%
MM001	32(-1.269)	2.01	7(1.269)	2.95	39(2.589)	2.13
MM002	50(-4.191)	3.11	22(4.191)	8.80	72(9.246)	3.88
MM003	9(-0.175)	0.55	1(0.175)	0.40	10(-2.023)	0.53
MM004	26(0.550)	1.61	2(-0.55)	0.60	28(-0.331)	1.47
MM006	9(0.666)	0.57	0(-0.666)	0.00	9(-2.008)	0.49
MM007	79(-0.451)	4.95	12(0.451)	4.85	91(7.595)	4.94
MM008	0(-1.022)	0.00	0(1.022)	0.00	0(-2.967)	0.00
MM009	44(0.975)	2.73	3(-0.975)	1.34	47(1.139)	2.54
MM010	9(0.666)	0.57	0(-0.666)	0.10	9(-2.008)	0.51
MM011	49(1.170)	3.05	3(-1.170)	1.31	52(1.334)	2.82
MM012	28(-0.296)	1.74	4(0.296)	1.81	32(0.860)	1.75
MM013	29(0.716)	1.84	2(-0.716)	0.60	31(-0.169)	1.67
MM014	3(-0.035)	0.16	0(0.035)	0.00	3(-2.603)	0.14
MM015	60(-0.092)	3.78	8(0.092)	3.32	68(4.776)	3.72
MM016	30(0.768)	1.89	2(-0.786)	0.60	32(-0.119)	1.72
MM017	2(-0.256)	0.11	0(0.256)	0.00	2(-2.762)	0.09
MM018	149(0.330)	9.31	18(-0.330)	7.21	167(12.645)	9.02
MM019	5(0.277)	0.34	0(-0.277)	0.08	5(-2.351)	0.30
MM020	98(-1.951)	6.14	22(1.951)	8.94	120(12.323)	6.51
MM025	99(-2.471)	6.20	25(2.471)	9.97	124(13.31)	6.71
MM026	57(-0.836)	3.54	10(0.836)	3.88	67(5.599)	3.59
MM027	3(-0.035)	0.21	0(0.035)	0.00	3(-2.603)	0.18
MM051	31(1.536)	1.92	0(-1.536)	0.00	31(-1.185)	1.66
MM052	26(0.550)	1.61	2(-0.550)	0.74	28(-0.331)	1.49
MM053	91(-1.818)	5.69	20(1.818)	7.86	111(11.319)	5.98
MM054	3(0.137)	0.25	0(-0.137)	0.00	3(-2.467)	0.22
MM055	39(-2.45)	2.42	12(2.45)	4.92	51(5.178)	2.75
MM056	86(-0.683)	5.39	14(0.683)	5.49	100(8.787)	5.40
MM057	48(-0.660)	2.98	8(0.660)	3.39	56(4.145)	3.04
MM058	17(-1.692)	1.05	5(1.692)	2.07	22(0.312)	1.19
MM059	33(-1.568)	2.10	8(1.568)	3.27	41(3.103)	2.25
MM060	27(-0.364)	1.67	4(0.364)	1.77	31(0.789)	1.68
MM061	4(0.137)	0.22	0(-0.137)	0.07	4(-2.467)	0.20
MM062	69(-1.618)	4.33	15(1.618)	6.16	84(8.363)	4.58
MM063	48(1.495)	2.99	2(-1.495)	0.84	50(0.596)	2.70
MM064	53(1.312)	3.34	3(-1.312)	1.14	56(1.477)	3.04
MM065	72(0.679)	4.52	7(-0.679)	2.73	79(4.727)	4.28
MM066	20(0.159)	1.27	2(0.159)	0.75	22(-0.712)	1.20
MM067	51(1.243)	3.19	3(1.243)	1.37	54(1.407)	2.95
MM068	11(-0.679)	0.67	2(0.679)	0.67	13(-1.517)	0.67
Total	1599(14.311)	100.02	248(-14.311)	100.00		
Total					1847	99.99

Significance of Factors	
Factor	P-value
Sex	<0.0001
Beach	<0.0001
Sex and Beach	0.0100

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5.4 Discussion

Elephant seals used to breed and moult on the west coast of Marion Island in the past, where Kaalkoppie beach was the main elephant seal breeding site (Condy 1977, 1979). At Kaalkoppie elephant seals bred and moulted on the extensively vegetated area behind the beach away from the wave action that pounded the main beach (Bester pers. comm.). Ever since the volcanic eruption in 1980 (Berruti 1982), access to the Kaalkoppie beach has been denied to elephant seals. Due to the inaccessibility of this beach and the population decline, elephant seals abandoned the whole west coast (present study). During the study period almost all elephant seal terrestrial activities were restricted to the east coast of the island (with the exception of Watertunnel Beach and Good Hope Bay in the southern coast) where there are numerous popular sites for hauling out (Fig.2.2).

The winter haulout is the least important but also, the least understood haulout (Pistorius *et al.* 1999a, b; Kirkman *et al.* 2001). The assumed low importance of the winter haulout is perhaps the reason why animals hauling out to winter do not have to be very specific about which sites to use. Mostly young animals participate in the winter haulout (Pistorius *et al.* 1999a,b; Hofmeyr 2000; Kirkman *et al.* 2001.). These young animals seek haulout sites on a basis different to those of old animals (Hofmeyr 2000) and all they appear to need is a beach with a flat surface on which they can lien (Bester 1982; Hofmeyr 2000). This behaviour might be related during their relatively short stay on shore (a few days at a time) compared to older animals (four weeks by adult females, adult males and subadults during the moult as well as adult females during the breeding season, and six weeks by adult males during the breeding haulout (Kirkman *et al.* 2003). Juvenile elephant seals, on the other hand, perhaps do not have enough previous haulout experience which result in the seemingly uninformed site choice (present study).

Both during the population decline and after population stabilization, younger (underyearlings and yearlings) animals appeared to be generalists in site usage while older (subadult and adult) animals were quite specific in site selection during the different haulouts. Difference in site preference between sexes of the same age group is only

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evident at the level of subadults and adults, implying that differential site utilization develops with age in southern elephant seals. The significant domination of males by females at certain sites during the breeding haulout is a result of the polygamous breeding in elephant seals as this only happens at the main breeding beaches where the harems are large.

The observed difference in site usage by southern elephant seals at high population density versus low population density suggests that population density has an effect on site selection by elephant seals at Marion Island. Campagna & Lewis (1992) found that there is change in habitat preference as the population of southern elephant seals increased at Peninsula Valdés, and the converse seems to apply to the Marion Island elephant seal population (present study). At high population density, elephant seals seemed to use all or most of the available sites, while at low population density they preferred certain sites.

No doubt the choice of coastline for haulout by elephant seals is influenced by the presence of suitable sites for breeding, moulting and resting, so the closure of Kaalkoppie beach, accompanied by the decrease in numbers of elephant seals, could have facilitated the abandoning of the sites on the western side of the island.

Over the whole study period, there are sites that are simply more popular than others, both during the decline and after stabilization of the elephant seal population. The qualities that make these sites attractive to southern elephant seals at Marion Island will be assessed in Chapter 7.

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CHAPTER 6 SOCIAL INFLUENCE ON HAULOUT SITE USAGE BY ELEPHANT SEALS

6.1 Introduction

The haulout pattern of southern elephant seals at Marion Island shows a high degree of organization, with the peak haulout of different age classes at different times (Condy 1979). There is, however, overlap between haulout events at the population scale (Kirkman *et al.* 2003), as illustrated in Fig. 6.1 (taken from Wilkinson 1992). The elephant seal haulout sequence, characterized by a high degree of synchronization and annual regularity is similar to that occurring at other elephant seals breeding grounds (Condy 1979; Carrick *et al.* 1962).

During the winter and the moult haulout, southern elephant seals show a pronounced degree of gregariousness and thigmotactism, except for underyearling seals that lie singly (Carrick *et al.* 1962). This serves to raise the environmental temperatures, as it is noticeable that on cold days the aggregations are more closely packed than on warm sunny days during the moulting season (Laws 1960). The degree of association between individual seals during the moulting season depends on the tolerance between different age groups, with adult females being more tolerant of the younger animals at Marion Island (Panagis 1984). Most of the aggregations comprize animals of the same age groups (this study).

During the breeding season, female elephant seals haul out at beaches that are appropriated by beach masters (Carrick *et al.* 1962). Laws (1954) reported that bulls do not contribute to harem formation and growth in numbers, but bulls may prevent females from leaving the harems. Cows are more safe from harassment in large harems than in small harems. In large harems, chances of cows interacting with harassing secondary bulls are less (Galimberti *et al.* 2000a). Breeding females have a tendency of selecting sites with a mature, large beachmaster during the breeding season as they offer protection to breeding cows from harassment by secondary bulls (Galimberti *et al.* 2000a). The fear

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of harassment from these inexperienced bulls could also be a reason why females aggregate during the breeding season as secondary bulls target isolated cows (Galimberti *et al.* 2000b).

