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HABITAT AND NEST-SITE SELECTION OF MEW AND GLAUCOUS-WINGED GULLS IN COASTAL BRITISH COLUMBIA

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ABSTRACT.—The types of lakes, islands and nest sites Mew Gulls (*Larus canus*) selected on Vancouver Island, British Columbia, were examined. Mew Gulls nested on lakes that had significantly more islands and rivers, were larger, had longer shore lines, were closer to the sea, and were at lower altitudes than lakes not used by gulls. The nesting population of Mew Gulls on Vancouver Island was estimated from a highly significant regression equation containing these lake variables.

Mew Gulls significantly preferred small islands without trees, with a substrate of bare rock or low herbaceous cover. Nests were strongly associated with island crests and with a flat moss-covered substrate, and were significantly higher and farther from the water than randomly chosen matched points. Mew Gulls also nested frequently on tops of poles, pilings or tree stumps emerging from the water. On Vancouver Island, Mew Gulls nested mostly (80%) as solitary pairs.

Island and nest site selection by Mew Gulls was compared with that of Glaucous-winged Gulls (*Larus glaucescens*), a colonial nester at southeastern Vancouver Island. Ground-nesting Glaucous-winged Gulls selected islands that were significantly smaller, had a lower relief, were less forested and contained a higher percentage of bare rock or ground with low herbaceous cover than islands where gulls were absent. Nests of solitary pairs of Glaucous-winged Gulls, like Mew Gulls, were strongly associated with island crests, but unlike Mew Gulls, these had a grass substrate. Colonial Glaucous-winged Gulls showed no association with any island location, but were strongly associated with a bare rock substrate and, to a lesser extent, with grass. Matched points taken from both solitary and colonial nests occurred on significantly steeper slopes than nests and were also closer to shore.

Interspecific variation and plasticity in the nest site establishment of Mew and Glaucous-winged gulls are explored and their implications discussed.

The breeding range of Mew Gulls (*Larus canus*) in Eurasia extends as a broad band from northwestern Europe to Kamchatka in the eastern USSR, but is restricted to the northwestern portion of North America (Voous 1960). Atlases on breeding distribution of birds do not show the Mew Gull nesting in central and southern British Columbia (e.g., Voous 1960, Godfrey 1966), although it is a widespread, albeit dispersed breeder there. Campbell (1970) made the first attempt to compile information on the breeding status of Mew Gulls in British Columbia, but quantitative data were lacking at the time. Aspects of the nesting biology of Mew Gulls in British Columbia were described by Vermeer and Devito (1986). In this paper, we examine which lakes, islands, and sites Mew Gulls selected for nesting on Vancouver Island, British Columbia.

Island and nest site selection by Mew Gulls is compared with that of Glaucous-winged Gulls (*Larus glaucescens*) in the Gulf Islands at southeastern Vancouver Island. These species are the only coastal nesting larids in British Columbia. Glaucous-winged Gulls nest almost completely in the marine habitat in British Columbia (Drent and Guiguet 1961). The nesting biology of Glaucous-winged Gulls has been studied by Vermeer (1963), Ward (1973) and Hunt and Hunt (1976), but some aspects of its selection of islands and nest sites will be dealt with for the first time in this paper.

We also compare the nesting habitat of Mew Gulls on Vancouver Island with that of this species in northern Europe. The comparison will be subjective, because although the habitat of the species in Europe has been described (e.g., Bianki 1967, Haftorn 1971, Vaisanen and Jarvinen 1977, Götmark 1982), statistical treatment of nest-site selection similar to our method is lacking.

METHODS

Surveys of nesting Mew Gulls on Vancouver Island were conducted during the last week of May and first half of June in 1984 and 1985 on 58 lakes accessible by road (Table 1, Fig. 1). Lakes were chosen from those present on a Canadian Hydrographic Service (CHS) chart (Chart No. 4C 3001, scale 1:525,000). The entire shoreline of each lake was explored by boat and the position of each nest was mapped. The number of islands present was noted in the field, while measurements of lake area, perimeter, altitude, and distance to sea were made from 1:50,000 and 1:80,000 scale maps. Mean lake depths and supporting morphometric data for 40 lakes were obtained from lake inventory files of the Fisheries Branch, Ministry of Environment, Victoria, British Columbia. The number of rivers entering or leaving a lake was determined by counting the blue lines indicating the water courses on the CHS chart. The extent of human disturbance at a lake was determined by a method similar to that described for loons

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TABLE 1
LAKES ON VANCOUVER ISLAND SURVEYED FOR NESTING MEW GULLS IN MAY AND JUNE OF 1984 AND 1985

Name of lake	Number of nests	Name of lake	Number of nests
1. Georgie Lake	0	30. Mohun Lake	2
2. Nahwitti Lake	0	31. Morton Lake	0
3. Kains Lake	3	32. Amor Lake	1
4. Quatse Lake	0	33. Gray Lake	0
5. Alice Lake	4	34. Boot Lake	0
6. Victoria Lake	1	35. Goslin Lake	0
7. Benson Lake	0	36. John Hart Lake	0
8. Maynard Lake	0	37. Campbell Lake	2
9. Iron Lake	0	38. Beavertail Lake	0
10. Lac Truite	0	39. Gooseneck Lake	1
11. Three Isle Lake	4	40. Middle Quinsam Lake	0
12. Keogh Lake	0	41. Wokas Lake	0
13. Nimpkish Lake	4	42. Upper Quinsam Lake	0
14. Atluck Lake	0	43. Upper Campbell Lake	0
15. Wolfe Lake	0	44. Buttle Lake	0
16. Mukwilla Lake	0	45. Wolf Lake	0
17. Woss Lake	0	46. Comox Lake	1
18. Klaklakama Lake 1	0	47. Elsie Lake	0
19. Klaklakama Lake 2	0	48. Great Central Lake	2
20. Schoen Lake	0	49. Sproat Lake	3
21. Vernon Lake	0	50. Horne Lake	1
22. Muchalat Lake	0	51. Cameron Lake	0
23. McCreight Lake	0	52. Muriel Lake	3
24. Pye Lake	0	53. Kennedy Lake	24 (27)*
25. Lower Stella Lake	0	54. Maggie Lake	3
26. Stella Lake	1	55. Nanaimo Lake 1	0
27. Roberts Lake	1	56. Nanaimo Lake 2	0
28. Mud Lake	0	57. Cowichan Lake	11
29. Amor Lake	1	58. Nitinat Lake	0

* 24 nests in 1984 and 27 nests in 1985.

by Vermeer (1973). Ten disturbance units were given for each patrolled campsite and resort, five units for each wilderness campsite (camp area or a spot for 1 or 2 campers), and one unit for each house and summer cottage bordering a lake. For each nesting island, the surface area and the distance to the mainland shore and nearest island were determined from maps or actual site measurements. Presence of trees (> 1.5 m tall) and percent bare ground (low herbaceous cover and/or bare rock) were noted. At Kennedy Lake, measurements were taken at each island for later comparison between islands with and without nests. The dominant vegetation, distance to shore, nest height above water, distance to nearest tree, and microslope were determined for nests and for matched points 2 m away from nests. Microslope was determined from the average maximum slope over a 30 cm distance centered at the nest or matched point. Matched points were selected randomly from one to 10 compass points, similar to the method described by Burger and Gochfeld (1981). The distance of 2 m was chosen arbritrarily, but probably fell within the nesting territory as the distance to the nearest neighboring nest, where more than one pair of gulls nested on an island, ranged from 3.5 to 15 m.

