NEST SITE SELECTION IN BLACK OYSTERCATCHERS

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ABSTRACT

Nest site selection by Black Oystercatchers (*Haematopus bachmani*) was studied in Laskeek Bay, Haida Gwaii, British Columbia in June and July, 2001. Eight islands were included in the study, of which seven were less than 250 ha in area. Black Oystercatcher density was found to decrease with increasing island size. The birds were found to nest only on those islands that were inaccessible to terrestrial predators, such as raccoons (*Procyon lotor*). Compared to randomly selected sites, actual nest sites were situated where there was a more gradual sloping intertidal area, a moderate slope to the high tide line, in closer proximity to low lying shoreline vegetation, further away from the canopy periphery and finally also where a field of vision of less than 180° was available. Nest sites with all these characteristics were shown to exist on Louise Island, the largest island. Hence, the absence of breeding Black Oystercatchers from this island was attributed to the presence of terrestrial predators, namely raccoons.

INTRODUCTION

The Black Oystercatcher (*Haematopus bachmani*) nests along the Pacific Coast of North America from the western Aleutian Islands, Alaska, to Baja, California (Vermeer *et al*. 1989, Andres and Falxa 1995). Its population is estimated at less than 11,000 individuals, with most in Alaska (4,500 - 7,000 individuals) and British Columbia (1,000 - 2,000 individuals) (Andres and Falxa 1995).

Breeding Black Oystercatchers tend to favor solid rocky shorelines and headlands. However, their nesting habitat can also include mixed sand and gravel beaches (Andres and Falxa 1995). Nests, consisting of an open scrape lined mainly with rock chips, pebbles and shell fragments, are also more likely to be found at non-forested sites with gradual shoreline slopes (Andres and Falxa 1995, Andres 1998). They forage almost exclusively in the intertidal zone, mostly during low tide. Prey consists mainly of marine invertebrates, particularly limpets, chitons, mussels, whelks, barnacles, crabs and isopods (Andres and Falxa 1995, Smith 1995, Hazlitt 2001).

Black Oystercatcher eggs and chicks undergo a high rate of predation by both mammalian and avian predators. In British Columbia, these predators include raccoons (*Procyon lotor*), river otters (*Lutra canadensis*), Bald Eagles (*Haliaeetus leucocephalus*), Glaucous-winged Gulls (*Larus glaucescens*), Northwestern Crows (*Corvus caurinus*) and Common Ravens (*Corvus corax*) (Andres and Falxa 1995).

Many studies have been conducted on the breeding and foraging behaviour of Black Oystercatchers, but there have been relatively few concerning their nesting habitat selection. In British Columbia, Vermeer *et al.* (1989, 1992a) carried out several studies on the nesting habitat of Black Oystercatchers around Vancouver Island. The only study of Black Oystercatcher habitat in Haida Gwaii was conducted by Vermeer *et al*. (1992b) in Skidegate Inlet. There has yet to be a nesting habitat study performed on the more isolated islands of the archipelago: those not in close proximity to towns.

In this study we attempt:

(1) to determine the relationship between island size and density of Black Oystercatcher nest sites.

(2) to determine which island characteristics, other than size, are associated with high densities of Black Oystercatchers.

(3) to determine how Black Oystercatchers select their territory and nest site, once they have selected their island.

(4) to determine whether in terms of physical characteristics, there is any reason why Black Oystercatchers should not nest on large islands.

In particular, we wanted to determine why Black Oystercatchers nest mainly on the smaller, isolated islands and why the birds do not breed on the larger islands represented by Louise Island.