Underyearlings and yearlings appear to avoid older seals during haulouts. Condy (1979) found that the decline in numbers of wintering juveniles accelerates during September when the number of cows hauling out to breed increase at the beaches. During the moult and the winter haulouts, first year elephant seals lie around singly while seals of other age groups are gregarious and thigmotactic (Carrick *et al.* 1962).

This chapter aims to determine the influence of certain age and sex groups on the choice of a haulout site by other age groups.

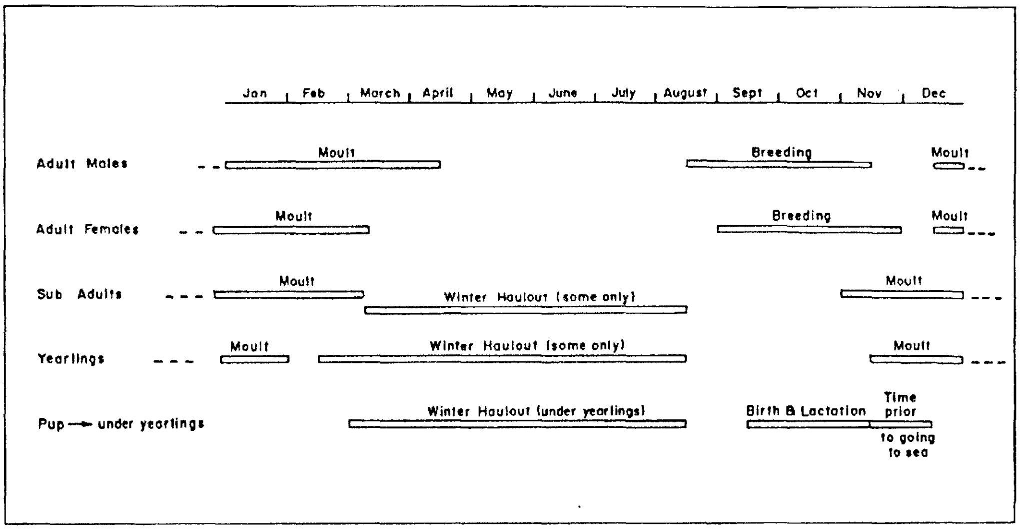

Fig 6.1. Southern elephant seal haulout pattern at Marion Island (Taken from Wilkinson 1992).

6.2 METHODS

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Statistical analysis of data was restricted to that from individual months when significant overlap in haulouts between different age groups occurred. These overlaps, noted in Wilkinson (1992), are summarized in Table 6.1.

Data from each month with overlapping haulouts was treated separately. Frequencies of occurrence of animals in each of the age classes from each site were calculated using the SAS statistical package. To test for statistical significant differences in the frequencies of occurrence of the different age classes, a standardized Log-Linear Coefficient (z), was computed for each age group and site using the Log-Linear Model. The Log-Linear coefficient is significant at /z/ = 2.58 (Agresti 1990).

Table 6.1 Summary of the haulout overlaps in elephant seals at Marion Island. Section 2.3 describes the codes used for the different age classes

Month	Period	Age classes
January	Moult	20,30,40
February	Moult	20,30,40
March	Moult	40
	Winter	20,30
May	Winter	10,20,30
June	Winter	10,20,30
July	Winter	10,20,30
November	Breeding	40
	Moult	20,30
December	Moult	20,30,40

6.3 Results

Moult Overlap.

From December to February there is an overlapping moult haulout by yearlings, subadults and adults. During December, yearlings significantly discriminated against sites MM018, MM020, MM025, and MM026, while subadults only discriminated against site MM026. No sites were significantly preferred during this month ($P < 0.0001$). During January, adult males preferred sites MM025 and MM057, and females preferred

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site MM064. There was no discrimination against any site during this month (P = 0.0339). During February, no sites were discriminated against or preferred (P = 0.1104) (Tables 6.2 – 6.4).

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Table 6.2. Results of the Log-Linear model applied to the contingency table for beach and age classes during the January overlapping moult haulout. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if /z/≥2.58.

	Yearlings	Subadults	A-Females	A-Males	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	10(-0.459)	94(0.302)	54(-0.459)	4(0.416)	162(5.022)
MM002	13(-0.269)	125(0.916)	56(-1.405)	5(0.478)	199(6.904)
MM003	4(0.283)	44(1.060)	28(0.959)	0(-0.887)	76(-0.948)
MM004	16(1.171)	101(0.404)	40(-2.344)	4(0.266)	161(5.611)
MM006	4(1.688)	8(-1.167)	8(-0.252)	0(-0.203)	20(-2.774)
MM007	19(0.153)	162(0.852)	108(0.883)	4(-0.831)	293(8.757)
MM008	0(0.523)	0(-1.168)	0(-0.821)	0(1.461)	0(-4.391)
MM009	9(0.530)	77(1.031)	45(0.518)	1(-0.892)	132(1.631)
MM010	3(1.005)	18(0.437)	5(-0.942)	0(-0.264)	26(-2.588)
MM011	12(1.248)	106(1.736)	57(1.164)	0(-1.514)	175(0.833)
MM012	2(-1.014)	33(0.180)	30(1.266)	0(0.150)	65(-1.055)
MM013	5(-0.529)	71(1.359)	42(0.902)	1(-0.606)	119(0.818)
MM014	2(1.438)	4(-1.029)	2(-1.188)	0(0.372)	8(-3.940)
MM015	21(0.821)	162(1.141)	82(-0.534)	4(-0.712)	269(8.465)
MM016	6(-0.017)	66(1.191)	34(0.210)	1(-0.561)	107(0.704)
MM017	0(0.193)	2(-0.250)	0(-1.198)	0(1.164)	2(-4.456)
MM018	25(-0.224)	206(0.195)	179(2.179)	6(-0.904)	416(13.054)
MM019	3(0.941)	18(0.354)	7(-0.734)	0(-0.298)	28(-2.505)
MM020	20(0.010)	161(0.304)	117(0.929)	5(-0.554)	303(10.027)
MM025	12(-2.163)	126(-1.603)	105(0.146)	13(2.874)	256(11.767)
MM026	6(-1.484)	71(-0.539)	56(0.443)	5(1.395)	138(4.051)
MM027	1(0.579)	4(-0.934)	3(-0.604)	0(0.411)	8(-3.945)
MM051	4(0.326)	39(0.803)	3(1.101)	0(-0.867)	72(-1.004)
MM052	6(0.309)	41(-0.219)	29(0.655)	1(-0.370)	82(0.194)
MM053	12(-1.770)	130(-0.696)	34(0.593)	8(1.569)	253(10.276)
MM054	2(0.655)	9(-0.653)	103(0.010)	0(-0.090)	19(-2.986)
MM055	5(-1.012)	70(0.759)	8(1.004)	2(-0.054)	126(1.794)
MM056	11(-1.545)	163(1.562)	49(0.976)	5(-0.013)	278(8.075)
MM057	6(-2.015)	74(-1.267)	99(0.432)	7(2.592)	152(5.533)
MM058	4(-0.875)	47(0.002)	65(-0.87)	3(1.264)	79(0.649)
MM059	5(-0.504)	53(0.316)	25(-0.186)	2(0.317)	91(0.861)
MM060	4(-0.054)	64(1.608)	31(1.317)	0(-1.048)	106(-0.497)
MM061	2(1.823)	1(-1.898)	38(-0.714)	0(0.622)	5(-4.284)
MM062	9(-1.326)	134(1.557)	74(0.549)	4(0.029)	221(5.964)
MM063	5(-0.704)	78(1.447)	50(1.328)	1(-0.714)	134(1.104)
MM064	3(-1.552)	77(1.461)	72(2.775)	1(-0.667)	153(0.945)
MM065	15(-0.675)	159(1.031)	96(0.180)	5(-0.191)	275(8.817)
MM066	3(-1.310)	56(0.826)	35(0.585)	1(0.453)	95(0.479)
MM067	11(0.621)	84(0.689)	67(1.531)	1(-1.174)	163(2.435)
MM068	0(-0.973)	7(-0.710)	8(0.396)	1(1.678)	16(-3.279)
Total	300(-7.837)	2945(22.974)	1945(14.963)	98(-15.042)	5289

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.0339

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Table 6.3. Results of the Log-Linear model applied to the contingency table for beach and age classes during the February overlapping moult haulout. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if /z/≥2.58.