Surveys on nesting Glaucous-winged Gulls were conducted in the Gulf Islands, from 49°09'N (including the Flat Top Islands) to 48°33'N (D'Arcy Island) during June and July 1985. All islands were visited by boat, the number of nesting gulls was counted at each nesting island and the number and position of each colony or solitary nest site were mapped. For each island the percent bare ground (low herbaceous cover and/or bare rock) and extent of forestation (> 50 percent = forested island) was noted. The surface area, distance to mainland (Vancouver Island) and maximum height of each island were determined from the CHS chart No. 3310 (sheets 1 to 4) or at the site.

Observations similar to those made on Mew Gulls were made on the nest sites of Glaucous-winged Gulls. Approximately 5% of the ground nests (up to a maximum of 10 nests) were selected randomly from each colony. Matched points were selected 2 m from solitary nests and the selected colonial nesting pairs. Since only a small number of solitary Glaucous-winged Gull pairs were located on islands (there were more on beacons and cliffs), one island with three and another with two pairs were included in the single pair category. Those two islands were large and the pairs nested far apart in a solitary manner.

For both lake and island parameters, an overall or multivariate test was conducted to test the hypothesis of equal population mean vectors for lakes and islands with and without nests (see Hummel and Sligo 1971). The Wilks Lambda statistic (λ) was used. Following a

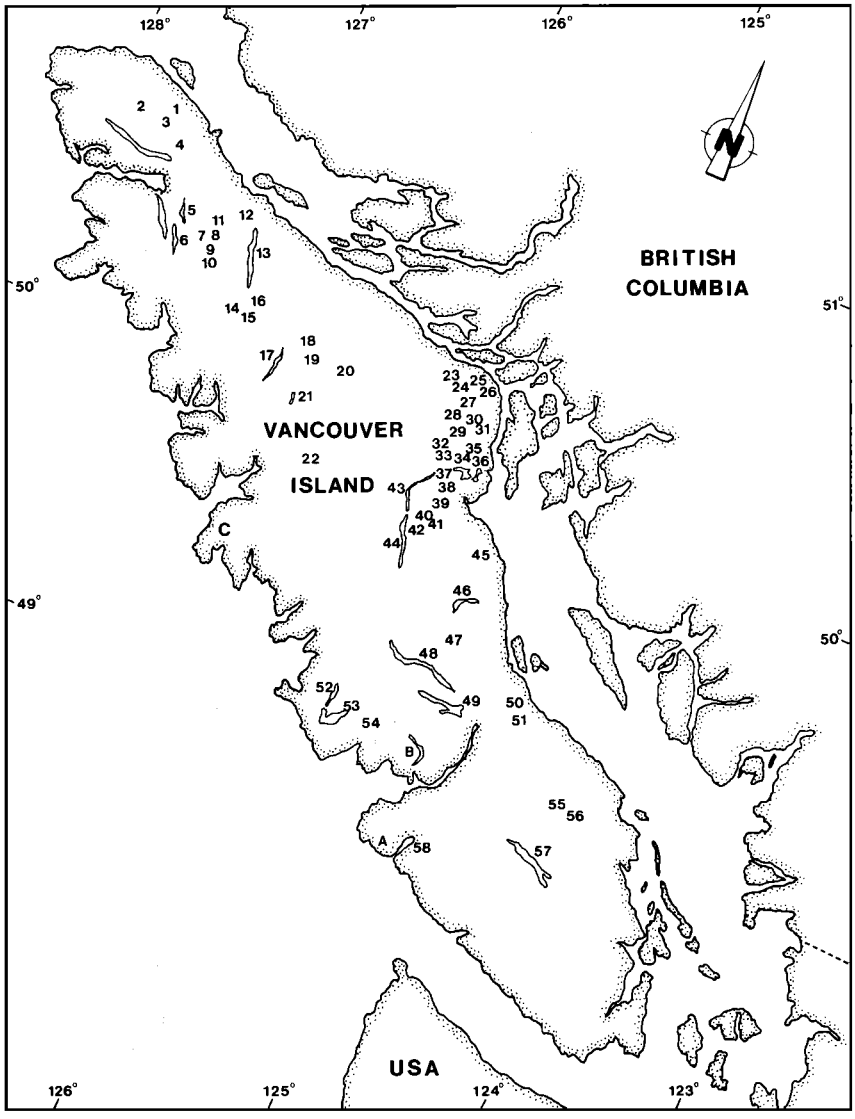

FIGURE 1. Lakes surveyed and those with nesting Mew Gulls on Vancouver Island, 1984 and 1985. A = Tsusiat lake, B = Henderson Lake, C = Hesquiat Lake.

significant overall difference, a univariate ANOVA was run on each variable separately. At Kennedy Lake, classification of islands with and without nests was determined by Discriminant Analysis. Relationships between the number of nests per lake and other lake variables were determined from regression analyses. Data analyses were performed using the SPSSx statistical package at the University of Victoria.

Association of nest position and absence or presence of vegetation for nests of Mew and Glaucous-winged gulls and their matched points was determined by Chi-square analyses. Distance measurements to nests and matched points were analyzed using the normal approximation of the Sign Test (see Zar 1974).

RESULTS

Nest Dispersion and Population of Mew Gulls

Seventy-six nests with eggs or small chicks were found on islands (38), on tops of poles and tree stumps in the water (29), and in trees (9) on 20 of the 58 lakes (Table 1, Fig. 1). All nests on poles, tree stumps, and in trees were single nests. Of the 38 nests on islands, 23 were solitary, one island had 4, three islands 3, and one island 2 nests. The Mew Gull, with 80 percent of the nests

