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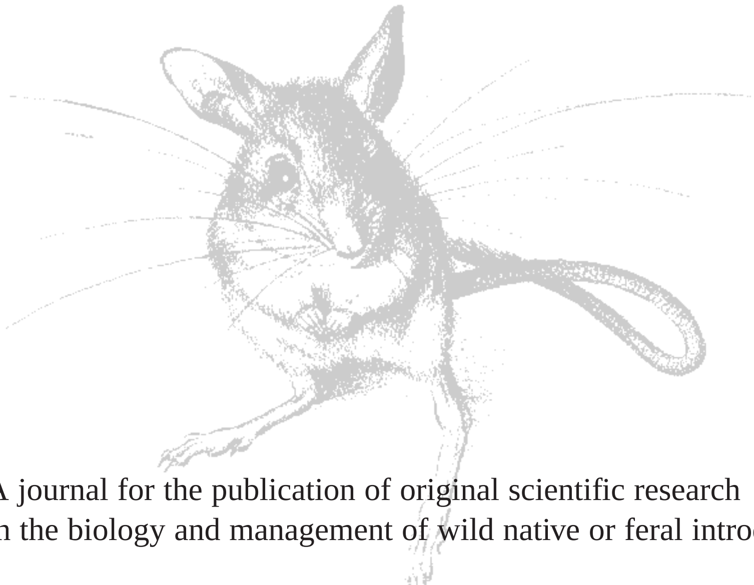

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Breeding Habitat Preferences of the New Zealand Fur Seal (*Arctocephalus forsteri*) on Banks Peninsula

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Abstract

Colonies of New Zealand fur seals (*Arctocephalus forsteri*) on Banks Peninsula, New Zealand, were surveyed between March and August 1993 to compare breeding and non-breeding habitat features. Breeding habitat was characterised by large angular boulders, beaches that were steeper than those of non-breeding habitat, and numerous escape zones, crevices and ledges. Non-breeding habitat was less steep, had smaller rounder boulders and was less exposed to the sun. Multivariate analyses confirmed that overall habitat differences were statistically significant ($P < 0{\cdot}05$). A linear discriminant function was calculated for the two habitat types. The resulting classification rule suggested that crevices, ledges and slope were particularly useful predictors of breeding status. The rule had 96% success in classifying the original sites as breeding or non-breeding and now requires validation by further field surveys in areas with different climate, geology and latitude. If establishment of breeding colonies at sites currently used only by non-breeding seals can be predicted from habitat features, this could provide useful information for managers of coastal sanctuaries.

Introduction

Although seals rely on aquatic habitats for their food resources, they must also spend time ashore on either land or sea ice to breed, moult and rest (Riedman 1990). Habitat selection out of the water depends on many factors, including proximity to food resources, isolation from human disturbance, shelter from extreme weather and suitability for breeding activities (Riedman 1990). This dependence on land and the consequent vulnerability has resulted in many seal species being exploited by humans.

New Zealand fur seals (*Arctocephalus forsteri*) were once abundant around the New Zealand coast (Richards 1994) and its offshore islands, with breeding colonies from the far north (35°S) to Stewart Island (47°S; Davidson 1987). Exploitation by Maori and Europeans for meat and fur resulted in a huge reduction in numbers, and restriction of breeding on the New Zealand mainland to the south of the South Island (Davidson 1987). Since receiving full protection in 1916, the population of New Zealand fur seals has increased and begun to recolonise suitable rocky habitat around New Zealand coasts. Non-breeding seals currently haul out as far north as Three Kings Islands; however, the northernmost breeding records are at Cape Palliser, Wellington (Dix 1993).

While on land, New Zealand fur seals live in various aggregations, some of which are transient and seasonal. Wilson (1981) described the colonies as forming a continuum from *rookeries*, where mostly females, pups and bulls are seen, to *hauling grounds*, where only males occur. However, Wilson (1981) considered that most colonies fall into one of three reasonably distinct groups: rookeries, hauling grounds and *immature* colonies (defined by Wilson as colonies where yearlings and immatures make up more than 40% of the population).