	Yearlings	Subadults	A-Females	A-Males	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	8(0.273)	10(-0.978)	16(-2.179)	14(2.754)	48(6.983)
MM002	7(0.192)	13(-0.172)	19(-1.650)	9(1.301)	49(7.175)
MM003	1(-0.260)	5(1.062)	14(1.767)	0(-1.111)	20(-0.922)
MM004	1(-0.771)	7(1.345)	12(0.954)	1(-0.618)	21(-0.236)
MM006	1(0.673)	1(-0.092)	3(0.128)	0(-0.465)	5(-2.285)
MM007	7(-0.922)	16(-0.238)	42(0.955)	9(0.547)	74(8.849)
MM008	0(0.361)	0(-0.109)	0(-0.696)	0(0.443)	0(-3.041)
MM009	4(0.424)	4(-0.510)	12(0.011)	3(0.040)	24(1.605)
MM010	3(2.435)	1(0.263)	0(-1.425)	0(-0.205)	4(-2.461)
MM011	7(0.071)	16(1.184)	35(1.370)	3(-1.513)	61(5.533)
MM012	1(-0.811)	4(0.037)	13(1.169)	2(0.169)	20(-0.184)
MM013	4(1.278)	6(0.961)	11(0.741)	0(-1.370)	21(-0.334)
MM014	1(1.447)	0(-0.348)	0(-0.952)	0(0.220)	1(-2.894)
MM015	11(1.205)	12(-0.579)	28(-0.144)	6(-0.440)	57(7.221)
MM016	5(0.496)	11(1.171)	14(-0.152)	2(-1.013)	32(2.487)
MM017	0(0.361)	0(-0.109)	0(-0.696)	0(0.443)	0(-3.041)
MM018	9(-0.144)	13(-0.729)	51(2.098)	6(-0.577)	81(8.660)
MM019	1(0.977)	0(-0.796)	2(0.531)	0(-0.205)	3(-2.461)
MM020	13(0.409)	16(-1.129)	52(1.186)	9(-0.191)	91(11.228)
MM025	2(-2.556)	20(1.198)	36(0.779)	15(2.746)	73(6.227)
MM026	3(-0.657)	10(0.835)	7(-2.387)	8(2.567)	28(2.769)
MM027	0(0.361)	0(-0.109)	0(-0.696)	0(0.443)	0(-3.041)
MM051	1(0.130)	2(0.065)	10(1.574)	0(-0.8450	13(-1.522)
MM052	1(-0.397)	2(-0.568)	14(1.924)	1(-0.248)	18(-0.933)
MM053	7(-0.419)	12(-0.887)	36(0.344)	11(1.025)	67(8.697)
MM054	0(-0.395)	1(0.120)	5(1.116)	0(-0.307)	6(-2.278)
MM055	3(-1.062)	10(0.282)	16(-0.629)	8(1.664)	37(3.783)
MM056	7(-1.193)	26(1.567)	40(0.292)	9(-0.101)	82(9.545)
MM057	2(-1.086)	7(-0.008)	13(-0.398)	6(1.892)	28(2.183)
MM058	2(-0.391)	7(0.913)	10(-0.094)	2(-0.199)	21(0.546)
MM059	1(-1.381)	9(1.203)	11(-0.275)	5(1.328)	26(1.135)
MM060	1(-0.887)	9(1.952)	7(-0.558)	2(0.095)	19(-0.048)
MM061	0(0.361)	0(-0.109)	0(-0.696)	0(0.443)	0(-3.041)
MM062	8(-0.448)	21(1.025)	36(0.292)	7(-0.513)	72(8.545)
MM063	0(-1.126)	1(-0.938)	16(2.212)	3(1.468)	20(-1.097)
MM064	7(1.219)	6(-0.811)	27(1.725)	2(-1.172)	42(2.865)
MM065	10(0.969)	13(-0.148)	29(0.185)	5(-0.784)	57(6.756)
MM066	2(0.103)	3(-0.358)	13(1.327)	1(-0.555)	19(-0.392)
MM067	4(-0.440)	9(0.043)	19(0.115)	5(0.350)	37(3.626)
MM068	0(0.026)	0(-0.460)	1(0.491)	0(0.111)	1(-2.747)
Total	164(-4.025)	306(1.303)	675(9.134)	160(-4.503)	1290

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.1104

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Table 6.4. Results of the Log-Linear model applied to the contingency table for beach and age classes during the December overlapping moult haulout. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if /z/≥2.58.

	Yearlings	Subadults	A-Females	A-Males	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	69(0.706)	139(1.560)	19(0.703)	0(-1.044)	227(0.323)
MM002	125(-0.569)	172(-1.164)	28(-1.787)	5(1.740)	330(8.762)
MM003	47(0.798)	58(0.062)	6(-1.542)	1(0.541)	112(-0.916)
MM004	93(0.500)	150(0.884)	27(0.493)	1(-0.704)	271(2.624)
MM006	28(1.029)	30(0.212)	3(-0.853)	0(-0.042)	61(-2.472)
MM007	116(-0.959)	251(1.449)	39(0.006)	3(-0.169)	409(7.145)
MM008	9(0.539)	12(0.328)	0(-1.288)	0(0.853)	21(-3.826)
MM009	52(0.383)	100(1.097)	19(0.993)	0(-0.886)	171(-0.143)
MM010	34(0.522)	38(-0.229)	11(0.808)	0(-0.428)	83(-1.467)
MM011	138(1.940)	168(1.052)	22(-0.584)	1(-0.829)	329(2.977)
MM012	19(-1.781)	36(-1.015)	11(0.705)	1(0.862)	67(-1.802)
MM013	79(1.016)	89(-0.184)	17(-0.159)	1(-0.241)	186(1.262)
MM014	25(0.967)	15(-1.239)	5(0.180)	0(0.038)	45(-2.735)
MM015	145(1.747)	214(1.74)	24(-0.627)	1(-0.983)	384(3.432)
MM016	55(-0.067)	82(-0.057)	17(0.241)	1(-0.061)	155(0.747)
MM017	9(0.046)	6(-1.292)	2(-0.131)	0(0.628)	17(-4.118)
MM018	164(-2.932)	283(-1.691)	74(0.831)	9(1.496)	530(15.953)
MM019	17(0.064)	25(0.022)	4(-0.192)	0(0.057)	46(-2.768)
MM020	116(-2.922)	224(-0.884)	42(0.882)	8(2.135)	390(11.854)
MM025	79(-3.291)	228(1.082)	43(0.848)	3(0.564)	354(7.656)
MM026	69(-2.632)	104(-2.678)	34(0.761)	5(1.916)	212(6.108)
MM027	8(0.397)	4(-1.564)	1(-0.432)	0(0.887)	13(-4.527)
MM051	26(-0.257)	52(0.515)	12(0.941)	0(-0.459)	90(-1.379)
MM052	21(-0.838)	64(1.025)	13(1.093)	0(-0.477)	98(-1.328)
MM053	127(-0.662)	199(-0.305)	40(-0.043)	4(0.400)	370(8.139)
MM054	12(-0.127)	16(-0.408)	3(-0.171)	0(0.300)	31(-3.376)
MM055	47(0.332)	94(1.149)	16(0.762)	0(-0.807)	157(-0.374)
MM056	106(-0.412)	218(1.423)	35(0.301)	2(-0.494)	361(5.190)
MM057	54(-1.352)	91(-0.758)	24(0.750)	2(0.497)	171(2.282)
MM058	58(-0.463)	91(-0.184)	10(-1.094)	2(1.639)	161(1.756)
MM059	50(0.601)	76(0.667)	16(0.857)	0(-0.771)	142(-0.479)
MM060	50(0.377)	109(1.358)	16(0.648)	0(-0.850)	172(-0.246)
MM061	15(0.435)	9(-1.591)	4(0.362)	0(0.320)	28(-3.457)
MM062	76(-0.809)	160(1.703)	24(-0.247)	2(0.031)	262(3.620)
MM063	73(0.136)	123(0.701)	22(0.320)	1(-0.443)	219(1.854)
MM064	100(0.919)	133(0.433)	26(0.428)	1(-0.670)	260(2.521)
MM065	114(-0.818)	218(0.730)	39(0.307)	3(-0.094)	375(6.932)
MM066	29(-1.358)	71(0.599)	10(-0.179)	1(0.424)	111(-0.616)
MM067	110(1.483)	119(0.028)	24(0.201)	0(-0.635)	254(2.416)
MM068	9(-1.579)	10(-2.500)	5(0.397)	1(1.924)	25(-4.277)
Total	2574(22.613)	4278(30.859)	790(-2.056)	62(-19.950)	7707

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	<0.0001

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Table 6.5. Results of the the Log-Linear model applied to the contingency table for beach and age classes during the overlapping March moult haulout for adults and winter haulout for juvenile elephant seals. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if /z/≥2.58.