STUDY AREA AND METHODS

Study Area

The study was conducted in Laskeek Bay, Haida Gwaii, from 7 June to 21 July 2001. Eight islands were chosen for the study, all of which offered accessible non-forested Black Oystercatcher breeding sites along the rocky shoreline. Seven were less than 250 ha in area and without terrestrial mammalian predators: (Reef Island, 249 ha; East Limestone Island, 48 ha; West Limestone Island, 16 ha; Low Island, 9.6 ha; South Low Island, 4.5 ha; Skedans Islands, 18.9 ha; Lost Islands, 5.3 ha; areas taken from Martin *et al.* [1995]). The eighth island, Louise Island (35,000 ha) was chosen to represent the larger islands of the archipelago. Besides size, Louise Island differs from the other seven islands in being without breeding Black Oystercatchers and in the presence of terrestrial predators: martens and raccoons. Many Black Oystercatcher nest sites were situated on small, non-forested islets neighboring the main islands. Where these islets were connected to the main islands at low tide they were considered a part of the island that they abutted.

Methods

Surveys and Measurements. Three types of sites were studied: (1) actual nest sites, (2) potential nest sites and (3) random sites. Actual nest sites were those where actual scrapes were found and were located on the seven smaller islands. Potential nest sites were situated on Louise Island and were chosen for their resemblance to actual nest sites. These were included in order to determine whether the absence of breeding Black Oystercatchers on the larger islands was caused by a lack of suitable habitat. Each of these sites was selected based on criteria presented in existing literature and on the typical characteristics of Black Oystercatcher nest sites observed in our study. Finally, random sites were selected randomly from areas where measurements could be taken safely along the rocky shore of the seven smaller islands. The general locations of these sites were determined by previous study (Stockton 2002) and the exact site of measurement was randomly determined by the toss of a marker. All sites were visited by boat and on foot. Actual nest sites were located using census data from previous years from the Laskeek Bay Conservation Society records.

Two types of variables were investigated: nest site/territory variables and island variables. Nest site variables were measured for each real, selected or randomly assigned nest site:

(1) distance to the high tide line (distance from the nest site to the barnacle zone or the highest tide wrack, whichever was closest): measured along transects in 3 or 4 directions from the nest site towards the water (depending on whether the site was located on shore or on an islet) and as close to the cardinal points as possible. For analysis, we used only the shortest distance out of the 3 or 4 measured, as this should best capture the threat of nest washout by high tides.

(2) slope to the high tide line: measured using a Silva compass and taken at 3 evenly spaced points along the same transect as the distance to the high tide line.

(3) nest substrate: categorized as large/small rock chips, or as pebbles and/or shell fragments.

(4) arc horizon, an indicator of the bird's field of vision from the nest: estimated as the degree of the view free from vertical rock taller than 20 cm in a 1 m radius around the nest.

(5) total vegetation cover within a 5m radius, an estimate of the degree of exposure of the nest.
(6) distance to the canopy periphery
(7) distance to the nearest tree >3 m tall.
(8) distance to the area of >50% vegetation cover.

Variables 6-8 were all measured to the nearest 10 cm using a 60 m tape. All measurements and data were taken as close to the time of low tide as possible in order to increase the accuracy of the intertidal measurements.

(9) degree of connectivity to the main island: always connected, never connected, or connected only at low tide.
(10) The width of the intertidal (the distance between the high tide line and the low tide mark): measured along transects in 3 or 4 directions (as close to the cardinal points as possible) from the nest site towards the water (depending on whether the site was located on shore or on an islet).
(11) slope of the intertidal: taken at 3 points evenly spaced along the same transect as the width of the intertidal using a Silva compass.
(12) shoreline type: the predominant type within a 30 m radius from the nest, e.g. solid volcanic, limestone, cobbles, pebbles and/or gravel.

Island variables were those variables specific to the island in its entirety.

(1) island area (in ha): taken from Martin *et al*. (1995).
(2) island perimeter: measured using a map measurer and a 1:50,000 chart.
(3) mean intertidal width: estimated by taking the mean intertidal width of each site and then averaging all sites on a given island.
(4) intertidal area: estimated as the product of the mean intertidal width and the island perimeter.
(5) total shoreline area: estimated by multiplying the island perimeter by the mean distance from the high tide line to the area of >50% vegetation cover.
(6) number of Black Oystercatcher pairs (Table 1) and the presence of raccoons (*Procyon lotor*) were recorded using the Laskeek Bay Conservation Society 2001 census data.
(7) density of Black Oystercatchers on each island: estimated by two methods (a) number of pairs/km^2 of shoreline; (b) number of pairs/km length of shoreline.