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During the breeding season, these colonies are dominated by territorial males, females and pups [for a description of these age-classes see Wilson (1981)]. Pups are born in late November to early January, with their mothers mating about eight days later (Goldsworthy and Shaughnessy 1994). Once mating is completed, males leave breeding colonies and most move northwards to hauling grounds for the winter (Crawley and Wilson 1976). Females spend the first 10 days with their pups, then begin feeding trips that become progressively longer as the pups get older (King 1983). Females and pups remain on the rookeries until August or later and pups are usually weaned at 8–10 months of age (Crawley 1990). Seals that are not involved in breeding form non-breeding colonies on nearby rocky beaches (Crawley and Wilson 1976). Young seals sometimes form immature colonies close to rookeries during the breeding season and late summer; however, these seem to be rare in New Zealand (Wilson 1981).

This period of highest rookery use coincides with some of the warmest temperatures of the year. This has important implications for breeding seals as they are more reluctant to leave the rookery to cool in the sea than non-breeding seals. Males risk losing their territories if they are left unguarded and females must spend time on land to feed their pups. Fur seals, with their large size, thick blubber layer and dense pelage, are primarily adapted to the cool marine environment (Gentry 1973; King 1983). On land, temperatures can reach 32°C in parts of New Zealand where colonies occur and seals may suffer from heat stress (Mattlin 1978).

Habitat

On the mainland of New Zealand, breeding colonies of New Zealand fur seals are presently found on exposed rocky shores at Cape Farewell, at Cape Foulwind, on the Open Bay Islands and south along the coast of Fiordland to Stewart Island (see Crawley 1990). In addition, four rookeries have become established relatively recently along the southern shores of Cook Straight (Taylor *et al.* 1995). Non-breeding colonies occur in a wider variety of habitat, and are distributed around most of the South Island, and in the south of the North Island in winter (King 1983). New Zealand fur seals also occur on New Zealand's sub-antarctic islands (Mattlin 1987) and in Australia (Shaughnessy *et al.* 1994), but in this study only the mainland New Zealand population of *A. forsteri* is referred to unless otherwise stated.

Crawley and Wilson (1976) surveyed seal colonies around New Zealand, and found that the following features were common to nearly all rookeries:

(i) shelter from storms, as either offshore rocks or reefs, or larger rocks along the seaward fringe of the colony, or areas above the splash zone where seals could retreat from big waves;

(ii) broken and irregular terrain, either jumbled angular rocks, or terrain broken by erosion features.

The descriptive study by Crawley and Wilson (1976) has been the only detailed comparison of habitat features in breeding and non-breeding colonies for New Zealand fur seals. Terrain at breeding and non-breeding colonies in the Nelson–Malborough region was compared by means of a simple rating system of only four factors (Taylor *et al.* 1995). No quantitative habitat comparisons between such colonies have been made and little is known about the establishment of breeding sites. As populations of New Zealand fur seals are increasing, coastal and wildlife managers need to be aware of which areas may be colonised by an expanding population. The aim of this study was therefore to quantitatively compare features of breeding and non-breeding habitat of New Zealand fur seals in order to identify which feature (if any) can be used to predict where breeding and non-breeding colonies may establish.

Methods

Study Area

This study examined seal colonies on Banks Peninsula, Canterbury (Fig. 1); most colonies were originally mapped during a boat survey in 1980, and subjected to land-based counts between 1972 and 1991 (Wilson, unpublished data). Additional colonies were located through discussion with Department of