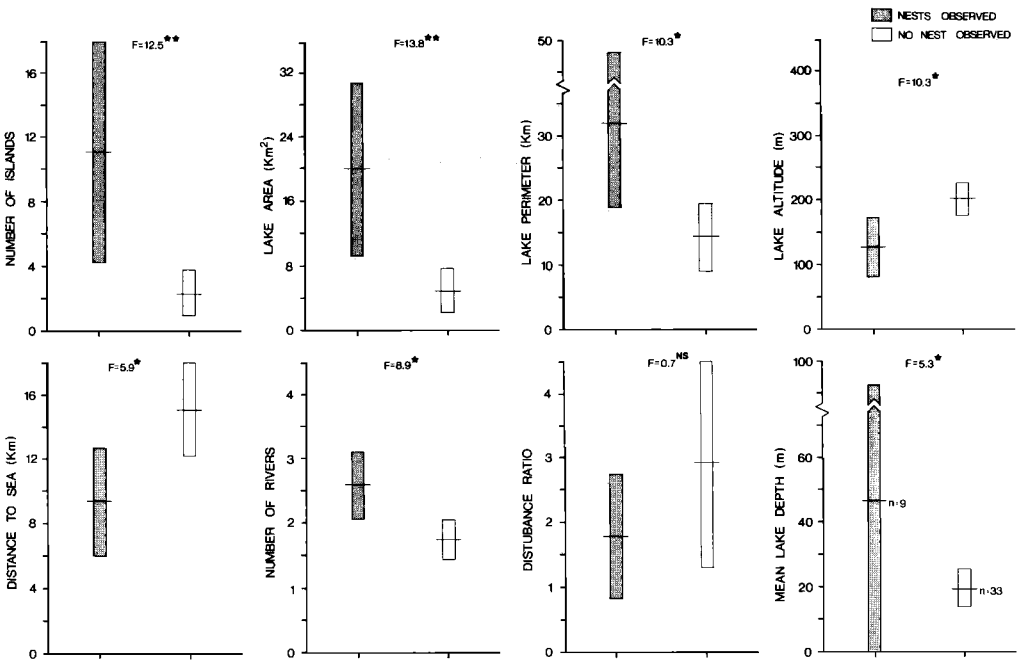

Figure 2. Means (horizontal lines) and 95 percent confidence intervals (rectangles) of variables of lakes with (n = 19) and without (n = 39) nesting Mew Gulls on Vancouver Island, 1984 and 1985. Overall significance with multivariate test: Wilks Lambda = 0.658, F = 3.715, $P = 0.003$. Mean lake depth not included in multivariate test. Values of univariate F test (df = 1,56) are shown on Figure. *$P < 0.05$, **$P < 0.001$.

found being single, is therefore predominantly a solitary nester on Vancouver Island.

To estimate the total nesting population of Mew Gulls on Vancouver Island, the numbers of observed Mew Gull nests (NN) on lakes were regressed on the following lake variables: number of islands present (NI), lake area (LA), lake perimeter (LP), lake altitude (ALT), distance of a lake to sea (DS), and the number of rivers associated with a lake (NR). The estimated regression equation was:

$$NN = 1.07 + 0.127\,NI + 0.276\,LA - 0.155\,LP + 0.001\,ALT - 0.039\,DS + 0.125\,NR.$$
$$(F_{6,51} = 68.79, \quad R^2 = 0.890, \quad \hat{R}^2 = 0.877, \quad P < 0.0001)$$

Of a total of 123 lakes shown on the CHS chart, 58 were surveyed, and 65 lakes were not surveyed for nesting Mew Gulls in 1984 and 1985. Of the latter, Tsusiat, Henderson and Hesquiat lakes were known, from previous surveys, to have together 7 pairs of nesting gulls (B.C. Prov. Museum records). Using the above regression, it was predicted that 44 pairs of gulls nested on the 62 lakes not surveyed and lacked nesting records. The overall nesting population of nesting Mew Gulls on Vancouver Island lakes was estimated at 127 pairs for 1984 and 1985.

Habitat Selection by Mew Gulls

A multivariate test for seven variables showed an overall significant difference between lakes with and without nesting Mew Gulls (Fig. 2). Univariate tests for each separate variable in-

TABLE 2

Discriminant Analysis between Lakes with and without Mew Gulls on Vancouver Island, Using Number of Islands, Lake Area, Lake Perimeter, Altitude, Distance to Sea and Number of Rivers

Observation		Prediction	
Lake category	Number of lakes	Number of lakes with nests (%)	Number of lakes without nests (%)
Lakes with nests	19	15 (78.9)*	4 (2.1)
Lakes without nests	39	7 (17.9)	32 (82.1)*

Discriminant function = 0.492 NI − 0.022 LA + 0.47 LP + 0.002 ALT − 0.538 DS + 0.304 NR. Wilks Lambda = 0.661, $\chi^2 = 21.93$, 6 df, $P = 0.0012$.

* Lakes correctly classified at 47/58 = 81%.

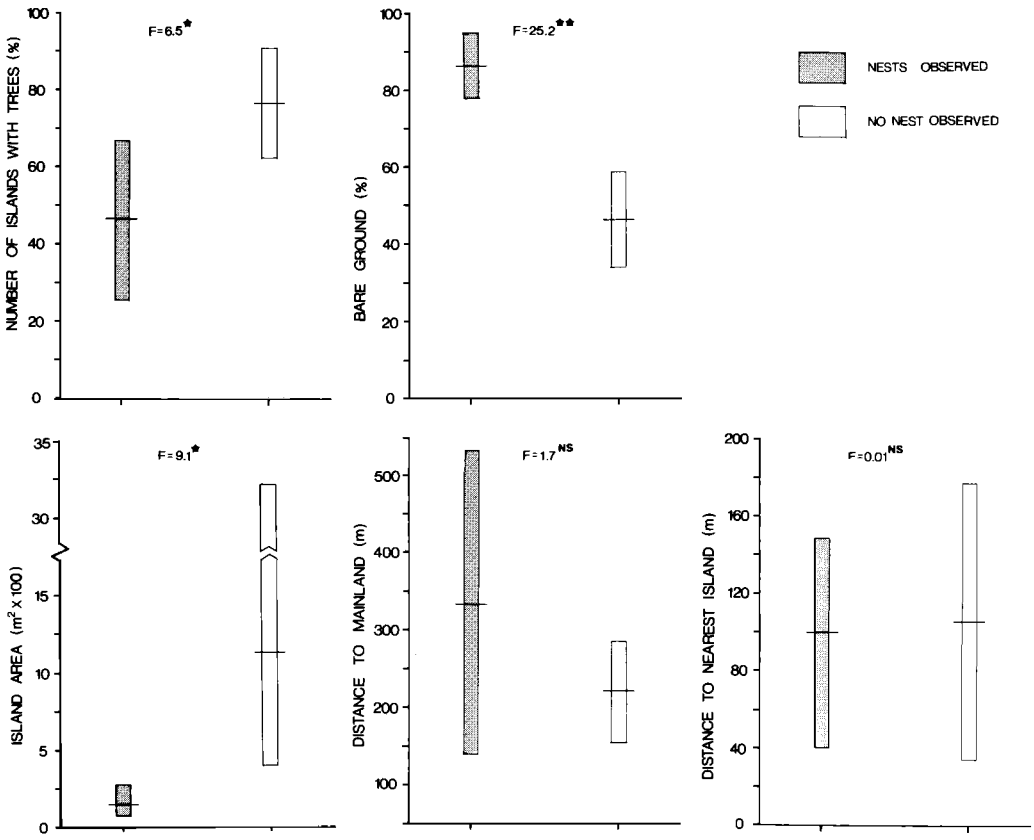

FIGURE 3. Means and 95 percent confidence intervals of variables of islands with (n = 26) and without (n = 38) nesting Mew Gulls on Kennedy Lake, 1984 and 1985. Overall significance with multivariate test: Wilks Lambda = 0.690, F = 5.206, $P = 0.01$. Univariate F test (df = 1,62).

dicated that Mew Gulls nested on lakes which had significantly more islands and rivers, were larger, and had a longer shoreline than lakes where gulls were absent (Fig. 2). Gulls also nested significantly more often on low altitude lakes and close to the sea. Since lakes at low altitude on Vancouver Island are close to the sea, those two variables are interdependent (r = 0.672). Of the seven variables tested separately, only estimated extent of human disturbance did not appear to be a significant limiting factor to nesting Mew Gulls (Fig. 2). Because of the smaller sample size than for the previously mentioned seven variables, mean lake depth was not included in the multivariate test. Of the lakes analyzed, those with nesting gulls appeared to be deeper (Fig. 2). The discriminant function of the six significant lake variables correctly classified 81 percent of the lakes surveyed (Table 2).