	U/yearlings	Yearlings	Subadults	A-Females	A-Males	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	17(-0.107)	34(-0.512)	13(0.110)	0(-0.800)	11(2.721)	75(2.086)
MM002	27(0.310)	59(0.211)	16(-0.200)	0(-1.079)	16(3.030)	118(3.183)
MM003	4(-0.236)	16(0.786)	3(0.376)	0(0.320)	0(-0.702)	23(-1.545)
MM004	20(1.356)	52(1.742)	16(1.597)	0(-0.369)	0(-1.399)	88(0.374)
MM006	3(-0.185)	15(1.316)	1(-0.816)	0(0.549)	0(-0.465)	19(-2.079
MM007	15(-2.661)	87(0.986)	27(0.761)	1(0.256)	7(0.548)	139(7.296)
MM008	1(-0.237)	2(-0.691)	0(-0.801)	0(1.173)	0(0.190)	3(-3.226)
MM009	6(-0.752)	13(-0.889)	5(-0.347)	0(-0.175)	5(2.183)	29(-0.244)
MM010	8(0.727)	18(0.722)	4(0.105)	0(0.190)	0(-0.834)	30(-1.200)
MM011	28(1.876)	59(1.754)	10(0.279)	1(0.607)	0(-1.639)	98(1.171)
MM012	5(-0.617)	11(-0.893)	4(-0.305)	0(0.012)	3(1.459)	23(-0.873)
MM013	11(0.779)	40(1.715)	9(0.884)	0(-0.142)	0(-1.170)	60(-0.277)
MM014	6(0.495)	13(0.379)	3(-0.046)	0(0.334)	0(-0.668)	22(-1.584)
MM015	18(0.108)	50(0.724)	16(0.724)	0(-0.781)	5(0.750)	89(1.989)
MM016	7(-0.586)	32(1.144)	6(-0.129)	0(-0.233)	1(0.283)	46(-0.037)
MM017	3(0.246)	4(-0.713)	1(-0.472)	0(0.770)	0(-0.240)	8(-2.628)
MM018	38(1.370)	93(1.606)	19(0.365)	0(-1.096)	6(0.363)	157(3.206)
MM019	8(0.238)	9(-1.454)	4(-0.406)	0(-0.032)	3(1.372)	24(-0.731)
MM020	26(-1.411)	79(-0.068)	16(-1.780)	3(0.809)	11(1.308)	135(8.848)
MM025	26(-0.025)	33(-2.479)	15(-0.519)	1(-0.272)	14(3.045)	89(5.290)
MM026	10(-0.395)	25(-0.218)	7(-0.365)	0(-0.447)	5(1.994)	47(0.734)
MM027	0(-0.606)	0(-1.261)	0(-0.333)	0(1.566)	0(0.620)	0(-3.592)
MM051	6(0.524)	12(0.245)	3(-0.019)	0(0.348)	0(-0.674)	21(-1.619)
MM052	4(-1.061)	1(0-1.219)	4(-0.311)	1(1.616)	1(-0.087)	20(-1.086)
MM053	24(0.005)	71(0.852)	22(0.745)	0(-1.066)	9(1.710)	126(3.119)
MM054	2(-0.933)	3(-1.900)	3(0.206)	0(0.462)	2(1.566)	10(-2.211)
MM055	9(-0.232)	14(-1.285)	6(-0.309)	0(-0.302)	6(2.344)	35(0.208)
MM056	28(-1.057)	72(-0.607)	37(1.551)	1(-0.753)	13(1.727)	151(7.151)
MM057	10(-0.549)	32(0.315)	11(0.553)	0(-0.500)	4(0.938)	57(0.928)
MM058	18(0.924)	38(0.844)	7(-0.544)	0(-0.515)	3(0.359)	66(0.969)
MM059	13(0.102)	23(-0.624)	8(-0.213)	0(-0.499)	6(1.867)	50(0.931)
MM060	9(0.119)	23(0.393)	8(0.641)	0(-0.174)	1-0.390)	41(-0.230)
MM061	2(-0.562)	6(-0.412)	3(0.522)	0(0.623)	0(-0.393)	11(-2.310)
MM062	22(-1.285)	43(-2.268)	13(-1.757)	3(1.192)	12(2.242)	93(7.491)
MM063	7(-1.427)	42(1.389)	11(0.665)	1(0.804)	1(-0.931)	62(1.088)
MM064	17(0.922)	51(1.632)	22(2.288)	0(-0.392)	0(-1.423)	90(0.440)
MM065	27(1.243)	55(0.982)	15(0.694)	0(-0.787)	3(-0.225)	100(1.980)
MM066	8(0.603)	17(0.461)	6(0.712)	0(0.137)	0(-0.889)	31(-1.056)
MM067	25(1.481)	45(0.891)	18(1.620)	0(-0.613)	1(-1.091)	89(1.266)
MM068	4(0.927)	4(-0.390)	0(-1.093)	0(0.900)	0(-0.093)	8(-2.699)
Total	524(0.749)	1307(22.137)	397(4.698)	12(-11.476)	152(-5.916)	2396

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.0085

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Table 6.6. Results of the Log-Linear model applied to the contingency table for beach and age classes during the May overlapping winter haulout between underyearling, yearling and subadult elephant seals. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if $/z/\geq 2.58$.

	U/yearlings	Yearlings	Subadults	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	16(-0.428)	10(0.081)	30(0.382)	58(4.114)
MM002	32(0.894)	20(1.441)	29(-2.483)	81(8.467)
MM003	3(-1.553)	5(1.075)	12(0.799)	20(-2.079)
MM004	19(1.710)	17(0.556)	50(1.383)	86(7.461)
MM006	4(-0.309)	7(2.723)	3(-2.002)	14(-2.826)
MM007	24(-0.729)	17(0.341)	45(0.407)	86(8.034)
MM008	0(-1.266)	2(1.427)	3(0.483)	5(-3.451)
MM009	12(-0.210)	7(0.342)	19(-0.186)	38(1.264)
MM010	139(0.616)	6(-0.209)	16(-0.382)	35(0.511)
MM011	37(1.599)	15(-0.588)	38(-0.898)	90(8.599)
MM012	18(2.640)	5(-0.177)	8(-2.086)	31(-0.407)
MM013	23(1.518)	11(0.432)	18(-1.957)	52(3.486)
MM014	6(0.263)	3(-0.021)	8(-0.253)	17(-2.358)
MM015	29(1.061)	12(-0.388)	34(-0.617)	75(6.647)
MM016	16(0.613)	6(-0.966)	25(0.668)	47(1.803)
MM017	3(0.786)	0(-1.007)	5(0.858)	8(-3.086)
MM018	45(2.032)	12(-2.265)	59(1.101)	116(9.671)
MM019	4(0.111)	6(2.550)	2(-2.131)	12(-3.128)
MM020	32(-0.541)	21(0.168)	56(0.401)	109(11.151)
MM025	22(0.601)	8(-1.353)	38(1.250)	68(4.329)
MM026	7(0.459)	3(-0.240)	9(-0.175)	19(-2.074)
MM027	0(-0.372)	0(0.120)	1(0.319)	1(-3.786)
MM051	7(-0.129)	5(0.541)	10(-0.497)	22(-1.467)
MM052	3(-1.493)	4(0.511)	14(1.369)	21(-2.097)
MM053	28(1.745)	8(-1.492)	33(0.264)	69(4.613)
MM054	5(-0.443)	3(-0.208)	12(0.799)	20(-2.079)
MM055	11(0.757)	3(-1.226)	18(0.980)	32(-0.603)
MM056	27(0.192)	13(-0.766)	45(0.808)	85(7.371)
MM057	8(0.375)	2(-1.330)	18(1.635)	28(-1.379)
MM058	17(-0.820)	17(1.619)	28(-0.928)	62(5.435)
MM059	7(0.572)	3(-0.144)	8(-0.409)	18(-2.204)
MM060	4(-0.662)	4(0.772)	8(-0.129)	16(-2.506)
MM061	5(0.240)	2(-0.391)	8(0.263)	15(-2.722)
MM062	15(-0.700)	10(-0.054)	32(0.885)	57(3.554)
MM063	16(-0.051)	10(0.260)	24(-0.265)	50(3.012)
MM064	19(-1.406)	20(1.760)	36(-0.404)	75(7.029)
MM065	13(-0.616)	9(0.142)	26(0.530)	48(2.403)
MM066	6(0.860)	1(-1.091)	9(0.759)	16(-2.618)
MM067	22(0.332)	11(-0.392)	32(0.145)	65(5.046)
MM068	8(1.271)	2(-0.628)	7(-0.416)	17(-2.429)
Total	587(0.519)	323(-7.991)	881(9.525)	1793

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.1700

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Table 6.7. Results of the Log-Linear model applied to the contingency table for beach and age classes during the June overlapping winter haulout between underyearling, yearling and subadult elephant seals. The numbers in brackets are the standardized estimated Log-Linear coefficients, significant if /z/≥2.58.