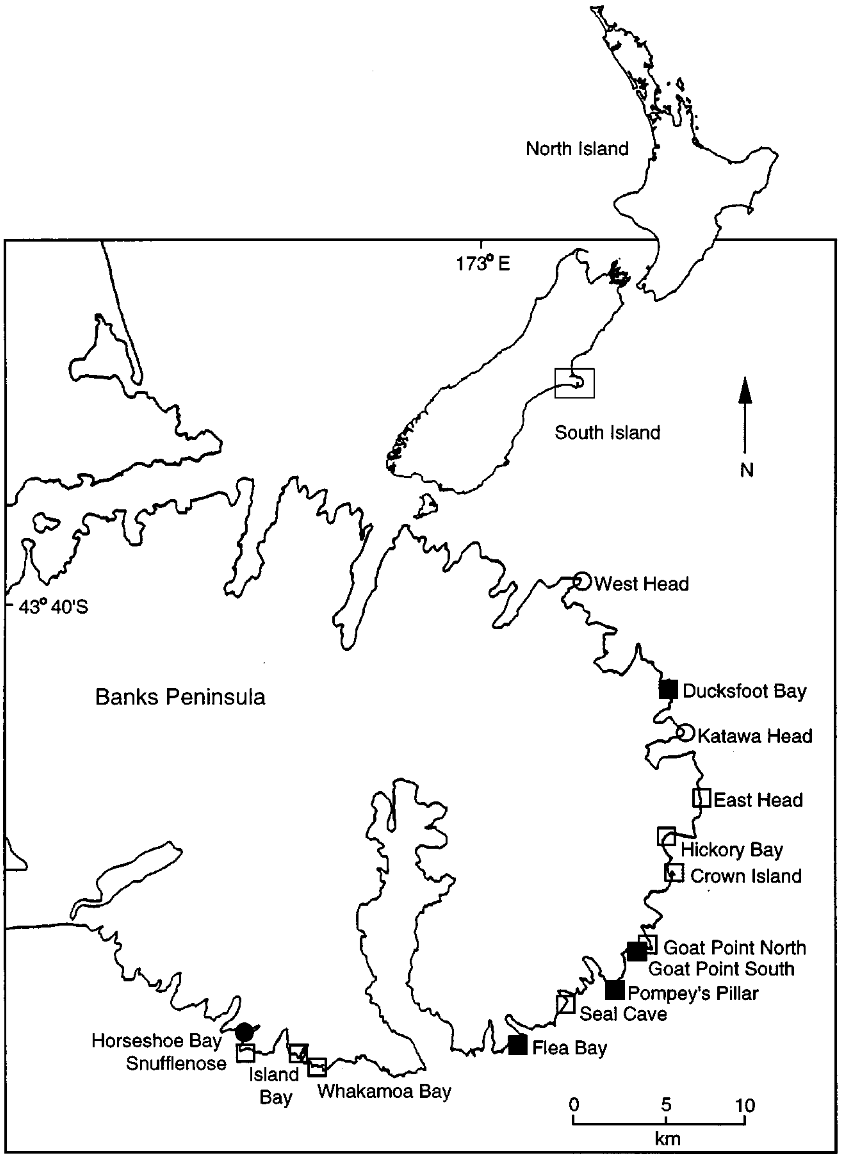

Fig. 1. Locations and breeding status (in 1993) of known seal colonies on Banks Peninsula. □, non-breeding colony; ■, new breeding colony; ●, breeding colony; ○, not surveyed in 1993.

Conservation staff and local farmers. Of 12 known colonies, we visited 10 between 12 April and 15 August 1993 and three additional colonies not previously identified: Whakamoa Bay, Goat Point South and Hickory Bay (Fig. 1).

Habitat Survey

At all colonies visited, a sketch of the aerial view of the colony was made from the cliff top. The location of females with their pups was used to categorise breeding and non-breeding areas, which were noted on the sketch. At colonies that were not accessible by foot, detailed descriptions of the habitat features measured at accessible colonies were recorded.

Four of the colonies visited were accessible by foot. At these colonies, habitat transects that ran at right angles to the coastline were spaced at semi-regular intervals (approximately 20 m from each other). The number of transects was thus proportional to the size of the colony.