The average width of the shoreline of an island helps to further quantify the amount of shoreline available for nesting and should therefore be incorporated, along with island perimeter, into the calculation of Oystercatcher density. However, Vermeer *et al.* (1992) calculated Black Oystercatcher density in Skidegate Inlet in relation to shoreline length and to allow comparison between studies, we also used this approach.

Table 1
Number of Black Oystercatcher pairs breeding in Laskeek Bay, Queen Charlotte Islands, British Columbia, 2001

Island	Number of Black Oystercatcher pairs
East Limestone	3
West Limestone	1
Skedans Islands	5
South Low	5
Low	2
Reef and adjacent islets	7
Lost	5
Louise	0

Statistical Analysis. The majority of the statistical analyses performed were designed to test differences between our three site types, particularly between the actual nest sites and the potential nest sites and between the actual nest sites and the random sites. The distribution of each variable was tested for normality using the Kolmogorov-Smirnov test for goodness of fit (Sokal and Rohlf 1969, section 16.2). Only five variables differed significantly from normal, the exceptions being: mean intertidal width, distance to the canopy periphery, distance to the nearest tree > 3 m tall, distance to the area of > 50% vegetation cover and the total percent vegetation cover within a 5 m radius. These five variables were normalized by log-transformation so that they could be used in analyses assuming a normal distribution.

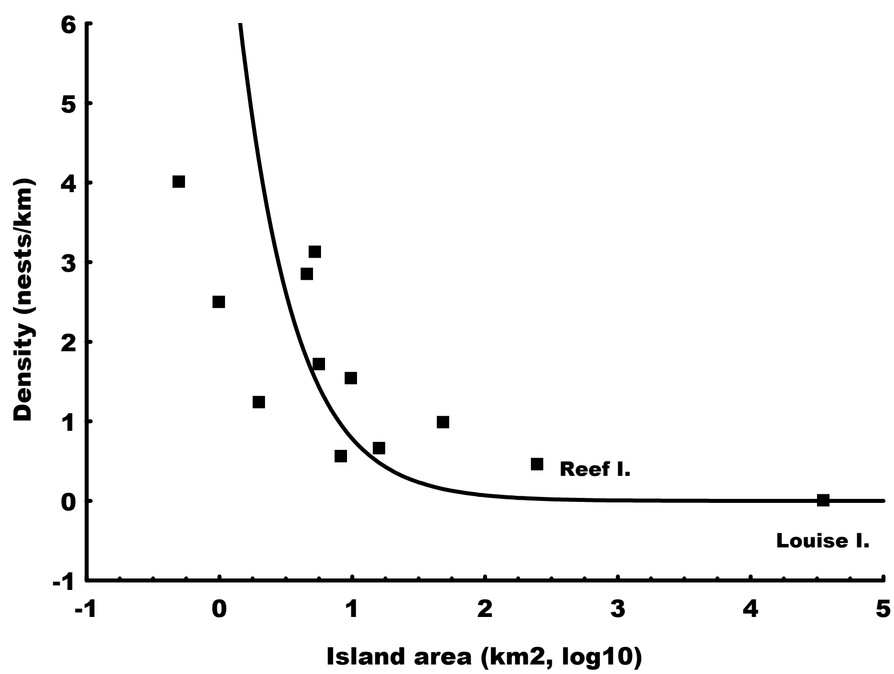
Mann-Whitney U tests were employed to determine which variables differed between site types, i.e. which variables set the actual nest sites apart from the potential nest sites and the random sites. The Mann-Whitney test was used instead of the two sample *t* test because when both tests are applicable, the former is more powerful (Zar 1999). We expected that some of the measured variables would be highly intercorrelated. Consequently, we calculated a correlation matrix involving all the study variables. Where close and significant correlations were found among groups of variables, all but one of the variables involved were removed before multivariate analysis. A discriminant function analysis was then performed using the remaining variables, none of which had inter-correlations > r = 0.30, in order to establish which variables best discriminate between site types and were therefore the best predictors of site type.