	U/yearlings	Yearlings	Subadults	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	12(-0.443)	5(-0.842)	34(1.753)	51(3.528)
MM002	19(0.458)	9(0.189)	25(-0.729)	53(5.845)
MM003	3(-0.192)	2(0.535)	5(-0.434)	10(-2.147)
MM004	16(-0.181)	8(-0.117)	31(0.631)	55(5.420)
MM006	6(1.987)	2(1.334)	0(-2.074)	8(-2.399)
MM007	13(-1.200)	9(0.215)	36(1.162)	58(5.649)
MM008	1(0.817)	0(0.246)	0(-0.893)	1(-3.235)
MM009	8(1.411)	3(0.617)	4(-1.899)	15(-1.212)
MM010	5(-1.308)	7(1.876)	11(-0.523)	23(0.632)
MM011	25(1.0864)	3(-2.421)	43(2.058)	71(4.116)
MM012	4(0.073)	2(0.245)	5(-0.388)	11(-1.786)
MM013	11(0.798)	3(-0.150)	13(-0.628	27(1.130)
MM014	7(1.805)	2(0.545)	2(-1.984)	11(-2.099)
MM015	25(0.460)	1(-0.182)1	38(-0.257)	74(8.560)
MM016	8(-0.853)	5(-0.004)	23(1.035)	36(1.962)
MM017	0(-0.966)	1(1.121)	2(0.183)	3(-3.047)
MM018	32(1.151)	9(-1.145)	48(0.373)	89(9.635)
MM019	2(0.075)	0(-0.937)	9(1.535)	11(-2.177)
MM020	21(0.770)	6(-1.302)	38(1.072)	65(5.644)
MM025	10(0.157)	2(-1.652)	33(2.547)	45(1.292)
MM026	2(-1.773)	4(1.184)	12(1.086(	18(-0.998)
MM027	0(-1.807	1(0.979)	3(0.546)	4(-2.905)
MM051	3(-0.605)	3(1.015)	6(-0.475)	12(-1.745)
MM052	3(-1.239)	5(1.793)	8(-0.444)	16(-0.987)
MM053	23(0.738)	6(-1.669)	47(1.713)	76(6.374)
MM054	3(-0.035)	1(-0.332)	7(0.517)	11(-2.120)
MM055	12(1.422)	2(-1.187)	15(0.337)	29(0.457)
MM056	21(1.533)	2(-2.530)	48(2.764)	71(2.960)
MM057	3(-0.830)	3(0.808)	8(0.024)	14(-1.462)
MM058	15(0.678)	4(-1.206)	28(1.060)	47(3.056)
MM059	5(-0.217)	3(0.365)	9(-0.219)	17(-0.850)
MM060	9(0.827)	1(-0.918)	14(0.488)	24(-0.008)
MM061	1(-0.526)	1(0.555)	2(-0.036))	4(-3.030)
MM062	19(0.397)	8(0.139)	27(-0.604)	54(5.946)
MM063	13(-0.002)	3(-1.286)	35(1.968)	51(3.186)
MM064	20(0.715)	7(-0.701)	31(0.199)	58(5.569)
MM065	22(-0.003)	11(0.388)	35(-0.490)	68(8.247)
MM066	1(-1.088)	1(0.021)	9(1.488)	11(-2.364)
MM067	27(1.482)	9(-0.482)	30(-0.884)	66(7.254)
MM068	3(-0.103)	3(1.454)	3(-1.357)	9(-2.286)
TOTAL	433(0.655)	172(-8.477)	783(9.221)	1389

Significance of Factors	
Factor	P-value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.0385

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Table 6.8. Results of the Log-Linear model applied to the contingency table for beach and age classes during the July overlapping winter haulout of underyearling, yearling and subadults elephant seals. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if $/z/\geq 2.58$.

	U/yearlings	Yearlings	Subadults	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	15(1.416)	8(-0.257)	8(-0.983)	31(2.016)
MM002	29(1.944)	19(0.103)	14(-1.751)	62(7.329)
MM003	6(1.611)	2(0.294)	1(-1.384)	9(-2.427)
MM004	27(0.604)	22(0.206)	21(-0.767)	70(9.386)
MM006	4(1.347)	3(1.041)	1(-1.482)	7(-2.566)
MM007	17(-1.685)	24(0.843)	28(1.000)	69(8.966)
MM008	1(0.833)	0(-0.289)	0(-0.370)	1(-3.328)
MM009	9(0.419)	10(1.126)	4(-1.326)	23(0.430)
MM010	7(0.098)	5(-0.578)	8(0.539)	20(-0.277)
MM011	30(1.037)	16(-1.827)	30(1.053)	76(9.629)
MM012	9(2.206)	4(0.416)	1(-1.781)	14(-1.915)
MM013	9(0.019)	7(-0.055)	9(0.037)	25(1.044)
MM014	4(0.015)	6(1.362)	2(-1.172)	12(-2.011)
MM015	22(1.771)	7(-2.274)	19(1.074)	50(4.872)
MM016	11(-0.227)	10(-0.222)	12(0.468)	33(2.641)
MM017	2(0.050)	3(0.931)	1(-0.801)	6(-3.036)
MM018	24(-0.781)	26(0.447)	28(0.353)	79(10.896)
MM019	1(-0.759)	5(1.965)	1(-0.751)	7(-2.919)
MM020	14(-1.416)	20(0.747)	22(0.793)	56(6.636)
MM025	9(-1.467)	8(-1.499)	29(3.707)	46(3.377)
MM026	3(-1.399)	5(-0.017)	10(1.806)	18(-0.984)
MM027	0(-0.028)	0(0.052)	0(-0.024)	0(-3.396)
MM051	3(-0.163)	2(-0.670)	5(0.985)	10(-2.360)
MM052	3(-0.825)	5(0.581)	5(0.341)	13(-1.729)
MM053	19(-1.993)	21(-0.972)	46(0.447)	86(10.593)
MM054	2(-1.343)	5(0.713)	6(0.958)	13(-1.827)
MM055	6(-0.788)	5(-0.989)	14(2.140)	25(0.329)
MM056	15(-1.539)	14(-1.393)	38(3.483)	67(7.309)
MM057	3(-0.438)	5(0.958)	3(-0.425)	11(-2.136)
MM058	14(-0.599)	12(-0.833)	22(1.591)	48(5.037)
MM059	4(-0.264)	4(-0.021)	5(0.298)	13(-1.695)
MM060	8(0.938)	2(-1.870)	10(1.653)	20(-0.817)
MM061	1(-0.759)	1(-0.611)	5(1.780)	7(-2.919)
MM062	15(0.688)	9(-0.978)	14(0.402)	38(3.272)
MM063	16(0.612)	14(0.421)	11(-0.957)	41(3.956)
MM064	15(-0.328)	12(-0.867)	21(1.319)	48(5.112)
MM065	31(1.269)	20(-0.717)	22(-0.449)	73(9.701)
MM066	2(-1.213)	5(0.853)	4(0.623)	11(-1.988)
MM067	22(0.661)	15(-0.779)	20(0.182)	57(6.881)
MM068	5(0.612)	5(0.853)	2(-1.200)	12(-1.988)
Total	437(0.499)	372(-0.902)	507(0.393)	1318

Significance of Factors	
Factor	P-Value
Group	<0.0001
Beach	<0.0001
Group and Beach	0.0034

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Table 6.9. Results of the Log-Linear model applied to the table for beach and age classes during the November overlapping breeding haulout for adults and moult haulout for juvenile elephant seals. The numbers in brackets are the standardized estimated Log-Linear coefficients and are significant if $/z/\geq 2.58$.