For each transect, a profile sketch was made to show five different zones, from below the high tide mark (Zone 0) to the cliff (Zone 4). The main beach area was usually divided into lower and upper zones (Zones 1 and 2), distinguished by a marked change in slope or rock size. At some colonies, a third zone was present, characterised by bare, vegetated, or rocky slopes above the main beach area (Zone 3). For each transect, an assessment was made on the day visited of how exposed a particular site was to winter sun: the proportion of the day that direct sun could be received was recorded on a scale of 1–4, with a score of 1 being 'full sun' and 4 being 'full shade'. The slopes of Zones 1 and 2 were measured with a clinometer. We then estimated the height of each zone by measuring its width with a tape measure and dividing this by the sine of the slope. Within Zones 1 and 2, the angularity and size of each rock on the transect line were recorded, together with the percentage of the line consisting of pebbles (<0·02 m diameter). Angularity was ranked on a scale of 1 (rounded) to 5 (highly angular) according to the following criteria:

1, rounded rocks with no flat faces or sharp edges;
2, approximately 25% of surface with flat faces and edges mainly 100–135°, remainder of rock rounded;
3, approximately 50% of surface with flat faces and edges 100–135°, remainder of rock rounded;
4, approximately 75% of surface with flat faces and edges 100–135°, few rounded faces; and
5, highly angular rocks with flat faces, sharp edges < 100° and few rounded faces.

The number of visible seals, rock pools, ledges, escapes and crevices within 10 m of the transect was recorded. These habitat features were defined as follows:

Rock pool, pool > 1 m wide, retaining water at low tide;
Ledge, a smooth rock or rock shelf large enough for a seal to rest on;
Escape, an area of high ground at the rear of the colony (above the high tide line) where waves could be avoided in severe weather; and
Crevice, a space beneath rocks large enough to shade an adult seal for at least part of the day.

A general description was made of Zones 0, 3 and 4, with the presence of offshore rocks and reefs noted in the description of Zone 0.

Analysis

Seals were present mostly in Zones 1 and 2. Separation of these two zones proved unnecessary for the analysis, so they were combined.

From the rock size and angularity scores, a 'rock index' for each transect was calculated. Each rock on the transect was arbitrarily weighted by its size and angularity according to the values shown in Table 1. This was an attempt to convert the linear transect measurement to an area measurement taking into account each rock's contribution to the formation of crevices and provision of shade. Size 1 (0·02–0·6 m) rocks were given a score of 0 because they did not contribute significantly to the formation of crevices or the provision of shade. The individual rock scores were summed to give an overall rock index for each transect.

Table 1. Weighting table for calculation of the rock index, using rock size and an angularity index, to assess the contribution of each rock to the provision of shade and formation of crevices

Rock size	Rock angularity				
	1	2	3	4	5
1 (0·02–0·6 m)	0	0	0	0	0
2 (0·6–1·25 m)	0	1	1	1	1
3 (1·25–2·5 m)	1	2	3	4	5
4 (2·5–5·0 m)	2	4	9	16	25
5 (> 5·0 m)	3	8	27	54	125

Average slope and maximum height of the main beach area were calculated from the heights and widths of Zones 1 and 2.

Analyses were conducted with the statistical analysis packages STATISTIX Version 4.0 (Analytical Software, St Paul, USA) and SYSTAT Version 5.0 (Systat Inc., Evanston, Illinois, USA).

Initial comparison of habitat features in breeding and non-breeding areas was undertaken by means of univariate statistical tests. For categorical variables, such as presence/absence of escapes and ledges, Fisher's exact tests of association were used (Sokal and Rohlf 1981). Continuous variables, such as maximum height above sea level, were compared by means of general linear models (MGLM procedure in SYSTAT), with location and breeding status included as categorical variables. Where necessary, data were log-transformed before analysis to ensure that variances were homogeneous. Unless otherwise specified, means are presented ± standard errors.

We anticipated that correlations among habitat factors would confound the univariate tests described above. Numerous correlations were confirmed by inspection of an overall correlation matrix, so correlated variables were combined into two composite variables (relating to rockiness and steepness, respectively) by principal component analysis (PCA; FACTOR procedure in SYSTAT). These composite variables, and remaining variables not included in the PCA, were checked for residual correlation. Unweighted logistic regression was then used to test for habitat differences between breeding and non-breeding areas. Finally, a linear discriminant function was calculated and a classification rule derived (Morrison 1990) to predict the breeding status of seal colonies from habitat factors.

Results

A total of 23 transects was completed at the four accessible colonies (Table 2). At the remaining colonies, information on habitat variables was gathered from the cliff-top (Table 3).