Islands used by nesting Mew Gulls were smaller, had a greater percentage of bare ground, and usually lacked trees (Fig. 3). Nesting by Mew Gulls at 75 percent of the islands could be predicted on the basis of the latter two variables alone (Table 3). There was no significant difference between nesting and non-nesting islands with respect to the nearest distance to the mainland or the nearest neighboring island.

Comparison of island nest sites with their matched points indicates that nests were strongly associated with island crests which have a moss substrate whereas matched points were associated with island slopes and peripheries on moss or bare rock (Table 4). Nests were situated on nearly flat surfaces (2°), which usually contained a small depression to secure them, while their matched points occurred on significantly steeper slopes (30°) (Fig. 4). Nests also were significantly farther and higher from the water than their matched points. Gulls nested significantly farther apart when more than one pair was present than if nests had been randomly distributed (Fig. 4).

Poles, pilings, or tree stumps used by nesting Mew Gulls frequently were joined and about 2

TABLE 3
DISCRIMINANT ANALYSIS BETWEEN ISLANDS WITH AND WITHOUT MEW GULLS ON KENNEDY LAKE, 1984 AND 1985, USING PRESENCE OF TREES AND PERCENT BARE GROUND

Observation		Prediction	
Island category	Number of islands	Number of nesting islands (%)	Number of non-nesting islands (%)
Nesting islands	26	22 (84.6)*	4 (15.4)
Non-nesting islands	38	12 (31.6)	26 (68.4)*

Discriminant function = 0.178 tree + 1.0999 bare ground. Overall significance tested, Wilks Lambda = 0.707, $\chi^2 = 21.11$, 2 df, $P < 0.005$.

* Islands correctly classifed at 48/64 = 75%.

TABLE 4
NEST POSITION AND ABSENCE OR PRESENCE OF VEGETATION FOR 42 NEST SITES AND THEIR MATCHED POINTS OF MEW GULLS ON VANCOUVER ISLAND, 1984 AND 1985

Variables measured	Number of nest sites (percentage in parentheses)	Number of matched points (percentage in parentheses)
Nest position		
On crest of island	39 (92.9)	4 (9.5)
On flat top of island	1 (2.4)	0 (0.0)
On slope of island	2 (4.7)	27 (64.3)
On island periphery	0 (0.0)	11 (26.2)
Chi-square values[1]	196.3**	40.5**
Chi-square values	62.0**	
Absence/presence of dominant vegetation		
Bare rock	6 (14.6)	21 (51.2)
Moss	27 (65.9)	13 (31.7)
Grass	5 (12.2)	4 (9.8)
Shrub	3 (7.3)	3 (7.3)
Chi-square values	36.95**	20.95**
Chi-square values	16.34**	

[1] Shown are Chi-square values with 3 degrees of freedom.
** $P < 0.001$.

to 2.5 m above water (Table 5). Trees used for nesting were moderate-sized coniferous trees close to shore. The nests were on limbs not far from the trunk or on broken tops at an average height of 9 m above the water surface (Table 5).

NEST DISPERSION AND POPULATION OF GLAUCOUS-WINGED GULLS

Glaucous-winged Gulls nested primarily in colonies and on the ground. A total of 3393 nesting pairs was found at 46 sites (Fig. 5). At these sites, 3269 pairs nested on the ground at islands, 119 pairs on cliffs (some in cliff cavities), 4 pairs on beacons, and 1 pair on a piling. Only 0.5 percent were observed to be solitary nesters.

HABITAT SELECTION BY GLAUCOUS-WINGED GULLS

Glaucous-winged Gulls nested on islands of various sizes but a majority of the population nested on islands 2 to 10 ha in size (Fig. 6). Ground nesting occurred on small to moderate sized islands but cliff nests predominated on large islands (Fig. 6).

A multivariate test for six island variables showed significant difference between islands with and without Glaucous-winged Gulls (Table 6). Univariate tests for each separate variable indicated that islands with gulls were significantly less forested and had more bare ground and cliffs than those without gulls (Table 6). No significant differences were observed in island area, height and distance of island to nearest mainland. That there was no significant difference in island size between nesting and non-nesting islands can be explained in that gulls nesting on cliffs generally nested on much larger islands, and were not as restricted by island size as ground-nesting gulls (Fig. 6). Since the vast majority of Glaucous-winged Gulls nested on the ground, a separate analysis of variance was carried out for islands without cliffs. Univariate tests for each separate variable indicated that ground-nesting Glaucous-winged Gulls selected islands which were significantly smaller, had a lower relief, were not forested and contained a higher percentage of bare ground than islands where gulls were absent (Fig. 7). Of the five variables tested separately, only distance to the mainland did not differ significantly between nesting and non-nesting islands.

Comparison of island nest sites with their matched points indicated that the nests of solitary Glaucous-winged Gulls, like Mew Gulls, were strongly associated with island crests, while their matched points showed no association with any position (Table 7). Nests of solitary pairs were strongly associated with grass as opposed to their matched points which were always on bare rock. Nests of colonial pairs showed no association with any position variable, but were strongly associated with bare rock and, to a lesser extent with grass, while matched points mostly occurred on bare rock. Matched points of both solitary and colonial nests occurred on significantly