	Yearlings	Subadults	A-Females	A-Males	Total
Sites	Freq(z)	Freq(z)	Freq(z)	Freq(z)	Freq(z)
MM001	40(-1.266)	52(0.424)	3(-0.839)	6(1.647)	101(2.983)
MM002	86(-2.412)	92(-1.307)	12(0.362)	15(1.841)	205(11.974)
MM003	33(1.563)	25(1.116)	0(-1.114)	1(0.053)	59(-1.471)
MM004	77(-0.670)	70(-0.701)	13(1.965)	4(-0.811)	164(7.249)
MM006	19(1.324)	13(0.775)	0(-0.557)	0(-0.448)	32(-2.344)
MM007	69(-3.266)	108(0.286)	20(3.182)	7(-0.809)	204(10.569)
MM008	10(0.909)	4(-0.424)	0(-0.166)	0(-0.057)	14(-3.135)
MM009	24(-0.273)	39(1.678)	2(-0.011)	1(-0.629)	66(-0.620)
MM010	29(1.753)	20(1.199)	0(-0.747)	0(-0.638)	49(-1.936)
MM011	80(-1.756)	74(-1.665)	13(1.293)	10(0.704)	177(10.002)
MM012	16(-0.705)	6(-2.938)	4(2.089)	2(0.776)	28(-1.919)
MM013	49(1.091)	33(0.035)	5(1.135)	1(-1.188)	88(0.738)
MM014	15(0.982)	13(0.881)	0(-0.505)	0(-0.396)	28(-2.455)
MM015	95(0.677)	85(0.475)	6(-0.702)	7(0.118)	193(6.962)
MM016	45(-2.511)	42(-2.366)	8(1.290)	9(1.725)	104(5.662)
MM017	7(0.884)	1(-1.280)	0(0.157)	0(0.265)	8(-3.644)
MM018	113(-3.299)	121(-2.050)	30(3.377)	14(0.069)	278(17.048)
MM019	15(0.861)	17(1.266)	0(-0.564)	0(-0.455)	32(-2.330)
MM020	78(-4.181)	97(-1.990)	27(3.789)	11(0.319)	213(14.084)
MM025	64(-0.234)	76(1.182)	5(-0.418)	5(-0.074)	150(4.736)
MM026	60(-0.186)	32(-2.937)	7(0.774)	7(1.167)	106(4.712)
MM027	0(-1.704)	1(-0.916)	0(0.4000)	2(3.072)	3(-4.046)
MM051	24(1.210)	17(0.624)	0(-0.950)	1(0.299)	42(-1.885)
MM052	17(0.901)	23(1.654)	0(-0.659)	0(-0.550)	40(-2.126)
MM053	66(-7.321)	74(-5.887)	36(4.676)	32(4.617)	208(18.883)
MM054	10(0.648)	7(0.224)	0(-0.282)	0(-0.173)	17(-2.914)
MM055	24(0.492)	27(1.003)	0(-1.270)	3(1.363)	54(-1.177)
MM056	81(-4.774)	101(-2.420)	28(3.786)	15(0.888)	226(15.792)
MM057	34(1.327)	24(0.514)	1(-0.552)	1(-0.365)	60(-1.110)
MM058	41(-2.719)	43(-1.988)	14(3.564)	5(-0.099)	103(5.433)
MM059	32(-0.035)	26(-0.458)	1(-1.174)	6(2.311)	65(0.193)
MM060	33(-3.285)	39(-2.000)	6(0.319)	12(3.366)	90(4.834)
MM061	15(0.095)	10(-0.721)	1(0.088)	1(0.274)	27(-2.439)
MM062	38(-5.049)	53(-2.580)	14(2.317)	13(2.834)	119(8.875)
MM063	34(0.164)	54(1.620)	8(2.296)	0(-1.620)	96(0.091)
MM064	60(1.625)	54(1.556)	3(-0.131)	1(-1.263)	118(0.913)
MM065	65(-2.085)	75(-0.644)	13(1.798)	7(-0.061)	160(8.234)
MM066	16(0.647)	33(2.224)	0(-0.727)	0(-0.617)	49(-1.980)
MM067	88(2.689)	59(1.886)	2(-0.262)	0(-1.562)	149(-0.040)
MM068	7(0.684)	2(-0.901)	0(0.043)	0(0.152)	9(-3.504)
Total	1709(19.742)	1744(18.501)	285(-9.816)	202(-11.057)	3943

Significance of Factors
Factor
Group
Beach
Group and Beach

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Moult-Winter overlap.

During March, adult males and a few adult females are still moulting while underyearlings (pups from the previous breeding season) engage in the rest haulout. Adult males preferred sites MM001, MM002 and MM025, underyearlings disfavoured site MM007 ($P = 0.0085$) (Table 6.5).

Winter overlap.

During May, June and July subadults (mostly males), yearlings and underyearlings engage in the winter haulout. During May, there is no significant differential site use by the different age groups ($P = 0.1700$). There is no discrimination against any site during this month. Only subadults showed preference for site MM056 during June ($P = 0.0385$), and subadults preferred sites MM025 and MM056 during July ($P = 0.0034$) (Tables 6.6 – 6.8).

Breeding-Moult overlap.

During November, while adult elephant seals are still in the breeding haulout, yearlings and a few subadults haul out for moulting. Adults preferred sites MM007, MM018, MM020, MM053, MM056, MM058, MM060 and MM062. Subadults discriminated against sites MM012, MM026, MM053 and MM062. Yearlings preferred site MM067 and discriminated against sites MM007, MM018, MM020, MM053, MM056, MM058, MM060 and MM062 ($P < 0.0001$) (Table 6.9).

6.4 Discussion

From December to February, all age groups except pups of the previous breeding season are moulting. Yearlings and subadult elephant seals discriminated against sites that are

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preferred by adult seals, especially the adult males. Young animals and females do not appear to avoid each other during the moulting season (this study), as adult females are more tolerant of young animals during the moult haulout (Panagis 1984). The use of sites MM025 and MM057 by adult males and MM064 by adult females show that adult elephant seals purposefully select sites for the haulouts (present study).

Though adult males preferred sites MM001, MM002 and MM025 more than other age groups during the March overlap between adult males and juveniles for the moult and winter haulouts respectively, there seems to be no influence on juvenile site selection by adult males because juveniles did not significantly avoid these sites. The habit of moulting adult males to almost always select the vegetated humps behind the beaches (present study) while wintering juveniles would be lying around singly (Carrick *et al.* 1962) on the beach where there is a flat topography (Hofmeyr 2000; Bester 1980), this means no direct interaction between the two groups and hence no influence.

During the overlap in the winter haulout (May, June and July) between underyearling, yearling and subadult southern elephant seals, there is no significant difference in site use by these age groups. The absence of social influence during this overlap is likely to be caused by lack of haulout experience for seals hauling out for the winter. Individuals that haul out during this time are not preferential (present study) and no direct interaction takes place amongst individuals during this haulout as they lie singly and there are very few of them around at any one time (Carrick *et al.* 1962; Pistorious *et al.* 1999a,b; this study).

Young animals, first the yearlings and then the subadults haul out to moult while breeding adults are still present. This overlap is particularly significant during November. During this overlap yearlings significantly avoid the beaches that the adults preferred, mostly the main breeding beaches. At the sites where the harems are large, there are more secondary bulls, and chances of sexual harassment of animals not in the harems (outside the protection of the beachmaster) by these inexperienced, high libido males are elevated (Galimberti *et al.* 2000a). This can also happen to pups as they leave the harem after

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weaning (this study). This harassment occurs more often when there are fewer cows on land (Galimberti *et al.* 2000b), which is precisely the time when these young seals haul out for the moult. Lactating cows are also fairly aggressive during this period, which would further repel moulting seals from these sites.

The moulting and the breeding haulout periods of overlap produced clear evidence of the influence of one social group on another social groups` choice of haulout site. The winter haulout data, however, do not give a clue of social influence on terrestrial haulout usage. It is clear that there are sites that are simply superior to others, most of these sites are the same sites identified in the previous chapters as the main breeding and moulting beaches. It is at these sites where the influence of one social group on another social group`s site selection was most evident.

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Chapter 7 SITE SUITABILITY FOR THE HAULOUTS OF SOUTHERN ELEPHANT SEALS AT MARION ISLAND.

7.1. INTRODUCTION.

In the previous chapters it has been established that southern elephant seals of different age and sex groups prefer different sites during the different haulout events. Site suitability has been alluded to for the moult and the winter haulout at the Vestfold Hills, Antarctica (Tierney 1977), for the breeding season haulout at Kerguelen Island (van Aarde 1980) and for the moulting season haulout at Macquarie Island (Carrick *et al.* 1962), but has received little or no attention at Marion Island (present study).

Subadult and non-breeding southern elephant seals haul out to moult at the Vestfold Hills, Antarctica. The presence of suitable haulout sites there attracts southern elephant seals to the continent (Tierney 1977), and extends the area over which seals range and feed from their islands of origin (Tierney 1977; Gales & Burton 1989). During the breeding season, it is the regular haulout sites on islands that are sought, except in the case of the Peninsula Valdés (Laws 1994). Breeding seals rarely haul out on pack ice (Laws 1956).