Table 2. Colonies of New Zealand fur seals on Banks Peninsula that were accessible by foot, and the number of transects completed at each between April and August 1993

Site	Date visited	No. of transects		
		Breeding site	Non-breeding site	Total
Horseshoe Bay	1 May	7	0	7
Goat Point South	23 April	2	1	3
Hickory Bay	1 August	0	3	3
Ducksfoot Bay	12 April	4	6	10

Univariate Analyses

Univariate analyses suggested that there were several significant differences in breeding and non-breeding habitat (Table 4). Ledges, escapes and crevices were more common on breeding transects than on non-breeding transects. The rock index was significantly higher and the percentage of pebbles on the transect line significantly lower on breeding transects. Average slope of the beach, maximum height of the beach and sun index were all significantly higher at breeding transects than at non-breeding transects.

The only habitat factor that was significantly affected by location (i.e. which of the four colonies the transect was from) was rock index. A significant difference in rock index between breeding and non-breeding transects was still evident when location was incorporated as a repeated-measures variable in the analysis.

Offshore rocks were found in both breeding and non-breeding habitat. Width and number of rock pools were not significantly different in breeding and non-breeding habitat.

Table 3. Habitat notes for colonies not accessible by foot, as viewed from the cliff top

Colony	Description
Snufflenose	Not described.
Island Bay	Boulder beach (rock size and angularity Classes 1–4), plus flat-topped, large rocks. Narrow beach, backed by high, steep cliffs.
Whakamoa Bay	Raised rock shelf, angular (Class 4) continuous rock outcrops. Some loose boulders at the rear of the beach (Sizes 1–4). Two big tide pools. Boulder beach adjacent but not used by seals.
Flea Bay	Steep, rocky beach, about 25 m wide, backed by high, sheer cliff. Rocks variable (Sizes 1–5), mostly angular (Classes 3–5). Many large (Sizes 4, 5) boulders. Abundant crevices, good escape zones at cliff base along the whole beach. One large offshore rock. Immatures and subadult males using raised rocky outcrop with tide pool, adjacent to main colony. West end of beach less angular and smaller rocks, not as steep, with a large tide pool used by many immatures and yearlings.
Seal Cave	Small beach, open cave formed by overhanging cliff. Half of beach flat, with small (1–2), rounded stones; other half steep with angular (Classes 4, 5), small (1–3) rocks. Large crevice in one section of the cave.
Pompey's Pillar	Continuous rock, raised shelves with standing water. Angular (Classes 4, 5) rocks, many ledges, no crevices.
Goat Point North	Gently sloping boulder beach, about 10 m wide, 30 m long at high tide, with overhanging cliff. Some Size 3, angularity Class 5 boulders below the high tide mark.
Crown Island	Colony on mainland outcrop opposite Crown Island: small, flat area with steepish rocky banks, and a large rock pool.
East Head	Large (Sizes 4, 5), angular (Classes 3–5) boulders and assorted sizes 1–3, angularity 3–5 rocks. One large, raised rock near the water's edge used by seals. Very few pebbles. Beach 10–15 m wide, with a good escape zone at the rear. Two high, but smallish, offshore rocks.

Table 4. Habitat factors and univariate tests for non-breeding (n = 10) and breeding (n = 13) transects at four colonies accessible by foot on Banks Peninsula

P-value refers to a chi-square test for categorical variables or a general linear regression for continuous variables. Significance: *, $P < 0{\cdot}05$; **, $P < 0{\cdot}01$; n.s., not significant ($P > 0{\cdot}05$)

Variable	Non-breeding site (count or mean ± s.e.)	Breeding site (count or mean ± s.e.)	*P*	Significance
Categorical variables				
Ledges present	2	9	0·036	*
Escapes present	6	13	0·024	*
Crevices present	2	11	0·003	**
Offshore rocks present	5	2	0·169	n.s.
Continuous variables				
Rock index	17·8 ± 4·73	95·8 ± 23·8	0·015^{AB}	*
Pebbles on transect (%)	30·3 ± 8·18	3·58 ± 2·64	0·000^{A}	**
Slope of beach (°)	7·06 ± 0·75	14·9 ± 2·53	0·009^{A}	**
Width of beach (m)	19·9 ± 3·02	21·3 ± 1·80	0·667	n.s.
Maximum height of beach (m)	1·95 ± 0·27	3·83 ± 0·58	0·018^{A}	*
Rock pools	0·60 ± 0·31	0·85 ± 0·13	0·630	n.s.
Sun index	2·20 ± 0·20	2·69 ± 0·13	0·046	*

^{A}Data log-transformed to homogenise variances. ^{B}Location effect significant.