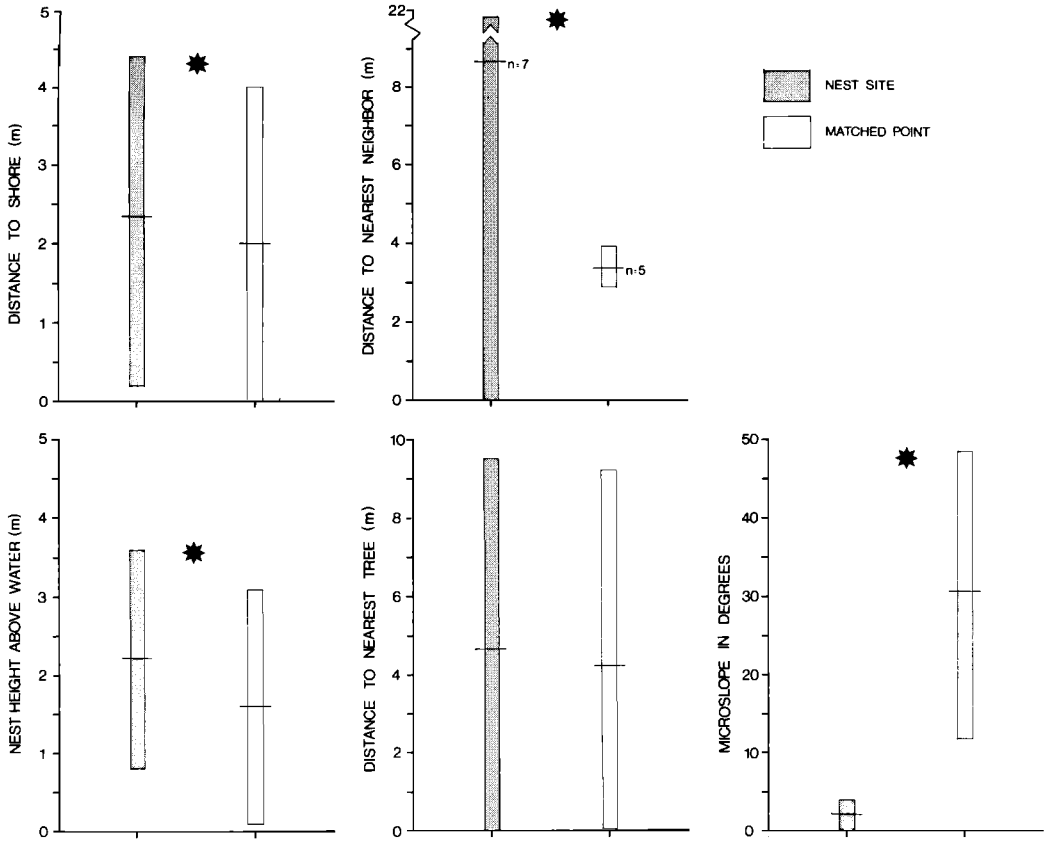

FIGURE 4. Means and 95 percent confidence intervals of variables of 42 island nest sites and their 42 matched points of Mew Gulls on Vancouver Island, 1984 and 1985. An asterisk indicates significant difference ($P < 0.05$) by normal approximation of the Sign Test.

steeper slopes and were closer to shore than nest sites (Fig. 8). No difference was observed between nests and matched points for distance to nearest neighboring nest and height above water.

DISCUSSION

Nest Dispersion and Population of Mew Gulls

Nest dispersion

One of the factors determining nest dispersion in Mew Gulls is the physical aspect of the nesting habitat. Other factors which may affect nest dispersion or extent of coloniality in gulls are predation, social factors, and food availability (e.g., Burger and Shisler 1980, Burger 1981, Andersson et al. 1981, Götmark 1982, and Götmark and Andersson 1984), but their discussion falls outside the scope of this paper. If a nesting substrate consists of a small rock, pole or tree stump, there is no room for colony establishment. On Vancouver Island most of the lake islands with nesting Mew Gulls were very small and devoid of trees. Moderate-sized islands usually were densely forested. The relative scarcity of moderate-sized islands without trees may have been one of the factors determining the predominant solitary nesting pattern of Mew Gulls. Götmark and Andersson (1984) reported that Common (=Mew) Gulls, on lakes with densely wooded islands in southern Sweden, avoided breeding among trees and were forced to nest solitarily on scattered boulders and small skerries.

Population

We estimated the total population of Mew Gulls on Vancouver Island at 127 pairs. Campbell (1970), who reviewed the nesting status of Mew Gulls in British Columbia 16 years ago, reported only three known nesting lakes on Vancouver Island: Cowichan, Kennedy, and Sproat lakes. At present there are 23 known nesting lakes

TABLE 5
NESTING PARAMETERS FOR MEW GULLS ON TOPS OF POLES, PILINGS AND TREE STUMPS EMERGING FROM THE WATER AND IN TREES ALONG LAKE SHORES ON VANCOUVER ISLAND, 1984 AND 1985

Location of nest, parameters	Number of nests	Mean and standard deviation
Nests on poles, pilings, tree stumps		
Number of poles/stumps in a group	24	1.96 ± 1.81
Area of nesting platform (m^2)	23	1.07 ± 1.14
Nest height above water (m)	24	2.39 ± 1.71
Distance to mainland (m)	24	62.6 ± 96.8
Distance to nearest pole or island (m)	24	28.5 ± 42.8
Tree nests		
Distance of tree to shore (m)	9	3.07 ± 2.89
Nest height above water (m)	9	9.03 ± 4.96
Tree diameter (m)	5	0.38 ± 0.17
Tree height (m)	8	9.13 ± 5.52
Distance from tree trunk (m)	9	0.89 ± 0.80
Distance to nearest tree (m)	7	2.46 ± 1.40

(Fig. 1, Table 1). The increase in lakes used by Mew Gulls over the past 16 years may not represent a population increase on Vancouver Island, but a better knowledge of nesting localities. Many nests found during this survey were on lakes not investigated previously.

To detect if the population is changing, we suggest that Mew Gulls on Vancouver Island be surveyed every 10 to 15 years. The nesting chronology of the species shows that the best time for conducting surveys is the first half of June, when most clutches have been laid, but have not yet hatched (Vermeer and Devito, 1986). Another practical reason for the suggested surveys is that lakes and rivers in British Columbia, including Vancouver Island, are being increasingly dammed for hydro-electricity and reservoirs. It appears that regulated lakes have fewer nesting Mew Gulls than natural ones (Vermeer and Devito, unpubl. data). Weselowski et al. (1984) also found that the damming of the Vistula River in Poland for reservoir purposes resulted in a withdrawal of terns and waders as well as a decline in numbers of gulls in the heavily changed section of the river.

HABITAT SELECTION BY MEW GULLS

The lakes most frequently selected by Mew Gulls were large, deep, and had many islands and several rivers. The large number of islands may have been the important feature. Larger lakes generally have more islands and, therefore, have more potential nest sites. Poles, pilings and tree stumps, which generally are most numerous on large lakes (due to logging activity), are also used as nest sites. We did not investigate the number of poles, pilings and tree stumps in a lake in relation to nest site requirements. Prior to our study Mew Gulls had not been recorded using those sites on Vancouver Island.

Many potential nesting islands, poles, and stumps were unused, suggesting that there are other requirements for nesting. In a study at Kennedy Lake, adult Mew Gulls fed mostly on crayfish in the lake and associated rivers (Vermeer and Devito 1986). This may explain the apparent importance of rivers, although the number of rivers is usually a function of lake size. Adults brought their young fish which were caught in the nearby marine intertidal zone. Mew Gulls rely, therefore, only partially on nesting lakes and their rivers for food, and the remainder of their diet comes from marine habitats. This may explain why many Mew Gulls nested close to the sea.