RESULTS

Island Habitat

Black Oystercatcher density decreased with increasing island area (Figure 1). There was no significant relationship, however, between Oystercatcher density and mean shoreline width for each island. Birds nested mainly on the smaller islands, i.e. those without terrestrial predators, such as raccoons.

Figure 1
Relationship of Black Oystercatcher nest density to island area in Laskeek Bay



Territory Habitat

Of the 18 actual nest sites studied, 17 were connected to the main study island at all times, and only one was on a separate islet that was never connected. Most of the shorelines on which Black Oystercatchers nested were composed of solid volcanic rock, followed by limestone, cobbles, pebbles and gravel (Figure 2). The width of the intertidal zone adjacent to the actual nest sites averaged 22.4 m and was not significantly different from that of the potential nest sites and the random sites, which averaged 16.2 m and 20.2 m respectively (Table 2). Intertidal slope was also similar between actual nest sites (18.6°) and potential nest sites (21.8°), as well as between actual nest sites and random sites (20.1°). Black Oystercatchers tended to line their scrapes mainly with small rock chips and shell fragments (Figure 3).

Figure 2
Nest substrate for Black Oystercatchers in Laskeek Bay, B.C.

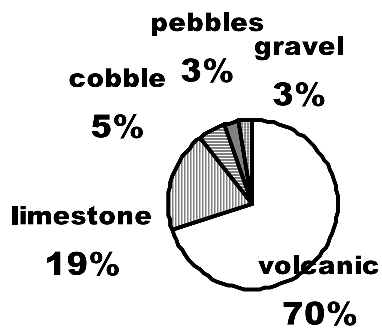


Figure 3
Nest lining used by Black Oystercatchers in Laskeek Bay

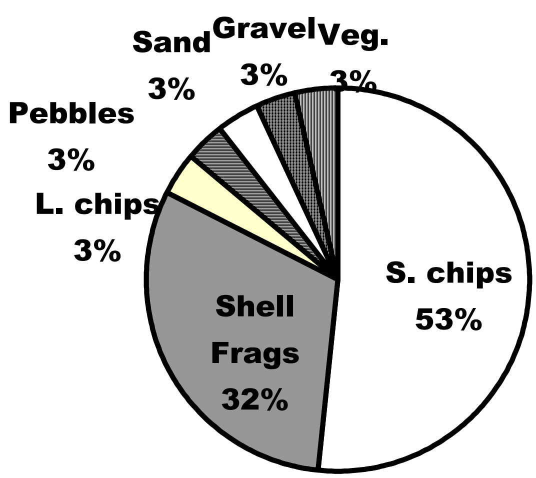


Table 2
Comparison of territory and nesting variables of Black Oystercatchers in Laskeek Bay, Queen Charlotte Islands, British Columbia, 2001

Variable	Actual nest sites $n = 17$	Potential nest sites $n = 15$	Random sites $n = 15$
	Mean ± SD	Mean ± SD	Mean ± SD
Intertidal width (m)	22.4 ± 17.8	16.2 ± 7.7	20.3 ± 12.4
Intertidal slope (°)	19 ± 9	22 ± 9	20 ± 12
Shortest distance to high tide line (m)	17.8 ± 8.2	8.4 ± 3.5	8.9 ± 4.7
Slope to high tide line (°)	23 ± 8	24 ± 8	20 ± 8
Distance to canopy periphery (m)	64.6 ± 84.4	48.2 ± 40.6	28.8 ± 49.7
Distance to nearest tree > 3 m tall (m)	63.2 ± 85.1	51.3 ± 40.8	31.7 ± 49.2
Distance to area > 50% vegetation cover (m)	59.6 ± 87.4	51.0 ± 41.8	28.5 ± 49.9
Arc Horizon (°)	163 ± 93	150 ± 70	232 ± 135
Total vegetation cover within 5 m radius (%)	16 ± 14	12 ± 10	5 ± 12