Multivariate Analyses

As expected, several correlations were apparent among habitat variables (Table 5). Two groups of correlations were apparent, with one related to the nature of rocks on the beach (with ledges, pebble percentage and rock pools all correlated with rock index). The other group related to the profile of the beach (with escapes and slope correlated with maximum height of the beach).

Principal components analysis on each of these two groups of variables produced two composite variables (Table 6). The first was labelled ROCKY, and it incorporated ledges, rock index, pebble percentage and rock pools. The ROCKY axis explained 51·8% of the variance in these four variables in our data set. The second composite variable was labelled STEEP, and it incorporated maximum height and slope of the beach, sun index, and the presence of escapes. This axis explained 57·9% of the variance in the second group of variables. The loading of each variable on these PCA axes is shown in Table 6.

Table 5. Correlation matrix of habitat factors measured on transects at seal colonies
*, $P < 0{\cdot}1$ for a univariate test

	Rock index	Beach height	Crevices	Pebbles (%)	Ledges	Rock pools	Escape areas	Sun index
Beach slope	0·105	0·844*	0·267	–0·223	–0·006	–0·350*	0·368*	0·343
Sun index	0·188	0·311	0·200	–0·083	–0·039	0·139	0·181	
Escape areas	0·407*	0·436*	0·102	–0·369*	0·210	0·195		
Rock pools	0·398*	–0·247	–0·182	–0·178	0·293			
Ledges	0·479*	0·117	0·054	–0·243				
Pebbles (%)	–0·501*	–0·170	–0·459*					
Crevices	0·085	0·184						
Beach height	0·267							

Table 6. Composite variables obtained by principal components analyses, with loadings of original variables

ROCKY		STEEP	
Original variable	Loading	Original variable	Loading
Ledges	–0·491	Escape areas	0·412
Rock index	–0·598	Slope of beach	0·591
Pebbles (%)	0·463	Beach height	0·598
Rock pools	–0·434	Sun index	0·352

The two composite variables were plotted on a scatterplot (Fig. 2), which demonstrates a strong separation between breeding and non-breeding transects. Arrows indicate transects that are outliers in comparison with other colonies of their type; these will be referred to in the discussion.

The two composite variables, ROCKY and STEEP, were relatively uncorrelated with the remaining univariate factor, CREVICES (r = –0·15 and 0·25, respectively). These factors were therefore treated as three independent variables in a three-way analysis with logistic regression. Coefficients in the full model were not significant, so CREVICES was dropped from the model. In this reduced model, both composite variables differed significantly between breeding and non-breeding transects (Table 7). When either ROCKY or STEEP was replaced with CREVICES, CREVICES remained non-significant ($P > 0{\cdot}05$).

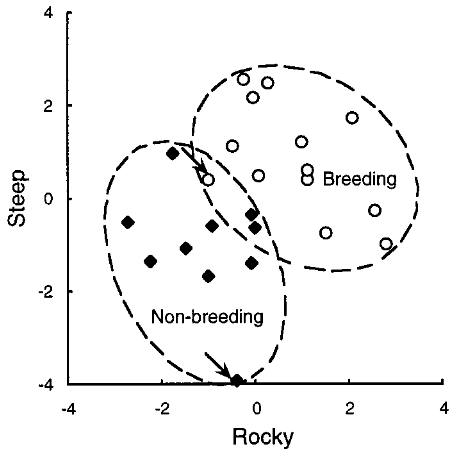

Fig. 2. Scatterplot of the two composite variables STEEP and ROCKY, derived from principal components analysis on habitat features of four colonies of New Zealand fur seals on Banks Peninsula. Arrows indicate apparent outliers.