Mew Gulls nested predominantly on the crests of small treeless islands that were largely moss-covered and bare rock. Small bare islands may be less frequently patrolled by mammalian predators such as mink and river otter than the larger forested islands, and nesting on a crest may allow the Mew Gull to see any approaching predator from a distance.

HABITAT SELECTION BY GLAUCOUS-WINGED GULLS

Glaucous-winged Gulls in the Gulf Islands nested predominantly on the ground of small to moderate-sized islands. Only a small fraction of the population (4%) nested on cliffs, and this usually occurred on larger islands. Cliff nesting occurred on larger islands perhaps because (1) most cliffs occurred there, and (2) cliffs are inaccessible, whether on small or large islands, to

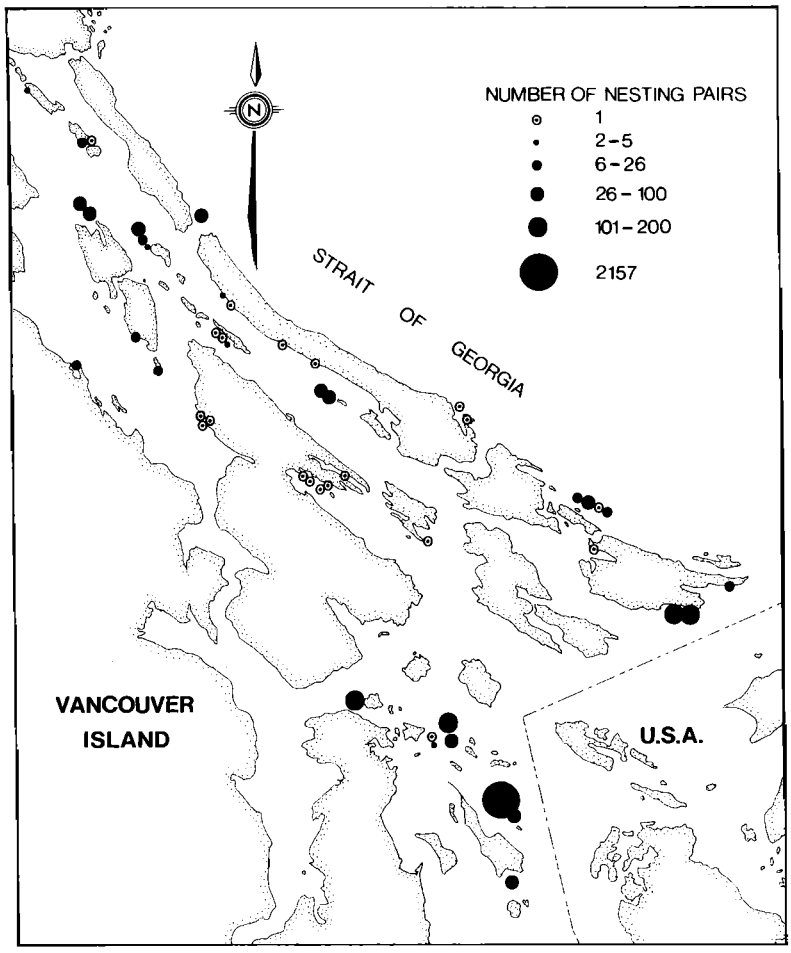

FIGURE 5. Nest dispersion of Glaucous-winged Gulls in the Gulf Islands, SE Vancouver Island, 1985.

mammalian predators such as the river otter (*Lutra canadensis*) (Foottit and Butler 1977, Verbeek and Morgan 1978). It is not surprising that ground-nesting gulls used relatively small islands with few trees. Most of the large forested islands had villages or residences with cats and dogs, and undoubtedly established populations of wild predators, which could prey upon eggs, chicks and possibly adults. Gulls also avoided small and moderate-sized islands that were forested, possibly because of difficulties they had in negotiating departure from and landing at nest sites among trees.

Solitary pairs of Glaucous-winged Gulls preferred island sites near crests for nesting. Colonial pairs, on the other hand, did not show a preference for any nest-site location, perhaps because nests in large and often saturated colonies are uniformly distributed. Intraspecific aggression at these latter locations may play a decisive role in the spacing of pairs and consequent site establishment (Vermeer 1970). Elevation in a colony is not as essential as it is for solitary nesters, as the alarm calls of gulls nesting on crests will warn those in more concealed conditions of the approach of predators. On Mandarte Island, a long-established and the largest colony in the Gulf Islands (Fig. 5), many gulls nest at the end of a tunnel underneath shrubs.

Interspecific Variation in Nest-site Selection between Mew and Glaucous-winged Gulls

Mew and Glaucous-winged gulls in British Columbia nest in very different macrohabitats, the former in fresh and the latter in marine waters. In Europe, however, Mew Gulls nest commonly in marine waters in association with larger Her-

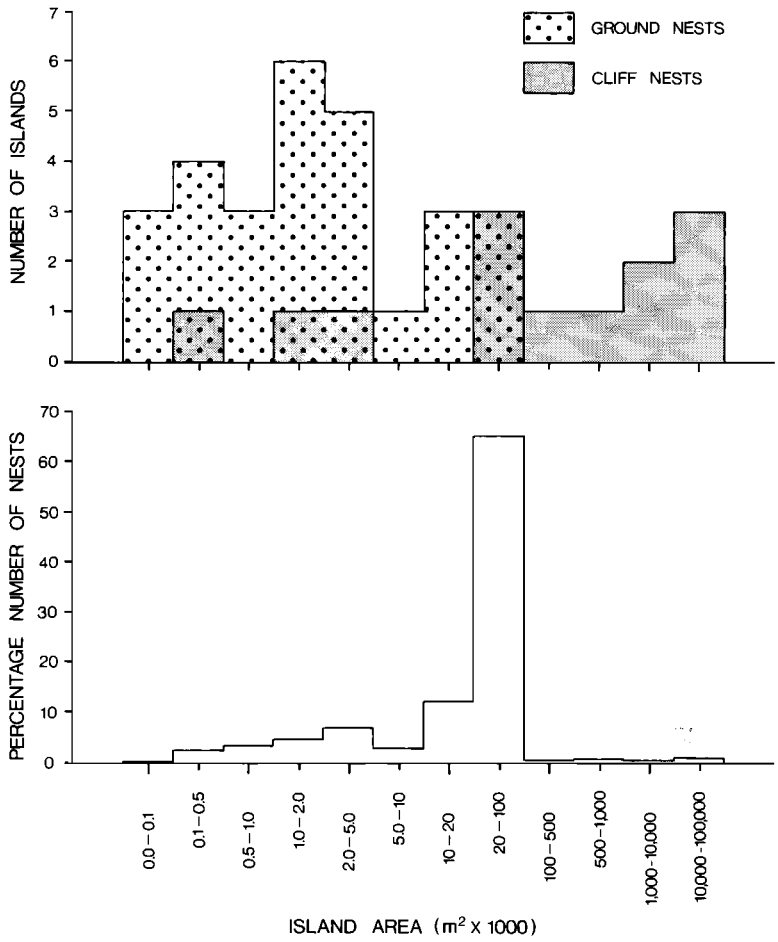

FIGURE 6. Comparison of numbers of nests and island size for ground and cliff-nesting Glaucous-winged Gulls, Gulf Islands, 1985.