Nesting Habitat

Nest sites used by breeding Black Oystercatchers tended to be significantly further from the high tide mark than were the potential nest sites and the random sites. These actual nest sites were also significantly further from the canopy periphery and had a significantly greater amount of vegetation within a 5 m radius than did the random sites. The remaining nest site variables, i.e. intertidal width and slope, slope to the high tide line, distance to the nearest tree > 3 m tall, distance to the area of > 50% vegetation cover and arc horizon, were all similar between the three types of sites.

The correlation matrix revealed that the distances to the canopy periphery, to the nearest tree > 3 m tall and to the area of > 50% vegetation cover were all significantly correlated with each other and therefore the last two variables were removed. The mean intertidal width of each nest site was found to correlate significantly with both the mean intertidal slope and the mean slope to the high tide line of each site. The latter two variables, however, did not correlate significantly with each other. Consequently, the mean intertidal width variable was removed and was not included in further applications.

Habitat Selection

From the discriminant function analysis, the following five variables provided the best discrimination between the three categories of Black Oystercatcher nest site and were included in the final model: intertidal slope, slope to the high tide line, the distance to the canopy periphery, the arc horizon and the total amount of vegetation cover within a 5 m radius (Table 3).

Table 3
Summary of discriminant function analysis

Variable	Standardized discriminant function coefficients
Intertidal slope	0.10
Slope to high tide	0.18
Dist. to canopy periphery	0.78
Arc horizon	-0.29
% vegetative cover	0.98

Distances between groups (p-levels significant at p < 0.05)

Site Type	Actual	Potential	Random
Actual	-	0.96	0.00002
Potential	-	-	0.00003
Random	-	-	-

In this study, the birds tended to select nest sites that had a gradually sloping intertidal area, a moderate slope to the high tide line, were away from the forest edge, provided a field of vision less than 180° and had a substantial amount of vegetation within a 5 m radius (Figure 4). The standardized discriminant function coefficients of the vegetation cover surrounding the nest (b = 0.98) and of the distance to the canopy periphery (b = 0.78) suggest that these two variables contributed most to the discrimination between site types. Overall, the final model suggested that the potential nest sites were not significantly different from the actual nest sites ($P = 0.96$). The bivariate plot of the discriminate function shows that potential nest sites formed a subset of the actual nest sites (Figure 5). The model also showed that both the actual nest sites and the potential nest sites differed significantly from the random sites ($P < 0.001$).

DISCUSSION

Island Habitat

The average density of Black Oystercatchers in Laskeek Bay was 0.43 pairs/km^2 shoreline or 0.61 pairs/km of shoreline. An error was noted in Vermeer et al.'s (1992) calculation of the density of Black Oystercatchers at Skidegate Inlet. In the publication, there were 54 Black Oystercatcher pairs occupying 87 km of shoreline. The density was subsequently reported as 1.61 pairs/km of shoreline, instead of 0.62 pairs/km of shoreline. This calculation, however, did not include the shoreline perimeter of non-nesting islands or coasts. When these lengths are included, the shoreline of Skidegate Inlet is 207 km long. The density then becomes 0.26 pairs/km of shoreline, noticeably smaller than that of Laskeek Bay (0.61 pairs/km of shoreline). Skidegate Inlet may have a smaller density of Black Oystercatchers because it is closer to both towns and to islands supporting several terrestrial predators, such as raccoons, or because Skidegate Inlet, having restricted inflow from Hecate Strait, experiences a lower tidal range than the islands of Laskeek Bay.