Table 7. Unweighted logistic regression table for the influence of ROCKY and STEEP variables on breeding status of seal habitat transects
*, $P < 0{\cdot}05$

Predictor variables	Coefficient	s.e.	*P*
Constant	115	52	0·027*
ROCKY	–211	94	0·025*
STEEP	268	120	0·025*
Deviance	0·06		
P-value	1·00		
d.f.	20		

Although the composite variables were excellent predictors of the breeding status of a colony, they cannot easily be measured in the field. We therefore used SYSTAT to calculate a linear discriminant function for the two groups. We chose to investigate crevices, slope and ledges as predictors because they were uncorrelated, statistically significant ($P < 0{\cdot}01$) in univariate tests and simple to measure. This produced the following classification rule, where W is the Wald–Anderson classification statistic (Morrison 1990):

Assign colony to 'breeding' if $W > 0$ and otherwise to 'non-breeding' where

$$W = -14{\cdot}1 + 5{\cdot}0C + 4{\cdot}1S + 5{\cdot}5L$$

and $L = 0$ if ledges absent, 1 if present; $C = 0$ if crevices absent, 1 if present; and $S = \ln$ (average slope of transect). When this rule was applied to the original data, only 1 of 23 transects (4%) was misclassified.

Discussion

The current distribution of New Zealand fur seals on rugged, inaccessible coastline may primarily be a legacy of hunting rather than habitat preference. Secretive individuals that escaped the sealers may have modified site preferences and recolonisation patterns of subsequent generations of seals. This has been suggested for the Guadalupe fur seal (*A. townsendi*); before sealing, rookeries apparently occurred on open beaches, whereas after sealing they have occurred only at the base of high cliffs (Peterson *et al*. 1968). In New Zealand, there is little evidence to suggest that fur seals ever lived in habitat types other than those where they are now present. However, if populations continue to recolonise previously inhabited areas, some expansion into a broader range of habitat types may occur. In South Westland where rocky beaches are few, several colonies have sand between the rocks and sea at low tide and at one colony (Arnott Point) the male seals haul out on a sandy beach (Wilson 1981).

Breeding seals on Banks Peninsula showed clear habitat preferences. In general, breeding transects were steeper than non-breeding transects, with large angular rocks, an escape zone at the rear, crevices and ledges. Non-breeding transects were less steep, had smaller less angular rocks and were less exposed to the sun. These characteristics can be seen in Fig. 2, where the separation between non-breeding and breeding transects is distinct.

The habitat features of one breeding transect (indicated by an arrow in Fig. 2) were similar to those of the non-breeding transects. This transect had no ledges, a low rock index and no rock pools, resulting in a low ROCKY value. However, a large cave was present at the rear of the beach, which may explain its use as breeding habitat (we noted several pups and one female in the cave during our visit).

The other outlier, a non-breeding transect indicated by the second arrow in Fig. 2, had a very low STEEP value because the slope of the transect was almost 0°, which was unusual for beaches on Banks Peninsula.

The nine inaccessible colonies, which were assessed from the cliff top, generally supported the previously described trends (Table 3). Island Bay and Goat Point North (non-breeding) were both typical boulder beaches, with smaller, rounder boulders than were present on breeding colonies. Whakamoa Bay colony (non-breeding) was located on a raised rock shelf with some loose boulders at the back of the beach. There were large tide pools and some elevated rock outcrops that were used by seals. There was a boulder beach next to this raised shelf, but no seals were seen using this area. Flea Bay, where pups were observed, was a steep exposed beach with many large angular boulders. Crevices were abundant, and escape zones were present along the length of the beach. East Head habitat (non-breeding) was similar to that of a breeding colony. Boulders were mostly large and angular. Seals used an area at the base of a grassy cliff where there was bare ground, which would have provided an adequate escape from stormy weather.