ring Gulls (*Larus argentatus*) as well as Greater Black-backed Gulls (*Larus marinus*), although the different species have distinct habitat preferences (Götmark 1982, Hanssen 1984, see also Bianki 1967). The reason Mew Gulls are restricted to the fresh water habitat in British Columbia and not in Europe is unknown. Perhaps the Mew Gull is gradually expanding into a new habitat

TABLE 6
ANALYSIS OF VARIANCE OF MEANS OF VARIABLES OF ISLANDS WITH (N = 41) AND ISLANDS WITHOUT (N = 160) NESTING GLAUCOUS-WINGED GULLS IN THE GULF ISLANDS, 1985

Univariate F test (df = 1,199)	Mean square error	F statistic	Signif. of F
Variables			
Natural log of island area (m^2)	20.82	2.22	0.138
Island height (m)	275.64	0.06	0.807
Natural log of distance to nearest mainland (m)	9.69×10^6	0.24	0.620
Forest present	3.58	15.26	<0.001
Bare ground (%)	3.46×10^4	24.46	<0.001
Cliffs present	2.64	24.52	<0.001

Overall significance with the multivariate test Wilks Lambda = 0.712, F = 13.066, $P < 0.001$

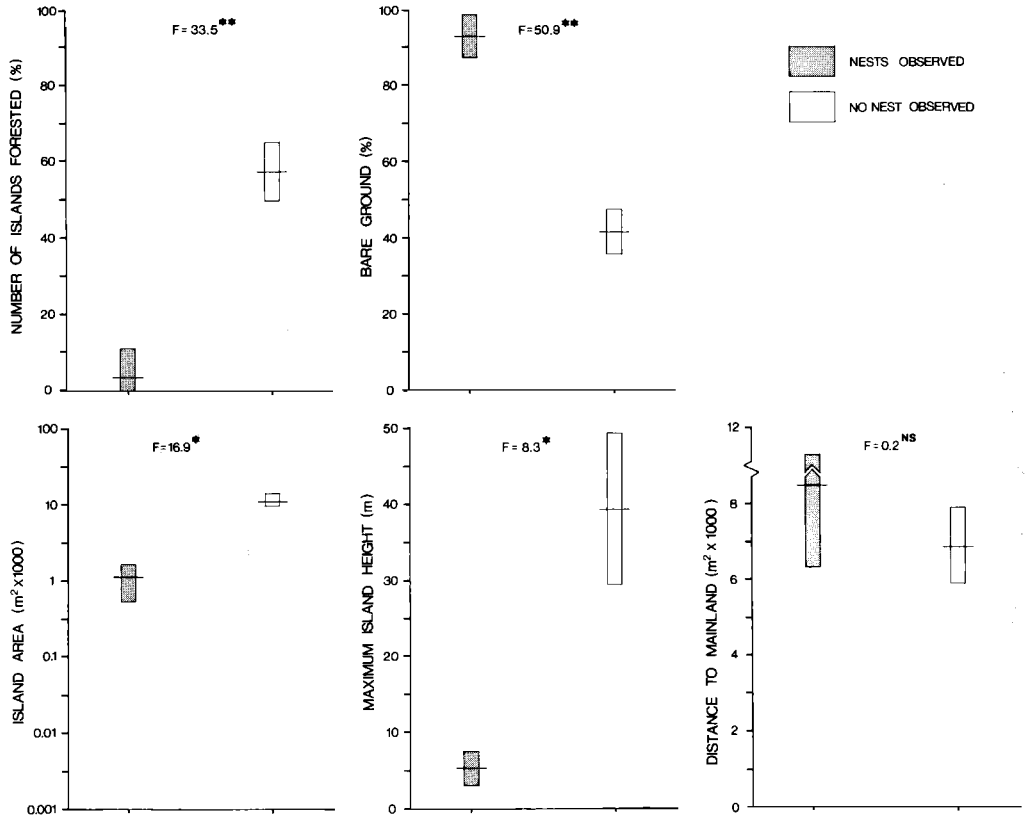

FIGURE 7. Means and 95 percent confidence intervals of variables of islands with (n = 29) and without (n = 160) ground-nesting Glaucous-winged Gulls in the Gulf Islands, 1985. Overall significance with multivariate test: Wilks Lambda = 0.761, F = 9.541, $P < 0.001$. Univariate F test (df = 1,87).

in British Columbia, because the niche in the marine environment is already filled by Glaucous-winged Gulls.

In some instances, Mew and Glaucous-winged gulls nest in different microhabitats (e.g., cliffs versus trees), but selection of island sites by solitary pairs is remarkably similar. Solitary pairs of both species nested on the crests of small islands with low herbaceous cover of grass or moss. Grass usually grows on the elevated interior of small islands used by Glaucous-winged Gulls, while most of the perimeter is bare rock subject to wave action during high tides and storms. Mew Gulls in Scandinavia, like Glaucous-winged Gulls in British Columbia, nest on grass substrates on low and small to moderate-sized islands in the marine environment (Vaisanen and Jarvinen 1977, Hanssen 1984). In contrast to the marine habitat, Mew Gulls nesting on rocky islands, poles, tree stumps, and pilings in Vancouver Island lakes, are usually safe from wave action and tides.

Plasticity in Habitat Selection of Mew and Glaucous-winged Gulls

Mew Gulls

Mew Gulls nest mostly on small, fresh water islets, on poles and tree stumps on large lakes in British Columbia (this study); on marshes and small islands in ponds, lakes and rivers in Alaska (Bent 1921, Strang 1974, Burger and Gochfeld pers. comm.); and on marine islands in the Gulf of Alaska (Hatch et al. 1978). In Scandinavia, they nest in bogs, on islands in ponds and lakes (Ytreberg 1956, Haftorn 1971, Götmark and Andersson 1984) as well as on islands in the sea (Götmark 1982, Hanssen 1984), and in trees and on roofs of houses (Haftorn 1971). In the interior of Poland, Mew Gulls nest extensively on river islands (Weselowski et al. 1984). On islands in the White Sea of the western USSR, Mew Gulls prefer to nest on maritime meadows and in areas with crowberries (Bianki 1967). In Scandinavia, they also nest in mountain heath (*Empetrum ni-*

TABLE 7
NEST POSITION AND ABSENCE OR PRESENCE OF VEGETATION FOR NEST SITES AND THEIR MATCHED POINTS OF 12 SOLITARY AND 42(44) COLONIAL PAIRS OF GLAUCOUS-WINGED GULLS IN THE GULF ISLANDS, SE VANCOUVER ISLAND, 1985