Figure 4

Variables affecting the situation of Black Oystercatcher nest sites: (a) slope angle from nest to high tide; (b) slope angle of adjacent intertidal; (c) % vegetation cover within 5 m of nest; (d) visibility from nest (degrees of arc horizon); (e) distance to edge of forest canopy (m). Boxes – standard deviation; vertical bars – range

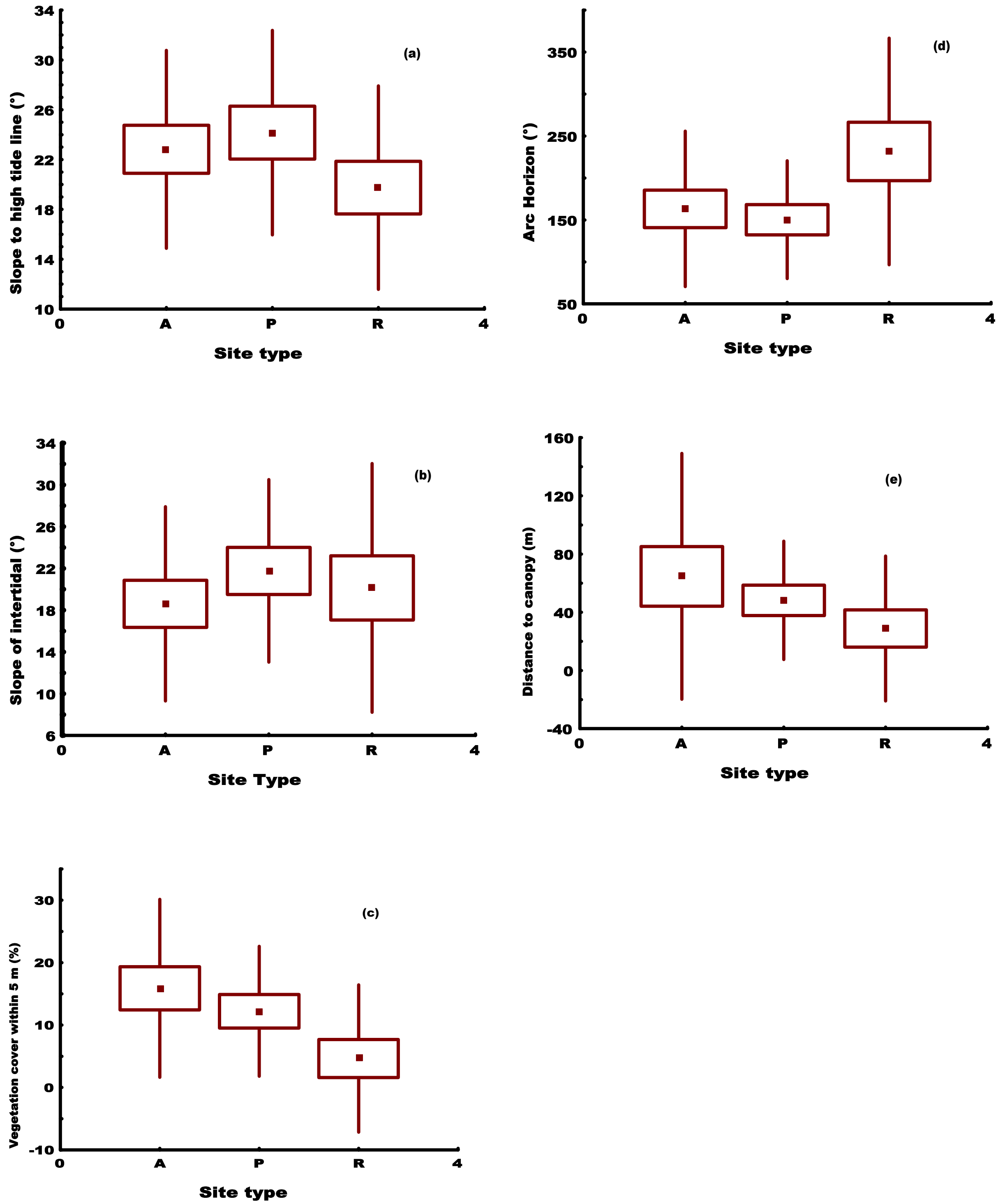
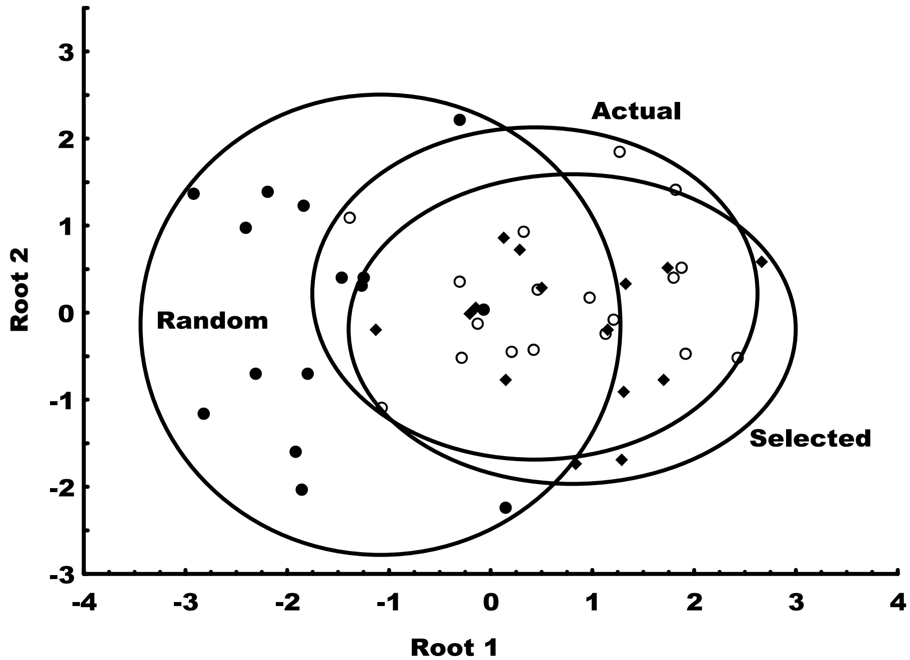