Comparison of habitat preferences between breeding and non-breeding seals is complicated by two factors. First, the length of time seals have been in residence at a site may influence whether the colony is breeding. On Banks Peninsula, at least three colonies used only by non-breeding seals in the 1970s have subsequently become breeding colonies (Wilson 1981; authors' personal observations). Wilson (1974) suggested that immature colonies may represent a stage in the evolution of a rookery.

Second, Crawley and Wilson (1976) suggested that local population pressure may affect the type of habitat used. Although current population densities are well below estimates of population numbers prior to sealing, colonies at some locations have reached fairly high densities. Wilson (1974) compared breeding habitat on islands with low, medium and high densities of New Zealand fur seals. At low densities (e.g. Bench Island), breeding seals used only rugged terrain. At medium density (e.g. Solander Island), all areas with angular boulders were used for breeding, while at high densities (e.g. Five Fingers Peninsula and the Seal Islands), all types of rocky terrain except stony beaches were used. Therefore, when higher seal densities are reached on Banks Peninsula, the clear habitat preferences of breeding seals that we found may not be so distinct.

A possible reason for breeding seals selecting broken irregular terrain is to assist in behavioural thermoregulation. Breeding seals have more strict requirements than non-breeding seals because they are more restricted to the rookery and are reluctant to go to sea to cool off (Crawley and Wilson 1976). The importance of habitat for thermoregulation is evident from observations of male New Zealand fur seals using rock pools and shade for cooling at Open Bay Islands (Stirling 1970) and in southern Australia (Gentry 1973).

Mattlin (1978) studied the relationship between air temperature and the use of shade by males, females and pups in 1975 and 1976 at Open Bay Islands (46°S). In both years, all three seal classes made increasing use of shade as temperature increased ($P < 0{\cdot}001$). Mattlin (1978) also assessed the physical characteristics of territories on the rookery and determined preference for them by recording numbers of females and pups present. The most preferred sites were those containing rock cover that provided shade, standing water (pools or puddles) and easy access to the sea.

Carey (1989) conducted experiments manipulating shade and pools (separately) in a rookery at Open Bay Islands. He assessed the response of seals to alterations of these features between years and found that females responded to both increased shade and pools, while males responded primarily to the addition of pools to a territory. Carey's (1989) experiment suggests that seals are able to assess the cooling potential of a site and that this factor is an important aspect of their site preference.

Wilson's (1974) comparative study of breeding and non-breeding habitat throughout New Zealand supported this thermoregulation hypothesis, as breeding seals typically occupied beaches with rocks that provided shade (although rock pools were not present at all breeding colonies). In addition to relief from heat stress, Crawley and Wilson (1976) suggested that shelter from storms was important in determining breeding habitat preferences. Pups and female New Zealand fur seals both used vegetated areas adjacent to rookeries to escape not only from high temperatures but also from stormy weather (Crawley and Wilson 1976).

Prediction of Breeding Status from Habitat Features

The classification rule derived from our data was able to predict the status of known colonies on Banks Peninsula with greater than 90% accuracy (22 of 23 correctly classified). This is likely to underestimate the true misclassification rate if the rule was applied to new (i.e. independent) data from other colonies (Kleinbaum *et al.* 1988). Mathematical procedures for estimating true misclassification rates were not pursued, given the small sample size of this study.

If the classification rule was validated by measuring habitat factors at colonies of known status in other areas where climate, latitude and geology differed, it may prove useful in predicting whether existing non-breeding colonies will evolve into breeding colonies. It also has the potential to predict the location of new colonies. Any habitat classified as breeding habitat is likely to be suitable for a hauling ground or immature colony as well.

In conclusion, the main finding of this study was that there are significant differences between habitats used by breeding and non-breeding seals on Banks Peninsula. These differences may be related to the greater thermoregulatory requirements of breeding seals. The simple classification rule that was derived using crevices, ledges and slope as predictors may prove useful in predicting the likelihood of existing non-breeding colonies becoming breeding colonies and identifying probable sites for the establishment of new colonies. However, the classification rule needs to be tested over a wider range of areas before its general applicability is known. This suggests an area of future study on habitat of the New Zealand fur seal, and potential for application to other species of fur seal that occur on similar types of habitat to that of New Zealand fur seals.

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