Variables measured	Solitary nesters		Colonial nesters	
	Number of nest sites	Number of matched points (percentage in parentheses)	Number of nest sites	Number of matched points
Nest position				
On crest of island	9 (75.0)	3 (35.0)	12 (28.6)	8 (19.0)
On flat top of island	1 (8.3)	1 (8.3)	8 (19.0)	10 (23.8)
On slope of island	2 (16.7)	5 (41.7)	10 (23.8)	15 (35.7)
On island periphery	0 (0.0)	3 (35.0)	12 (28.6)	9 (21.4)
Chi-square values[1]	0.67*	2.67	1.05	2.76
Chi-square values	5.79		2.45	
Absence/presence of dominant vegetation				
Bare rock	3 (25.0)	12 (100.0)	24 (54.5)	38 (86.4)
Moss	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Grass	9 (75.0)	0 (0.0)	15 (34.1)	4 (9.1)
Shrub	0 (0.0)	0 (0.0)	5 (11.4)	2 (4.5)
Chi-square values[1]	18.0**	36.0**	31.3**	89.9**
Chi-square values	14.4**		10.4**	

[1] Three degrees of freedom.
* $P < 0.05$, ** $P < 0.005$.

grum) in association with Arctic Skuas (*Stercorarius parasiticus*) (Götmark and Andersson 1980). Nesting in trees is common in British Columbia (this study) and in certain regions in Norway (Haftorn 1971), and apparently occasional in Alaska (Bent 1921, Dick et al. 1976), Finland (Silvola 1957) and the northeastern USSR (Bianki 1967). From the above observations it is evident that the nest habitat of Mew Gulls varies tremendously over its breeding range. The different nesting patterns of Mew Gulls may be the result of inherent behavioural differences among populations or may reflect species plasticity. At Stavanger in northern Norway, Mew Gulls nesting in mountain heath in association with Arctic Skuas had significantly smaller nests and less nest material than at a nearby colony on a lake island (Götmark and Andersson 1980). The gulls nesting in mountain heath, of which crowberry is an important component, apparently nest in similar habitat as those at Kandalaksha Bay, USSR. Bianki (1967) observed that Mew Gulls at Kandalaksha Bay nested primarily in maritime meadows with crowberry patches. In this habitat Mew Gulls commonly built on driftwood logs, hillocks, and small rocks, but when on dry level ground the nest site was often simply a hole with a meager lining of grass stems. Bianki's (1967) observation of the two nest types within a crowberry meadow suggests a high degree of plasticity within the same nesting population.

Glaucous-winged Gulls

Glaucous-winged Gulls, unlike Mew Gulls, usually are restricted to the marine habitat in the North Pacific Ocean (Drent and Guiguet 1961, Sowls et al. 1978). One pair of Glaucous-winged Gulls was observed nesting on top of a piling on Cowichan Lake during our survey of Mew Gulls. In Washington and Oregon, a small number of Glaucous-winged Gulls nested in colonies of California (*Larus californicus*) and Ring-billed gulls (*L. delawarensis*) about 300–500 km from the mouth of the Columbia River (Conover 1984). Inland-nesting of Glaucous-winged Gulls appears to be a recent phenomenon. Hybridization between Glaucous-winged and Herring gulls on inland lakes, however, has been observed in Alaska (Williamson and Peyton 1963) and in British Columbia (Merilees 1974).

Within the marine habitat, Glaucous-winged Gulls nest on islands, jetties, cliffs, beacons, pilings, bridge abutments, barges, derricks, log booms and occasionally in cliff cavities and large trees (Drent and Guiguet 1961, Campbell 1975, this study) as well as on roofs of buildings in coastal cities (Oldaker 1963, Eddy 1982, authors' unpubl. observations). The occupation of roofs by Glaucous-winged Gulls has increased during the last three decades and many hundreds of gulls presently nest on roofs in Seattle and Vancouver (Eddy 1982, Vermeer unpubl. observations). The above observations indicate that the Glaucous-

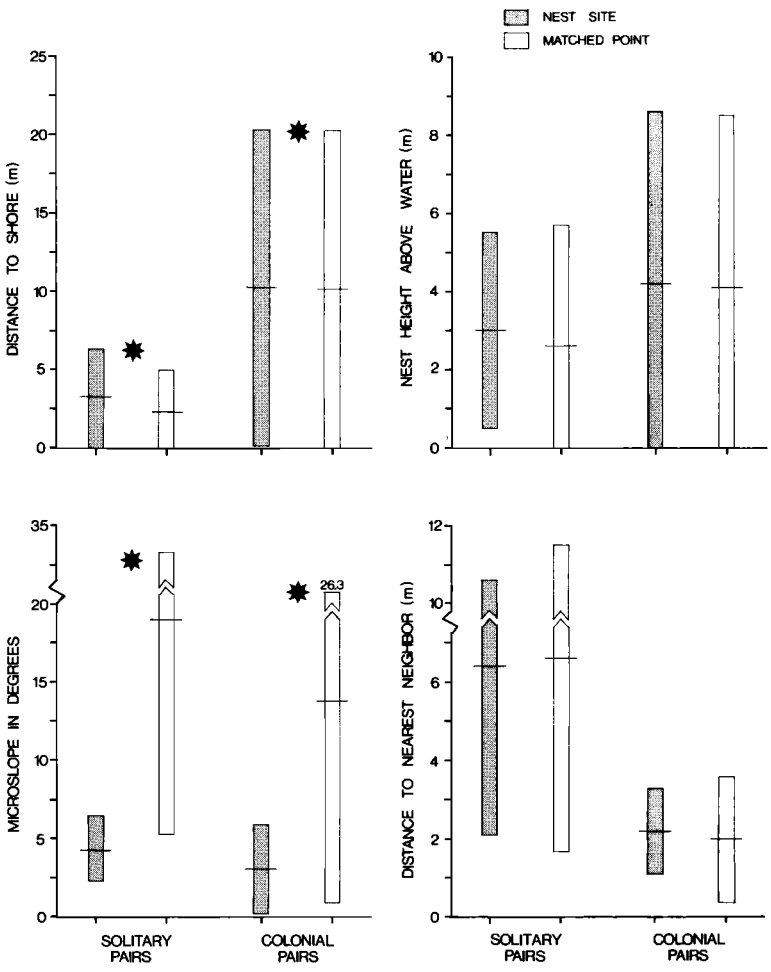

FIGURE 8. Means and 95 percent confidence intervals of variables for nest sites and their matched points of 12 solitary and 42 colonial pairs of Glaucous-winged Gulls in the Gulf Islands, 1985. An asterisk indicates significant difference ($P < 0.05$) by normal approximation of the Sign Test.

winged Gull, like the Mew Gull, is very plastic in its choice of nesting habitat. The recent invasion by Glaucous-winged Gulls of inland lakes and rivers, albeit on a limited scale, and on roofs of city buildings may result from a rapidly expanding population, facilitated by an increasing supply of human refuse (Drent and Guiguet 1961, Vermeer 1963, Butler et al. 1980).

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