On the Courbet Peninsula, Iles Kerguelen, four substrate types, namely sand, pebbles, cobbles and vegetated humps were important to breeding southern elephant seals (van Aarde 1980). The harem sizes seemed to be influenced by the surface structure of the breeding area (van Aarde 1980). Harems located on sandy beaches were reported to be nearly triple the size of those on pebble beaches, which in turn were about twice as large as those on vegetated humps behind the actual beach front (van Aarde 1980; Bester & Lenglart 1982).

At Macquarie Iisland, yearlings usually lie singly at the beach front while subadults seals use the beach front and the vegetated humps (tussock) at the back of the beach and are

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gregarious (Carrick *et al.* 1962). Batchelor bulls and older subadults prefer wallows while adult females prefer deeper wallows further inland of the beach. Adult bulls of breeding age use the tussock and the open beaches during the moult.

Though direct human disturbance has been rejected as a possible cause of population decline at Marion Island (Wilkinson & Bester 1988), it may cause sufficient disturbance that may result in cows abandoning harems (Laws 1956). Gales & Burton (1989) reported a decrease in the number of seals on Davis Beach in the Vestfold Hills during 1961- 1963 and attributed this decline to anthropogenic disturbance caused by daily visits to the beach and the killing of seals for dog food.

The accessibility of suitable areas on islands and continental coastlines for moulting during the summer is shown to be the reason for selection of these sites (Gales & Burton 1989). During the breeding season access to the breeding ground seems to be more important than a sheltered beach (Carrick *et al.* 1962). A rock platform just under the low water mark may hinder the hauling out by seals at some beaches that may seem favourable in other respects. The slope from waterline mark to the breeding or moulting ground may also make it difficult for seals to haul out at some beaches.

In this chapter I aim to assess the importance of site suitability using the following aspects of their physiognomy: presence of moult wallows, substrate make-up and beach type, and the likelihood of effects of anthropogenic disturbance in haulout site selection by different age groups during the various haulout events.

7.2 Methods

The various aspects of physiognomy were assessed from all the sites that were preferred by different age classes of elephant seals for the different haulout events. Not all sites have access to the wallows. If seals could access the vegetation behind the main beach, the site is said to have moult wallows. Some sites have one big open beach while some are several tiny outlets. The former are called single sites while the later are component

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sites. There are four types of substrate make-up, namely sand, pebbles, boulders and rocks. I used management regime status (Prince Edward Islands Management Plan Working Group 1996) of the sites as a measure of the level of anthropogenic disturbance. Sites in diffent management zones have different anthropogenic disturbance level.

7.3 Results

Comparing sites with moult wallows and sites without moult wallows, sites with moult wallows were generally preferred over sites without moult wallows, though this was not always statistically significant (Fig. 7.1). Though only statistically significant in two cases, single beaches were prefered more than component beaches (Fig 7.2). Sites in the wilderness area (zone 3) are preferred, followed by zone 4 and zone 2. Zone 1 is the least favoured. (Fig. 7.3). Generally, beaches with a smoother substrate are preferred to those with a rough substrate. Sites dominated by pebbles are used more than sites dominated by boulders which in turn are preferred more than sites dominated by rocks (Fig. 7.4).

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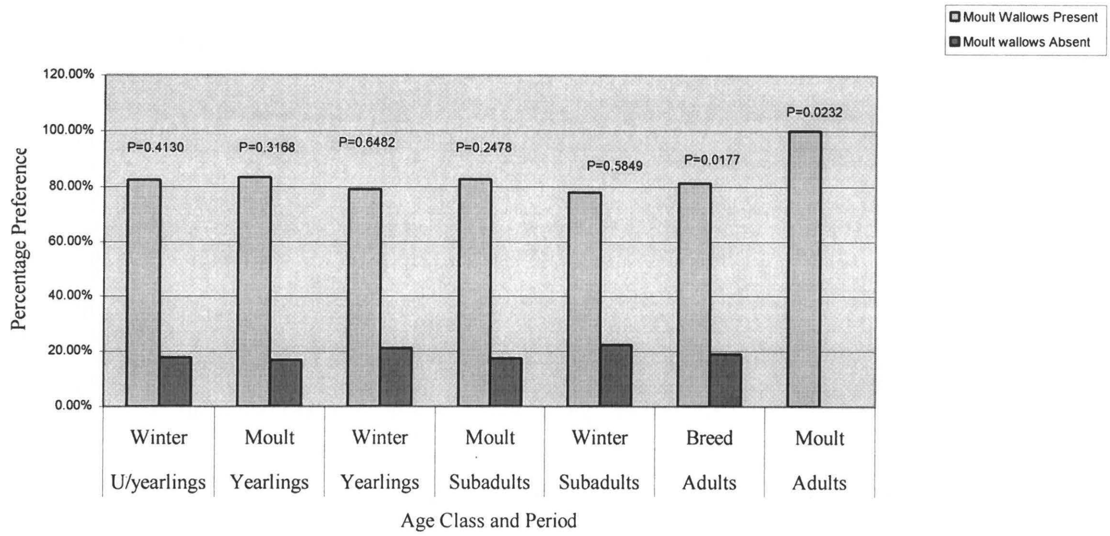

Fig. 7.1. Comparing the usage of sites with moult wallows and those without moult wallows during the different haulout season for the different age groups.

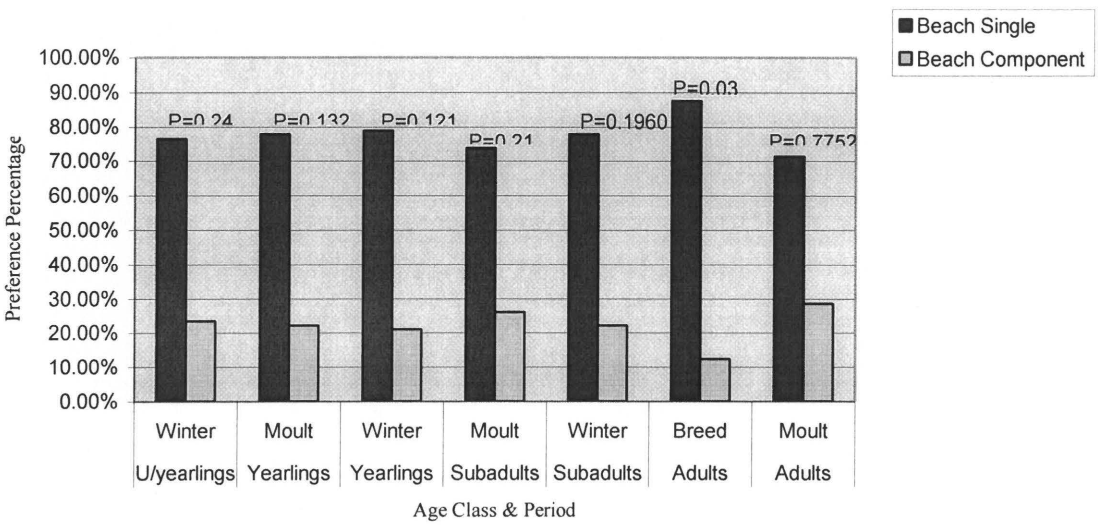

Fig 7.2. Comparing theh usage of single and component sites by southern elephant seals at Marion Island.

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Table 7.1. Description of the sites where elephant seals haul out at Marion Island

CODE	Site	Wallows Area	Substrate Description	Single or Component	Zone
001	Boulders	Y	B	Single	1
002	Trypot	Y	PB	Component	2
003	Maccaroni North	N	PR	Single	4
004	Maccaroni Main	N	PB	Single	4
005	Maccaroni Rocks	N	BR	Single	4
006	Archway North	Y	PR	Component	3
007	Archway Main	Y	PB	Single	3
008	East Cape	N	R	Component	3
009	Hansen Point	Y	PB	Single	3
010	Tiny Beaches	N	B	Component	3
011	Bullard North	N	PB	Single	3
012	Bullard South	Y	P	Single	3
013	Killer Whale Cove	Y	B	Single	3
014	Waterfall Beach	N	P	Single	3
015	Landfall Beach	Y	PB	Single	3
016	Sealer`s Cave	N	PB	Single	4
017	Whalebird Point	Y	B	Component	3
018	Funk Bay	Y	P	Single	3
019	Kildalkey Rocks	Y	P	Component	3
020	Kildalkey Beach	Y	PB	Single	3
025	Watertunnel Beach	Y	RP	Component	3
026	Goodhope East	Y	SB	Single	3
027	Goodhope West	Y	P	Single	4
051	Storm Petrel Bay	Y	PR	Component	3
052	ST Bay-Goney Bay	Y	RB	Component	3
053	Goney Bay	Y	PR	Single	3
054	Goney Bay-Log Beach	Y	RP	Component	3
055	Log Beach	Y	B	Component	3
056	King Penguin Bay	Y	PB	Single	3
057	KP Bay-Pinnacles Beach	Y	RPB	Component	3
058	Pinnacles Beach	Y	P	Single	3
059	Sea Elephant Bay	Y	P	Single	3
060	Blue Petrel Bay North	N	PB	Single	3
061	Blue Petrel Bay South	N	B	Single	3
062	Sealer's Beaches North	Y	P	Single	3
063	Sealer's Beaches South	N	P	Single	3
064	Sealer's Beaches-Ship`s Cove	Y	RPB	Component	3
065	Ship`s Cove	Y	SB	Single	2
066	Ship`s Cove- van den Boogaard	N	RB	Component	2
067	Van den Boogaard	Y	RB	Single	2
068	Rockhopper Bay	Y	RB	Single	2
	Notes:	Y=present	S=Sand		
		N=absent	P=Pebbles		
			R=Rocks		
			B=Boulders		