Figure 5
Discriminant function plot comparing actual, random and selected nest sites. Note that actual and selected sites overlap more or less completely, but that random sites include many that fall well outside the scores for actual sites



The islands used by Black Oystercatchers in Skidegate Inlet are considerably smaller (average perimeter = 143 m) than those used in Laskeek Bay (average perimeter = 4564 m). However, when density is plotted against perimeter of shoreline, average density in Skidegate Inlet (average island perimeter = 0.143 km, average no. pairs/island = 1.8) is similar to that predicted by average island perimeter by the relationship of perimeter to density seen in Laskeek Bay (see Figure 1). This suggests that Black Oystercatchers prefer the smallest islands that provide suitable nest security. Because of the greater wave action in Laskeek Bay, islands of the size used by oystercatchers in Skidegate Inlet would not provide security from wave-wash.

Black Oystercatcher density decreased with increasing island area (Figure 1). On Reef Island, the largest of the seven smaller islands, two out of three nests were on islets or headlands that were almost cut off from the main island at low tide. There are many apparently suitable sites on Reef Island and no terrestrial predators. Despite this, the density of Oystercatcher is very low. This fact that oystercatchers tend to avoid this larger island suggests that site selection is based on an innate response to island size, as opposed to an adaptive response to the presence or absence of predators. The fact that they tend to settle on islets suggests an immediate association of island size with predator presence. This interpretation contradicts the assumption made by Vermeer *et al.* (1989) and Vermeer *et al.* (1992b) that the birds recognize and react to the absence of predators and subsequently distance themselves from such threats.

Territory Habitat

With the exceptions of two sites on Reef Island, most actual nest sites studied were connected to the island in question at all times. This differs from Andres' findings in Prince William Sound, Alaska in 1998 where he reported a greater use of islets as breeding Black Oystercatcher territory. Islets may be less important in Laskeek Bay because suitable habitat is abundant on the smaller islands or because islets in Laskeek Bay are less sheltered, making the zone affected by high waves less predictable than in the enclosed waters of Prince William Sound.