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7.4 Discussion

Southern elephant seals of all age groups showed a trend of preferring sites with moult wallows to those without moult wallows during all haulouts. This, however, does not mean that moult wallows are being used during all these haulouts,as only subadults and adults use wallows and only during the moult haulout (Carrick *et al.* 1962; this study). For the moult haulout of the yearlings and winter haulout of subadults, yearlings and underyearlings, the open beach front is normally preferred.

Adult males are known to use the open beaches during the moult (Carrick *et al.* 1962). This might be true only before they actually start shedding the moulted skin and after the moulting has been completed but before leaving the shore for the feeding trip (this study). Moult wallows hide animals from the chilling effect of wind during moulting, which according to Boily (1995) is associated with high thermal demands. The tendency of lying in closely packed groups (Fig 7.5) by subadults and adults also serves the purpose of meeting the thermal requirements by reducing the surface area of seals exposed to wind. Moulting elephant seals also use the sides of the moult excavations to scratch themselves as moulting is associated with skin irritations in elephant seals (Carrick *et al.*1962).

The general trend for elephant seals in the present study is that they prefer larger sites during the several haulouts, a situation that is especially true for adults during the breeding and the moulting haulouts. Van Aarde (1980) described and compared four substrate types preferred by elephant seals at Kerguelen Island, namely, sand, pebble, cobble and vegetated humps and found that southern elephant seals prefer the sites with smooth surfaces to rough ones during the breeding season.Though the dominant substrate types identified at Marion Island are pebbles, rocks and boulders, the trend is the same with smoother pebbles prefered over boulders and rocks respectively. Hofmeyr (2000) reveals that wintering animals need a site with flat surfaces where they can lie and rest. It would not matter for subadults and adults to haul out on less

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favourite surface site during the moult because they are going to move to the back of the beach anyway (present study).

Access by people to sites in zone 3 is limited and this could be the reason for this zone to be favoured by elephant seals. Human interference is known to cause disturbance to harems of elephant seals (Laws 1956; Gales & Burton 1989) though it was rejected as significant factor in the decline of the elephant seal population at Marion Island (Wilkinson & Bester 1988) and regarded as negligeble disturbance at Macquarie Island (Burton & van den Hoff 2002). At Signy Island a bull was observed successfully driving nine of twelve cows that were leaving a harem after human interference back into the harem. At Marion Island I have observed a bull guiding a cow back to the harem after she attempted leaving because of anthropogenic disturbance. Interactions between elephant seals and humans are rarely negative (Burton & Van den Hoff 2002), although the trampling of pups by bulls during the breeding season could result in death later.

Fig 7.4. Typical moult wallow with adult seals packed together at Watertunnel Beach, Marion Island.

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CHAPTER 8 CONCLUSIONS

It was previously found that young southern elephant seals, *M. leonina*, appear to haul out for the winter at sites that are not visited by older seals hauling out to breed (Hofmeyr 2000). These juveniles also seemed to avoid sites that are used by breeding animals when there is an overlap in haulouts. Observation also suggested that southern elephant seals prefer certain haulout sites to others for the different types of haulouts.

These observations prompted the hypothesis that there is a differential site useage by different age and sex classes of elephant seals. It has, furthermore, been hypothesized that there is an inter-age class influence on haulout site choice. There was a perceived need to quantitatively address these hypotheses in order to describe terrestrial habitat selection with more certainty. This study was aimed at detecting and describing the social factors (age, sex and status) and the topographical factors (physical characteristics of the sites) that are of importance in terrestrial habitat selection by southern elephant seals.

Mark-Recapture data was used in this study. Since the mark-recapture programme was initiated for collecting demographic data, the dataset had to be edited for use in the present study (see chapter 2, section 2.6 for details).

Young southern elephants seals (underyearlings and yearlings), during the moult and the winter haulouts, and subadults during the winter haulout, did not show significant preference for certain haulout sites over others. On the other hand, sexually mature seals (subadults and adults) showed significant preference for haulout sites during their moult and breeding haulouts. Furthermore, there are no intersexual differences in site preference during all haulout events by underyearlings and yearlings whereas it is a different case with mature elephant seals. It can therefore be concluded that differential site use by southern elephant seals depends on age, and thus experience and hence familiarity with the island haulout sites.

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The patterns and differences in site usage between different age and sex groups were the same during the stage of population decline and after population stabilization. However, at higher population density (during population decline), elephant seals used more sites than at lower population densities (after population stabilization). At higher population density, animals tended to use all available sites while at lower density they only used the most suitable sites. Population density therefore has an effect on terrestrial haulout site usage by southern elephant seals.

When there is overlap in haulout between different age groups, the effect of one age group on another depends on the haulout type the different age groups are engaged in. The only major intolerance between age groups is during the November (Breed-Moult) overlap. The avoidance of major breeding sites by juveniles hauling out to moult can be attributed to two factors; the fact that cows are aggressive during this period, and their fear of sexual harassment by secondary bulls. Furthermore, breeding seals occupy the best spots at the beachfront while moulting juveniles also use these areas during the moult. During the other periods of overlap adults (during the moulting season) are found in the wallows and juveniles (resting) at the beachfront.

Southern elephant seals of different age classes prefer the sites with access to moult wallows rather than those without moult wallows. It is, however, apparent that not all age groups of seals actually use the moult wallows, and not for all haulout periods either. These areas are always preferred during the moult haulout by subadults and adults. Most elephant seal terrestrial activities take place on relatively large, open beaches, probably because of the greater space for movement these sites offer and the opportunity they provide for the seals to avoid the wave action that might disturb them on land. Sites with smooth surfaces are used more often than sites with rocks and big boulders. While seals are sufficiently agile to negotiate boulders smaller than their own body size, they struggle to move over larger boulders and rocks, and therefore avoid beach types with such physiognomy.

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The currently designated wilderness zone on Marion Island (Zone 3) has the most and best sites for elephant seal terrestrial activity. Such zoning of the island (in 1996) may have promoted the stabilization of the elephant seals population by limiting human access to popular breeding and hauling sites of the southern elephant seal population of Marion Island.

It would be ideal for breeding colony (pupping) beaches to have Zone 4 status. However, interactions between elephant seals and humans are rarely negative (Burton & Van den Hoff 2002) and have been rejected as significant onshore factors in the decline of the Marion Island elephant seal population (Wilkinson & Bester 1988). The presence of humans at the sites cause a lot of aggressive movements by breeding bulls which result in the trampling of pups by bulls possibly resulting in death of pups later.

I would suggest partial closure of only Archway, Trypot & Ship's Cove beaches to visitors other than fieldworkers during the month of October when most of the breeding takes place. Before and after that month there are still many interesting elephant seal behaviour for visitors to observe, including pupping, suckling and breeding/fighting. During this time visitors should be restircted to the vegetated humps and cliffs and nowhere near the harems.

Further studies could include the following:

1. Underwater topography.

Many sites seem to have the physiognomic characteristics of a good haulout site, but are not utilized by elephant seals. It is possible that inshore topograhical factors affect the ease of access to these sites.

2. Seal movement on the beaches.

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In order to have a better idea of the influence of the presence of certain age and sex classes on the use of particular sites by other sex and age classes, a closer look at the movement and interactions of individuals at a site is needed.

3. Winter and moult haulouts.

Though arguably the least important, the winter haulout might be responsible for familiarizing seals with good future breeding and moulting sites. Information on site fidelity and philopatry of southern elephant seals that utilize the winter haulout is therefore important. For the same reasons it is important to know which age and sex groups associate with one another during the moult, and the influence it might have on the subsequent breeding season haulouts.

4. Movement between sites.

In this study it was assumed that once a seal hauls out on a beach it does not move to another beach during that particular haulout period. Investigating the changing of sites during particular haulout seasons can improve the information on site selection.

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