The type of shoreline on which the majority of the Black Oystercatchers in Laskeek Bay nested was primarily solid rock. The high use of this form of substrate is most likely due to its abundance rather than intentional selection by the birds. However, the density of Oystercatchers on East Limestone Island, where the shoreline is composed exclusively of limestone, is unusually high. It is possible that the limestone provides additional nutrients and therefore supports a more highly productive foraging area.

The materials used by the Oystercatchers to line their scrapes were mostly rock chips and shell fragments. Small rock chips were used more often most likely because flaky volcanic rock was widely available. Although shells were also quite abundant, particularly from limpets and mussels, it is possible that the birds used more rock chips than shells for camouflage purposes because the lighter colored shells could be seen more easily by predators.

Habitat Selection

To address the essential purpose of this study, i.e. to determine why Oystercatchers nest precisely where they do on the smaller islands, all the variables measured were narrowed down to a select few that seem to best describe those nesting habitat characteristics found most attractive to Black Oystercatchers. In Laskeek Bay, Black Oystercatchers were found to be most attracted to nest sites that (1) have territories with a gradually sloping intertidal area, (2) have a moderate slope to the high tide line, (3) are away from the forest edge, (4) provide a field of vision less than 180° but are therefore still somewhat concealed from approaching predators, (5) have a substantial amount of vegetation within a 5 m radius (Figure 5).

A gradually sloping intertidal area is most likely of greatest importance when the birds are foraging. Not only would a shallower sloping intertidal have a greater surface area and therefore a greater food supply, but it may also facilitate parental provisioning since it would be easier for chicks to accompany parents on feeding excursions (Andres 1998, Hazlitt *et al.* 2002, Hazlitt 1999). A moderately sloping territory (up to the high tide mark) would also facilitate the displacement of chicks, i.e. they could more easily follow their parents around the territory, thereby reducing the risk of predation.

The trend for Oystercatchers to nest away from the forest edge may be a predator avoidance mechanism. Nesting further away from the forest canopy and therefore also from the perches of potential predators may be an attempt to reduce predation by Bald Eagles, Common Ravens and Northwestern Crows. The birds also tended to construct their nests where there was on average 165° of unobstructed view, i.e. free from rock greater than 20 cm tall, the approximate height a brooding Oystercatcher. This degree of rock cover would help to conceal eggs from approaching predators, and at the same time provide a brooding parent with a view of the surrounding territory. Vermeer *et al.* (1989) found similar results in the Gulf islands in that Oystercatchers there tended to nest near elevated logs or rocks. They stressed concealment from predators as the main factor, but also suggested protection from sun and prevailing winds as possible explanations. The amount of vegetation surrounding the nest was found to be substantial, averaging over 17% within a 5m radius. Taller grasses and sedges would likely help to hide eggs and chicks from both avian and terrestrial predators.

In Laskeek Bay, Oystercatchers tended to nest at least 17.8 m from the high tide line, significantly further than the distance of 8.24 m observed by Vermeer, Morgan and Smith (1989). This latter distance was measured on islands in the Gulf Islands without nesting gulls and is even larger than the distance measured on islands with nesting gulls in that study (5.38 m). Differences between the two studies are perhaps a result of the Gulf Islands being more sheltered from large waves.

As all the habitat characteristics of the actual nest sites, with the exception of distance to the high tide line, were similar on the seven smaller islands and on Louise Island, lack of suitable habitat cannot be the sole explanation for the absence of breeding Oystercatchers on Louise Island. The possibility that food may be less abundant on the coast of the larger islands than on the smaller islands, as suggested by Vermeer et al. (1989) for the Gulf Islands, seems unlikely to be the explanation. The major headlands on the larger islands are comprised of the same rocks and receive the same degree of exposure as the smaller islands. Although the presence of factors not measured in the present study cannot be excluded, the presence of mammal predators on the largest islands seems the simplest explanation for the low density of Oystercatchers found there.

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